



INVENTORY & MONITORING DIVISION

Northeast Temperate Network

JANUARY 2023

Forest Health Update for Saratoga NHP: 2006 - 2022

The Northeast Temperate Network (NETN) forest health monitoring crew has been visiting the 32 NETN forest plots in Saratoga NHP (SARA) for 16 years on an alternating 4-year cycle.

As with other parks in the network, the forests in SARA are

in peril of collapse in the near future. Decades of regeneration failure have led to much of the park forest to a state of collapse. Invasive shrub thickets continue to increase while canopy tree species decline.

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

KEY FINDINGS

- As with other parks in the Network, the forests in SARA are in a **high state of peril**.
- Overabundant deer, invasive shrubs and exotic pests/pathogens, are severely impacting forest health to the point that forest loss is beginning to occur.
- As canopy openings have increased from intense storms and exotic pests/pathogens, invasive shrubs have increased and further suppressed regeneration from being able to fill in the gaps.
- Deer impacts are **unsustainable** throughout the park and a long-term deer management program, including strategic fencing, culling, or both will be needed to allow the forest to sustain itself.
- Reducing invasive shrubs to 10-20% cover and maintaining it for 5 to 10 years could give tree seedlings time enough to regenerate before invasive shrubs can expand and choke them out.



Summary of SARA 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



Little to no regeneration is being observed in many forest health plots (Plot 11 pictured) in the park.

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 SARA are experiencing **severe regeneration debt**. While there are some positive trends in seedling density over time, the increases are almost entirely restricted to the smallest size classes (Maps 1 & 2). In the most recent survey, only 10 out of 32 plots met the target of 0.25 seedlings/m², and only 1 out of 29 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 severely understocked in SARA. All

but one out of 32 plots were **severely understocked** in the most recent survey (Map 5). Note that these results are more extreme than in the 2018 report, because [ash](#) is no longer considered a canopy species because the emerald ash borer (EAB) usually kills it before it can reach.

High deer impacts continue to be observed throughout SARA, with all but one plot rated high or very high for deer browse impacts in the most recent survey (Map 6). Managing deer, either through strategic fencing or culling, will be necessary to reverse this trajectory.

Equally concerning is the composition of the regeneration layer, which is dominated by subcanopy species (Map 3). Subcanopy species are

short-stature trees, such as hophornbeam, musclewood, and striped maple, that rarely reach beyond the subcanopy layer of a forest. Ash species are the most common species in the regeneration layer, but as noted earlier, are also now considered subcanopy species. Species dominant in

the canopy, including white pine, red maple, [oak species](#) and hickory species, are rare in the regeneration layer (Map 4).

Invasive Species

Invasive cover **continues to be high** in SARA. As canopy openings have increased from climate change fueled intense storms (e.g.

the May 2018 storm) and exotic pests/pathogens, invasive shrubs have largely filled the gaps and further suppressed native tree regeneration.



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



Exotic bush honeysuckle continues to flourish in the park (plot 4 pictured).

In the most recent survey, all but one forest plot had at least one invasive species, and 18 out of 32 plots had five or more invasive species (Map 7). The most abundant invasive species in SARA were shrubs, particularly exotic bush honeysuckle, common buckthorn, and multiflora rose (Map 8). In addition, Japanese stiltgrass was detected for the first time in 2022, occurring in 2 plots (plots 27 & 30). As a demonstration of the speed it can spread, in the 6-year span between cycle 3 and 4 Japanese stiltgrass invaded and rapidly increased to averaging 40% cover in plot 30 (Map 8).

While invasive shrubs were already abundant in SARA when monitoring began in 2006, they have continued to increase significantly in cover by 2.2% over each 4-year cycle. Exotic bush honeysuckle, the most abundant invasive species in SARA (found in 94% of plots), has increased significantly in cover by 2% per cycle since monitoring began. Plots with the greatest invasive shrub cover also tend to have low canopy cover and little to

no tree regeneration (e.g., 4, 12, 32), indicating that these invasive shrubs are suppressing regeneration.

NETN recommends major and sustained management action to reduce both deer population and the densest invasive shrub thickets in the park. In particular, invasive management efforts should focus on stands with a moderate to large component of ash in the canopy. Reducing

deer browse pressure and invasive shrubs to 10-20% cover, and maintaining this it for 5-10 years could give tree seedlings the time needed to propagate before invasive shrubs



Emerald ash borer

can expand and choke them out. We strongly encourage park managers and NPS staff to seek ways to reverse the trajectory that SARA's forests are currently on, before more forest cover and species are lost.

Forest Structure & Composition

The canopy layer in SARA is fairly diverse, with a mix of white pine, maple, ash, elm, hickory, oak, and other species (Map 4). However, if tree mortality and

recruitment patterns continue, canopy composition will likely shift, and diversity will decline over time. Many of the most common canopy species in SARA have experienced elevated mortality over time. The only species recruiting to tree size and gaining in stem density are black birch, common buckthorn, [American beech](#), ash and other subcanopy species (primarily hophornbeam). Elevated ash mortality from emerald ash borer is starting to occur in SARA and is expected to increase over the coming years (Map 9). As a result, while overall basal area has continued to increase in SARA over time, gains are almost entirely through incremental stem growth of remaining trees, rather than recruitment of new trees.

When regeneration failure persists for decades, declines in the density of small diameter trees are often a signal of impending forest loss. This signal is apparent in SARA, where the density of small trees (i.e., trees < 20 cm diameter at breast height) has declined over time. In fact, forest loss is already underway. In plot 12, there were 7 live trees at the start of monitoring in 2006, and they were a mix of America



Plots with the lowest canopy cover (Plot 27 pictured) have little to no observed tree regeneration and the highest invasive species cover.

elm, black cherry, and white pine. By 2018, there were no live trees or even saplings on the plot. Plot 19, which had several large down white pine from the spring 2018 storm (Map 10), had even fewer seedlings in 2022 than previous cycles before the storm. Moreover, the plots with the lowest canopy cover (4, 12, and 32; Map 10) had little to no observed regeneration in the most recent cycle, and have the highest invasive species cover (Maps 8 & 9). This is all strong evidence that overabundant deer and invasive shrubs are

causing regeneration failure in SARA and leading to forest loss in the most extreme cases.

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, SARA has its own [web page](#) providing a convenient one-stop shopping place for all things SARA related.

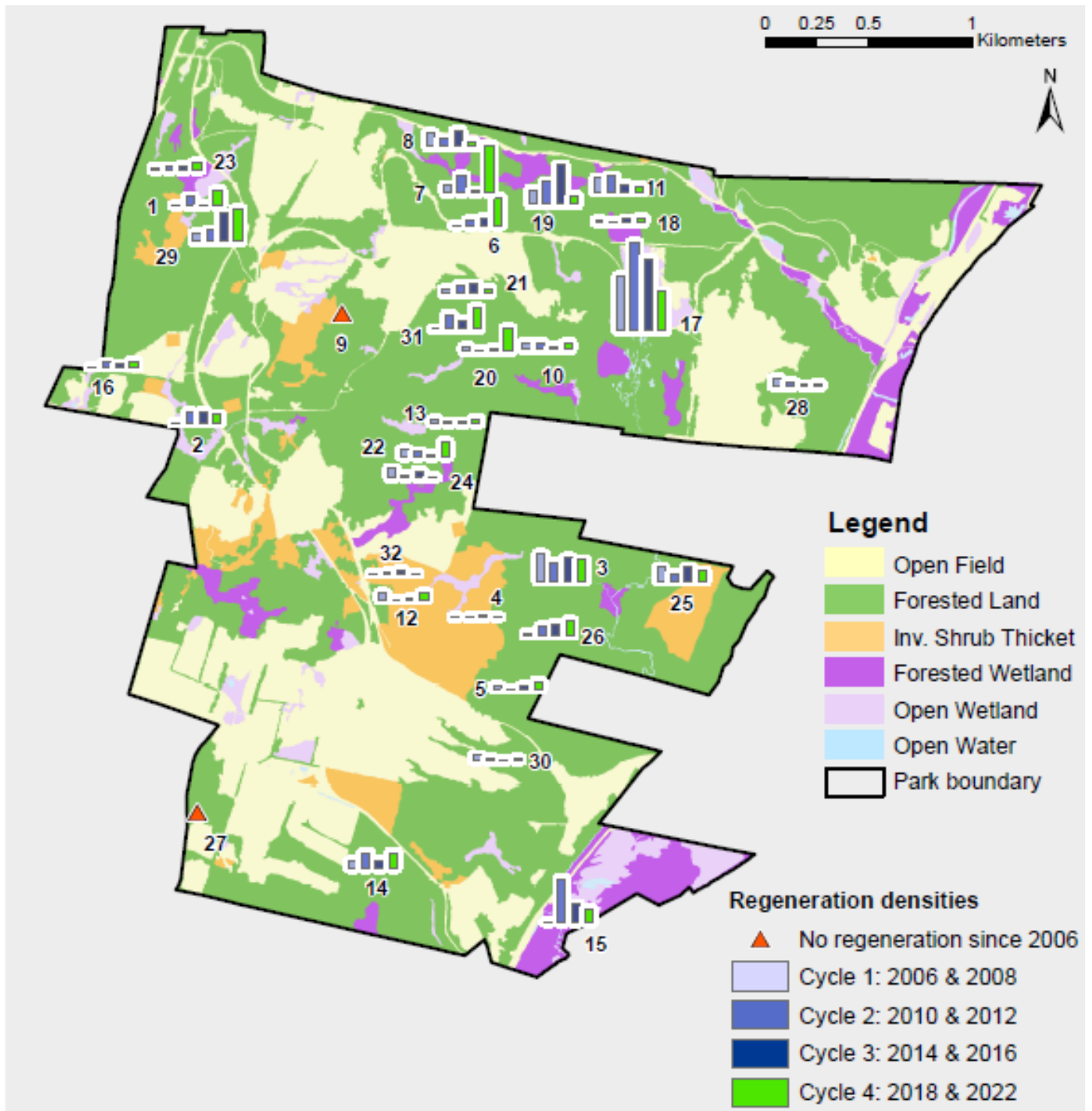
The recently launched [Resilient Forests Initiative](#) contains many useful resources and insights

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 an alternating panel, with plots 1-16 sampled in 2006, 2010, 2014, and 2018, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Densities range from 0 to 2.1 stems/m², and only include native canopy-forming species. Note the unit change from 2018 report to match manuscript in review. Plot 15 was not sampled in Cycle 1.

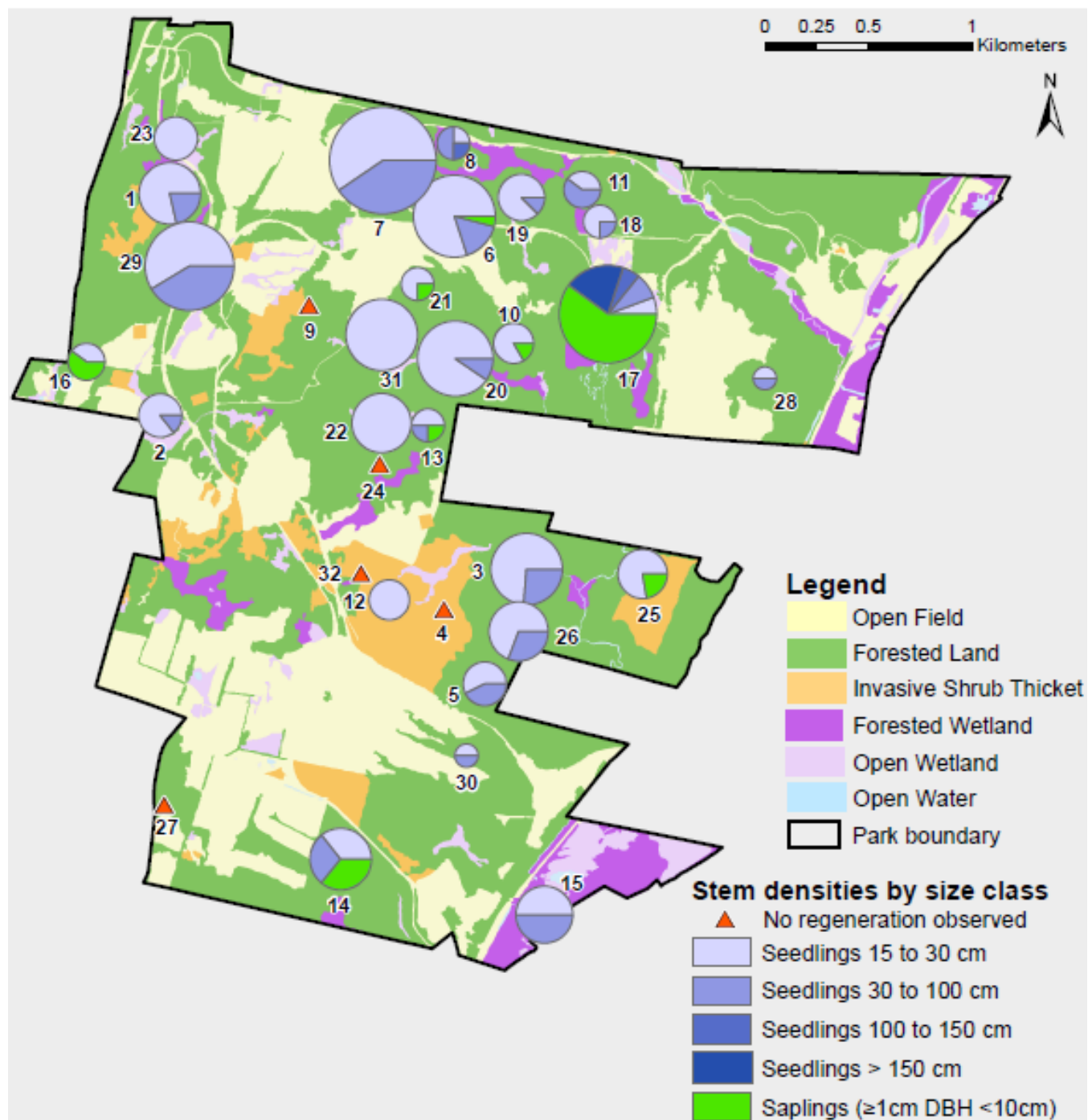
MAP 1: TREE REGENERATION: MONITORING CYCLE



PARK MONITORING MAPS

Trends in tree regeneration by size class observed in forest plots in the most recent 4 survey cycle (2018 and 2022). Plots are sampled in an alternating panel, with plots 1-16 sampled in 2018, and plots 17-32 sampled in 2022. Pie size is proportional to the total plot-level regeneration and location may be shifted to prevent overlap. Total densities range from 0 to 1.1 stems/m² and only include native canopy-forming species.

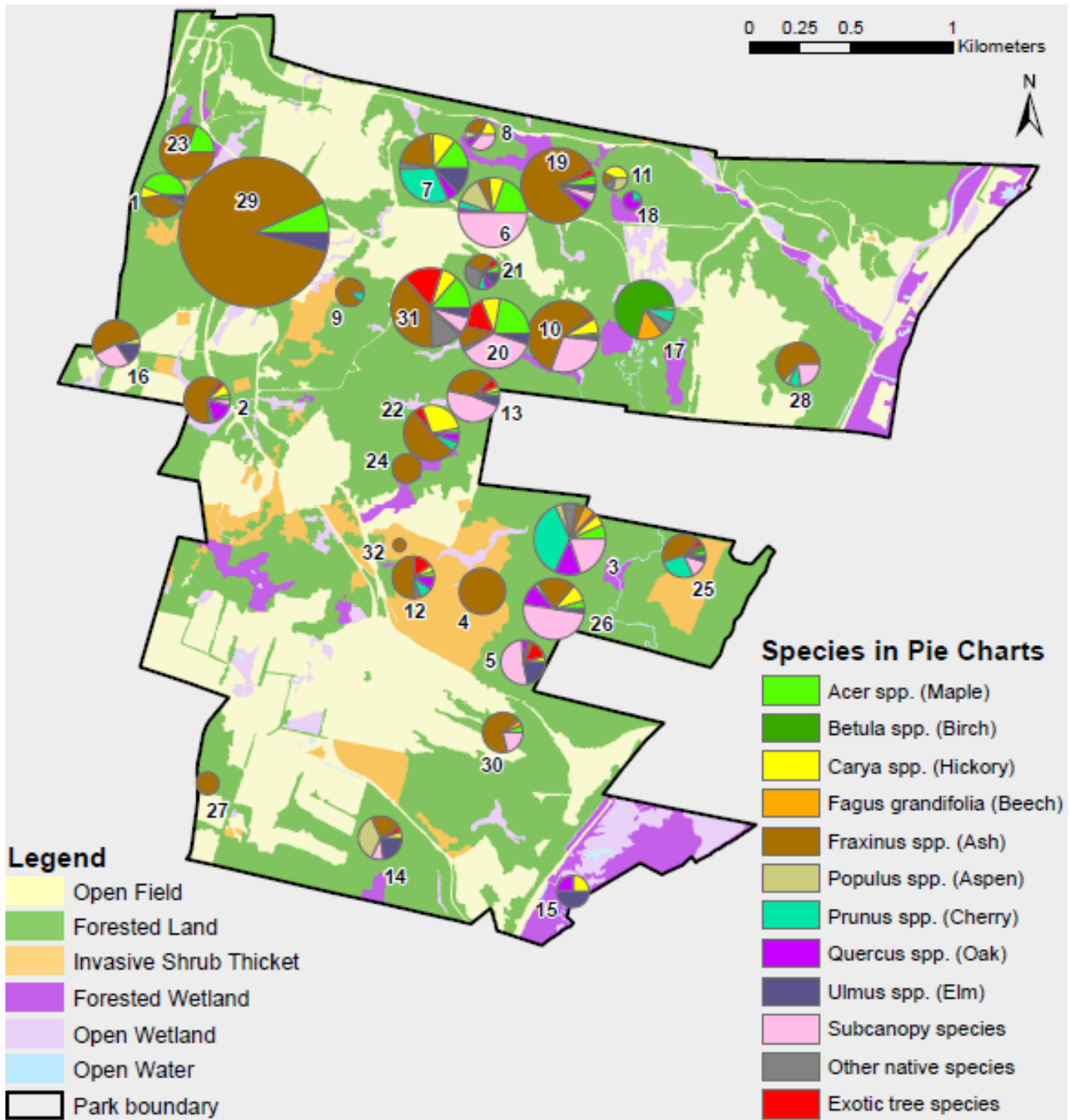
MAP 2: TREE REGENERATION: SIZE CLASS



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 1-16 were sampled in 2018, and plots 17-32 were sampled in 2022. Pie size is proportional to the total plot-level regeneration (plot-level density range: 0.05 to 7.0 stems/m²). Note the unit change from the 2018 report to match manuscript in review. Pies may be shifted from actual plot location to prevent overlap.

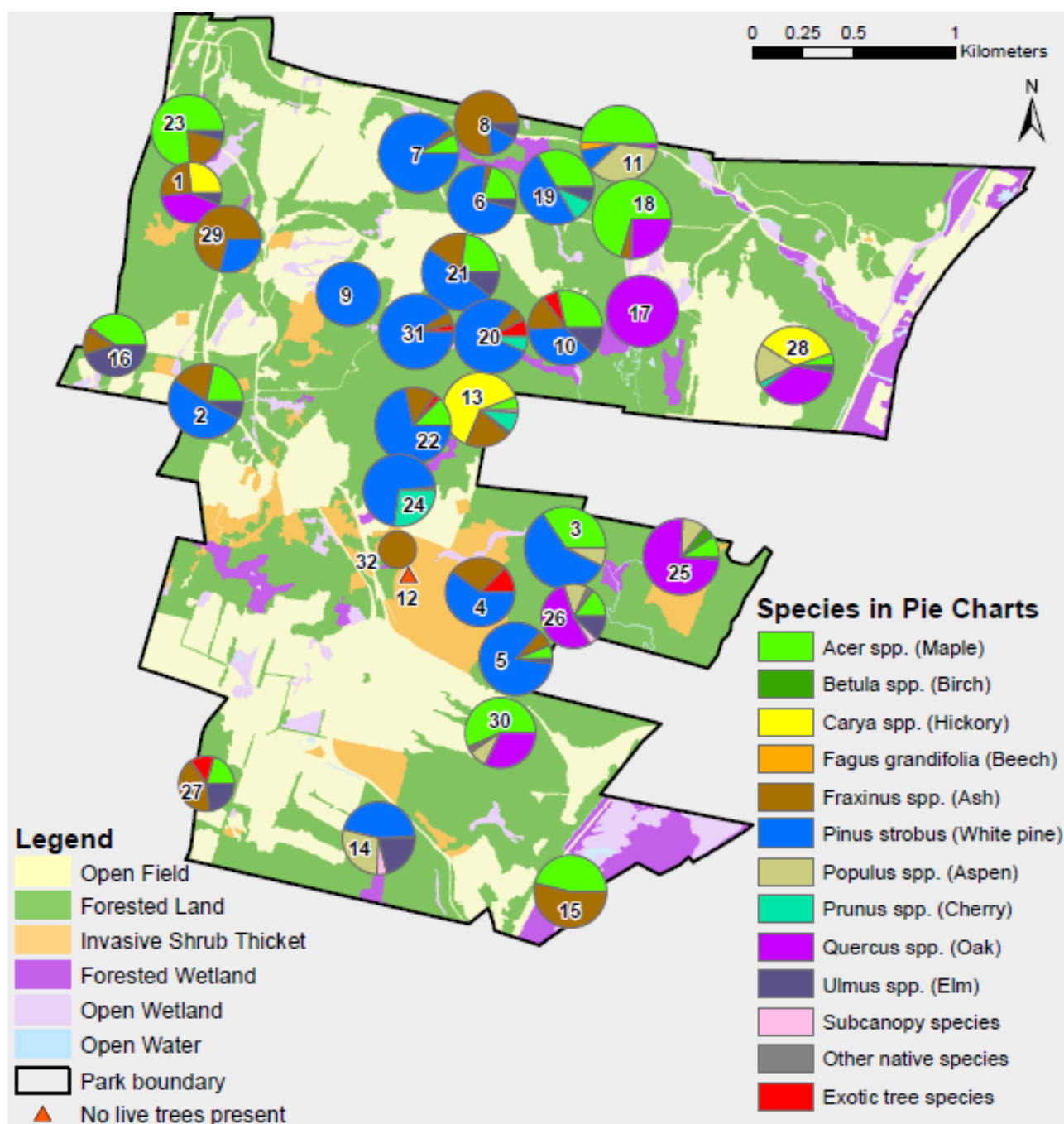
MAP 3: TREE REGENERATION: COMPOSITION



PARK MONITORING MAPS

Trends in tree composition, 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 1-16 sampled in 2018, and plots 17-32 sampled in 2022. Pie size is proportional to the total plot-level basal area (range: 0 to 58.6 m²/ha). Pies may be shifted from actual plot location to prevent overlap.

MAP 4: TREE CANOPY: COMPOSITION



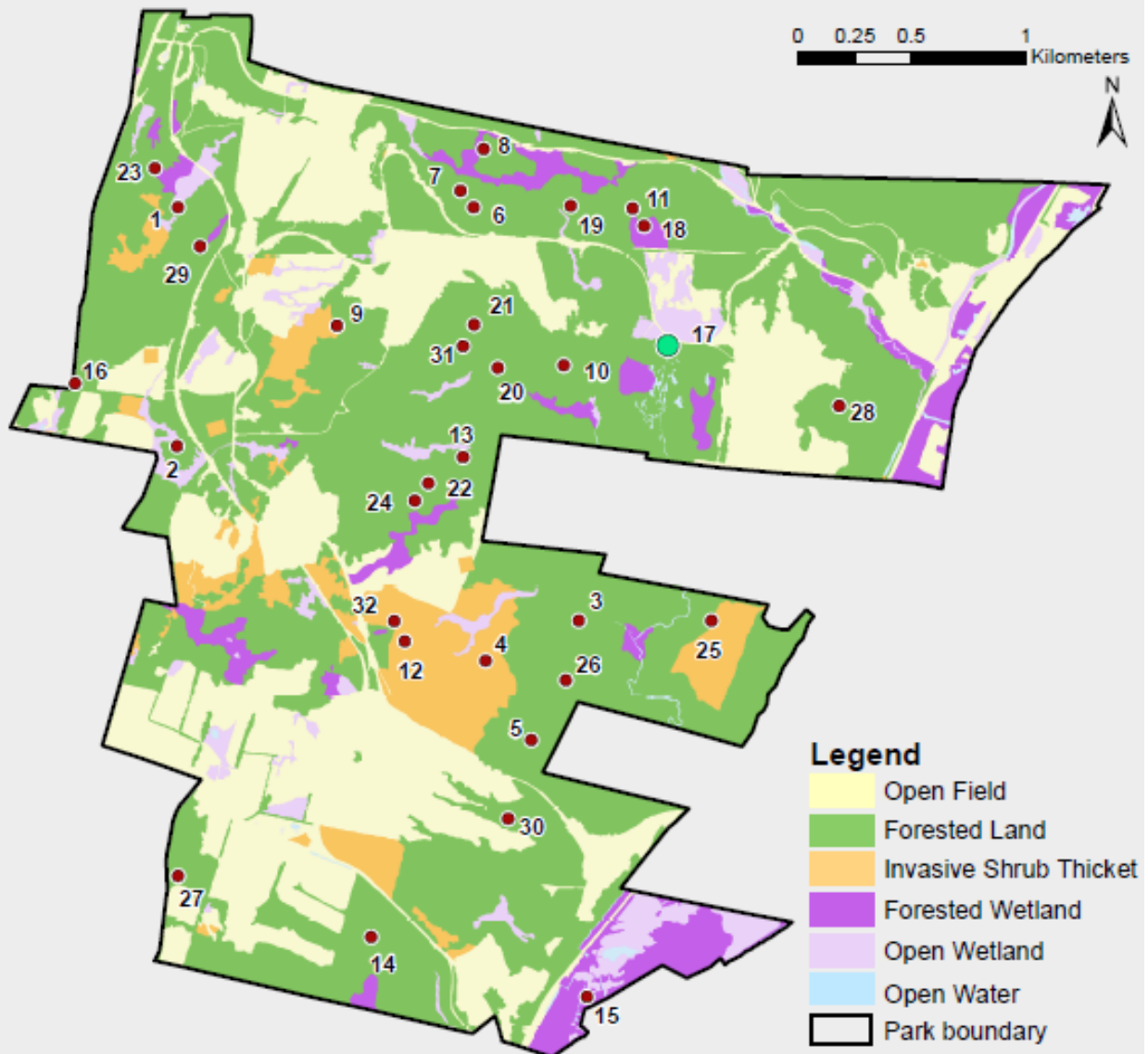
PARK MONITORING MAPS

Trends in the regeneration stocking index for the most recent survey cycle (2018 & 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 and only includes native canopy-forming species (range 0 to 249.3).

MAP 5: TREE REGENERATION: STOCKING INDEX

Stocking Index Ranges

- < 25: Severely understocked. Regeneration is insufficient to replace the forest canopy.
- 25 to 50: Moderately stocked regeneration for areas with low deer impacts.
- 50 to 100: Sufficient regeneration to replace forest canopy in areas with low deer impacts.
- > 100: Sufficiently stocked with regeneration for areas with high deer impacts.



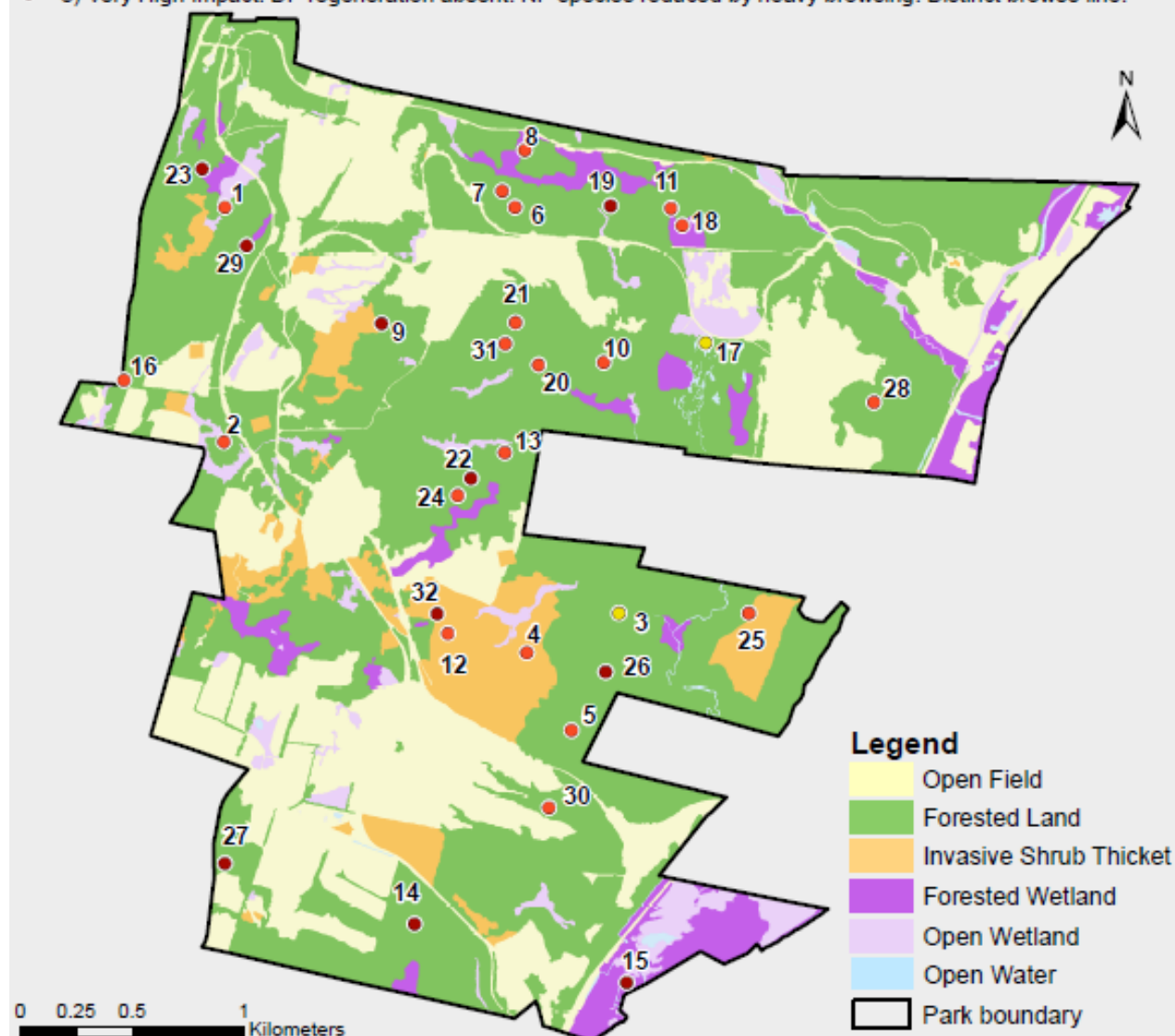
PARK MONITORING MAPS

Index of deer browse impacts observed in forest plots in the most recent survey cycle (2019 & 2022). Plots are sampled in an alternating panel, with plots 1-16 sampled in 2018 and plots 17-32 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

Deer Browse Index

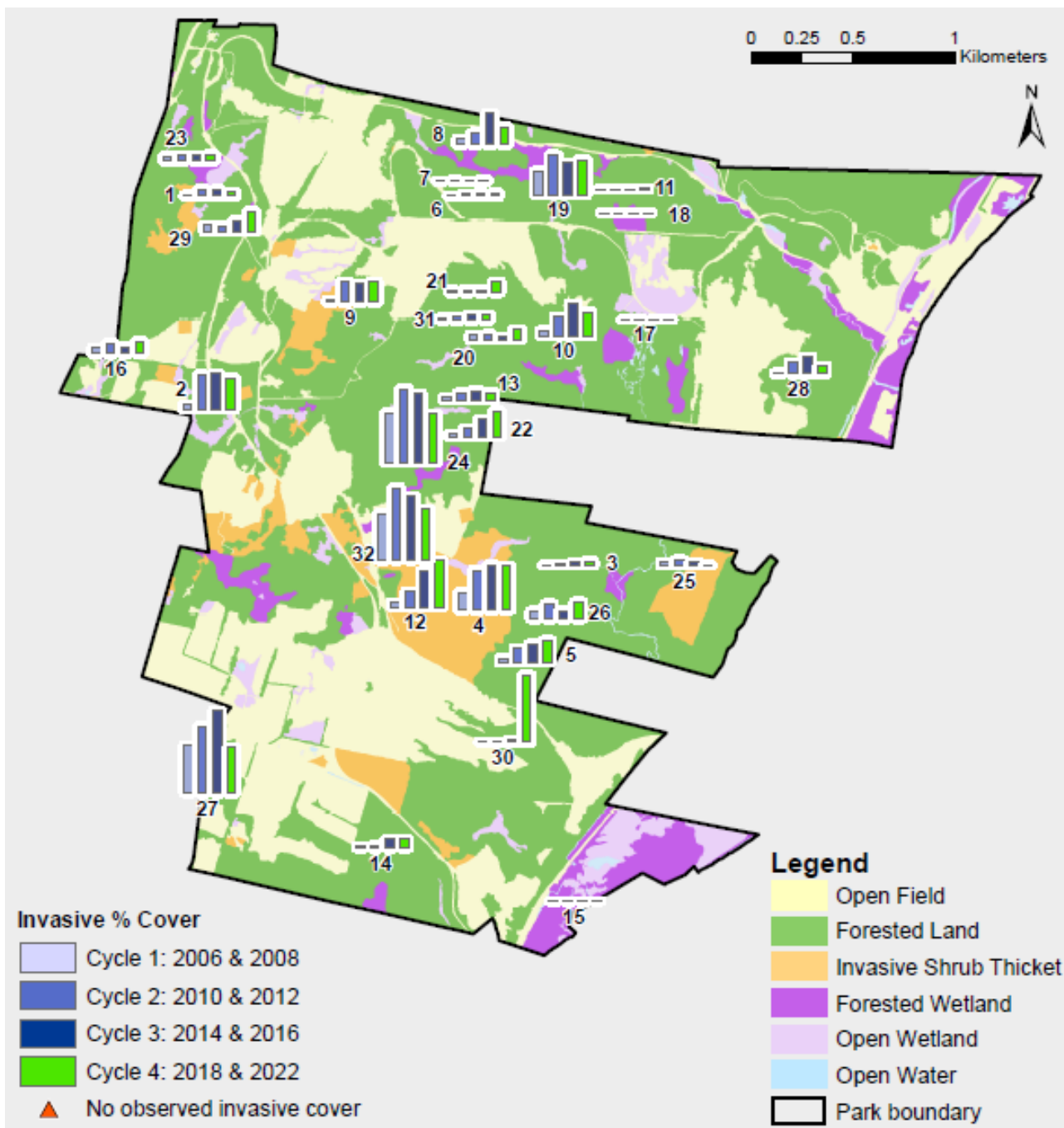
- 1) No Impact: found only in well-maintained deer exclosures.
- 2) Low Impact: deer preferred (DP) species abundant and of varying heights.
- 3) Medium Impact: DP species present, but most under 30 cm tall. DP herbs present, but stunted, and flowering is uncommon.
- 4) High Impact: DP species are rare 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 reduced by heavy browsing. Distinct 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 1-16 sampled in 2006, 2010, 2014, and 2018, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Average invasive cover ranges from 0 to 75.8%.

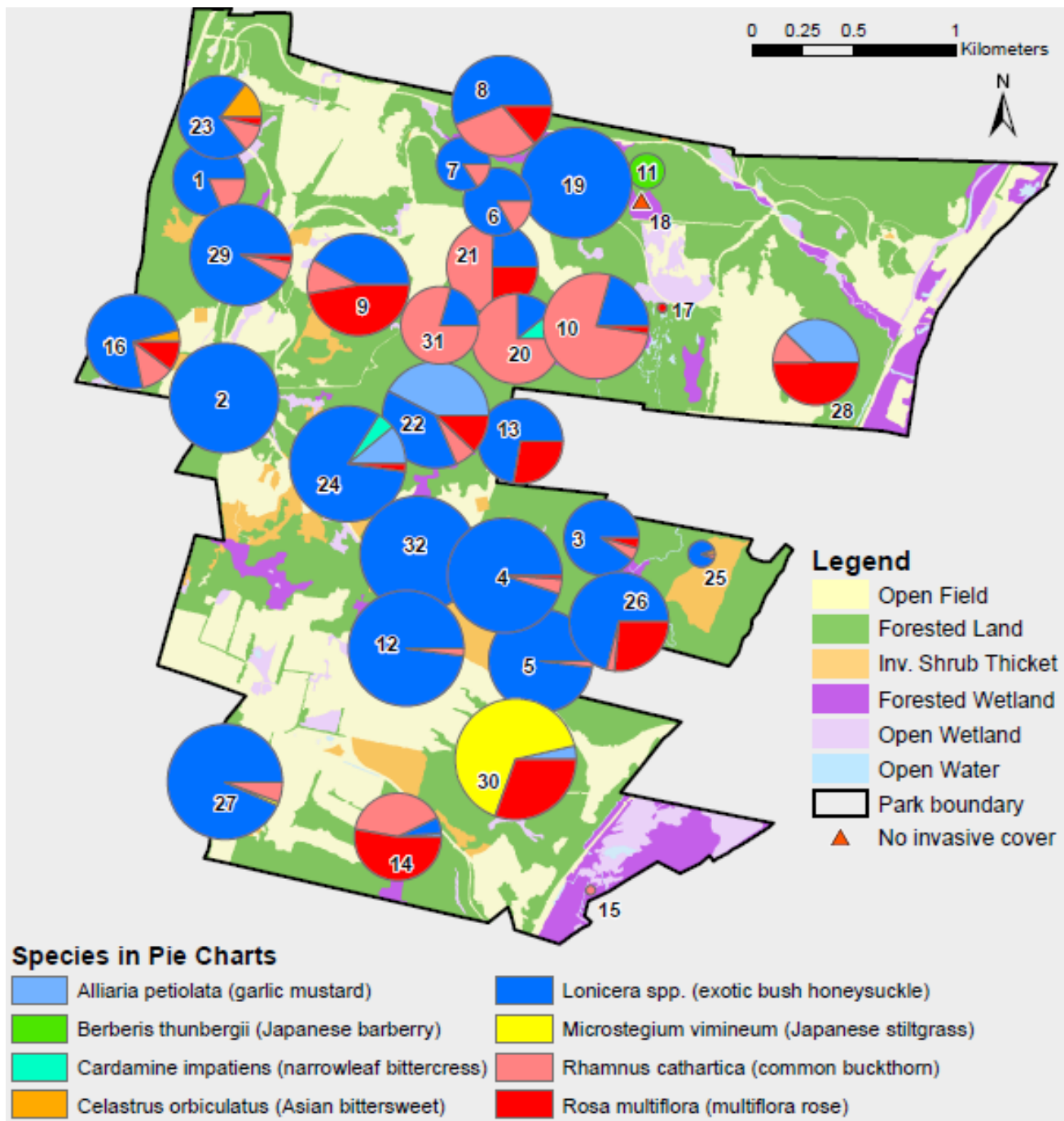
MAP 7: INVASIVES % COVER BY CYCLE



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 1-16 sampled in 2018, and plots 17-32 sampled in 2022. Pie size is proportional to total invasive cover (range: 0 to 61.9%), and location may be shifted to prevent overlap.

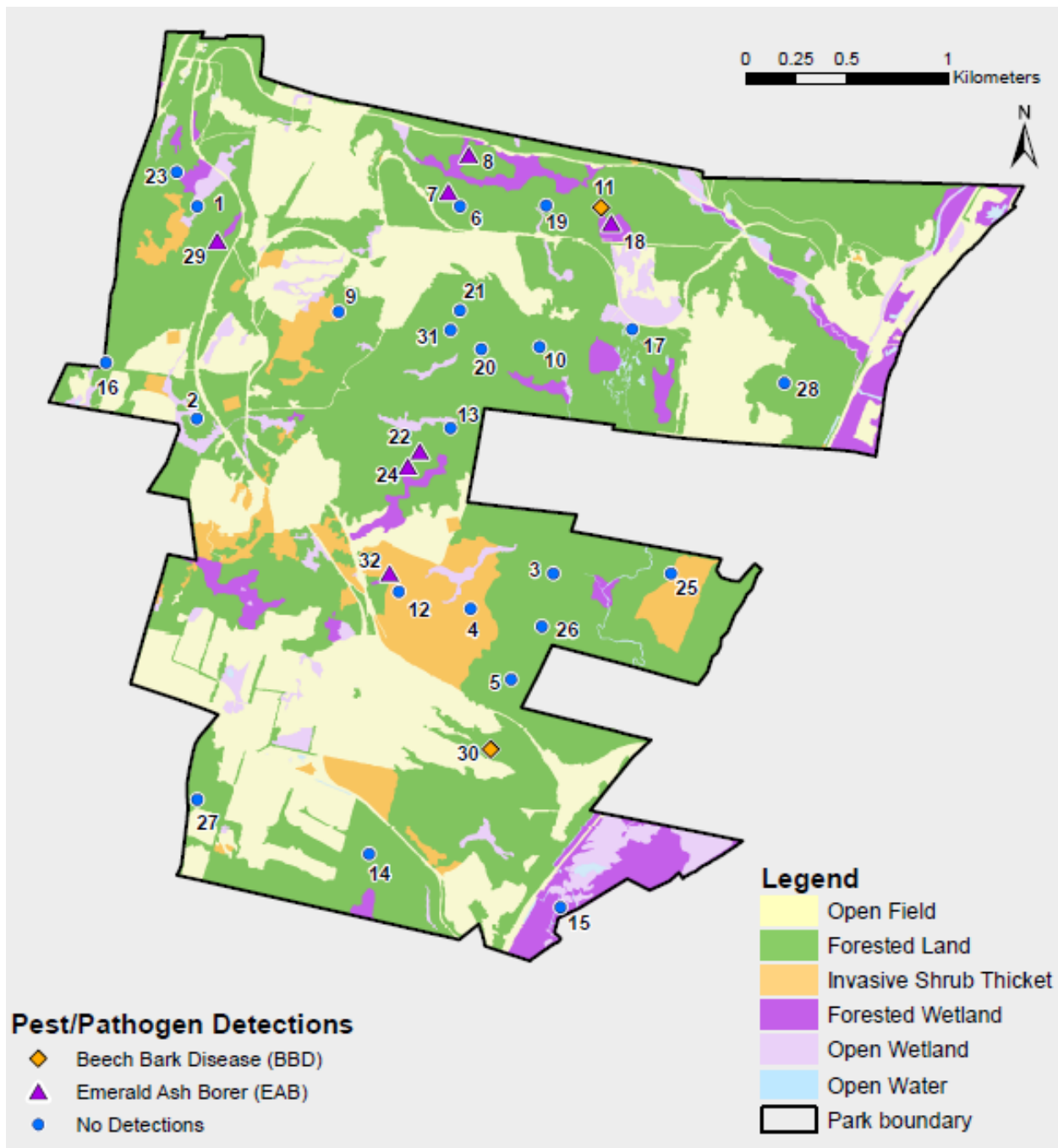
MAP 8: INVASIVES % COVER BY SPECIES



PARK MONITORING MAPS

Priority pest and pathogen detections in forest plots sampled from 2018-2022. Plots are sampled in an alternating panel with plots 1-16 sampled in 2018 and plots 17-32 sampled in 2022.

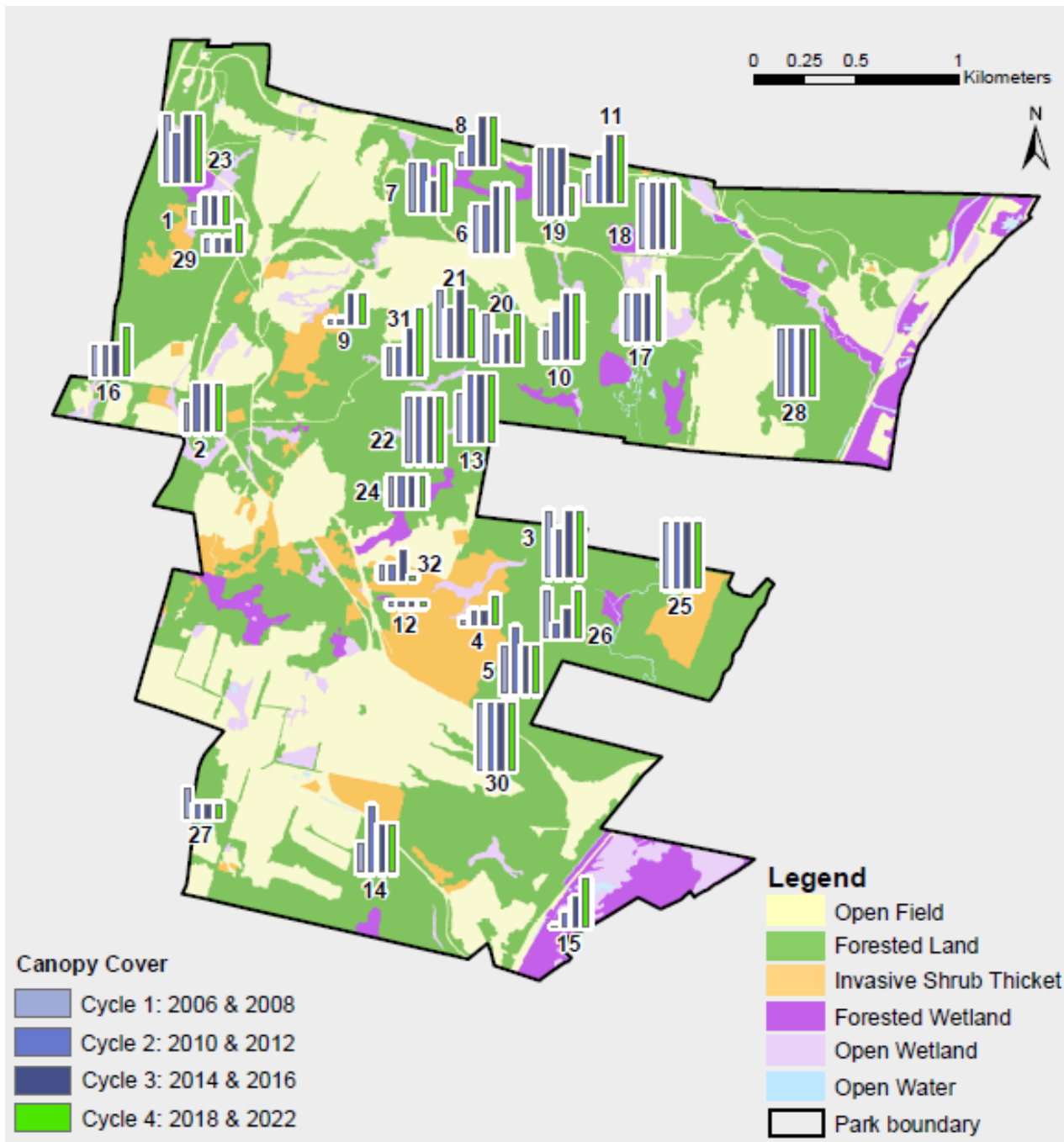
MAP 9: FOREST PEST/PATHOGEN DETECTIONS



PARK MONITORING MAPS

Trends in tree canopy cover in forest plots sampled from 2006-2022. Plots are sampled in an alternating panel, with plots 1-16 sampled in 2006, 2010, 2014, and 2018, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Canopy cover ranges from 0 - 10% to >75%.

MAP 10: CANOPY COVER BY CYCLE



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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