

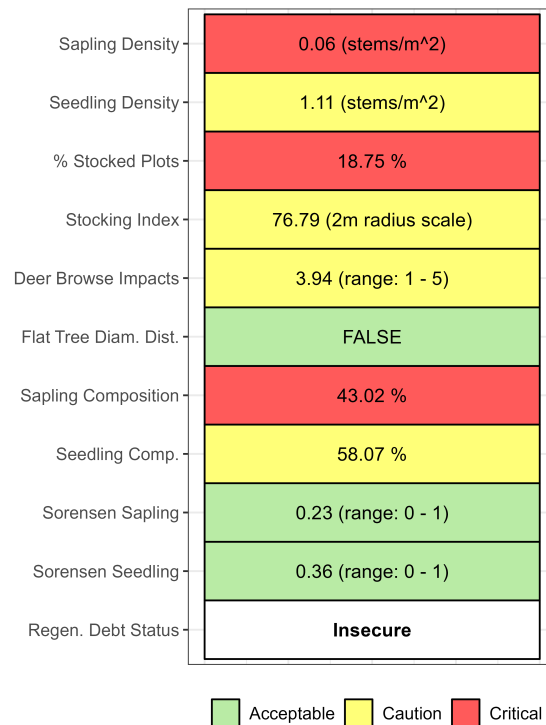


Figure 1. Regeneration Debt status for the most recent 4-year census (2022 – 2024) in Hopewell Furnace National Historic Site (HOFU). Flat Tree Diam. Dist. stands for Flat Tree Diameter Distribution. If TRUE, the density of small trees is lower than expected due to chronic regeneration failure. Sapling/Seedling 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>).

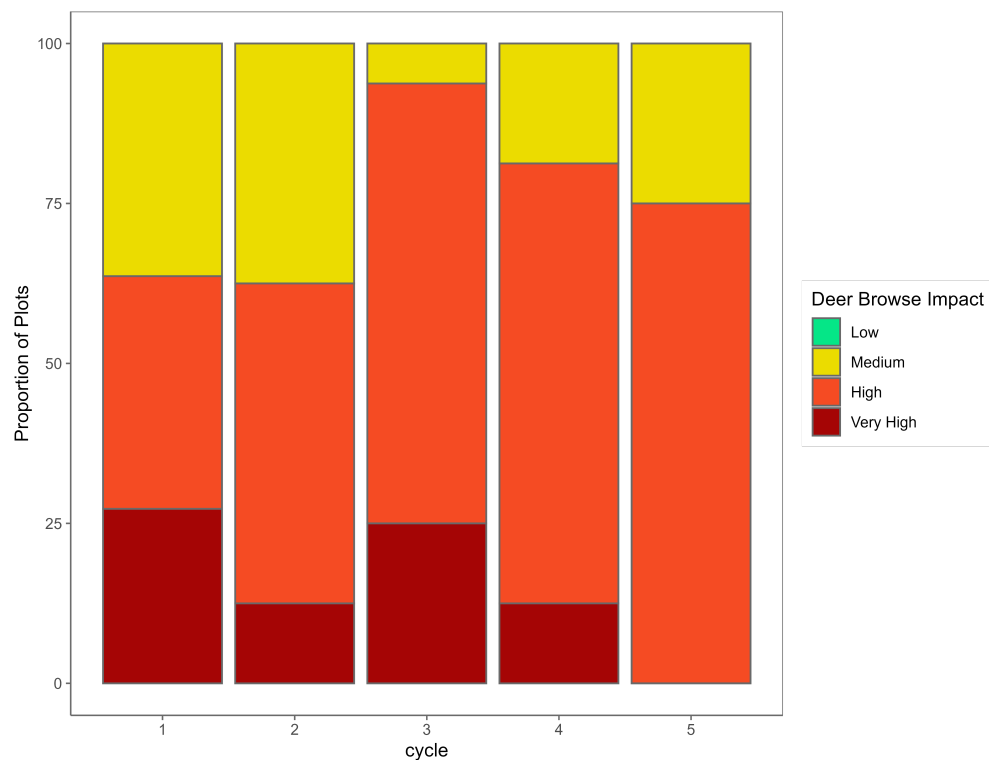
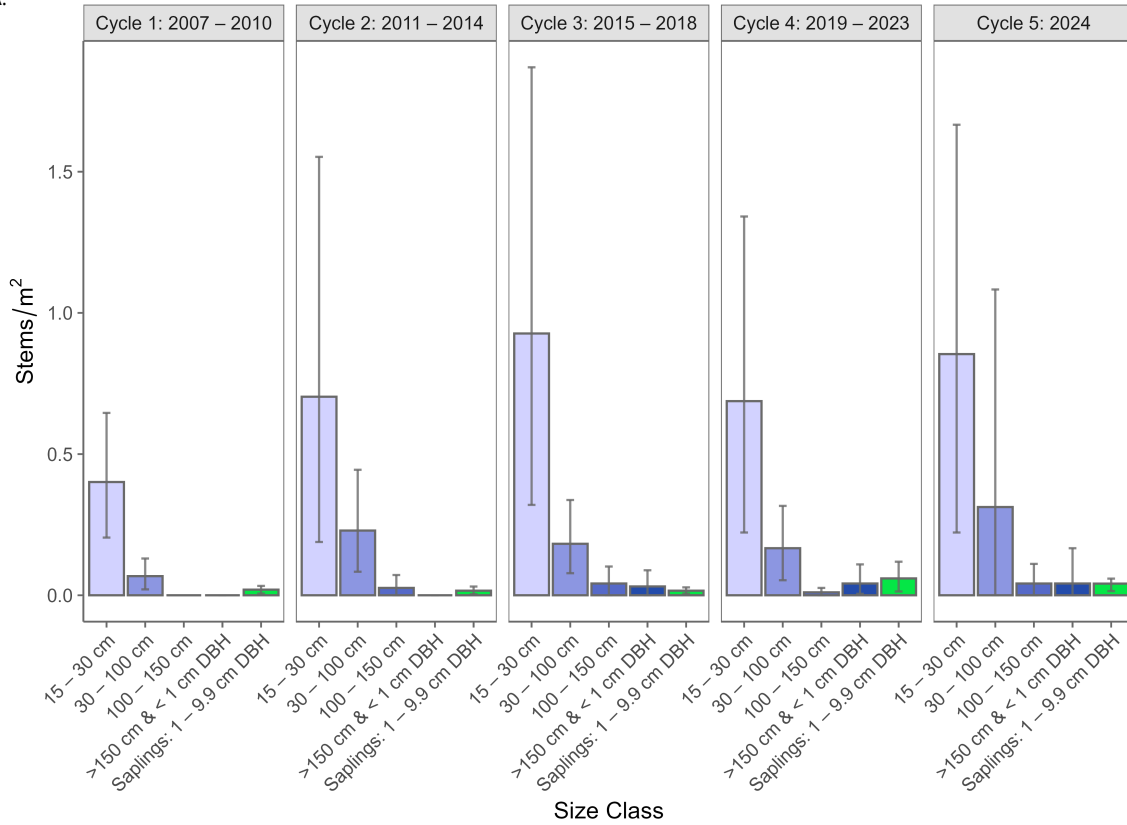


Figure 2. Deer browse impacts by cycle in Hopewell Furnace National Historic Site (HOFU). Cycle 1: 2007 – 2010; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. **Note that Cycle 5 is only partially complete.**



A.



B.

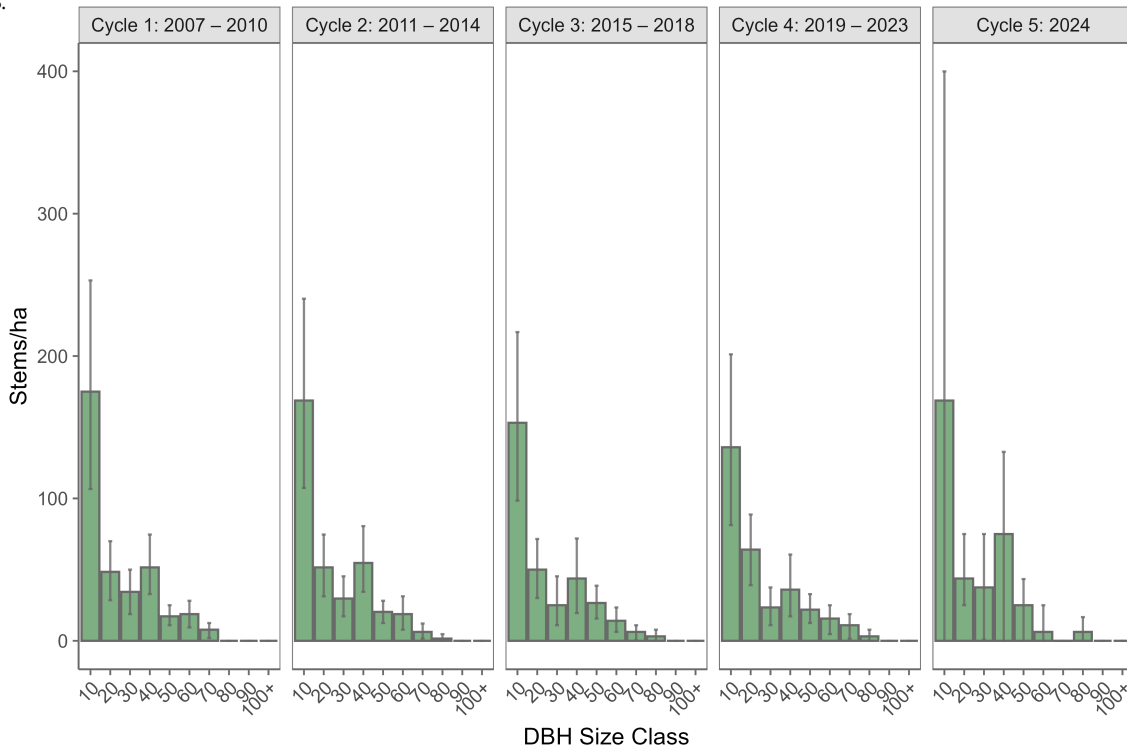


Figure 3. Stem density distributions by cycle in Hopewell Furnace National Historic Site (HOFU). Cycle 1: 2007 – 2014; Cycle 2: 2011 – 2014; Cycle 3: 2015 – 2018; Cycle 4: 2019 – 2023; Cycle 5: 2024. **Note that Cycle 5 is only partially complete.** Figure A shows regeneration densities by size class. 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.

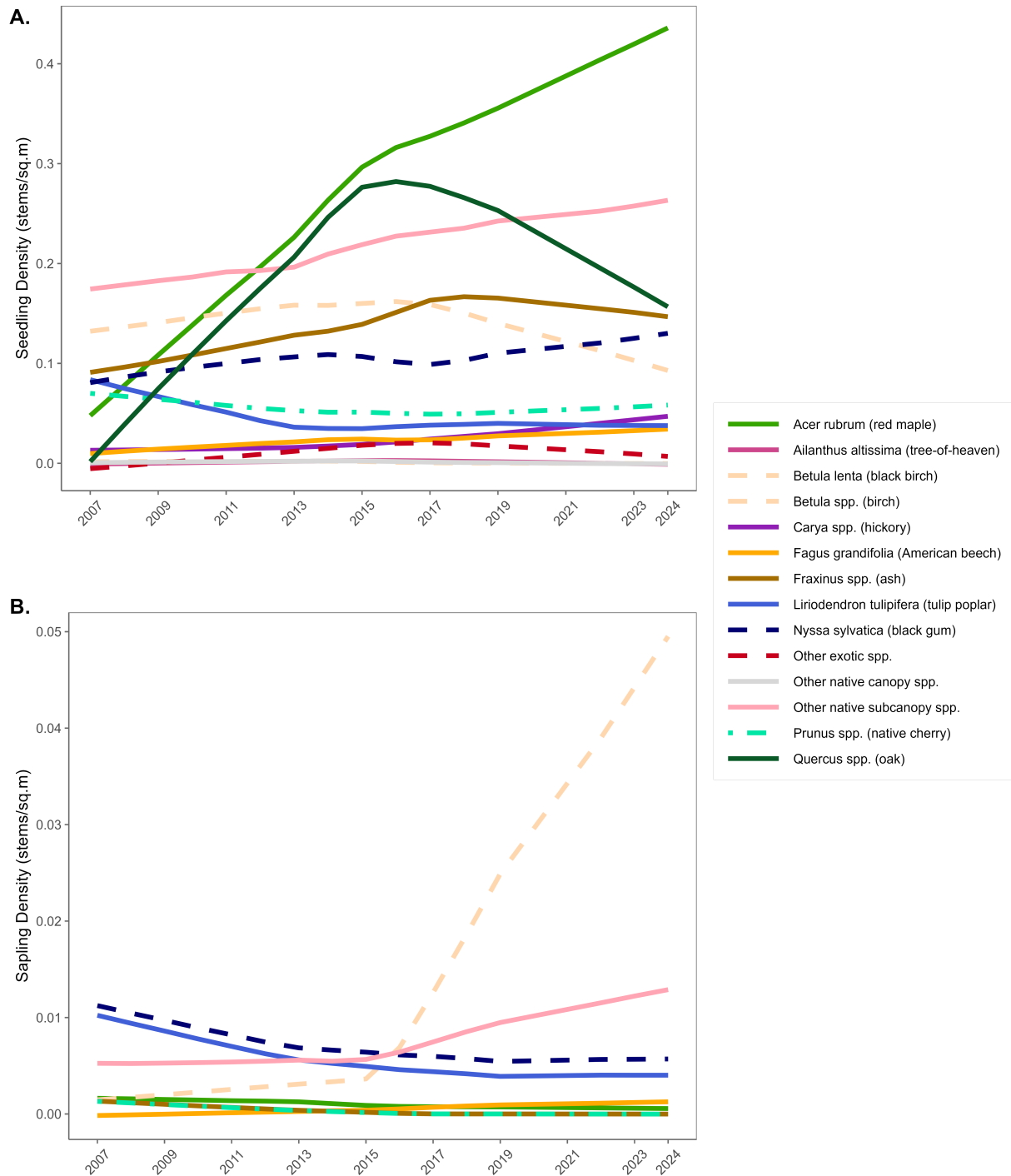


Figure 4. Loess smoothed changes in stem density for seedlings (A) and saplings (B) by species group and sample year in Hopewell Furnace National Historic Site. Specified loess span approximated a linear trend between consecutive sample events per panel.

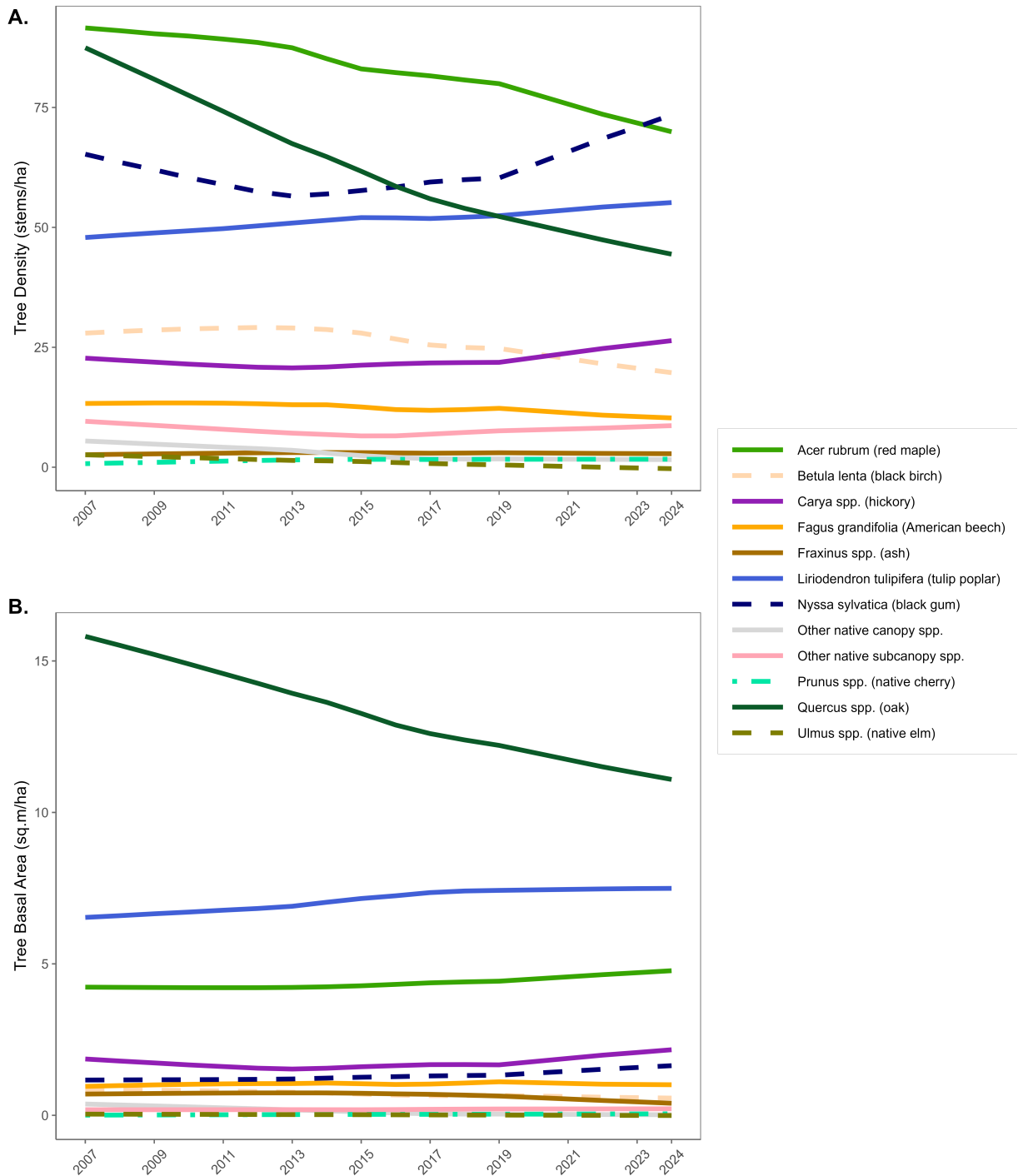


Figure 5. Loess smoothed changes in tree stem density (A) and basal area (B) by species group and sample year in Hopewell Furnace National Historic Site. Specified loess span approximated a linear trend between consecutive sample events per panel.

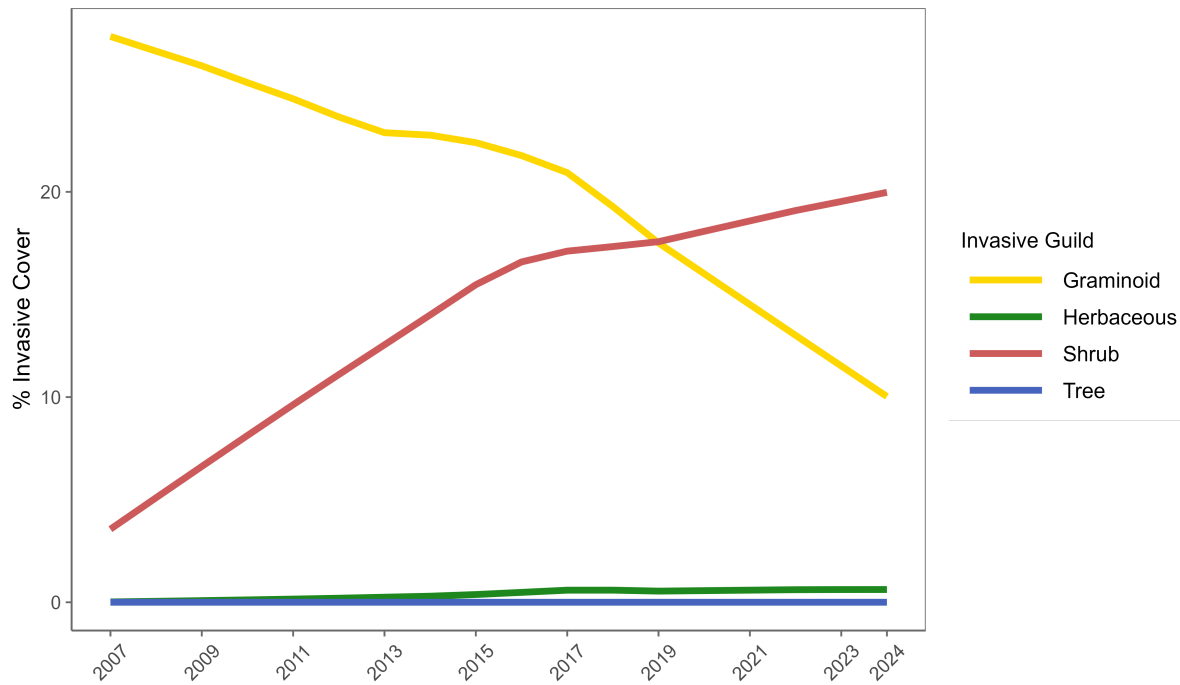


Figure 6. Loess smoothed changes in invasive plant percent cover by guild and sample year in Hopewell Furnace National Historic Site. Specified loess span approximated a linear trend between consecutive sample events per panel.



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
50	1	0.17	0.00	0.25	0.00	0.25	0.11	0.09	0.06	0.05	0.05	3.14	0.00	25.38	0.00	4.15
51	1	1.75	1.17	1.00	0.75	1.25	0.00	0.00	0.02	0.04	0.06	25.13	39.84	71.38	104.93	174.04
52	1	0.83	0.25	0.75	0.92	3.17	0.09	0.09	0.08	0.07	0.06	10.43	3.14	9.42	11.56	53.41
53	1	0.17	0.08	0.25	0.08	0.33	0.00	0.00	0.00	0.00	0.00	2.14	1.01	3.14	1.01	4.15
83	2	0.00	0.00	0.08	0.08	-	0.00	0.00	0.00	0.00	-	0.00	0.00	1.01	1.01	-
84	2	0.17	0.75	1.08	0.08	-	0.01	0.01	0.01	0.01	-	2.14	10.43	17.84	2.14	-
85	2	0.75	1.75	1.42	1.33	-	0.00	0.00	0.00	0.00	-	11.56	30.41	21.99	21.99	-
86	2	0.67	0.75	1.83	2.83	-	0.04	0.04	0.06	0.45	-	24.25	28.40	61.07	279.98	-
163	3	0.25	0.25	0.17	0.42	-	0.00	0.00	0.00	0.00	-	3.14	4.15	2.14	6.28	-
164	3	2.00	8.58	9.33	6.50	-	0.00	0.00	0.00	0.26	-	30.41	206.34	486.95	563.85	-
165	3	0.25	0.08	0.17	0.25	-	0.00	0.00	0.00	0.00	-	3.14	1.01	2.14	3.14	-
166	3	0.00	0.00	0.00	0.08	-	0.01	0.01	0.01	0.01	-	0.00	0.00	0.00	1.01	-
247	4	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-
248	4	0.50	0.58	1.00	0.33	-	0.02	0.01	0.01	0.00	-	7.29	10.43	13.57	4.15	-
249	4	0.00	0.58	1.00	0.58	-	0.00	0.00	0.00	0.00	-	0.00	7.29	16.71	9.42	-
251	4	0.00	0.50	0.58	0.25	-	0.04	0.00	0.00	0.07	-	7.41	10.43	82.69	99.90	-



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 Hopewell Furnace National Historic Site (HOFU) that can be attributed to protocol change is 0.02% and 0.31 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
50	1	70.00	41.59	102.03	87.51	43.24	1	6	8	9	8
51	1	11.46	6.58	22.06	28.19	15.61	5	6	6	7	8
52	1	0.00	0.00	0.00	0.00	0.00	0	0	0	1	0
53	1	79.83	67.81	97.34	95.33	48.69	2	5	5	7	6
83	2	46.02	40.98	6.18	26.11	-	4	8	8	10	-
84	2	8.95	4.33	5.47	12.67	-	4	5	6	8	-
85	2	0.01	0.13	0.16	21.74	-	1	3	3	6	-
86	2	0.00	0.00	0.00	2.53	-	0	1	1	6	-
163	3	1.22	11.35	2.22	5.68	-	6	6	7	8	-
164	3	0.00	0.45	0.65	1.77	-	3	6	5	6	-
165	3	22.29	44.62	37.39	44.69	-	7	7	7	9	-
166	3	4.38	39.27	51.12	49.16	-	1	3	3	4	-
247	4	85.71	94.00	81.79	93.94	-	8	9	8	8	-
248	4	58.99	89.85	40.25	53.92	-	5	5	4	6	-
249	4	31.98	70.96	14.64	12.47	-	6	6	6	6	-
251	4	0.01	10.12	6.18	5.68	-	3	4	6	8	-



Table 3. Number of plots out of 16 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>Ailanthus altissima</i>	tree-of-heaven	Yes	2019	0	0	1	0	0
<i>Alliaria petiolata</i>	garlic mustard	Yes	2007	5	2	3	3	1
<i>Berberis thunbergii</i>	Japanese barberry	Yes	2007	9	13	14	15	3
<i>Berberis vulgaris</i>	common barberry	Yes	2019	0	2	0	0	0
<i>Catalpa bignonioides</i>	southern catalpa	No	2019	0	0	0	1	0
<i>Celastrus orbiculatus</i>	Asiatic bittersweet	Yes	2007	7	12	11	13	3
<i>Dioscorea oppositifolia</i>	Chinese yam	Yes	2013	0	1	1	0	0
<i>Duchesnea indica</i>	mock strawberry	No	2007	2	0	3	3	1
<i>Euonymus</i>	burningbush	Yes	2019	0	0	0	2	0
<i>Euonymus fortunei</i>	climbing euonymus	Yes	2007	1	0	0	0	0
<i>Glechoma hederacea</i>	ground ivy	Yes	2007	0	0	0	1	0
<i>Ligustrum</i>	privet	Yes	2009	0	1	1	2	2
<i>Lonicera - Exotic</i>	honeysuckle - exotic	Yes	2007	2	2	2	5	0
<i>Lonicera japonica</i>	Japanese honeysuckle	Yes	2007	2	3	4	5	2
<i>Malus</i>	apple	No	2019	0	0	1	2	1
<i>Microstegium vimineum</i>	Japanese stiltgrass	Yes	2007	13	13	13	16	3
<i>Persicaria longiseta</i>	Asiatic lady's thumb	Yes	2009	4	8	9	11	2
<i>Persicaria perfoliata</i>	mile-a-minute weed	Yes	2007	0	0	2	8	1
<i>Prunus avium</i>	sweet cherry	No	2019	0	0	0	0	3
<i>Rosa multiflora</i>	multiflora rose	Yes	2007	6	11	10	13	3
<i>Rubus phoenicolasius</i>	wine raspberry	Yes	2007	7	12	12	13	2
<i>Viburnum dilatatum</i>	linden arrowwood	Yes	2019	0	0	0	2	0



Table 4. Invasive plant and pest/pathogen early detections in Hopewell Furnace National Historic Site 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
HOFU-050	2024	435101	4451801	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-085	2022	434342	4452052	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-086	2022	435074	4452049	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-163	2022	434105	4450558	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-248	2023	434602	4452066	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-249	2023	434845	4451801	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-251	2023	435096	4451552	<i>Persicaria perfoliata</i>	mile-a-minute weed	herbaceous
HOFU-083	2022	434359	4451310	<i>Agrilus planipennis</i>	emerald ash borer	pest
HOFU-083	2022	434359	4451310	<i>Cryptococcus fagisuga/Neonectria spp. complex</i>	beech bark disease	pest
HOFU-085	2022	434342	4452052	<i>Cryptococcus fagisuga/Neonectria spp. complex</i>	beech bark disease	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 rubrum</i>	Acer rubrum (red maple)	Acer rubrum (red maple)
<i>Amelanchier</i>	Other native subcanopy spp.	-
<i>Betula lenta</i>	Betula lenta (black birch)	Betula lenta (black birch)
<i>Carpinus caroliniana</i>	Other native subcanopy spp.	Other native subcanopy spp.
<i>Carya</i>	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>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>Ilex opaca</i>	Other native subcanopy spp.	-
<i>Liriodendron tulipifera</i>	Liriodendron tulipifera (tulip poplar)	Liriodendron tulipifera (tulip poplar)
<i>Nyssa sylvatica</i>	Nyssa sylvatica (black gum)	Nyssa sylvatica (black gum)
<i>Prunus</i>	Prunus spp. (native cherry)	-
<i>Prunus serotina</i>	Prunus spp. (native cherry)	Prunus spp. (native cherry)
<i>Quercus</i>	Quercus spp. (oak)	-
<i>Quercus (Red group)</i>	Quercus spp. (oak)	-
<i>Quercus (White group)</i>	Quercus spp. (oak)	-
<i>Quercus alba</i>	Quercus spp. (oak)	Quercus spp. (oak)
<i>Quercus coccinea</i>	-	Quercus spp. (oak)
<i>Quercus montana</i>	-	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>Ulmus americana</i>	-	Other native canopy spp.
<i>Viburnum prunifolium</i>	Other native subcanopy spp.	-