

Forest Data Summaries for Saint-Gaudens National Historic Site: 2006-2018

Background

Summaries are based on data collected in Northeast Temperate Network (NETN) long-term forest monitoring plots. There are 21 NETN forest plots in SAGA. Each plot is sampled on an alternating 4-year cycle, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 11-21 sampled in 2008, 2012, and 2016. Within each forest plot, tree and stand measurements, including an assessment of deer browse impact, are made within 20 x 20 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-m² 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 summaries and interpretations of forest health to help inform park staff of any potential issues detected by NETN forest monitoring. This report has been updated to include results from the 6/11-6/14/2018 survey, which is the first of two panels in Cycle 4. Note that summaries are considered preliminary until after the 2018 data are thoroughly checked and certified at the end of the field season.

Summary

Overall, forests in SAGA are relatively healthy, particularly when compared to other parks in NETN. However, there are a few points of concern that may impact the forest's long-term viability. First, forests in much of SAGA are dominated by hemlock (*Tsuga canadensis*) and are vulnerable to hemlock woolly adelgid (HWA; See Map 6). These stands also either lack regeneration or are dominated by beech (*Fagus grandifolia*) regeneration (See Maps 4 & 5), both of which raise concerns about the future of these stands as HWA causes hemlock mortality. Early management of invasive shrubs, particularly in these vulnerable hemlock stands, is essential to prevent large populations, such as near plot 5, from establishing (See Maps 7 & 8). SAGA's hemlock stands can be protected through annual monitoring for infested trees and rapid response and/or treatment if HWA is detected. Woolly masses should become evident on the undersides of needles from mid to late March into April. Individual hemlock trees can be treated for HWA, either through pruning localized infestations or systemic insecticides, allowing ecologically and/or culturally important trees to persist. Mechanical removal of beech regeneration may also be necessary to encourage regeneration of other native tree species that are not disease prone and to ensure long-term forest cover in the park.

Interpretation of Maps

Map 1. Regeneration by Cycle

Tree regeneration densities are relatively stable within plots, and vary across plots. Regeneration density tends to be lowest in plots on steep ravines (e.g., plots 11, 12 & 14). No seedlings or saplings have ever been found in plot 16, which is located on the steep slope behind the Ravine Studio and high rates of erosion may be preventing tree recruitment there.

Map 2. Regeneration by Size Class

Healthy forests typically have tree seedlings and saplings of varying sizes, whereas forests with impacts from deer browse tend to be dominated by seedlings less than 30cm (~1 ft) tall. SAGA appears to have a good range of size classes represented, particularly saplings, although many are beech (see Map 5).

Map 3. Index of Deer Browse Impacts: 2016 & 2018

The index of deer browse impacts (DBI) is a 1 to 5 scale that qualitatively assesses deer impacts to a plot. A DBI value of 1 describes a forest in the complete absence of deer and a value of 5 corresponds to an

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understory experiencing very high deer impacts (i.e. no regeneration or herbaceous species preferred by deer present and visible browse on non-preferred species). Mean DBI scores above 3.5 indicate that forest plots have sustained such heavy browse that the understory composition has shifted from browse-preferred woody and herbaceous species (e.g., sugar maple and liliaceous herbs) to browse-resistant or non-preferred species (e.g., beech, ferns and invasive species). The average DBI in cycle 3 (2014 & 2016) was 3.2, medium impact. This value is up from the cycle 2 (2010 & 2012) average of 2.4, low impact, suggesting that deer impacts are potentially increasing. In addition, the 10 plots sampled in Cycle 4 (2018) averaged 3.5 for DBH, whereas the same group of plots in Cycle 3 (2014) averaged a DBI of 3.1. Plots with the highest DBI scores tend to be on the steep ravines.

Map 4. Regeneration Stocking Index: 2016 & 2018

The regeneration stocking index quantifies whether current seedling and sapling densities are sufficient to restock a forest canopy, and only includes canopy-forming tree species. The index is a weighted sum of native seedling and sapling densities where larger size classes are weighted higher in the calculation. Areas with high deer impacts require a stocking index of 100 to be sufficiently stocked to replace the forest canopy. Based on the most recent survey cycle (2016 & 2018), four of 21 plots (19%) are sufficiently stocked for areas with high deer impacts. Eight out of 21 plots (38%) are severely understocked. However, four of these plots are dominated by mature hemlocks (*Tsuga canadensis*), which typically have low regeneration rates. The stocking index may not be as informative in these stands.

Map 5. Regeneration Composition

Beech (*Fagus grandifolia*) dominates the regeneration layer in half of the SAGA plots. The dominance of beech in the regeneration layer is concerning because of beech bark disease (BBD), which causes girdling cankers that stunt growth and slowly kill the tree. Dying trees often sprout ‘suckers’ that can form dense thickets. These beech thickets can both suppress regeneration of other tree species and reduce native herbaceous diversity.

The regeneration on plots 20 and 21 is largely made up of low canopy species that rarely, if ever, grow tall enough to enter the canopy (e.g. striped maple (*Acer pensylvanicum*)). The presence of native low canopy trees does not indicate an outright problem, as these species contribute to overall forest diversity and structure. However, striped maple and other browse-resistant low canopy species have been shown to increase in areas with high deer densities to the point where the regeneration of other tree species is suppressed. We recommend monitoring the relative abundance of low canopy species in SAGA in anticipation of this potential future concern.

Map 6. Canopy Tree Composition by Basal Area

Basal area, which is a common metric to assess tree abundance, is the cross-sectional area occupied by each species (based on the diameter at breast height) on a plot, converted to m²/ha. Plots with a high basal area have larger and/or more trees than plots with a low basal area. The most common tree species represented in SAGA’s forest canopy are white pine (*Pinus strobus*), hemlock, and red oak (*Quercus rubra*), in that order. The future of hemlock in the Northeast is threatened by HWA, which was found in Sullivan County in 2014 and could spread to the park soon. Once infested, a hemlock tree will generally succumb to the pest within one to two decades. Areas of the park dominated by hemlock, particularly in the Ravine, are most vulnerable to HWA and should be targeted for spring monitoring.

Map 7 + 8. Priority Invasive Species % Cover by Cycle and Composition

Priority invasive species were not observed in most SAGA plots, and were at low levels where detected for all but Plot 5 (Map 7 & Table 2). Plot 5 is partially covered by a dense thicket of exotic bush honeysuckle (*Lonicera* spp.) and Japanese barberry (*Berberis thunbergii*). Invasive shrub % cover on this plot increased between cycle 1 and 2, but held steady in cycle 3. A more subtle change, but perhaps more

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concerning, is the increase in the number of plots with invasive species present. Invasive shrubs were detected on five plots in cycle 3, two more than in previous cycles (Table 3). There was also an increase in the total number of invasive detections in each plot from Cycle 1 to Cycle 3. The increase in detections is due to new populations of a previously detected species (i.e. Norway maple (*Acer platanoides*) or detections of new species (i.e. glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*)). These new populations are still relatively small and sparse (Map 8) and should be high priority for management.

Map 9. Earthworms: Presence or Absence

Earthworms are present in 15 out of 21 plots. Interestingly, all of the plots with invasive plants also have invasive earthworms, although not all plots with earthworms have invasive plants (Map 9). Snake worms (*Amyntas agrestic*), which were recently detected by park staff in MABI and MIMA, were not detected in the SAGA plots sampled in 2018. However, the timing of sampling in SAGA is not ideal for distinguishing snake worms from the more common European earthworms (family: Lumbricidae), and the snake worm may have gone undetected.

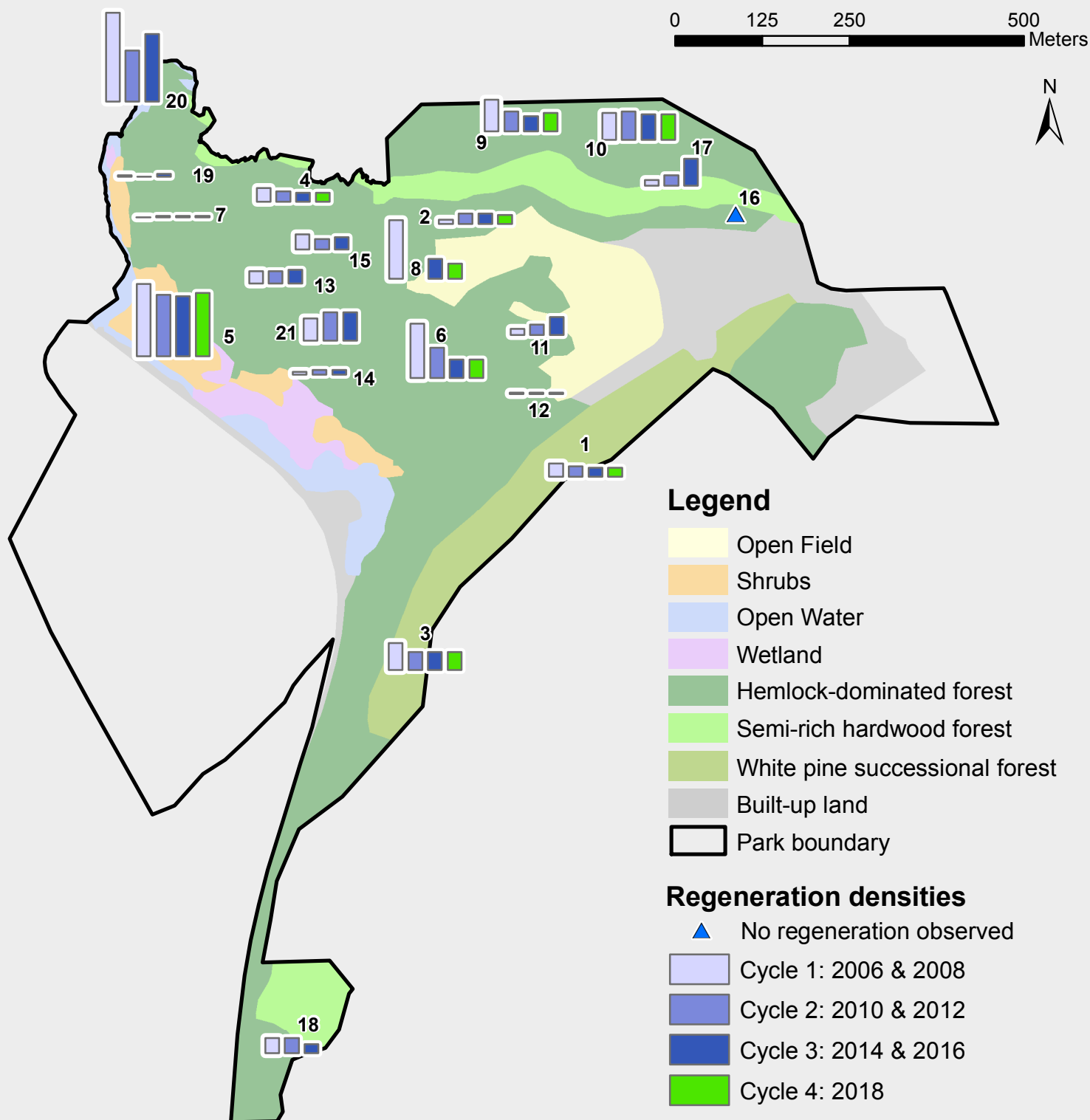
Map 10 + 11. Coarse Woody Debris Levels and by Cycle

Coarse woody debris (CWD) volume has been relatively stable across plots in SAGA. Notable exceptions are plots 16 and 21, where several large conifers fell on the plots between the second and third cycle and added considerably more plot-level CWD volume. A recent review of temperate and boreal forest organisms that are dependent on dead wood found a threshold of 20-50 m³/ha (285.8-714.6 ft³/ac) of CWD volume was required to support a broad suite of these species (Müller and Bütler 2010). Using these thresholds, 12 out of 21 plots in SAGA meet this minimum requirement, with 8 plots even exceeding the 50 m³/ha threshold. Results indicate that most forest plots in the park meet minimum CWD thresholds. It is important to note, however, that very large CWD pieces, which are important habitat for species like American marten and black bears, may still be lacking in SAGA. We just are not aware of any published thresholds for temperate forests that can be used for comparison.



Map 1. Regeneration by Cycle

Trends in tree regeneration stem densities, including seedlings and saplings, observed in forest plots sampled from 2006-2018. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 11-21 sampled in 2008, 2012, and 2016. Densities range from 0 to 15,650 stems/hectare. Plot 8 regeneration data were not collected in 2010. Date: 6/20/2018





Map 2. Regeneration by Size Class

Trends in tree regeneration stem densities by size class observed in forest plots in the most recent survey cycle (2016 & 2018). Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2018, and plots 11-21 sampled in 2016. Pie size is proportional to the total plot-level regeneration (plot-level density range: 0 to 6,897 stems/hectare for an individual size class). Pies may be shifted from actual plot location to prevent overlap. Date: 6/21/2018.

0 125 250 500 Meters

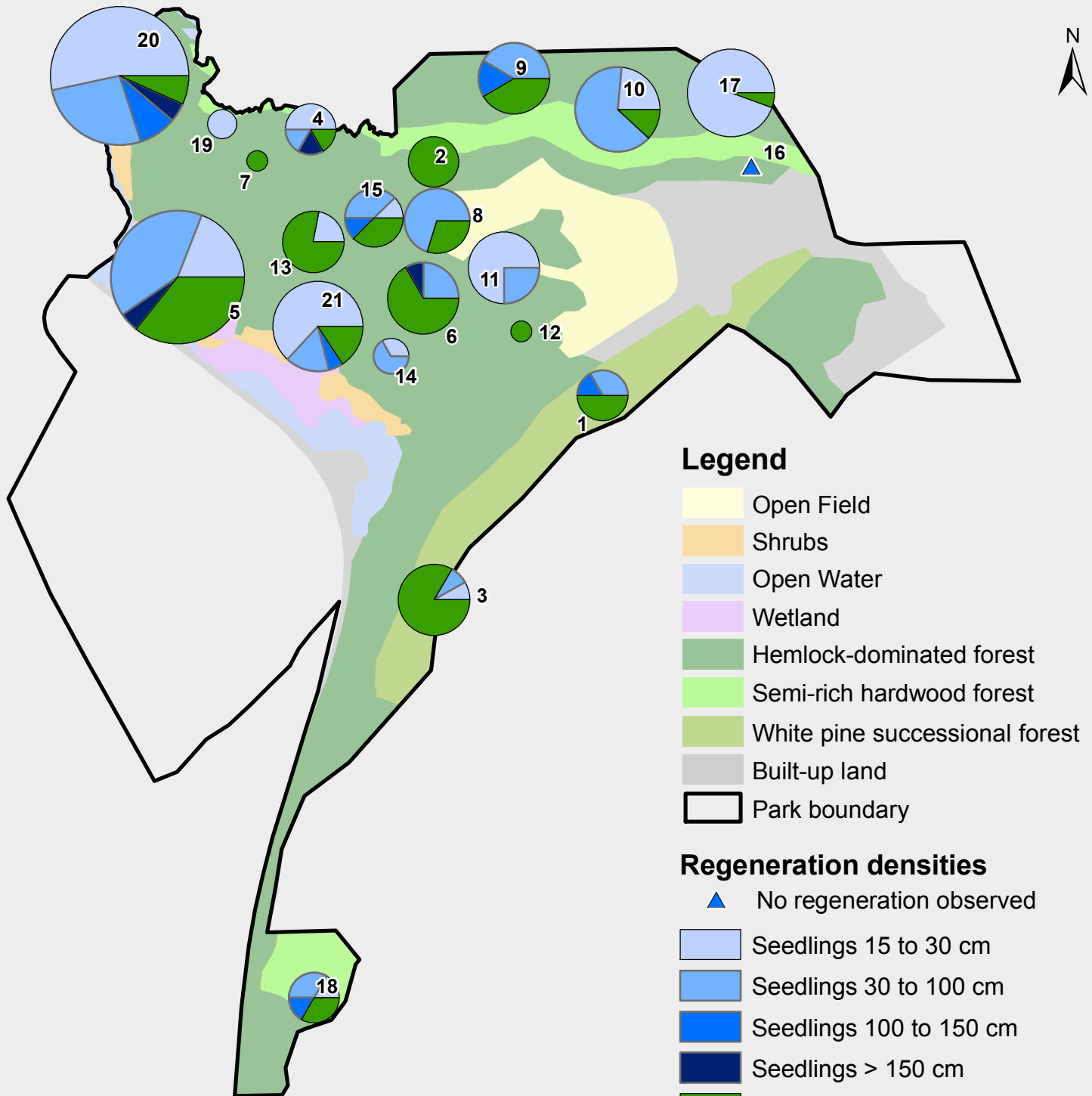


Legend

- Open Field
- Shrubs
- Open Water
- Wetland
- Hemlock-dominated forest
- Semi-rich hardwood forest
- White pine successional forest
- Built-up land
- Park boundary

Regeneration densities

- No regeneration observed
- Seedlings 15 to 30 cm
- Seedlings 30 to 100 cm
- Seedlings 100 to 150 cm
- Seedlings > 150 cm
- Saplings (≥ 1 cm DBH <10cm)

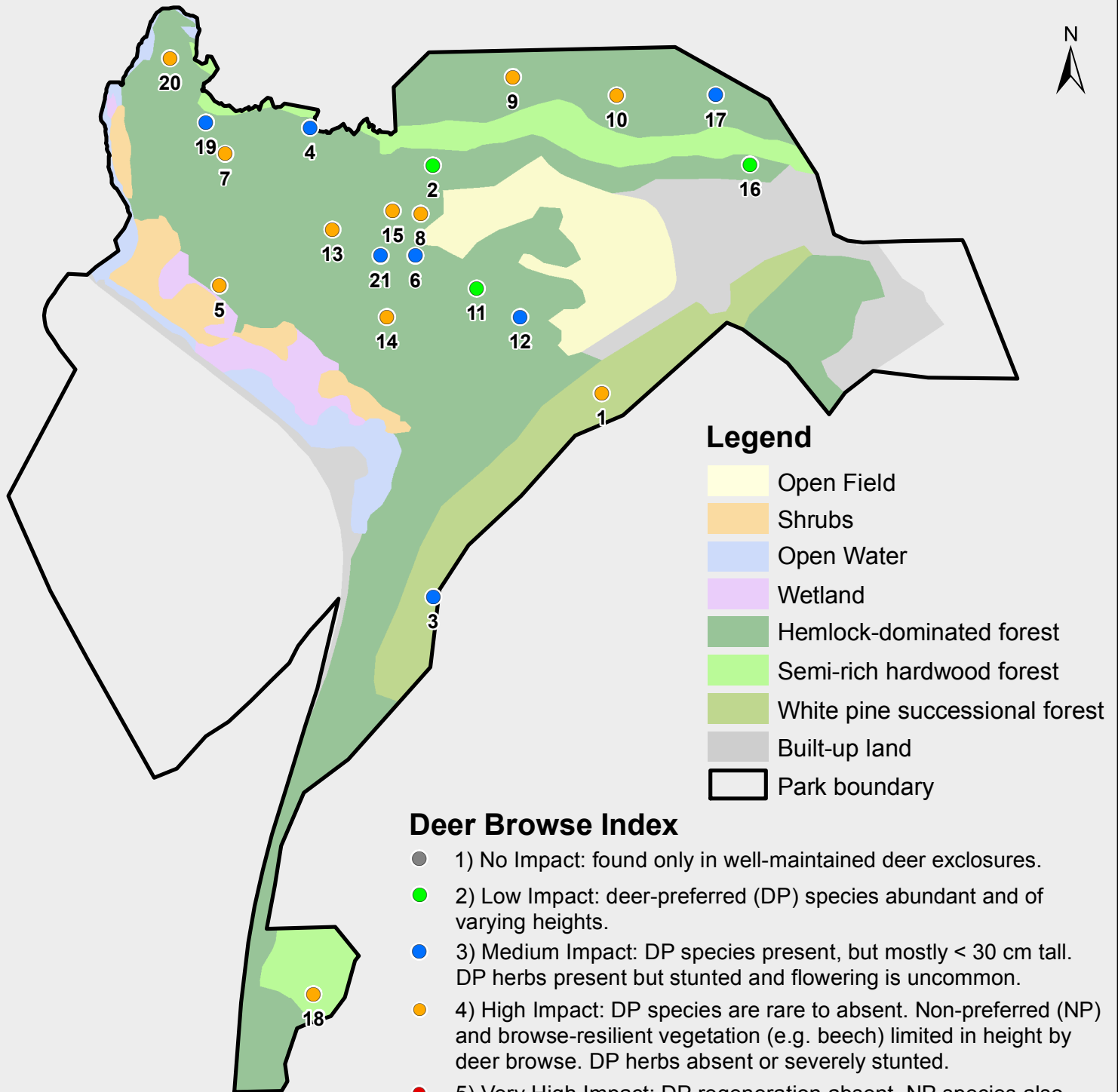




Map 3. Index of Deer Browse Impacts: 2016 & 2018

Index of deer browse impacts observed in forest plots in the most recent four years of sampling (2016 & 2018). Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2018 and plots 11-21 sampled in 2016. Deer browse impacts are assessed on a scale of 1-5, with 1 representing no impact and 5 representing severe impacts. Date: 6/21/2018.

0 125 250 500
Meters





Map 4. Regeneration Stocking Index: 2016 & 2018

Trends in the regeneration stocking index for the most recent 4 years of sampling (2016 & 2018). 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 0-297). See Table 1 for plot-level stocking index values. Date: 6/21/2018.

0 125 250 500
Meters

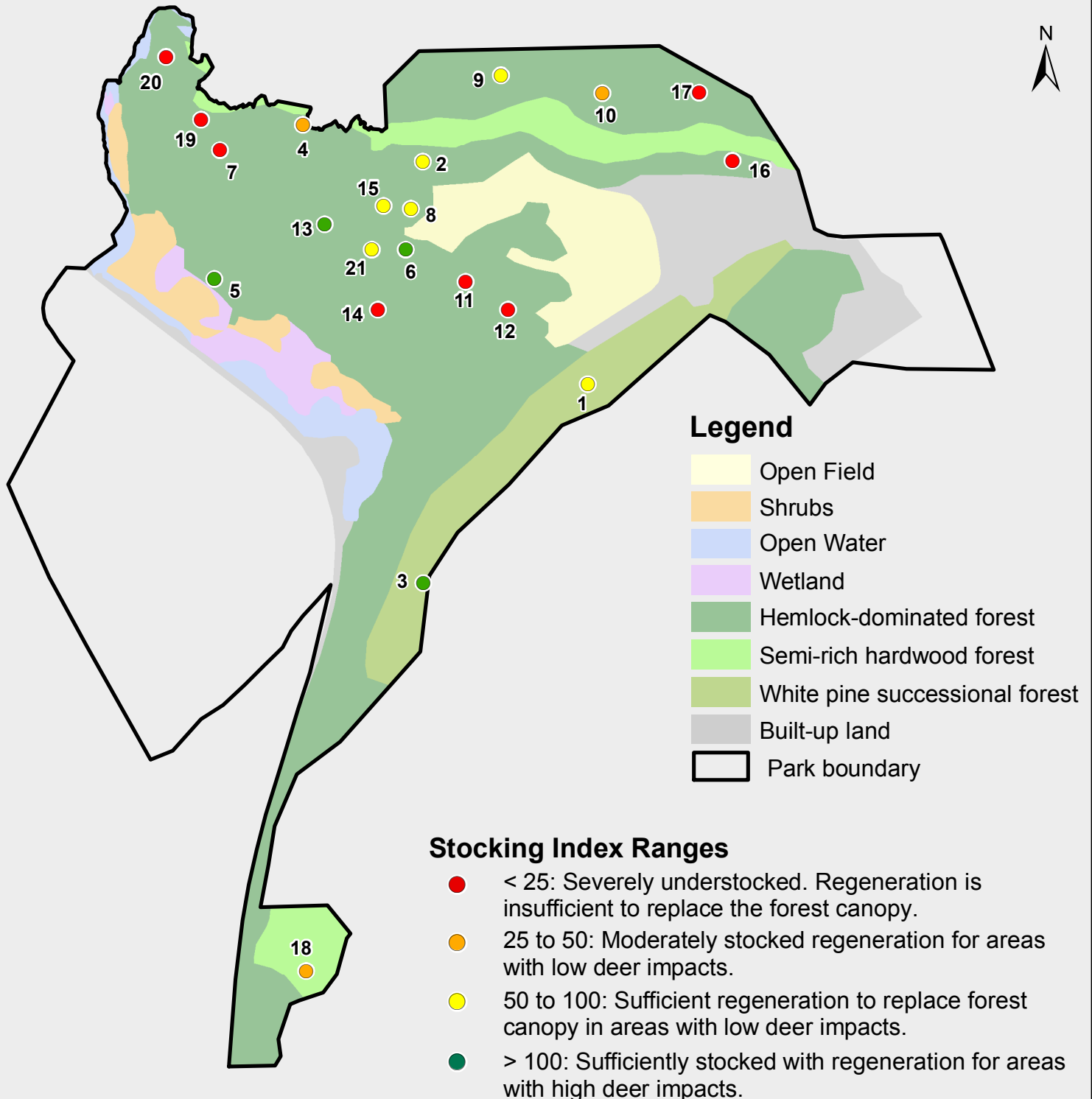


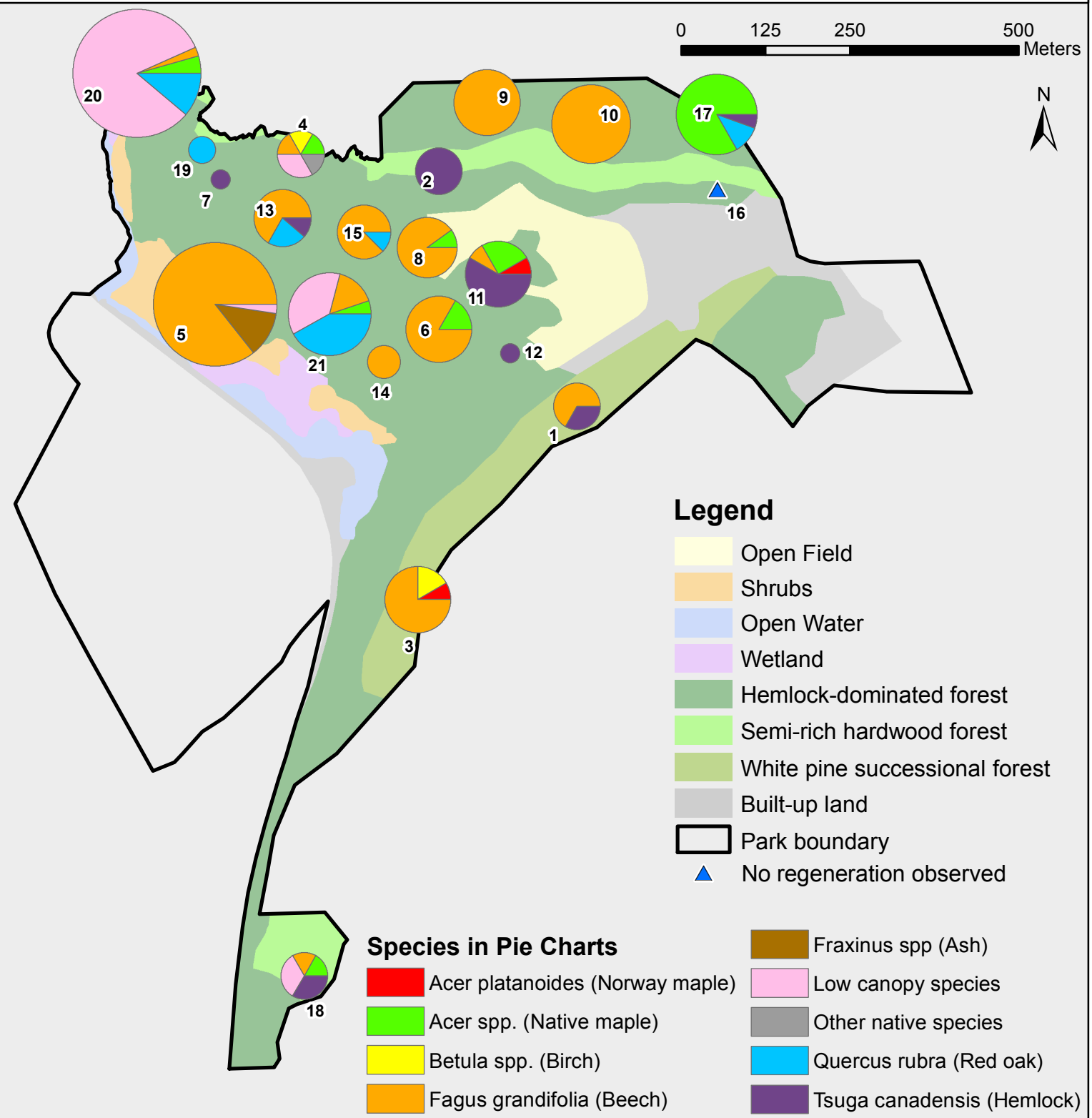
Table 1. Average plot-level seedling and sapling stem densities per hectare and stocking index by cycle. Cycle 1 = 2006 & 2008; Cycle 2 = 2010 & 2012; Cycle 3 = 2014 & 2016; Cycle 4 = 2018 only. Plots are sampled in alternating years, with Panel 1 sampled the first year, and Panel 2 sampled the second year. The stocking index qualifies whether current regeneration densities are sufficient to restock a forest canopy, and only includes native canopy-forming tree species. The index is a weighted sum of seedling and sapling densities where larger seedling classes get higher weights. Green fields are plots that have a stocking index >100, sufficient to replace a forest canopy in areas of high deer impacts. Color coding matches the Regeneration Stocking Index map.* Plot 8 regeneration data is missing from Cycle 2 visit.

Plot	Panel	Seedlings per hectare				Saplings per hectare				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
1	1	0.0	1061.0	795.8	795.8	2387.3	795.8	795.8	795.8	150.0	58.0	58.0	58.0
2	1	795.8	530.5	0.0	0.0	0.0	1326.3	1856.8	1591.5	2.0	96.7	116.7	100.0
3	1	1591.5	530.5	265.3	530.5	3183.1	2652.6	2917.8	2652.6	204.0	167.7	184.0	151.0
4	1	795.8	1326.3	1326.3	1326.3	1591.5	530.5	265.3	265.3	150.0	47.0	57.0	34.0
5	1	6366.2	6631.5	6896.7	7162.0	6366.2	4244.1	3713.6	3978.9	508.0	334.7	287.7	297.0
6	1	7162.0	2917.8	1326.3	1061.0	2387.3	2387.3	1856.8	2122.1	158.0	172.7	168.0	152.0
7	1	0.0	265.3	0.0	0.0	0.0	0.0	265.3	265.3	0.0	0.3	16.7	16.7
8	1	7162.0	0.0	2387.3	1856.8	3183.1	0.0	1061.0	795.8	213.0	NA*	72.0	54.7
9	1	3183.1	2122.1	1326.3	1856.8	2387.3	1326.3	1326.3	1326.3	157.0	93.3	86.3	100.0
10	1	4774.6	4509.4	3978.9	3978.9	0.0	530.5	530.5	530.5	11.0	59.0	59.0	42.0
11	2	795.8	1326.3	3183.1		265.3	530.5	0.0		17.3	35.7	4.7	
12	2	0.0	0.0	0.0		265.3	265.3	265.3		16.7	16.7	16.7	
13	2	0.0	0.0	530.5		2122.1	2122.1	1856.8		133.3	133.3	117.3	
14	2	530.5	795.8	795.8		0.0	0.0	0.0		1.0	1.3	1.7	
15	2	1856.8	1061.0	1326.3		795.8	795.8	795.8		92.3	52.7	59.0	
16	2	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
17	2	530.5	1591.5	4509.4		530.5	265.3	265.3		34.0	18.7	22.3	
18	2	1856.8	1856.8	1061.0		795.8	795.8	530.5		56.7	57.0	40.3	
19	2	265.3	0.0	530.5		0.0	0.0	0.0		0.3	0.0	0.7	
20	2	15650.2	8223.0	11140.8		0.0	795.8	795.8		6.7	2.7	9.3	
21	2	3448.4	3713.6	4244.1		530.5	1326.3	795.8		52.0	53.3	53.0	



Map 5. Regeneration Composition

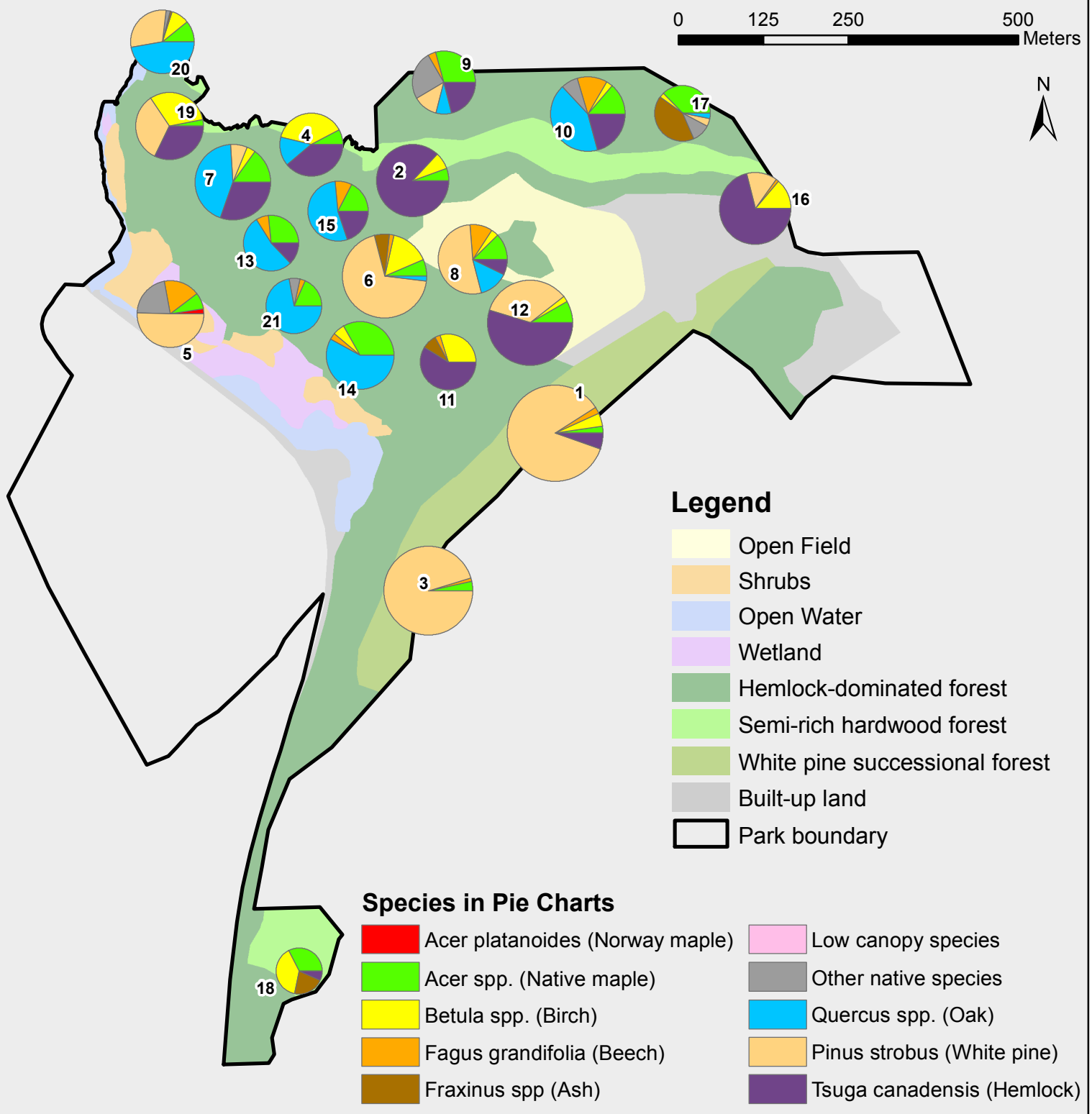
Trends in tree regeneration, including seedlings and saplings, by species group observed in forest plots in the most recent survey cycle (2016 & 2018). Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2018, and plots 11-21 sampled in 2016. Pie size is proportional to the total plot-level regeneration (plot-level density range: 0 to 11,937 stems/ha). Pies may be shifted from actual plot location to prevent overlap. *Striped maple (*Acer pensylvanicum*) is included in the Low canopy species group, rather than the Maple (*Acer* spp.) group. Date: 6/21/2018.





Map 6. Canopy Tree Composition by Basal Area

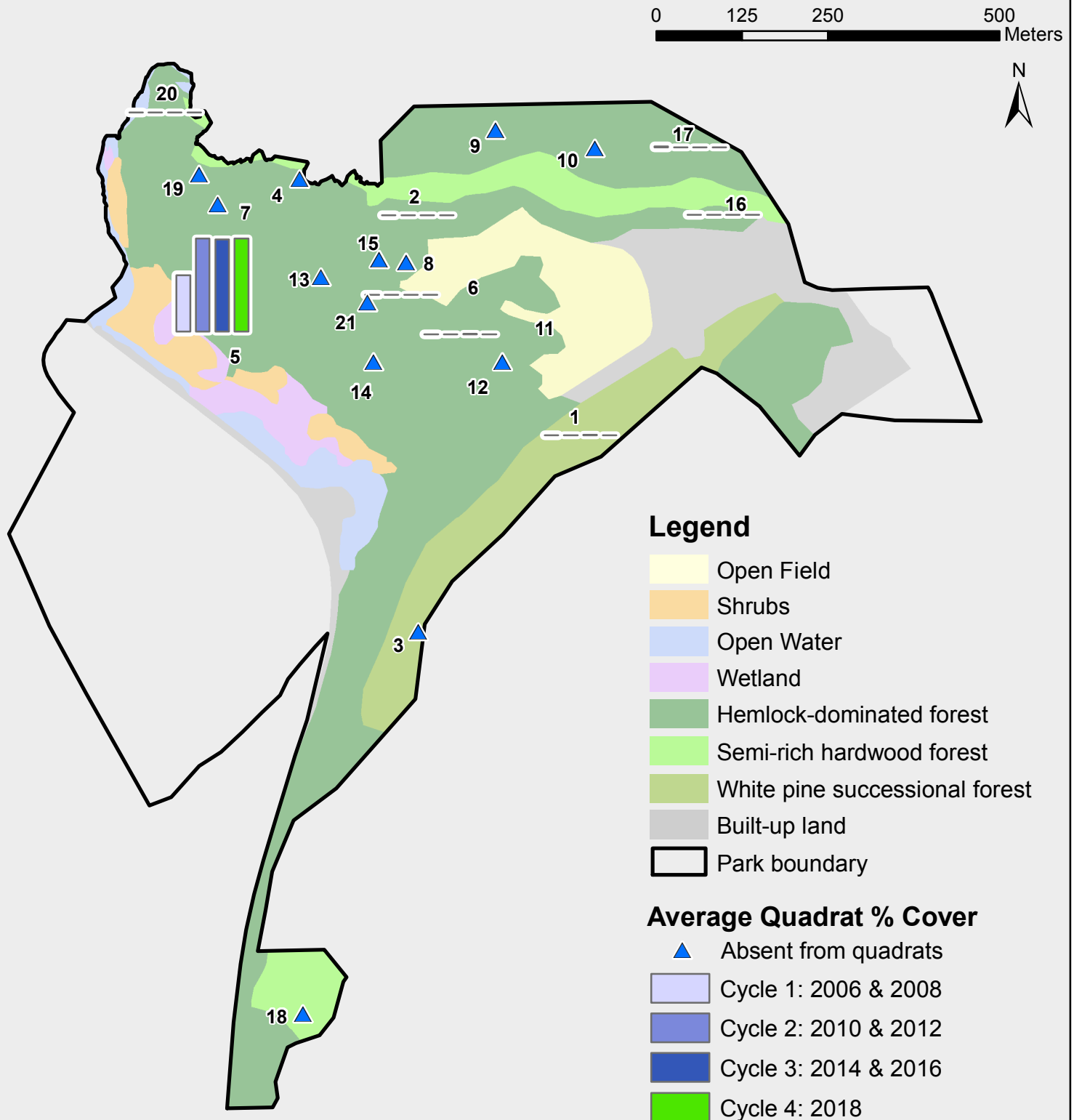
Trends in tree composition, by species group, observed in forest plots in the most recent survey cycle (2016 & 2018). Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2018, and plots 11-21 sampled in 2016. Pie size is proportional to the total plot-level basal area (plot-level basal area range: 19.0 to 82.6 m²/hectare). Pies may be shifted from actual plot location to prevent overlap. *Striped maple (*Acer pensylvanicum*) is included in the Low canopy species group, rather than the Maple (*Acer* spp.) group. Date: 6/21/2018.





Map 7. Priority Invasive Species % Cover by Cycle

Trends in percent cover of priority invasive species observed in plots sampled from 2006-2018. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 13-24 sampled in 2008, 2014, and 2016. Average priority invasive species cover ranges from 0 to 22%. Date: 6/21/2018.





Map 8. Priority Invasive Species % Cover by Species

Trends in percent cover of priority invasive species observed in plots sampled from 2006-2018. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 13-24 sampled in 2008, 2014, and 2016. Average priority invasive species cover ranges from 0 to 22%. Note that a trace of *Rhamnus cathartica* cover was found on plot 5. Date: 6/21/2018.

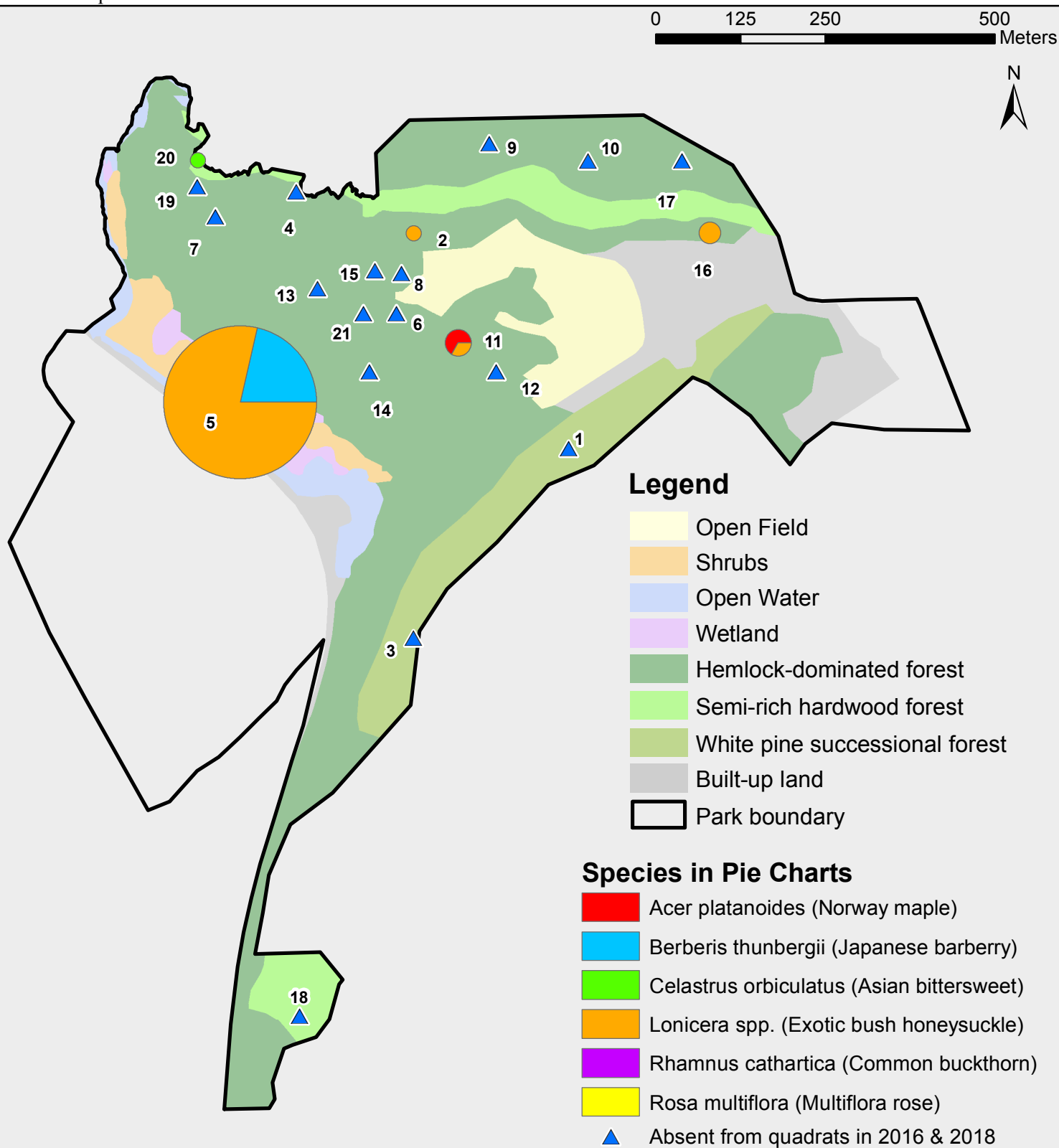


Table 2. Invasive species detections in SAGA plots in the most recent survey cycle. GPS Coordinates are in NAD83 UTM Zone 18N

Plot	Year	X Coord	Y Coord	Latin Name	Common
1	2018	712527	4819562	<i>Acer platanoides</i>	Norway maple
1	2018	712527	4819562	<i>Lonicera</i> spp.	exotic bush honey suckle
2	2018	712290	4819882	<i>Lonicera</i> spp.	exotic bush honey suckle
3	2018	712291	4819276	<i>Acer platanoides</i>	Norway maple
3	2018	712291	4819276	<i>Berberis thunbergii</i>	Japanese barberry
5	2018	711991	4819713	<i>Acer platanoides</i>	Norway maple
5	2018	711991	4819713	<i>Berberis thunbergii</i>	Japanese barberry
5	2018	711991	4819713	<i>Euonymus</i> spp.	burningbush
5	2018	711991	4819713	<i>Lonicera</i> spp.	exotic bush honey suckle
5	2018	711991	4819713	<i>Rhamnus cathartica</i>	common buckthorn
5	2018	711991	4819713	<i>Rosa multiflora</i>	multiflora rose
11	2016	712352	4819709	<i>Acer platanoides</i>	Norway maple
11	2016	712352	4819709	<i>Lonicera</i> spp.	exotic bush honey suckle
11	2016	712352	4819709	<i>Solanum dulcamara</i>	climbing nightshade
16	2016	712735	4819883	<i>Euonymus</i> spp.	burningbush
16	2016	712735	4819883	<i>Lonicera</i> spp.	exotic bush honey suckle
17	2016	712687	4819981	<i>Lonicera</i> spp.	exotic bush honey suckle
17	2016	712687	4819981	<i>Rhamnus frangula</i>	glossy buckthorn
17	2016	712687	4819981	<i>Rosa multiflora</i>	multiflora rose
20	2016	711922	4820032	<i>Celastrus orbiculatus</i>	oriental bittersweet

Table 3. Number of plots where exotic species were detected by cycle. Cycle 1 = 2006 & 2008; Cycle 2 = 2010 & 2012; Cycle 3 = 2014 & 2016; Cycle 4 = 2018. Species list includes all exotic vascular plant species that are capable of dominating Northeastern US forest habitats, and does not include all exotic species detected in SAGA forest plots. Priority invasive species are bolded. Note that only one half of plots have been sampled in Cycle 4, with a maximum plot count of 10 instead of 21.

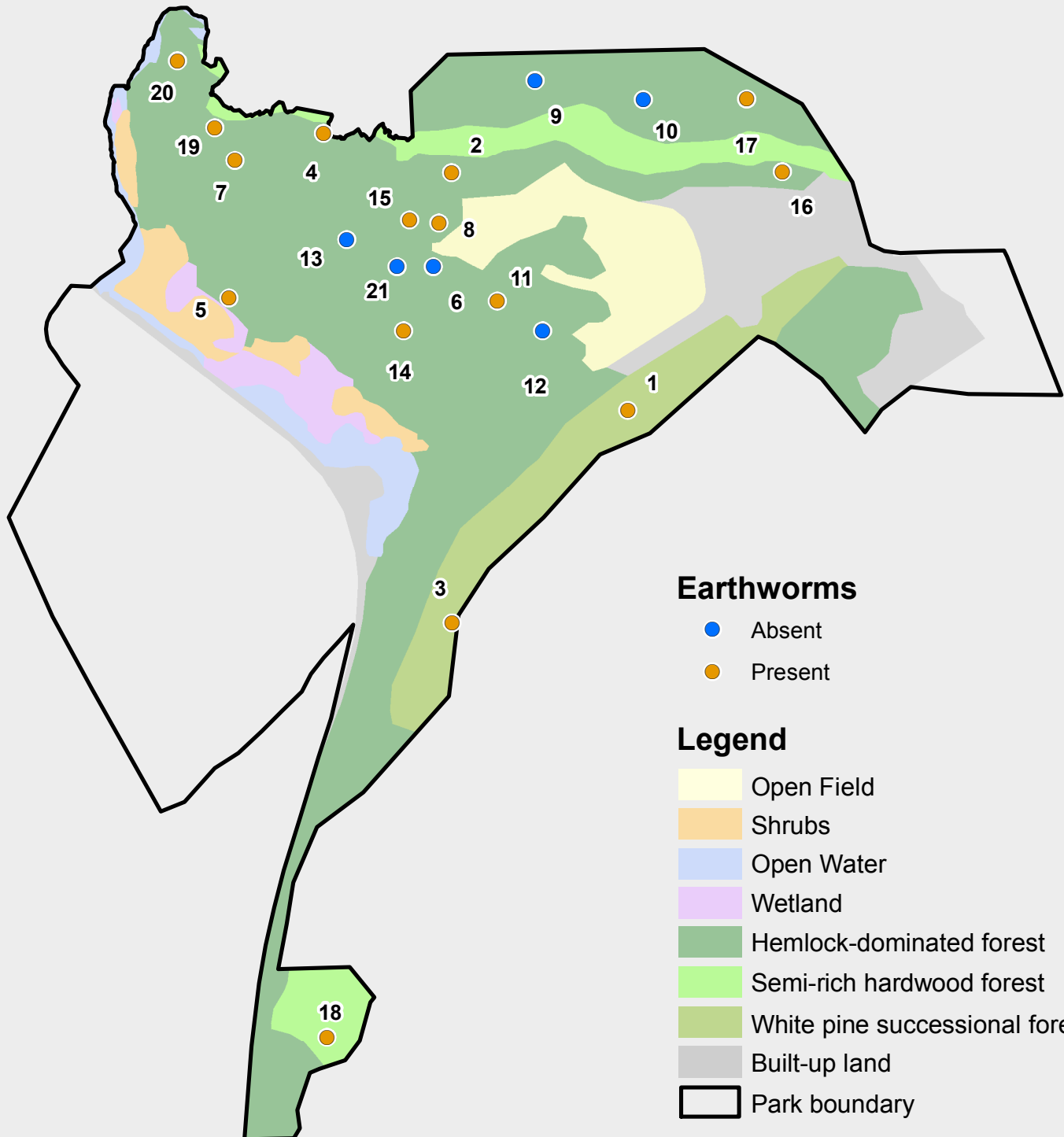
Latin Name	Common	Cycle 1	Cycle 2	Cycle 3	Cycle 4
<i>Acer platanoides</i>	Norway maple	1	1	5	3
<i>Berberis thunbergii</i>	Japanese barberry	4	2	2	2
<i>Celastrus orbiculatus</i>	oriental bittersweet	0	2	1	0
<i>Euonymus</i> spp.	burningbush	0	1	1	1
<i>Ligustrum</i> spp.	privet	0	1	0	0
<i>Lonicera</i> spp.	exotic bush honeysuckle	5	6	5	3
<i>Rhamnus cathartica</i>	common buckthorn	0	1	1	1
<i>Rhamnus frangula</i>	glossy buckthorn	0	0	1	0
<i>Rosa multiflora</i>	multiflora rose	0	0	1	1
<i>Solanum dulcamara</i>	climbing nightshade	2	0	1	0
<i>Verbascum thapsus</i>	flannel mullein	1	0	1	0



Map 9. Earthworms: Presence or Absence

Presence or absence of earthworms detected on forest plots. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2018 and plots 11-21 sampled in 2016. For this analysis, earthworms presence on a plot was considered permanent once detected. For instance, if earthworms were observed on a plot in Cycle 2, but not in Cycle 3, earthworms are still considered 'Present'. Date: 6/22/2018.

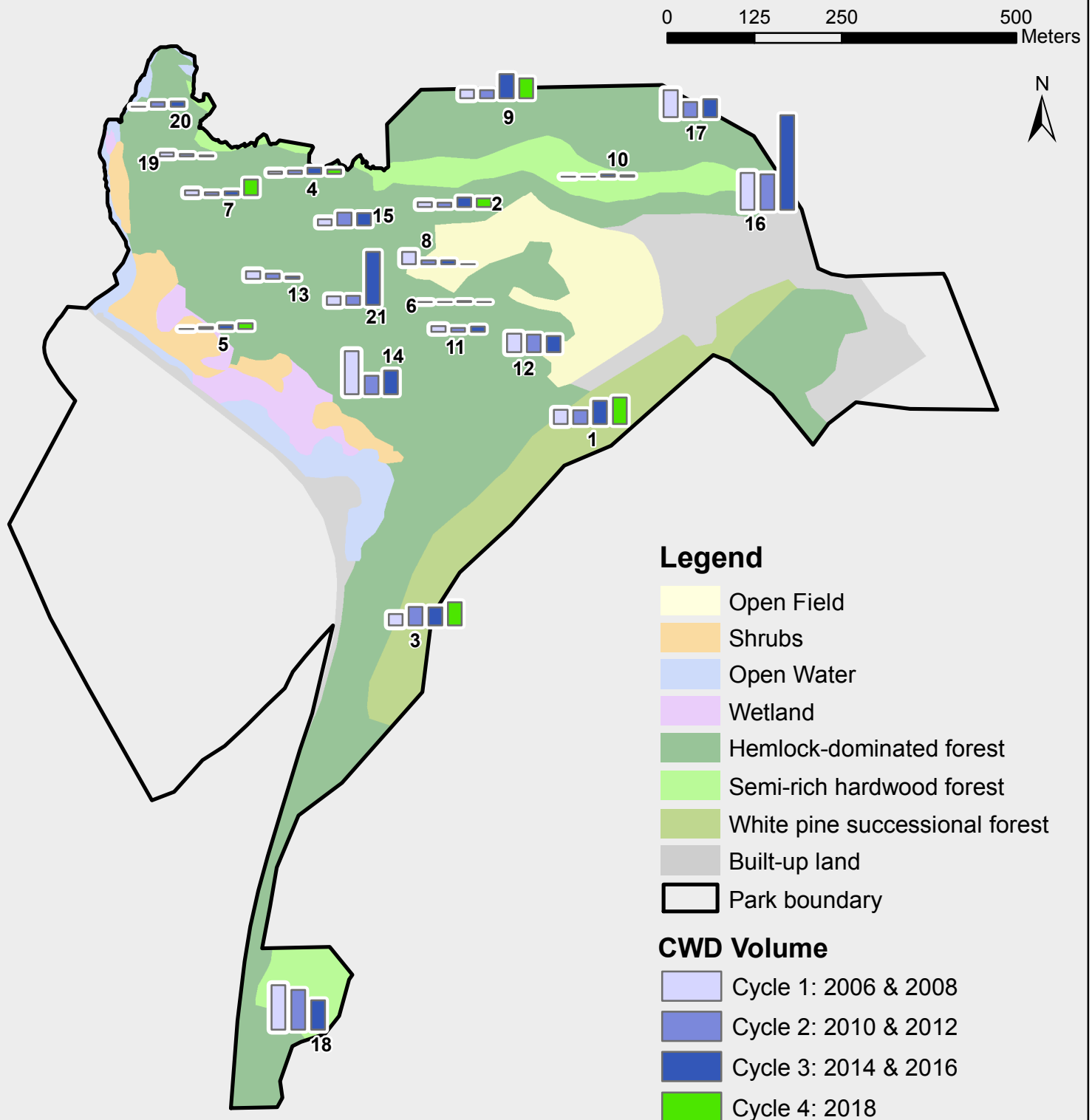
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Map 10. Coarse Woody Debris by Cycle

Trends in Coarse Woody Debris (CWD) volume observed in plots sampled from 2006-2018. Each plot is sampled on a 4-year cycle in an alternating panel, with plots 1-10 sampled in 2006, 2010, 2014, and 2018, and plots 11-21 sampled in 2008, 2012, and 2016. CWD volume ranges from 0 to 288.7 m³/ha (4,126.6 ft³/ac). Date: 6/18/2018.





Map 11. Coarse Woody Debris Levels: 2016 & 2018

Coarse woody debris volume (m^3/ha) for the most recent 4 year survey cycle (2016 & 2018). Plots 1-10 were sampled in 2018, and plots 11-21 were sampled in 2016. Volumes range from 0 - $288.7 \text{ m}^3/\text{hectare}$ ($4,127 \text{ ft}^3/\text{ac}$). Plots are color coded by volume to indicate whether they meet the $20\text{-}50 \text{ m}^3/\text{ha}$ ($285.8\text{-}714.6 \text{ ft}^3/\text{ac}$) threshold in Müller & Büttler (2010). Date: 6/22/2018.

