



Map 1. Tree Regeneration by Size Class

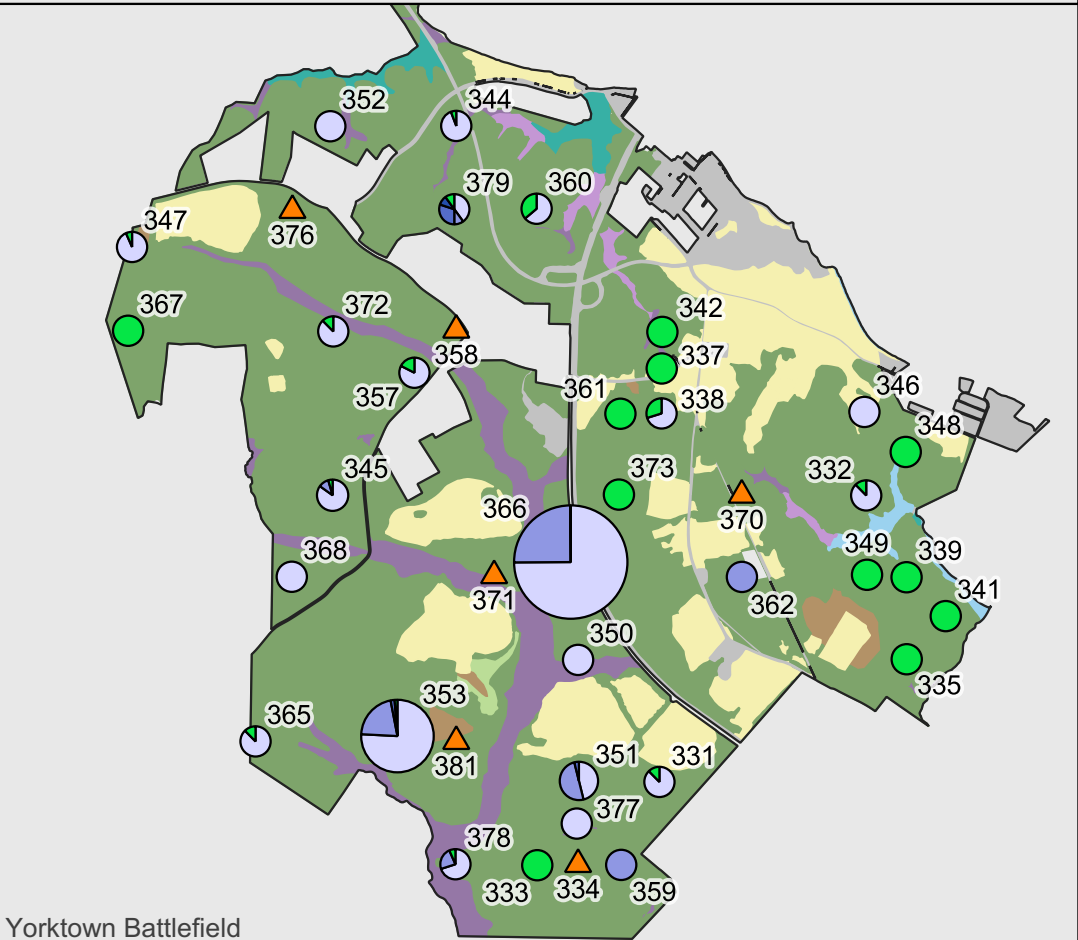
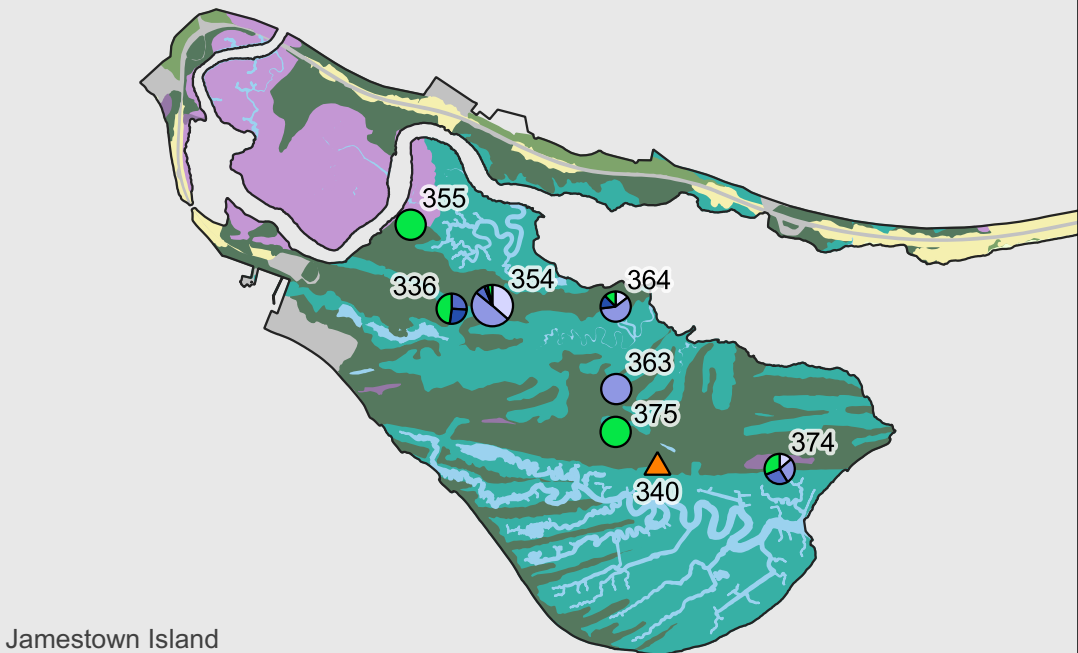
Tree regeneration stem densities by size class in forest plots from the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level regeneration density. Pies may be shifted to prevent overlap. Densities range from 0 to 8.8 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. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. Reporting Date: 08/20/2020.

Vegetation types

- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

Regeneration density

- Seedlings 15 – 30 cm
- Seedlings 30 – 100 cm
- Seedlings 100 – 150 cm
- Seedlings > 150 cm
- Saplings
- None present



0 3 6 km



Map 2. Tree Regeneration by Cycle

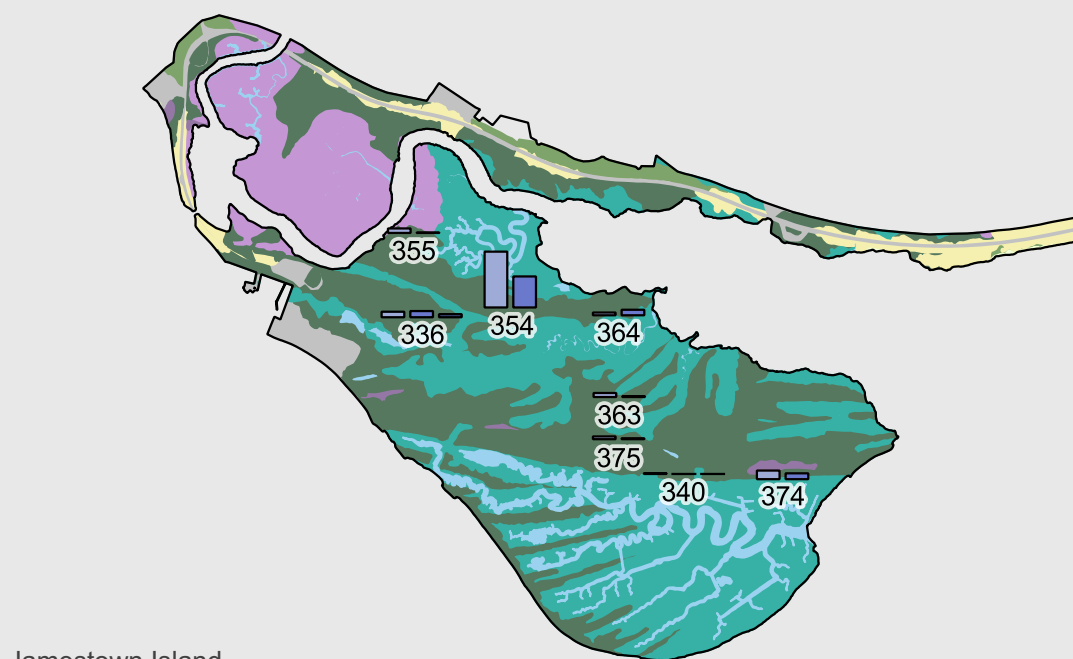
Tree regeneration stem densities, including seedlings and saplings, in forest plots sampled from 2007 – 2019. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Densities range from 0 to 11.7 stems/sq.m, and only include native canopy-forming species. Charts may be shifted to prevent overlap. The number of bars per plot corresponds to the number of times the plot has been sampled. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. Reporting Date: 08/20/2020.

Vegetation types

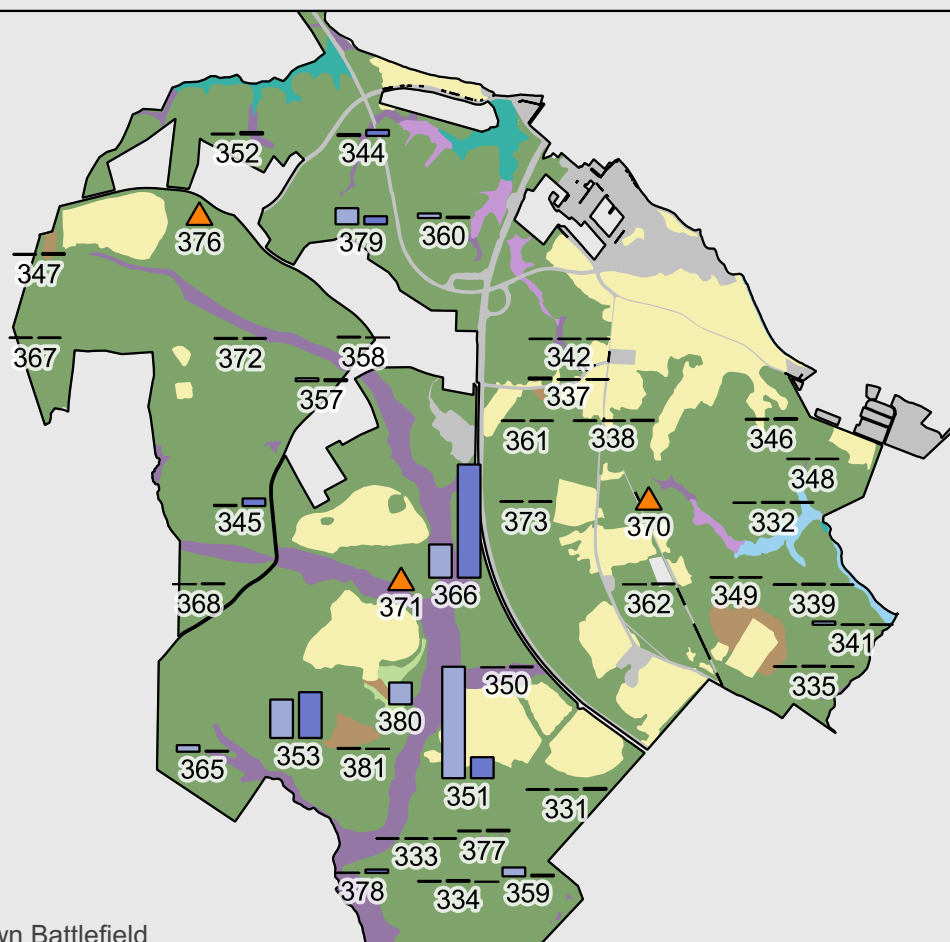
- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

Regeneration density

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



Jamestown Island



Yorktown Battlefield



0 3 6 km

Table 1a. Average plot-level seedling and sapling stem densities (stems/sq.m), and stocking index by cycle for Colonial National Historical Park (Yorktown Battlefield). Only native canopy-forming species are included. Cycle 1 is 2011 – 2014; Cycle 2 is 2015 – 2018. Note that only a 1/4 of the plots have been sampled for Cycle 3 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. Note that plot 380 was not sampled in Cycle 2 due to flooding by beaver dam.

Plot	Seedlings per sq. meter			Saplings per sq. meter			Stocking Index		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
331	0	0	0.2	< 0.1	< 0.1	< 0.1	2.4	2.4	1.3
332	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	0.7	0.7
333	0	0	0	< 0.1	< 0.1	< 0.1	0.6	0.6	0.6
334	< 0.1	0.2	0	0	0	0	0.2	0.2	0
335	0	< 0.1	0	< 0.1	< 0.1	< 0.1	0.6	0.7	0.6
337	0.2	0	0	< 0.1	< 0.1	< 0.1	1.3	0.6	0.6
338	0	0	< 0.1	< 0.1	< 0.1	< 0.1	2.9	2.4	1.9
339	0	< 0.1	0	< 0.1	< 0.1	< 0.1	1.2	1.3	0.6
341	0.3	0	0	< 0.1	< 0.1	< 0.1	0.9	0.6	0.6
342	0	0	0	< 0.1	< 0.1	< 0.1	1.2	1.2	1.2
344	0.2	0.6	-	< 0.1	< 0.1	-	1.3	2.4	-
345	< 0.1	0.8	-	< 0.1	< 0.1	-	1.9	2.6	-
346	< 0.1	0.2	-	< 0.1	0	-	0.7	0.2	-
347	< 0.1	0.2	-	< 0.1	< 0.1	-	0.7	0.8	-
348	0	0	-	< 0.1	< 0.1	-	1.2	1.2	-
349	0	0	-	< 0.1	< 0.1	-	1.2	1.2	-
350	0	0.1	-	0	0	-	0	< 0.1	-
351	11.5	2.2	-	0	0	-	14.2	4.8	-
352	< 0.1	0.3	-	0	0	-	< 0.1	0.3	-
353	3.9	4.7	-	< 0.1	< 0.1	-	6.4	10.2	-
357	0.3	0.2	-	< 0.1	< 0.1	-	2.6	1.9	-
358	< 0.1	0	-	0	0	-	< 0.1	0	-
359	0.9	0.2	-	0	0	-	1.3	0.3	-
360	0.4	< 0.1	-	< 0.1	< 0.1	-	3.4	2.4	-
361	0	0	-	< 0.1	< 0.1	-	2.4	2.4	-
362	0	< 0.1	-	0	0	-	0	0.2	-
365	0.7	< 0.1	-	< 0.1	< 0.1	-	1.3	0.7	-
366	3.4	11.7	-	< 0.1	< 0.1	-	4.4	15.2	-
367	0	0	-	< 0.1	< 0.1	-	1.8	1.8	-
368	0	< 0.1	-	0	0	-	0	< 0.1	-

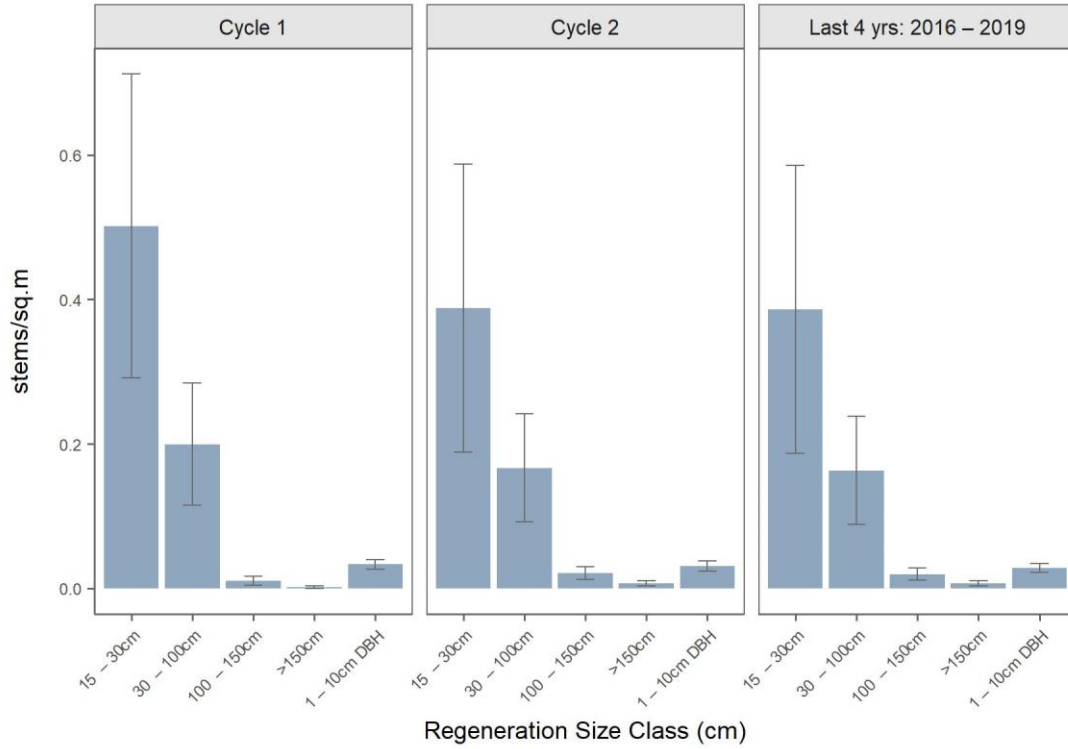
Table 1a. (continued)

Plot	Seedlings per sq. meter			Saplings per sq. meter			Stocking Index		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
370	0	0	-	0	0	-	0	0	-
371	0	0	-	0	0	-	0	0	-
372	< 0.1	< 0.1	-	< 0.1	< 0.1	-	0.7	0.7	-
373	0	0	-	< 0.1	< 0.1	-	1.2	1.2	-
376	0	0	-	0	0	-	0	0	-
377	< 0.1	0.2	-	0	0	-	0.2	0.2	-
378	0	0.3	-	< 0.1	< 0.1	-	1.2	1.6	-
379	1.6	0.8	-	< 0.1	< 0.1	-	7.7	13.8	-
380	2.3	-	-	0	-	-	4.0	-	-
381	< 0.1	0	-	0	0	-	< 0.1	0	-

Table 1b. Average plot-level seedling and sapling stem densities (stems/sq.m), and stocking index by cycle for Colonial National Historical Park (Jamestown Island). Only native canopy-forming species are included. Cycle 1 is 2011 – 2014; Cycle 2 is 2015 – 2018. Note that only a 1/4 of the plots have been sampled for Cycle 3 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 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
336	0.3	0.4	0.2	0.2	0.2	0.2	15.5	19.0	13.5
340	< 0.1	0	0	0	0	0	< 0.1	0	0
354	5.7	3.1	-	< 0.1	0.1	-	17.8	19.4	-
355	0.3	0	-	0.1	0	-	7.0	1.8	-
363	0.4	< 0.1	-	0	0	-	0.6	0.2	-
364	0.2	0.5	-	0.1	< 0.1	-	10.2	8.5	-
374	0.8	0.4	-	0.1	0.2	-	8.2	13.2	-
375	0.2	0	-	0.1	< 0.1	-	6.1	4.7	-

A)



B)

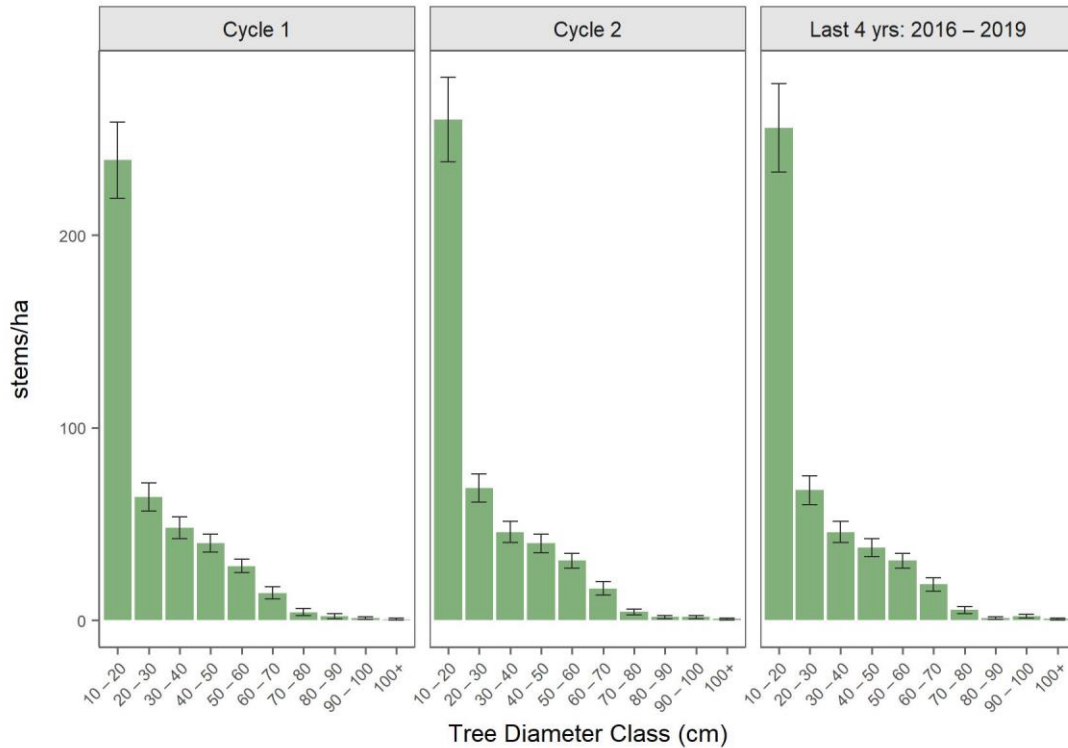


Figure 1. Stem density distributions for Colonial National Historical Park. Figure A shows seedling and sapling densities by size class. Figure B shows tree density by diameter at breast height at 10 cm increments. Cycle 1 is 2011 – 2014, Cycle 2 is 2015 – 2018, last four years are 2016 – 2019. The last 4 years is the most recent survey of every plot. Error bars is ± 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 – 19.4). 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. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. Reporting Date: 08/20/2020.

Vegetation types

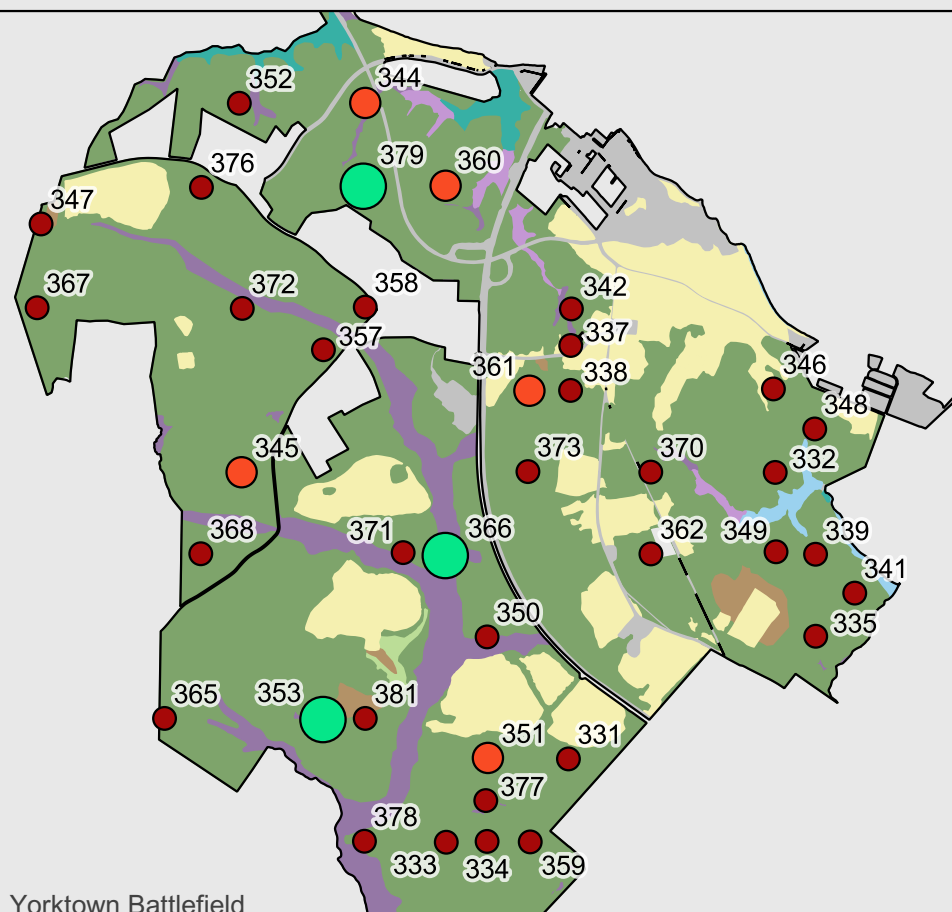
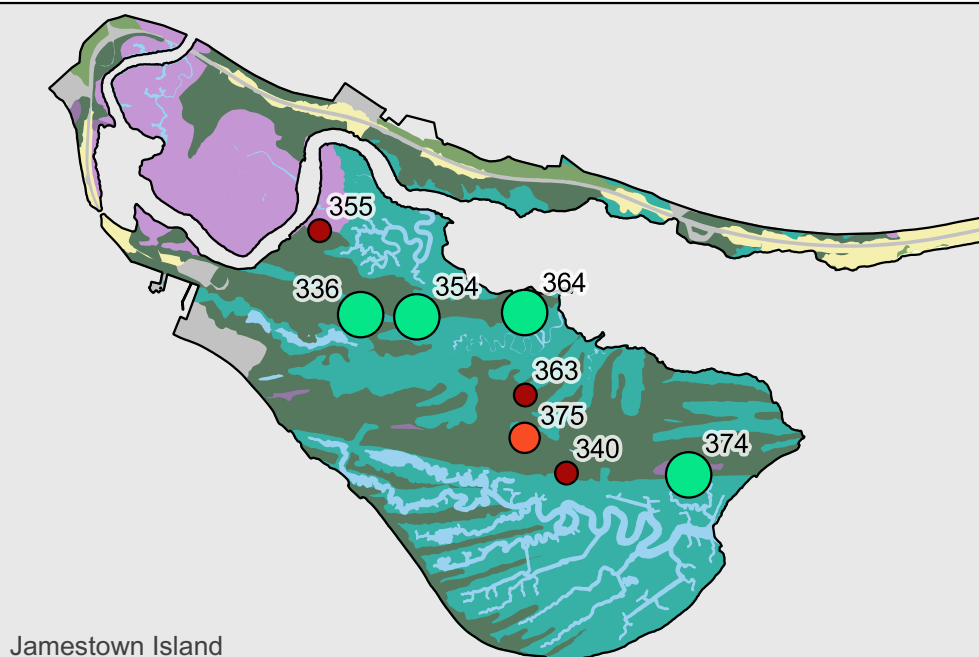
- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

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.



0 3 6 km



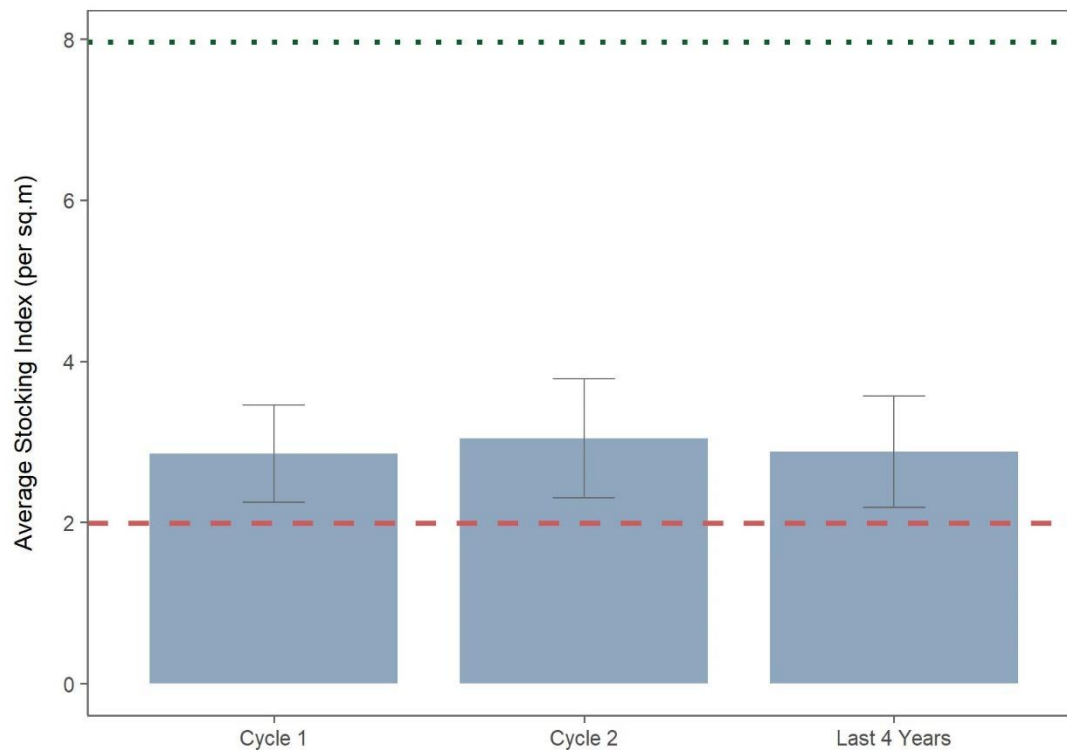


Figure 2. Regeneration stocking index averaged by cycle in Colonial National Historical Park. The index is a weighted sum of seedling and sapling densities where larger seedling size classes get higher weights. The stocking index only includes native canopy-forming species (range: 0 – 19.4). Values below 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 2011 – 2014, Cycle 2 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. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. Reporting Date: 08/20/2020.

Vegetation types

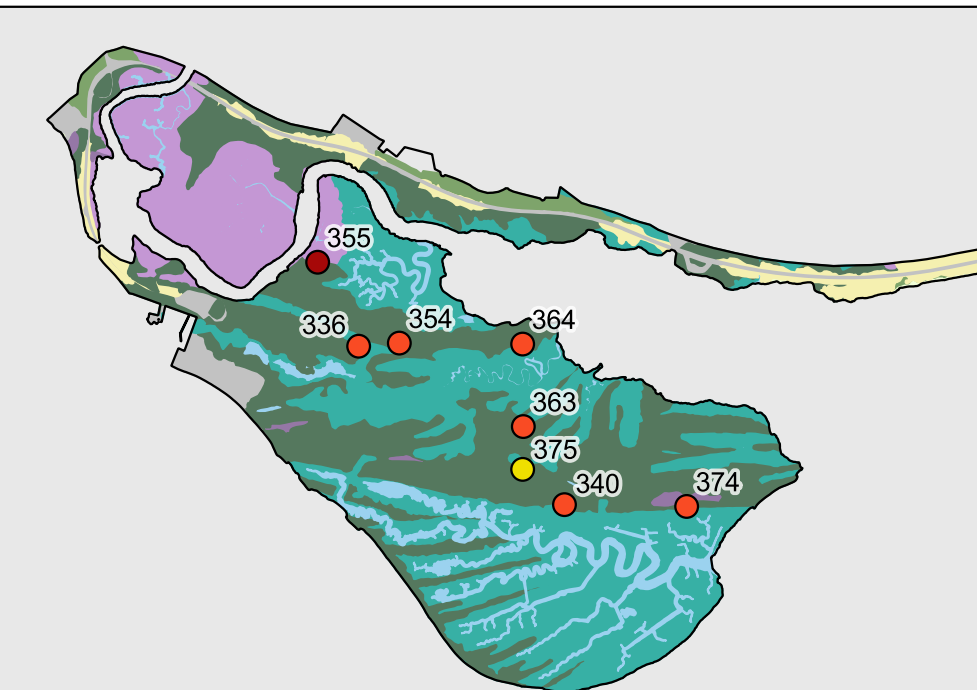
- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

Deer browse index

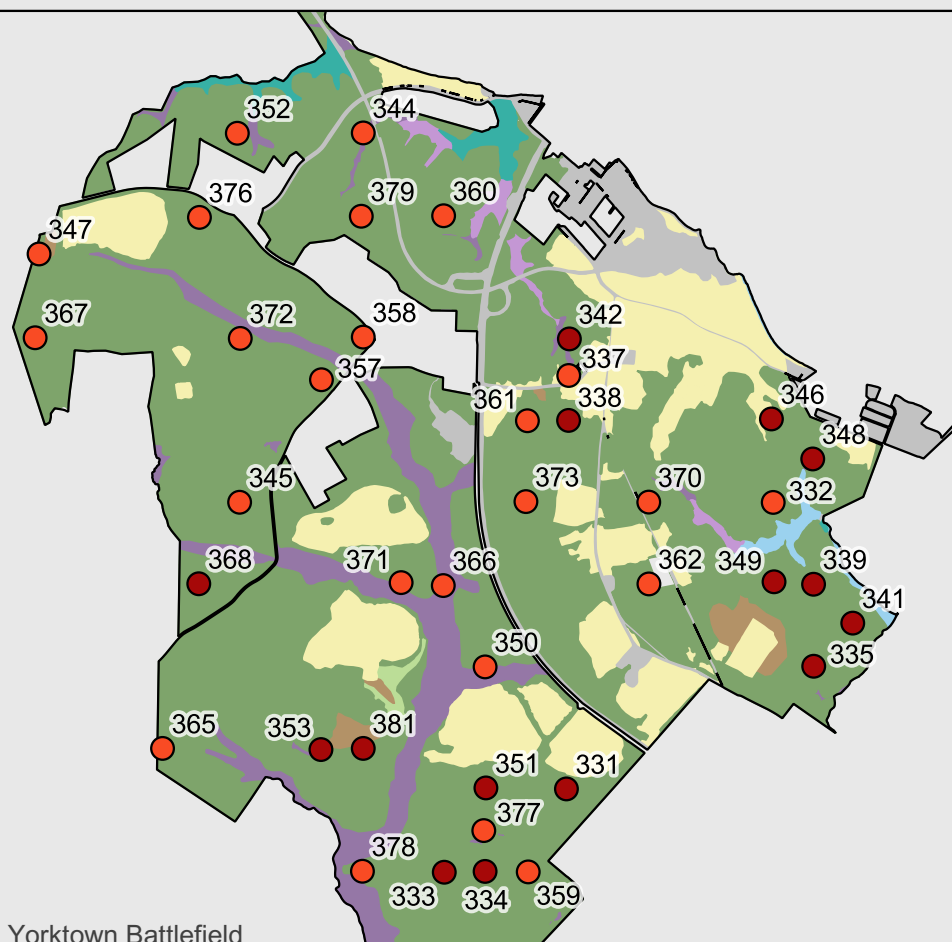
- 1) No impact: found only in well-maintained deer exclosures.
- 2) Low impact: deer preferred (DP) species abundant and of varying heights.
- 3) Medium impact: DP species present, but mostly under 30 cm tall. DP herbs present but stunted and flowering uncommon.
- 4) High impact: DP species are rare 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 3 6 km



Jamestown Island



Yorktown Battlefield

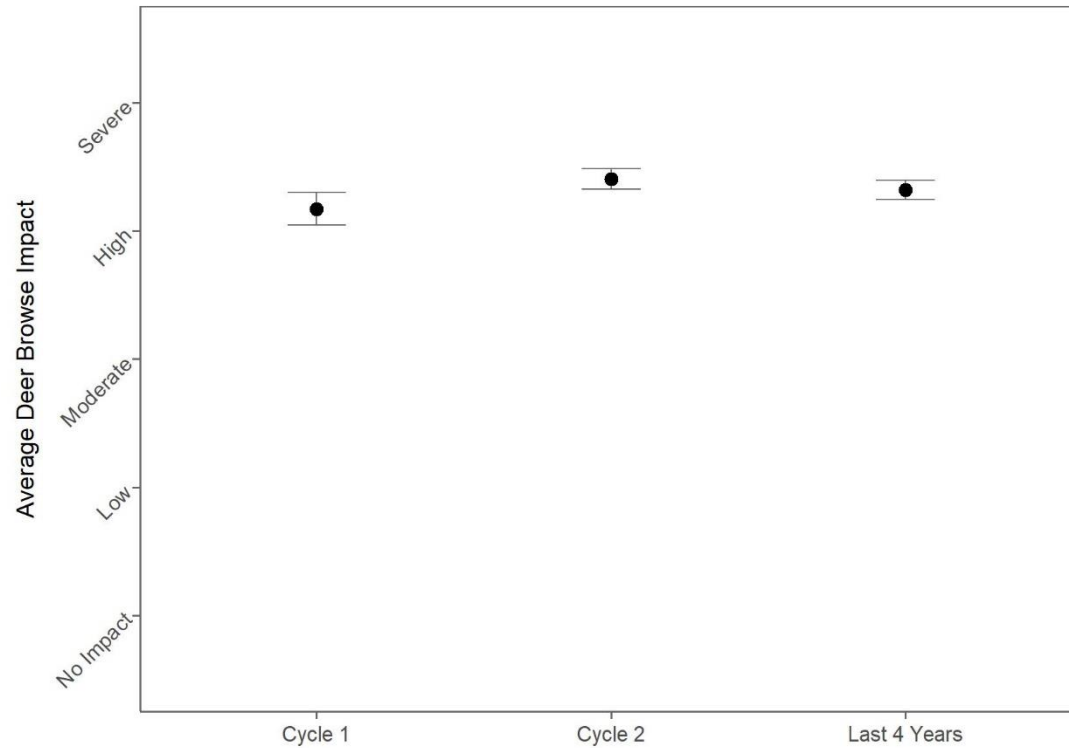


Figure 3. Average deer browse impact by cycle in Colonial National Historical Park. Deer browse impacts are assessed on a scale of 1 – 5, with 1 representing no impact and 5 representing severe impacts. Cycle 1 is 2011 – 2014, Cycle 2 is 2015 – 2018, Last 4 years is 2016 – 2019. Note that the average DBI calculation for Cycle 1 is missing data for one plot. Error bars are ± 1 SE.



Map 5. Tree Regeneration by Composition

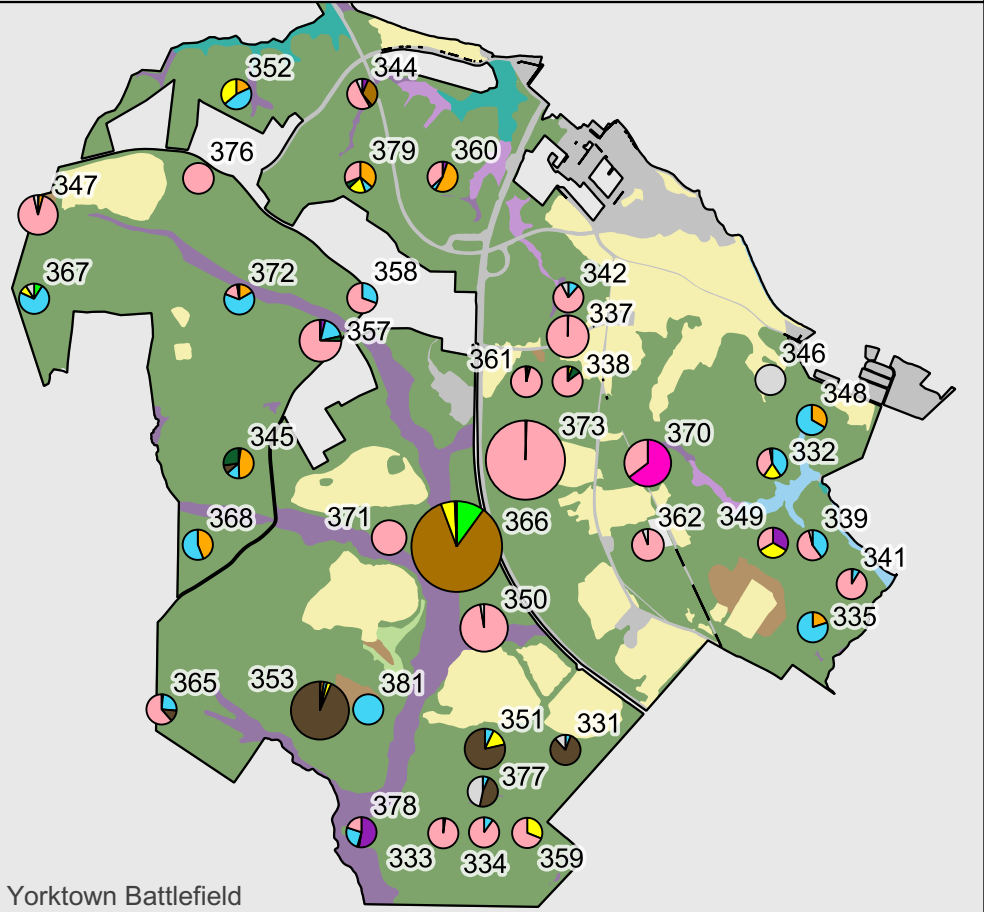
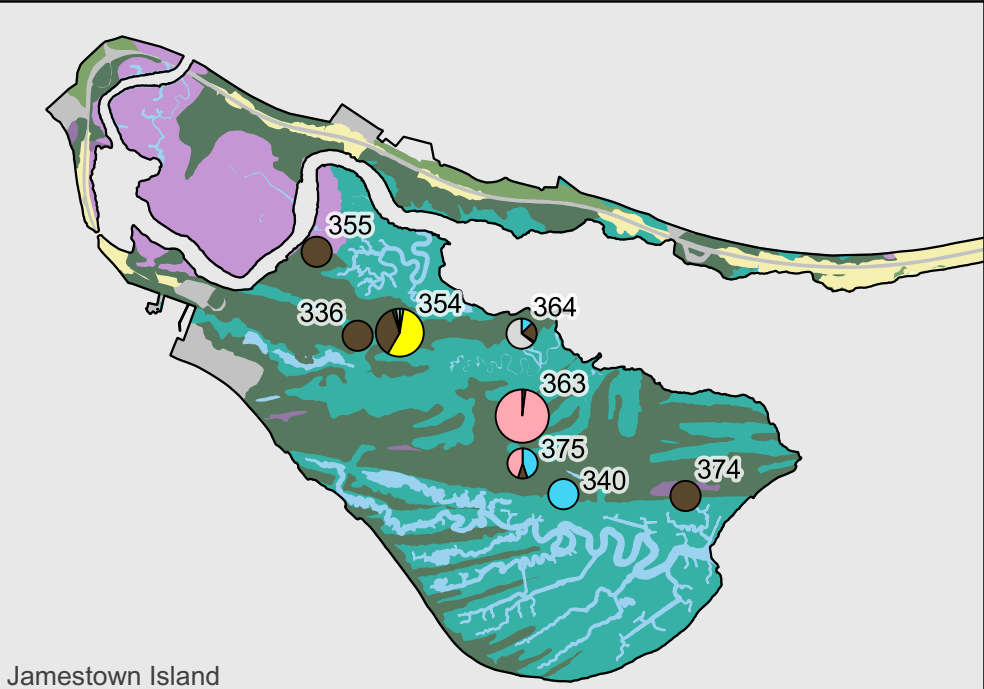
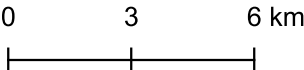
Tree regeneration stem densities, including seedlings and saplings, by species group observed in forest plots sampled in the most recent survey cycle (2016 – 2019). Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. Pie size is proportional to plot-level regeneration density. Pie size is proportional to plot-level regeneration density. Pies may be shifted to prevent overlap. Densities range from 0 to 9.9 stem/sq.m for an individual species group. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. See <https://npsforveg.shinyapps.io/midn/> for more specific plot level information. Reporting Date: 08/20/2020.

Vegetation types

- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

Species in pie charts

- Acer rubrum (Red maple)
- Ailanthus altissima (Tree-of-heaven)
- Carya spp. (Hickory)
- Fagus grandifolia (Beech)
- Fraxinus spp. (Ash)
- Ilex opaca (American holly)
- Liquidambar styraciflua (Sweetgum)
- Liriodendron tulipifera (Tuliptree)
- Pinus taeda (Loblolly pine)
- Quercus spp. (Oak)
- Low canopy species
- Other native species



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 45.2 sq.m/ha for an individual species group. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. See <https://npsforveg.shinyapps.io/midn/> for more specific plot level information. Reporting Date: 08/20/2020.

Vegetation types

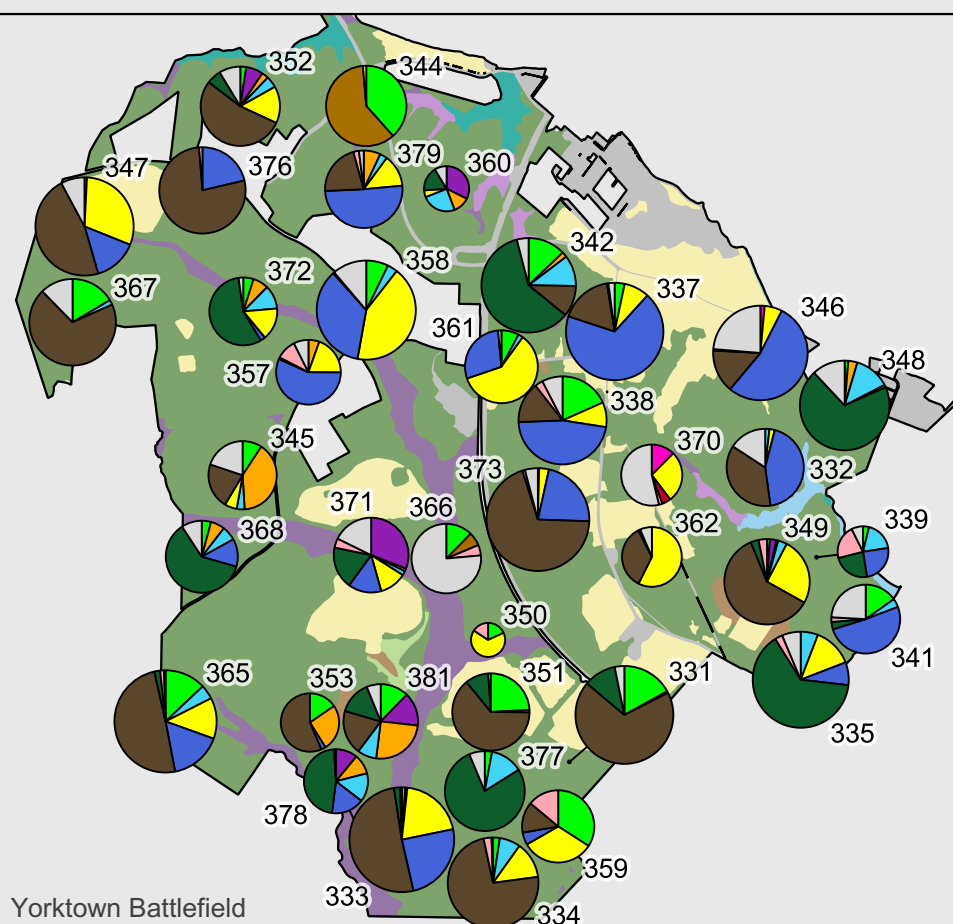
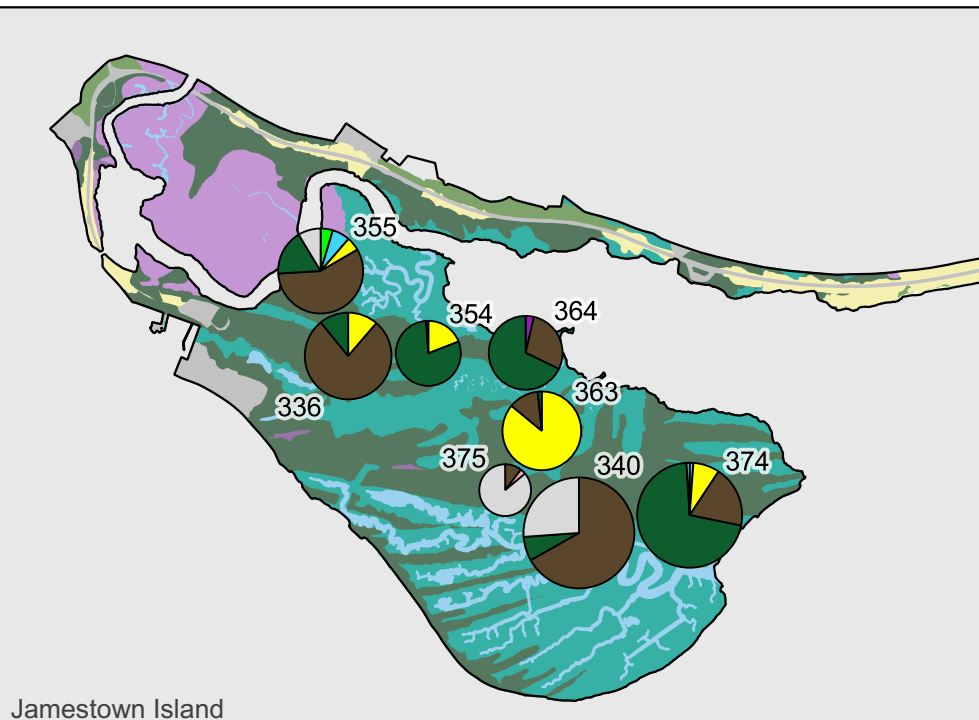
-  Mixed forest
-  Deciduous forest
-  Successional forest
-  Conifer plantation
-  Forested wetland/ Floodplain
-  Open wetland
-  Open field
-  Beach
-  Salt/ brackish marsh
-  Open water
-  Developed land
-  Park boundary

Species in pie charts

-  Acer rubrum (Red maple)
-  Ailanthus altissima (Tree-of-heaven)
-  Carya spp. (Hickory)
-  Fagus grandifolia (Beech)
-  Fraxinus spp. (Ash)
-  Ilex opaca (American holly)
-  Liquidambar styraciflua (Sweetgum)
-  Liriodendron tulipifera (Tuliptree)
-  Pinus spp. (Pine)
-  Quercus spp. (Oak)
-  Other exotic species
-  Low canopy species
-  Other native species



A horizontal number line with three tick marks. The first tick mark is labeled '0', the second is labeled '3', and the third is labeled '6 km'.





Map 7. Invasive % Cover by Cycle

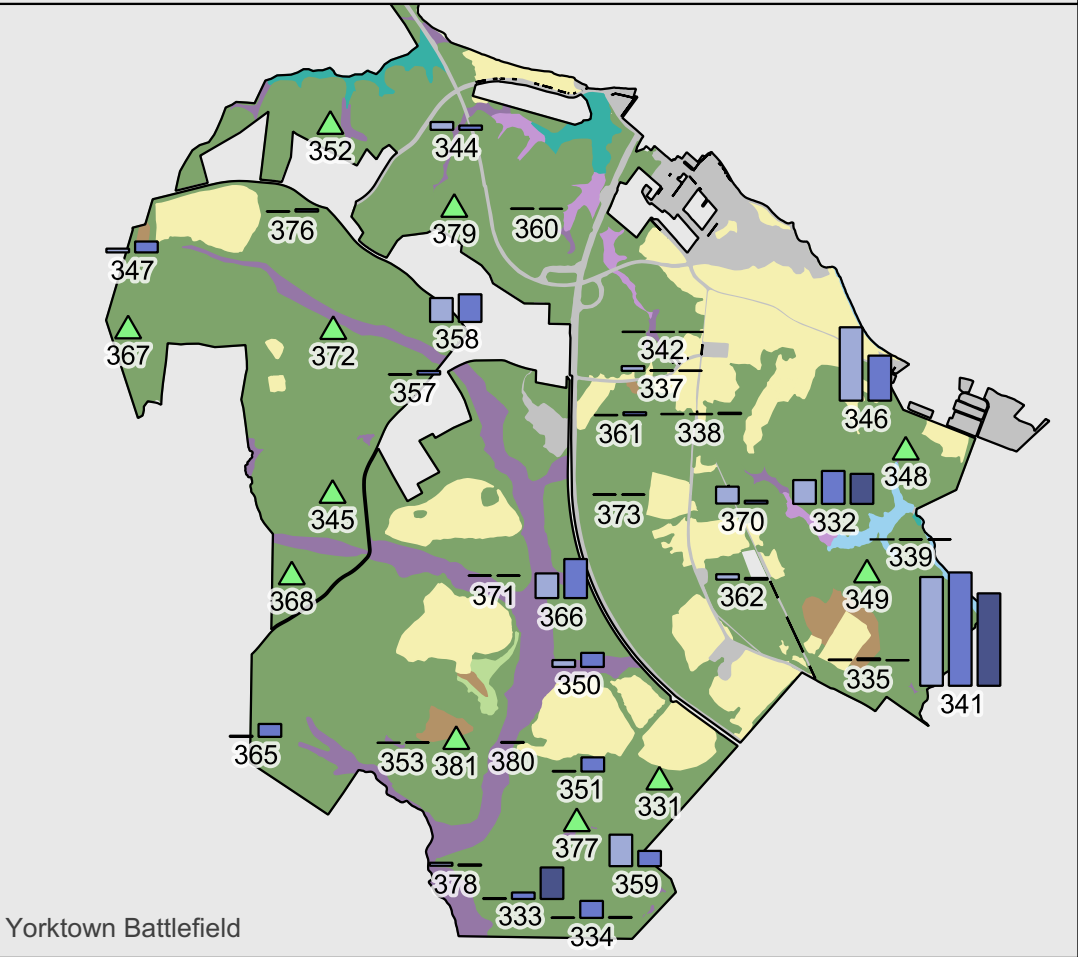
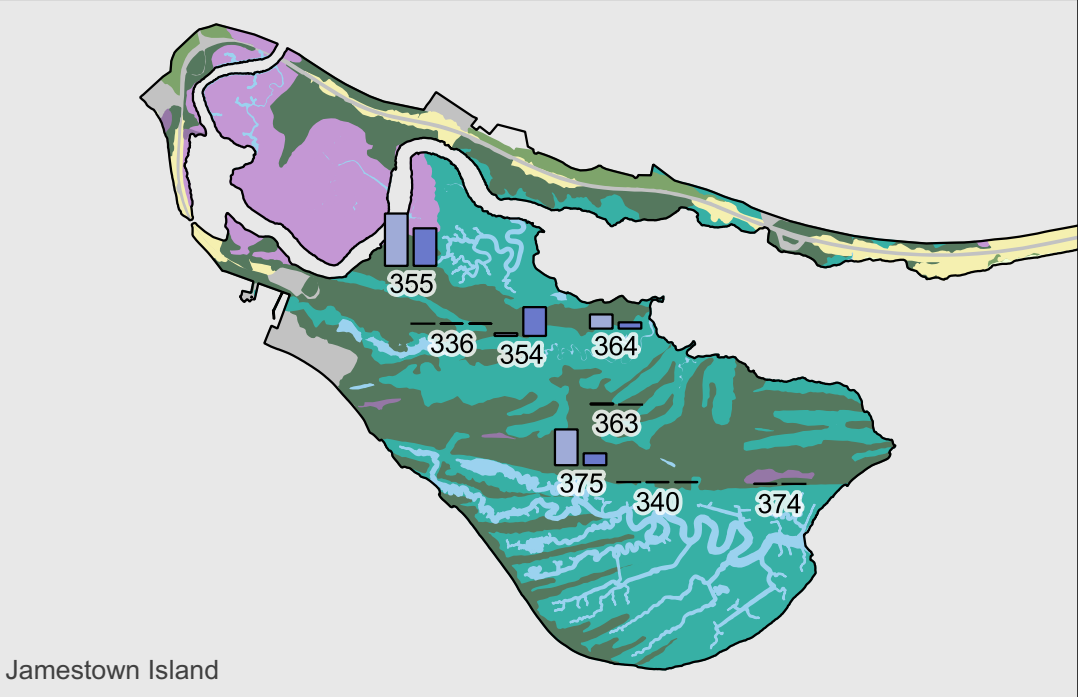
Average percent cover of invasive species observed in quadrats in forest plots sampled from 2011 – 2019. Each plot is sampled on a 4-year cycle in a rotating panel, with one quarter of the plots sampled every year. The number of bars per plot corresponds to the number of times the plot has been sampled. Average invasive cover per plot ranges from 0 to 56.7%. See Table 2 for % cover values. See Table 3 for a species list. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. Reporting Date: 08/20/2020.

Vegetation types

- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
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- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

Invasive % cover

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



0 3 6 km

Table 2a. Average % cover of invasive species detected in each plot by cycle in Colonial National Historical Park (Yorktown Battlefield). Cycle 1 is 2011 – 2014, Cycle 2 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 3 in 2019. See Table 3 for a species list. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam.

Plot	Average % cover		
	Cycle 1	Cycle 2	Cycle 3
331	0	0	0
332	11.9	16.5	15.0
333	0.4	3.3	15.8
334	0.2	8.5	0.5
335	0.3	0.9	<0.1
337	2.4	0.4	0.1
338	<0.1	<0.1	0.6
339	0	<0.1	<0.1
341	54.4	56.7	46.2
342	<0.1	0	0
344	3.9	2.2	-
345	0	0	-
346	36.7	22.5	-
347	1.9	5.4	-
348	0	0	-
349	0	0	-
350	3.4	7.0	-
351	0.3	7.1	-
352	0	0	-
353	<0.1	0.3	-
357	0.2	1.8	-
358	12.0	13.8	-
359	15.7	7.6	-
360	0.1	<0.1	-
361	0.2	1.5	-
362	2.7	0.8	-
365	0.6	6.5	-
366	12.3	19.5	-
367	0	0	-
368	0	0	-
370	8.4	1.4	-
371	<0.1	<0.1	-
372	0	0	-
373	<0.1	<0.1	-
376	0.2	1.2	-
377	0	0	-

Table 2a. (continued)

Plot	Average % cover		
	Cycle 1	Cycle 2	Cycle 3
378	1.5	0.7	-
379	0	0	-
380	0.43	-	-
381	0	0	-

Table 2b. Average % cover of invasive species detected in each plot by cycle in Colonial National Historical Park (Jamestown Island). Cycle 1 is 2011 – 2014, Cycle 2 is 2015 – 2018. Note that only 1/4 of the plots have been sampled for Cycle 3 in 2019. See Table 3 for a species list.

Plot	Average % cover		
	Cycle 1	Cycle 2	Cycle 3
336	0	< 0.1	< 0.1
340	0	< 0.1	< 0.1
354	1.4	14.4	-
355	26.2	18.8	-
363	0.6	0	-
364	7.1	3.1	-
374	< 0.1	0	-
375	17.9	6.0	-



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 46.2% for an individual species. See Table 3 for more information. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam. Reporting Date: 08/20/2020.

Vegetation types

- Mixed forest
- Deciduous forest
- Successional forest
- Conifer plantation
- Forested wetland/ Floodplain
- Open wetland
- Open field
- Beach
- Salt/ brackish marsh
- Open water
- Developed land
- Park boundary

Species in pie charts

- Ailanthus altissima (Tree-of-heaven)
- Hedera helix (English ivy)
- Ligustrum spp. (Privet)
- Lonicera japonica (Japanese honeysuckle)
- Microstegium vimineum (Japanese stiltgrass)
- Other exotic herbs
- Other invasive woody species
- None present

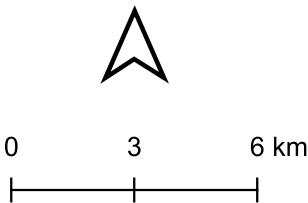
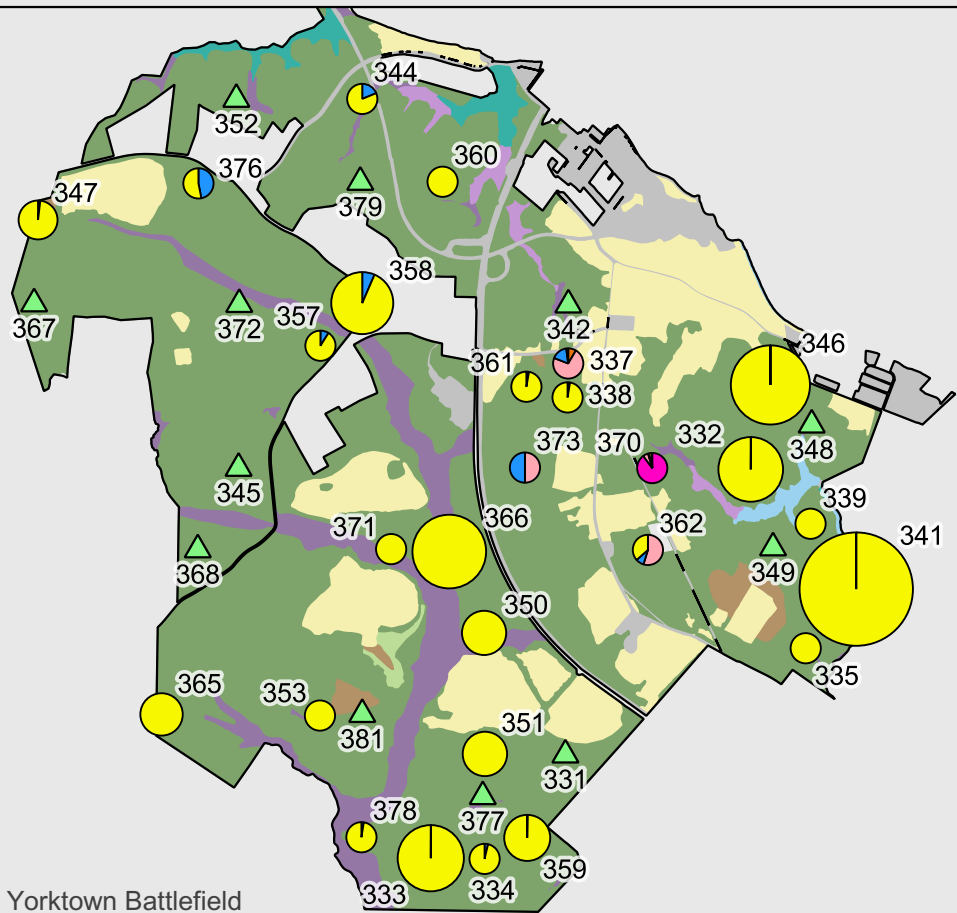
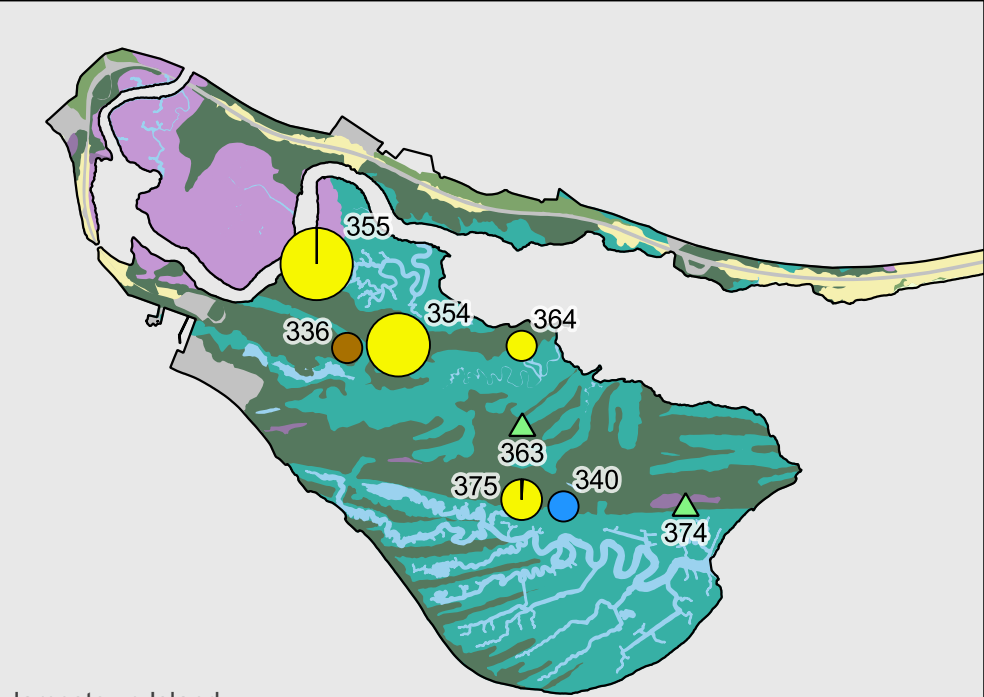


Table 3. Number of plots where invasive species were detected by cycle in Colonial National Historical Park. Cycle 1 is 2011 – 2014; Cycle 2 is 2015 – 2018. Note that only ¼ of the plots have been sampled for Cycle 3 in 2019. Note that not all species have been monitored for the same amount of time, as indicated by the Year added column. Species that are exotic to the mid-Atlantic region, but not considered invasive are indicated by *. Note that Plot 380 was not sampled in the most recent cycle due to flooding by beaver dam.

Latin name	Common name	Year added	Number of plots with species present		
			Cycle 1	Cycle 2	Cycle 3
<i>Ailanthus altissima</i>	Tree-of-heaven	2007	2	2	1
<i>Berberis bealei</i> ¹	Beale's barberry	2019	0	0	1
<i>Duchesnea indica</i> *	Mock strawberry	2007	1	3	1
<i>Hedera helix</i>	English ivy	2007	8	6	5
<i>Lespedeza cuneata</i>	Chinese lespedeza	2007	0	0	2
<i>Ligustrum</i> spp.	Privet	2009	16	17	6
<i>Lonicera</i> spp. - Exotic	Exotic bush honeysuckle	2007	0	1	0
<i>Lonicera japonica</i>	Japanese honeysuckle	2007	27	27	10
<i>Microstegium vimineum</i>	Japanese stiltgrass	2007	35	35	10
<i>Persicaria longisetata</i> *	Oriental lady's thumb	2009	4	2	0
<i>Rosa multiflora</i>	Multiflora rose	2007	1	3	0
Number of plots sampled	-	-	48	47	12

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