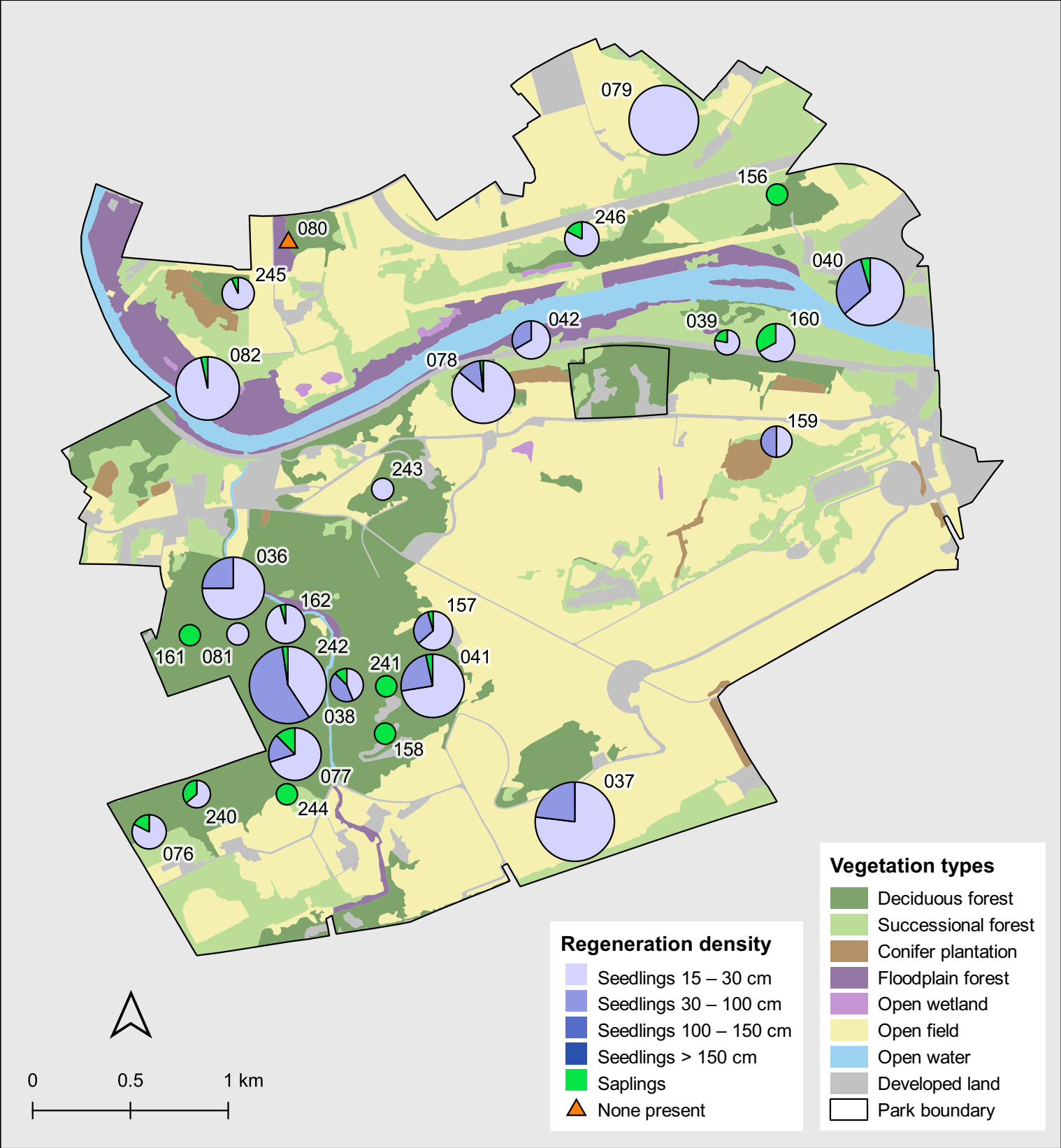




Map 1. Tree Regeneration by Size Class

Tree regeneration stem densities by size class in forest plots from the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level regeneration density. Pies may be shifted to prevent overlap. Densities range from 0 to 0.8 stems/sq.m for an individual size class and only include native canopy-forming species. Seedlings are individuals ≥ 15 cm tall and < 1 cm diameter at breast height (DBH). Saplings are individuals ≥ 1 cm and < 10 cm DBH. Reporting Date: 08/20/2020.





Map 2. Tree Regeneration by Cycle

Tree regeneration stem densities, including seedlings and saplings, in forest plots sampled from 2007 – 2019. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Densities range from 0 to 1.6 stems/sq.m, and only include native canopy-forming species. The number of bars per plot corresponds to the number of times the plot has been sampled. Densities are scaled to the maximum stem density at Hopewell Furnace National Historic Site (9.3 stems/sq.m). Reporting Date: 08/20/2020.

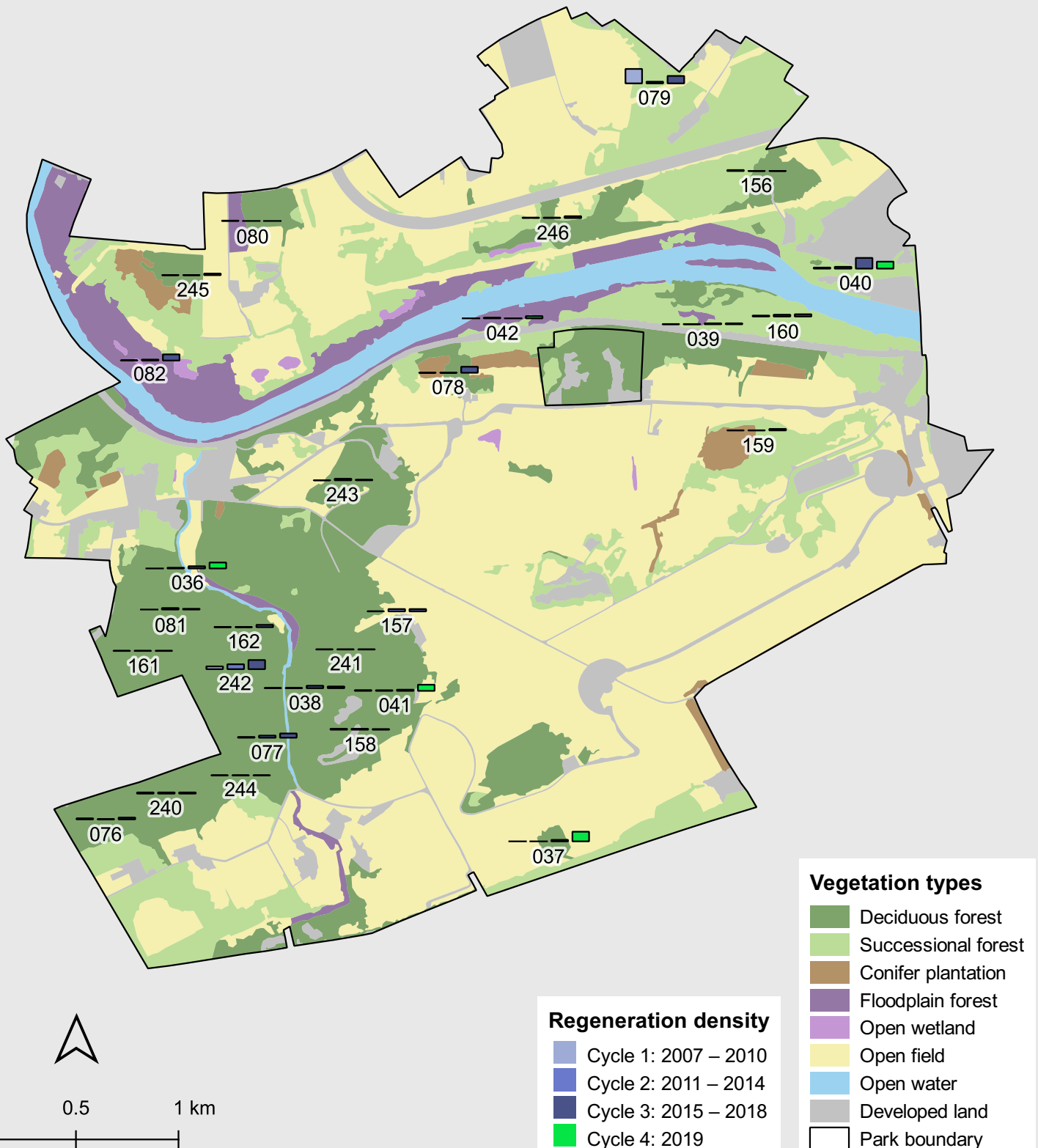
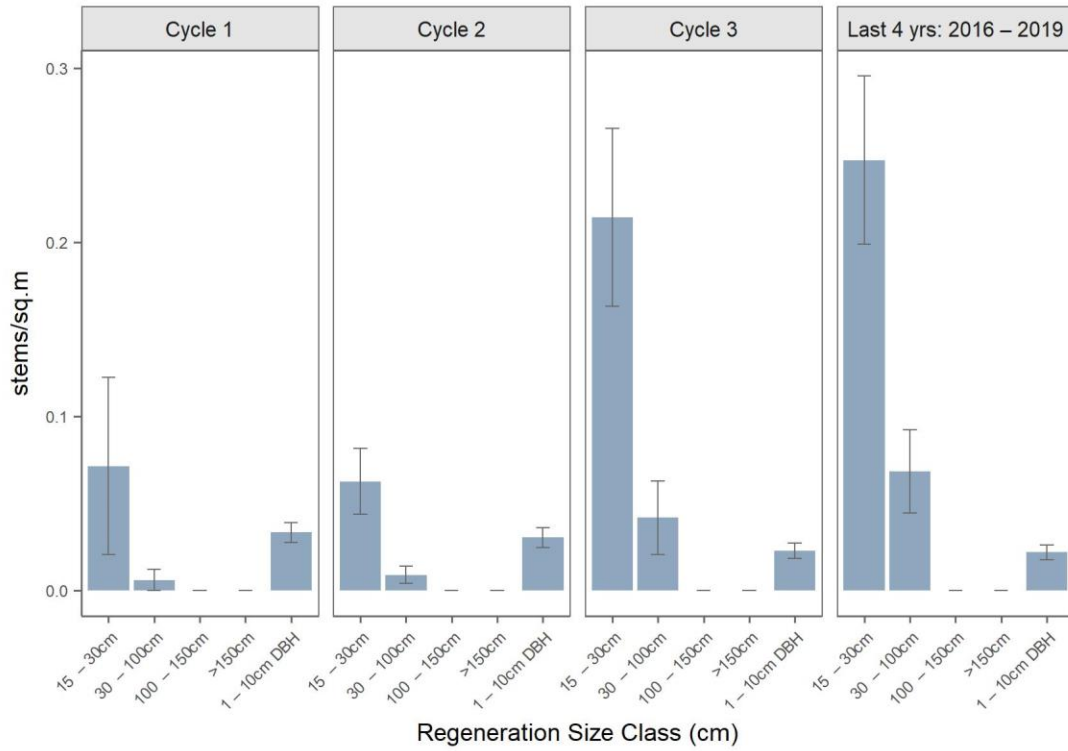


Table 1. Average plot-level seedling and sapling stem densities (stems/sq.m), and stocking index by cycle in Valley Forge National Historical Park. Only native canopy-forming species are included. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 4 in 2019. 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. Stocking index values below 2 indicate severely understocked regeneration. Forests in areas with high deer densities need a stocking index value of at least 8 to be sufficiently stocked. No plots in Valley Forge National Historical Park meet this threshold.

Plot	Seedlings per sq. meter				Saplings per sq. meter				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
036	0	< 0.1	0.3	0.7	0	0	0	0	0	< 0.1	0.3	0.8
037	0	0	0.2	1.1	0	0	0	0	0	0	0.2	1.3
038	0	0	0.3	0.2	< 0.1	< 0.1	< 0.1	< 0.1	1.2	1.2	1.5	1.4
039	0	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.2	1.2	1.3	1.3
040	< 0.1	0.2	1.2	0.8	< 0.1	< 0.1	< 0.1	< 0.1	1.9	1.9	3.0	2.8
041	0	0	< 0.1	0.7	< 0.1	< 0.1	< 0.1	< 0.1	4.1	3.5	2.4	2.0
042	0	< 0.1	0	0.3	0	0	0	0	0	< 0.1	0	0.3
076	< 0.1	0	0.2	-	< 0.1	< 0.1	< 0.1	-	1.9	1.8	1.9	-
077	0	0.2	0.4	-	< 0.1	< 0.1	< 0.1	-	4.1	3.7	3.4	-
078	0	0	0.7	-	< 0.1	< 0.1	< 0.1	-	1.2	1.2	1.3	-
079	1.6	0.2	0.8	-	< 0.1	< 0.1	0	-	3.5	1.3	0.8	-
080	0	0	0	-	< 0.1	0	0	-	1.8	0	0	-
081	0	0.2	< 0.1	-	0	0	0	-	0	0.3	< 0.1	-
082	0	< 0.1	0.7	-	< 0.1	< 0.1	< 0.1	-	1.2	1.3	1.8	-
156	< 0.1	0	0	-	< 0.1	< 0.1	< 0.1	-	1.3	0.6	0.6	-
157	0	0.3	0.3	-	< 0.1	< 0.1	< 0.1	-	0.6	0.8	0.9	-
158	0	0	0	-	0.1	0.1	< 0.1	-	5.3	5.3	3.5	-
159	0	0	0.2	-	< 0.1	< 0.1	0	-	0.6	0.6	0.3	-
160	0	< 0.1	0.2	-	0.1	0.1	< 0.1	-	5.3	6.0	4.3	-
161	0	0	0	-	< 0.1	< 0.1	< 0.1	-	1.2	1.2	1.2	-
162	0	0	0.3	-	< 0.1	< 0.1	< 0.1	-	1.2	1.2	0.8	-
240	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	-	2.4	2.4	2.4	-
241	0	0	0	-	< 0.1	< 0.1	< 0.1	-	1.2	1.2	1.2	-
242	0.3	0.5	1.0	-	< 0.1	< 0.1	< 0.1	-	3.2	2.9	2.8	-
243	0	0.2	< 0.1	-	< 0.1	< 0.1	0	-	0.6	0.8	< 0.1	-
244	0	0	0	-	< 0.1	< 0.1	< 0.1	-	1.2	1.2	1.2	-
245	0	0	0.2	-	< 0.1	< 0.1	< 0.1	-	0.6	0.6	0.8	-
246	0	0	0.2	-	< 0.1	< 0.1	< 0.1	-	2.4	2.4	1.9	-

A)



B)

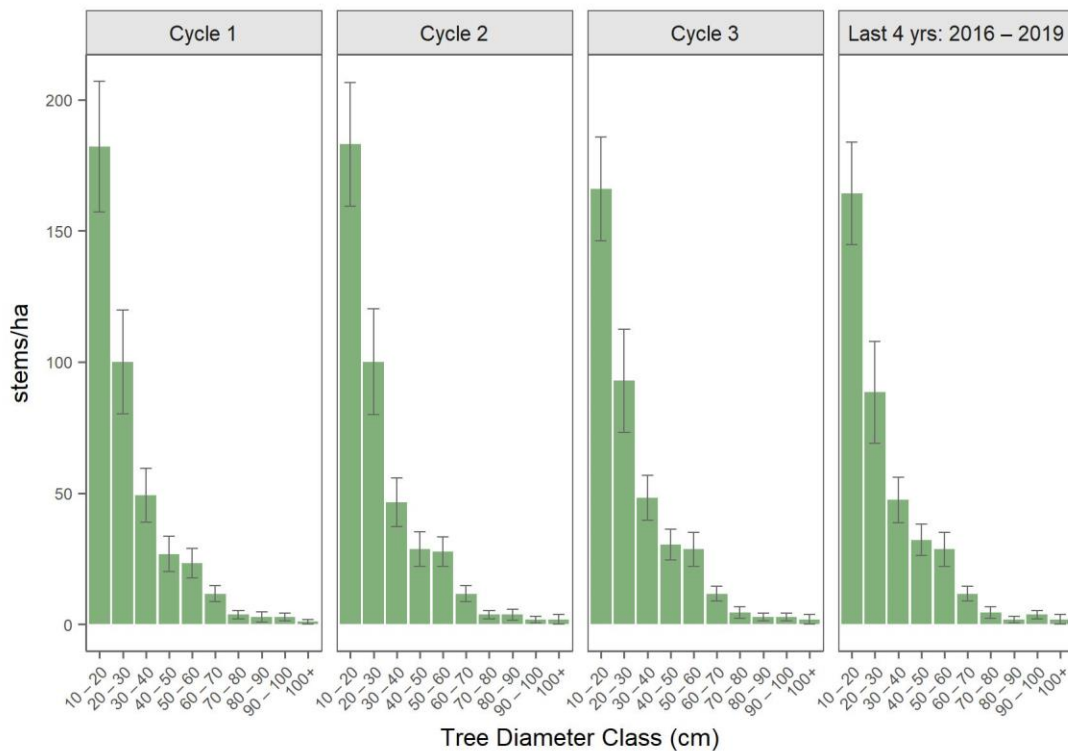


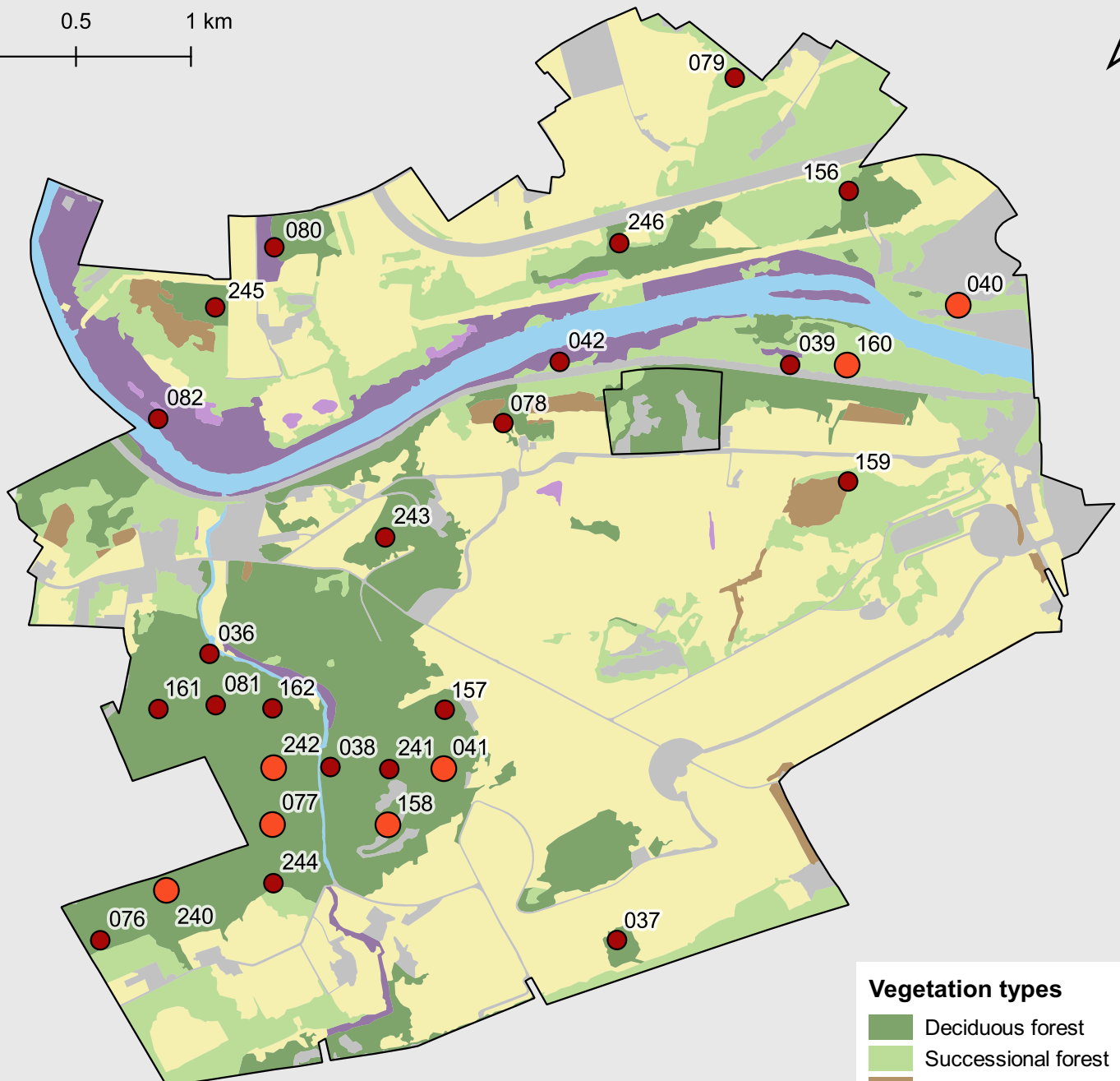
Figure 1. Stem density distributions for Valley Forge National Historical Park. Figure A shows seedling and sapling densities by size class. Figure B shows tree density by diameter at breast height at 10 cm increments. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. The last 4 years is the most recent survey of every plot. Error bars are ± 1 SE.



Map 3. Tree Regeneration Stocking Index

Regeneration stocking index for the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every 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. The stocking index only includes native canopy-forming species (range: 0 – 4.3). Values below 2 are severely understocked. Values above 8 are sufficiently stocked for areas with high deer abundance. See Table 1 for plot-level stocking values. Reporting Date: 08/20/2020.

0 0.5 1 km



Stocking index ranges

- < 2: Severely understocked. Regeneration is insufficient to replace the forest canopy.
- 2 – 5: Moderately stocked regeneration for areas with low deer impacts.
- 5 – 8: Sufficient regeneration to replace forest canopy in areas with low deer impacts.
- > 8: Sufficiently stocked with regeneration for areas with high deer impacts.

Vegetation types

- Deciduous forest
- Successional forest
- Conifer plantation
- Floodplain forest
- Open wetland
- Open field
- Open water
- Developed land
- Park boundary

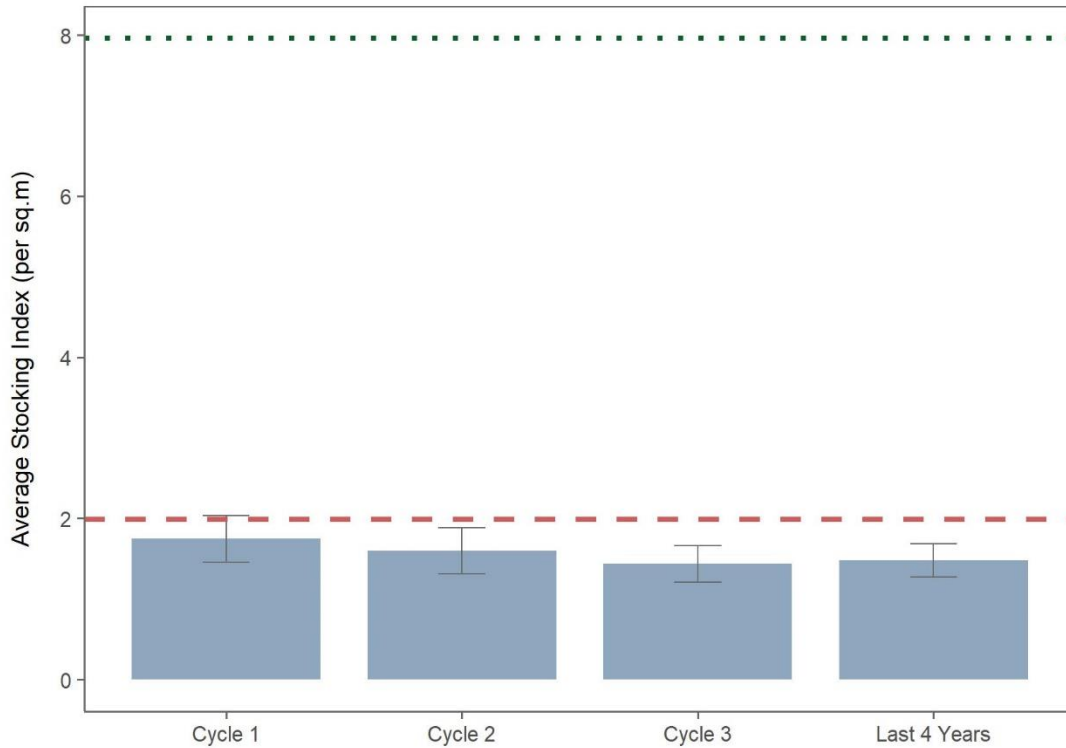


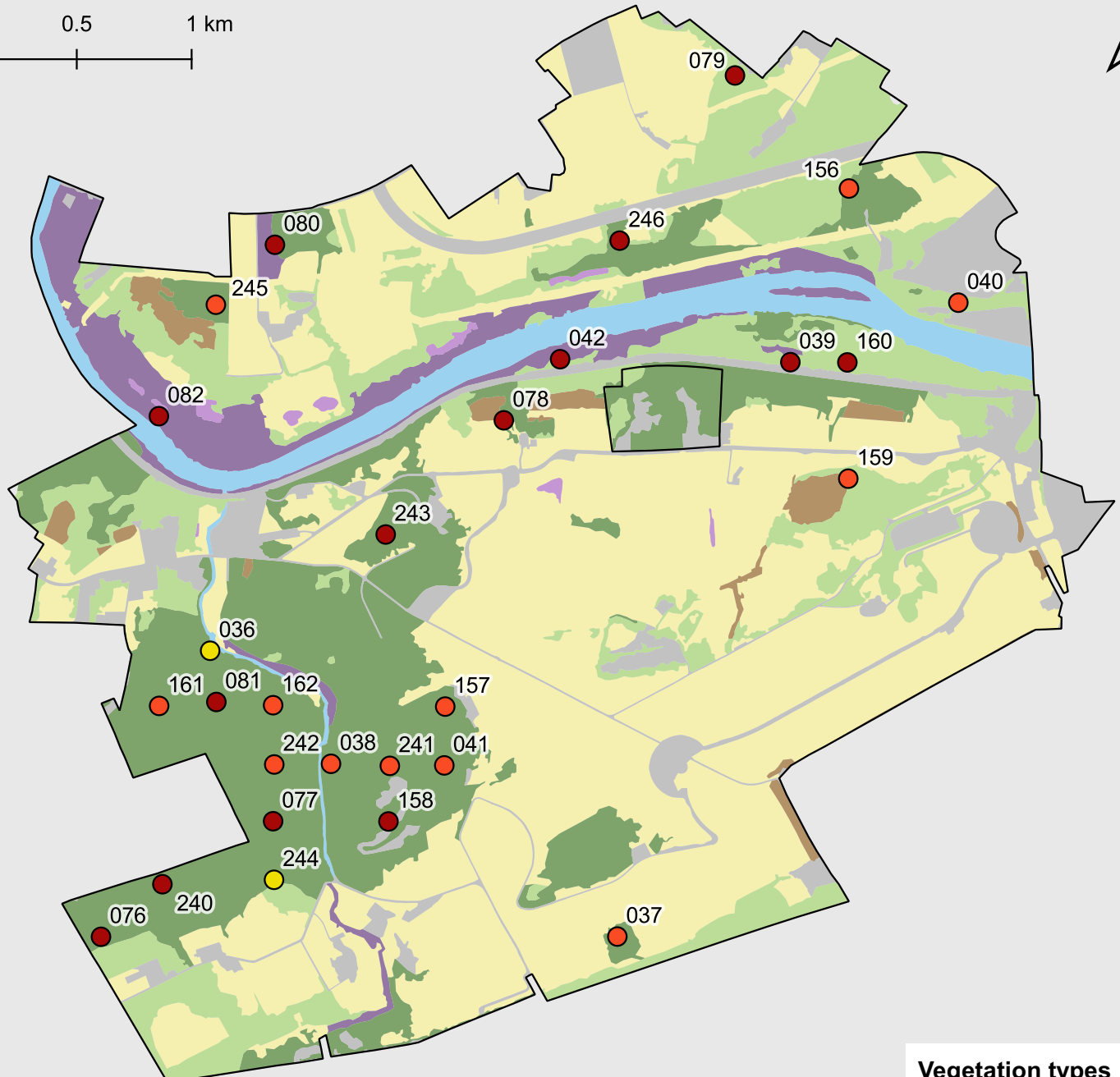
Figure 2. Regeneration stocking index averaged by cycle in Valley Forge National Historical Park. The index is a weighted sum of seedling and sapling densities where larger seedling size classes get higher weights. The stocking index only includes native canopy-forming species (range: 0 – 4.3). Values below 2 (red dashed line) are severely understocked. Values above 8 (green dotted line) are sufficiently stocked for areas with high deer abundance. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018, Last 4 Years is 2016 – 2019. Error bars are ± 1 SE.



Map 4. Index of Deer Browse Impacts

Index of deer browse impacts observed in forest plots in the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle, with one quarter of the plots sampled every year. Deer browse impacts are assessed on a scale of 1 – 5, with 1 representing no impact and 5 representing severe impacts. Reporting Date: 08/20/2020.

0 0.5 1 km



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.

Vegetation types

- Deciduous forest
- Successional forest
- Conifer plantation
- Floodplain forest
- Open wetland
- Open field
- Open water
- Developed land
- Park boundary

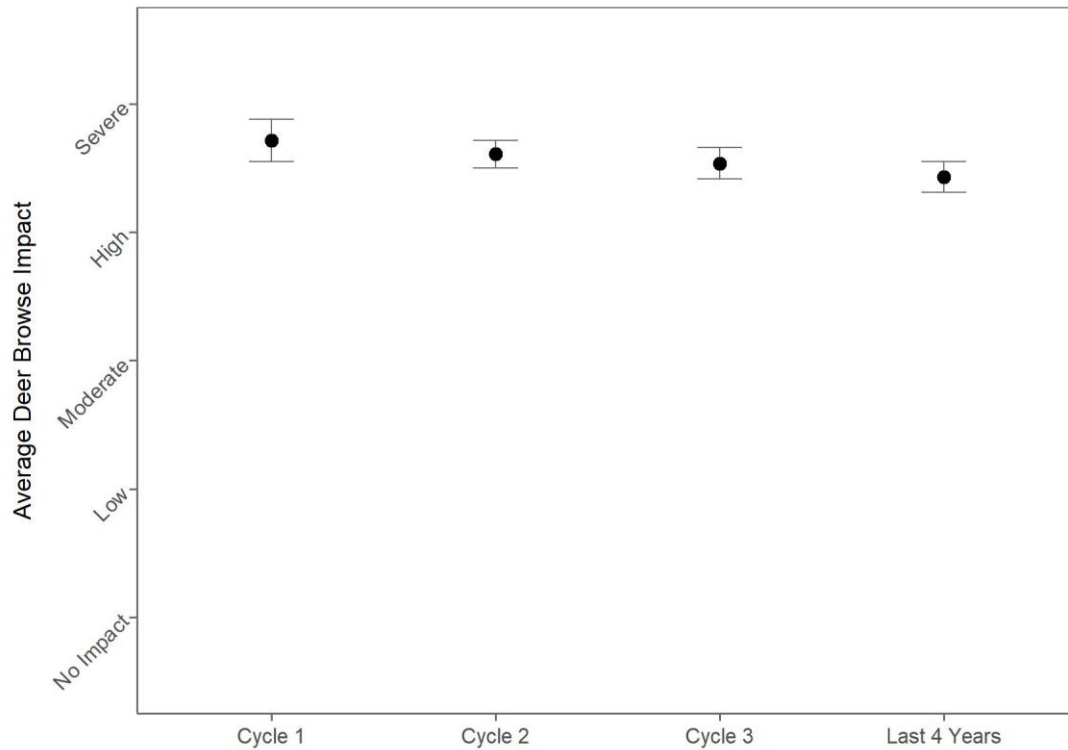


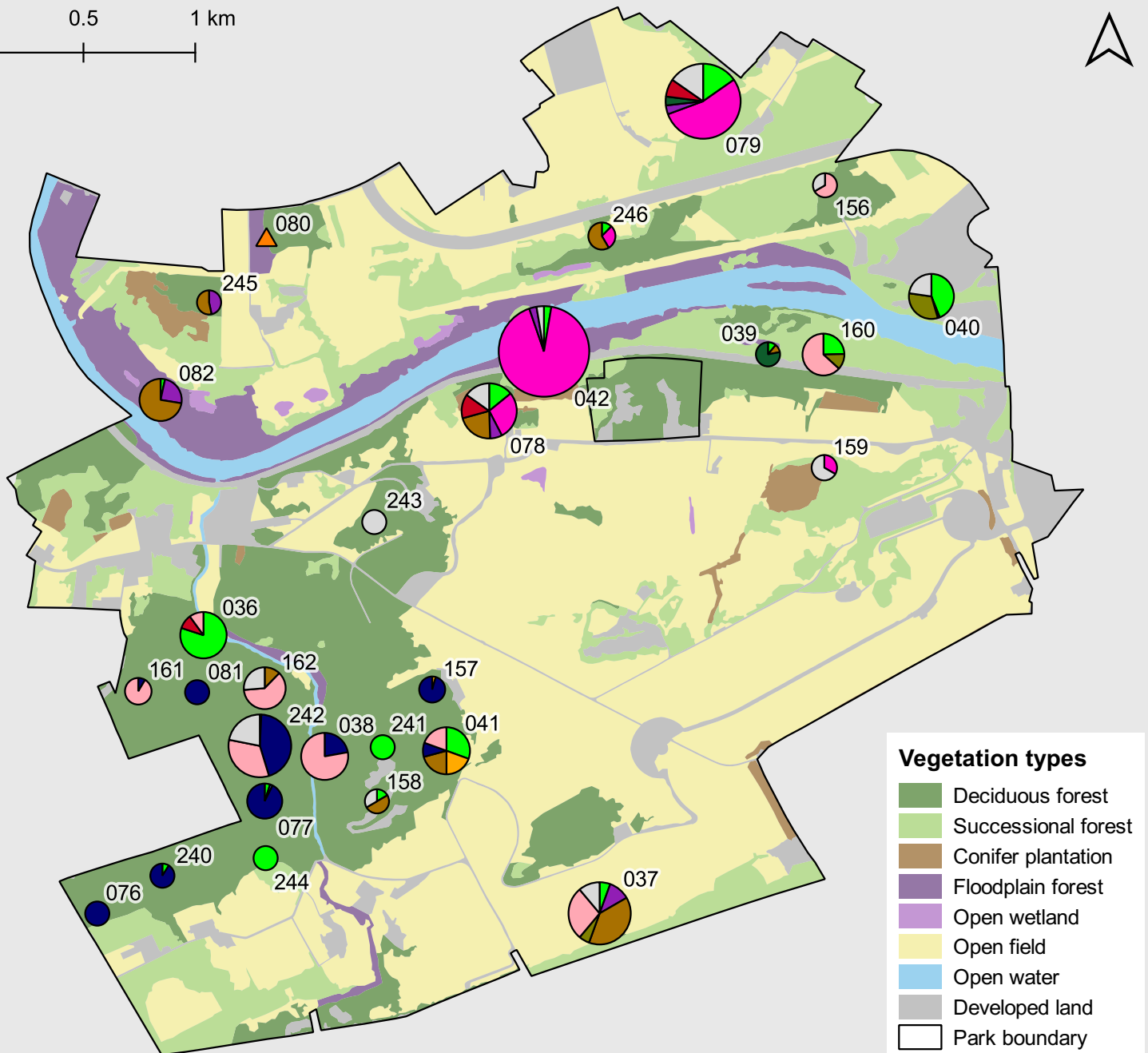
Figure 3. Average deer browse impact by cycle in Valley Forge National Historical Park. Deer browse impacts are assessed on a scale of 1 – 5, with 1 representing no impact and 5 representing severe impacts. Cycle 1 is 2009 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018, Last 4 Years is 2016 – 2019. DBI was not collected until 2009. Error bars are ± 1 SE. Note that DBI values reported for the VAFO/HOFU regeneration project were not reported correctly. The values in this figure are correct.



Map 5. Tree Regeneration by Composition

Tree regeneration stem densities, including seedlings and saplings, by species group observed in forest plots sampled in the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level regeneration density. Pies may be shifted to prevent overlap. Densities range from 0 to 2.9 stems/sq.m for an individual species group. See <https://npsforveg.shinyapps.io/midn/> for more specific plot level information. Reporting Date: 08/20/2020.

0 0.5 1 km

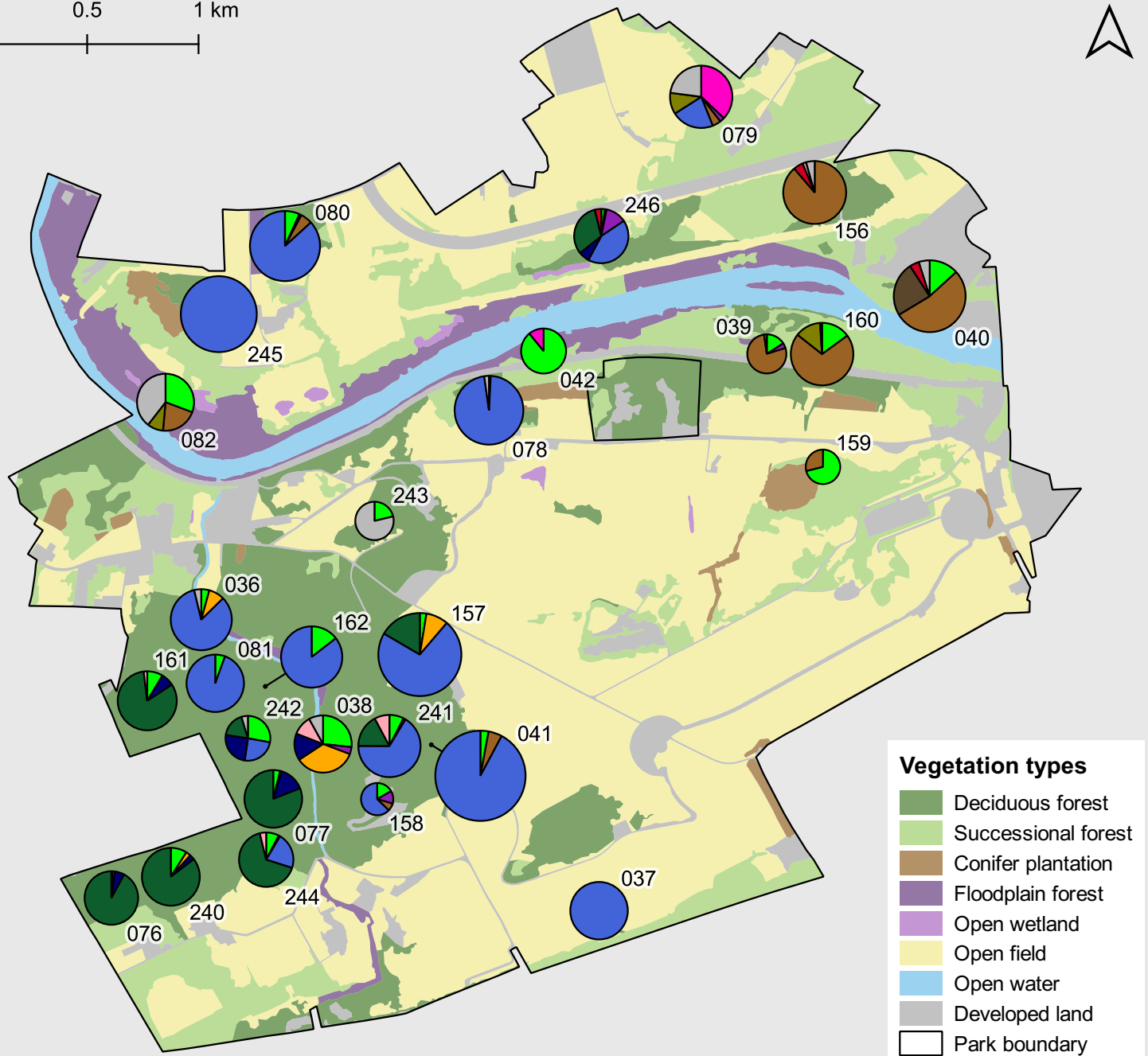




Map 6. Tree Canopy Composition

Live basal area by species group observed in forest plots sampled in the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level basal area. Pies may be shifted to prevent overlap. Basal areas range from 0 to 72.4 sq.m/ha for an individual species group. See <https://npsforveg.shinyapps.io/midn/> for more specific plot level information. Reporting Date: 08/20/2020.

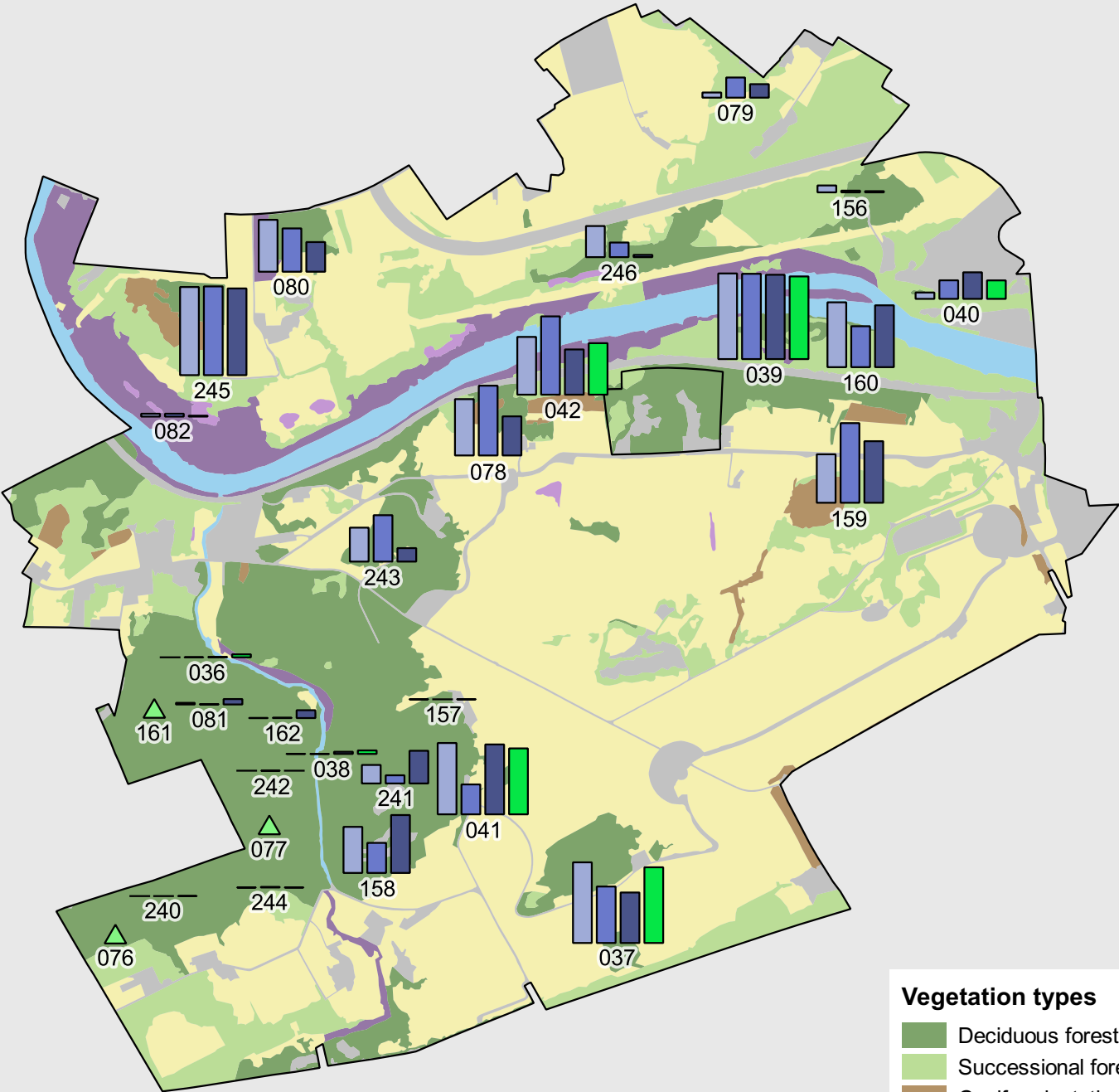
0 0.5 1 km





Map 7. Invasive % Cover by Cycle

Average percent cover of invasive species observed in quadrats in forest plots sampled from 2007 – 2019. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Average invasive cover per plot ranges from 0 to 96.3%. See Table 2 for % cover values. See Table 3 for a species list; only species monitored since 2007 were included in this metric. Densities are scaled to the maximum average invasive cover per plot at Hopewell Furnace National Historic Site (102.0%). Reporting Date: 08/20/2020.



Vegetation types

- Deciduous forest
- Successional forest
- Conifer plantation
- Floodplain forest
- Open wetland
- Open field
- Open water
- Developed land
- Park boundary

Invasive % cover

- Cycle 1: 2007 – 2010
- Cycle 2: 2011 – 2014
- Cycle 3: 2015 – 2018
- Cycle 4: 2019
- None present

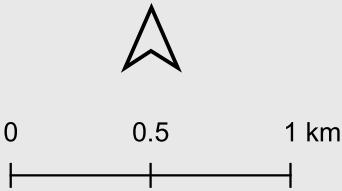


Table 2. Average % cover of invasive species detected in each plot by cycle in Valley Forge National Historical Park. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 4 in 2019. See Table 3 for a species list; only species monitored since 2007 were included in this metric.

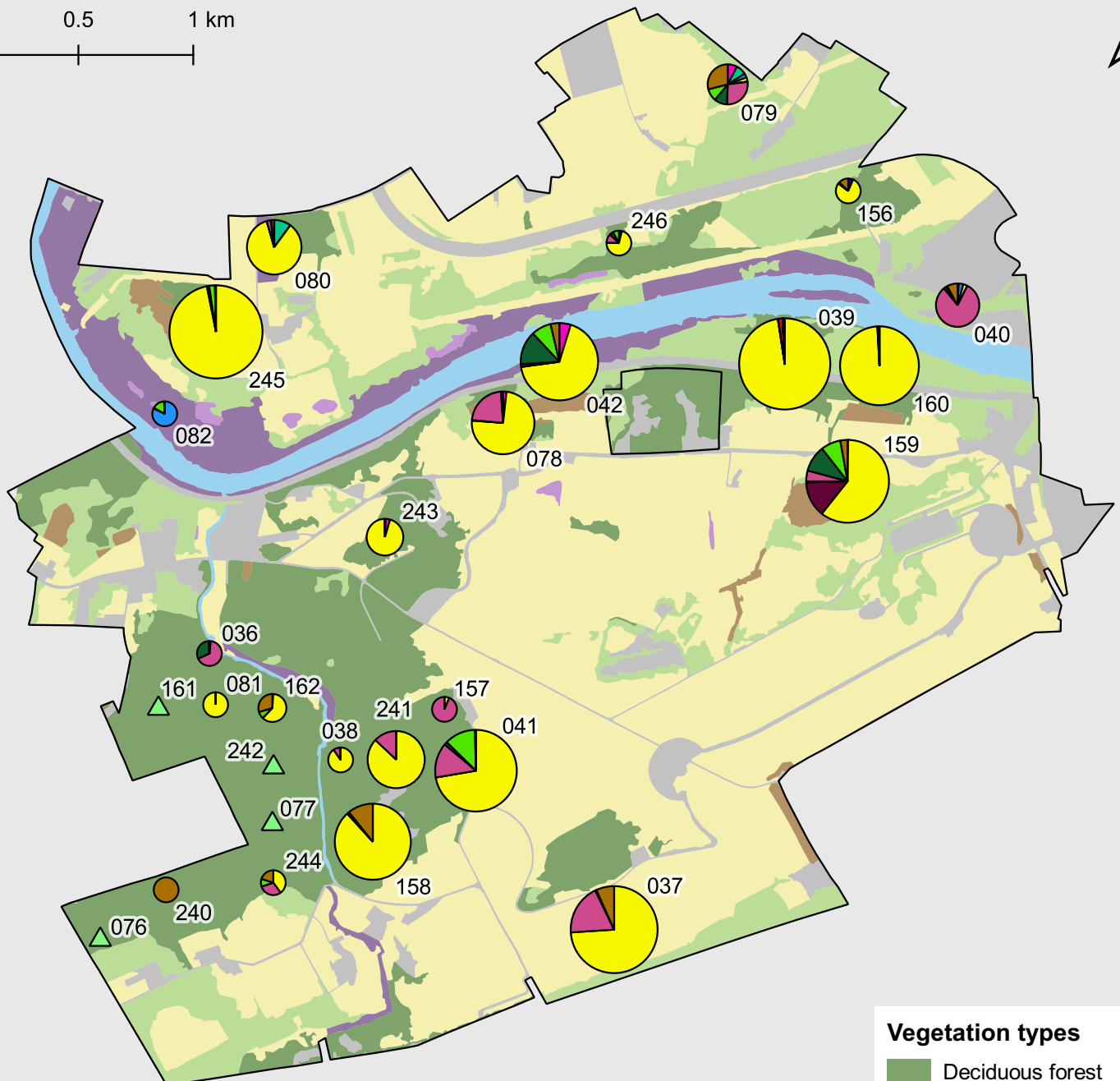
Plot	Average % cover			
	Cycle 1	Cycle 2	Cycle 3	Cycle 4
036	0	< 0.1	0.6	3.2
037	87.5	61.3	54.8	82.1
038	0.1	< 0.1	2.3	3.8
039	92.9	92.5	91.5	89.7
040	6.9	20.1	28.8	20.0
041	77.4	32.4	75.8	71.5
042	62.7	85.0	49.1	55.9
076	0	0	0	-
077	0	0	0	-
078	61.1	75.7	42.4	-
079	5.6	21.9	14.6	-
080	56.3	47.0	32.2	-
081	1.8	0.4	5.9	-
082	3.1	3.1	1.0	-
156	7.5	1.9	1.3	-
157	0.1	0	0.1	-
158	50.0	32.6	62.8	-
159	52.6	86.4	66.8	-
160	70.4	44.4	67.1	-
161	0	0	0	-
162	0.05	0.4	8.5	-
240	0	0	< 0.1	-
241	20.1	8.9	35.5	-
242	0	< 0.1	0	-
243	36.8	50.3	14.6	-
244	< 0.1	0.6	0.1	-
245	95.6	96.3	94.1	-
246	33.8	15.8	2.5	-



Map 8. Invasive % Cover by Species

Average percent invasive cover by species observed in quadrats in forest plots sampled in the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level invasive cover. Pies may be shifted to prevent overlap. Average invasive cover ranges from 0 to 91.3% for an individual species. See Table 3 for more information. Reporting Date: 08/20/2020.

0 0.5 1 km



Species in pie charts

- | | |
|--|--|
| ■ <i>Acer platanoides</i> (Norway maple) | ■ <i>Rosa multiflora</i> (Multiflora rose) |
| ■ <i>Ailanthus altissima</i> (Tree-of-heaven) | ■ <i>Rubus phoenicolasius</i> (Wine raspberry) |
| ■ <i>Berberis thunbergii</i> (Japanese barberry) | ■ Other exotic herbs |
| ■ <i>Lonicera japonica</i> (Japanese honeysuckle) | ■ Other invasive herbs |
| ■ <i>Microstegium vimineum</i> (Japanese stiltgrass) | ■ Other invasive woody species |
| ■ <i>Persicaria perfoliata</i> (Mile-a-minute) | ▲ None present |

Vegetation types

- Deciduous forest
- Successional forest
- Conifer plantation
- Floodplain forest
- Open wetland
- Open field
- Open water
- Developed land
- Park boundary

Table 3. Number of plots where invasive species were detected by cycle in Valley Forge National Historical Park. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 4 in 2019. Note that not all species have been monitored for the same amount of time, as indicated by the Year added column. Species that are exotic to the mid-Atlantic region, but not considered invasive are indicated by *.

Latin name	Common name	Year added	Number of plots with species present			
			Cycle 1	Cycle 2	Cycle 3	Cycle 4
<i>Acer platanoides</i>	Norway maple	2007	4	3	4	2
<i>Ailanthus altissima</i>	Tree-of-heaven	2007	3	9	11	1
<i>Alliaria petiolata</i>	Garlic mustard	2007	12	18	22	7
<i>Berberis thunbergii</i>	Japanese barberry	2007	5	6	8	2
<i>Cardamine impatiens</i>	Narrowleaf bittercress	2007	2	1	3	2
<i>Celastrus orbiculatus</i>	Oriental bittersweet	2007	5	17	22	6
<i>Elaeagnus</i> spp. ¹	Exotic olive	2019	0	0	1	0
<i>Euonymus fortunei</i>	Climbing euonymus	2007	1	1	1	0
<i>Hedera helix</i>	English ivy	2007	0	1	1	0
<i>Ligustrum</i> spp.	Privet	2009	0	4	5	4
<i>Lonicera</i> spp. - Exotic	Exotic bush honeysuckle	2007	2	5	11	0
<i>Lonicera japonica</i>	Japanese honeysuckle	2007	4	11	9	1
<i>Lonicera maackii</i>	Amur honeysuckle	2007	0	1	3	4
<i>Microstegium vimineum</i>	Japanese stiltgrass	2007	22	22	24	7
<i>Morus alba</i>	Mulberry	2007	0	0	0	1
<i>Persicaria longisetata</i> *	Oriental lady's thumb	2009	1	9	14	6
<i>Persicaria perfoliata</i>	Mile-a-minute	2007	2	2	5	3
<i>Ranunculus ficaria</i>	Fig buttercup	2007	0	0	2	0
<i>Rosa multiflora</i>	Multiflora rose	2007	2	9	14	5
<i>Rubus phoenicolasius</i>	Wine raspberry	2007	6	13	22	7
<i>Viburnum sieboldii</i> ¹	Siebold's arrowwood	2019	0	0	1	1
Number of plots sampled	-	-	28	28	28	7

¹Species was added to the indicator list for quadrats in 2019, but has also been monitored in microplots since 2007.