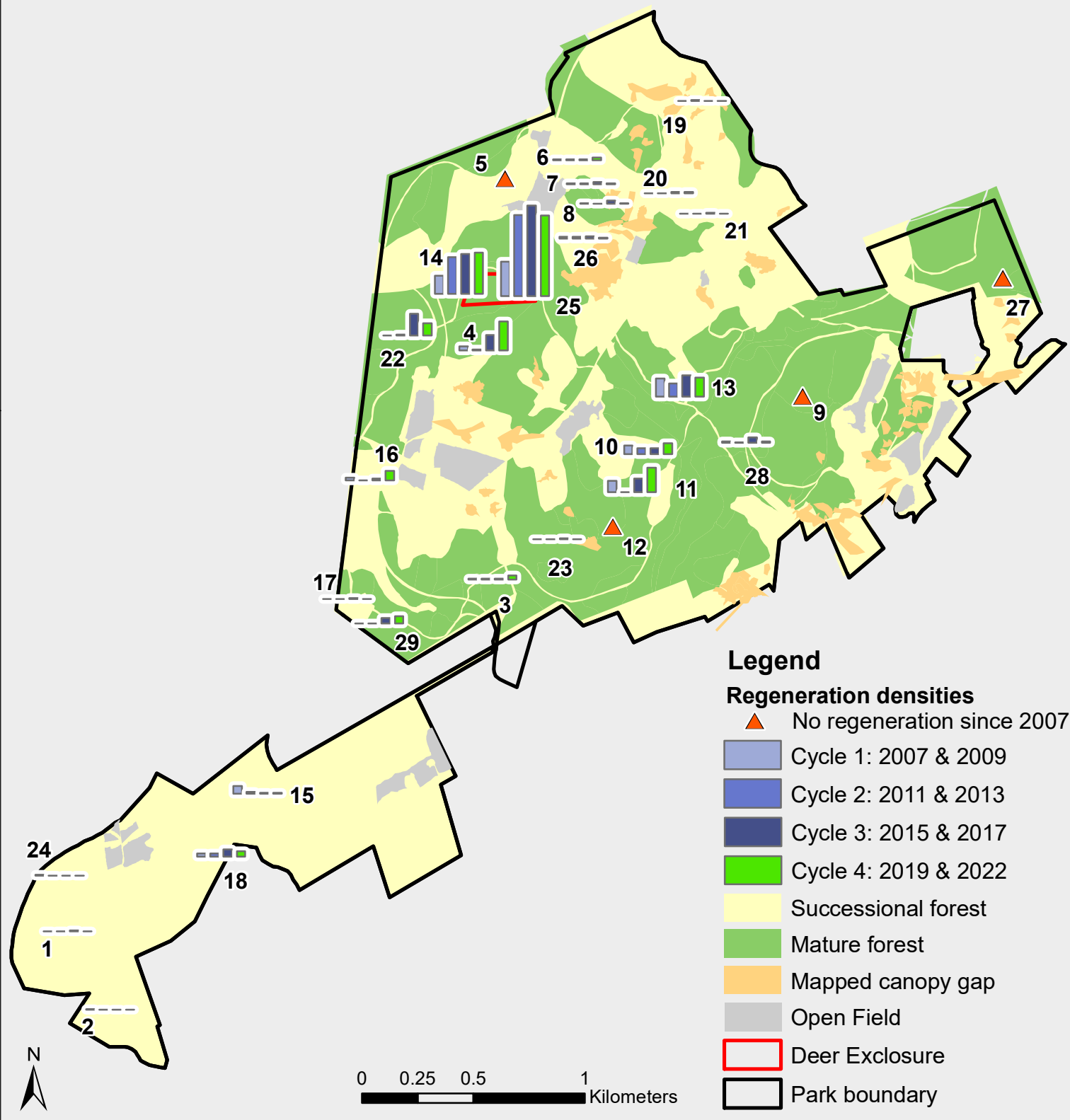




Map 1. Tree Regeneration by Cycle

Trends in tree regeneration stem densities, including seedlings and saplings, in forest plots sampled from 2007-2022. Plots are sampled in an alternating panel, with plots 1-15 sampled in 2007, 2011, 2015, and 2019, and plots 16-29 sampled in 2009, 2013, 2017, and 2022. Densities range from 0 to 3.1 stems/m², and only include native canopy-forming species. Note the unit change from 2019 report to match manuscript in review. See Table 1 for more details. Date: 7/15/2022.





Map 2. Tree Regeneration by Size Class

Trends in tree regeneration by size class in forest plots from the most recent survey cycle (2019 and 2022). Plots are sampled in an alternating panel, with plots 1-15 sampled in 2019, and plots 16-29 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 2.7 stems/m² and only include native canopy-forming species. Note the unit change from 2019 report to match manuscript in review. See Table 1 for more details. Date: 7/19/2022.

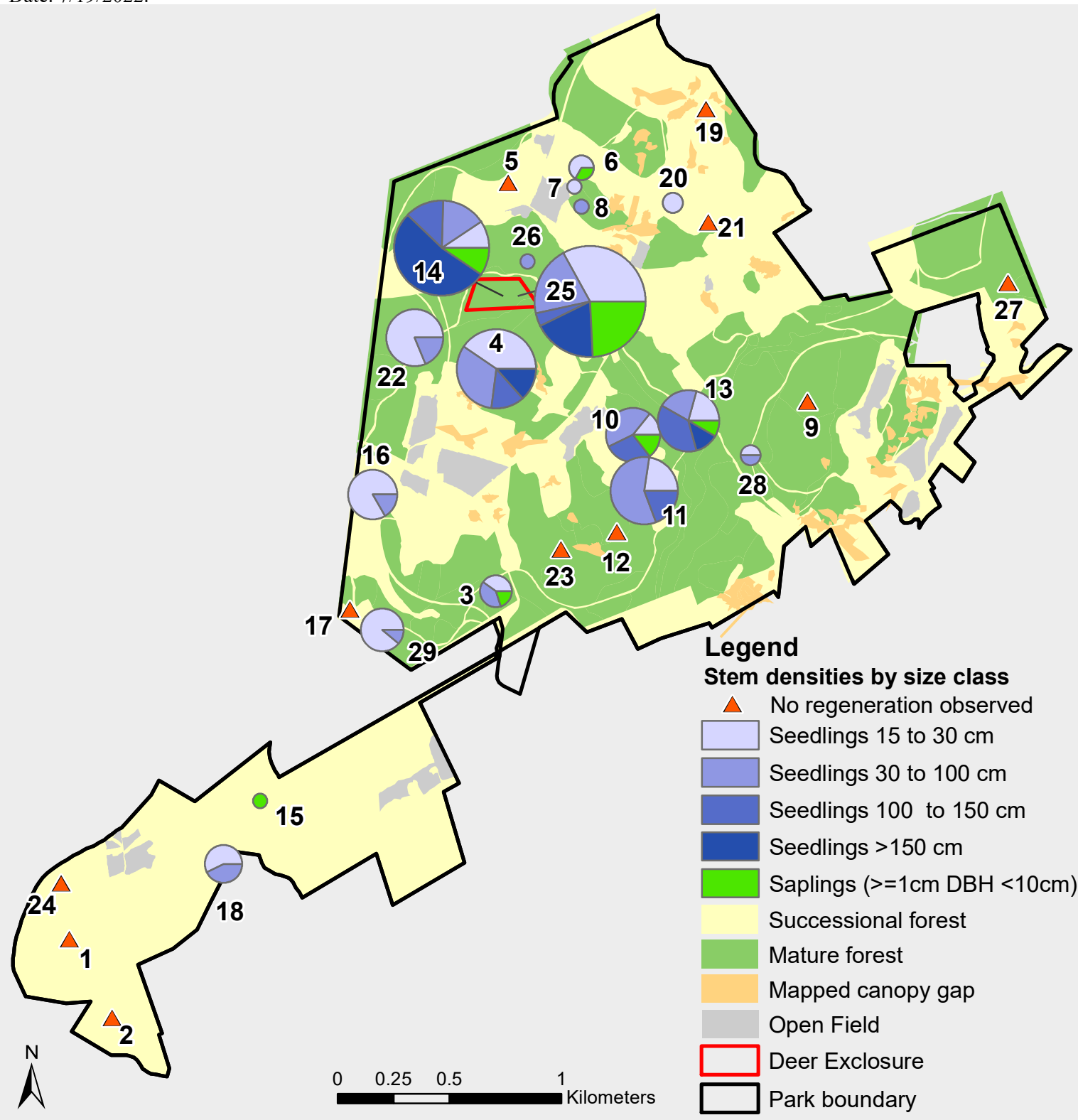


Table 1. Average plot-level seedling and sapling stem densities, converted to stems per m², and stocking index by cycle. Only native, canopy-forming species are included. Note that *Fraxinus* spp. (ash species) are no longer considered canopy-forming species, which differs from the 2019 summary. Cycle 1= 2007 & 2009; Cycle 2= 2011 & 2013; Cycle 3= 2015 & 2017, Cycle 4= 2019 & 2022. 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 (~1,000 seedlings/acre) and 0.14 saplings/m² (~550 saplings/acre) or have a stocking index >100. Blue-highlighted plots are in the deer enclosure.

Plot	Panel	Seedlings per m ²				Saplings per m ²				Stocking Index			
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4
1	1	0	0	0.03	0	0	0	0	0	0	0	0.33	0.0
2	1	0.03	0	0	0	0	0	0	0	0.33	0	0	0
3	1	0	0	0	0.11	0.03	0.03	0.03	0.03	0	0	0	2
4	1	0.13	0.03	0.53	0.98	0	0	0	0	1.67	0.33	29	129.67
5	1	0	0	0	0	0	0	0	0	0	0	0	0
6	1	0	0	0.0	0.05	0.03	0.03	0.03	0.03	0	0	0	0.67
7	1	0	0	0.08	0.03	0.03	0.03	0	0	0	0	1	0.33
8	1	0.03	0	0.11	0.03	0	0	0	0	0.33	0	1.33	0.7
9	1	0	0	0	0	0	0	0	0	0	0	0	0
10	1	0.24	0.13	0.16	0.32	0.05	0.1	0.05	0.05	37.33	35.3	19.3	48
11	1	0.37	0	0.45	0.82	0	0	0	0	6	0	15	54.33
12	1	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0.56	0.4	0.66	0.58	0.05	0.05	0.05	0.05	12.33	15.33	45	115
14	1	0.6	1.25	1.33	1.3	0	0	0.03	0.13	10.33	282.67	518.67	603.67
15	1	0.21	0.03	0	0	0.05	0.03	0.03	0.03	3	0.33	0	0
16	2	0.05	0	0.05	0.32	0.03	0	0	0	1.0	0	0.7	4.67
17	2	0	0	0.03	0	0	0	0	0	0	0	0.33	0
18	2	0.11	0.11	0.24	0.19	0	0	0	0	1.33	2.33	4.33	3.33
19	2	0	0.03	0	0	0	0	0	0	0	0.33	0	0
20	2	0	0	0.05	0.05	0	0	0	0	0	0	0.67	0.67
21	2	0	0	0.03	0	0	0	0	0	0	0	0.3	0
22	2	0	0.03	0.74	0.42	0	0	0	0	0	0.33	11.33	6.33
23	2	0	0	0.03	0	0	0	0	0	0	0	0.33	0
24	2	0	0	0	0	0.03	0	0	0	0	0	0	0
25	2	1.17	2.76	2.52	2.07	0	0	0.56	0.66	27.67	633.67	910.33	768.67
26	2	0.03	0.05	0.1	0.03	0.03	0	0	0	0.67	7.33	1.67	0.67
27	2	0	0	0	0	0	0	0	0	0	0	0	0
28	2	0.03	0.03	0.19	0.05	0.03	0	0	0	0.33	0.33	2.33	1
29	2	0	0.0	0.19	0.24	0	0	0	0	0	0.0	2.33	3.33

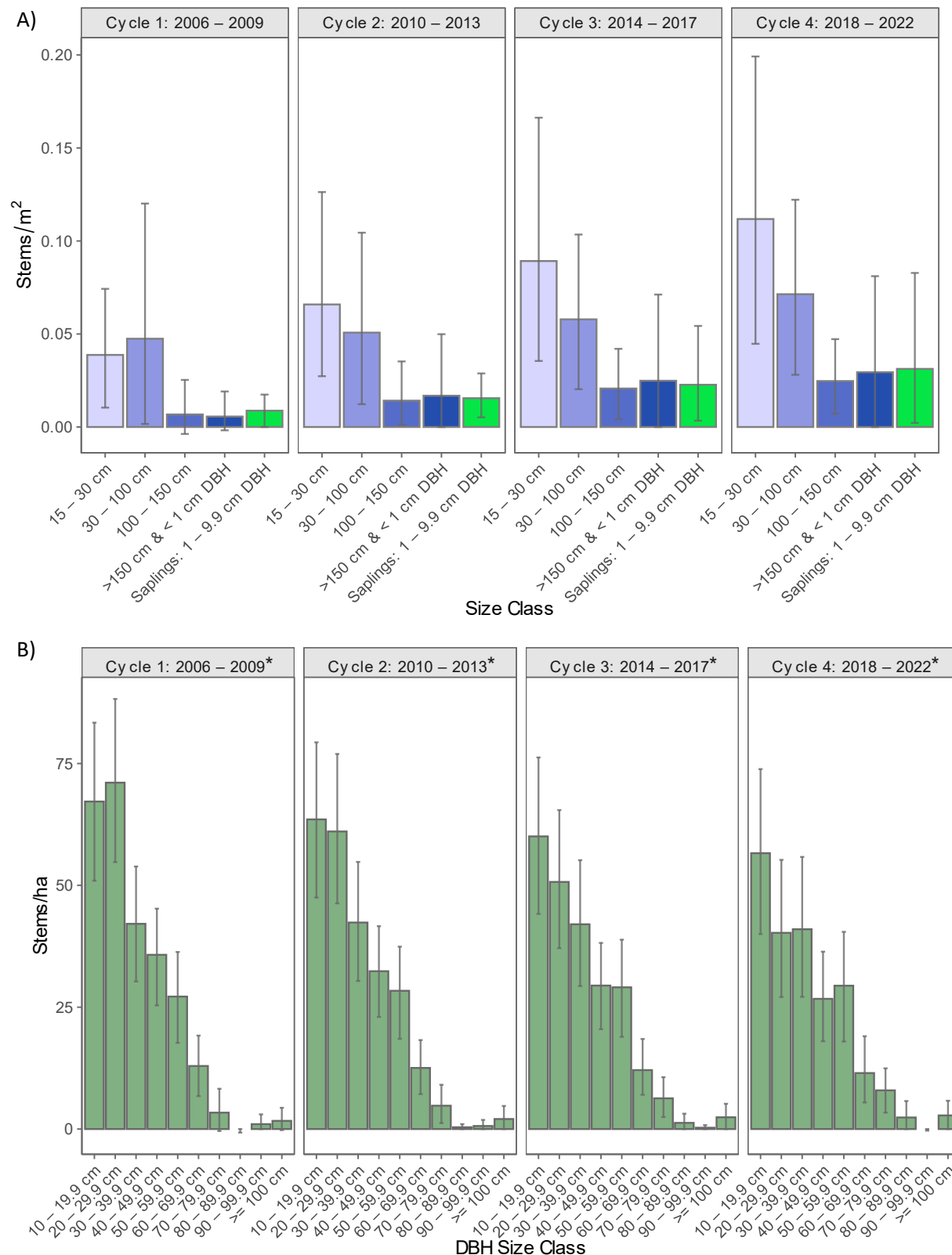


Figure 1. Stem density distributions by survey cycle in Morristown National Historical Park. Cycle 1 is 2006-2009; Cycle 2 is 2010-2013; Cycle 3 is 2014-2017; Cycle 4 is 2018-2022. Figure A shows regeneration densities by size class. Figure B shows tree density by diameter at breast height (DBH) increments.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

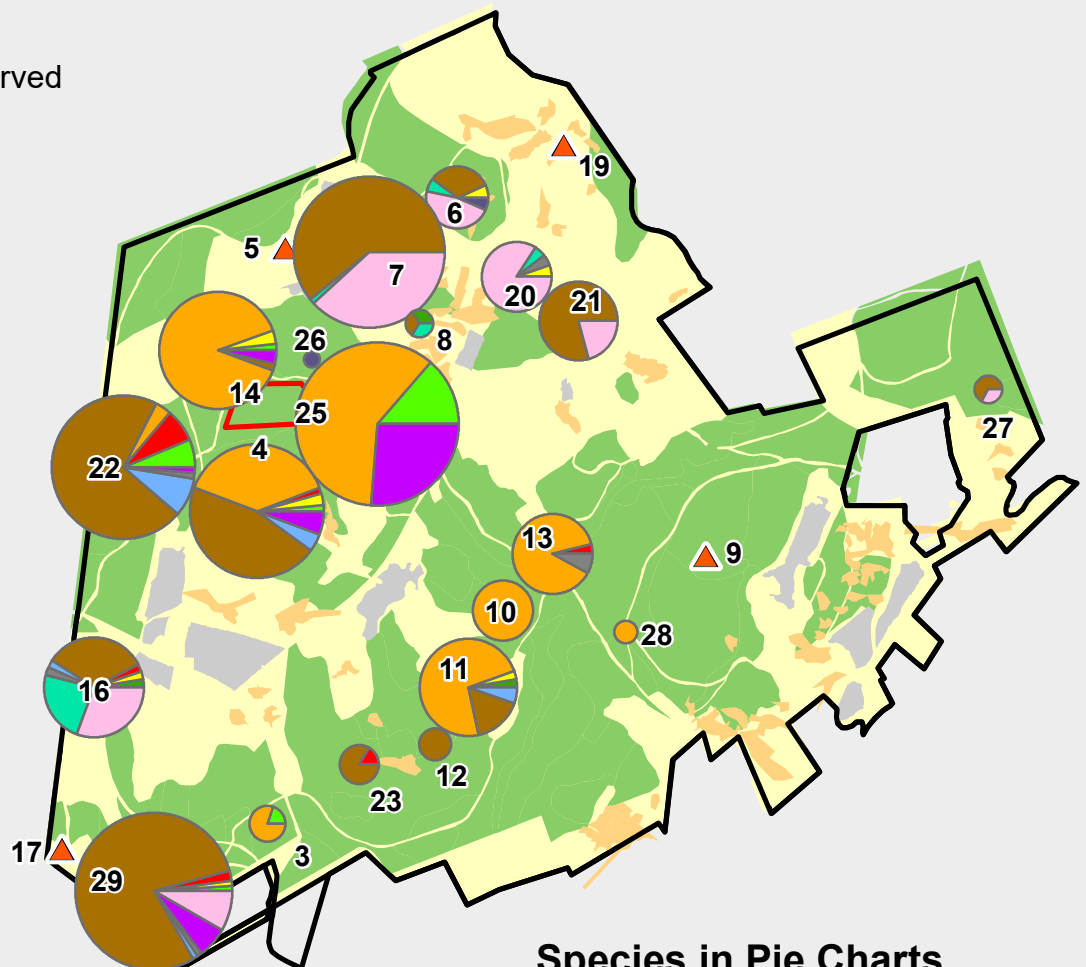


Map 3. Tree Regeneration Composition

Trends in tree regeneration, including seedlings and saplings, by species group observed in forest plots in the most recent survey cycle (2019 and 2022). Plots are sampled in an alternating panel, with plots 1-15 sampled in 2019, and plots 16-29 sampled in 2022. Pie size is proportional to the total plot-level regeneration density (plot-level density range: 0 to 2.75 stems/m²). Note the unit change from the 2019 report to match manuscript in review. Pies may be shifted from actual location to prevent overlap. Date: 7/28/2022.

Legend

- No regeneration observed
- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



Species in Pie Charts

- Acer spp. (Maple)
- Betula lenta (Black birch)
- Carya spp. (Hickory)
- Fagus grandifolia (Beech)
- Fraxinus americana (White ash)
- Liriodendron tulipifera (tulip poplar)
- Prunus spp. (Cherry)
- Quercus spp. (Oak)
- Ulmus spp. (Elm)
- Subcanopy species
- Other native species
- Exotic species



0 0.25 0.5 1 Kilometers

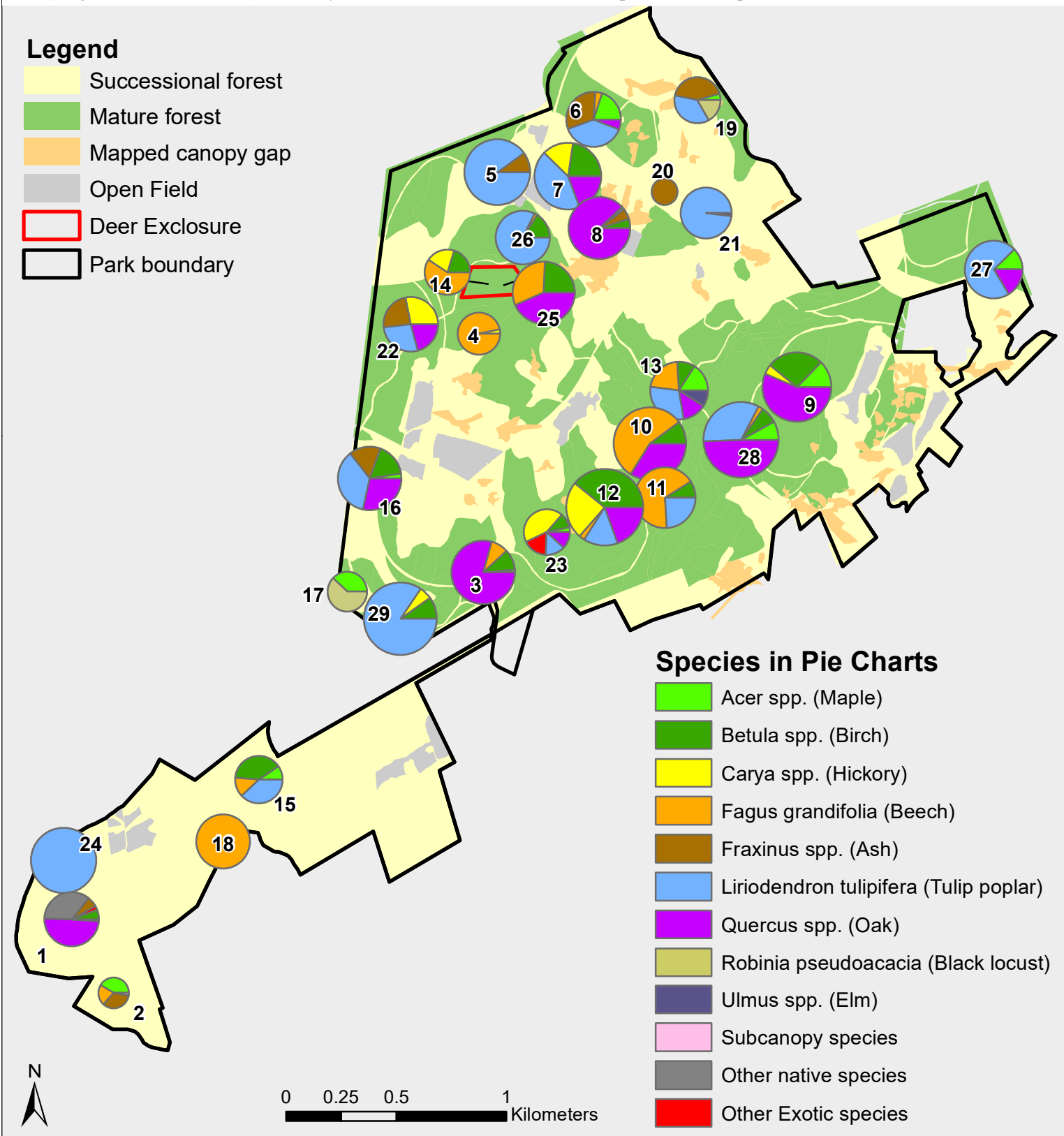


Map 4. Tree Canopy Composition

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 1-15 sampled in 2019, and plots 16-29 sampled in 2022. Pie size is proportional to plot-level basal area (range: 5.8 to 50.4 m²/ha). Pies may be shifted from actual location to prevent overlap. Date: 8/1/2022.

Legend

- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



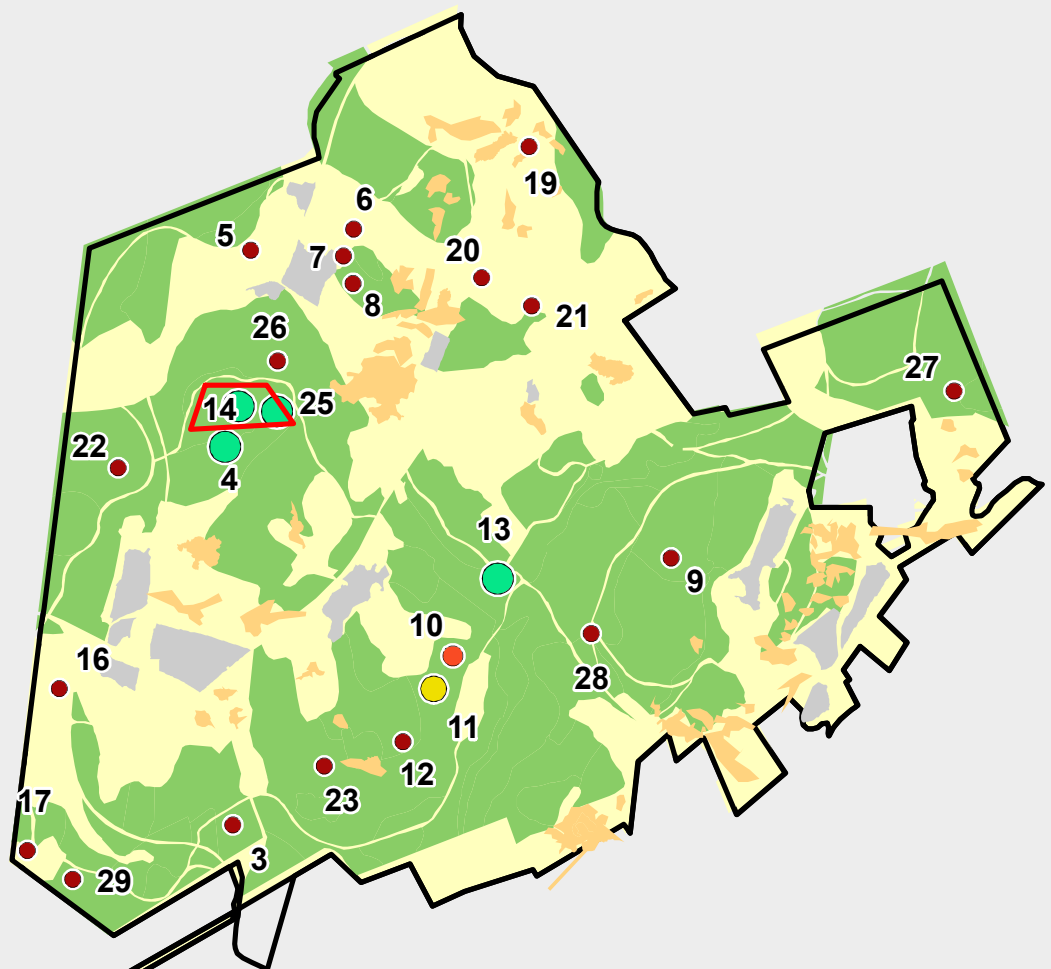


Map 5. Tree Regeneration Stocking Index

Trends the regeneration stocking index for the most recent survey cycle (2019 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 and only includes native canopy-forming species (range 0-769). See Table 1 for stocking index values. Date: 7/28/2022.

Legend

- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



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..



0 0.25 0.5 1
Kilometers

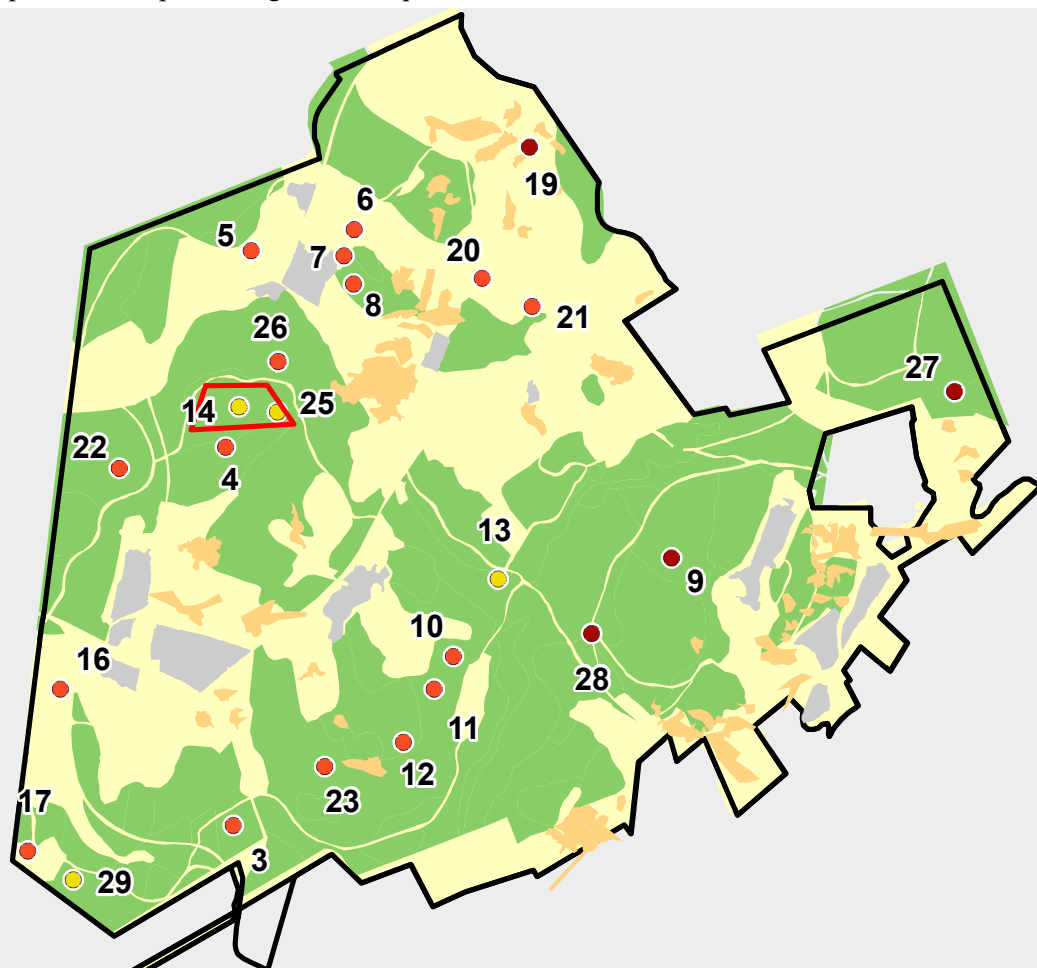


Map 6. Index of Deer Browse Impacts

Index of deer browse impacts observed in forest plots in the most recent survey cycle (2019 and 2022). Plots are sampled in an alternating panel, with plots 1-15 sampled in 2019 and plots 16-29 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: 8/1/2022.

Legend

- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- 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 under 30 cm tall. DP herbs present but stunted and flowering is uncommon.
- 4) High Impact: DP species are rare to absent. Non-preferred 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. Non-preferred species also reduced by heavy browsing. Distinct deer browse line.

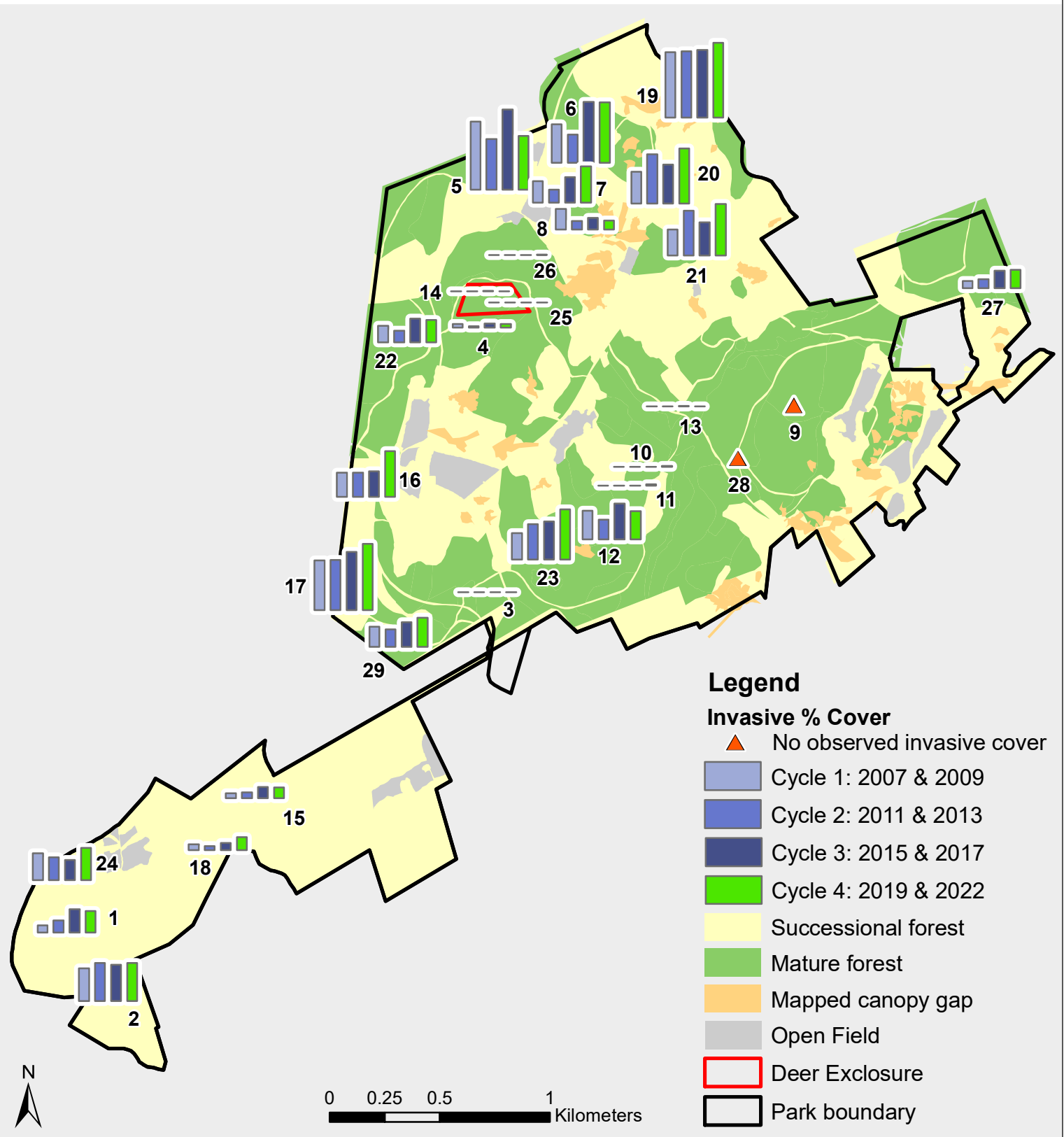


0 0.25 0.5 1 Kilometers



Map 7. Invasive % Cover by Cycle

Trends in percent cover of invasive species observed in quadrats for plots sampled from 2007-2022. Plots are sampled in an alternating panel, with plots 1-15 sampled in 2007, 2011, 2015, and 2019 and plots 16-29 sampled in 2009, 2013, 2017, and 2022. Average invasive cover ranges from 0 to >100%. See Table 2 for % cover values. Date: 8/2/2022.





Map 8. Invasive % Cover by Species

Trends in % invasive cover by species observed in quadrats for plots in the most recent survey cycle (2019 & 2022). Plots are sampled in an alternating panel, with plots 1-15 sampled in 2019 and plots 16-29 sampled in 2022. Pie size is proportional to total invasive cover (range: 0 to >100%), and location may be shifted to prevent overlap. See Table 2 for more information.
Date: 8/1/2022.

Legend

- No observed invasive cover
- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary

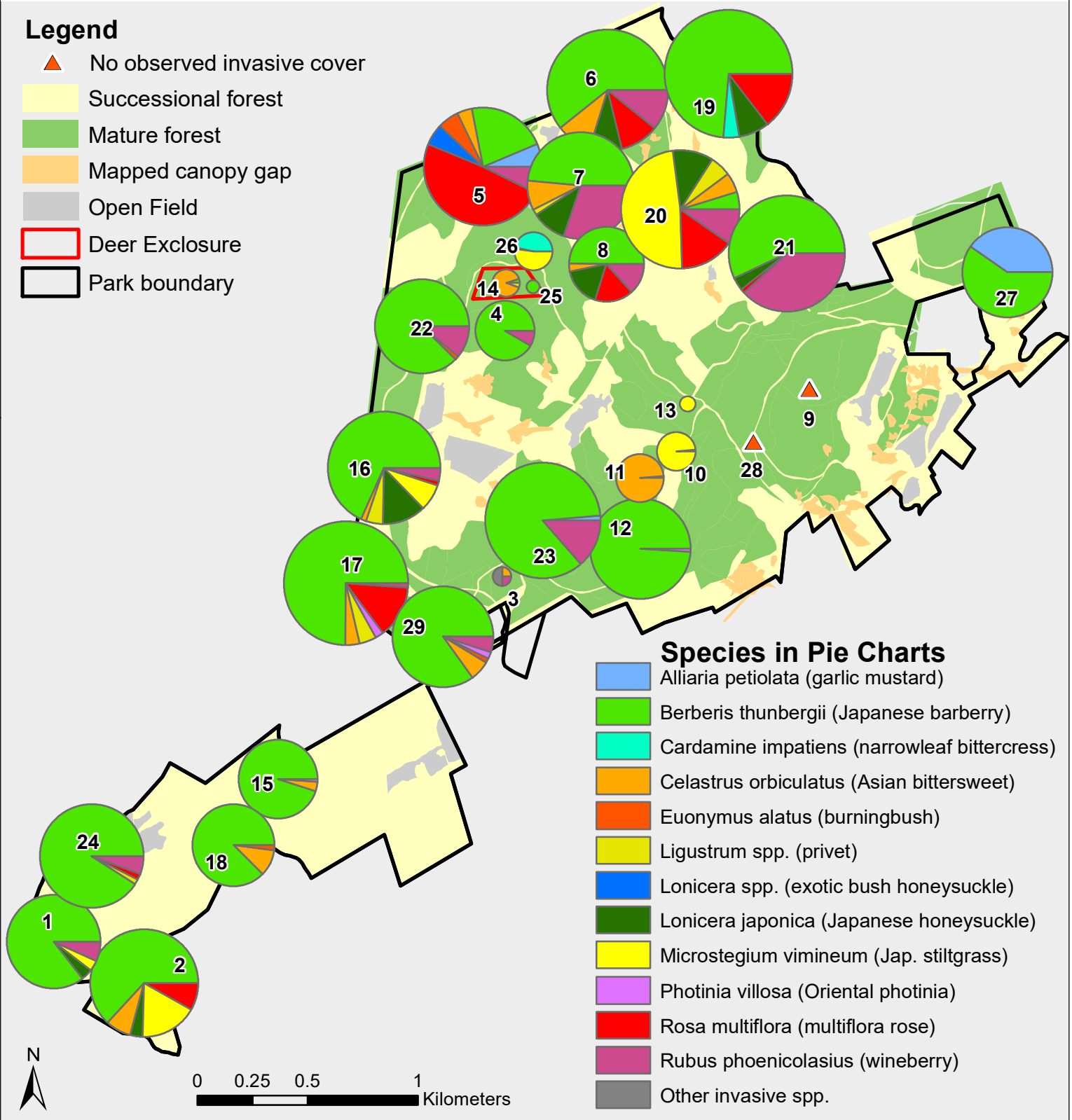


Table 2. Average % cover and number of invasive species detected in each plot by cycle. Cycle 1= 2007 & 2009; Cycle 2= 2011 & 2013; Cycle 3= 2015 & 2017, Cycle 4= 2019 & 2022. Plots are sampled in alternating years, with Panel 1 sampled the first year, and Panel 2 sampled the second year. Blue highlighted plots are in the deer enclosure.

Plot	Panel	Average % Cover				Number of Species per Plot			
		Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4
1	1	11.2	18.5	35.8	32.7	9	8	12	10
2	1	49.7	58.3	55.7	58.0	12	7	10	10
3	1	0.0	0.0	0.1	0.0	2	2	4	6
4	1	5.1	1.9	6.0	5.3	4	8	7	6
5	1	104.0	77.0	122.0	81.9	12	10	13	12
6	1	58.7	42.5	92.7	91.8	9	11	11	11
7	1	33.1	19.8	39.0	55.2	10	10	11	10
8	1	31.0	12.6	17.6	13.4	7	7	8	10
9	1	0.0	0.0	0.0	0.0	1	0	1	1
10	1	0.0	0.0	0.0	1.0	1	2	3	4
11	1	0.0	0.0	0.2	2.2	2	3	2	4
12	1	44.0	30.0	55.1	43.5	3	3	7	10
13	1	0.0	0.0	0.2	0.0	3	3	6	5
14	1	0.2	0.2	0.4	0.2	5	4	5	5
15	1	7.6	8.8	17.2	16.6	3	4	8	9
16	2	36.5	36.7	38.5	69.1	9	10	11	12
17	2	75.3	76.4	88.4	100.8	7	11	12	12
18	2	9.2	6.1	11.2	19.6	8	8	7	8
19	2	99.3	100.7	102.9	113.8	11	11	10	10
20	2	48.2	74.6	59.1	84.0	9	9	10	9
21	2	39.8	68.2	50.7	78.3	7	9	10	10
22	2	24.7	17.1	36.0	33.8	7	10	10	11
23	2	40.5	54.0	58.4	76.4	4	8	8	9
24	2	40.7	35.0	30.6	48.9	7	9	11	10
25	2	0.0	0.2	0.2	0.0	2	3	3	2
26	2	0.0	0.0	0.1	0.9	3	4	3	4
27	2	11.3	14.0	26.6	28.3	7	6	7	6
28	2	0.0	0.0	0.0	0.0	0	1	1	3
29	2	30.3	26.8	37.6	44.2	7	10	9	10

Table 3. Number of plots out of 29 where priority invasive species were detected by cycle. Cycle 1= 2007 & 2009; Cycle 2= 2011 & 2013; Cycle 3= 2015 & 2017; Cycle 4= 2019 & 2022. This list includes all exotic vascular plant species that are capable of dominating Northeastern US forest habitats, but does not include all exotic species detected in MORR forest plots.

Latin Name	Common Name	Cycle 1	Cycle 2	Cycle 3	Cycle 4
<i>Acer palmatum</i>	Japanese maple	0	1	1	1
<i>Acer platanoides</i>	Norway maple	1	3	3	4
<i>Actinidia</i> spp.	kiwi vine	0	0	2	1
<i>Ailanthus altissima</i>	tree-of-heaven	0	0	1	1
<i>Alliaria petiolata</i>	garlic mustard	13	11	11	10
<i>Ampelopsis brevipedunculata</i>	porcelainberry	1	1	1	1
<i>Aralia elata</i>	Japanese aralia	0	1	3	4
<i>Berberis thunbergii</i>	Japanese barberry	25	25	25	26
<i>Cardamine impatiens</i>	narrowleaf bittercress	19	18	20	19
<i>Celastrus orbiculatus</i>	Asian bittersweet	20	25	27	29
<i>Elaeagnus umbellata</i>	autumn olive	1	0	2	0
<i>Euonymus alatus</i>	burningbush	8	14	17	19
<i>Fallopia japonica</i>	Japanese knotweed	1	0	0	1
<i>Ligustrum</i> spp.	privet	7	14	14	14
<i>Lonicera</i> - Exotic	exotic bush honeysuckle	4	0	0	1
<i>Lonicera japonica</i>	Japanese honeysuckle	11	13	12	12
<i>Lysimachia nummularia</i>	creeping jenny	1	0	1	0
<i>Microstegium vimineum</i>	Japanese stiltgrass	21	20	19	18
<i>Photinia villosa</i>	Oriental photinia	0	5	14	13
<i>Ranunculus ficaria</i>	fig buttercup	1	1	1	0
<i>Rhamnus cathartica</i>	common buckthorn	3	0	0	0
<i>Rhodotypos scandens</i>	jetbead	1	2	2	1
<i>Robinia pseudoacacia</i>	black locust	4	3	6	4
<i>Rosa multiflora</i>	multiflora rose	12	15	18	20
<i>Rubus phoenicolasius</i>	wine raspberry	16	19	22	24
<i>Viburnum dilatatum</i>	linden arrowwood	1	2	3	6
<i>Viburnum sieboldii</i>	Siebold's arrowwood	1	1	5	7

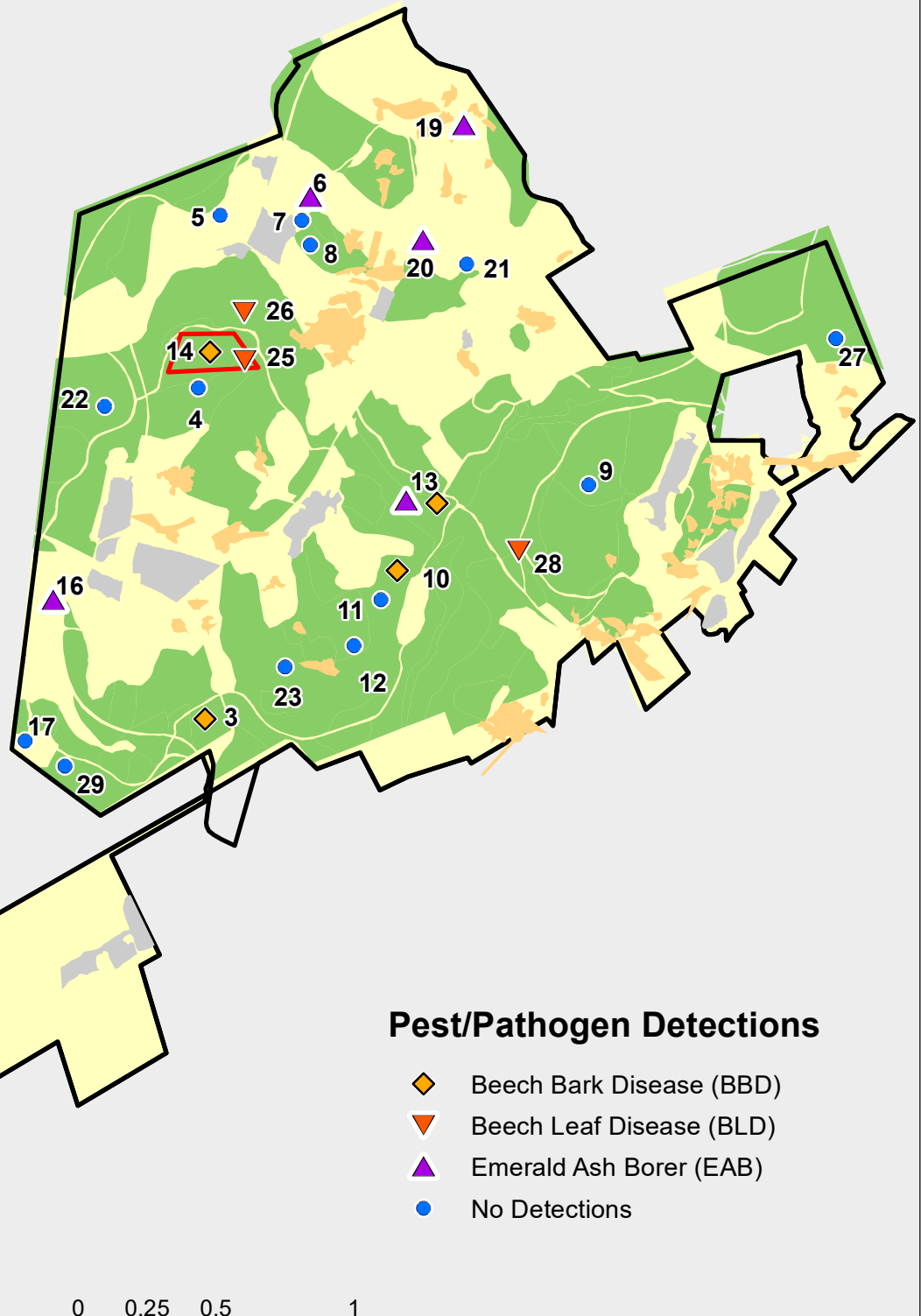


Map 9. Forest Pest/Pathogen Detections

Priority pest and pathogen detections in forest plots sampled from 2019-2022. Plots are sampled in an alternating panel, with plots 1-15 sampled 2019, and plots 16-29 sampled in 2022. Plots with multiple pests present (i.e., 13 and 18) have multiple symbols. Note that BLD may be more widespread than the map indicates, as plots 1-15 were sampled prior to the first detection of BLD. Date: 8/2/2022.

Legend

- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



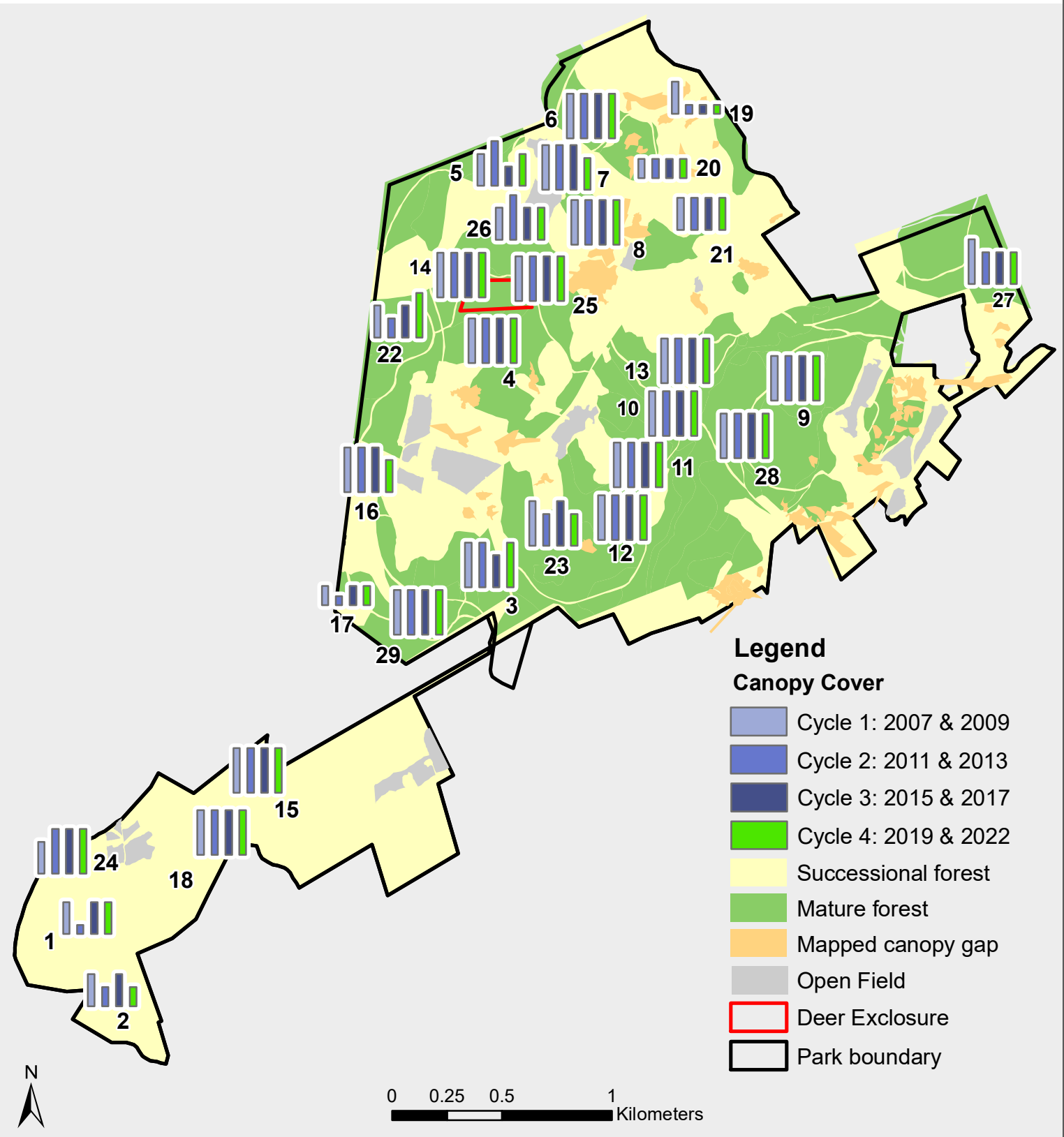
Pest/Pathogen Detections

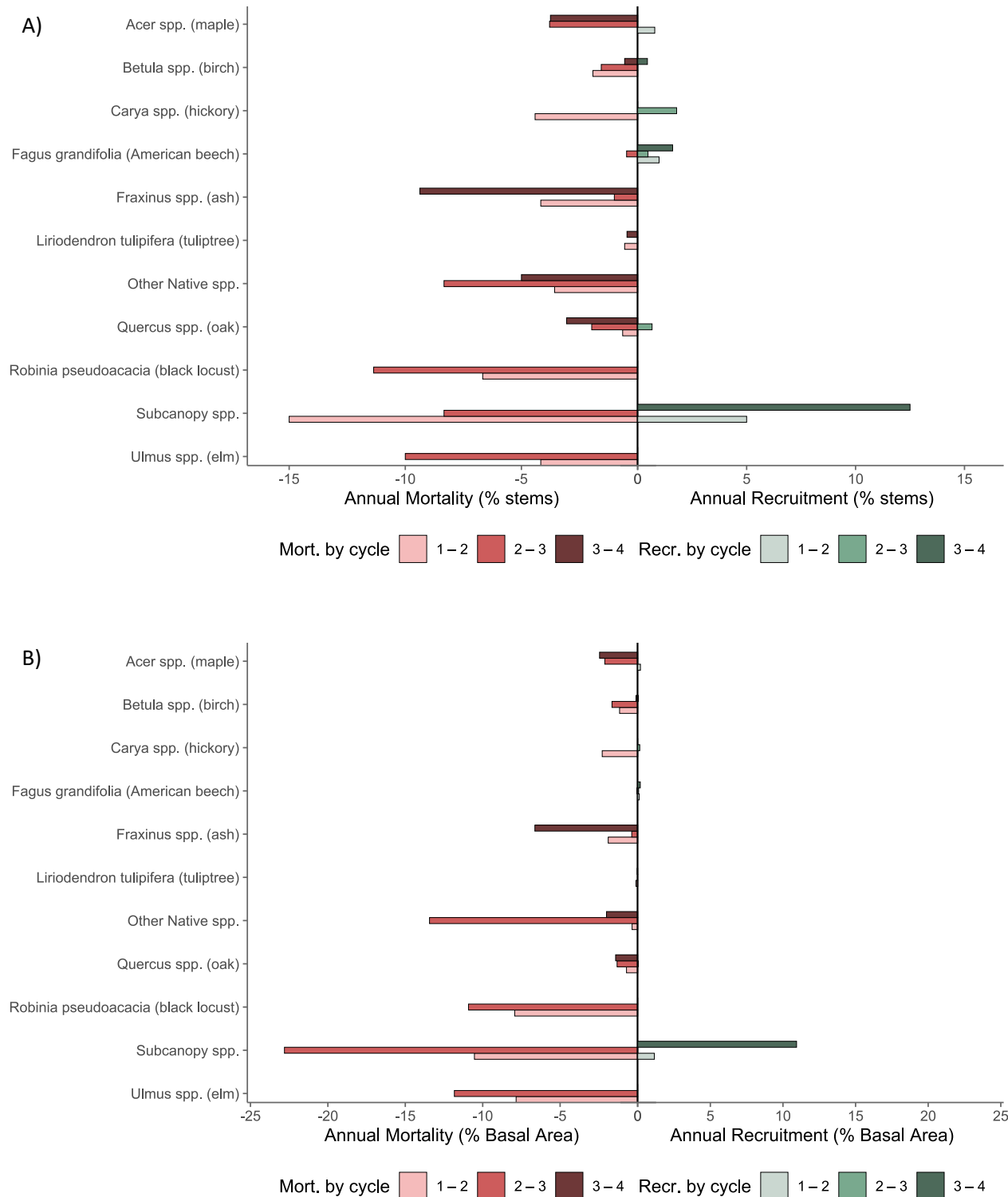
- Beech Bark Disease (BBD)
- Beech Leaf Disease (BLD)
- Emerald Ash Borer (EAB)
- No Detections



Map 10. Canopy Cover by Cycle

Trends in tree canopy cover in forest plots sampled from 2007-2022. Plots are sampled in an alternating panel, with plots 1-15 sampled in 2007, 2011, 2015, and 2019, and plots 16-29 sampled in 2009, 2013, 2017, and 2022. Canopy cover ranges from 10 - 25% to >75%. Date: 8/2/2022.





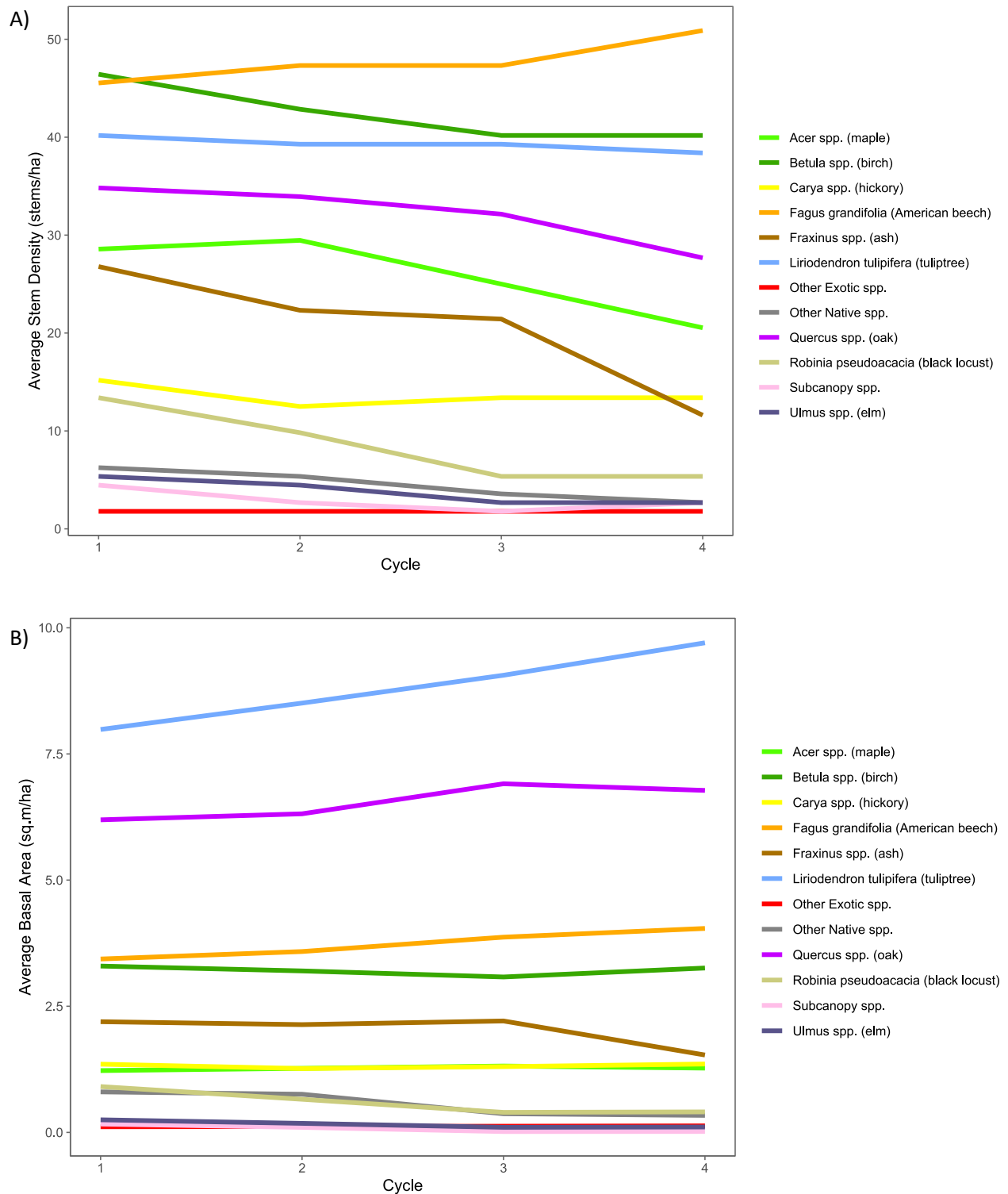


Figure 3. Change in stem density (A) and basal area (B) by species and cycle in Morristown National Historical Park. Cycle 1 = 2006 – 2009; Cycle 2 = 2010 – 2013; Cycle 3 = 2014 – 2017; Cycle 4 = 2018 – 2022.