

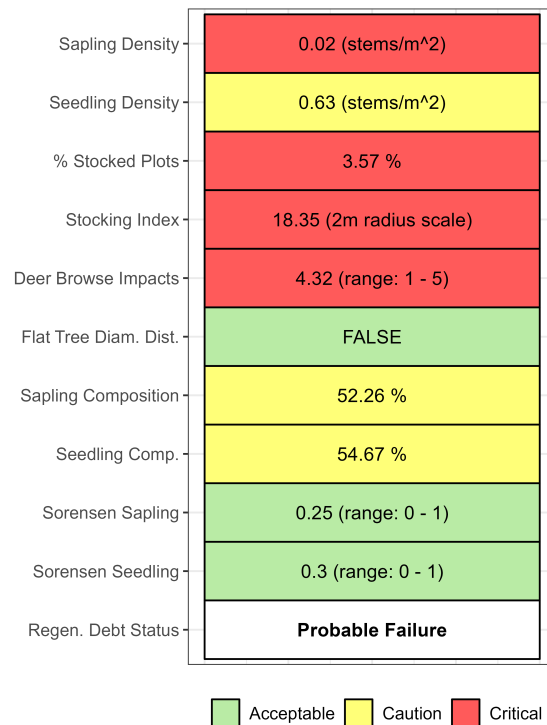


Figure 1. Regeneration Debt status for the most recent 4-year census (2022 – 2024) in Valley Forge National Historical Park (VAFO). Flat Tree Diam. Dist. stands for Flat Tree Diameter Distribution. If TRUE, the density of small trees is lower than expected due to chronic regeneration failure. Sapling/Seedling Composition is the % of total stems composed of native canopy-forming species. Sorensen is a measure of how closely the regen. layer matches canopy composition. For more details on metric calculations, thresholds and assessment of status, see Miller et al. 2023 (<https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.2837>).

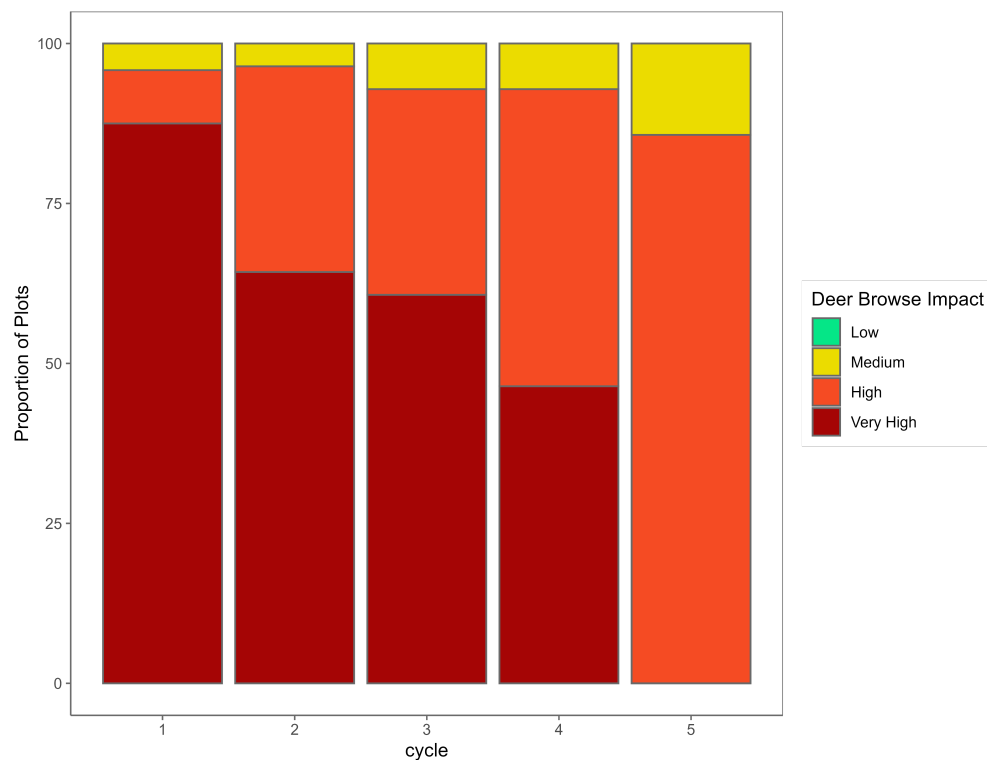
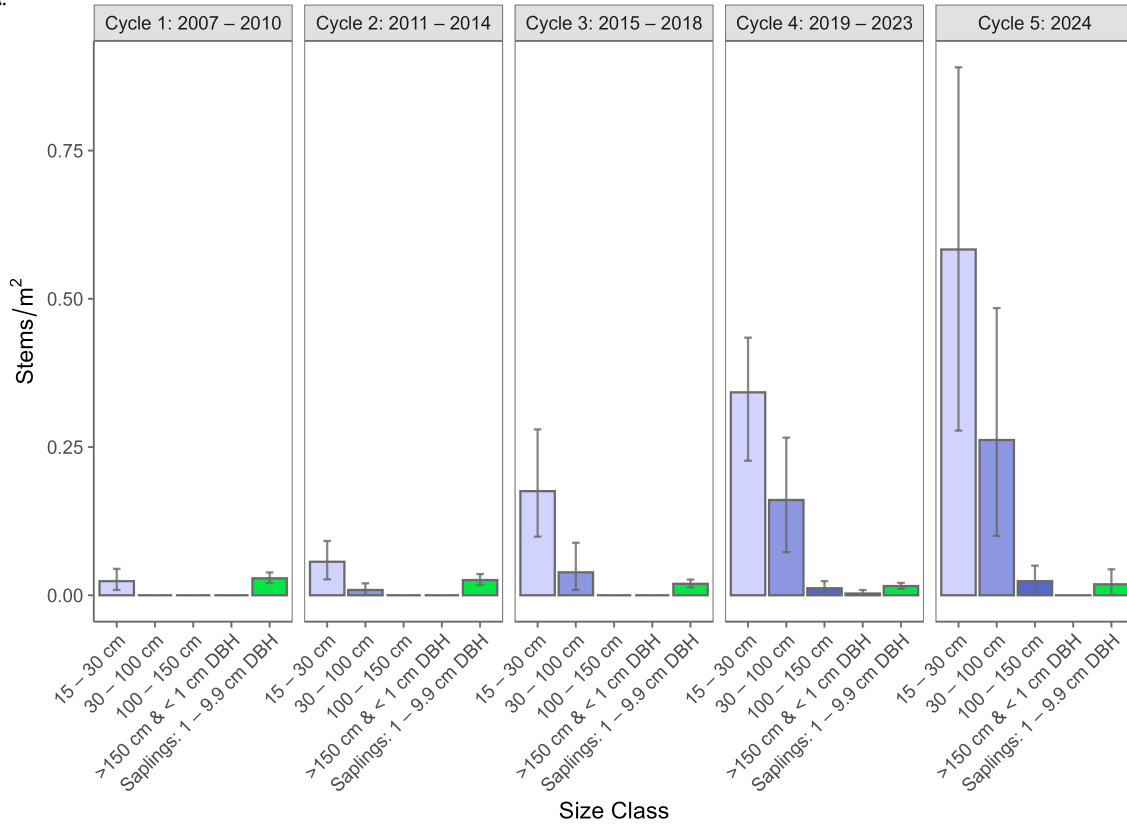


Figure 2. Deer browse impacts by cycle in Valley Forge National Historical Park (VAFO). Cycle 1: 2007 – 2010; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. **Note that Cycle 5 is only partially complete.**



A.



B.

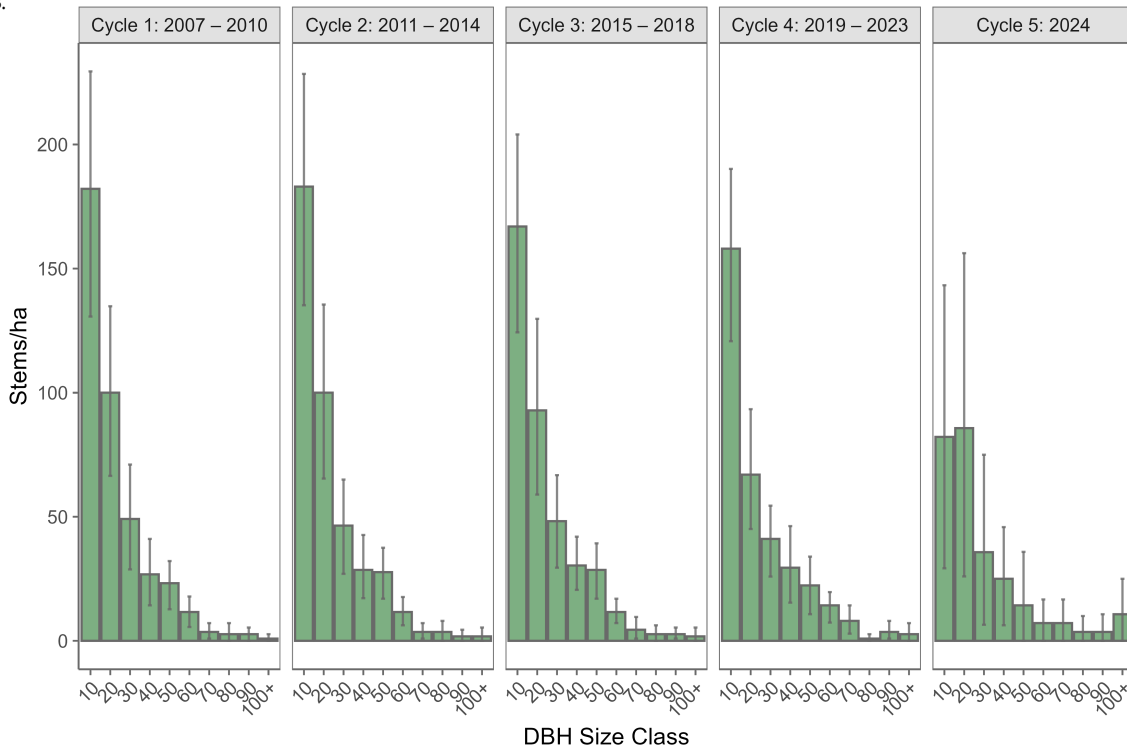


Figure 3. Stem density distributions by cycle in Valley Forge National Historical Park (VAFO). Cycle 1: 2007 – 2010; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. **Note that Cycle 5 is only partially complete.** Figure A shows regeneration densities by size class. Figure B shows tree density by diameter at breast height (DBH) increments. Error bars are 95% bootstrapped confidence intervals to account for non-normal error. An asterisk denotes a linear DBH distribution that is indicative of long-term recruitment failure.

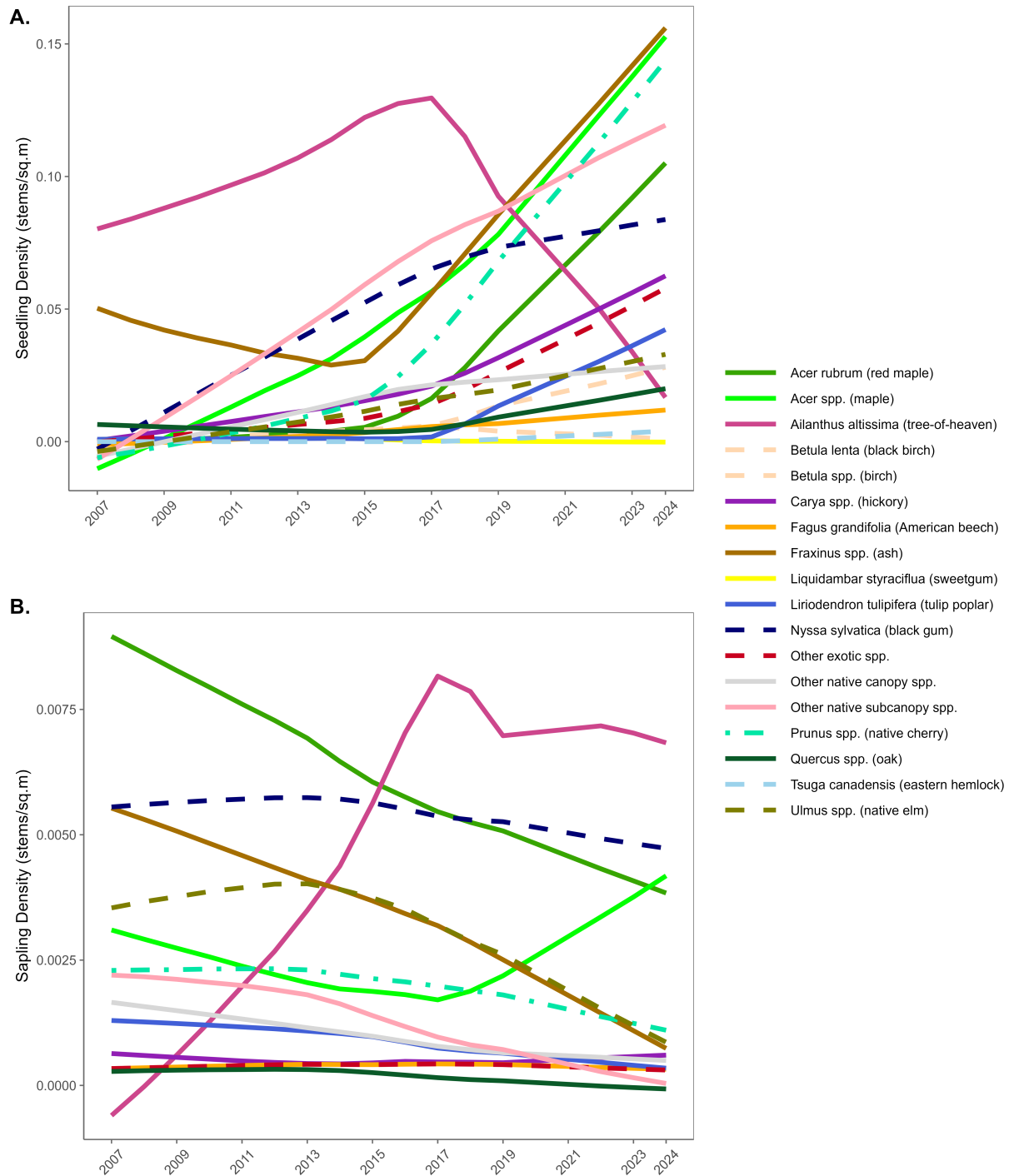


Figure 4. Loess smoothed changes in stem density for seedlings (A) and saplings (B) by species group and sample year in Valley Forge National Historical Park. Specified loess span approximated a linear trend between consecutive sample events per panel.

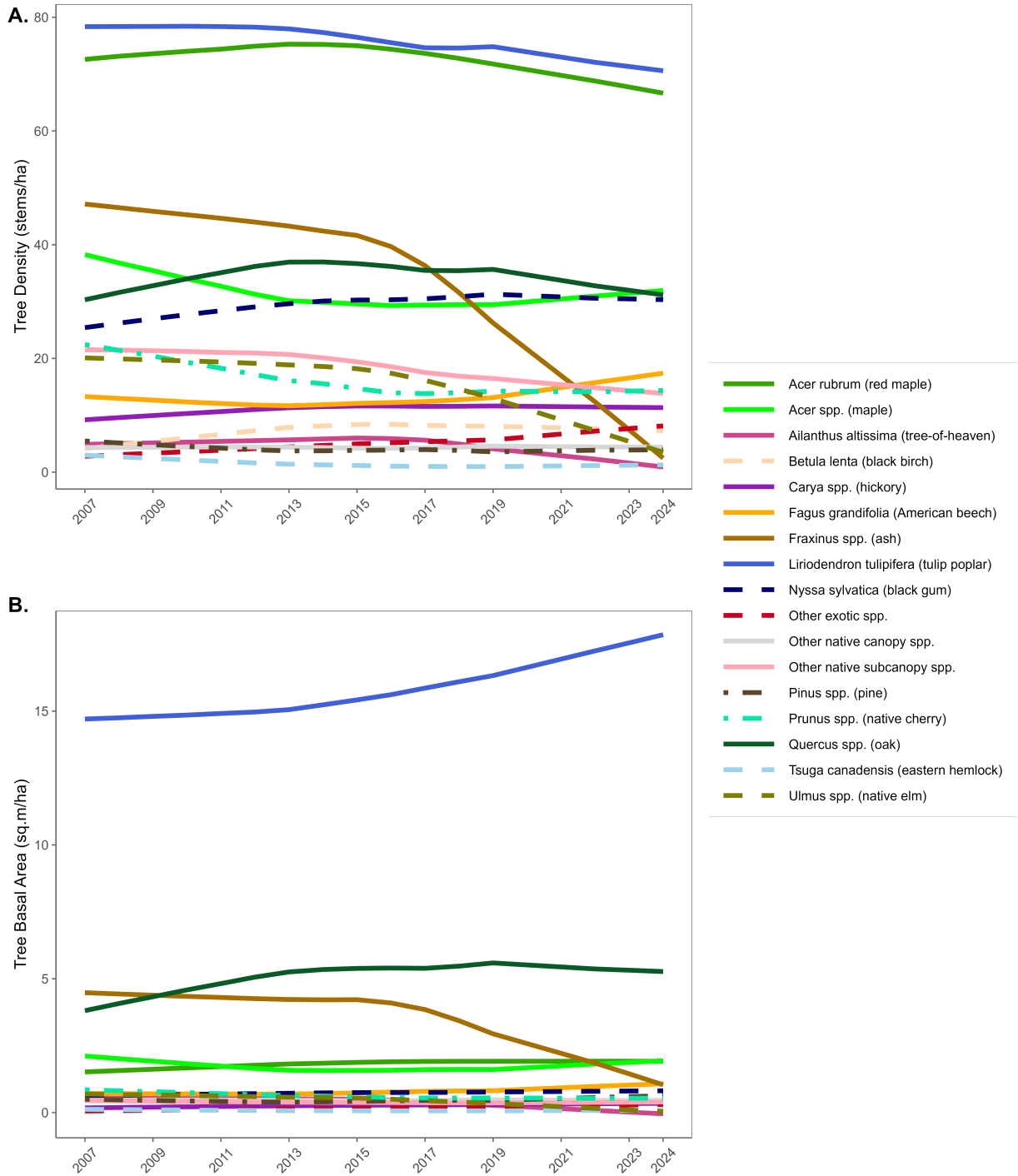


Figure 5. Loess smoothed changes in tree stem density (A) and basal area (B) by species group and sample year in Valley Forge National Historical Park. Specified loess span approximated a linear trend between consecutive sample events per panel.

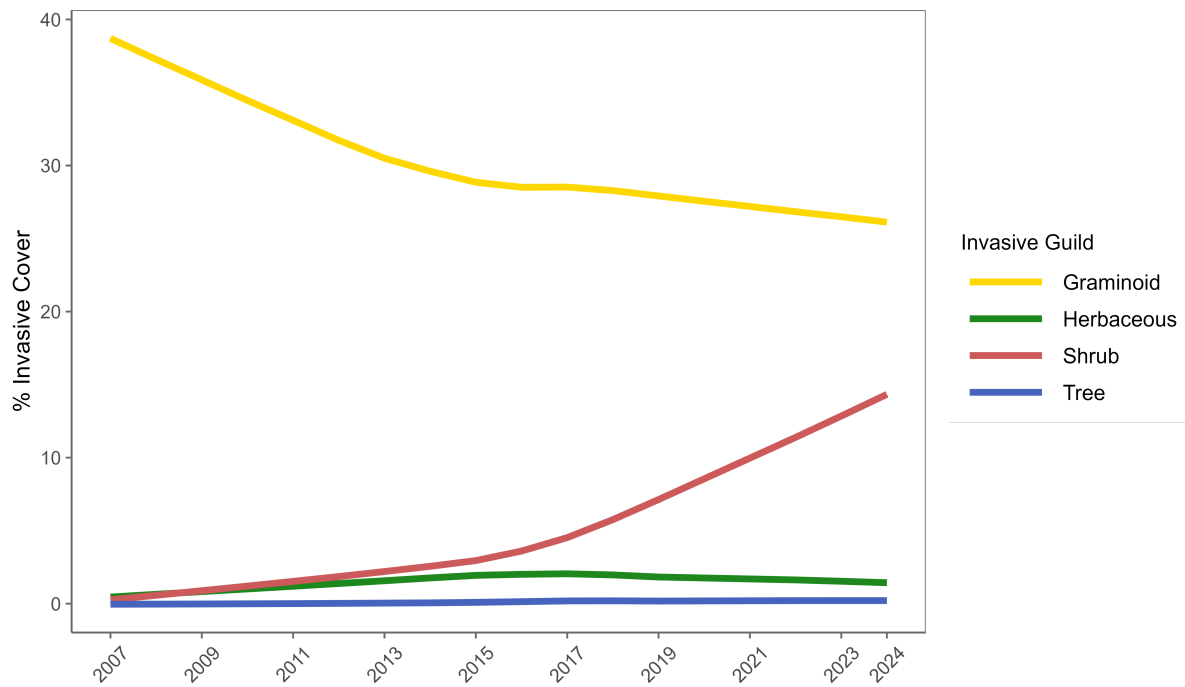


Figure 6. Loess smoothed changes in invasive plant percent cover by guild and sample year in Valley Forge National Historical Park. Specified loess span approximated a linear trend between consecutive sample events per panel.



Table 1. Average plot-level seedling and sapling stem densities (stems per m²) and stocking index (at the 2m radius scale) by cycle. Only native, canopy-forming species are included. Note that *Fraxinus* spp. (ash species) are no longer considered canopy-forming species. Cycle 1: 2007 – 2010; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. Plots are sampled in 4-year rotations, with a quarter of the plots sampled each year (i.e. a panel). 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. These are the same thresholds used in Figure 2 and are described in Miller et al. 2023. **Note that Cycle 5 is only partially complete.**

Plot	Panel	Seedlings per sq.m					Saplings per sq.m					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
36	1	0.00	0.08	0.25	0.67	1.92	0.00	0.00	0.00	0.00	0.00	0.00	1.01	4.15	10.43	33.55
37	1	0.00	0.00	0.17	0.50	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14	8.42	35.56
38	1	0.00	0.00	0.25	0.17	0.67	0.02	0.02	0.02	0.02	0.02	0.00	0.00	4.15	3.14	10.43
39	1	0.00	0.00	0.08	0.08	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	1.01	1.01	0.00
40	1	0.08	0.08	1.08	0.75	1.67	0.04	0.04	0.04	0.04	0.09	8.42	8.42	22.12	19.98	82.06
41	1	0.00	0.00	0.08	0.50	0.17	0.04	0.02	0.01	0.01	0.00	0.00	0.00	1.01	7.29	2.14
42	1	0.00	0.08	0.00	0.25	0.75	0.00	0.00	0.00	0.00	0.01	0.00	1.01	0.00	4.15	12.57
76	2	0.08	0.00	0.17	0.83	-	0.04	0.04	0.04	0.04	-	1.01	0.00	2.14	10.43	-
77	2	0.00	0.17	0.42	0.83	-	0.08	0.07	0.06	0.05	-	14.83	9.55	13.70	22.12	-
78	2	0.00	0.00	0.42	1.83	-	0.02	0.02	0.01	0.00	-	0.00	0.00	5.28	56.55	-
79	2	0.08	0.08	0.83	0.75	-	0.04	0.02	0.00	0.01	-	1.01	1.01	10.43	22.12	-
80	2	0.00	0.00	0.00	0.17	-	0.04	0.00	0.00	0.00	-	0.00	0.00	0.00	2.14	-
81	2	0.00	0.17	0.08	0.83	-	0.00	0.00	0.00	0.00	-	0.00	3.14	1.01	13.57	-
82	2	0.00	0.08	0.17	0.17	-	0.02	0.02	0.02	0.01	-	0.00	2.14	2.14	4.15	-
156	3	0.08	0.00	0.00	0.00	-	0.02	0.01	0.01	0.01	-	1.01	0.00	0.00	0.00	-
157	3	0.00	0.25	0.25	0.50	-	0.01	0.01	0.01	0.01	-	0.00	3.14	4.15	8.42	-
158	3	0.00	0.00	0.00	0.17	-	0.06	0.06	0.04	0.02	-	7.41	0.00	0.00	21.99	-
159	3	0.00	0.00	0.17	0.00	-	0.00	0.00	0.00	0.00	-	0.00	0.00	3.14	0.00	-
160	3	0.00	0.08	0.17	0.33	-	0.11	0.12	0.08	0.05	-	7.41	8.42	2.14	5.28	-
161	3	0.00	0.00	0.00	0.00	-	0.02	0.02	0.02	0.02	-	0.00	0.00	0.00	0.00	-
162	3	0.00	0.00	0.17	0.25	-	0.02	0.02	0.01	0.00	-	0.00	0.00	2.14	3.14	-
240	4	0.08	0.08	0.08	0.25	-	0.05	0.05	0.05	0.04	-	1.01	1.01	1.01	4.15	-
241	4	0.00	0.00	0.00	0.83	-	0.02	0.02	0.02	0.02	-	0.00	0.00	0.00	12.57	-
242	4	0.25	0.50	1.00	2.17	-	0.06	0.05	0.02	0.02	-	3.14	7.29	19.85	128.81	-
243	4	0.00	0.17	0.08	0.33	-	0.01	0.01	0.00	0.00	-	0.00	2.14	1.01	5.28	-
244	4	0.00	0.00	0.00	1.08	-	0.02	0.02	0.02	0.02	-	0.00	0.00	0.00	13.57	-
245	4	0.00	0.00	0.08	0.25	-	0.00	0.00	0.00	0.00	-	0.00	0.00	1.01	3.14	-
246	4	0.00	0.00	0.00	0.00	-	0.05	0.05	0.04	0.02	-	0.00	0.00	0.00	0.00	-



Table 2. Average % cover and number of invasive species detected in each plot by cycle. Cycle 1: 2007 – 2010; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. Plots are sampled in 4-year rotations, with a quarter of the plots sampled each year (i.e. a panel). **Note that Cycle 5 is only partially complete.** Plots with at least 10% average cover or 4 or more invasive species present are in yellow. Protocol evolution over time has impacted invasive species % cover and counts. The estimated change in invasive species % cover and count in Valley Forge National Historical Park (VAFO) that can be attributed to protocol change is 0.54% and 1.46 species per plot for the most recent census. More details can be found in the MIDN Summary of Major Protocol Changes. (<https://irma.nps.gov/DataStore/Reference/Profile/2189101>)

PlotCode	PanelCode	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
36	1	0.00	0.32	0.92	4.63	4.32	0	3	7	9	10
37	1	87.50	61.25	54.58	85.24	53.83	1	2	7	10	10
38	1	0.12	0.02	2.27	3.82	0.32	1	4	4	4	6
39	1	92.92	92.54	94.76	90.32	88.62	2	7	9	9	9
40	1	6.89	20.11	28.63	19.89	22.17	4	10	10	10	10
41	1	77.38	32.43	75.82	72.41	48.07	1	4	8	8	11
42	1	61.58	83.20	46.41	69.21	79.68	2	5	9	11	13
76	2	0.00	0.00	0.00	0.17	-	0	0	1	4	-
77	2	0.00	0.00	0.00	0.01	-	0	0	0	1	-
78	2	61.10	75.37	41.93	47.35	-	4	4	14	15	-
79	2	3.83	21.21	14.70	66.45	-	6	13	11	15	-
80	2	56.33	47.00	32.16	47.11	-	2	6	8	11	-
81	2	1.76	0.44	5.87	7.05	-	2	3	7	9	-
82	2	3.08	3.10	0.98	2.39	-	3	6	8	8	-
156	3	7.31	1.86	1.21	87.33	-	8	10	11	12	-
157	3	0.13	0.00	0.13	0.67	-	1	1	3	8	-
158	3	50.00	32.44	62.82	81.78	-	1	5	7	9	-
159	3	52.58	88.68	74.27	85.53	-	7	10	10	11	-
160	3	70.36	44.42	67.24	97.75	-	3	4	8	8	-
161	3	0.00	0.00	0.00	0.00	-	0	0	0	0	-
162	3	0.05	0.38	8.42	25.88	-	3	4	5	8	-
240	4	0.00	0.00	0.01	0.00	-	0	0	1	1	-
241	4	20.08	8.77	35.47	31.07	-	2	4	4	5	-
242	4	0.00	0.01	0.00	0.00	-	0	1	0	1	-
243	4	36.83	50.17	13.95	23.60	-	1	1	5	7	-
244	4	0.01	0.64	0.08	0.56	-	4	5	6	16	-
245	4	95.63	96.28	94.21	85.46	-	4	7	7	9	-
246	4	33.77	15.88	2.38	24.88	-	8	10	9	14	-



Table 3. Number of plots out of 28 where exotic species were detected. Cycle 1: 2007 – 2010; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. Priority invasive species capable of dominating Eastern US forest habitats are highlighted in yellow. **Note that Cycle 5 is only partially complete.** Protocol evolution has impacted the number of invasive species monitored through time. Species were not consistently monitored before the year specified in the Year Added column. More details can be found in the MIDN Summary of Major Protocol Changes. (<https://irma.nps.gov/DataStore/Reference/Profile/2189101>)

Latin Name	Common Name	Invasive	Year Added	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5
<i>Acer platanoides</i>	Norway maple	Yes	2019	4	3	3	8	3
<i>Ailanthus altissima</i>	tree-of-heaven	Yes	2019	3	4	5	5	2
<i>Albizia julibrissin</i>	mimosa	Yes	2019	0	0	0	1	0
<i>Alliaria petiolata</i>	garlic mustard	Yes	2007	12	18	22	20	7
<i>Aralia elata</i>	Japanese aralia	Yes	2019	0	0	0	1	0
<i>Berberis thunbergii</i>	Japanese barberry	Yes	2007	5	6	8	15	2
<i>Cardamine impatiens</i>	narrowleaf bittercress	Yes	2007	2	1	3	8	3
<i>Celastrus orbiculatus</i>	Asiatic bittersweet	Yes	2007	5	17	22	24	7
<i>Duchesnea indica</i>	mock strawberry	No	2007	4	4	7	9	2
<i>Elaeagnus</i>	exotic olive	Yes	2019	0	0	1	3	0
<i>Euonymus</i>	burningbush	Yes	2019	0	2	3	10	4
<i>Euonymus fortunei</i>	climbing euonymus	Yes	2007	1	1	1	2	0
<i>Hedera helix</i>	English ivy	Yes	2007	0	1	1	0	1
<i>Ilex crenata</i>	Japanese holly	No	2019	0	0	0	1	0
<i>Ligustrum</i>	privet	Yes	2009	0	4	5	8	3
<i>Lonicera - Exotic</i>	honeysuckle - exotic	Yes	2007	2	5	14	14	6
<i>Lonicera japonica</i>	Japanese honeysuckle	Yes	2007	4	11	9	12	4
<i>Malus</i>	apple	No	2019	1	1	3	4	0
<i>Microstegium vimineum</i>	Japanese stiltgrass	Yes	2007	21	22	24	23	7
<i>Morus alba</i>	white mulberry	No	2019	0	0	0	1	1
<i>Persicaria longiseta</i>	Asiatic lady's thumb	Yes	2009	1	9	14	16	4
<i>Persicaria perfoliata</i>	mile-a-minute weed	Yes	2007	2	2	5	9	3
<i>Philadelphus coronarius</i>	sweet mock orange	Yes	2019	0	0	0	1	0
<i>Photinia villosa</i>	Asiatic photinia	Yes	2019	0	0	0	2	0
<i>Prunus avium</i>	sweet cherry	No	2019	0	0	1	0	6
<i>Pyrus</i>	pear	No	2019	0	0	0	1	0
<i>Ranunculus ficaria</i>	fig buttercup	Yes	2007	0	0	2	1	0
<i>Rosa multiflora</i>	multiflora rose	Yes	2007	2	9	14	20	5
<i>Rubus phoenicolasius</i>	wine raspberry	Yes	2007	6	13	22	22	7
<i>Viburnum dilatatum</i>	linden arrowwood	Yes	2019	0	0	0	5	0
<i>Viburnum sieboldii</i>	Siebold's arrowwood	Yes	2019	0	0	1	1	1
<i>Wisteria</i>	exotic wisteria	Yes	2009	0	0	0	1	0



Table 4. Invasive plant and pest/pathogen early detections in Valley Forge National Historical Park observed in the most recent census of each plot. Coordinates are in UTM NAD83 Zone 18N.

Plot	Year	X	Y	Latin Name	Common Name	Type
VAFO-039	2024	463100	4439799	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-040	2024	463831	4440058	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-080	2022	460857	4440310	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-082	2022	460352	4439564	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-156	2022	463355	4440555	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-158	2022	461351	4437800	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-159	2022	463352	4439292	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-160	2022	463348	4439798	<i>Agilus planipennis</i>	emerald ash borer	pest
VAFO-076	2022	460100	4437298	<i>Cryptococcus fagisuga/Neonectria spp. complex</i>	beech bark disease	pest
VAFO-036	2024	460575	4438543	<i>Litylenchus crenatae ssp. Mcannii complex</i>	beech leaf disease	pest
VAFO-042	2024	462098	4439812	<i>Lycorma delicatula</i>	spotted lanternfly	pest



Table 5. List of tree species included in Maps 3 and 4 and how each was displayed.

Latin Name	Group: Map 3. Regeneration	Group: Map 4. Tree Canopy
<i>Acer negundo</i>	Acer spp. (maple)	Acer spp. (maple)
<i>Acer platanoides</i>	Other exotic spp.	Other exotic spp.
<i>Acer rubrum</i>	Acer rubrum (red maple)	Acer rubrum (red maple)
<i>Acer saccharinum</i>	-	Acer spp. (maple)
<i>Acer saccharum</i>	Acer spp. (maple)	Acer spp. (maple)
<i>Ailanthus altissima</i>	Ailanthus altissima (tree-of-heaven)	Ailanthus altissima (tree-of-heaven)
<i>Albizia julibrissin</i>	Other exotic spp.	-
<i>Betula lenta</i>	Betula lenta (black birch)	Betula lenta (black birch)
<i>Carya cordiformis</i>	Carya spp. (hickory)	Carya spp. (hickory)
<i>Carya glabra</i>	-	Carya spp. (hickory)
<i>Carya ovata</i>	-	Carya spp. (hickory)
<i>Carya tomentosa</i>	-	Carya spp. (hickory)
<i>Celtis occidentalis</i>	Other native canopy spp.	-
<i>Cercis canadensis</i>	Other native subcanopy spp.	-
<i>Cornus florida</i>	Other native subcanopy spp.	Other native subcanopy spp.
<i>Crataegus</i>	Other exotic spp.	-
<i>Fagus grandifolia</i>	Fagus grandifolia (American beech)	Fagus grandifolia (American beech)
<i>Fraxinus</i>	Fraxinus spp. (ash)	-
<i>Fraxinus americana</i>	Fraxinus spp. (ash)	Fraxinus spp. (ash)
<i>Juglans nigra</i>	-	Other native canopy spp.
<i>Liriodendron tulipifera</i>	Liriodendron tulipifera (tulip poplar)	Liriodendron tulipifera (tulip poplar)
<i>Malus</i>	Other exotic spp.	-
<i>Nyssa sylvatica</i>	Nyssa sylvatica (black gum)	Nyssa sylvatica (black gum)
<i>Ostrya virginiana</i>	Other native subcanopy spp.	-
<i>Pinus strobus</i>	-	Pinus spp. (pine)
<i>Platanus occidentalis</i>	-	Other native canopy spp.
<i>Populus grandidentata</i>	Other native canopy spp.	Other native canopy spp.
<i>Prunus</i>	Prunus spp. (native cherry)	-
<i>Prunus avium</i>	Other exotic spp.	-
<i>Prunus serotina</i>	Prunus spp. (native cherry)	Prunus spp. (native cherry)
<i>Quercus (Red group)</i>	Quercus spp. (oak)	-
<i>Quercus (White group)</i>	Quercus spp. (oak)	-
<i>Quercus alba</i>	-	Quercus spp. (oak)
<i>Quercus coccinea</i>	-	Quercus spp. (oak)
<i>Quercus montana</i>	Quercus spp. (oak)	Quercus spp. (oak)
<i>Quercus rubra</i>	-	Quercus spp. (oak)
<i>Quercus velutina</i>	Quercus spp. (oak)	Quercus spp. (oak)
<i>Sassafras albidum</i>	Other native subcanopy spp.	Other native subcanopy spp.
<i>Tsuga canadensis</i>	Tsuga canadensis (eastern hemlock)	Tsuga canadensis (eastern hemlock)
<i>Ulmus americana</i>	Ulmus spp. (native elm)	Ulmus spp. (native elm)
<i>Ulmus rubra</i>	Ulmus spp. (native elm)	-
<i>Viburnum prunifolium</i>	Other native subcanopy spp.	Other native subcanopy spp.