

# Forest Data Summaries for Morristown National Historical Park: 2007-2017.

## Background

Summaries are based on data collected in Northeast Temperate Network (NETN) long-term forest monitoring plots. There are 29 NETN forest plots in MORR, two of which are located in the large deer enclosure (14 and 25). Each plot is sampled on an alternating 4-year cycle, with plots 1-15 are sampled in 2007, 2011, and 2015, and plots 16-29 sampled in 2009, 2013, and 2017.

Within each forest plot, tree and stand measurements, including an assessment of deer browse impact, are made within 20x20 m square plots. Tree regeneration is tallied by size class within three 2-m radius circular microplots within each square plot. Coarse woody debris (CWD) is assessed using line intersect sampling along three 15-m transects originating at plot center. Understory diversity is monitored within eight 1-m<sup>2</sup> quadrats, and soil samples are obtained from a location adjacent to the plot. Plots are permanently marked and measured at the same location every cycle. For a more detailed description of the forest monitoring protocol, including background information, field methods, and sample design, refer to the [NETN forest monitoring protocol](#).

This document provides data summaries and brief interpretations of tree regeneration and invasive species data to help inform resource management staff of any potential forest issues detected by NETN forest monitoring. Note that summaries are considered preliminary until after the 2017 forest data are thoroughly quality checked and certified at the end of the field season.

## Interpretation of Maps

### Tree Regeneration

While tree seedling densities appear to be increasing in the plots in/around the deer enclosure, there are still many plots with few or no seedlings observed over the last 3 cycles (11 years) of monitoring. Densities are particularly low in the New Jersey Brigade unit of the park, and on the southeast part of Jockey Hollow. Regeneration also continues to be low or absent in the two plots (17 & 19) located in large gaps, and this is largely due to dense Japanese barberry (*Berberis thunbergii*) thickets that are suppressing regeneration in these gaps. Comparing seedling and sapling densities to the targets in the MORR Vegetation and White-tailed Deer Management Plan (target: 1,000-1,500 seedlings/acre and 550-900 saplings/acre), 10 out of 29 plots (34%) meet the lower range for seedling densities. Only plot 25 meets the target for sapling densities, which is one of the plots located in the deer enclosure. Saplings on plot 25 are entirely composed of beech (*Fagus grandifolia*).

### Regeneration Stocking Index

The regeneration stocking index quantifies whether current seedling and sapling densities are sufficient to restock a forest canopy. The index is a weighted sum of native seedling and sapling densities where larger size classes get higher weights in the calculation. Areas with high deer impacts, such as in MORR, require a stocking index of 100 to be sufficiently stocked to replace the forest canopy. Based on the most recent survey cycle (2015 and 2017), only 2 plots (14 & 25) are sufficiently stocked for areas with high deer impacts, both of which are located in the large deer enclosure. Nearly 80% of plots (23 out of 29) are severely understocked.

### Index of Deer Browse Impacts

While the index of deer browse impacts is slightly lower in Cycle 3 (average: 4.2) than Cycle 2 (average: 4.3), impacts remain high or very high for all plots except the two plots located in the deer enclosure. Anecdotally, deer-preferred herbaceous species, such as Solomon's Seal (*Polygonatum* spp.) and bellwort (*Uvularia* spp.), were observed in cycle 3 to be larger and occasionally reproductive in plots in/around the large deer enclosure. However, deer-preferred herbaceous species are still sparse in the park overall, and tree regeneration continues to be heavily impacted by deer browse.

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### **Regeneration by Size Class**

Healthy forests typically have tree seedlings of varying sizes, whereas forests with impacts from deer browse tend to be dominated by seedlings less than 30cm (~1 ft) tall. Of the 10 plots that met the 1,000 seedlings per acre target, only the 2 deer enclosure plots (14 and 25), and plots 11 and 13 have regeneration in a range of size classes, with beech as the dominant species across all size classes. Remaining plots that met the seedlings per acre target only had smaller size classes represented in the regeneration layer. For three of the six plots with saplings recorded (plots 2, 6 and 7), the saplings present are low stature forest species, such as flowering dogwood (*Cornus floridana*) and blackhaw (*Viburnum prunifolium*), which will not grow into the canopy. Beech is the predominant sapling species across remaining plots (plots 10, 13 and 15).

### **Regeneration Composition**

Beech and white ash (*Fraxinus americana*) are the dominant tree species in the regeneration layer across MORR. The dominance of both species is a concern, as forest pests/pathogens threaten their long-term status in the forest canopy. Beech bark disease (BBD), which is a pest/disease complex involving a scale insect and *Nectria* fungi, is the primary concern for beech. MORR is currently at the edge of the range of the *Nectria* fungi that cause the damage from BBD. During cycle 3, the BBD scale insect was detected on 46 out of 53 (87%) of the beech trees in NETN plots, but only 1 beech tree was found (on plot 10) to have suffered significant damage from BBD. If the *Nectria* fungus continues to spread, the forests in MORR will be greatly impacted. Emerald ash borer (EAB) is the primary concern for ash. EAB was detected in adjacent counties of Somerset in 2014 and Essex in 2016, and is only a matter of time before EAB spreads into Morris County. Encouraging other native tree regeneration, such as maples (*Acer* spp.), oak (*Quercus* spp.), and tulip poplar (*Liriodendron tulipifera*) will help ensure continual forest cover.

### **Invasive Shrub % Cover**

Where invasive shrubs have been present since the first survey cycle, their cover has increased over time, particularly between the second (e.g. 2011 & 2013) and third cycle (2015 & 2017). Japanese barberry (*Berberis thunbergii*) is the primary species that has increased, with 10-20% increase in cover between cycle 2 and 3 in plots 17, 22, 23 and 27. Plots near the large deer enclosure and near Mount Kemble are the least invaded by exotic shrubs.

In addition to increases in invasive shrub cover, eight invasive woody species increased in plot frequency by at least two plots between cycle 2 and cycle 3 (Table 3), including Japanese aralia (*Aralia elata*), oriental bittersweet (*Celastrus orbiculatus*), autumn olive (*Eleagnus umbellata*), burningbush (*Euonymus alatus*), oriental photinia (*Photinia villosa*), multiflora rose (*Rosa multiflora*), wine raspberry (*Rubus phoenicolasius*), and Siebold's arrowwood (*Viburnum sieboldii*). Additionally, kiwi vine (*Actinidia* spp.), an exotic vine known to be invasive in the southeastern US, was detected for the first time in MORR in two plots (plots 18 and 21). Although not mapped for this summary, herbaceous invasive species appear to be more stable both in % cover and plot frequency.

### **Summary**

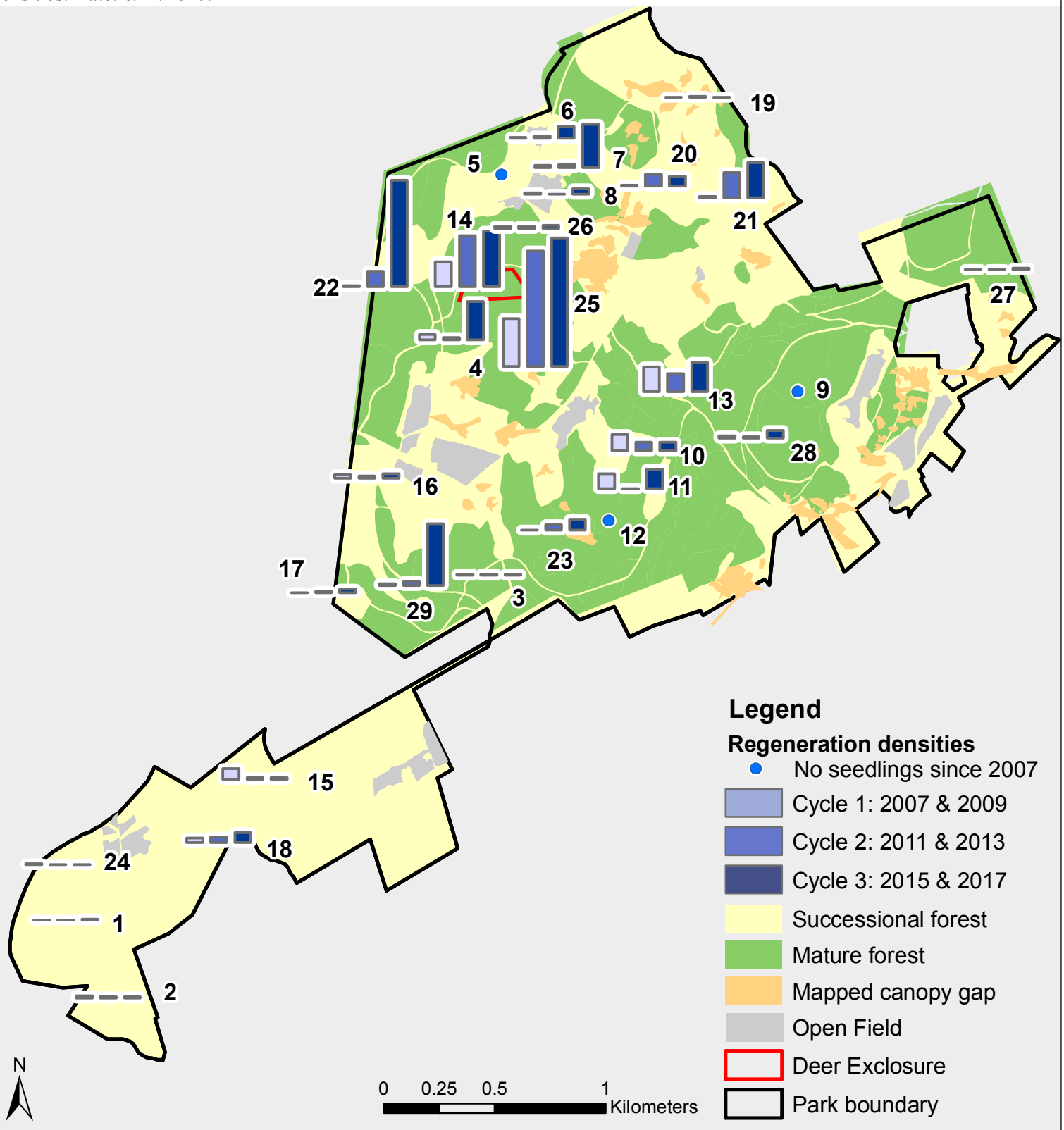
While tree regeneration has increased since monitoring began in 2007, regeneration levels remain too low to replace the forest canopy, particularly in the forest gaps where invasive shrub thickets are suppressing native vegetation. Given the lack of regeneration and increase of invasive shrubs in gaps, creating additional canopy openings to promote regeneration is not recommended for MORR.

Where regeneration levels are adequate, the regeneration layer is dominated by beech and white ash. Knowing that beech bark disease and emerald ash borer are very close to MORR, encouraging regeneration of other native tree species will be important to maintain long-term forest cover in the park. Invasive shrub removal, especially in the forest gaps, will also be necessary to promote tree regeneration and to fill in the canopy gaps in the park.



## Tree Regeneration

Trends in tree regeneration stem densities, including seedlings and saplings, observed in forest plots sampled from 2007-2017. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-15 sampled in 2007, 2011, and 2015, and plots 16-29 sampled in 2009, 2013, and 2017. Densities range from 0 to 12,667 stems/acre. See Table 1 for individual seedling and sapling densities. Date: 6/12/2017.



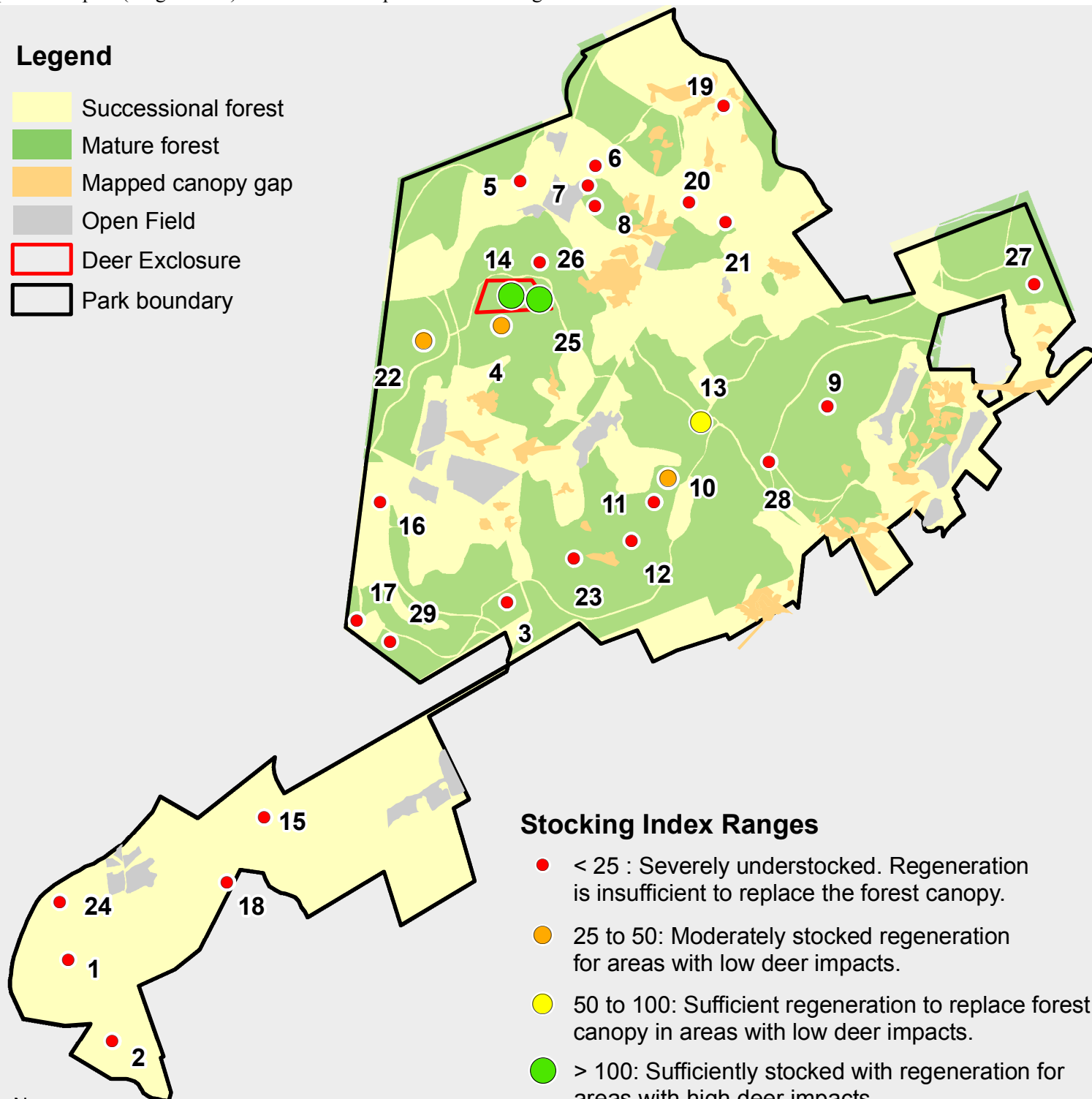


## Regeneration Stocking Index

Trends the regeneration stocking index for the most recent survey cycle (2015 & 2017). 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 is averaged over three 2-m radius microplots per forest plot (range 0-911). See Table 1 for plot-level stocking index values. Date: 6/12/2017.

### Legend

- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



### Stocking Index Ranges

- < 25 : Severely understocked. Regeneration is insufficient to replace the forest canopy.
- 25 to 50: Moderately stocked regeneration for areas with low deer impacts.
- 50 to 100: Sufficient regeneration to replace forest canopy in areas with low deer impacts.
- > 100: Sufficiently stocked with regeneration for areas with high deer impacts..



0 0.25 0.5 1 Kilometers

**Table 1.** Average plot-level seedling and sapling stem densities per acre and stocking index by cycle. Cycle 1= 2007 & 2009; Cycle 2= 2011 & 2013; Cycle 3= 2015 & 2017. Plots are sampled in alternating years, with Panel 1 sampled the first year, and Panel 2 sampled the second 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. Bolded fields are plots that meet the minimum management target of 1,000 seedlings/acre and 550 saplings/acre, or have a stocking index >100. Blue highlighted plots are in the deer enclosure.

| Plot | Panel | Seedlings per acre |                |                | Saplings per acre |         |               | Stocking Index |         |              |
|------|-------|--------------------|----------------|----------------|-------------------|---------|---------------|----------------|---------|--------------|
|      |       | Cycle 1            | Cycle 2        | Cycle 3        | Cycle 1           | Cycle 2 | Cycle 3       | Cycle 1        | Cycle 2 | Cycle 3      |
| 1    | 1     | 0.0                | 0.0            | 107.3          | 0.0               | 0.0     | 0.0           | 0.0            | 0.0     | 0.3          |
| 2    | 1     | 107.3              | 0.0            | 0.0            | 107.3             | 107.3   | 107.3         | 0.3            | 0.0     | 0.0          |
| 3    | 1     | 0.0                | 0.0            | 0.0            | 107.3             | 107.3   | 107.3         | 16.7           | 16.7    | 16.7         |
| 4    | 1     | 536.7              | 214.7          | <b>3757.1</b>  | 0.0               | 0.0     | 0.0           | 1.7            | 0.7     | 33.7         |
| 5    | 1     | 0.0                | 0.0            | 0.0            | 0.0               | 0.0     | 0.0           | 0.0            | 0.0     | 0.0          |
| 6    | 1     | 0.0                | 0.0            | 966.1          | 107.3             | 214.7   | 214.7         | 16.7           | 16.7    | 17.7         |
| 7    | 1     | 107.3              | 0.0            | <b>4079.1</b>  | 107.3             | 322.0   | 214.7         | 17.0           | 16.7    | 7.3          |
| 8    | 1     | 107.3              | 0.0            | 536.7          | 0.0               | 0.0     | 0.0           | 0.3            | 0.0     | 1.7          |
| 9    | 1     | 0.0                | 0.0            | 0.0            | 0.0               | 0.0     | 0.0           | 0.0            | 0.0     | 0.0          |
| 10   | 1     | <b>1288.2</b>      | 536.7          | 644.1          | 322.0             | 322.0   | 214.7         | 37.3           | 52.0    | 36.0         |
| 11   | 1     | <b>1502.8</b>      | 0.0            | <b>1932.2</b>  | 0.0               | 0.0     | 0.0           | 6.0            | 0.0     | 15.3         |
| 12   | 1     | 0.0                | 0.0            | 0.0            | 0.0               | 0.0     | 0.0           | 0.0            | 0.0     | 0.0          |
| 13   | 1     | <b>2254.3</b>      | <b>1610.2</b>  | <b>2683.7</b>  | 214.7             | 214.7   | 214.7         | 45.7           | 48.7    | 78.3         |
| 14   | 1     | <b>2469.0</b>      | <b>5045.3</b>  | <b>5367.3</b>  | 0.0               | 0.0     | 107.3         | 10.3           | 282.7   | <b>518.7</b> |
| 15   | 1     | 858.8              | 107.3          | 107.3          | 214.7             | 107.3   | 107.3         | 36.3           | 17.0    | 16.7         |
| 16   | 2     | 214.7              | 214.7          | 429.4          | 107.3             | 0.0     | 0.0           | 17.7           | 0.0     | 1.0          |
| 17   | 2     | 0.0                | 107.3          | 322.0          | 0.0               | 0.0     | 0.0           | 0.0            | 0.3     | 1.3          |
| 18   | 2     | 429.4              | 536.7          | 966.1          | 0.0               | 0.0     | 0.0           | 1.3            | 2.7     | 4.3          |
| 19   | 2     | 0.0                | 107.3          | 0.0            | 0.0               | 0.0     | 0.0           | 0.0            | 0.3     | 0.0          |
| 20   | 2     | 107.3              | <b>1180.8</b>  | 966.1          | 0.0               | 0.0     | 0.0           | 0.3            | 0.7     | 0.7          |
| 21   | 2     | 107.3              | <b>2469.0</b>  | <b>3435.1</b>  | 0.0               | 0.0     | 0.0           | 0.0            | 0.3     | 15.0         |
| 22   | 2     | 107.3              | <b>1502.8</b>  | <b>10519.9</b> | 0.0               | 0.0     | 0.0           | 0.3            | 3.7     | 38.0         |
| 23   | 2     | 0.0                | 536.7          | <b>1073.5</b>  | 0.0               | 0.0     | 0.0           | 0.0            | 0.3     | 1.3          |
| 24   | 2     | 0.0                | 0.0            | 0.0            | 107.3             | 0.0     | 0.0           | 16.7           | 0.0     | 0.0          |
| 25   | 2     | <b>4723.2</b>      | <b>11378.7</b> | <b>10412.6</b> | 0.0               | 0.0     | <b>2254.3</b> | 27.7           | 634.3   | <b>911.0</b> |
| 26   | 2     | 107.3              | 214.7          | 322.0          | 107.3             | 0.0     | 0.0           | 17.3           | 7.3     | 1.7          |
| 27   | 2     | 0.0                | 0.0            | 107.3          | 0.0               | 0.0     | 0.0           | 0.0            | 0.0     | 0.0          |
| 28   | 2     | 107.3              | 107.3          | 751.4          | 107.3             | 0.0     | 0.0           | 17.0           | 0.3     | 2.3          |
| 29   | 2     | 214.7              | 429.4          | <b>6118.7</b>  | 0.0               | 0.0     | 0.0           | 0.7            | 1.0     | 16.7         |

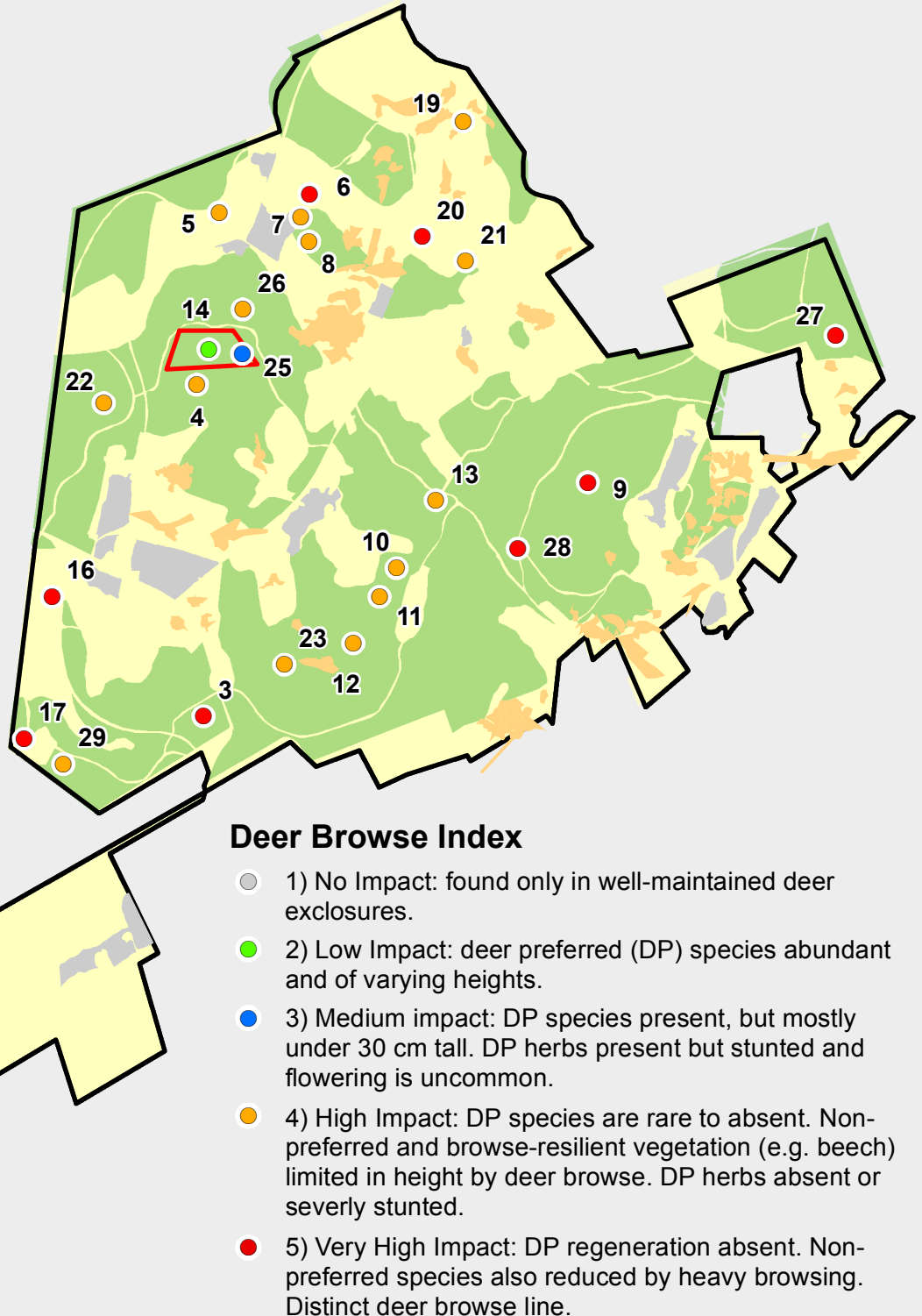


## Index of Deer Browse Impacts: Cycle 3

Index of deer browse impacts observed in forest plots in the most recent survey cycle (Cycle 3= 2015 & 2017). Each plot is sampled on a 4-year cycle, with plots 1-15 sampled in 2015 and plots 16-29 sampled in 2017. Deer browse impacts are assessed on a scale of 1-5, with 1 representing no impact and 5 representing severe impacts. Date: 6/12/2017.

### Legend

- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



### Deer Browse Index

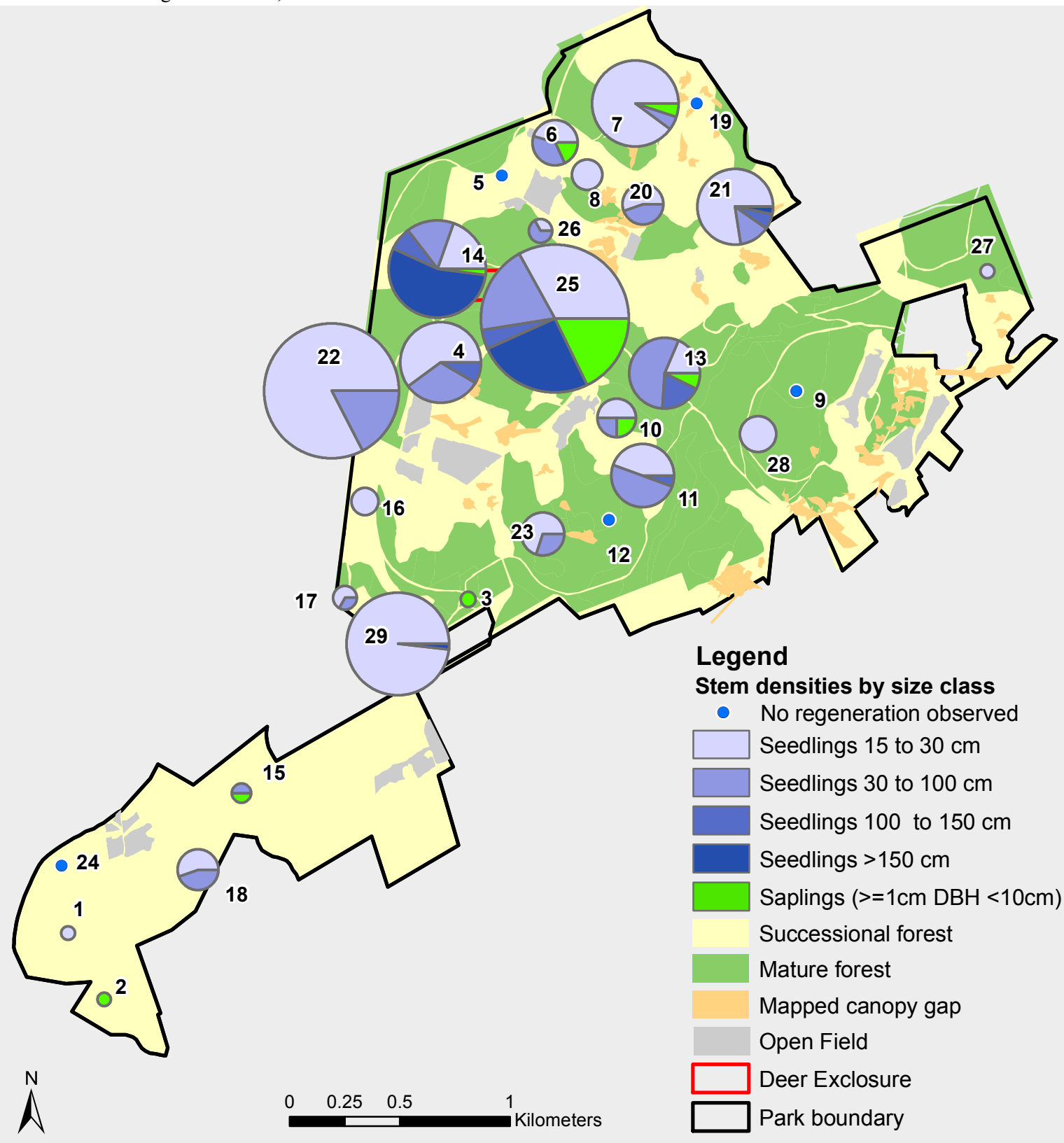
- 1) No Impact: found only in well-maintained deer exclosures.
- 2) Low Impact: deer preferred (DP) species abundant and of varying heights.
- 3) Medium impact: DP species present, but mostly under 30 cm tall. DP herbs present but stunted and flowering is uncommon.
- 4) High Impact: DP species are rare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



0 0.25 0.5 1  
Kilometers

## Regeneration by Size Class

Trends in tree regeneration stem densities by size class observed in forest plots in the most recent survey cycle (2015 & 2017). Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-15 sampled in 2015, and plots 16-29 sampled in 2017. Densities range from 0 to 8,695 stems/acre for an individual size class. Date: 6/12/2017



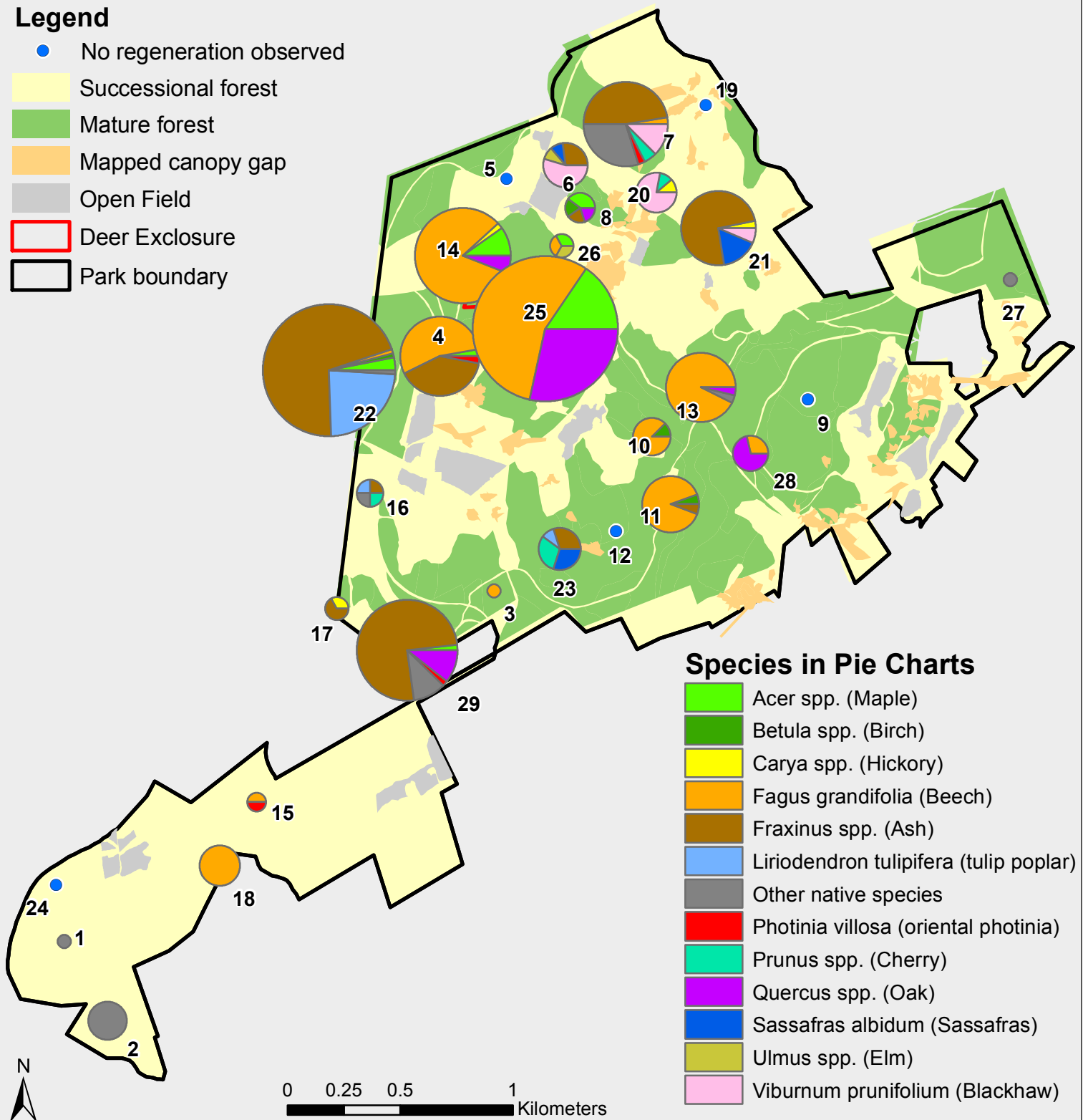


## Regeneration Composition

Trends in tree regeneration, including seedlings and saplings, by species group observed in forest plots in the most recent survey cycle (2015 & 2017). Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-15 sampled in 2015, and plots 16-29 sampled in 2017. Pie size is proportional to the total plot-level regeneration (plot-level density range: 0 to 12,670 stems/acre). Pies may be shifted from actual location to prevent overlap. Plots 14 and 25 are located in the enclosure. Date: 6/12/2017

### Legend

- No regeneration observed
- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclosure
- Park boundary



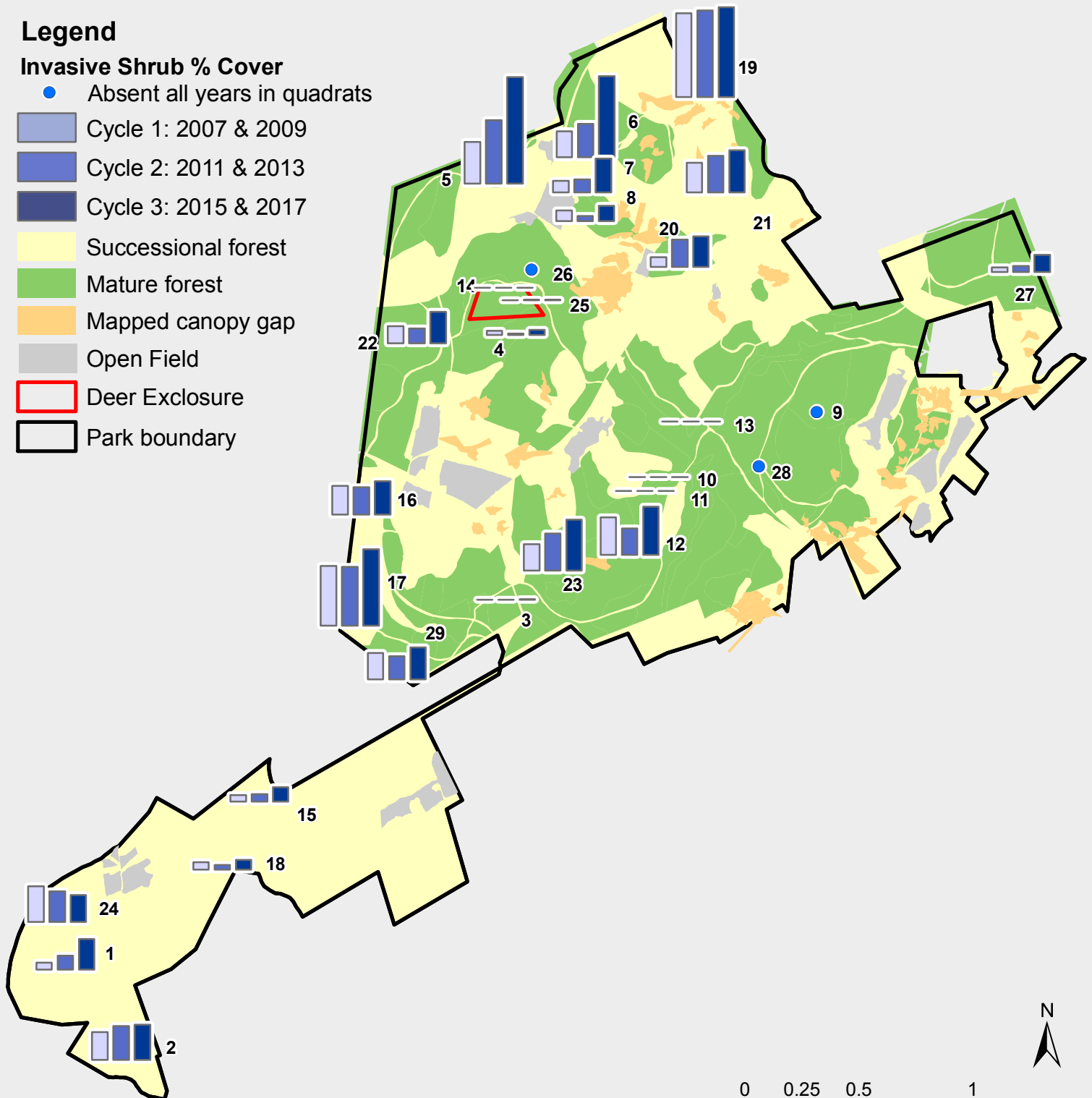
## Invasive Shrub % Cover by Cycle

Trends in percent cover of invasive shrub and vine species observed in quadrats for plots sampled from 2007-2017. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-15 sampled in 2007, 2011, and 2015, and plots 16-29 sampled in 2009, 2013, and 2017. Average invasive shrub cover ranges from 0 to >100%. See Table 2 for % cover values. Date: 6/12/2017.

### Legend

#### Invasive Shrub % Cover

- Absent all years in quadrats
- Cycle 1: 2007 & 2009
- Cycle 2: 2011 & 2013
- Cycle 3: 2015 & 2017
- Successional forest
- Mature forest
- Mapped canopy gap
- Open Field
- Deer Exclusion
- Park boundary



**Tabel 2.** Average exotic shrub cover per plot by cycle. Cycle 1= 2007 & 2009; Cycle 2= 2011 & 2013; Cycle 3= 2015 & 2017. Plots are sampled in alternating years, with Panel 1 sampled the first year, and Panel 2 sampled the second year. Blue highlighted plots are in the deer exclosure.

| Plot | Panel | Cycle1 | Cycle2 | Cycle3 |
|------|-------|--------|--------|--------|
| 1    | 1     | 8.0    | 15.9   | 35.0   |
| 2    | 1     | 31.3   | 38.4   | 39.9   |
| 3    | 1     | 0.0    | 0.0    | 0.0    |
| 4    | 1     | 5.0    | 1.9    | 6.0    |
| 5    | 1     | 47.5   | 72.0   | 121.1  |
| 6    | 1     | 29.5   | 38.0   | 92.6   |
| 7    | 1     | 13.5   | 15.1   | 38.5   |
| 8    | 1     | 12.0   | 5.7    | 17.4   |
| 9    | 1     | 0.0    | 0.0    | 0.0    |
| 10   | 1     | 0.0    | 0.0    | 0.0    |
| 11   | 1     | 0.0    | 0.0    | 0.2    |
| 12   | 1     | 42.5   | 30.0   | 55.0   |
| 13   | 1     | 0.0    | 0.0    | 0.0    |
| 14   | 1     | 0.0    | 0.2    | 0.4    |
| 15   | 1     | 7.6    | 8.8    | 16.7   |
| 16   | 2     | 32.9   | 31.5   | 38.1   |
| 17   | 2     | 67.8   | 66.8   | 87.1   |
| 18   | 2     | 8.4    | 5.2    | 11.2   |
| 19   | 2     | 95.7   | 99.0   | 102.5  |
| 20   | 2     | 11.3   | 31.3   | 34.9   |
| 21   | 2     | 33.7   | 41.6   | 48.0   |
| 22   | 2     | 19.6   | 17.1   | 36.0   |
| 23   | 2     | 30.0   | 42.2   | 57.9   |
| 24   | 2     | 40.7   | 34.9   | 30.5   |
| 25   | 2     | 0.0    | 0.2    | 0.2    |
| 26   | 2     | 0.0    | 0.0    | 0.0    |
| 27   | 2     | 5.6    | 7.1    | 20.0   |
| 28   | 2     | 0.0    | 0.0    | 0.0    |
| 29   | 2     | 30.3   | 26.6   | 36.7   |

**Table 3.** Number of plots where priority invasive species were detected by cycle. Cycle 1= 2007 & 2009; Cycle 2= 2011 & 2013; Cycle 3= 2015 & 2017. Species on the list include all exotic vascular plant species that are capable of dominating Northeastern US forest habitats, and does not include all exotic species detected in MORR forest plots. Species that increased in frequency by more than one plot between cycle 2 and 3 are bolded.

| Latin Name                          | Common Name                 | Cycle 1   | Cycle 2   | Cycle 3   |
|-------------------------------------|-----------------------------|-----------|-----------|-----------|
| <i>Acer platanoides</i>             | Norway maple                | 1         | 3         | 3         |
| <b><i>Actinidia spp.</i></b>        | <b>kiwi vine</b>            | <b>0</b>  | <b>0</b>  | <b>2</b>  |
| <i>Ailanthus altissima</i>          | Tree of heaven              | 0         | 0         | 1         |
| <i>Alliaria petiolata</i>           | garlic mustard              | 13        | 11        | 11        |
| <i>Ampelopsis brevipedunculata</i>  | porcelainberry              | 1         | 1         | 1         |
| <i>Aralia elata</i>                 | Japanese aralia             | 0         | 1         | 3         |
| <i>Berberis thunbergii</i>          | Japanese barberry           | 25        | 31        | 25        |
| <i>Cardamine impatiens</i>          | narrowleaf bittercress      | 19        | 20        | 20        |
| <b><i>Celastrus orbiculatus</i></b> | <b>oriental bittersweet</b> | <b>20</b> | <b>24</b> | <b>27</b> |
| <b><i>Elaeagnus umbellata</i></b>   | <b>autumn olive</b>         | <b>1</b>  | <b>0</b>  | <b>2</b>  |
| <b><i>Euonymus alatus</i></b>       | <b>burningbush</b>          | <b>8</b>  | <b>14</b> | <b>17</b> |
| <i>Fallopia japonica</i>            | Japanese knotweed           | 1         | 0         | 0         |
| <i>Ligustrum spp.</i>               | privet                      | 7         | 13        | 14        |
| <i>Lonicera spp.</i>                | honeysuckle - exotic        | 4         | 0         | 0         |
| <i>Lonicera japonica</i>            | Japanese honeysuckle        | 11        | 13        | 12        |
| <i>Lysimachia nummularia</i>        | creeping jenny              | 1         | 0         | 1         |
| <i>Microstegium vimineum</i>        | Japanese stiltgrass         | 21        | 20        | 19        |
| <i>Persicaria posumbu</i>           | Oriental lady's thumb       | 2         | 0         | 0         |
| <b><i>Photinia villosa</i></b>      | <b>oriental photinia</b>    | <b>0</b>  | <b>8</b>  | <b>14</b> |
| <i>Ranunculus ficaria</i>           | fig buttercup               | 1         | 1         | 1         |
| <i>Rhamnus cathartica</i>           | common buckthorn            | 3         | 0         | 0         |
| <i>Rhodotypos scandens</i>          | jetbead                     | 1         | 2         | 2         |
| <i>Robinia pseudoacacia</i>         | black locust                | 7         | 4         | 9         |
| <b><i>Rosa multiflora</i></b>       | <b>multiflora rose</b>      | <b>12</b> | <b>15</b> | <b>18</b> |
| <b><i>Rubus phoenicolasius</i></b>  | <b>wine raspberry</b>       | <b>16</b> | <b>19</b> | <b>22</b> |
| <i>Viburnum dilatatum</i>           | linden arrowwood            | 1         | 2         | 3         |
| <b><i>Viburnum sieboldii</i></b>    | <b>Siebold's arrowwood</b>  | <b>1</b>  | <b>1</b>  | <b>5</b>  |