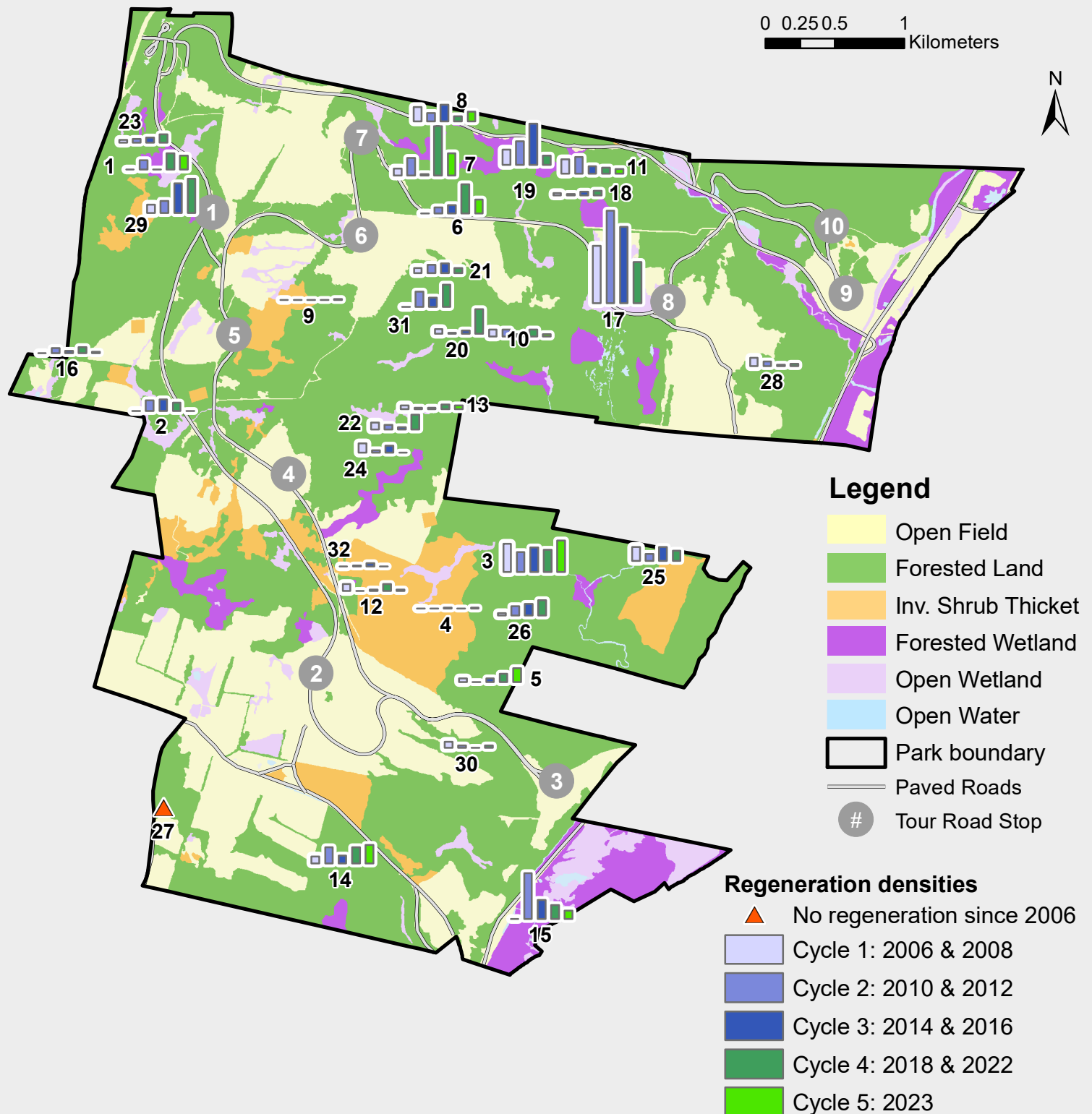




Map 1. Tree Regeneration by Cycle

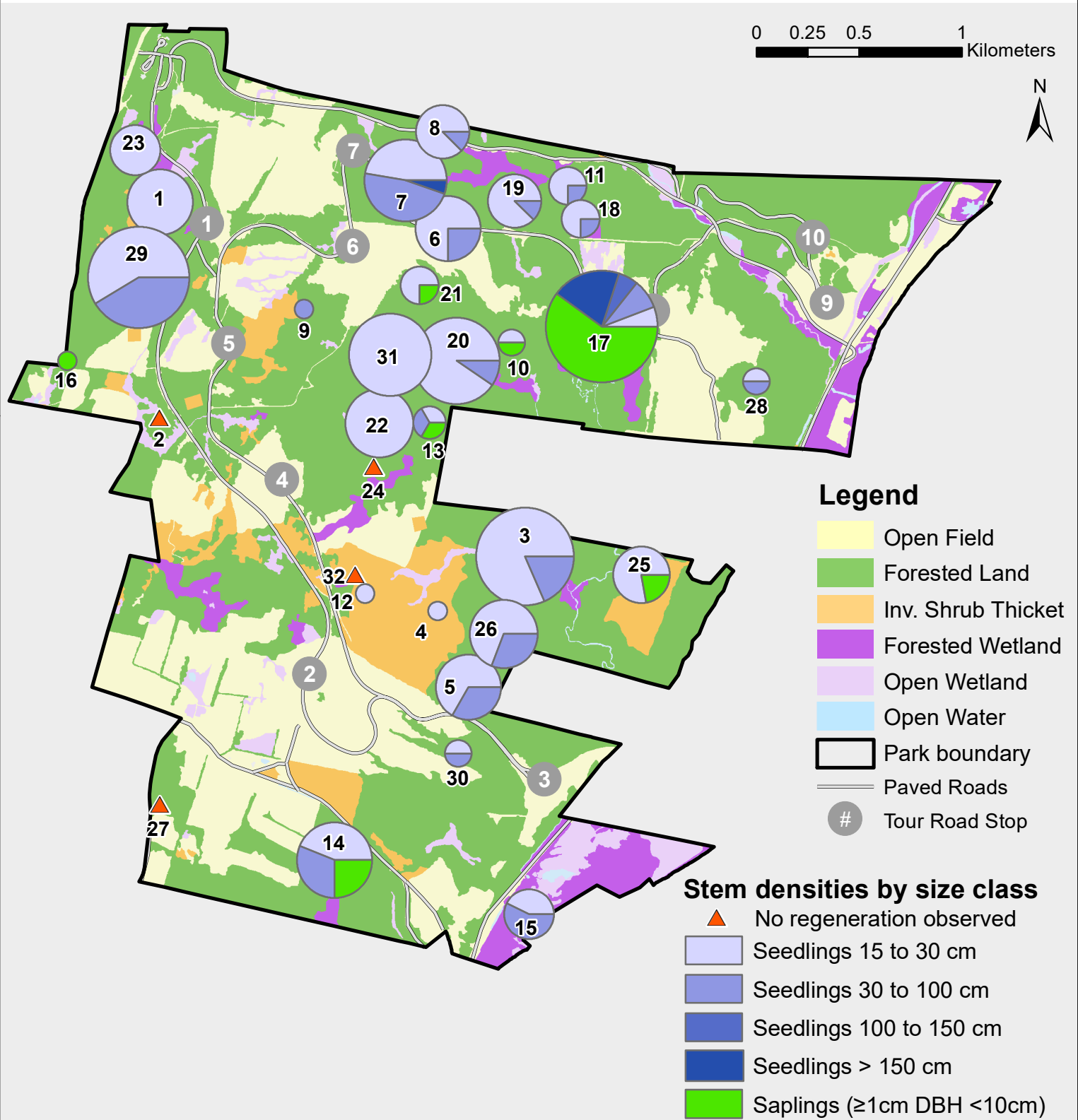
Trends in tree regeneration, including seedlings and saplings, observed in forest plots sampled from 2006 to 2023. Plots are sampled in an alternating panel, with plots 1-16 sampled in 2006, 2010, 2014, 2018, and 2023, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Densities range from 0 to 2.1 stems/m², and only include native canopy-forming species. Note that plot 15 was not sampled in Cycle 1. See Table 1 for more details. Date: 6/23/2023.





Map 2. Tree Regeneration By Size Class

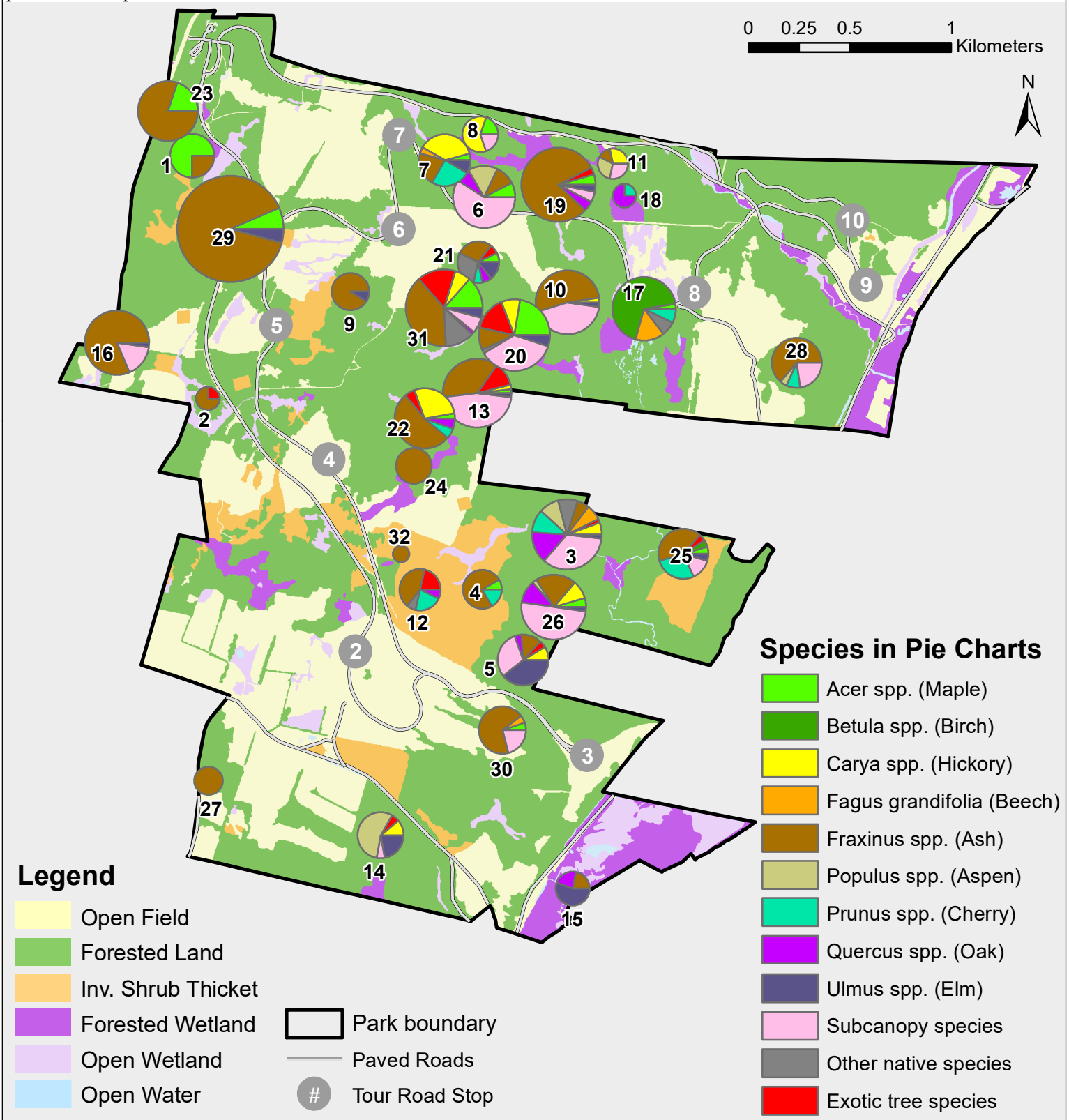
Trends in tree regeneration by size class observed in forest plots in the most recent 4-year census (2022 and 2023). Plots are sampled in an alternating panel, with plots 1-16 sampled in 2023, and plots 17-32 sampled in 2022. Pie size is proportional to the total plot-level regeneration and location may be shifted to prevent overlap. Total densities range from 0 to 0.9 stems/m² and only include native canopy-forming species. Date: 6/23/2023.





Map 3. Tree Regeneration Composition

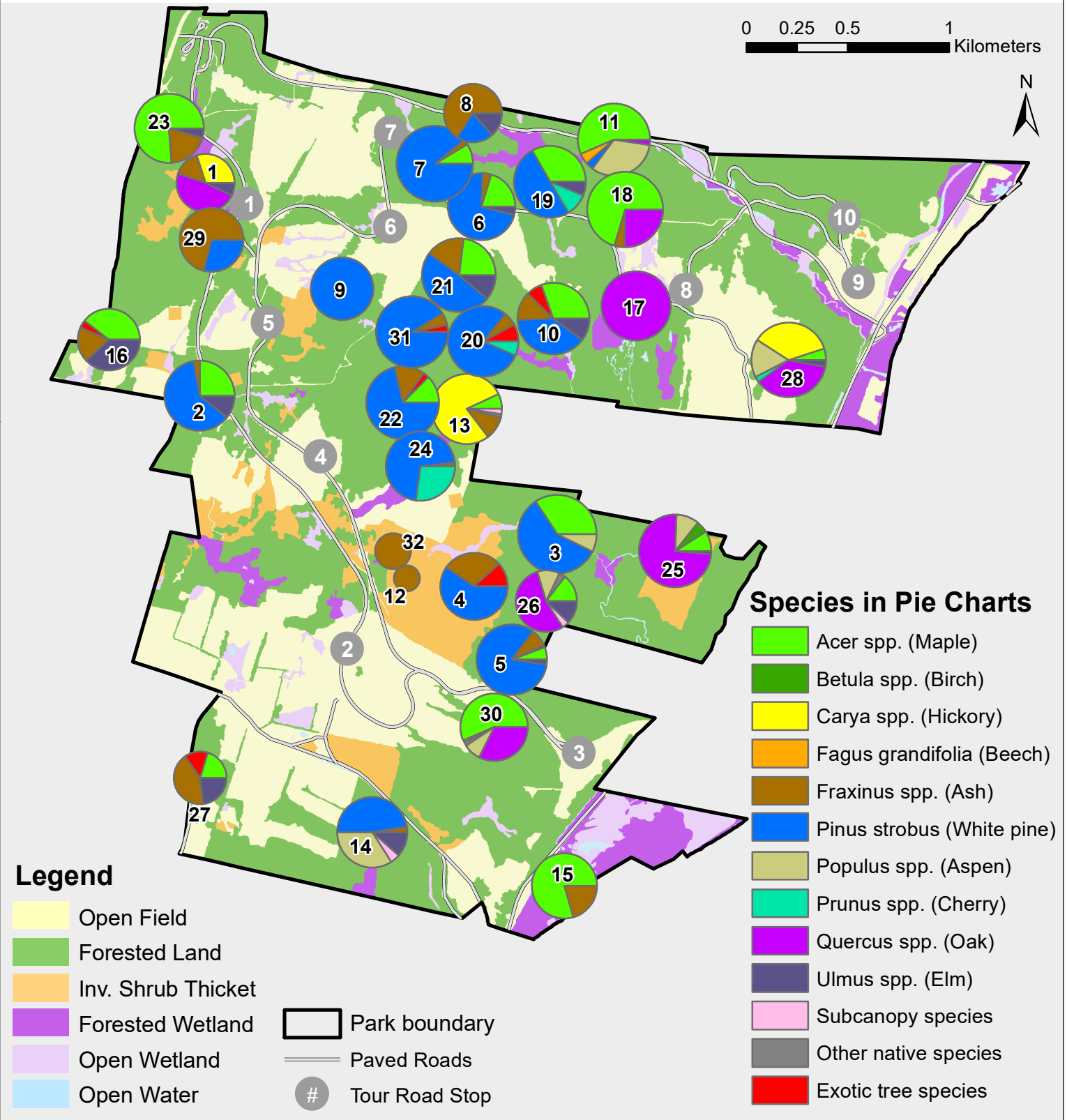
Trends in tree regeneration, including seedlings and saplings, by species group observed in forest plots in the most recent 4-year census (2022 and 2023). Plots 1-16 were sampled in 2023, and plots 17-32 were sampled in 2022. Pie size is proportional to the total plot-level regeneration (plot-level density range: 0.05 to 7.0 stems/m²). Pies may be shifted from actual plot location to prevent overlap. Date: 6/23/2023.





Map 4. Tree Canopy Composition

Trends in tree composition, by species group, observed in forest plots in the most recent 4-year census (2022 and 2023). Plots are sampled in an alternating panel, with plots 1-16 sampled in 2023, and plots 17-32 sampled in 2022. Pie size is proportional to the total plot-level basal area (range: 0.6 to 61.1 m²/ha). Pies may be shifted from actual plot location to prevent overlap.
Date: 6/26/2023.



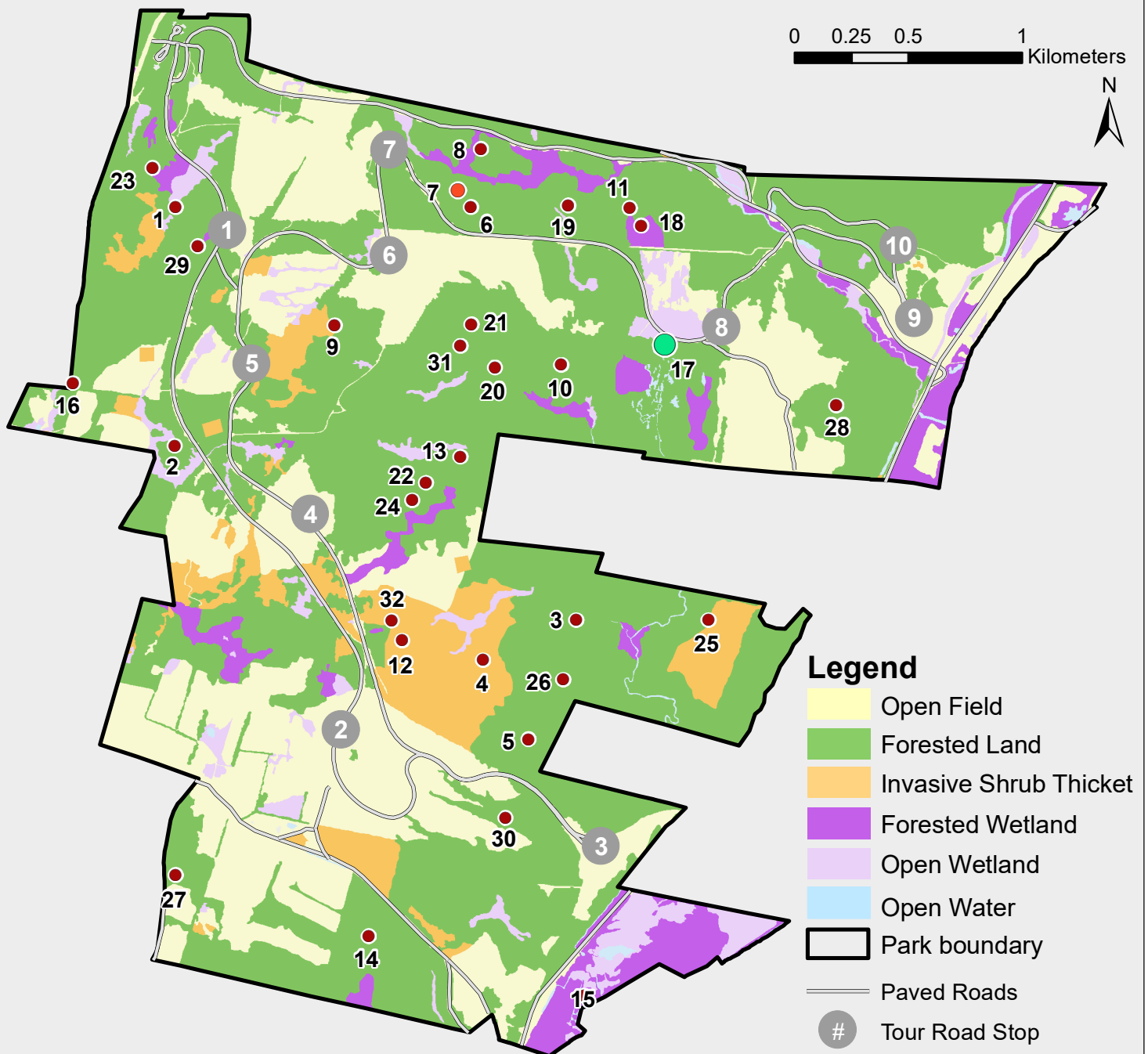


Map 5. Tree Regeneration Stocking Index

Trends in the regeneration stocking index for the most recent 4-year census (2022 & 2023). 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). See Table 1 for stocking index values. Date: 6/26/23.

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.



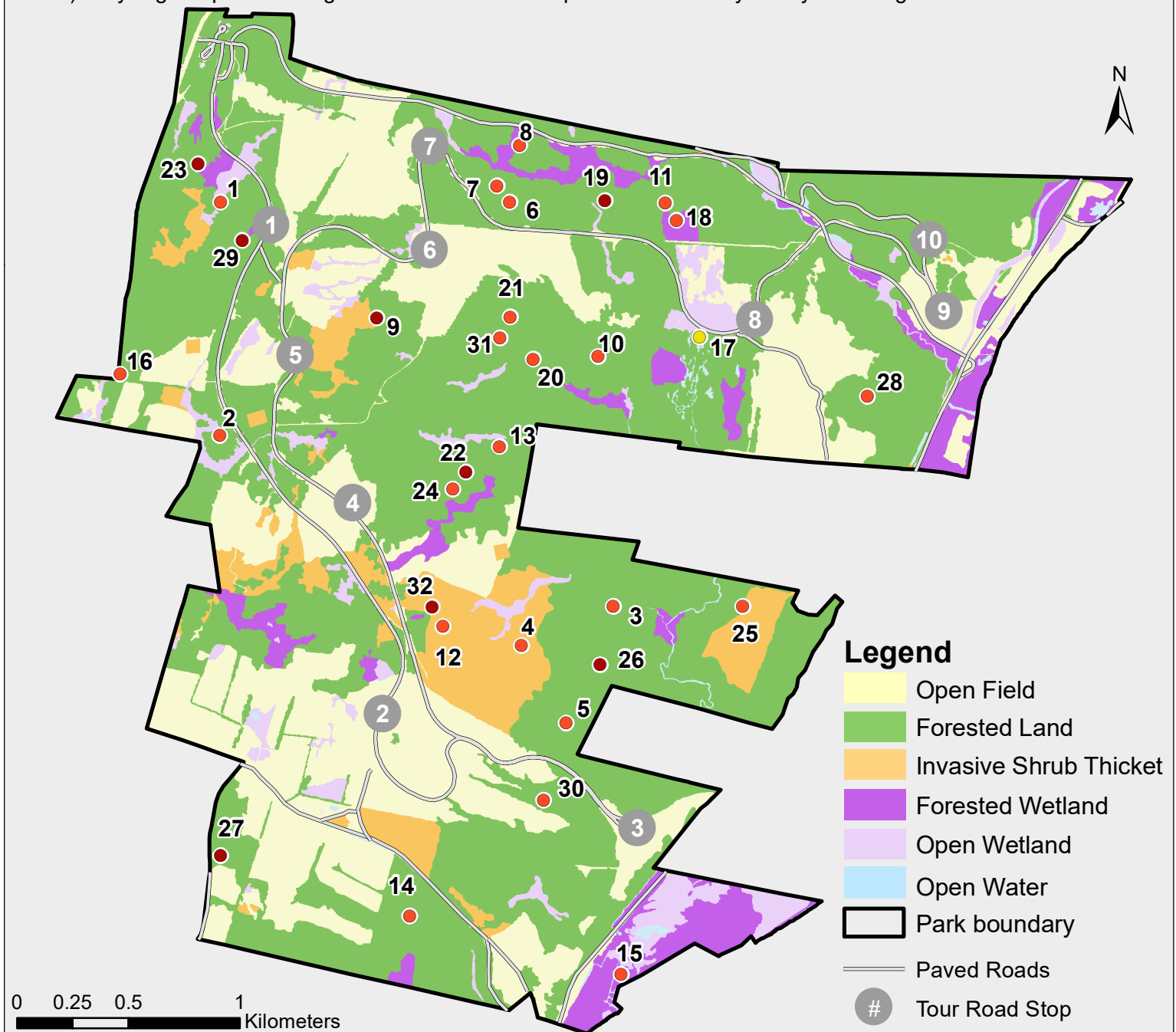


Map 6. Index of Deer Browse Impacts

Index of deer browse impacts observed in forest plots in the most recent 4-year census (2022 & 2023). Plots are sampled in an alternating panel, with plots 1-16 sampled in 2023 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. Date: 6/26/23.

Deer Browse Index

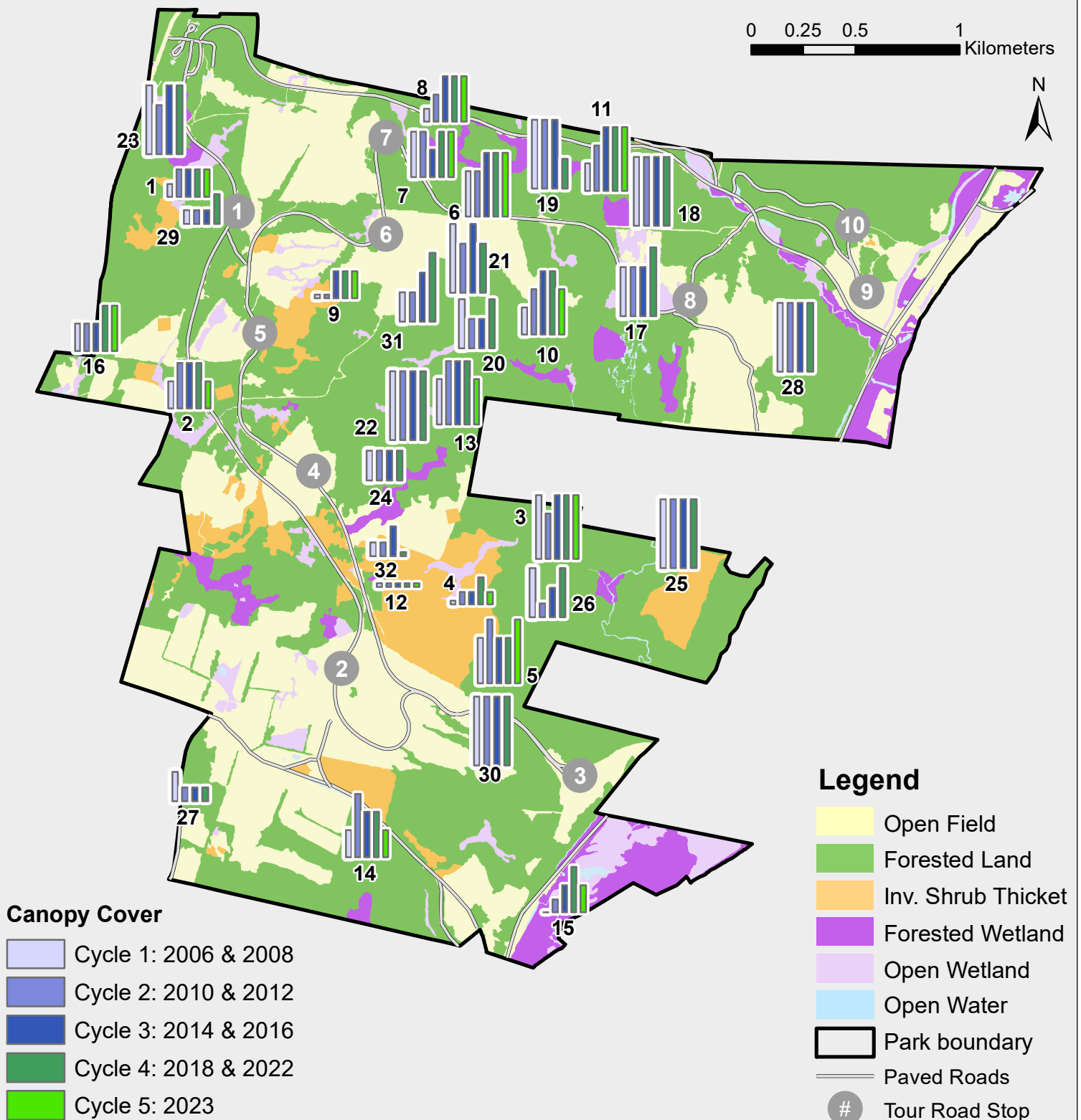
- 1) No Impact: found only in well-maintained deer exclosures.
- 2) Low Impact: deer preferred (DP) species abundant and of varying heights.
- 3) Medium Impact: DP species present, but most under 30 cm tall. DP herbs present, but stunted, and flowering is uncommon.
- 4) High Impact: DP species are rare 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.





Map 7. Canopy Cover by Cycle

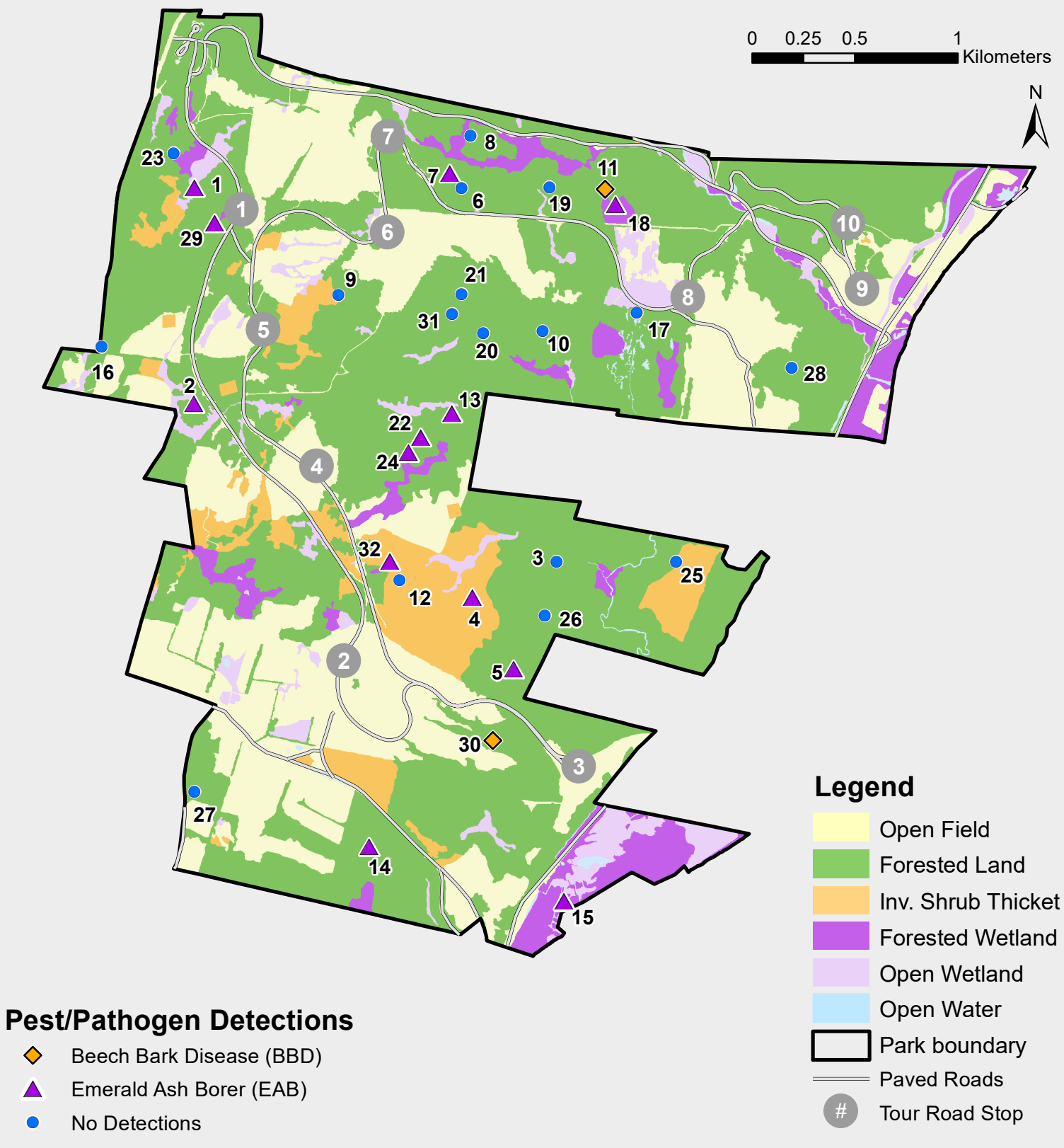
Trends in tree canopy cover in forest plots sampled from 2006-2023. Plots are sampled in an alternating panel, with plots 1-16 sampled in 2006, 2010, 2014, 2018, and 2023, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Canopy cover ranges from 0 - 10% to >75%. Date: 6/26/23.





Map 8. Forest Pest/Pathogen Detections

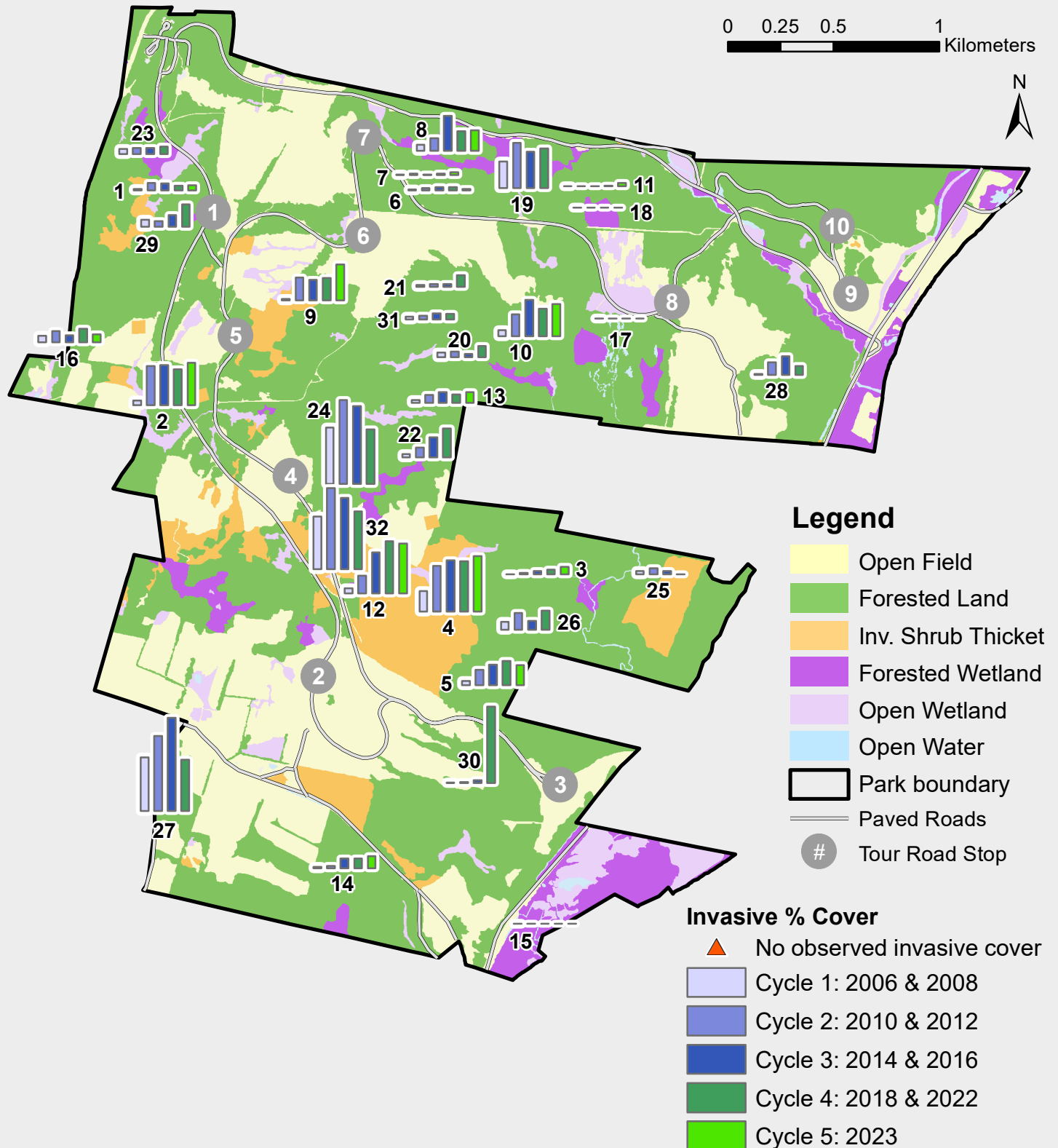
Priority pest and pathogen detections in forest plots sampled from 2022-2023. Plots are sampled in an alternating panel with plots 1-16 sampled in 2023 and plots 17-32 sampled in 2022. Date 6/26/23.





Map 9. Invasive % Cover by Cycle

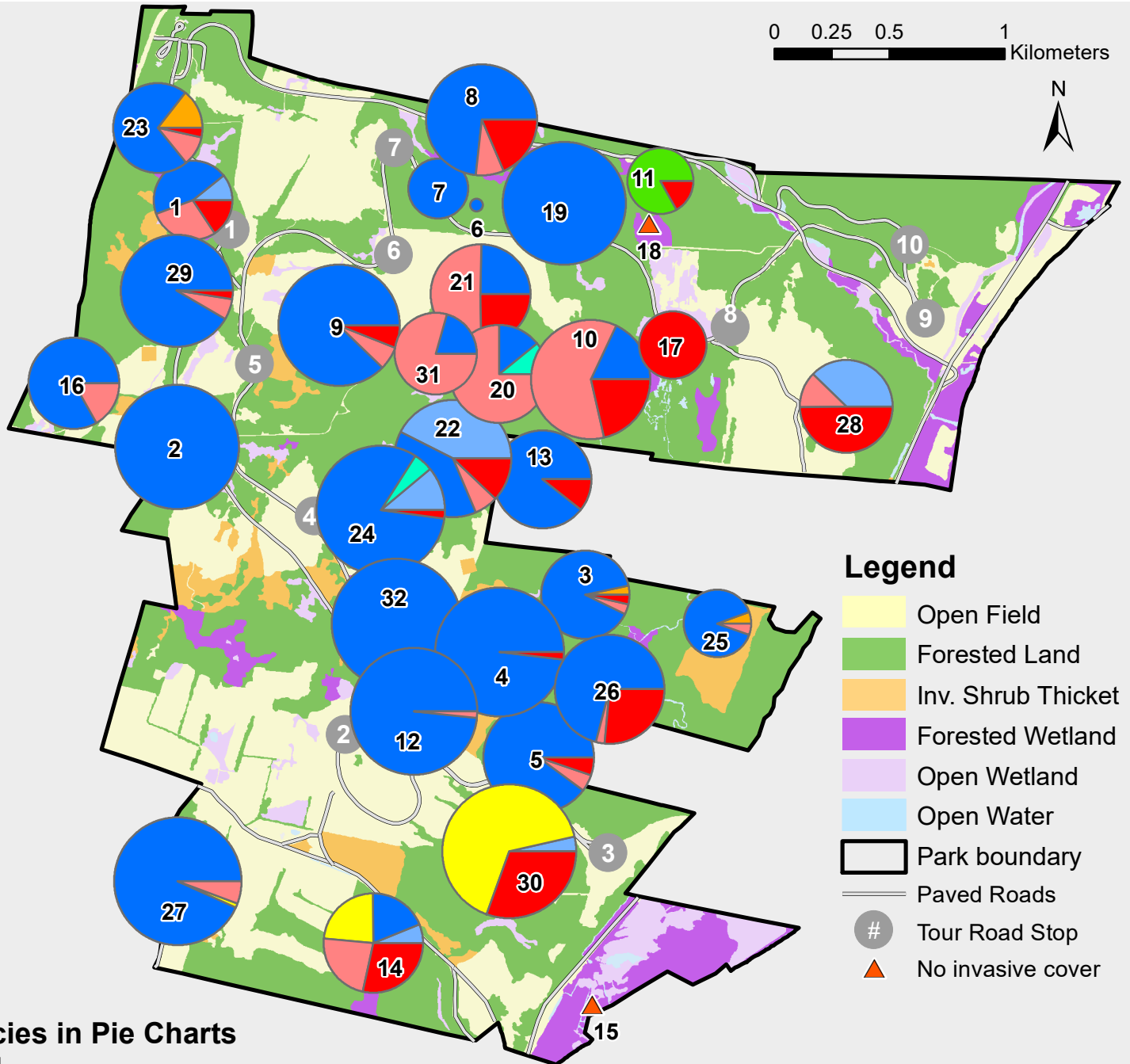
Trends in percent cover of invasive species observed in plots sampled from 2006-2023. Plots are sampled in an alternating panel, with plots 1-16 sampled in 2006, 2010, 2014, 2018, and 2023, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Average invasive cover ranges from 0 to 75.8%. See Table 2 for % cover values. Date: 6/26/23.





Map 10. Invasive % Cover by Species

Trends in % invasive cover by species observed in quadrats for plots in the most recent 4-year census (2022 & 2023). Plots are sampled in an alternating panel, with plots 1-16 sampled in 2023, 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. See Table 2 for more information.
Date: 6/26/23.



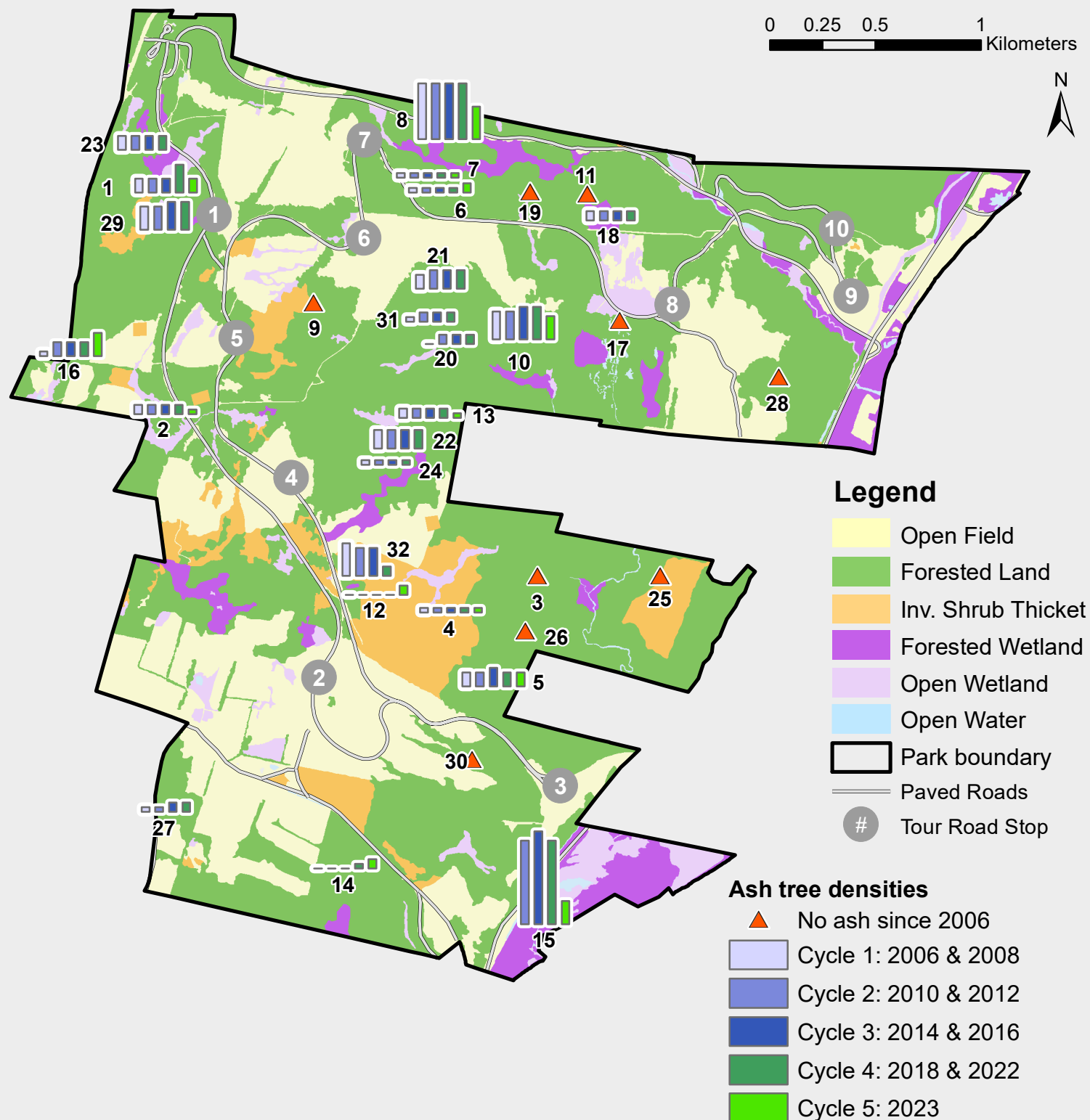
Species in Pie Charts

- | | |
|--|---|
| Acer platanoides (Norway maple) | Lonicera spp. (exotic bush honeysuckle) |
| Alliaria petiolata (garlic mustard) | Microstegium vimineum (Japanese stiltgrass) |
| Berberis thunbergii (Japanese barberry) | Rhamnus cathartica (common buckthorn) |
| Cardamine impatiens (narrowleaf bittercress) | Rosa multiflora (multiflora rose) |
| Celastrus orbiculatus (Asian bittersweet) | |



Map 11. Ash Tree Density by Cycle

Trends in ash tree density in forest plots sampled from 2006 to 2023. Plots are sampled in an alternating panel, with plots 1-16 sampled in 2006, 2010, 2014, 2018, and 2023, and plots 17-32 sampled in 2008, 2012, 2016, and 2022. Densities range from 0 to 20 stems/400 m² plot. Note that plot 15 was not sampled in Cycle 1. Date: 7/13/2023.



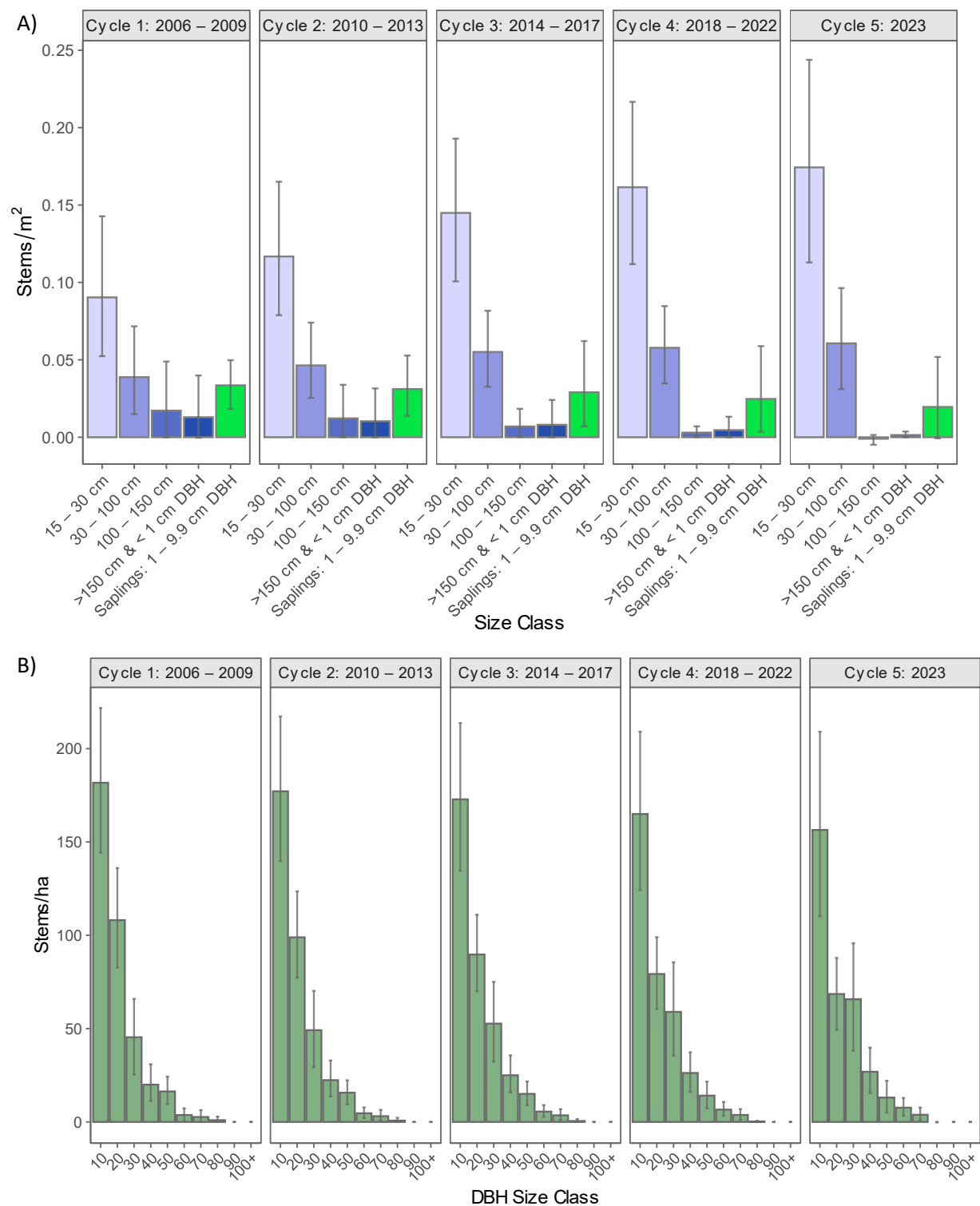


Figure 1. Stem density distributions in 10 cm increments by survey cycle in Saratoga National Historical Park. Cycle 1 is 2006–2009; Cycle 2 is 2010–2013; Cycle 3 is 2014–2017; Cycle 4 is 2018–2022; Cycle 5 is 2023. Note that Cycle 3 only includes the first panel of 16 plots. Figure A shows regeneration densities by size class. Figure B shows tree density by diameter at breast height (DBH) increments. Error bars are 95% bootstrapped confidence intervals. An asterisk denotes a linear DBH distribution that is indicative of long-term recruitment failure.

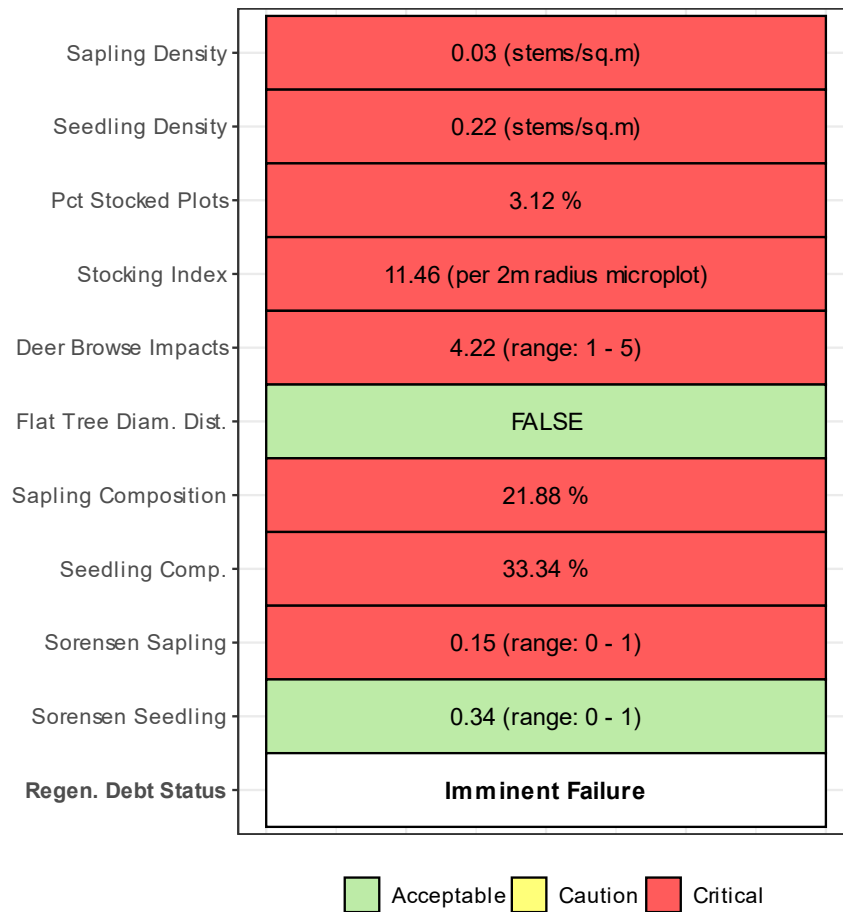
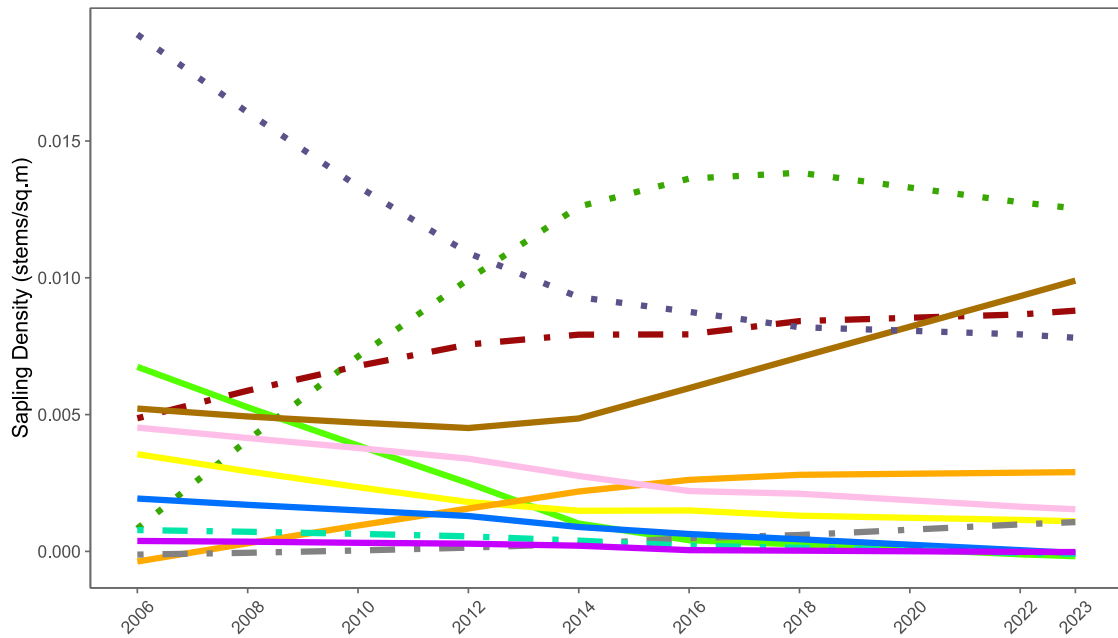


Figure 2. Regeneration Debt metrics and status for the most recent 4-year census (2022 and 2023) in Saratoga National Historical Park. Flat Tree Diam. Dist. stands for Flat Tree Diameter Distribution. If TRUE, the density of small trees is lower than expected due to chronic regeneration failure. See [Miller et al. 2023](#) for more details on metric calculations, thresholds, and assessment of status.

A)



B)

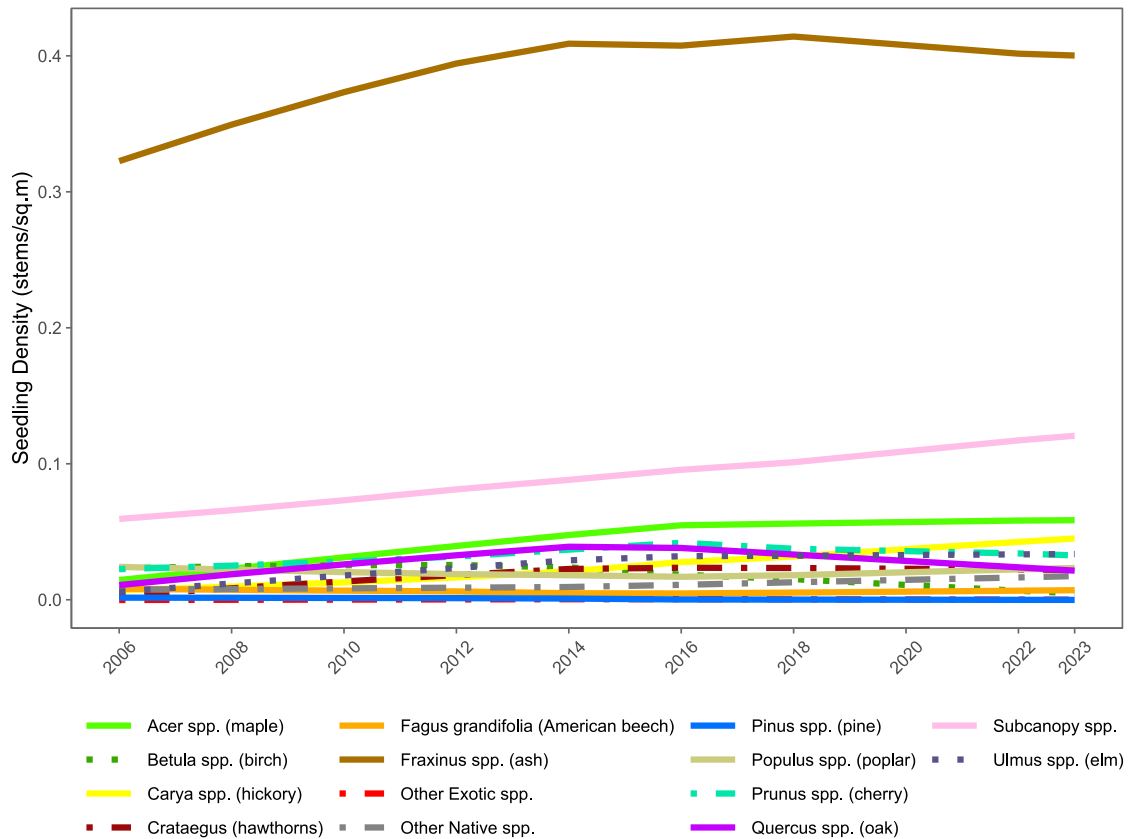


Figure 3. Loess smoothed changes in stem density for saplings (A) and seedlings (B) by species group and sample year in Saratoga National Historical Park. Specified loess span approximated a linear trend between consecutive sample events per panel.

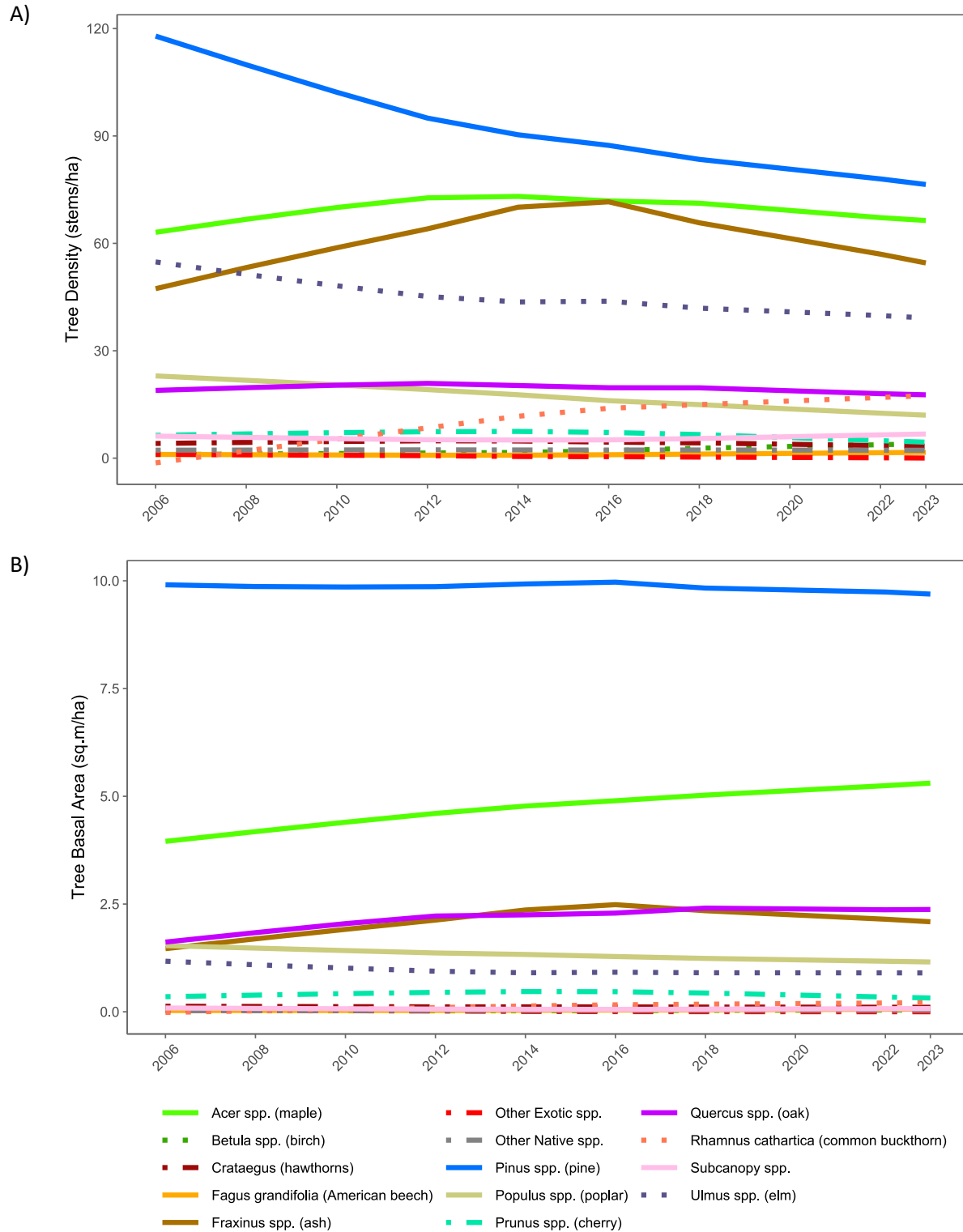


Figure 4. Loess smoothed changes in tree stem density (A) and basal area (B) by species group and sample year in Saratoga National Historical Park. Specified loess span approximated a linear trend between consecutive sample events per panel.

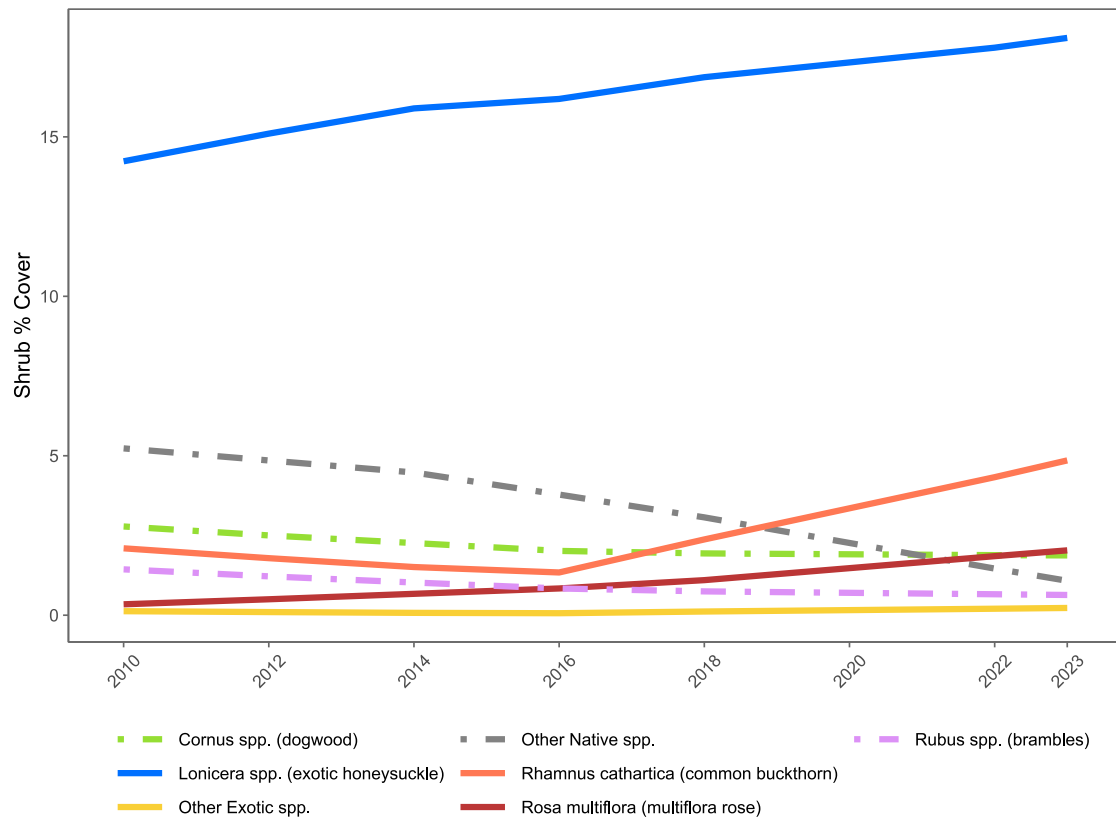


Figure 5. Loess smoothed changes in shrub % cover collected in 2-m radius microplots by species group and sample year in Saratoga National Historical Park. Specified loess span approximated a linear trend between consecutive sample events per panel. Note that this metric differs from quadrat % cover in that data collection started in 2010, and there's no height limit for shrub cover (vs. quadrats only including cover up to 1.5m).

Table 1. Average plot-level seedling and sapling stem densities, converted to stems per m², and stocking index by cycle. Only native, canopy-forming species are included. Note that *Fraxinus* spp. (ash species) are no longer considered canopy-forming species. Cycle 1 = 2006 & 2008; Cycle 2 = 2010 & 2012; Cycle 3 = 2014 & 2016; Cycle 4 = 2018 & 2022; Cycle 5 = 2023. Plots are sampled in alternating years, with Panel 1 sampled the first year, and Panel 2 sampled the second year. The stocking index quantifies whether current regeneration densities are sufficient to restock a forest canopy. The index is a weighted sum of seedling and sapling densities where larger seedling size classes get higher weights. Cells highlighted in green are plots that meet the minimum management target of 0.25 seedlings/m² and 0.14 saplings/m² or have a stocking index >100. Note that plot 15 was not sampled in cycle 1. Plots 17-32 have not yet been sampled in Cycle 5.

Plot	Panel	Seedlings per m ²					Saplings per m ²					Stocking Index				
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
1	1	0	0.19	0	0.37	0.32	0	0.03	0	0	0	0	3.33	0	5.67	4
2	1	0	0.24	0.27	0.19	0	0	0	0	0	0	0	3.33	3.67	2.67	0
3	1	0.64	0.45	0.56	0.5	0.72	0	0	0	0	0	9	7	7.67	8	10.67
4	1	0	0	0.03	0	0.03	0	0	0	0	0	0	0	0.67	0	0.33
5	1	0	0	0.08	0.19	0.32	0.08	0	0	0	0	0	0	1	3.33	5.33
6	1	0	0.13	0.19	0.64	0.32	0	0	0	0.03	0	0	2	2.67	9.33	5
7	1	0.08	0.4	0.03	1.11	0.5	0.08	0	0	0	0	2	5	0.33	19.67	25.67
8	1	0.32	0.19	0.37	0.11	0.21	0	0	0	0	0	4	3	6	8.33	3
9	1	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0.67
10	1	0.08	0.13	0.03	0.13	0.03	0.08	0.03	0.03	0.03	0.03	1	2	0.33	1.67	0.33
11	1	0.32	0.37	0.16	0.13	0.11	0	0	0	0	0	23	8.67	9.67	2.67	1.67
12	1	0.08	0	0.03	0.16	0.03	0.08	0	0	0	0	51	0	0.33	2	0.33
13	1	0	0	0	0.08	0.05	0.08	0.03	0.03	0.03	0.03	0	0	0	1.33	1
14	1	0	0.13	0.03	0.24	0.32	0.16	0.24	0.16	0.13	0.11	50	19	0.33	4.33	5.67
15	1	---	1.03	0.42	0.32	0.19	---	0	0	0	0	---	25	27	6	3.67
16	1	0	0.03	0.05	0.05	0	0	0.08	0	0.08	0.03	0	0.33	1.33	0.67	0
17	2	1.3	1.72	1.11	0.37	---	0	0.37	0.61	0.56	---	326.33	661.33	420.67	249.33	---
18	2	0.05	0.03	0.08	0.11	---	0	0	0	0	---	1.33	0.33	1	1.67	---
19	2	0.29	0.53	0.93	0.21	---	0.05	0	0	0	---	20.67	8.33	14	3	---
20	2	0.11	0.03	0.08	0.56	---	0	0	0	0	---	1.67	0.33	1	7.67	---
21	2	0	0.13	0.16	0.08	---	0.11	0.05	0.05	0.03	---	0	1.67	2	1	---
22	2	0.16	0.11	0.05	0.34	---	0	0	0	0	---	2	1.33	0.67	4.33	---
23	2	0	0.03	0.11	0.19	---	0.05	0.05	0	0	---	0	0.67	1.33	2.33	---
24	2	0.21	0.05	0.16	0	---	0	0	0	0	---	4.33	1.33	2.67	0	---
25	2	0.21	0.08	0.27	0.19	---	0.11	0.08	0.05	0.05	---	36.33	34.67	3.67	2.33	---
26	2	0.05	0.21	0.27	0.34	---	0	0	0	0	---	1	4.33	5	5.67	---
27	2	0	0	0	0	---	0	0	0	0	---	0	0	0	0	---
28	2	0.16	0.08	0.03	0.05	---	0.03	0.03	0	0	---	18.67	1	0.33	1	---
29	2	0.19	0.27	0.66	0.77	---	0	0	0	0	---	3.33	5	10.67	13.67	---
30	2	0.03	0.03	0	0.05	---	0.11	0.03	0	0	---	33.67	0.33	0	1	---
31	2	0	0.34	0.21	0.5	---	0	0	0	0	---	0	4.33	2.67	6.33	---
32	2	0	0.03	0.08	0	---	0	0	0	0	---	0	0.33	1	0	---

Table 2. Average % cover and number of invasive species detected in each plot by cycle. Cycle 1= 2006 & 2008; Cycle 2= 2010 & 2012; Cycle 3= 2014 & 2016; Cycle 4= 2018 & 2022; Cycle 5 = 2023. Plots are sampled in alternating years, with Panel 1 sampled the first year, and Panel 2 sampled the second year. Note that plot 15 was not sampled in the first cycle, and plots 17-32 have not yet been sampled in Cycle 5.

Plot	Panel	Average % Cover					Number of Species per Plot				
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
1	1	0.8	6.1	5.6	3.5	4.1	3	4	3	5	5
2	1	4.0	31.9	32.7	29.1	34.7	2	3	4	5	5
3	1	0.2	1.3	2.9	4.0	5.9	3	3	4	5	5
4	1	16.4	36.9	41.4	40.8	44.9	3	4	4	3	4
5	1	3.5	12.7	16.8	19.9	16.4	3	5	5	6	6
6	1	0.5	1.6	2.6	2.7	0.9	2	3	4	3	5
7	1	0.4	1.1	0.5	1.3	2.2	3	3	3	3	4
8	1	4.9	10.4	28.5	16.2	16.9	3	4	3	3	4
9	1	1.3	18.8	16.9	18.5	29.4	3	3	4	4	4
10	1	5.0	17.8	29.8	22.6	26.3	2	3	4	4	5
11	1	0.0	0.0	0.2	0.4	2.6	3	4	2	4	5
12	1	4.3	14.3	33.2	42.5	40.5	3	3	3	3	3
13	1	2.4	6.5	8.8	6.8	8.9	4	4	4	6	5
14	1	1.1	1.7	7.7	7.7	9.6	4	5	4	5	6
15	1	---	0.0	0.0	0.0	0.0	---	1	0	2	1
16	1	5.3	9.3	6.0	11.2	6.7	4	5	5	5	5
17	2	0.0	0.0	0.0	0.0	---	0	0	0	3	---
18	2	0.0	0.0	0.0	0.0	---	0	0	1	0	---
19	2	21.5	36.8	29.4	32.2	---	3	2	4	5	---
20	2	3.5	4.5	2.6	8.9	---	4	3	4	5	---
21	2	1.5	2.2	2.3	9.7	---	2	2	3	6	---
22	2	2.5	7.8	16.1	23.5	---	4	4	6	7	---
23	2	4.2	4.8	4.9	6.2	---	2	6	5	5	---
24	2	91.3	68.0	63.3	44.5	---	9	4	5	6	---
25	2	2.8	5.1	2.9	0.2	---	3	5	5	5	---
26	2	6.6	13.7	7.3	15.4	---	3	4	5	4	---
27	2	43.7	61.2	75.8	41.9	---	4	4	4	4	---
28	2	0.7	10.4	15.2	7.2	---	5	5	5	5	---
29	2	5.8	4.5	9.3	18.0	---	3	4	4	5	---
30	2	0.2	0.4	2.0	61.9	---	3	2	4	7	---
31	2	2.3	3.1	5.0	4.6	---	2	3	3	4	---
32	2	42.8	66.2	58.2	46.9	---	3	3	4	5	---

Table 3. Number of plots out of 32 where priority invasive species were detected by cycle. Cycle 1 = 2006 & 2008; Cycle 2 = 2010 & 2012; Cycle 3 = 2014 & 2016; Cycle 4 = 2018 & 2022; Cycle 5 = 2023. Species on the list include all exotic vascular plant species that are capable of dominating Northeastern US forest habitats, and does not include all exotic species detected in SARA forest plots. Note that the total number of plots in cycle 1 is 31 because plot 15 was not sampled. Only 16 plots have been sampled in cycle 5.

Latin Name	Common Name	Cycle1	Cycle2	Cycle3	Cycle4	Cycle 5
<i>Acer palmatum</i>	Japanese maple	0	0	0	1	0
<i>Alliaria petiolata</i>	garlic mustard	9	11	13	13	8
<i>Berberis thunbergii</i>	Japanese barberry	3	3	6	8	5
<i>Bromus inermis</i>	smooth brome	0	0	1	0	0
<i>Cardamine impatiens</i>	narrowleaf bittercress	0	0	4	6	2
<i>Celastrus orbiculatus</i>	Asian bittersweet	0	5	6	13	8
<i>Centaurea</i> spp.	knapweed	4	5	6	3	3
<i>Cirsium vulgare</i>	bull thistle	0	0	1	1	0
<i>Euonymus</i> spp.	burningbush	0	0	1	0	0
<i>Glechoma hederacea</i>	ground ivy	4	8	6	5	2
<i>Iris pseudacorus</i>	paleyellow iris	0	1	1	1	1
<i>Ligustrum</i>	privet	0	4	0	0	0
<i>Lonicera</i> spp.	exotic bush honeysuckle	29	29	29	30	15
<i>Lysimachia nummularia</i>	creeping jenny	3	4	4	4	2
<i>Lythrum salicaria</i>	purple loosestrife	0	1	0	0	0
<i>Microstegium vimineum</i>	Japanese stiltgrass	0	0	0	2	2
<i>Phalaris arundinacea</i>	reed canary grass	2	6	9	8	4
<i>Rhamnus cathartica</i>	common buckthorn	30	27	28	31	16
<i>Rosa multiflora</i>	multiflora rose	21	21	27	29	15
<i>Valeriana officinalis</i>	garden heliotrope	0	0	0	1	2
<i>Viburnum lantana</i>	wayfaringtree	0	0	1	0	0

Table 4. Early Detections by plot in the most recent 4-year census (2022 & 2023) in Saratoga National Historical Park. Coordinates are in NAD83 UTM Zone 18N.

Plot	X	Y	Latin Name	Common Name	Avg. % Cover	Type
1	610024	4762499	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
2	610021	4761450	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
4	611374	4760509	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
5	611575	4760160	<i>Cardamine impatiens</i>	narrowleaf bittercress	0	Herbaceous
5	611575	4760160	<i>Microstegium vimineum</i>	Japanese stiltgrass	0.0125	Graminoid
5	611575	4760160	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
7	611264	4762571	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
10	611717	4761804	<i>Cardamine impatiens</i>	narrowleaf bittercress	0	Herbaceous
13	611275	4761403	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
14	610873	4759296	<i>Microstegium vimineum</i>	Japanese stiltgrass	2.25	Graminoid
14	610873	4759296	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
15	611820	4759033	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
18	612070	4762417	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
20	611427	4761794	<i>Cardamine impatiens</i>	narrowleaf bittercress	0.95	Herbaceous
22	611124	4761287	<i>Cardamine impatiens</i>	narrowleaf bittercress	0.0125	Herbaceous
22	611124	4761287	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
24	611065	4761211	<i>Cardamine impatiens</i>	narrowleaf bittercress	2.2	Herbaceous
24	611065	4761211	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
27	610024	4759565	<i>Microstegium vimineum</i>	Japanese stiltgrass	0.4375	Graminoid
29	610122	4762327	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest
30	611474	4759815	<i>Cardamine impatiens</i>	narrowleaf bittercress	0	Herbaceous
30	611474	4759815	<i>Microstegium vimineum</i>	Japanese stiltgrass	40.825	Graminoid
32	610974	4760683	<i>Cardamine impatiens</i>	narrowleaf bittercress	0.4125	Herbaceous
32	610974	4760683	<i>Agrilus planipennis</i>	emerald ash borer	NA	Pest