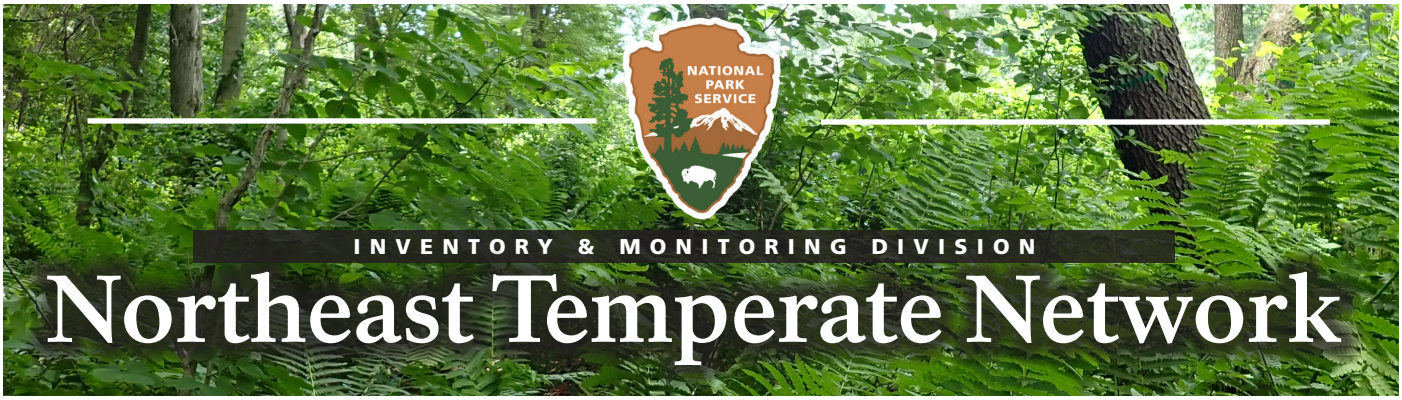


INVENTORY & MONITORING DIVISION

Northeast Temperate Network

JANUARY 2023

Forest Health Update for the Minute Man NHP: 2006 - 2022

The Northeast Temperate Network (NETN) forest health monitoring crew has been visiting the 20 NETN forest plots in Minute Man NHP (MIMA) for 16 years on an alternating 4-year cycle. This brief is a summary of forest health analysis with focus on tree regeneration and recruitment, deer population impacts, invasive plants and insects, tree species composition and condition, and tree mortality. Findings show that the forests in MIMA reflect a long history of human use, including a diverse flora composed of many non-native and old field species growing alongside native forest species.

The following is a further summary of the most recent findings, as wells as a series of park maps that visually display forest health monitoring data. Please contact NETN staff with any questions.

KEY FINDINGS

- As with several other parks in the Network, the forests in MIMA are in **peril of failure over time**.
- Park forests lack sufficient tree regeneration to replace the canopy and are vulnerable to large-scale disturbances that could lead to loss in forest cover.
- Deer, invasive shrubs, and exotic pests and pathogens are negatively impacting tree regeneration in MIMA, and a warming climate will likely exacerbate these issues.
- Managing deer, either through strategic fencing or culling, is likely necessary to prevent the forest loss being observed in other NETN parks.
- Canopy gaps from forest pests or disturbances may need help to avoid becoming permanent invasive shrub thickets. Efforts to limit the spread of well established invasive tree species will also help ensure a continual native forest canopy in MIMA.

Summary of MIMA Forest Health

Tree Regeneration and Deer

An abundant regeneration layer containing tree seedlings and saplings of varying sizes and composed of species found in the canopy is an important component of a healthy, stable forest. When forests lack sufficient regeneration, or the species composition in the regeneration layer does not match that of the canopy, we call this a "regeneration debt". In its most severe form, there is a complete lack of regeneration which, if allowed to persist, can ultimately lead to forest loss.

Compositional mismatch between the species in the regeneration layer and the

Deer, invasive shrubs, and exotic pests and pathogens are negatively impacting tree regeneration in many parts of MIMA (plot 18 pictured).

canopy is another type of regeneration debt that can be problematic if the species in the regeneration layer are invasive, like Norway maple, or suboptimal, including pest/disease prone species such as ash.

Forests in MIMA are experiencing **severe regeneration debt**, primarily due to a lack of sufficient tree regeneration. While there are some positive trends in seedling density over time, the increases are primarily restricted to the smallest size classes (Maps 1 & 2). In the 2022 survey, only 5 out of 20 plots met the target of 0.25 seedlings/m2, and only 2 out of 20 plots met the target of 0.14 saplings/m2. Note that these targets were established as part of a regional regeneration study currently in review. The regeneration stocking index, which quantifies whether current seedling and sapling densities are sufficient to restock a forest canopy, also continues to be s**everely understocked** in MIMA, with no plots meeting the stocking index target of 100 in most recent survey (Map 5). These results are more extreme than in the 2018 report because ash is no longer considered a canopy species now that emerald ash borer (EAB), which kills ash before they can reach, is present in the park (Map 9). Additionally, **high deer impacts** continue to be observed throughout MIMA, with 14 out of 20 plots rated high or very high for deer browse impacts in the most recent survey (Map 6). A long-term deer management plan that includes strategic fencing, culling, or both will help prevent forest loss that is being observed in other NETN parks.

White-tailed deer continue to have high impacts throughout the park.

On a positive note, where present, the regeneration layer is **relatively diverse** and primarily composed of native canopy-forming species (Map 3). The most common species regenerating are black cherry, white pine, white ash, red maple, and oak species. Plots that are dominated by white pine in the canopy tend to also have a white pine regeneration in the understory (Maps 3 & 4). Plots dominated by oak species in the canopy (e.g., plots 1, 8, 9, 14, and 16) have some oak regeneration, although mesophytic species (plants that grow under medium moisture conditions), like black cherry and red maple, tend to be more abundant than oak in the regeneration layer. If these patterns persist and

deer browse does not ultimately prevent recruitment, oak stands in MIMA are likely to shift more towards more black cherry and maple dominated forests.

The most concerning pattern in the regeneration layer is the abundance of Norway maple, a highly invasive tree species in the northeastern U.S, which is abundant in plots 3, 5, 10, 13, and 14 (Map 3). Other exotic species in the regeneration layer are post-agricultural species, such as apple trees, pear trees, and hawthorn, which are more a reflection of the land use history and less of a concern to forest health.

Multiflora rose and other invasives abound in some plots (13 pictured).

Invasive Plant Species

Invasive plant cover continues to be **relatively high** in MIMA. In the most recent survey, every forest plot had at least one invasive species, and 14 out of 20 plots had five or more invasive species (Map 7). The most abundant invasive species in MIMA were Norway maple and shrubs, particularly glossy buckthorn, oriental bittersweet, multiflora rose, exotic bush honeysuckle, and common buckthorn (Map 8). These species are all capable of suppressing forest regeneration and understory diversity and can increase dramatically in response to canopy disturbances, which are only likely to increase from climate-change fueled more intense storms. Reducing invasive shrub cover, particularly where ash is dying back from emerald ash borer (e.g., plots 4, 10, 13, 15, and 16), will help prevent these forests from converting to invasive shrub thickets, as is being observed in other NETN parks.

Forest Structure & Composition

The canopy layer in MIMA is fairly diverse, with a mix of white pine, maple, ash, elm, hickory, oak, and other species (Map 4). Exotic tree species are also a significant component in the canopy, particularly Norway maple and black locust, which are the fourth and fifth most abundant tree species based on basal area. Most concerning is that Norway maple is abundant in both the canopy and regeneration layer. Norway maple can suppress native plant growth because of its dense, shallow root systems and the deep shade produced by its canopy. Black locust, on the other hand, is an efficient nitrogen fixer that can both out-compete native species and facilitate invasion of exotic species through changing the surrounding soil chemistry. While black locust is native to the southeastern United States, it is considered an aggressive invader in the Northeastern US. On a positive note, black locust is nearly absent in the regeneration layer.

Emerald ash borer

While mortality is outpacing tree recruitment, most of the native canopy-forming species in MIMA have shown some recruitment to tree size and have maintained stable stem densities since monitoring began. The obvious exception is ash, which experienced elevated mortality in the most recent cycle and is unlikely to recruit additional stems now that EAB is present throughout the park (Map 9). Beech leaf disease (BLD) was also detected in 2022 in plot 15 (Map 9). BLD is a relatively new pathogen and expected mortality rates remain unknown, although BLD appears to impact beech regeneration most severely. Native maple stem density also declined in MIMA in the most recent cycle. While the underlying cause is unknown, a combination of typical dynamics of maturing forests (i.e., declines in stem density met with increases in basal area), and/or stress from repeated pest outbreaks, including winter moth and spongy moth (aka gypsy moth).

Several plots have maintained very low canopy cover over time, including plots 11, 12, 18, and 20, and do not appear to be succeeding to forest (Map 10). Deer browse impacts are high or very high in all of these plots (Map 6), which is likely preventing regeneration from recruiting into the canopy. Invasive shrub cover is also likely

Complex forest structure, like snags and coarse woody debris, are ecologically important features that are continuing to increase in the park over time.

suppressing native regeneration, particularly in plots 11 and 12 (Map 8).

Coarse woody debris volume has continued to increase in volume throughout the park, increasing from an average volume of 8.8 m3/ha in the first cycle to 17.8 m3/ha in the fourth cycle (Map 11). In addition, all but four plots now have some coarse woody debris present and four out of 20 plots meet or exceed the minimum threshold of 20 – 50 m3/ha of dead wood proposed by Müller and Bütler (2010) as needed to support the range of taxa dependent on dead wood habitat (Map 12). When monitoring began, six plots had no coarse woody debris present and only two plots met this threshold.

For more information

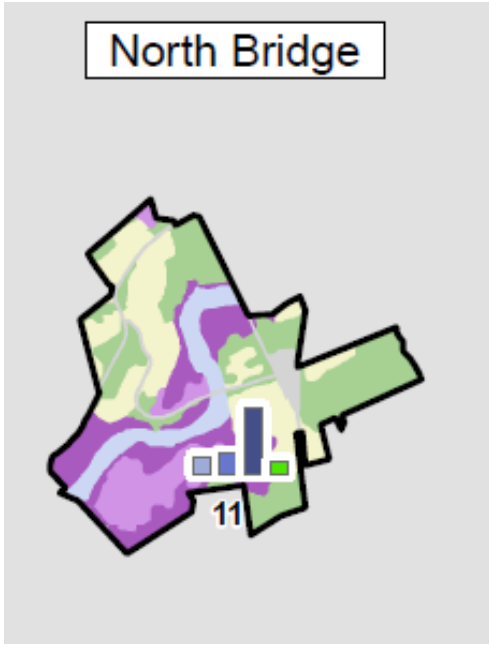
The NETN website is chock full of information related to park forest health as well as all the other long-term monitoring programs. Like all of NETN's parks, MIMA has its own web page providing a convenient one-stop shopping place for all things MIMA-related.

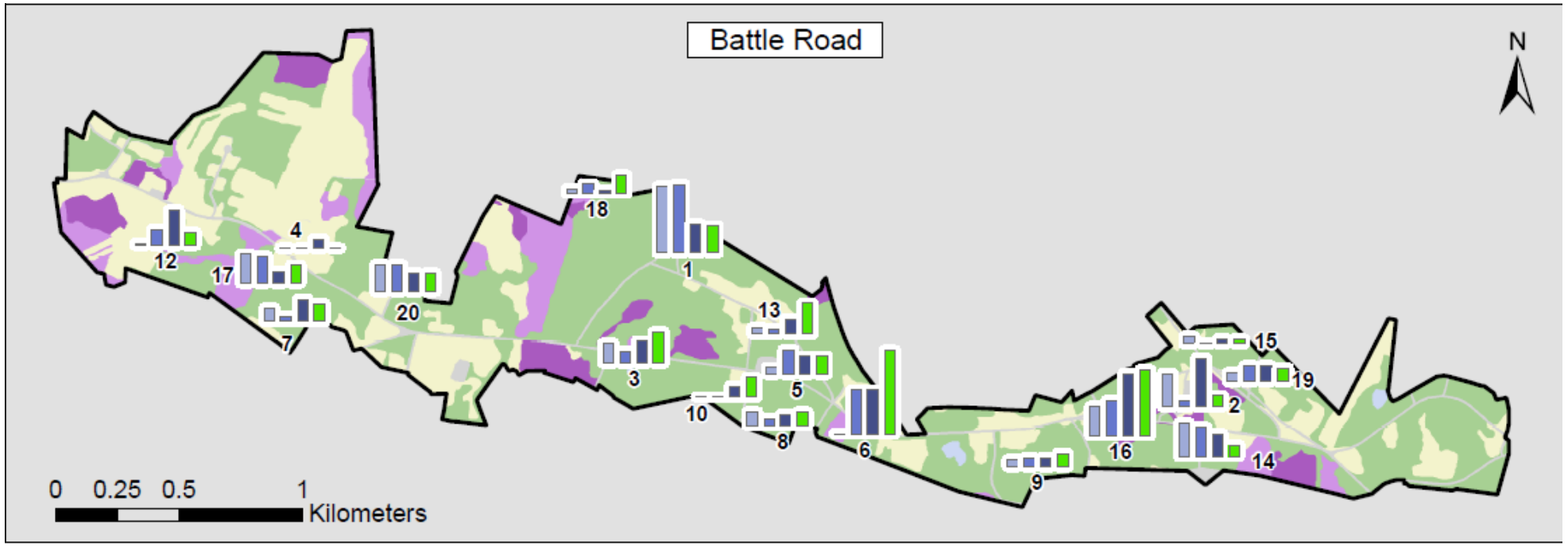
The recently launched Resilient Forests Initiative contains many useful resources and insights about the current and future efforts to help regional national parks manage forest health challenges by raising awareness of threats and fostering collaboration.

PARK MONITORING MAPS

Trends in tree regeneration, including seedlings and saplings, observed in forest plots sampled from 2006-2022. Plots are sampled in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 11-20 sampled in 2008, 2012, 2016, and 2022. Densities range from 0 to 1.0 stems/m2 and only include native canopy-forming species.

MAP 1: TREE REGENERATION: MONITORING CYCLE

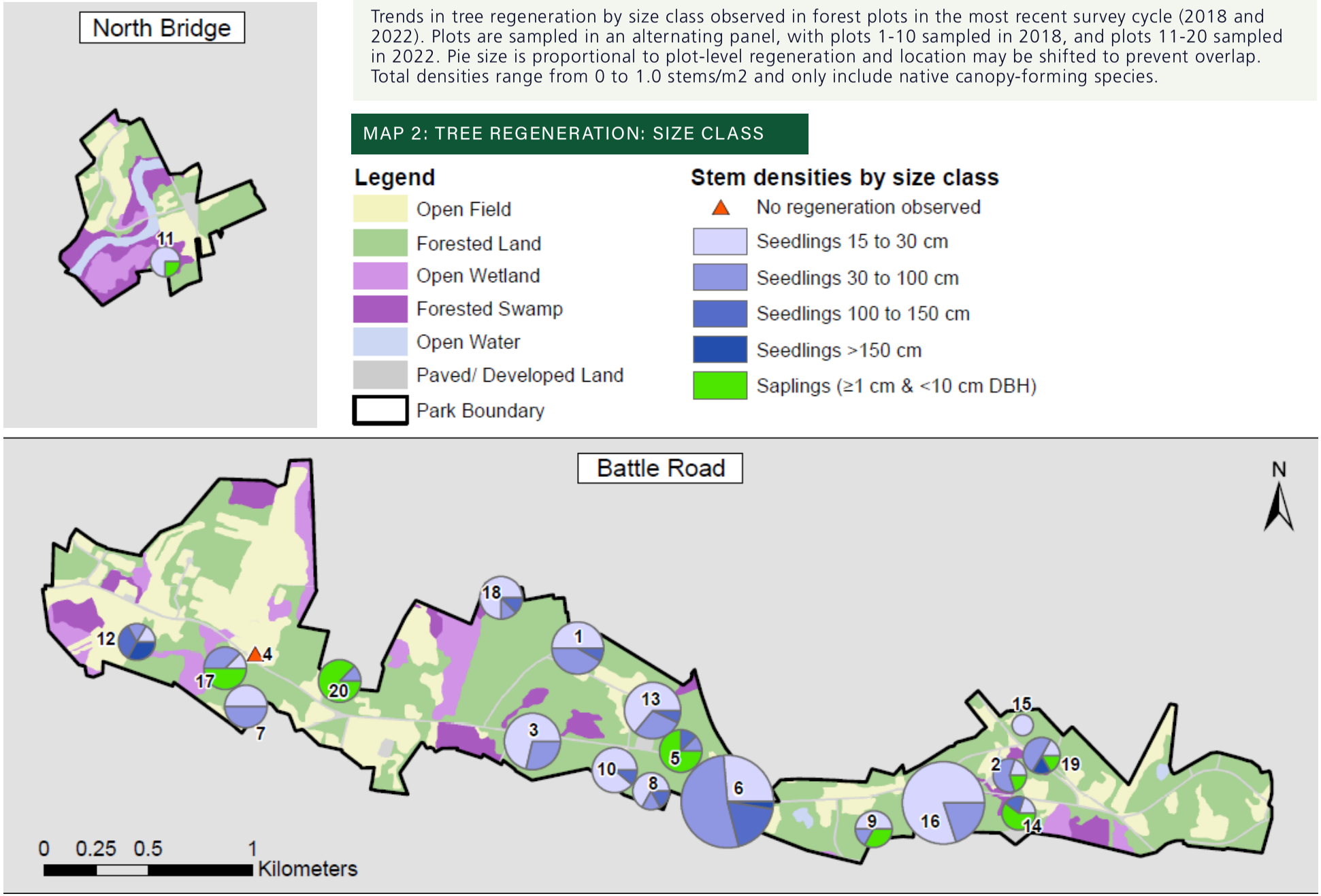




PARK MONITORING MAPS

Trends in tree regeneration by size class observed in forest plots in the most recent survey cycle (2018 and 2022). Plots are sampled in an alternating panel, with plots 1-10 sampled in 2018, and plots 11-20 sampled in 2022. Pie size is proportional to plot-level regeneration and location may be shifted to prevent overlap. Total densities range from 0 to 1.0 stems/m2 and only include native canopy-forming species.

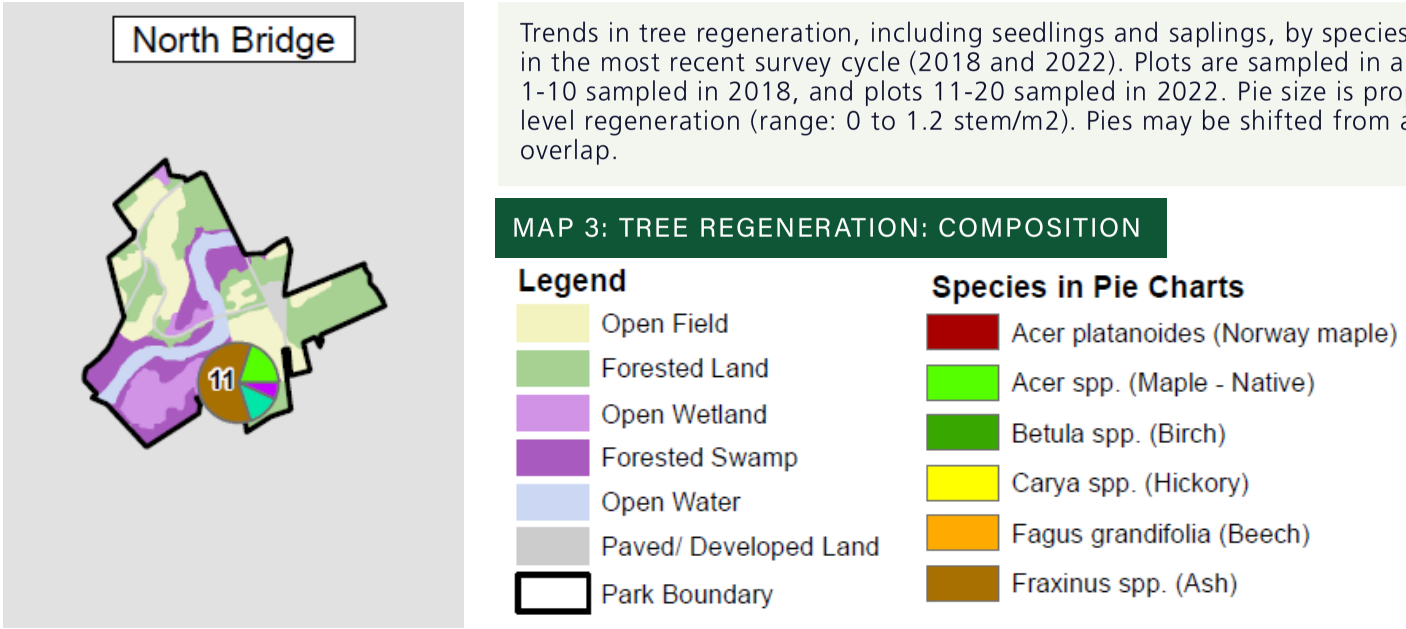
MAP 2: TREE REGENERATION: SIZE CLASS



PARK MONITORING MAPS

Trends in tree regeneration, including seedlings and saplings, by species group observed in forest plots in the most recent survey cycle (2018 and 2022). Plots are sampled in an alternating panel, with plots 1-10 sampled in 2018, and plots 11-20 sampled in 2022. Pie size is proportional to the total plot-level regeneration (range: 0 to 1.2 stem/m2). Pies may be shifted from actual plot location to prevent overlap.

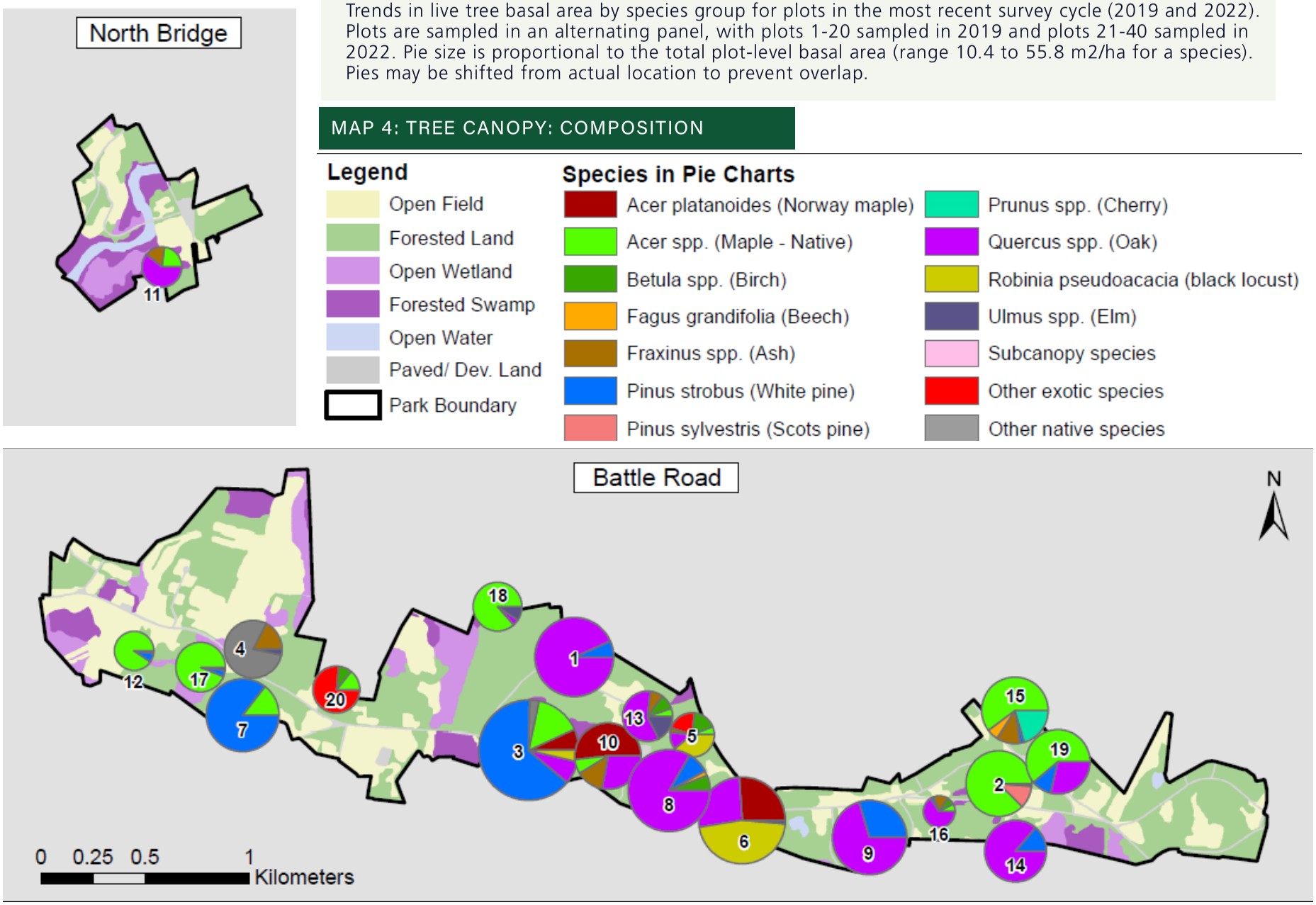
MAP 3: TREE REGENERATION: COMPOSITION



PARK MONITORING MAPS

Trends in live tree basal area by species group for plots in the most recent survey cycle (2019 and 2022). Plots are sampled in an alternating panel, with plots 1-20 sampled in 2019 and plots 21-40 sampled in 2022. Pie size is proportional to the total plot-level basal area (range 10.4 to 55.8 m2/ha for a species). Pies may be shifted from actual location to prevent overlap.

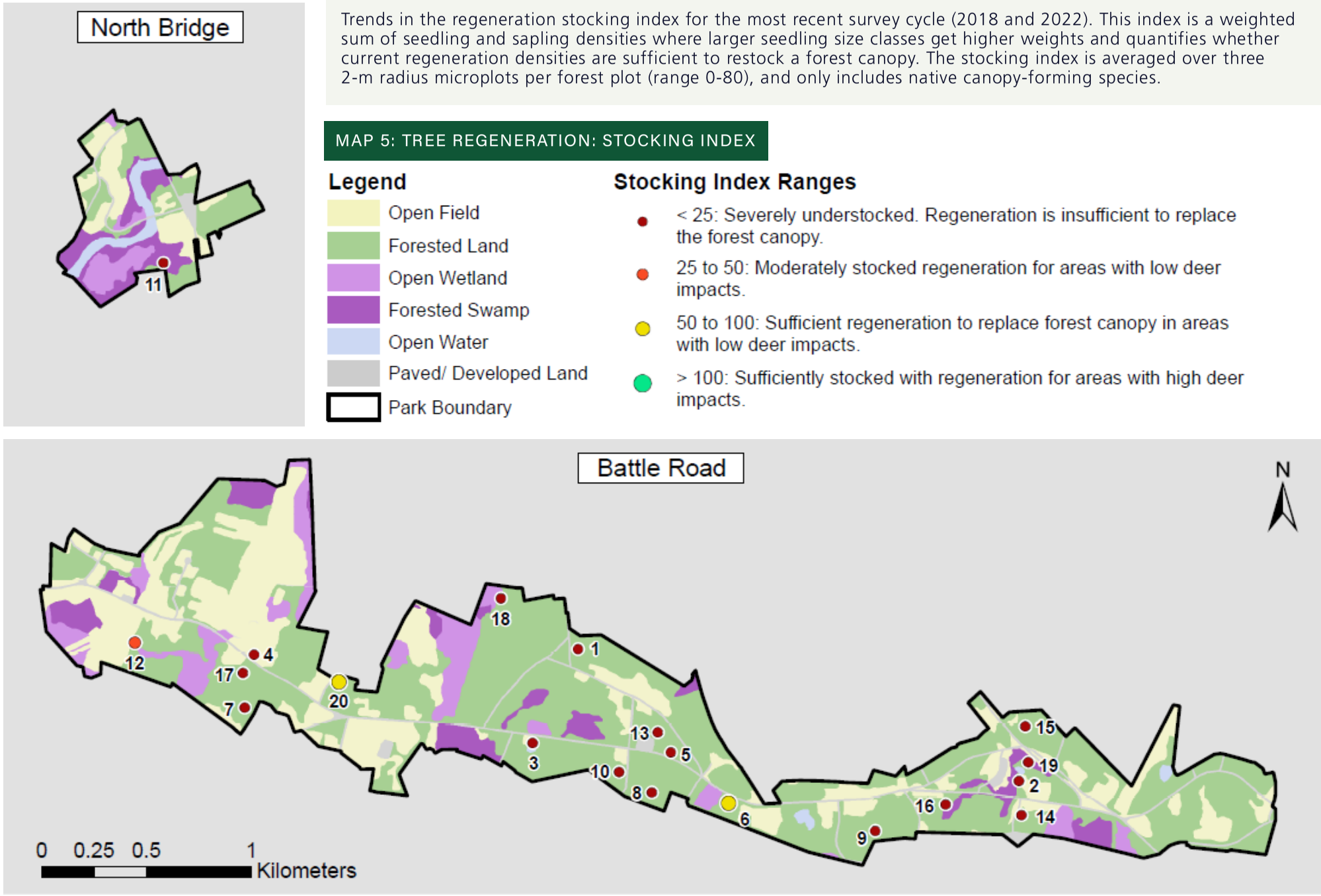
MAP 4: TREE CANOPY: COMPOSITION



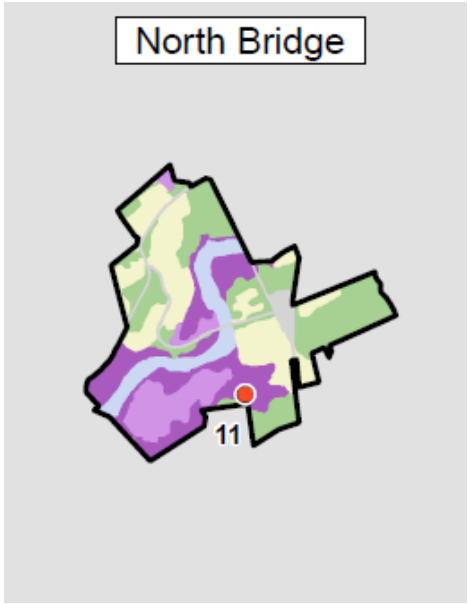
PARK MONITORING MAPS

Trends in the regeneration stocking index for the most recent survey cycle (2018 and 2022). This index is a weighted sum of seedling and sapling densities where larger seedling size classes get higher weights and quantifies whether current regeneration densities are sufficient to restock a forest canopy. The stocking index is averaged over three 2-m radius microplots per forest plot (range 0-80), and only includes native canopy-forming species.

MAP 5: TREE REGENERATION: STOCKING INDEX



PARK MONITORING MAPS



Index of deer browse impacts observed in forest plots in the most recent four years of sampling (2018 & 2022). Plots are sampled in an alternating panel, with plots 1-10 sampled in 2018 and plots 11-20 sampled in 2022. Deer browse impacts are assessed on a scale of 1-5, with 1 representing no impact and 5 representing severe impacts

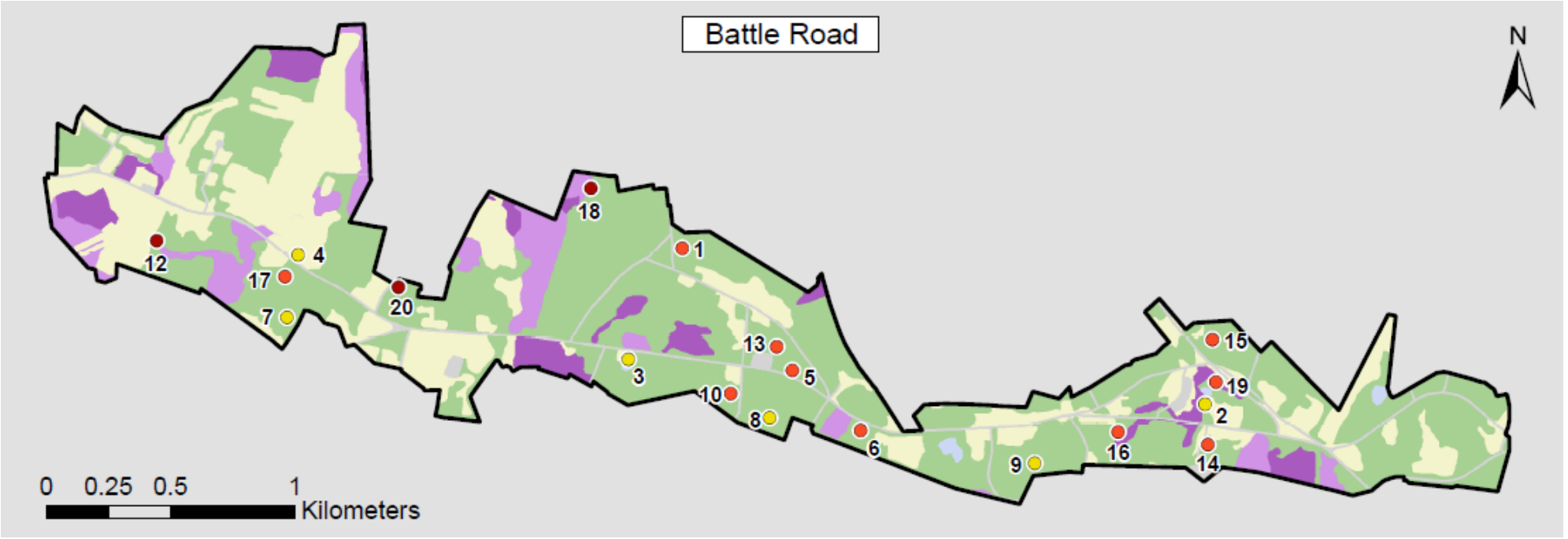
MAP 6: DEER BROWSE IMPACTS

Legend

- Open Field
- Forested Land
- Open Wetland
- Forested Swamp
- Open Water
- Paved/ Developed Land
- Park Boundary

Deer Browse Index

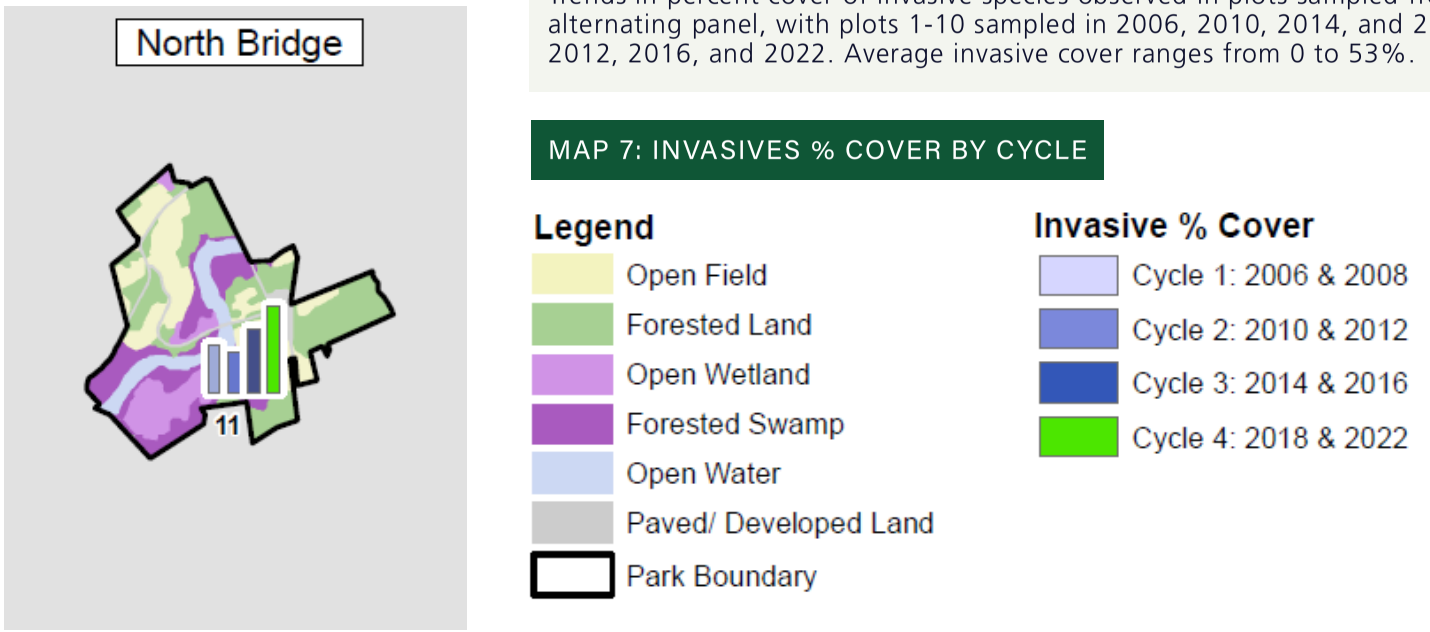
- 1) No Impact: found only in well-maintained deer exclosures.
- 2) Low Impact: deer-preferred (DP) species abundant and of varying heights.
- 3) Medium Impact: DP species present, but mostly < 30 cm tall. DP herbs present but stunted and flowering is uncommon.
- 4) High Impact: DP species are rare to absent. Non-preferred (NP) and browse-resilient vegetation (e.g. beech) limited in height by deer browse. DP herbs absent or severely stunted.
- 5) Very High Impact: DP regeneration absent. NP species also reduced by heavy browsing. Distinct deer browse line.

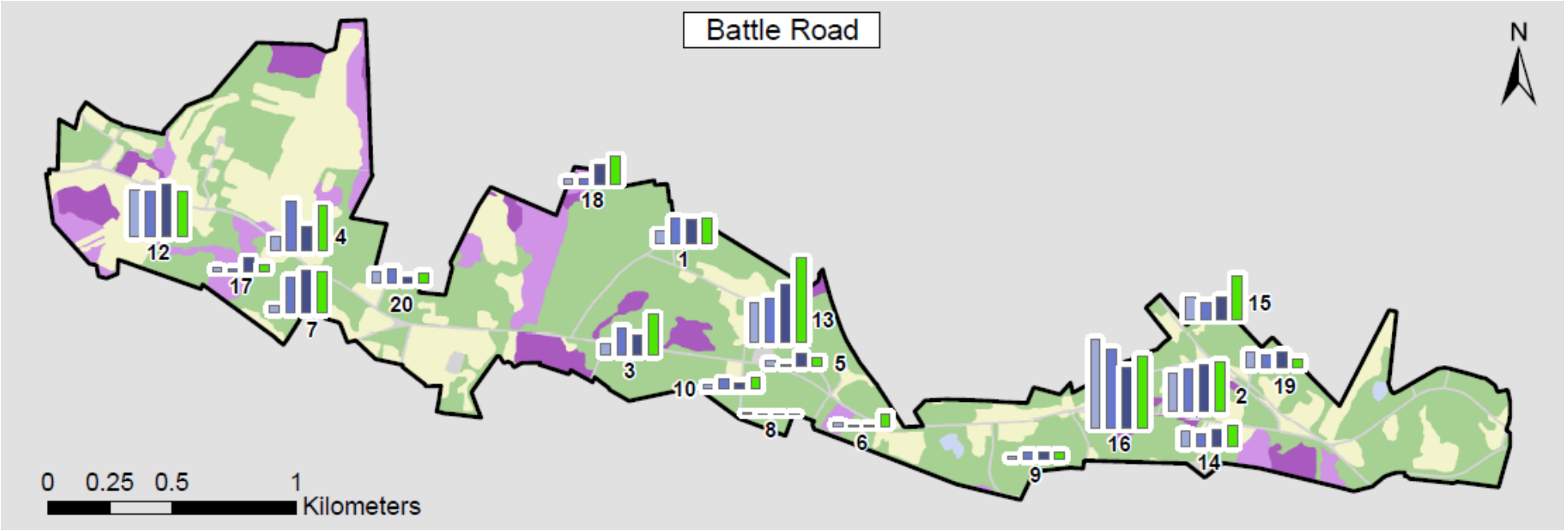


PARK MONITORING MAPS

Trends in percent cover of invasive species observed in plots sampled from 2006-2022. Plots are sampled in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 11-20 sampled in 2008, 2012, 2016, and 2022. Average invasive cover ranges from 0 to 53%.

MAP 7: INVASIVES % COVER BY CYCLE

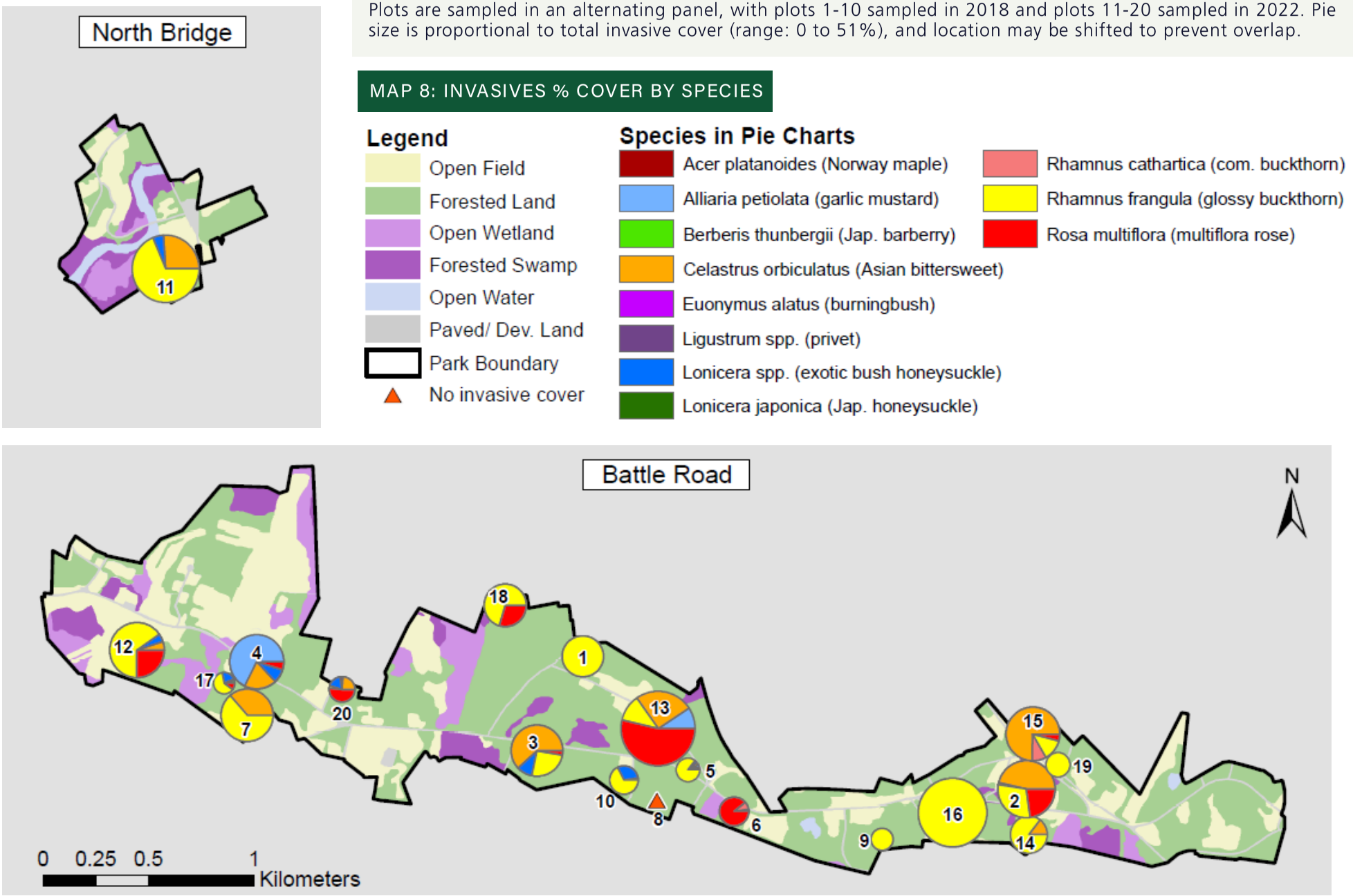




PARK MONITORING MAPS

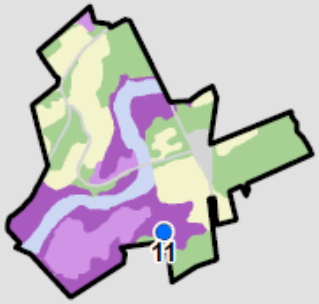
Trends in % invasive cover by species observed in quadrats for plots in the most recent survey cycle (2018 & 2022). Plots are sampled in an alternating panel, with plots 1-10 sampled in 2018 and plots 11-20 sampled in 2022. Pie size is proportional to total invasive cover (range: 0 to 51%), and location may be shifted to prevent overlap.

MAP 8: INVASIVES % COVER BY SPECIES



PARK MONITORING MAPS

North Bridge



Detections of priority forest pests in forest plots sampled during the most recent survey cycle (2018 and 2022). Plots are sampled in an alternating panel with plots 1-10 sampled in 2018 and plots 11-20 sampled in 2022. Note that BLD may be more widespread than map indicates, as plots 1-10 were sampled prior to its first detection in 2022.

MAP 9: FOREST PEST/PATHOGEN DETECTIONS

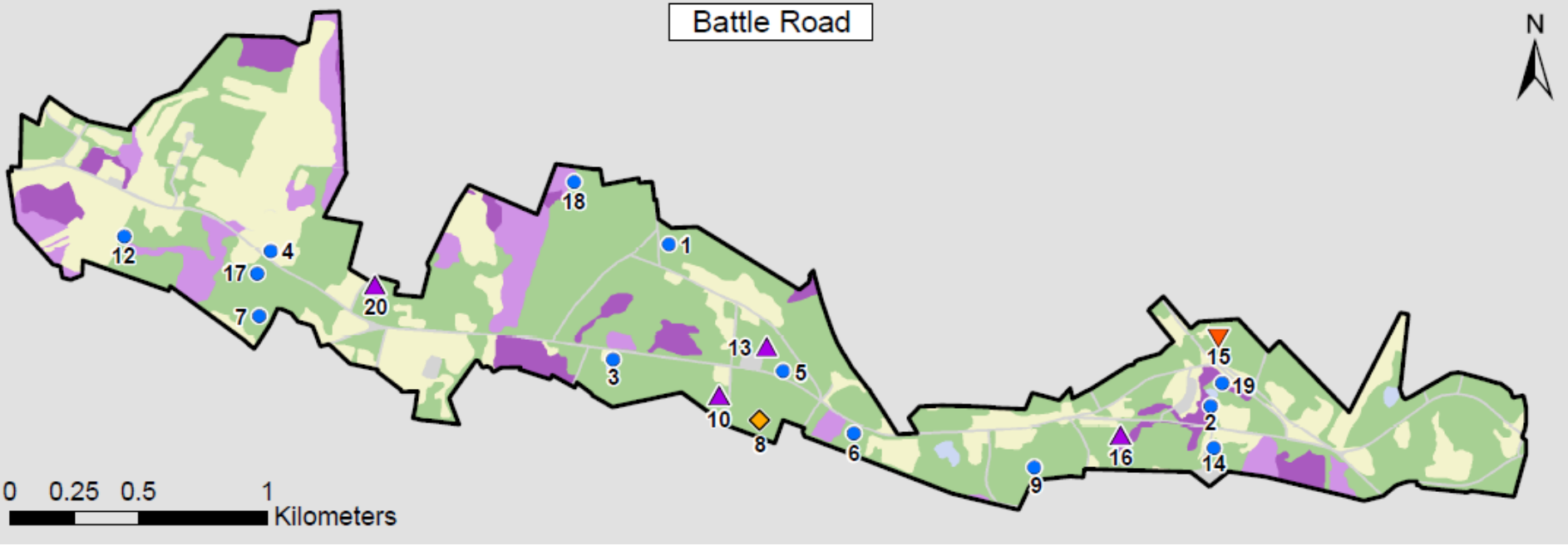
Legend

- Open Field
- Forested Land
- Open Wetland
- Forested Swamp
- Open Water
- Paved/ Developed Land
- Park Boundary

Pests/Pathogens

- Beech Bark Disease (BBD)
- Beech Leaf Disease (BLD)
- Emerald Ash Borer (EAB)
- No detections

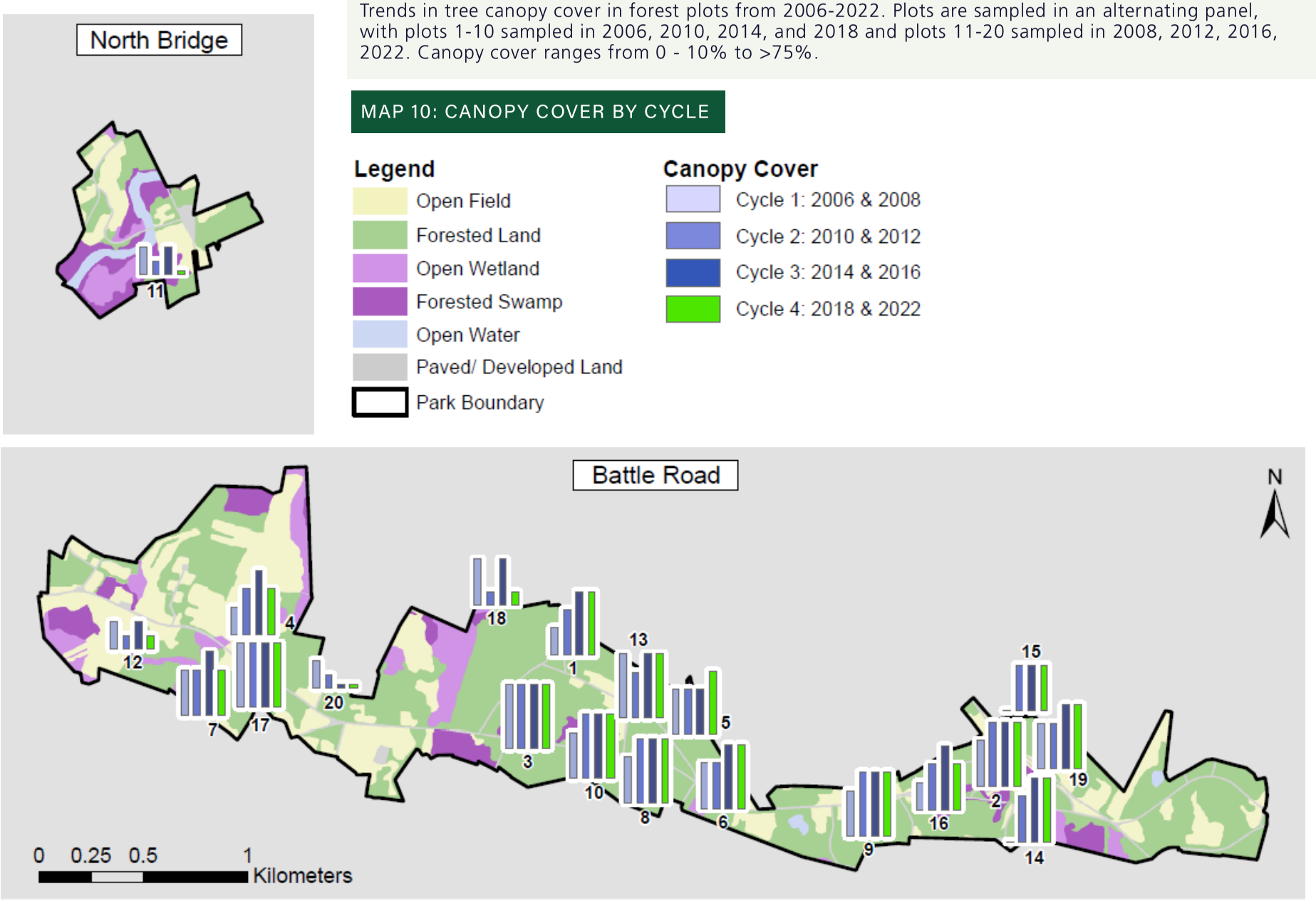
Battle Road



PARK MONITORING MAPS

Trends in tree canopy cover in forest plots from 2006-2022. Plots are sampled in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018 and plots 11-20 sampled in 2008, 2012, 2016, 2022. Canopy cover ranges from 0 - 10% to >75%.

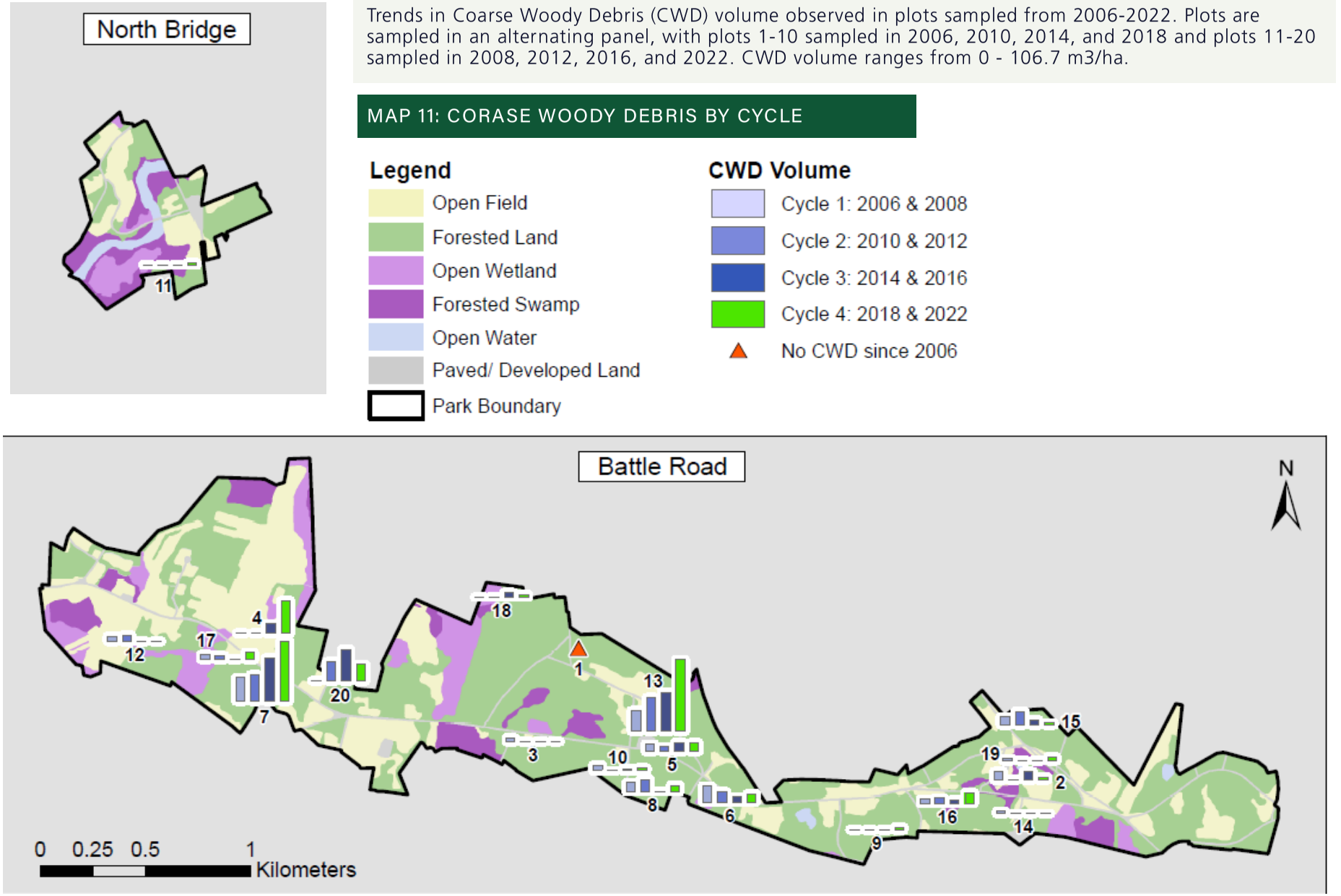
MAP 10: CANOPY COVER BY CYCLE



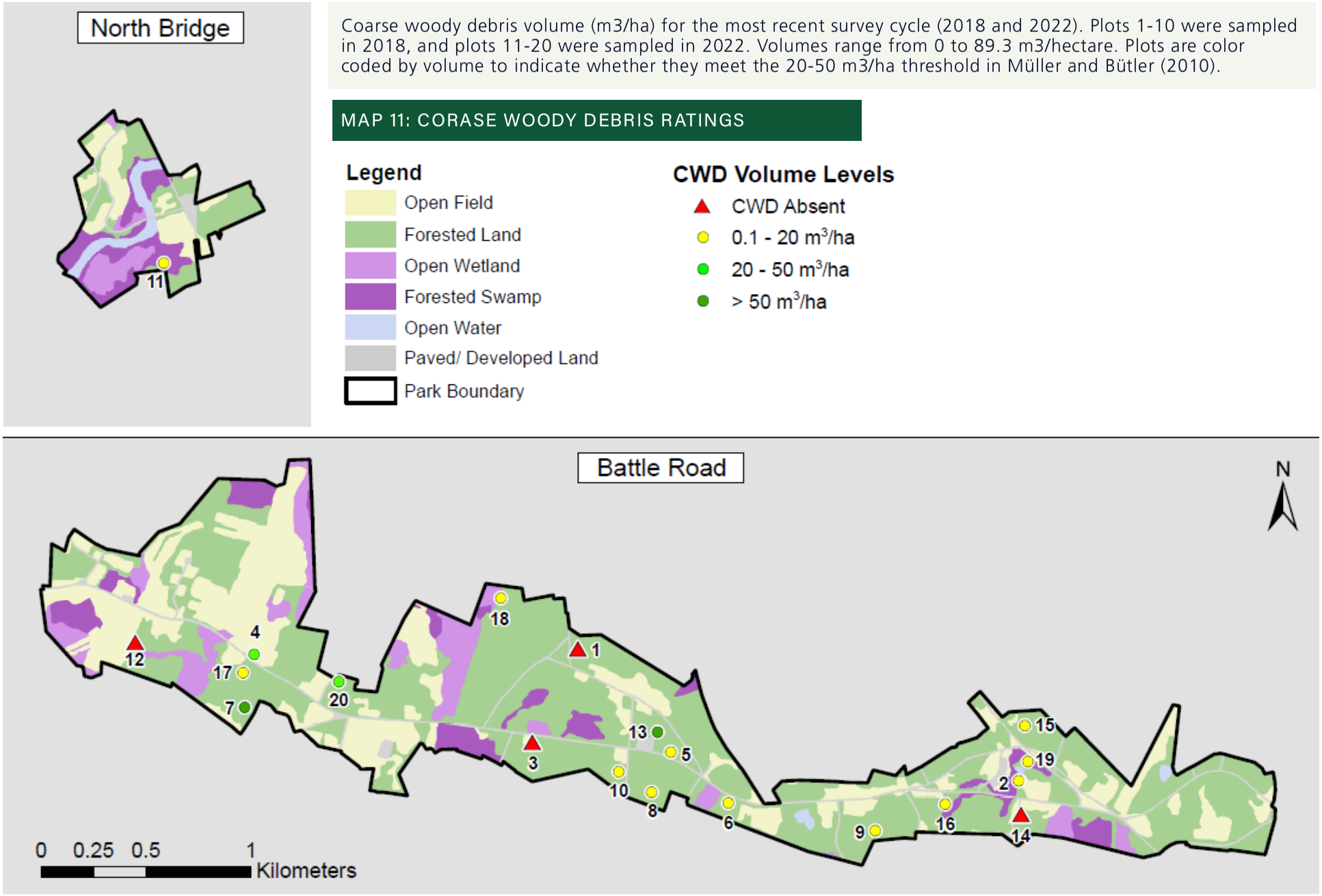
PARK MONITORING MAPS

Trends in Coarse Woody Debris (CWD) volume observed in plots sampled from 2006-2022. Plots are sampled in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018 and plots 11-20 sampled in 2008, 2012, 2016, and 2022. CWD volume ranges from 0 - 106.7 m3/ha.

MAP 11: CORASE WOODY DEBRIS BY CYCLE



PARK MONITORING MAPS



NETN FOREST HEALTH MONITORING STAFF

The NETN forest health monitoring crew is made up of a dedicated group of seasonal technicians (with support from the Schoodic Institute). It is lead by NETN biological technician Camilla Seirup. Protocol lead is NETN plant ecologist Kate Miller, who also analyzed the data and created the maps in this brief.

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