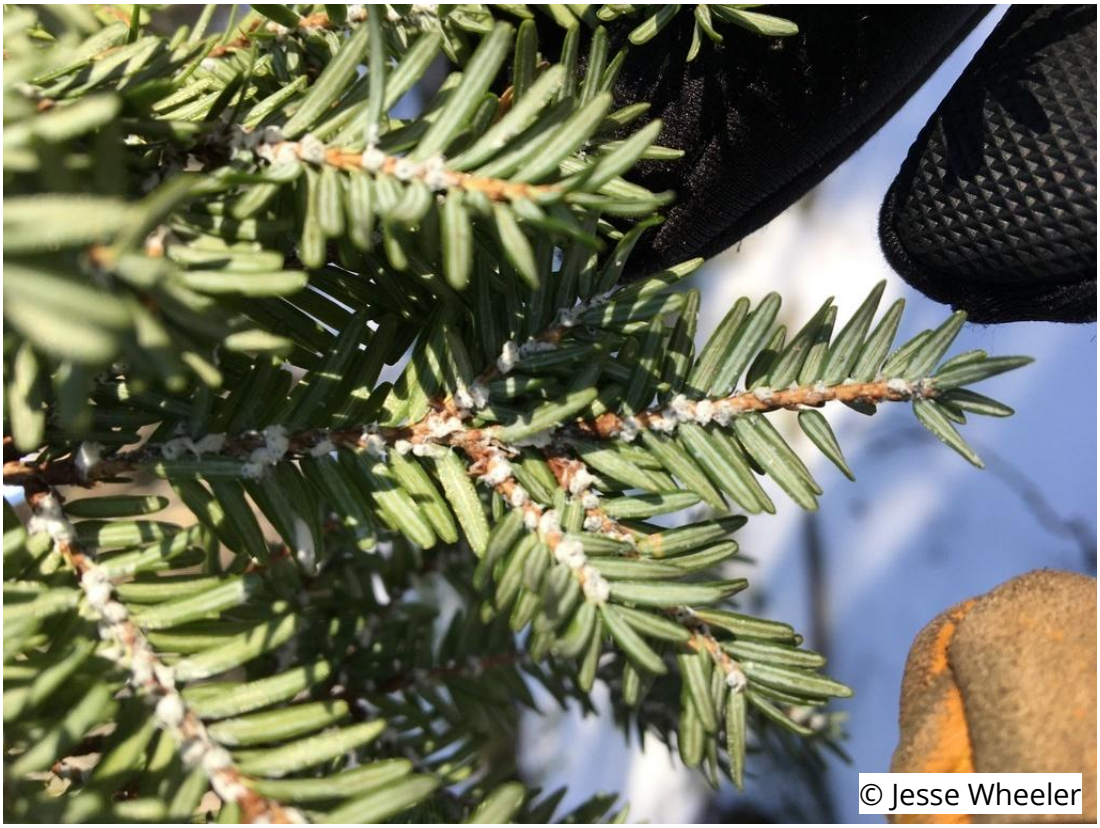
A PARTICIPATORY SCIENCE EARLY-DETECTION SYSTEM FOR INVASIVE PLANTS AND FOREST PESTS: FINAL REPORT

Kyle A. Lima, Tatia Bauer, Trevor Herrick, Andrew Deci, Megan Wenner, Eleanor Freed, and Nicholas A. Fisichelli



This project was led by Schoodic Institute at Acadia National Park in partnership with Maine Coast Heritage Trust.

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ABSTRACT

Climate change, invasive plants, and forest pests are rapidly changing forested ecosystems in the seven-state FEMC region. Detecting these changes early is critical to implementing cost-effective management and limiting the impact of disturbances. However, many forest disturbances likely go undetected until it is too late for cost-effective management because current monitoring protocols are labor intensive, focus on small monitoring plots which often miss invasive species, and require specialized skills. An early-detection system that can be applied over large spatial scales is needed to help protect forests and improve management of invasive species. Here, we help fill this critical monitoring gap by engaging and inspiring the large, rapidly growing, number of participatory scientists already interacting with protected areas. This project will be co-directed with the Maine Coast Heritage Trust (MCHT) who manages over 170,000 acres of land in over 150 preserves in coastal Maine. Together, we will develop an automated early-detection system that communicates observations and locations of species of management priority to forest managers that are reported in or near the 150+ preserves. We will supplement the general influx of participatory science data with organized bioblitzes at MCHT properties that also serve to train and encourage a diversity of volunteer monitors. This early-detection system can continue indefinitely with minimal effort and can be transferable to any protected area.

***Keywords*:** participatory science, early detection, forest management, forest pest, iNaturalist, invasive species, Maine, participatory science

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EXECUTIVE SUMMARY

In 2024, Schoodic Institute at Acadia National Park and Maine Coast Heritage Trust (MCHT) proposed to create an early-detection system that would allow forest managers and stewards to quickly and concisely learn about observations of priority species (e.g., forest insect pests) in or near their management areas through participatory science data from iNaturalist. Schoodic Institute scientists and MCHT property stewards identified a list of priority invasive species and pests (e.g., hemlock wooly adelgid, emerald ash borer, glossy buckthorn) and implemented this system across MCHT's 170,000+ acres of land in more than 150 preserves across Maine. We ran two training events to attempt to build a community of volunteer monitors, and we continue to work on communications with preserve visitors to help expand this project. Our project addresses two of the 2024 FEMC priority topics: (1) invasive pest monitoring and (2) invasive plants. We built this system with transferability at the forefront of the design, and thus this system can be adapted for any protected area or at any scale, throughout the seven-state area and beyond.

PROJECT RATIONALE

Forests are currently experiencing great change through impacts of invasive plants and forest pests that alter the landscape and affect ecosystem function (Boyd et al., 2013; Liebhold et al., 2017; Plotkin et al., 2021). These species impact forested ecosystems by reducing growth, abundance, and diversity of native species, for example, that together compose forests (Simberloff et al., 2013). Once invasive and pest species are established, management can be prohibitively costly and strategies such as chemical applications and biological controls can have unintended secondary impacts (Gandhi & Herms, 2010; Sweeney et al., 2021). Early detection of these species is essential for creating cost-effective management and preventing major change in forests (Paap et al., 2017; Poland et al., 2021).

Unfortunately, there are no individual forest management entities that work across the entire seven-state FEMC program area, making it extremely difficult to create and coordinate monitoring efforts. However, participatory science observers and observations are abundant across the whole focal area. More than 228,000 iNaturalist users have submitted over 9 million observations of over 27,500 species (iNaturalist) across the seven-state region. Aligning with and integrating this popular platform can be increasingly valuable at the management-relevant scale of individual forest parcels. Furthermore,

current monitoring protocols (e.g., plot-based monitoring) are not designed for early detection and often require specialized identification skills that make it too expensive for many small forest preserves (Boutin et al., 2009; Cohn, 2008). Turning recreational forest users into volunteer forest monitors could be a cost-effective way to monitor invasive plants and forest pests at large spatial scales, fill this critical monitoring gap, and inform local management. However, the great potential of these participatory science projects has been underutilized by forest managers, in part because it is currently difficult for managers to sift through the troves of data and find observations specific to the forests they work to protect.

METHODOLOGY

Early Detection System

Building upon a similar project with Acadia National Park, we developed an interface in R (an open-source software) that works to collect and share observations of priority species for MCHT stewards from publicly accessible participatory science platforms. We worked with MCHT stewards to develop a list of priority species to best benefit the management they want to and have capacity to act on. Then working in R, we developed a HTML RMarkdown document, styled with CSS, to build a webpage which synthesizes this info for stewards and communicates the information in a clear and appealing interface. Utilizing R, we also developed functionality to access iNaturalist and eBird APIs and communicate observations submitted to these platforms. We do this from within each of the 150+ preserves, as well as from a buffer zone around each preserve.

Using GitHub Pages, we displayed the findings via a webpage and built functionality to automate email alerts for MCHT managers each Monday morning. We also leveraged GitHub Actions to create automated workflows that runs these functions each week, presents them on the webpage, and sends the alert. Additionally, we created a downloadable database of priority-species observations that managers can refer to at any time and that is updated each week. The final product is a fully automated webpage that includes links to each observation of priority species detected in the last week (listed under appropriate categories), a map of locations for each of these species, and downloadable CSVs for all records of priority species in each preserve since inception of the program.

Data Collection and Volunteer Training

Data was collected by volunteer monitors, MCHT preserve stewards, and Schoodic Institute staff in conjunction with two separate training events. To encourage iNaturalist use in the MCHT region and help build a volunteer base of potential volunteer forest monitors, we hosted two bioblitz style trainings, one at Schoodic Forest Preserve and another at Cousins River Fields and Marsh Preserve. These trainings aimed to teach participants how to submit high-quality iNaturalist observations and identify the top six management-priority species. Post training, we organized a bioblitz to allow participants to practice making observations with iNaturalist, search for the priority species, and explore the preserve. We encouraged volunteers to use their newly acquired skills on their outings to these and other MCHT preserves, and beyond. The trainings were advertised on the Schoodic Institute and MCHT websites, as well as by fliers at MCHT preserve kiosks. We also developed communication materials including pamphlets about the priority species and how to identify them.

PROJECT OUTCOMES

The project has resulted in a multiple products and outcomes including:

1. Early detection system (webpage, backend functionality, email alerts)
2. List of MCHT priority species
3. ID guides for species of greatest concern to MCHT stewards
4. Relationship building and growth through successful collaboration between MCHT and Schoodic Institute

Early Detection System

The early detection report can be viewed at the following link:
https://kylelima21.github.io/MCHT_early_detection_system

The code and backend system are all publicly available on the project's GitHub repository, which can be viewed at this link:
https://github.com/Kylelima21/MCHT_early_detection_system

Priority Species List

With MCHT stewards, we compiled a list of species that were identified by stewards as important species to know more about observations of. These include invasive species, insect pests, tree pathogens, rare species, threatened and endangered species, and more.

Identification Guides

We designed identification guides in the form of pamphlets for visitors of two MCHT preserves: Schoodic Forest in Winter Harbor, ME and Cousins River Fields and Marsh in Yarmouth, ME. Working with stewards, we choose species that are the most important to learn about and that are identifiable through photos submitted to iNaturalist. These ID pamphlets are included at the end of this report starting on page 6.

Relationship Building

Another major outcome of this project was a successful collaboration with MCHT in the production and implementation of this project and resulting tools. Through the process, we have strengthened the relationship between our two organizations and is leading to future collaborations.

CONCLUSION

This project has resulted in a product that MCHT stewards are actively using to better understand distributions of invasive plants and forest insect pests (among other species) in and around the land they steward. Through this collaboration, Schoodic Institute and MCHT have been able to build upon an already strong relationship. We believe that this project has great capacity to help stewards and managers better monitor and detect priority species, and there is great opportunity to expand this tool to other organizations in and beyond the seven-state FEMC program area.

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SWEETGRASS

- A **NATIVE** species of conservation concern
- One of four sacred medicine plants to many indigenous tribal groups of North America
- For thousands of years, it has been gathered and used by indigenous peoples for rituals, prayers, braiding and weaving baskets, and other purposes
- Found in a wide variety of ecosystems – including wetlands, prairies, savannas, canyons, and dunes


How To Spot

- Leaves can grow 3 feet or longer
- Leaves are smooth, hairless, and shiny
- Leaves have a purplish-red tinge, especially near the base
- Known for its distinct, vanilla-like scent

Image credits: © Randy Mitchell on iNaturalist, © ecoseeds.com, © Nancy J. Turner

BLACK ASH/BROWN ASH

- A **NATIVE** species of conservation concern, highly threated by Emerald Ash Borer
- Found in wet, swampy areas
- The leaves are a critical food source for many species of frogs
- Also serve as food and habitat for many insects, birds, and mammals


How To Spot

- Leaves are pinnately compound (many small leaflets grow from several places along each twig stalk)
- Leaves are opposite (2 leaflets grow directly across from each other)
- Leaves have finely serrated edges
- Bark is gray and corky
- The new bud at the end of each twig resembles a chocolate chip

Image credits: © Derek Ziomber, © Patricia Butler, © Tom Norton on iNaturalist

Thank You!

- Questions? Contact Kyle Lima at **klima@schoodicinstitute.org**
- Don't forget to upload your observations to **iNaturalist!**

BioBlitz for a Resilient Forest Future

iNaturalist Early-Detection Training

6 Cousins River Focal Species

EMERALD ASH BORER

- EAB is an insect native to Asia
  - First detected in the United States in 2002
- Feeds on ash trees
  - Highly destructive
  - Eggs are laid in bark crevices, larvae feed beneath the bark
  - Disrupts the flow of water and nutrients in the tree, eventually girdling and killing it


How To Spot

- EAB adults bright metalic green, >0.5 in long
- Create D-shaped exit holes in the bark
- Larvae create S-shaped tunnels beneath the bark
- Ash leaves thin and bark splits

Image Credits: © human_landfill, © Kimberlie Sasan, © Jason Whittle on iNaturalist

BEECH LEAF DISEASE

- Caused by parasitic microscopic worms that feed inside the leaves
- Affects all beech species, but especially American beech
- First identified in Ohio in 2012 but has since spread across the eastern US
- Usually fatal to trees it infects

How To Spot

- Leaves show dark green bands between veins
- Leaves become thick, leathery, and curled at the edges

Image credits: © Scott and Tina Sherwood on iNaturalist, © tgrandin on iNaturalist, © Michael Tribone and Parisa Farjamfar

PURPLE LOOSESTRIFE

- Perennial herb native to Europe and Asia
  - Introduced to the United States in the 1800s
- Found in ditches, marshes, wet meadows and marshes and near lakes
- Outcompetes many native wetland plants, lowers biodiversity, and provides lower-quality habitat and food for wildlife
- Biological control
  - Managers have released certain beetle species that feed on purple loosestrife and reduce its tendency to spread


How To Spot

- Stems grow up to 6 feet in height
- Long, skinny leaves, often fuzzy,
- Reddish-purple flowers, ½ inch in diameter, with 5-7 petals
- Many flowers clustered tightly around the top of the stem

Image Credits: © Susan Elliot, © Brian Finzel on iNaturalist

SPRUCE BUDWORM

- Caterpillars of the spruce budworm moth eat the needles of spruce and fir trees
- Causes defoliation that eventually kills the host tree
- Periodic outbreaks have caused severe damage to spruce populations for at least 400 years

How To Spot

- Light green egg masses on the host tree
- Caterpillars are cream-colored upon hatching but turn dark brown with paired white spots along the back
- Moths are gray and brown with a wingspan of 21 to 30 mm
- Host trees may be defoliated


Image credits: © USDA Forest Service, © Karl Kroeker on iNaturalist, © Christian Grenier on iNaturalist

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JACK PINE

- A native species of conservation concern
- Grows in acidic, shallow, sandy to rocky soil
- Maine is at the very southern edge of its range
- Fire-dependent in some part of its range but not in Maine

How To Spot

- Typically shrub-like
- Needles are stiff, yellowish-green, and in bundles of two
- Buds are reddish brown
- Cones are small and may be curved
- **Note:** pitch pine may be confused with jack pine, but can be distinguished by its longer needles which grow in groups of three and larger cones which are less likely to curve

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HEMLOCK WOOLLY ADELGID (HWA)

- HWA is an insect native to East Asia
  - Introduced in eastern North America in the 1950s
- Sucks the sap from hemlock and spruce trees
- Causes particularly serious damage to eastern hemlock trees
  - HWA has affected 90% of their geographic range
  - Death usually occurs 4-10 years after infestation

How To Spot

- HWA individuals are brown, oval-shaped, <1 mm long
- Hemlock needles become gray-green and fall away
- Look for egg sacks: resemble tufts of cotton along the underside of hemlock branches

NOTE! Do not touch the HWA egg sacks → they are spread very easily!

Image Credits: © Cody Chapman, © BlueRidgeKitties, © Zygy on iNaturalist

BALSAM WOOLLY ADELGID (BWA)

- BWA is an insect native to Europe
  - Introduced to the United States in the early 1900s
- Infests balsam fir trees
  - Feeds on the bark
  - Releases toxins and eventually kills them

How To Spot

- Swollen and distorted twigs, called "gouting"
- Dead or dying branches of the fir turning red-brown
- Wooly tufts (egg sacks) along lower trunk, sometimes on large branches

Image Credits: © peterrabbit, © the swamp ass, © Ben on iNaturalist

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- Caterpillars of the spruce budworm moth eat the needles of spruce and fir trees
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