



Map 1. Tree Regeneration by Size Class

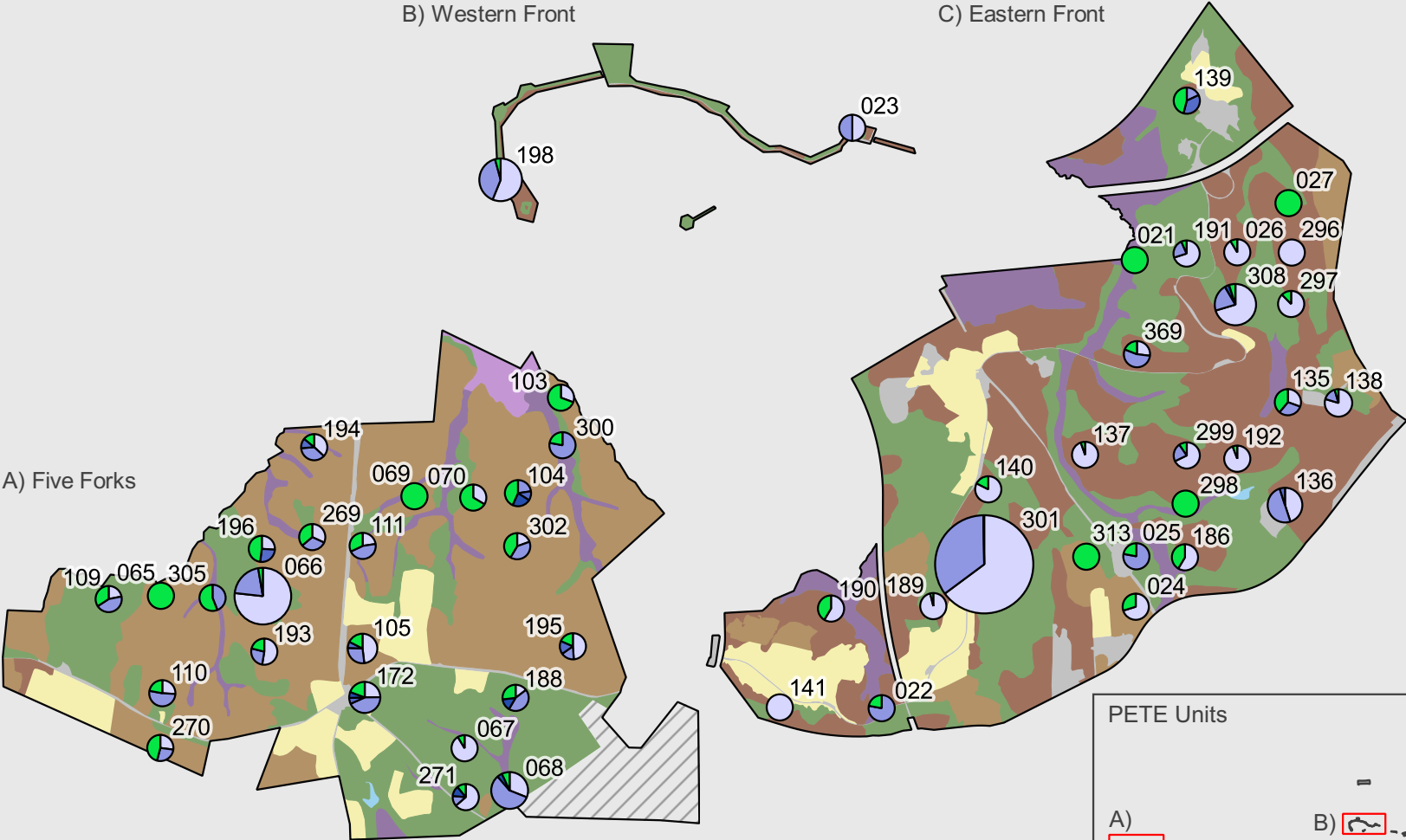
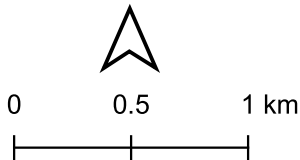
Tree regeneration stem densities by size class in forest plots from the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level regeneration density. Pies may be shifted to prevent overlap. Densities range from 0 to 8.7 stem/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.

Regeneration density

- Seedlings 15 – 30 cm
- Seedlings 30 – 100 cm
- Seedlings 100 – 150 cm
- Seedlings > 150 cm
- Saplings

Vegetation types

- Deciduous forest
- Successional forest
- Conifer forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Open water
- Developed land
- No vegetation data
- Park boundary





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. The number of bars per plot corresponds to the number of times the plot has been sampled. Densities range from 0 to 13.4 stems/sq.m, and only include native canopy-forming species. Charts may be shifted to prevent overlap. Plot 369 was not established until 2013 and was not sampled in Cycle 1. Reporting Date: 08/20/2020.

Regeneration density

- Cycle 1: 2007 – 2010
- Cycle 2: 2011 – 2014
- Cycle 3: 2015 – 2018
- Cycle 4: 2019

Vegetation types

- Deciduous forest
- Successional forest
- Conifer forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Open water
- Developed land
- No vegetation data
- Park boundary

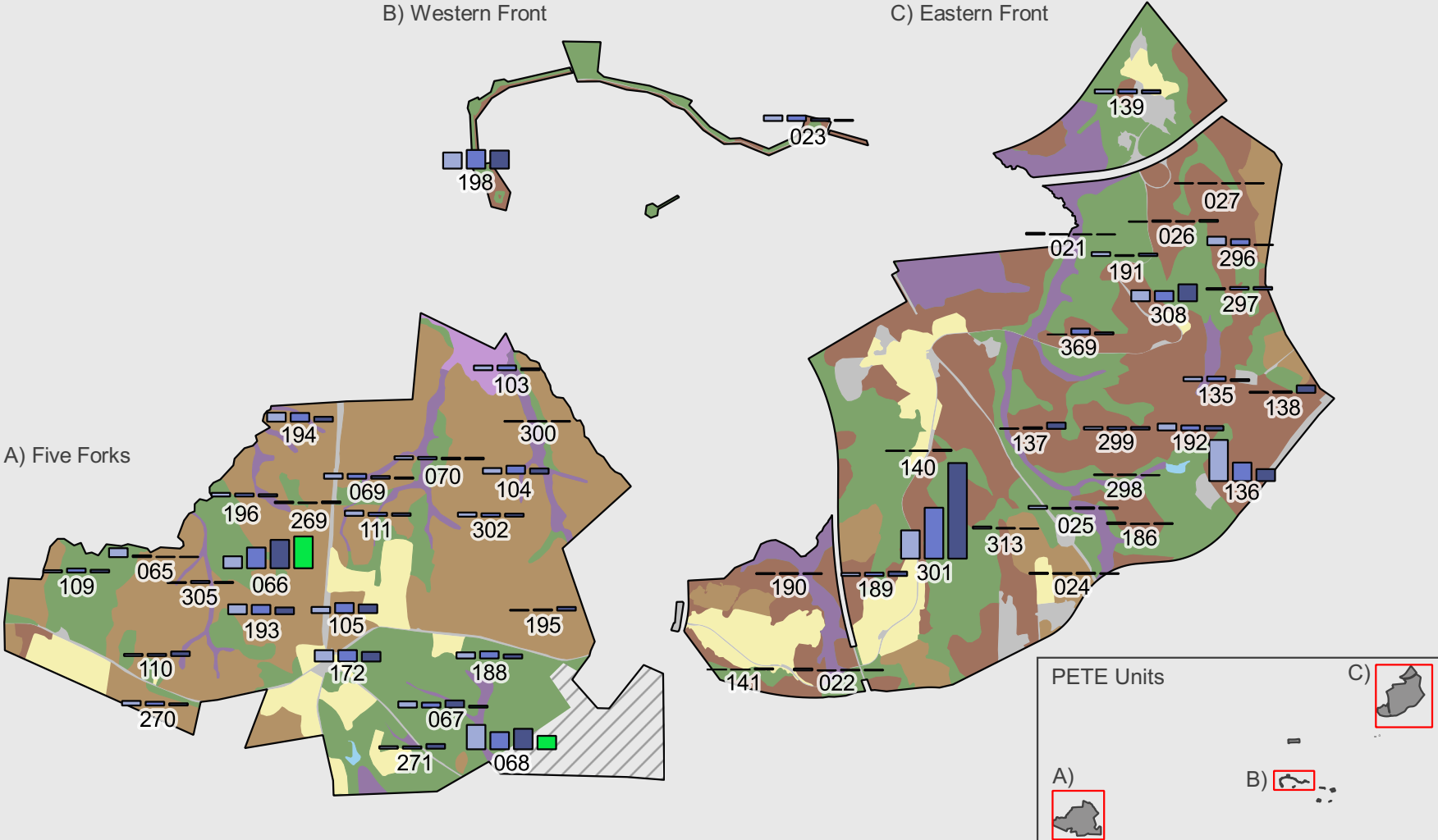


Table 1a. Average plot-level seedling and sapling stem densities (stems/sq.m), and stocking index by cycle for Petersburg National Battlefield Park (Five Forks). Only native canopy-forming species are included. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. Note that only 1/4 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. Plots that meet this threshold are green.

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
065	1.2	0.2	0	0	< 0.1	< 0.1	< 0.1	< 0.1	6.0	4.4	2.9	2.9
066	1.5	2.8	3.8	4.3	0.2	0.2	0.1	0.1	11.1	10.8	11.3	11.1
067	0.8	0.6	0.9	0.3	0.1	0.1	< 0.1	< 0.1	7.0	6.8	5.3	1.4
068	3.1	2.2	2.7	1.8	0.3	0.2	0.2	0.1	21.0	22.6	21.3	13.4
069	0.3	0.3	< 0.1	0	0.5	0.4	0.3	0.2	24.5	21.6	14.8	9.4
070	< 0.1	0	0	< 0.1	0.4	0.4	0.2	0.2	18.4	17.7	12.4	8.3
103	0.3	0.4	< 0.1	–	0.4	0.2	0.2	–	20.5	18.5	9.5	–
104	0.3	0.8	0.4	–	0.5	0.4	0.3	–	23.4	26.5	26.2	–
105	0.5	1.2	1.0	–	0.4	0.2	0.2	–	22.1	14.0	13.5	–
109	0.2	0.4	0.3	–	0.2	0.1	0.1	–	9.5	7.6	6.9	–
110	0.2	0.2	0.5	–	0.1	0.2	0.1	–	8.9	8.0	7.9	–
111	0.6	0.3	0.3	–	0.1	0.1	0.1	–	7.9	5.7	6.3	–
172	1.3	1.3	1.1	–	0.3	0.3	0.3	–	22.8	23.1	20.3	–
188	0.7	0.8	0.4	–	0.2	0.2	0.2	–	12.0	13.6	12.4	–
193	1.1	1.0	0.8	–	0.3	0.3	0.2	–	17.7	16.4	11.0	–
194	1.1	1.1	0.6	–	0.2	0.1	< 0.1	–	10.5	9.7	7.1	–
195	0	< 0.1	0.4	–	0.1	< 0.1	< 0.1	–	5.9	6.4	6.8	–
196	0.3	0.3	0.2	–	0.3	0.2	0.2	–	13.4	10.2	9.4	–
269	< 0.1	0	0.2	–	0.2	0.1	< 0.1	–	7.8	5.9	5.0	–
270	0.4	0.3	0.2	–	0.2	0.2	0.1	–	15.9	9.8	7.3	–
271	0.3	0.3	0.6	–	< 0.1	< 0.1	< 0.1	–	5.0	4.5	8.3	–
300	< 0.1	< 0.1	< 0.1	–	< 0.1	< 0.1	< 0.1	–	1.3	1.3	1.3	–
302	0.3	0.3	0.3	–	0.3	0.2	0.2	–	16.9	11.1	9.3	–
305	0	0.2	< 0.1	–	0.2	0.2	0.1	–	7.7	7.9	5.5	–

Table 1b. Average plot-level seedling and sapling stem densities (stems/sq.m), and stocking index by cycle for Petersburg National Battlefield Park (Eastern and Western Fronts). 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. Plots that meet this threshold are green. Plot 369 was not established until 2013 and was not sampled in Cycle 1.

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
021	0.2	0	0	0	< 0.1	< 0.1	< 0.1	< 0.1	4.3	2.9	1.8	1.8
022	0.3	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.6	1.2	1.3	1.3
023	0.8	0.8	0.3	0.2	< 0.1	< 0.1	< 0.1	0	3.8	1.6	1.0	0.3
024	< 0.1	< 0.1	0.2	< 0.1	0.1	< 0.1	< 0.1	< 0.1	5.4	3.0	1.9	1.9
025	0.3	< 0.1	0.2	0.2	< 0.1	< 0.1	< 0.1	< 0.1	4.5	3.7	3.3	2.7
026	0	0.2	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	2.9	1.9	1.9	1.4
027	0	0	0	0	< 0.1	< 0.1	< 0.1	< 0.1	2.9	2.9	2.4	2.4
135	0.4	0.5	0.2	–	0.2	0.1	0.1	–	8.2	7.7	5.6	–
136	5.8	2.6	1.7	–	0	0	0	–	9.3	3.8	4.1	–
137	0	0.2	0.8	–	< 0.1	< 0.1	< 0.1	–	2.9	3.2	3.2	–
138	< 0.1	0.2	1.0	–	< 0.1	< 0.1	< 0.1	–	4.2	3.1	3.5	–
139	0.3	0.3	0.3	–	0.2	0.2	0.2	–	13.2	15.3	14.1	–
140	0	0	0.2	–	< 0.1	< 0.1	< 0.1	–	2.4	2.4	1.9	–
141	0	0	0.2	–	0	0	0	–	0	0	0.2	–
186	0.2	0	< 0.1	–	< 0.1	< 0.1	< 0.1	–	3.7	2.9	3.0	–
189	0.3	0.4	0.6	–	< 0.1	< 0.1	< 0.1	–	4.5	2.8	1.8	–
190	< 0.1	< 0.1	< 0.1	–	< 0.1	< 0.1	< 0.1	–	3.7	4.2	3.0	–
191	0.5	< 0.1	0.3	–	< 0.1	< 0.1	< 0.1	–	7.1	2.4	1.6	–
192	0.9	0.7	0.6	–	< 0.1	< 0.1	< 0.1	–	3.9	2.6	2.4	–
198	2.1	2.5	2.4	–	0.2	0.1	0.1	–	12.4	13.0	8.7	–
296	1.2	0.8	< 0.1	–	< 0.1	< 0.1	0	–	8.3	5.9	< 0.1	–
297	0.2	0.3	0.3	–	< 0.1	< 0.1	< 0.1	–	3.1	2.8	2.7	–
298	< 0.1	< 0.1	0	–	< 0.1	< 0.1	< 0.1	–	1.9	1.3	1.2	–
299	0.3	0.3	0.3	–	< 0.1	< 0.1	< 0.1	–	8.4	10.9	2.2	–
301	3.9	7.1	13.3	–	< 0.1	< 0.1	< 0.1	–	5.7	10.3	19.8	–
308	1.4	1.3	2.3	–	0.1	0.1	0.1	–	9.5	12.6	12.7	–
313	0.3	< 0.1	0	–	< 0.1	< 0.1	< 0.1	–	2.1	1.3	1.2	–
369	–	0.8	0.3	–	–	< 0.1	< 0.1	–	–	4.5	3.4	–

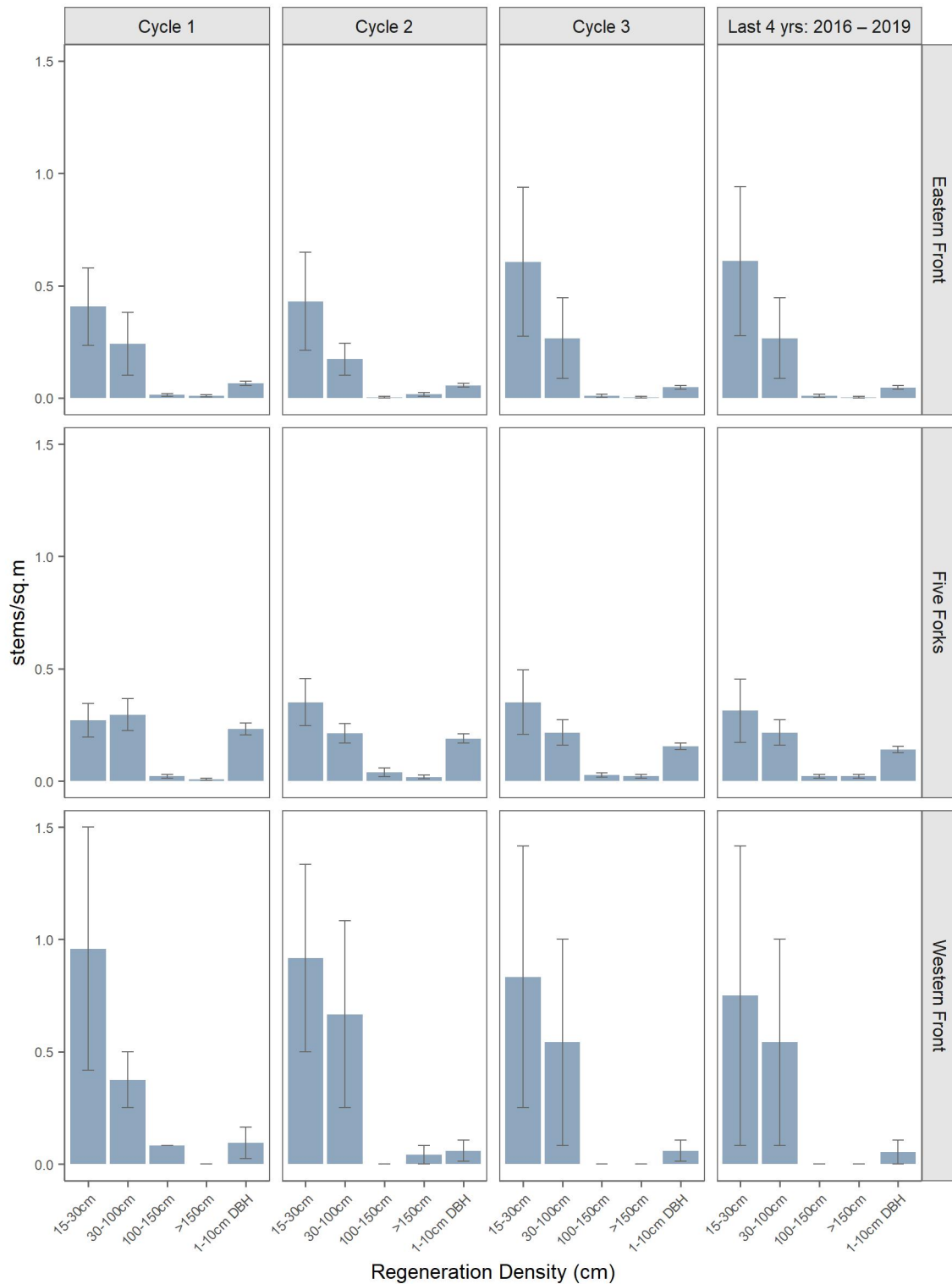


Figure 1. Seedling and sapling stem density distributions by size class for each unit in Petersburg National Battlefield Park. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. The last 4 years is the most recent survey of every plot. Error bars are ± 1 SE.

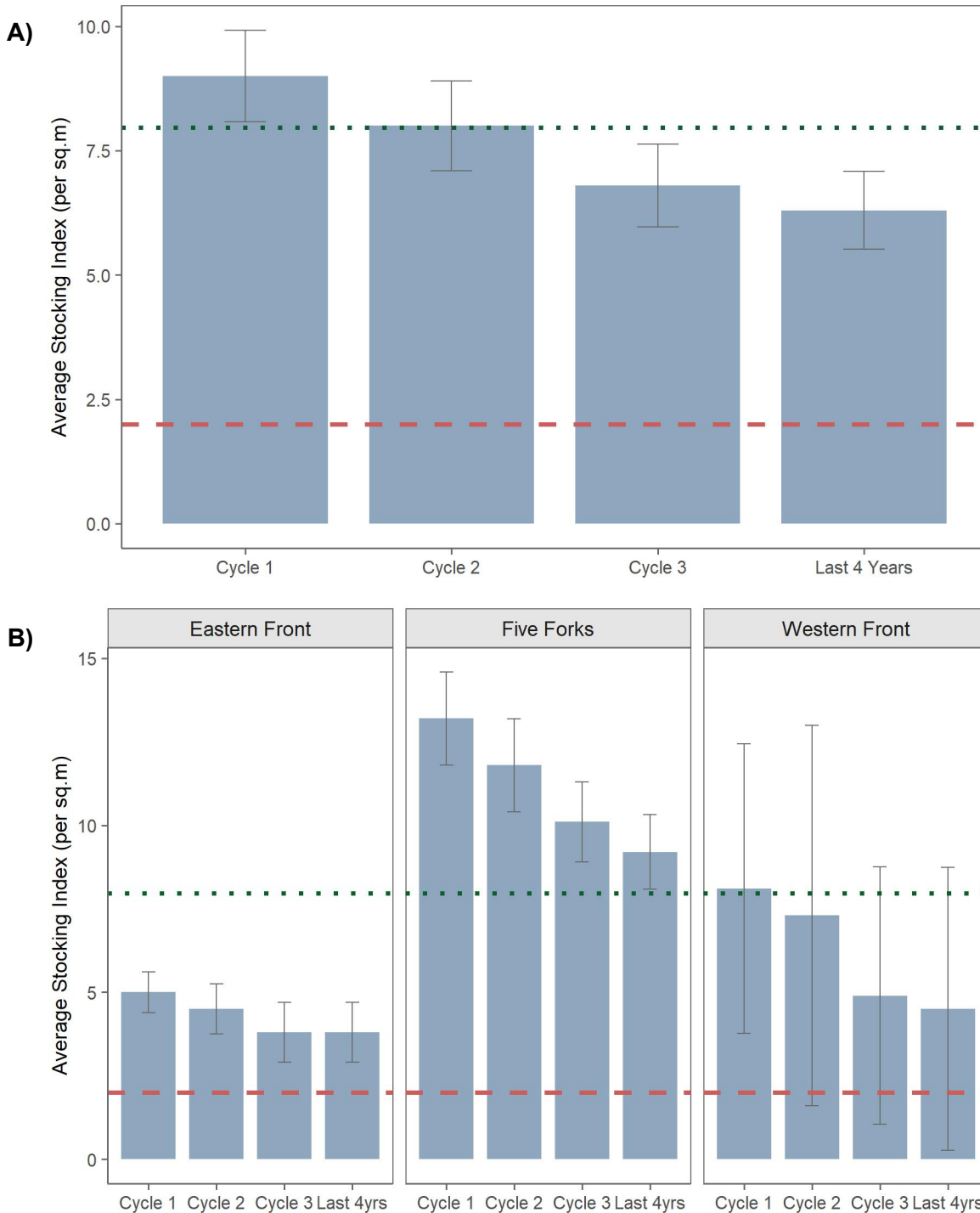


Figure 2. Regeneration stocking index averaged by cycle overall (A) and by unit (B) in Petersburg National Battlefield Park. The index is a weighted sum of seedling and sapling densities where larger seedling size classes get higher weights. The stocking index only includes native canopy-forming species (range: 0 – 40.1). 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 yrs is 2016 – 2019. Error bars are ± 1 SE.



Map 3. Tree Regeneration Stocking Index

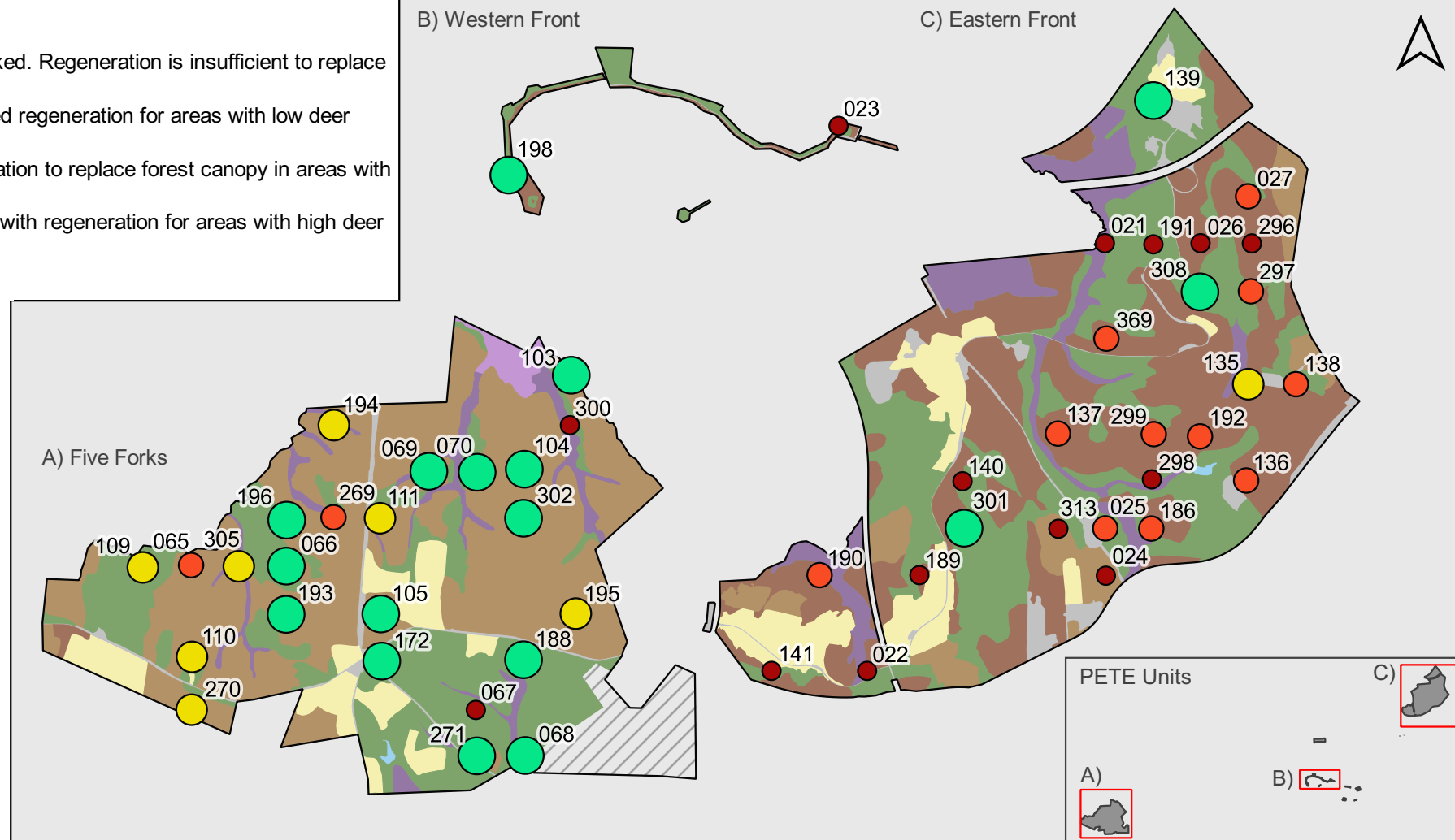
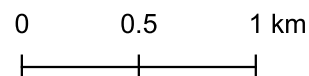
Regeneration stocking index for the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. The stocking index quantifies whether current regeneration densities are sufficient to restock a forest canopy. The 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: < 0.1 – 26.2). 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.

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 forest
- Conifer plantation
- Forested wetland/
Floodplain
- Open wetland
- Open field
- Open water
- Developed land
- No vegetation data
- Park boundary



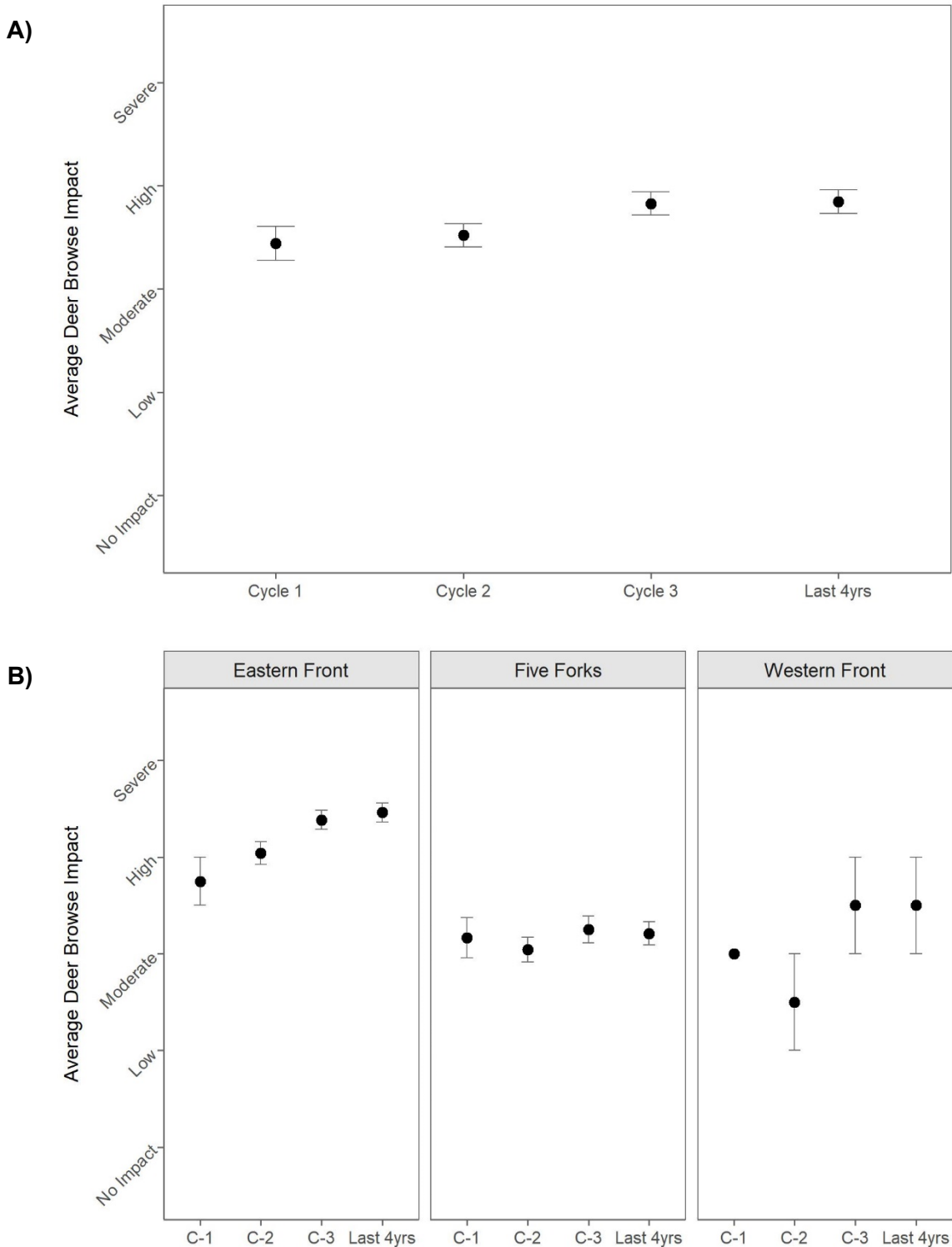


Figure 3. Average deer browse impact by cycle in Petersburg National Battlefield Park. Deer browse impacts are assessed on a scale of 1 – 5, with 1 representing no impact and 5 representing severe impacts. Cycle 1 is 2009 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018, Last 4 Years is 2016 – 2019. DBI was not collected until 2009. Error bars are ± 1 SE.



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.

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.

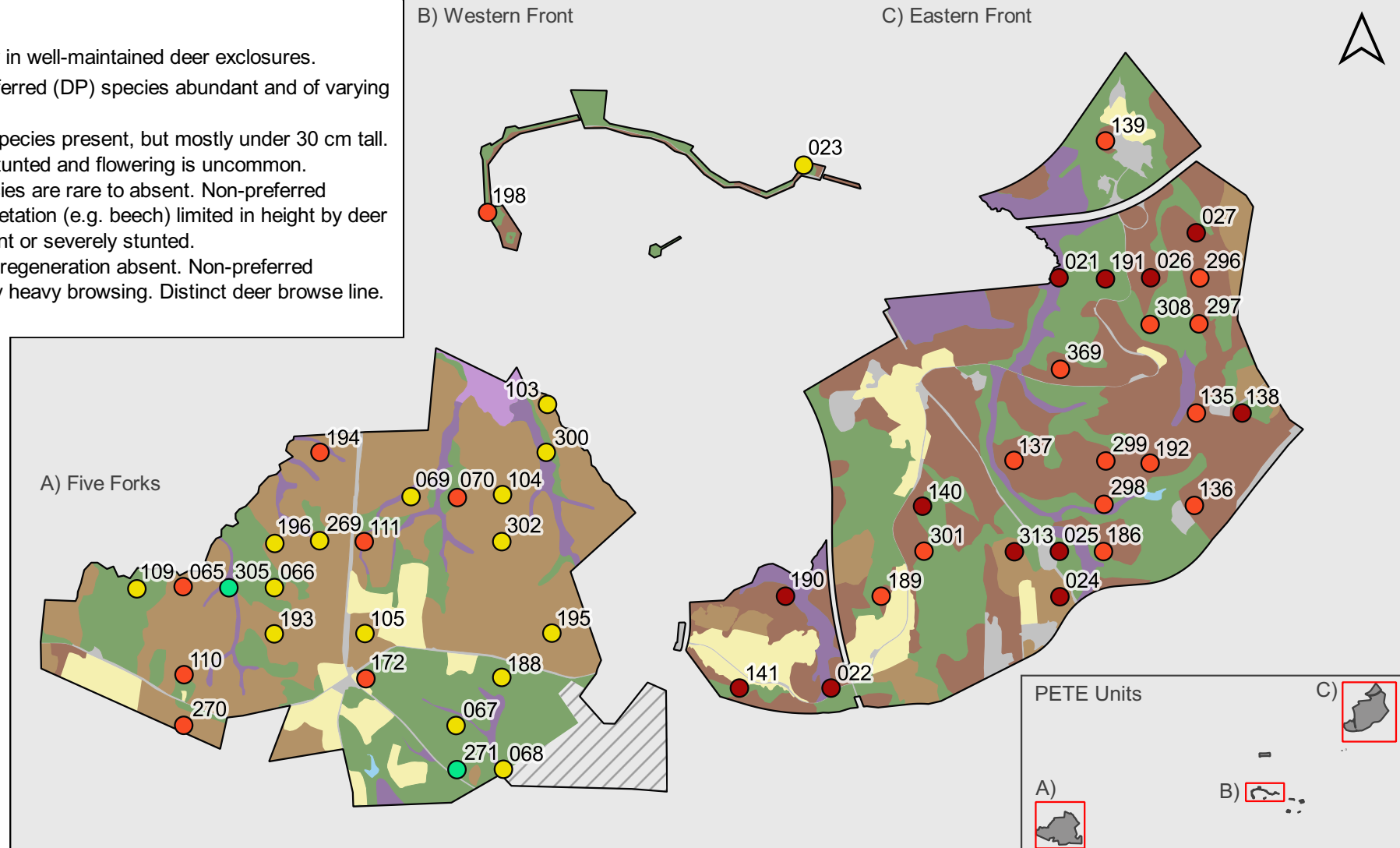
Vegetation types

- Deciduous forest
- Successional forest
- Conifer forest
- Conifer plantation
- Forested wetland/
Floodplain
- Open wetland
- Open field
- Open water
- Developed land
- No vegetation data
- Park boundary

0 0.5 1 km

B) Western Front

C) Eastern Front



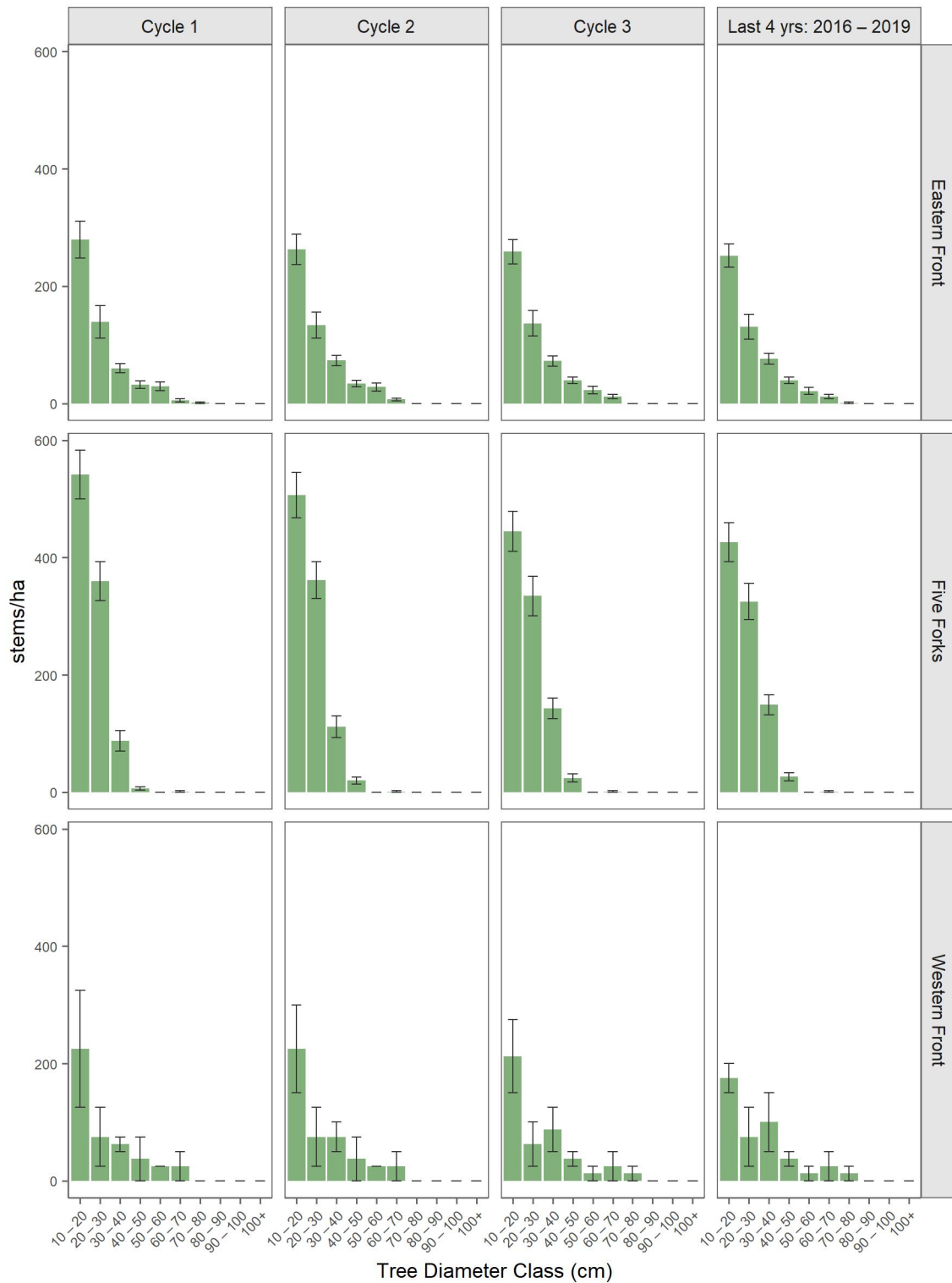


Figure 4. Tree stem density distributions by 10 cm diameter at breast height increments for each unit in Petersburg National Battlefield Park. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. The last 4 years is the most recent survey of every plot. Error bars are ± 1 SE.



Map 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 12.3 stem/sq.m for an individual species group. See <https://npsforveg.shinyapps.io/midn/> for more specific plot level information. Reporting Date: 08/20/2020.

Species in pie charts

- Acer spp. (Maple)

Carya spp. (Hickory)

Fagus grandifolia (Beech)

Fraxinus spp. (Ash)

Ilex opaca (American holly)

Liquidambar styraciflua (Sweetgum)

Liriodendron tulipifera (Tuliptree)
- Nyssa sylvatica (Black tupelo)

Pinus taeda (Loblolly pine)

Quercus spp. (Oak)

Exotic species

Low canopy species

Other native species

Vegetation types

- Deciduous forest

Successional forest

Conifer forest

Conifer plantation

Forested wetland/
Floodplain

Open wetland

Open field

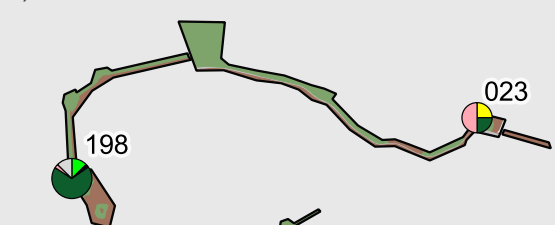
Open water

Developed land

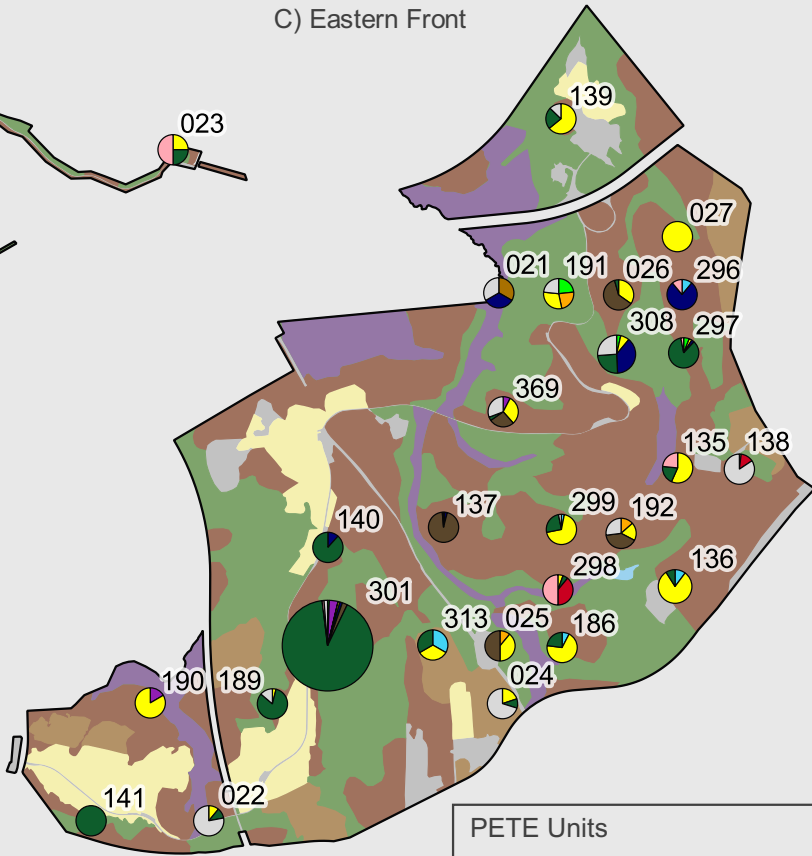
No vegetation data

Park boundary

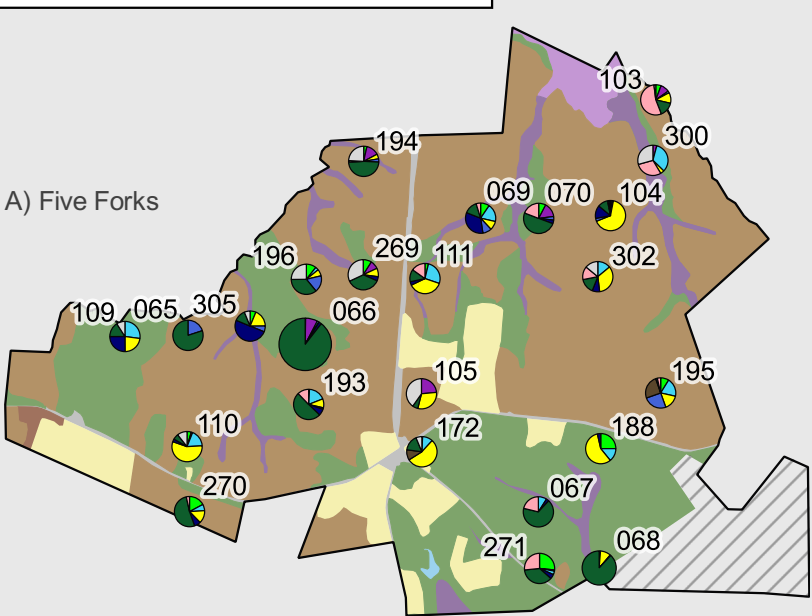
B) Western Front



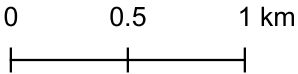
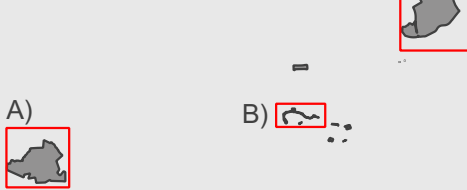
C) Eastern Front



A) Five Forks



PETE Units





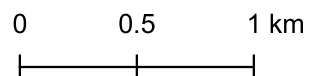
Map 6. Tree Canopy Composition

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 59.8 sq.m/ha for an individual species group. See <https://npsforveg.shinyapps.io/midn/> for more specific plot level information. Note: *Pinus* spp. is mostly *Pinus taeda*. Reporting Date: 08/20/2020.

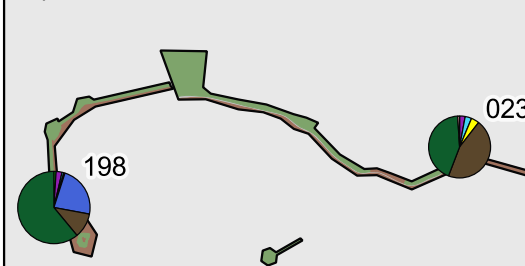
Species in pie charts



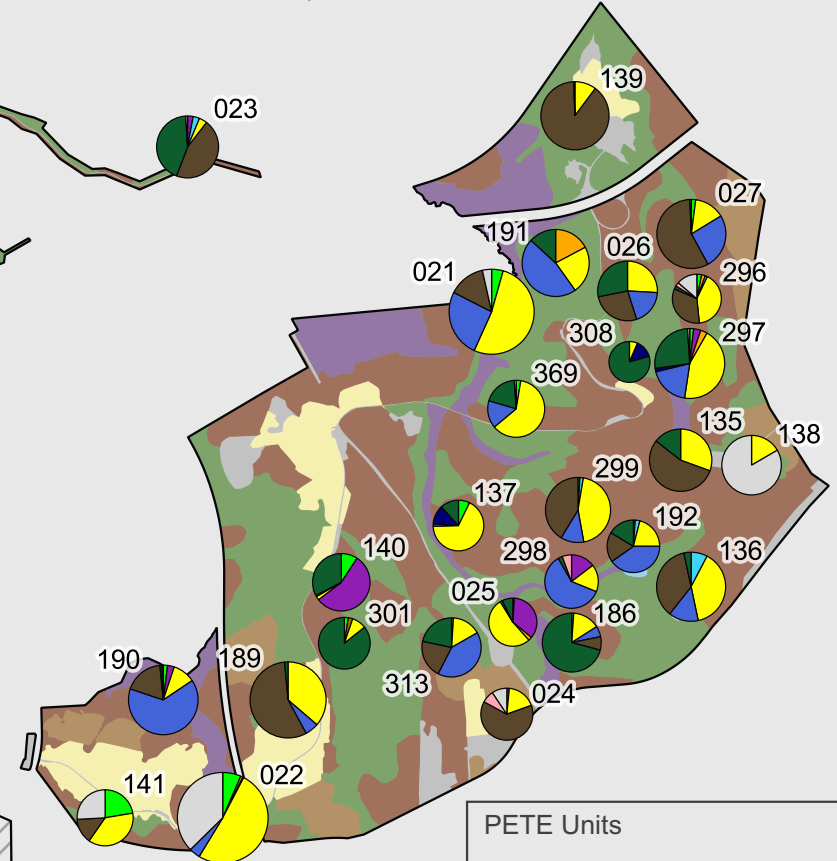
Vegetation types



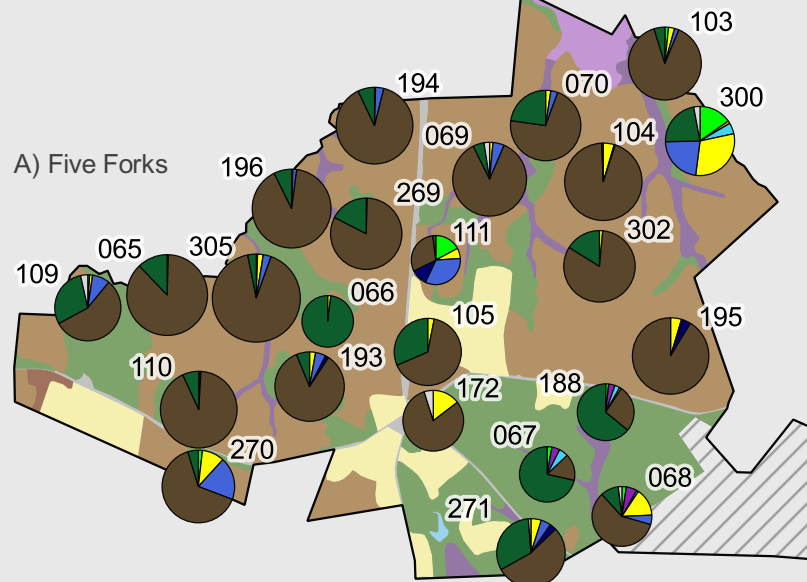
B) Western Front



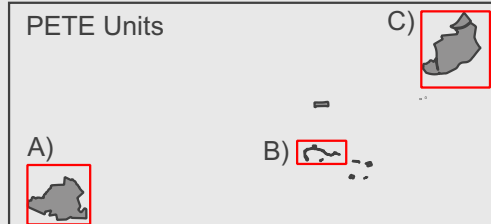
C) Eastern Front



A) Five Forks



PETE Units





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. The number of bars per plot corresponds to the number of times the plot has been sampled. Average invasive cover per plot ranges from 0 to 66.3%. See Table 2 for % cover values. See Table 3 for a species list; only species monitored since 2007 were included in this metric. Plot 369 was not established until 2013 and was not sampled in Cycle 1. Reporting Date: 08/20/2020.

Invasive % cover

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

Vegetation types

- Deciduous forest
- Successional forest
- Conifer forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Open water
- Developed land
- No vegetation data
- Park boundary

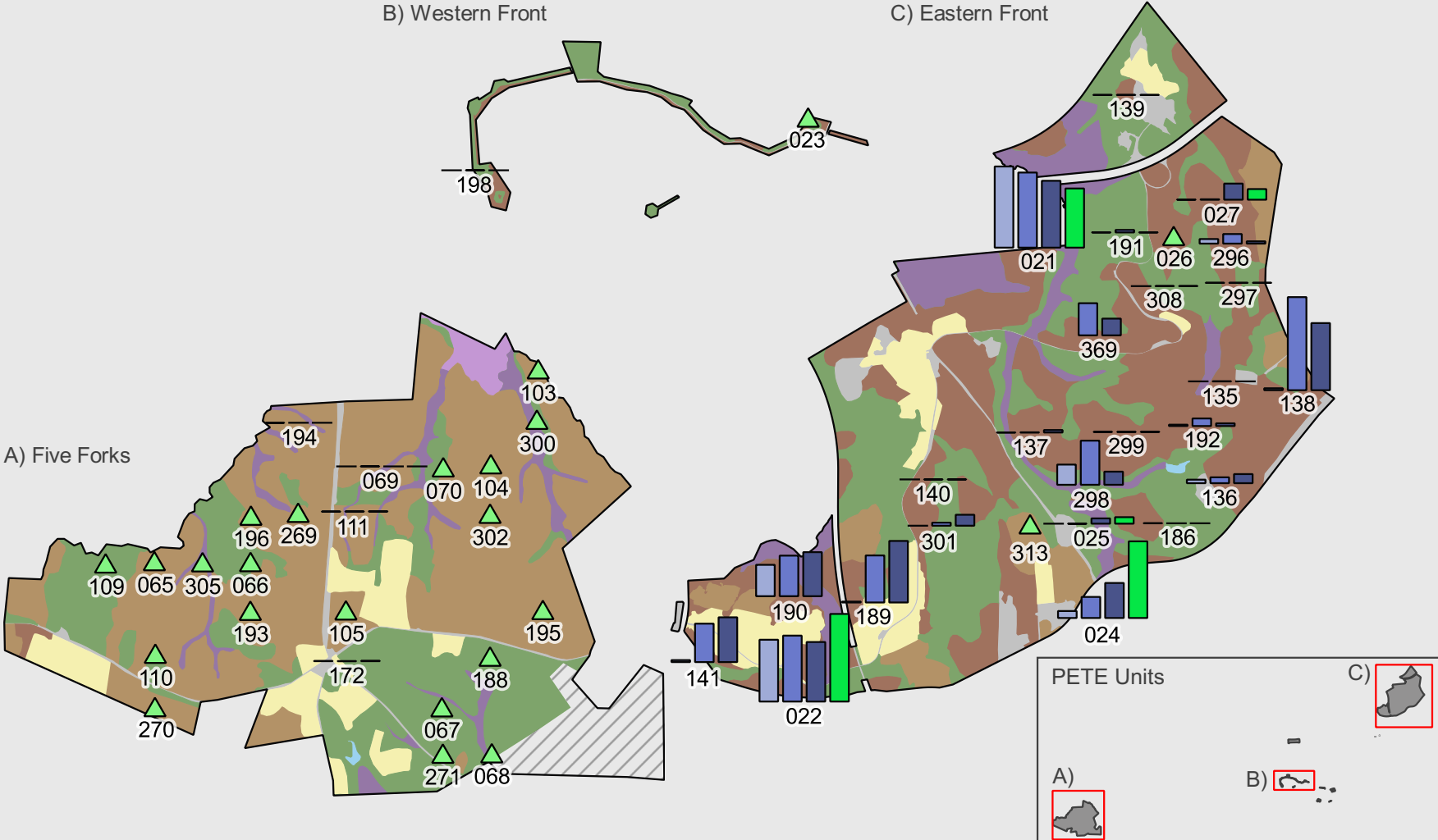
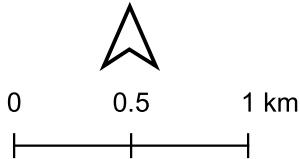


Table 2a. Average % cover and number of invasive species detected in each plot by cycle in Petersburg National Battlefield Park (Five Forks). Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 4 in 2019. See Table 3 for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

Plot	Average % cover			
	Cycle 1	Cycle 2	Cycle 3	Cycle 4
065	0	0	0	0
066	0	0	0	0
067	0	0	0	0
068	0	0	0	0
069	0	< 0.1	0	0
070	0	0	0	0
103	0	0	0	–
104	0	0	0	–
105	0	0	0	–
109	0	0	0	–
110	0	0	0	–
111	< 0.1	0.1	0.3	–
172	0.1	< 0.1	0.3	–
188	0	0	0	–
193	0	0	0	–
194	< 0.1	0	0	–
195	0	0	0	–
196	0	0	0	–
269	0	0	0	–
270	0	0	0	–
271	0	0	0	–
300	0	0	0	–
302	0	0	0	–
305	0	0	0	–

Table 2b. Average % cover of invasive species detected in each plot by cycle in Petersburg National Battlefield Park (Eastern and Western Fronts). 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 369 was not established until 2013 and was not sampled in Cycle 1.

Plot	Average % cover			
	Cycle 1	Cycle 2	Cycle 3	Cycle 4
021	57.8	53.5	47.6	42.1
022	44.0	46.9	42.4	62.4
023	0	0	0	0
024	5.0	15.0	24.9	54.6
025	0	< 0.1	3.8	4.6
026	0	0	0	0
027	0.1	0.3	11.5	7.6
135	0	< 0.1	0	–
136	2.5	4.2	6.5	–
137	< 0.1	0.1	1.8	–
138	1.4	66.3	47.6	–
139	< 0.1	< 0.1	< 0.1	–
140	0	< 0.1	< 0.1	–
141	1.4	27.4	31.9	–
186	< 0.1	0	0	–
189	0.6	33.5	43.8	–
190	22.3	28.9	31.4	–
191	< 0.1	1.8	< 0.1	–
192	1.0	5.4	1.9	–
198	0	< 0.1	0	–
296	3.3	6.8	1.6	–
297	< 0.1	< 0.1	< 0.1	–
298	14.4	31.4	9.4	–
299	< 0.1	< 0.1	0.1	–
301	0	2.2	7.8	–
308	0	< 0.1	< 0.1	–
313	0	0	0	–
369	–	22.9	11.9	–



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 61.9% for an individual species. See Table 3 for more information. Reporting Date: 08/20/2020.

Species in pie charts

- Ailanthus altissima (Tree-of-heaven)
- Hedera helix (English ivy)
- Lespedeza cuneata (Chinese lespedeza)
- Ligustrum spp. (Privet)
- Lonicera japonica (Japanese honeysuckle)
- Microstegium vimineum (Japanese stiltgrass)
- Morus alba (White mulberry)
- Other exotic herbs

Vegetation types

- Deciduous forest
- Successional forest
- Conifer forest
- Conifer plantation
- Forested wetland/
Floodplain
- Open wetland
- Open field
- Open water
- Developed land
- No vegetation data
- Park boundary

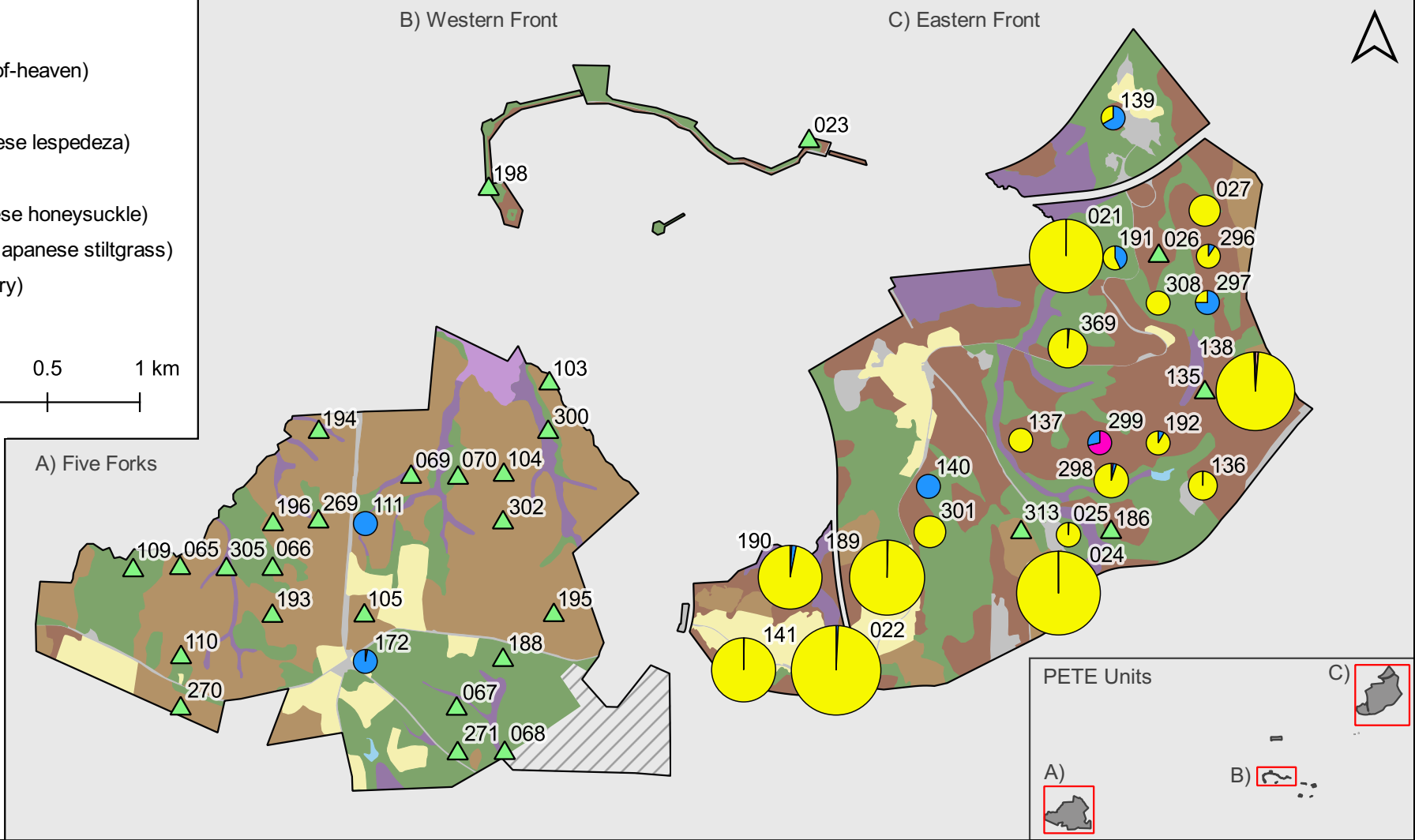
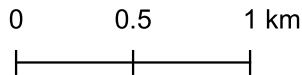


Table 3. Number of plots where invasive species were detected by cycle in Petersburg National Battlefield Park. Cycle 1 is 2007 – 2010, Cycle 2 is 2011 – 2014, Cycle 3 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 4 in 2019. Note that not all species have been monitored 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>Ailanthus altissima</i>	Tree-of-heaven	2007	1	1	2	0
<i>Berberis thunbergii</i>	Japanese barberry	2007	0	1	1	1
<i>Duchesnea indica</i> *	Mock strawberry	2007	0	1	1	1
<i>Elaeagnus</i> spp. ¹	Exotic olive	2019	0	1	2	1
<i>Euonymus fortunei</i>	Climbing euonymus	2007	1	0	0	0
<i>Hedera helix</i>	English ivy	2007	1	3	3	0
<i>Lespedeza cuneata</i>	Chinese lespedeza	2007	1	3	4	2
<i>Ligustrum</i> spp.	Privet	2009	0	5	8	2
<i>Lonicera</i> spp. - Exotic	Exotic bush honeysuckle	2007	4	0	0	0
<i>Lonicera japonica</i>	Japanese honeysuckle	2007	14	22	22	3
<i>Microstegium vimineum</i>	Japanese stiltgrass	2007	17	23	24	6
<i>Morus alba</i>	White mulberry	2007	0	1	1	0
<i>Nandina domestica</i> ¹	Heavenly bamboo	2019	0	1	1	0
<i>Persicaria longiseta</i> *	Oriental lady's thumb	2009	0	4	1	3
<i>Rosa multiflora</i>	Multiflora rose	2007	0	3	1	1
<i>Rubus phoenicolasius</i>	Wine raspberry	2007	0	0	1	0
Number of plots sampled	–	–	51	52	52	13

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