INTRODUCTION

Biological invasions—the establishment and spread of non-native species in new regions—is one of the greatest threats to the ecological security of the Great Lakes basin, which spans the United States and Canada.¹ The threat lies with the ability of a non-native introduced species to become invasive—to spread aggressively and cause undesirable impacts to the environment, economy, and human health.² However, not all non-native introduced species become invasive, at least not immediately. There can be a time lag between introduction, establishment, and harm, dictated by some local environmental condition (e.g., temperature or precipitation) that limits or suppresses the non-native species. When a shift in that environmental condition occurs, perhaps driven by changes in climate, nutrients, or water levels, a threshold may be breached, triggering an eruption in the once-inconspicuous (i.e., “sleeping”) non-native population. Once this biotic eruption has occurred, the newly invasive species may destabilize the local ecosystem, potentially even tipping an entire ecological system into an alternative state.³ Major changes or state shifts in ecosystems resulting from species invasions can undermine biodiversity, food, and economic security and even increase exposure to zoonotic diseases.⁴

The potential for non-native species to meet the “sleeper” definition is growing as climate change drives more frequent and intense fluctuations in weather events, thus providing conditions for these species to erupt. Consequently, management might require a new suite of special monitoring and response capabilities. However, the unpredictable nature of sleeper species makes it difficult for land and water resource managers to prioritize funds and conservation activities to predict and counter invasion potential. For instance, species introductions can occur in small batches and isolated areas, and species need time before they can establish populations large enough to be noticed.

Even if natural resource managers know that a non-native species is present, the complexity of how that species interacts with the environment makes it extremely difficult to pinpoint exactly how or when it may become invasive. Understanding what environmental factors currently suppress the species’ population would bring resource managers closer to identifying potential tipping points that would release the sleeper, enabling invasion (Fig. 1). This management complexity grows when also accounting for the variety of ways species are introduced to new regions.

As climate change creates opportunities for some species to be more successful, it will be challenging to build preventative frameworks that target already established invasive species while also adapting these frameworks to detect and monitor sleeper species rapidly. This briefer highlights the need for a cohesive management plan with a rapid response structure to address the threat of invasive and sleeper species, with emphasis on synergizing data collection, collaboration, and public translation of the threat.

While this is a global issue, this briefer focuses on the environments, industries, and communities of the Laurentian Great Lakes, located in the northern Midwest of the United States and southern Canada (Fig. 2). These lakes are threatened by species introductions and invasions driven by booming recreational and shipping industries and an expanding economy.

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5 Bradley, “Preparing for sleeper species.”
6 Idem
VECTORS OF SPECIES INTRODUCTION AND SPREAD

Understanding vectors of species introductions is key to mitigating their impacts. Invasive species are a leading cause of biodiversity loss, where invaders outcompete and displace native plants and animals. How species reach new destinations is a function of an increasingly connected world. Most invasions in the Great Lakes over the last 60 years are attributed to international trade (either an unintentional consequence of shipping or deliberately, as cargo to be sold to pet stores, bait shops, and aquariums). Approximately one new species was introduced into the Great Lakes every six to seven months between 1959 and 2006, and transportation continues to spread non-native organisms into new regions of the lakes despite an array of management interventions.

The zebra mussel (*Dreissena polymorpha*) is one of the most notorious examples of the Great Lakes invasive species. They hitched a ride in the ballast waters of ships from Eastern Europe and Western Russia and have since altered the social, economic, and ecological security of the Great Lakes. These mussels can attach to almost any surface, leading to high management costs for drinking water facilities and other industrial infrastructure. Both zebra and native freshwater mussels form large colonies; however, their impacts on the surrounding ecosystem are very different. Zebra mussels are prolific filter feeders, filtering bacteria, fungus, and zooplankton that are consumed by fish. The native mussels only filter out bacteria and fungus, creating biological hotspots that favor plankton and macroinvertebrates for fish to consume. Today, the long-term management of this well-established mussel costs the Great Lakes region about $300-500 million annually in damages and maintenance costs for removing colonies from power

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8 Idem


10 Ibid

plant and water treatment intakes, boats, docks, and other industrial complexes.  

Ballast water is used to stabilize ships in transit. It can unintentionally contain plants, fish, and microorganisms that are then released into new environments as the water is discharged and exchanged to selectively change the vessel’s weight or reduce draft. Trailered watercraft (e.g., Motorized fishing boats, personal watercraft, and non-motorized vessels like canoes or kayaks) are another route for the accidental spread of invasive species. Plants and microorganisms can easily hitchhike on these watercraft as they are trailered between different bodies of water. Wading boots with felt soles and other fibrous materials can harbor invasive bacteria and aquatic species. Six states and Yellowstone National Park restrict the use of felt-bottom waders to help minimize the risk of new introductions.

**EXAMPLES OF SLEEPER SPECIES**

One example of a sleeper species that erupted in a freshwater system is the spiny water flea (*Bythotrephes longimanus*), native to northern Europe and Asia. This species was found in 2009 during a routine sampling event in Lake Mendota, Wisconsin. The density of the species found during the sampling event suggested a lake-wide infestation instead of just a few individuals, which would indicate a new or early emergence. Later studies found that the spiny water flea had persisted in low numbers for years before a thermal threshold (a critical temperature that, when surpassed, can lead to an irreversible change in the system) was crossed, and the population was then able to increase exponentially. This non-native zooplankter is not a good food source for native fish due to its characteristic long spines. They also prey on other zooplankton, ultimately diminishing the integrity of the food web and reducing filtration rates with cascading reductions in water clarity. The cost of restoring water clarity in Lake Mendota was estimated to be $86-163 million. Spiny water fleas have been established in all five of the Great Lakes, where boating and trailering have served as the primary transport vector. No effective management strategy exists, and a greater focus has been placed on preventing further introduction and spread.

The gloomy scale insect (*Melanaspis tenebricosa*) is another suspected sleeper species; however, this one is native to the southeastern United States and has become a common street-tree pest in urban areas. The insect is now reaching areas outside of its natural range due to increasing temperatures. These insects persist in plant nurseries and are then transported via

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16 Ibid
trade. The gloomy scale is being recognized as a sleeper species due to strengthening urban heat islands in the Midwest, which are creating more suitable environments for the insect to thrive.18 Urban tree planting is increasingly being employed as a tool for combating heat stress in urban islands, but the effectiveness of such prescriptions is threatened by this new insect. Heavily infested trees will experience a thinning canopy and branch loss, eventually leading to death. The gloomy scales use their piercing-sucking mouthparts to penetrate the bark and steal nutrients and energy from the tree. These insects are creating another barrier to successfully establishing robust tree canopies and combating heat islands in urban environments.19

Figure 4: General invasion curve showing how prevention is the most efficient and least costly method of combating invasive species.

THE UNFORGIVING INVASION COST CURVE: HORIZON SCANNING FOR THE NEXT ERUPTION

The economic costs of addressing a species invasion grow alarmingly as the area it occupies increases (Fig. 4).20 Therefore, it is prudent to identify potential invaders before they can be introduced or spread. Invasive species data hubs and other data collaborations can be critical tools in preventing the spread and minimizing the chances for eruptions of non-native species, especially when employing the public’s help. Pooling information enables land and water resource managers to conduct horizon scans, a process used in invasive species management to assess the threats posed by potentially introduced species and prioritize them accordingly. This data collection and sharing is a collaborative effort that can enable natural resource managers to identify and potentially preempt threats from introduced species, which, if they erupt, can destabilize the integrity of social and economic systems and the structure of the environment.

POLICY AND DATA SHARING

The typical strategy for managing invasive species involves treatments to reduce their populations physically or chemically. In some cases, a biological control (e.g., a parasite from the species’ native range that specializes in it and is unlikely to become invasive) may be deployed after lengthy study, testing, and regulatory approval. Regardless of the strategy, the most economical way to protect the environment

18 Ibid
20 Ibid
from biological invasions is to focus on prevention, which requires multiple concerted management tactics and collaborative efforts. Collaborations can work across communities and sectors, but it can be extremely difficult to garner enough support when there is limited funding and information about potential species or what threshold could trigger an eruption. Therefore, the primary goal in prevention is to be vigilant, watching for and reporting new introductions along with species that are already introduced.21

Targeting specific vectors (e.g., motorized and non-motorized vessels) for invasive species has been an effective approach, especially for the Great Lakes region. The treatment of the ballast water (via water exchanges with additional treatments of hypochlorite, chlorine dioxide, ultraviolet radiation, or deoxygenation to reduce the survivability of organisms in the tanks) has helped reduce the risk of new introductions of invasive species to aquatic systems.22 New technologies are being developed; however, the policies to implement them are not yet fully developed—leaving gaps in understanding of what ballast water management systems are necessary on board, what ports require them, and who must comply. For the shipping industry, vessel operations become complicated when ballast water regulations differ between the US Coast Guard (USCG) and the US Environmental Protection Agency (EPA). There can also be variations in regulations imposed by each of the Great Lakes states that need a stronger hand in protecting water resources. It becomes a gamble for operators to invest in new technology without a cohesive regulatory framework.

Collaborative research and field data collection are needed to fully understand the efficacy of ballast water management systems. This information has the potential to help government leaders work together to strengthen the regulatory framework, create an industry baseline, and then make investments in treatment technologies sufficient to protect the Great Lakes ecosystems and the people and businesses that rely on them.

**ECOLOGICAL DIPLOMACY**

The Great Lakes Water Quality Agreement between the United States and Canada emphasized “the need to strengthen efforts to address new and continuing threats to the quality of the Waters of the Great Lakes, including aquatic invasive species, nutrients, chemical substances, discharge from vessels, climate change impacts, and the loss of habitats and species.”23 The sustained success of this long-term invasive species management plan relies on policymakers to support collaborations that streamline data collection and sharing and enable flexible funding strategies that support early detection and rapid responses—a complex system of actions that need to work seamlessly.24

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TRANSLATING SCIENCE INTO ACTION

The public plays an important role in the unintentional transportation of invasive species and their detection and eradication. This duality highlights the power of education and engagement at all levels of the invasion curve (Figure 4). Programs that empower communities to help with early detection and rapid response can become powerful tools in increasing the success of novel species detections, such as the spotted Lanternfly (*Lycorma delicatula*), red swamp crayfish (*Procambarus clarkii*), or spongy moth (*Lymantria dispar*), in parks or neighborhoods or pet stores.25 Organizations that operate at national to local scales are creating successful programs when they have the funding and community support to effectively translate complex socio-economic and biological information (from policy and research) into actionable steps. Communities can be empowered and become part of the solution to protecting their environments.

Communicating how the public can contribute to preventing and addressing invasive species is key to effective threat mitigation. Many non-profit watershed organizations within the Great Lakes region share the mission to educate and engage with a diversity of stakeholders about invasive species; however, greater access to a variety of information (e.g., multilingual flyers), tools (e.g., cleaning supplies for fishing and paddling equipment), and funding sources (e.g., federal, state, or private foundations) are needed to find a shared understanding and create a significant impact together. It is not just about the number of people to interact with; instead, it is the depth and consistency of the interaction that can create trust and a willingness for a volunteer to come back and continually help. This level of communication has been particularly effective when applied to regular users of impacted natural resources. For example, “clean, drain, dry” has become a familiar tagline for the Clean Boats, Clean Waters initiative, which has grown into a successful aquatic invasive species public education and engagement program in the Great Lakes region.26

The Midwest Invasive Species Information Network (MISIN) is another example of a thriving community and professional engagement program27. Paddlers are well-positioned to notice changes along their favored waterways and can use this network to report signs of new or increasingly established invasive species. Professional natural resource practitioners can then use the tool collaboratively to provide further access to data, maps, and training for reporting invasive species. The MISN is an important resource for practitioners and an excellent example of citizen science in action; however, communication and citizen science have limitations, and the most significant impacts can be accomplished with many other preventive measures.

RECOMMENDATIONS

The following recommendations are focused on staying ahead of the invasive species curve and minimizing impacts on the economy, environment, and cultural resources. Prevention is the best and first line of defense against invasive species collection efforts that are current, accurate, and accessible to a wide

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25 Michigan Department of Natural Resources. “Eyes in the Field,” accessed January 24, 2024
27 Midwest Invasive Species Network. 2022. https://www.misin.msu.edu/
range of communities and natural resource professionals. Collaboration among policymakers, natural resource practitioners, industry leaders, and the public is imperative to unify efforts working toward prevention and early detection. This will help inform decisions about where and how to invest in programs to control current and future invasions.

**Educate and enlist the public:** The goal of public outreach is to help raise awareness and engage the public in efforts to prevent, monitor, and combat non-native and invasive species. A higher level of engagement will help local land and water managers in the early detection and identification of invasive species. Data collected by the public can also help inform local management decisions and regional efforts for tracking and preventing invasive species.

**Motivate industry to reduce species introductions:** Prevention is key in protecting natural resources from the threats of biological invasion. Industry can take a lead role in this defense through better management of transportation networks, monitoring source materials, and acquiring a more in-depth understanding of invasive species hotspots. Early detection and rapid response (EDRR) are key tools for finding and eradicating potential invasive species before they spread. This can help minimize threats while keeping up with new technologies and evolving industry needs.

**Fund early identification and control of sleeper species:** Once an invasive species becomes established, the costs of management rise tremendously. Taking preventative actions (e.g., regular surveillance, sampling, and coordination with neighboring resource managers) before the species eruption, rather than reactive measures after it has occurred, is most cost-effective and successful at controlling and even sometimes eradicating non-native species (Figure 4).

**Establish an international and interstate introduced-species management plan:** A comprehensive, well-managed, transboundary invasive species program can help prevent the spread of non-native species to additional systems. Collaboration, extensive data collection, and public communications would be at the core of this plan.

**Update and unify the standards for Early Detection and Rapid Response (EDRR):** Streamlining EDRR standards that are more coordinated, attentive, and keep pace with the evolution of industry and technological advancements will be needed to ensure the security of the Great Lakes from future invasions. Preventing invasive species from being established is the most cost-effective; however, when prevention fails, eradication and control become imperative to managing the species as quickly as possible.

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29 Reaser. “Early detection of and rapid response (EDRR) to invasive species.”
CONCLUSION

Sleeper species are a threat to ecological security globally due to their unpredictable nature and our lack of preparedness to deal with acute biotic eruptions. The Great Lakes are especially vulnerable in that they contain 21% of the Earth’s freshwater—providing drinking water to over 30 million people between the United States and Canada—and support rare and globally unique ecosystems.\(^30\) The Great Lakes are also a powerhouse for recreation, agriculture, energy production, and transportation of raw materials for manufacturing products used regionally and globally.\(^31\) An ecological disruption here could have profound socioeconomic and environmental impacts that affect the movement of goods, people, capital, and ecosystem processes. Degradation of this system (by chemical pollution via increased industrial activities and transportation or the collapse of the fisheries resulting from invasive species introductions) would result in catastrophe for millions.

The unique characteristics of the Great Lakes ecosystems, industries, and communities present a challenging socio-ecological context for future invasive species management. Mitigating visible invasive species while preparing for those not yet “awakened” will require collaboration among scientists, policymakers, and the public. Scientifically sound information is a key driver in developing the best management strategies but is not the sole solution. Communication and collaboration remain at the core of strengthening the security of the Great Lakes and empowering the communities that rely on the innumerable co-benefits that the Great Lakes provide.
