Baseline Sampling of Jack Pine Ecosystems in the Kirtland's Warbler Wildlife Management Area 2024-2025

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We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan's twelve federally recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous peoples.

Cover: Recoverable pine barrens in tract CR19. All photos by Tyler J. Bassett.

ACKNOWLEDGEMENTS

Funding for this project was provided by Huron Pines. We would like to thank Bryant Eddy of Huron Pines, and Lindsey Grayson and Sara Siekierski of the United States Fish and Wildlife Service, for their communications and support throughout our work on this project. Steve Woods with the Michigan Department of Natural Resources, Parks and Recreation Department, initiated the project and co-developed the approach while working with Huron Pines. Jesse Lincoln was integral to the execution of this project, contributing to field surveys and providing edits on an earlier draft of this report that greatly improved the clarity of language and its utility for managers from Huron Pines and USFWS. Administrative support was provided by Ashley Adkins, Katelyn Brolick, Mike Monfils, Sarah Carter, and Deb Richardson.

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INTRODUCTION

The Northern Lower Peninsula and Eastern Upper Peninsula of Michigan support millions of hectares of ecosystems dominated or co-dominated by jack pine (*Pinus banksiana*); these ecosystems include pine barrens and dry northern forest natural communities, early successional grasslands with young jack pine, and jack pine plantations. Jack pine ecosystems provide the majority of the global breeding habitat for the Kirtland's warbler (*Setophaga kirtlandii*), a species recently delisted from federal endangered species status (Olson 2002). Natural jack pine ecosystems were historically influenced by regular fire, either ignited by lightning or Indigenous Peoples (Kashian et al. 2012, Booth et al. 2023). Today, jack pine ecosystems are managed for Kirtland's warbler and other wildlife and plant species, using prescribed fire and silvicultural methods (Spaulding and Rothstein 2009, Comer 2010, Kashian et al. 2012).

The United States Fish and Wildlife Service (USFWS) owns and manages 2,710 hectares (6,700 acres) in the Kirtland's Warbler Wildlife Management Area (KWWMA) containing jack pine ecosystems in eight counties in the Northern Lower Peninsula. The KWWMA is comprised of 127 separate tracts ranging in size from 2 to 315 hectares (5-780 acres) (Figure 1). Effective management of the KWWMA requires surveys and monitoring to determine baseline conditions and to subsequently track the effects of management through time. *S*urveys to describe natural communities are needed to better understand the range of ecological integrity across the region and to select targets for management. Monitoring is needed prior to management to establish quantitative baseline conditions, so that the impacts of management on vegetative composition and ecosystem structure can be assessed. To this end, Michigan Natural Features Inventory (MNFI) contracted with Huron Pines in 2023 to conduct baseline surveys and monitoring in several KWWMA tracts which have continued through 2025. A previous report has been published on the field efforts of 2023 (Bassett and Lincoln 2024) while this report reflects work done during 2024 and 2025.

In addition to assessing management impacts to ecosystems, these efforts can also serve as a model for tracking the successes of restoring and managing jack pine ecosystems across the Northern Lower Peninsula and Eastern Upper Peninsula. There is growing interest in the region to collaborate and share resources across land managed by USFWS, Huron Pines, the United States Forest Service, the Michigan Department of Natural Resources, and other partners under the coordination of the Northern Pine Plains Partnership. Calibrating methods for surveys and monitoring, and sharing metrics of success, will improve outcomes for the conservation of jack pine ecosystems throughout the region.

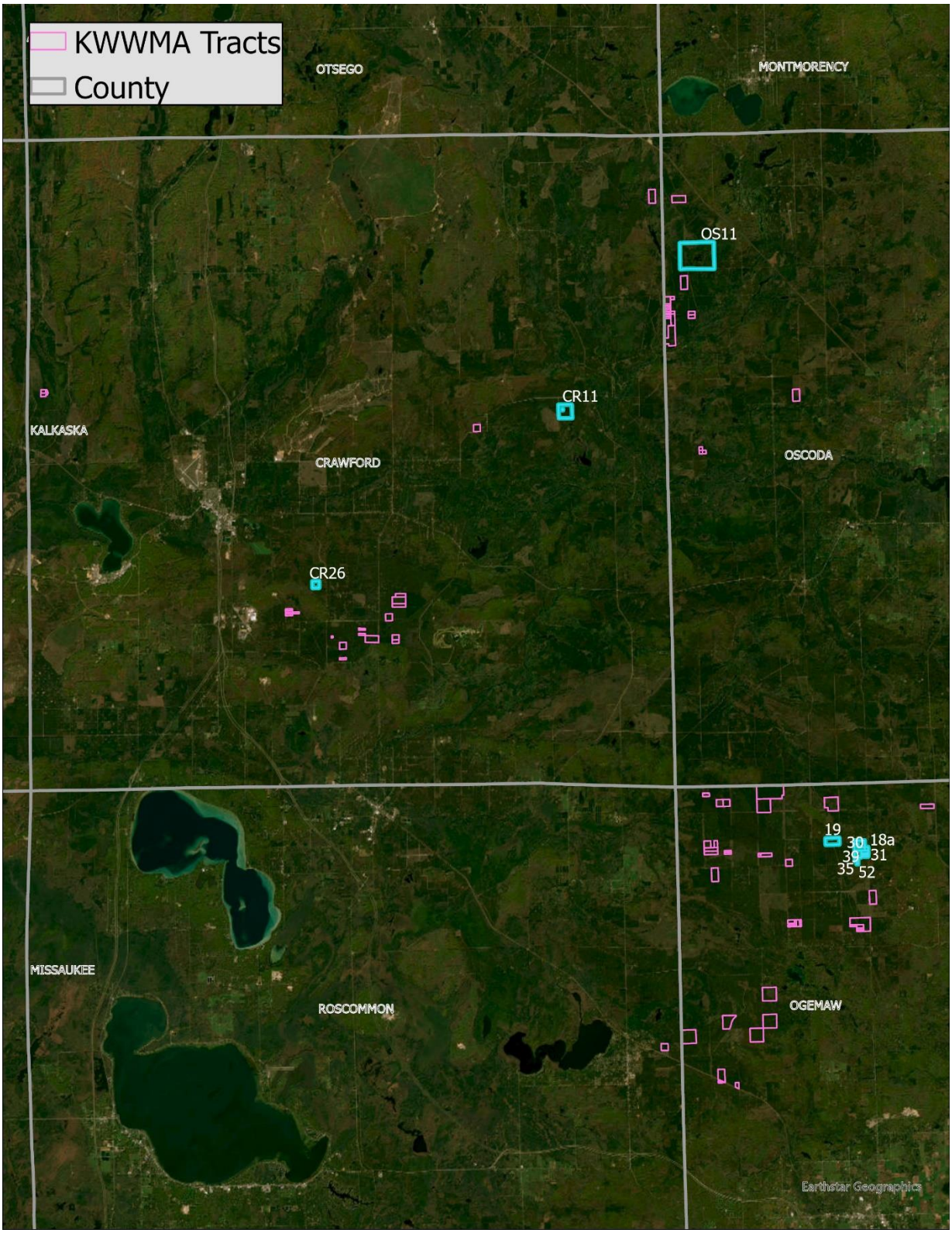

Figure 1. KWWMA tracts in the Northern Lower Peninsula of Michigan (one additional tract each in Montmorency and Presque Isle counties, not pictured). 2024-25 sampling targets in Crawford, Ogemaw, and Oscoda Counties are highlighted in cyan and labeled.

METHODS

We conducted quantitative plot sampling in 14 tracts in 2024 to generate baseline data on species composition and ecosystem structure ahead of planned management with fire and thinning, and natural community evaluation in 2 tracts in 2025 to assess ecological integrity and help prioritize future management.

Plot sampling

From July 15 to 19, 2024, we conducted plot sampling in 14 tracts in Crawford (26), Ogemaw (12, 15, 18, 18a, 30/31, 35, 39/27, 52), and Oscoda (11-North, 11-South, 11-Southeast, 11-Southwest, 11-West) Counties (FiguresFigure **1**,Figure **2**). We sampled 1,000 m^2 circular plots (18 m^2 radius) and 1x1 m frequency quadrats along parallel, equidistant transects. For each tract, we generated one transect for every 20 acres (tracts < 20 acres received one transect). On each transect, we generated two equidistant circular plot sampling points and seven equidistant frequency quadrat sampling points (Figure 2). Transects and sampling points were generated in ArcGIS Pro 3.3.

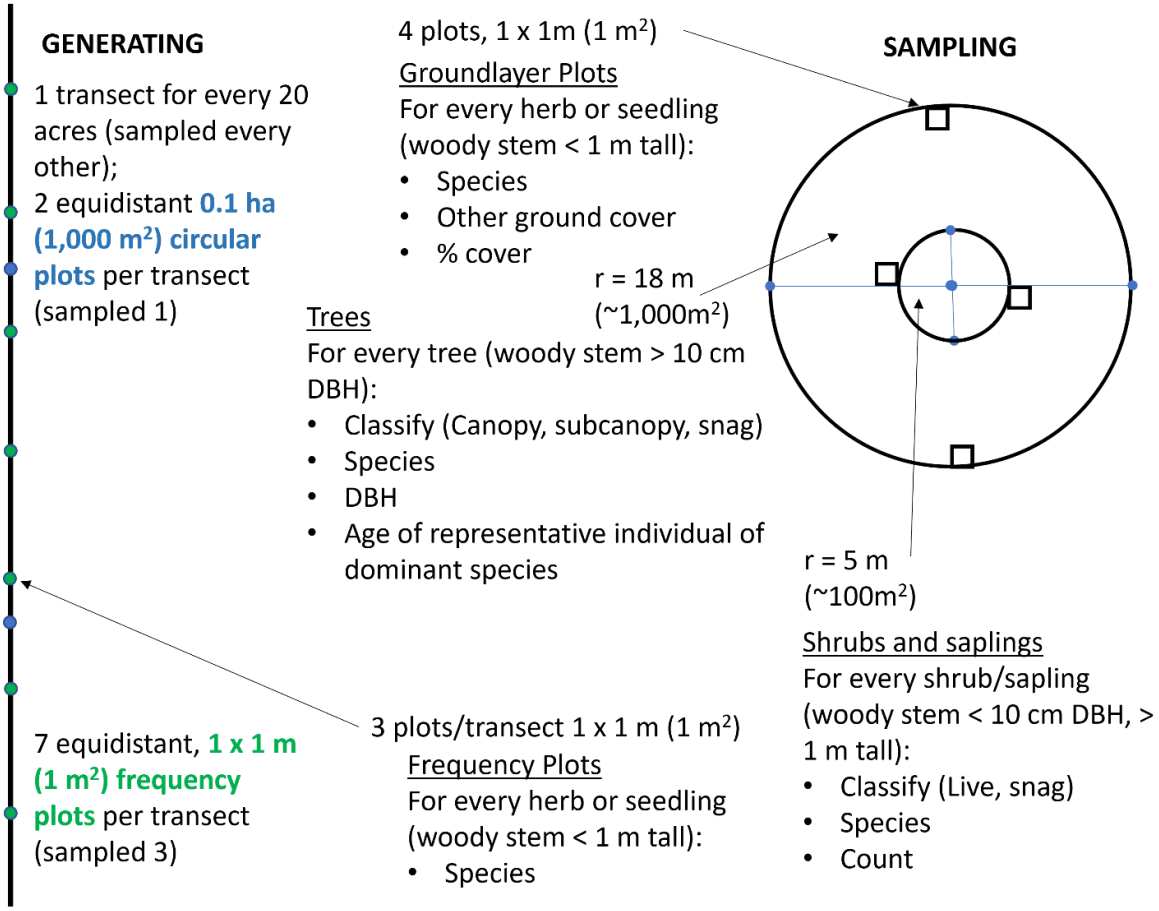

Figure 2. Sampling approach. First, we generated equidistant transects in each tract (left of panel). Then we sampled presence-absence of ground layer species in 1 m^2 *frequency plots* (green dots along transect) and trees, shrubs and saplings, and the ground layer plant community in nested 1000 m^2 *circular plots* (blue dots along transect).

In most cases, we sampled every other transect at each site (N = 17 transects) (Table 1). We combined two pairs of adjacent tracts for sampling, OG30/31 and OG 27/39. On each sampled transect, we randomly selected one circular plot and recorded vegetation data in three vertical strata (canopy, shrub and sapling, ground layer). In the 1,000 m^2 circular plot, we recorded the diameter at breast height (DBH; cm) of all trees (woody stems > 10 cm DBH), noted tree class (canopy [maximum canopy height of stand], subcanopy [less then maximum canopy height], snag [standing dead tree]) and estimated the age of a representative canopy tree with an increment borer (Figure 2). In a 100 m^2 nested plot (5 m^2 radius) in the center of the circular plot, we counted the number of shrub or sapling stems (woody stem < 10 cm DBH, > 1 m tall) for each species, noting shrub class (live, snag) (Figure 2). We sampled the ground layer plant community (herbaceous plants and woody stems < 1 m tall) in four 1 m^2 quadrats, two along the transect inside the margin of the circular plot and two at opposite ends of a line parallel to the transect outside the nested plot (Figure 2). Here, we recorded the percent cover of each species as well as the abundance of leaf litter, woody debris, bare ground, and tree bases according to the following classes: 0-1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95-100%. We measured the depth of leaf litter (to the nearest 0.5 cm) inside each of the four quadrat corners. Finally, we conducted a meander survey within the circular plot and recorded ground layer plant species that had not previously been recorded within the ground layer quadrats.

We also recorded the presence of ground layer plant species in three equidistant frequency quadrats along each transect (the two closest to each end and the central quadrat) (Figure 2). When equidistant frequency quadrats were in unsuitable habitat (e.g., wetland), we selected the next available quadrat. We also conducted meander surveys while sampling transects to generate more comprehensive vascular plant species lists for each tract, beyond those previously recorded within frequency quadrats or circular plots. With these meanders, we also generally characterized natural communities and documented rare species encountered opportunistically.

Meander surveys

We conducted meander surveys in two tracts of the KWWMA from September 3 to 4, 2025. Meander surveys evaluated the ecological integrity of natural communities in CR11 and OG19, following Natural Heritage Methodology (NatureServe 2002, Faber-Langendoen et al. 2016, 2024). Ecological integrity is defined as “an assessment of the structure, composition, function, and connectivity of an ecosystem as compared to reference ecosystems operating within the bounds of natural or historical disturbance regimes” (Faber-Langendoen et al. 2016, p. 3). This methodology evaluates natural communities in order to assign a quality rank (referred as the element occurrence rank or EO Rank ranging from A [Excellent estimated viability/ecological integrity] to D [Poor estimated viability/ecological integrity]) based on three rank factors: condition, size, and landscape context (NatureServe 2002). We largely focused on assessing condition. The *condition* of natural communities includes most of the site-level characteristics that describe ecological integrity and includes plant community structure and composition, plant and animal indicator species, ecological processes, and hydrology. *Size* is evaluated because larger occurrences of any natural community are assessed more favorably than smaller ones, but the expected or historical size of each natural community type varies. The pine

barrens, oak-pine barrens, dry northern forest, and dry-mesic northern forest that characterize KWWMA lands are 'matrix communities' that dominated large portions (patch size typically 2,000 to 10,000 ha) of the Michigan landscape prior to European colonization. Finally, the ecological integrity of natural communities is also influenced by *landscape context*. Natural communities that are embedded in landscapes dominated by high-quality natural communities are more buffered from biological and anthropogenic stressors than those that are embedded in heavily managed, agricultural, or developed landscapes.

Data analysis

We conducted Floristic Quality Assessments (FQAs) using the species lists generated during plot sampling or meander surveys for each tract (Reznicek et al. 2014). The FQA utilizes plant species composition to derive the Floristic Quality Index (FQI), a quantitative metric of habitat quality that can be used as a relatively objective comparison among natural community occurrences of the same type. Drawing upon expert consensus among botanists familiar with the flora of Michigan, each vascular plant species native to Michigan has been assigned an a priori coefficient of conservatism (C-value) that ranges from 0 to 10 on a scale of increasing conservatism or fidelity to pre-European colonization habitats (Reznicek et al. 2014). Plant species with a C-value of 7 to 10 are considered highly conservative (Herman et al. 2001). A C-value of 4 to 6 indicates moderate conservatism and a C-value of 1 to 3 indicates low or no conservatism (e.g., ruderal species). Non-native species were given a C-value of 0 for these calculations. We calculated FQI for each natural community occurrence as

$$FQI = \overline{C} \times \sqrt{n}$$

where $\overline{C}$ = mean C-value and n = species richness. Sites with an FQI of 35 or greater are generally considered to be floristically important from a statewide perspective (Herman et al. 2001).

Plot sampling was intended to provide baseline data so that change in measured ecosystem attributes could be analyzed following future sampling events. Therefore, we did not conduct statistical analyses of any of the quantitative data from plot sampling but provide summary tables in APPENDIX A for visual comparison of attributes among tracts.

RESULTS AND DISCUSSION

We do not provide the results of detailed data analyses in this report because most data were collected to serve as a baseline against which to gauge management efficacy. We have provided raw data, shapefiles, and select data summaries to Huron Pines and USFWS, and provide a few summary figures in APPENDIX A. Rare plant observations have been entered into the Michigan Natural Heritage Database (MNFI 2025).

Below, we provide general characterizations of each tract supported by plot sampling, meander surveys, and aerial imagery interpretation (Table 1). First, we note the primary natural community or natural communities that can serve as a management target for each tract. Each tract is degraded by previous land uses (e.g., silviculture, fire exclusion), so may not closely match all attributes of the natural community indicated here (Cohen 2010a, Cohen 2010b, Comer 2010). When ambiguous, we relied heavily on plant species composition to aid in classification, based on our experience with communities in the region, and our observations of species that are more likely to occur in barrens vs. forests (Lincoln et al. 2023, 2024, 2025; Bassett and Lincoln 2024; Bassett et al. 2024). Specifically, we highlight species that suggest continuity of a site with historical (i.e., pre-European colonization) land cover, regardless of the community type suggested by contemporary canopy structure (i.e., closed-canopied for forests and heterogenous canopy closure for barrens). We also note any rare plant species observed during surveys. We emphasize characteristic vegetation patterns for each tract, especially features that differentiate between tracts, floristic patterns that characterize the condition of a tract, and attributes that suggest opportunities or barriers for restoration. For all tracts except CR11 and OG19, descriptions are based primarily on results of plot sampling and aerial imagery interpretation rather than meander surveys; therefore, descriptions may not comprehensively describe each tract. When available, we have supplemented plot sampling data with additional observations, including those made by Bassett and Lincoln (2024).

In general, we recommend regular application of low intensity prescribed fire (every 5-25 years) in late summer through the dormant season, which should improve the ecological integrity of natural communities in the KWWMA. Regular, low-intensity fire encourages the regeneration of jack, red (*Pinus resinosa*), and white pine (*Pinus strobus*) while limiting the regeneration of pyrophobic hardwood species like black cherry (*Prunus serotina*) and Hill's oak (*Quercus ellipsoidalis*). Low-intensity fire also "primes" canopy trees for future fires by stimulating resin production that seals the bark against subsequent injury; reduces ladder fuels and stimulates the growth of fine herbaceous fuels that will support subsequent ground fires; reduces the risk of wildfire by reducing the chance of crown fires; triggers serotiny in jack pine cones required for recruitment; and stimulates population growth through seed germination, recruitment, and growth in conservative forbs and grasses that make up most of the species richness (Gauthier et al. 1996, Mitchell et al. 2006, Hauser 2008, Cohen 2010a, Cohen 2010b, Comer 2010, Jolly et al. 2016, Wu et al. 2023).

Table 1. Summary of surveyed sites. Data on tracts 11 in Crawford County and 19 in Ogemaw County from meander surveys, all others from plot sampling (Figure 2).

Tract	County	Hectares (acres)	Transects	Primary Natural Community	Canopy Age(s)	Species Richness (% native)	FQI	Mean C
11	Crawford	63.48 (156.86)	0	Pine barrens	103, 46	41 (92.7%)	30.1	4.7
26	Crawford	16.07 (39.71)	1	Pine barrens	38	26 (92.6%)	23.5	4.6
12	Ogemaw	16.16 (39.92)	1	Dry northern forest	116, 57	21 (100%)	22.9	5.0
15	Ogemaw	20.19 (49.90)	2	Dry northern forest	83, 49	23 (100%)	35.4	5.3
18	Ogemaw	16.15 (39.91)	1	Dry northern forest	59	11 (96.3%)	15.3	4.6
18a	Ogemaw	4.04 (9.99)	1	Dry northern forest	31	27 (100%)	25.5	4.9
19	Ogemaw	32.74 (80.91)	0	Dry northern forest	98, 84, 53	33 (97%)	29.3	5.1
30/31	Ogemaw	8.77 (21.68)	1	Dry northern forest	29	14 (100%)	19.1	5.1
35	Ogemaw	4.03 (9.96)	1	Dry-mesic northern forest	100, 20	20 (100%)	21.5	4.8
39/27	Ogemaw	6.09 (15.04)	1	Dry northern forest	111, 53	13 (100%)	16.9	4.7
52	Ogemaw	2.02 (4.99)	1	Dry northern forest	70	14 (100%)	16.1	4.3
11-N	Oscoda	26.49 (65.47)	2	Oak-pine and pine barrens, dry-mesic northern forest	NA*	67 (88.1%)	33.6	4.1
11-S	Oscoda	8.90 (22.00)	1	Weave plantation	NA*	34 (94.1%)	26.2	4.5
11-SE	Oscoda	24.52 (60.58)	2	Dry northern forest	56, 41	33 (100%)	24.1	4.2
11-SW	Oscoda	15.29 (37.78)	1	Row plantation	NA*	41 (97.6%)	29.5	4.6
11-W	Oscoda	10.37 (25.63)	1	Weave plantation	NA*	33 (93.9%)	25.3	4.4
		Total:	17					

*A value of NA indicates either missing or omitted data

Crawford County Tracts

We conducted meander surveys at one tract in Crawford County, CR11, and plot sampling at another, CR26. The latter was sampled following the 2023 Wilderness Trail Fire.

Tract CR11

Natural community: Pine barrens
Rare species: Hill's thistle (*Cirsium hillii*, Special Concern)

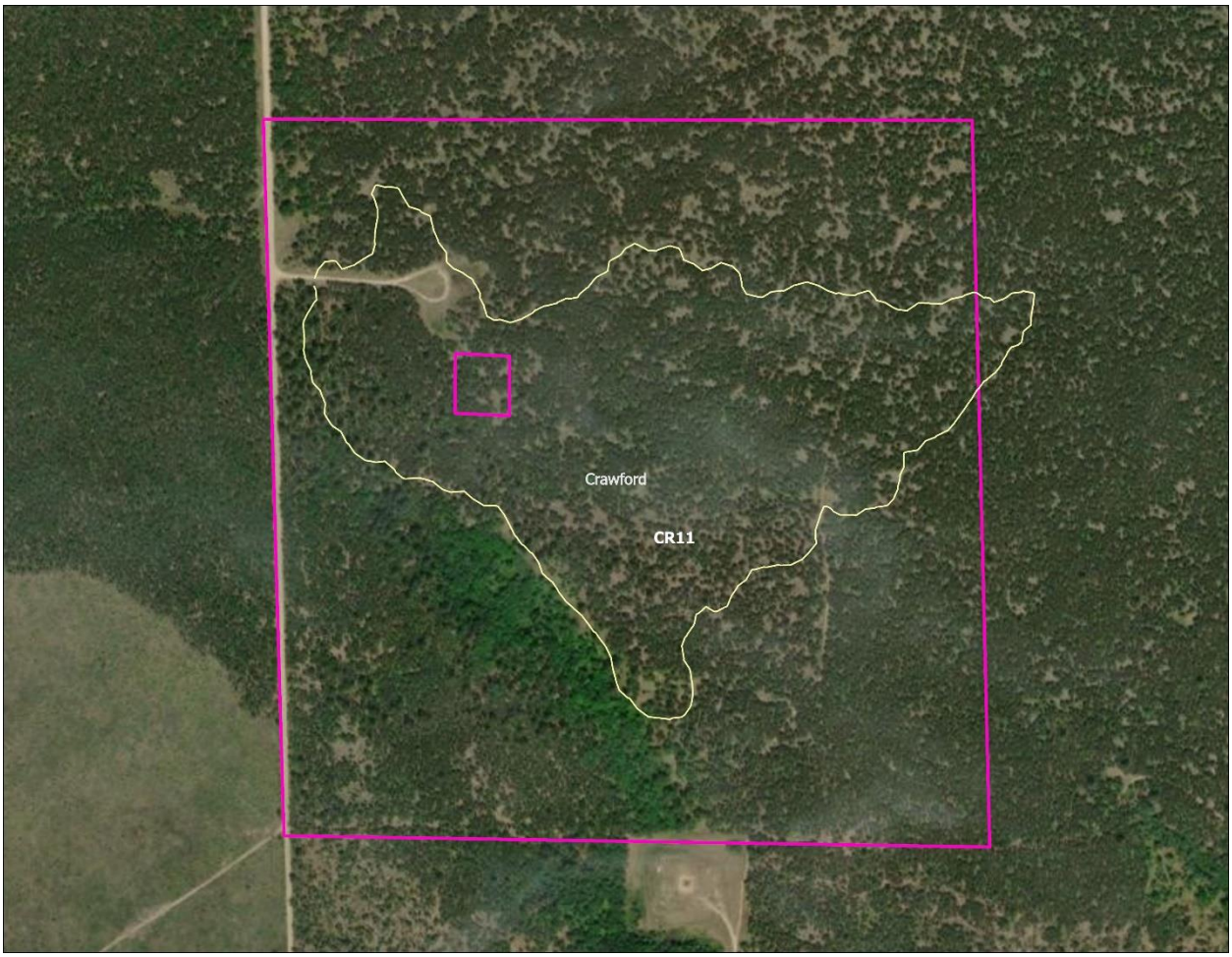

Figure 2. Tract 11 in Crawford County, with survey track from 9/4/2025.

This tract is a degraded but recoverable pine barrens, possessing representative species composition but mostly lacking conservative species. Anthropogenic soil disturbance was apparent in several areas, although the precise origin was not clear. The canopy was strongly dominated by jack pine and was approximately 50 years old, regenerating following the Bald Hill Fire which burned 485 hectares (1,200 acres) in 1975 (Kashian and Barnes 1982). Several stumps with fire char were also observed, although occasional coarse woody debris suggested canopy mortality. There was also a sparse supercanopy of approximately 100-year old red pine

which was more abundant in the western 1/3rd of this tract where the structure and composition was more similar to dry northern forest. Jack pine was dense in the subcanopy and tall shrub layers, with the exception of several small openings throughout. Low sweet blueberry (*Vaccinium angustifolium*) was dominant in the low shrub layer, with locally dense patches of sweet fern (*Comptonia peregrina*), sand cherry (*Prunus pumila*), and shadbush serviceberry (*Amelanchier spicata*). The ground layer was dominated by reindeer lichen (*Cladonia mitis* and *C. rangiferina*). Species with low (C-value 0-3) to moderate (C-value 4-6) conservatism were frequent, especially Pennsylvania sedge (*Carex pensylvanica*), poverty grass (*Danthonia spicata*), and bracken fern (*Pteridium aquilinum*), while highly conservative species (C-value 7-10) like Gillman's goldenrod (*Solidago simplex*) and western sunflower (*Helianthus occidentalis*) were infrequent to rare. Five individuals of Hill's thistle were observed in 2025 in a small opening in the far west of this tract. Non-native species were observed including occasional common St. John's-wort (*Hypericum perforatum*) and rare occurrences of spotted knapweed (*Centaurea stoebe*) and yellow hawkweed (*Hieracium caespitosum*). Ant mounds formed by *Formica* spp. were common (Figure 3).

Figure 3. An example of an ant mound formed by *Formica* spp. in tract CR11.

Tract CR26

Natural community: Pine barrens

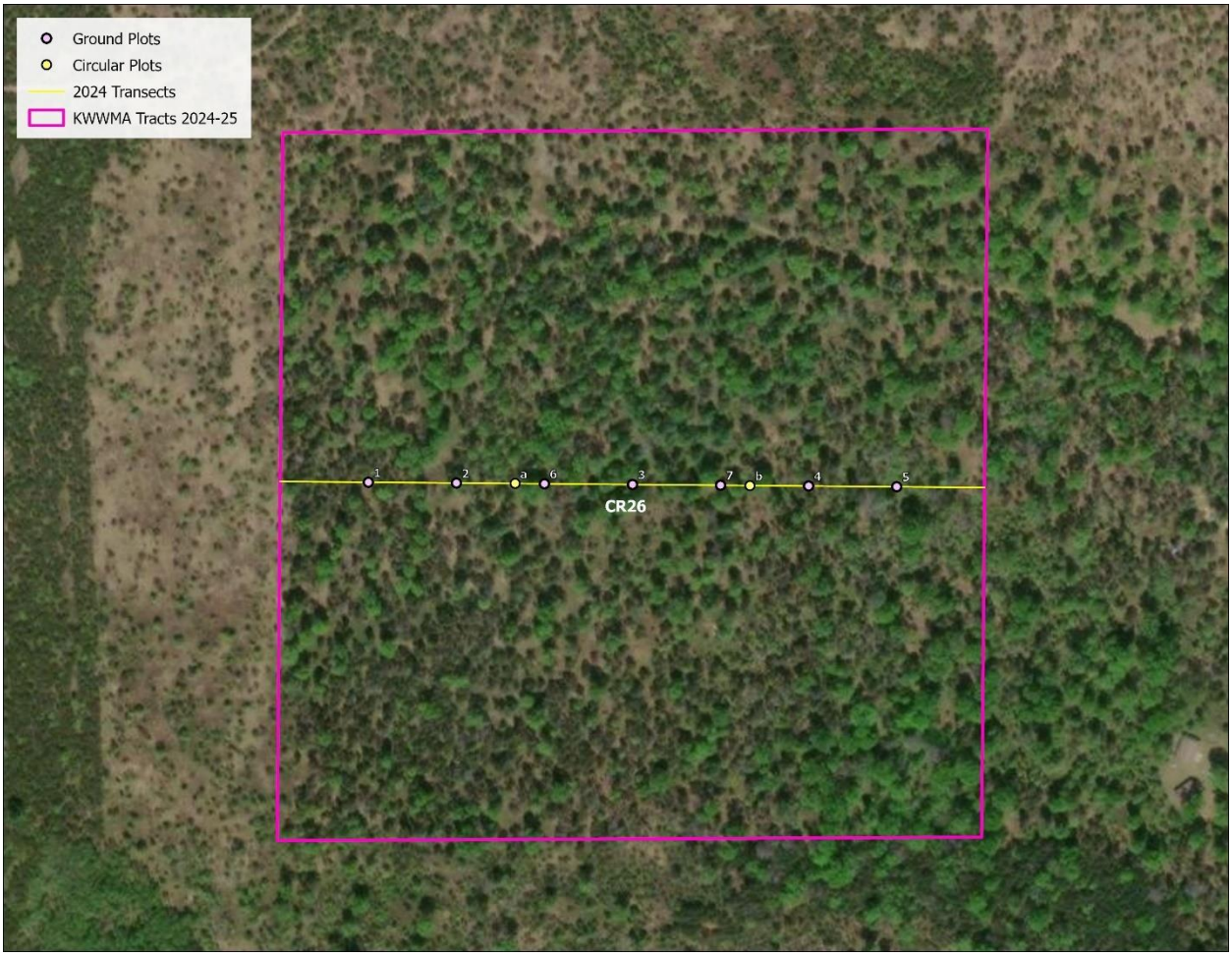

Figure 4. Tract 26 in Crawford County.

This tract burned in the 2023 Wilderness Trail Fire, a 971-hectare (2,400-acre) wildfire that caused widespread mortality of canopy trees and heavy reduction in both litter and ladder fuels. Approximately 25% of canopy trees in the circular plot were alive while the remaining canopy trees were snags (Figure 5). All surviving canopy trees were Hill's oak while snags included jack pine and Hill's oak. Black cherry, Hill's oak, jack pine, red pine, and white pine were all present in the subcanopy, suggesting moderate post-fire regeneration of canopy trees. While much of the litter layer was absent, low shrubs such as sweet fern, sand cherry, and low sweet blueberry were common. The ground layer was dominated by bracken fern and Pennsylvania sedge, while rice-grass (*Piptatheropsis pungens*) was common (Figure 5). The prevalence of bracken fern is often associated with recent closed-canopied conditions, but at this site may also be a transient response to the Wilderness Trail Fire along with the presence of weedy native species such as fireweed (*Erechtites hieracifolius*) and pearly everlasting (*Anaphalis margaritacea*). Bull thistle (*Cirsium vulgare*) is the only non-native species observed

in this tract, but we recommend monitoring for invasive species which may spread from neighboring two-tracks into soils exposed by the wildfire. The post-fire trajectory of canopy structure and species composition is uncertain, so additional monitoring will be required to inform future management targets.

Figure 5. The ground layer in CR26, here dominated by bracken fern. Blackened tree stems are jack pine snags while other trees are living and dead Hill's oak.

Ogemaw County Tracts

We conducted plot sampling in a contiguous block of 10 tracts in Ogemaw County (Figure 6), and meander surveys at one additional tract, OG19.

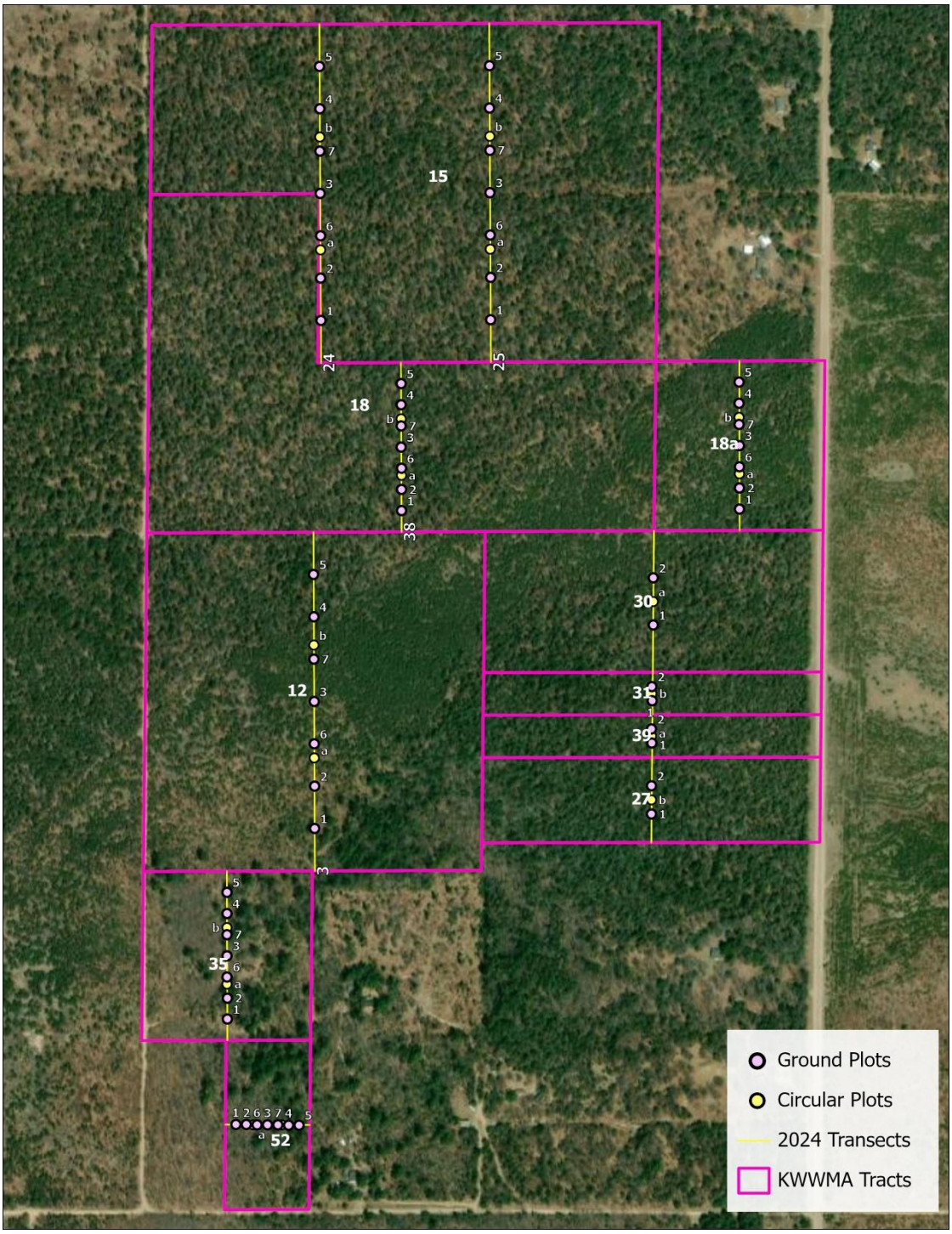

Figure 6. Tracts 12, 15, 18, 18a, 27, 30, 31, 35, 39, and 52 in Ogemaw County.

Tract OG12

Natural communities: Dry northern forest

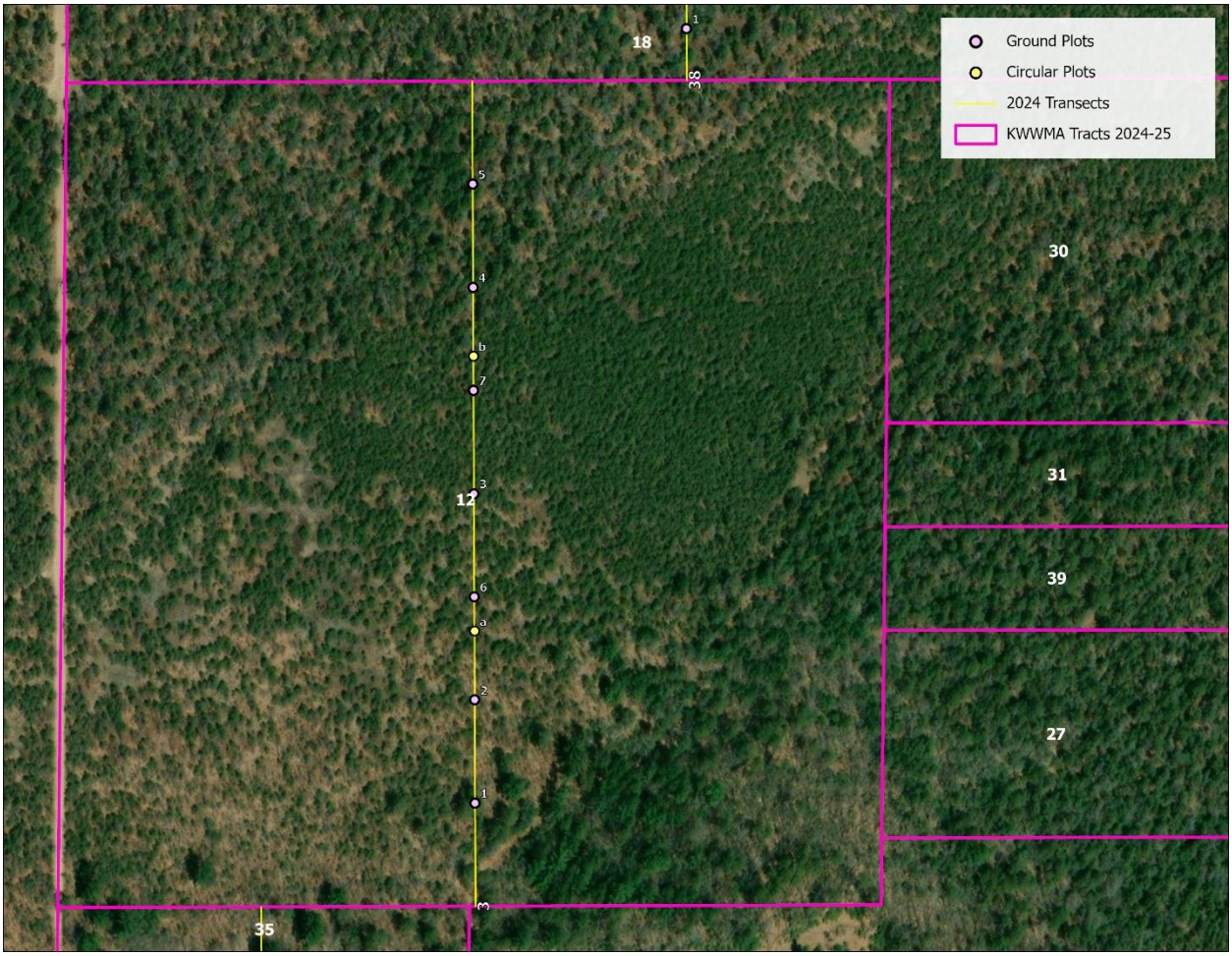

Figure 7. Tract 12 in Ogemaw County.

This tract is a degraded dry northern forest, although portions have pine barrens structure. The canopy was strongly dominated by jack pine with very few occurrences of Hill's oak. The subcanopy was open and thin, composed primarily of Hill's oak with a few occurrences of jack pine and white pine. The ground layer was mostly composed of moderately conservative species like shadbush serviceberry, low sweet blueberry, cow-wheat (*Melampyrum lineare*), harebell (*Campanula rotundifolia*), sweetfern, big bluestem (*Andropogon gerardii*), and poverty grass. Highly conservative species included huckleberry (*Gaylussacia baccata*), trailing-arbutus (*Epigaea repens*), sand cherry, rice-grass, and bear-berry (*Arctostaphylos uva-ursi*). Species such as huckleberry and trailing-arbutus that are more likely to occur in dry northern forests were prevalent in the ground flora, while species indicative of pine barrens were lacking. The southeastern half of this tract was in the path of the Perry Holt fire of 1998 and largely dominated by early jack pine regeneration. There was less regeneration in the southwestern

quarter of the tract making this area structurally more similar to pine barrens. No non-native invasive species were documented in this tract.

Tract OG15

Natural community: Dry northern forest

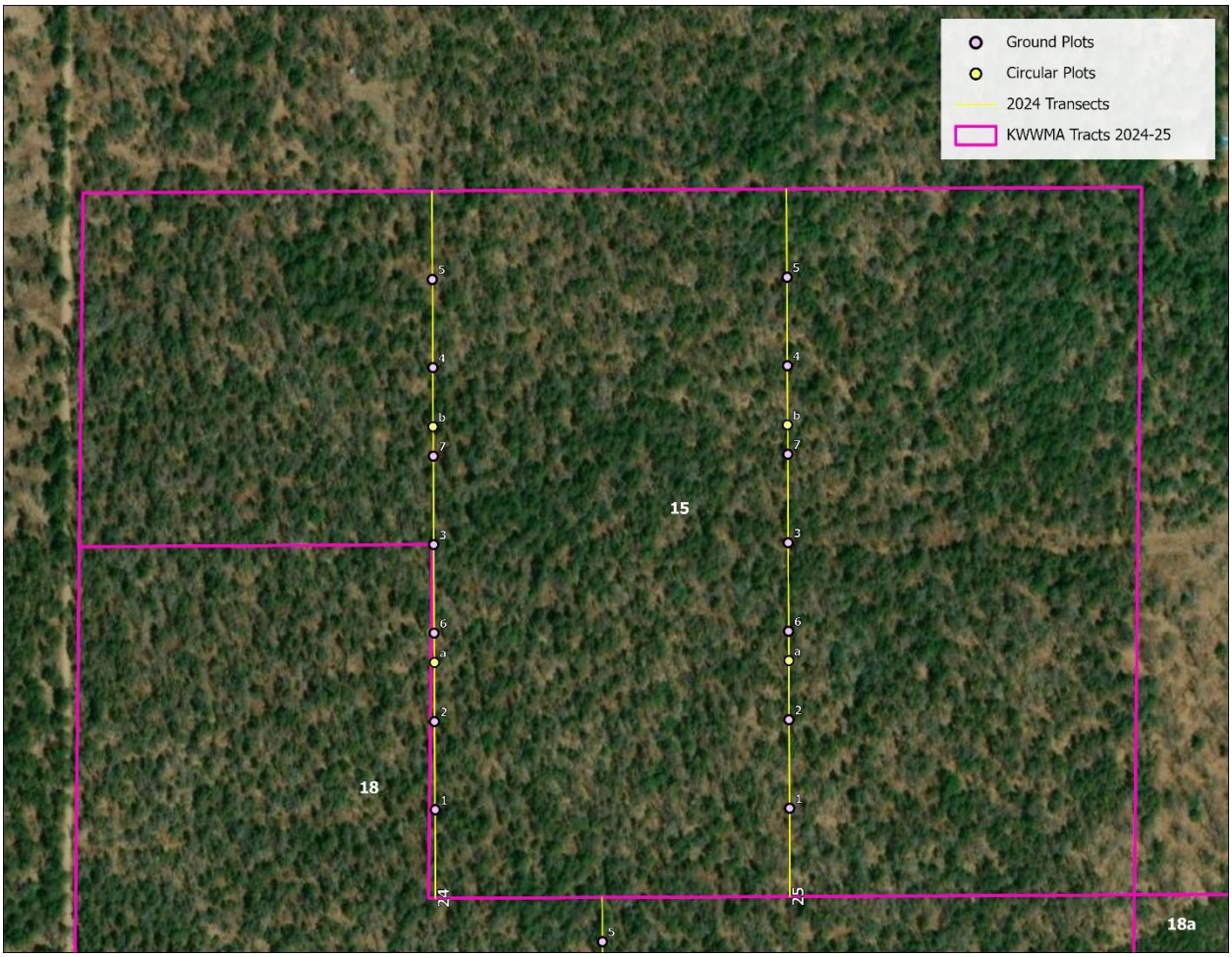

Figure 8. Tract 15 in Ogemaw County.

This tract had a canopy dominated primarily by jack pine with occasional Hill's oak. Snags of both canopy species were occasional. The subcanopy was somewhat sparse and composed mostly of Hill's oak with infrequent occurrences of jack pine, red pine, and white pine. The ground layer was structurally and compositionally diverse. Pennsylvania sedge was abundant. Moderately conservative species included low sweet blueberry, hair grass (*Avenella flexuosa*), and wintergreen (*Gaultheria procumbens*). Highly conservative species included common frostweed (*Crocanthemum* canadense), trailing-arbutus, rice-grass, huckleberry, bear-berry, and ground-cedar (*Diphasiastrum tristachyum*). This tract supported several species that are indicative of dry northern forests or large closed-canopied portions of barrens such as trailing-

arbutus, wintergreen, and huckleberry. This tract had an FQA of 35.4 which indicates it is floristically significant (Herman et al. 2001) and zero non-native invasive species were recorded.

Tract OG18

Natural community: Dry northern forest

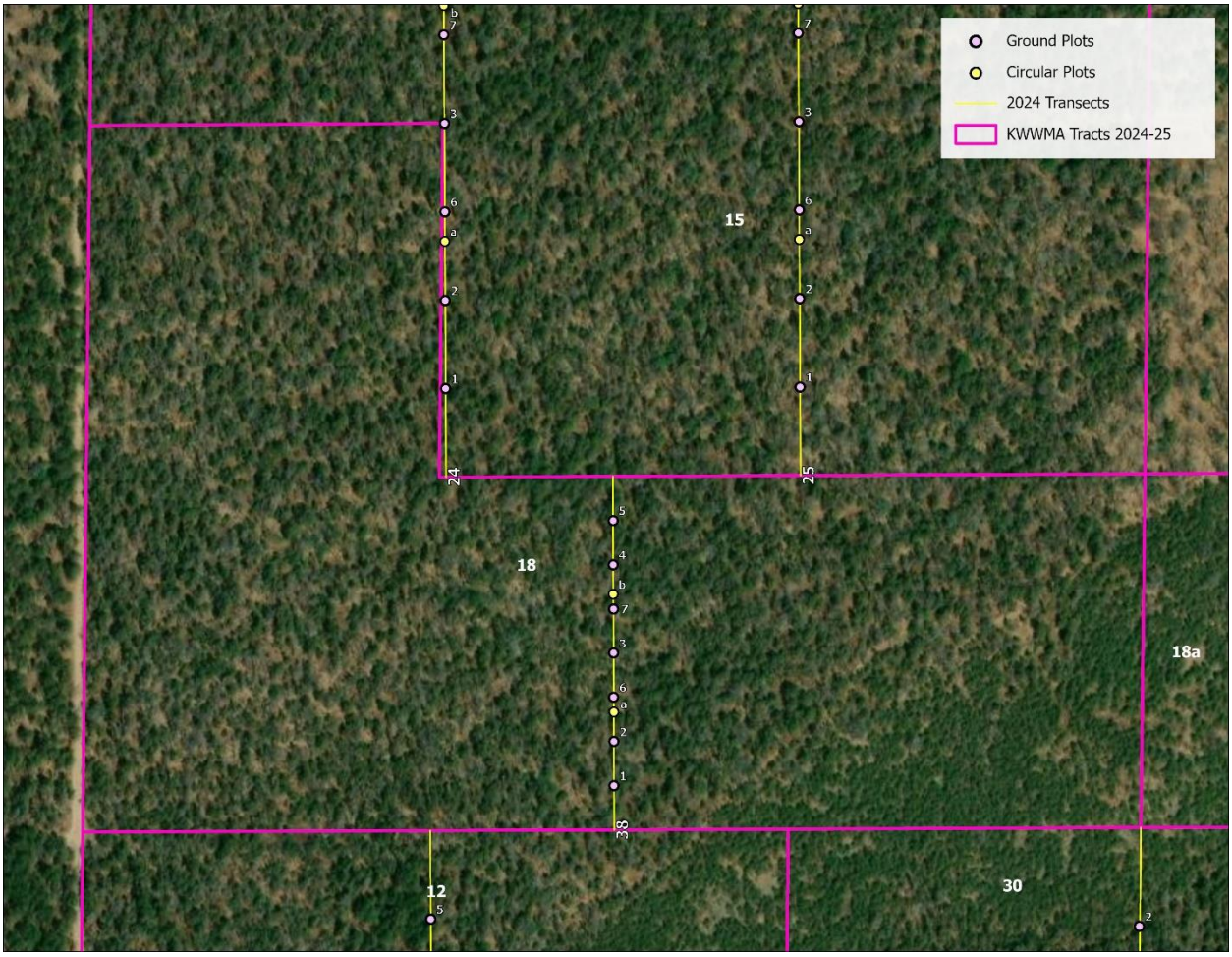

Figure 9. Tract 18 in Ogemaw County.

This tract had a canopy dominated by jack pine with occasional Hill's oak. The subcanopy was thinner than the canopy and evenly-dominated by jack pine with white pine as a co-dominant. Red pine was rare. A few standing dead snags of Hill's oak and jack pine were observed in the canopy and subcanopy, but most trees were alive. The shrub layer was sparse with Hill's oak as the most commonly observed species. The most frequent species of the ground layer was low sweet blueberry. Feathermosses (order Hypnales), wintergreen, and young saplings of Hill's oak were also commonly noted in this stratum. Rice-grass was the only highly conservative species documented in tract OG18. This tract supported species generally found in forests and not

barrens such as trailing-arbutus, wintergreen, bracken fern, and cow-wheat. An approximately 2 ha (4.5 ac) area in the southeast of the track was in the path of the Perry Holt Fire of 1998.

Tract OG18a

Natural community: Dry northern forest

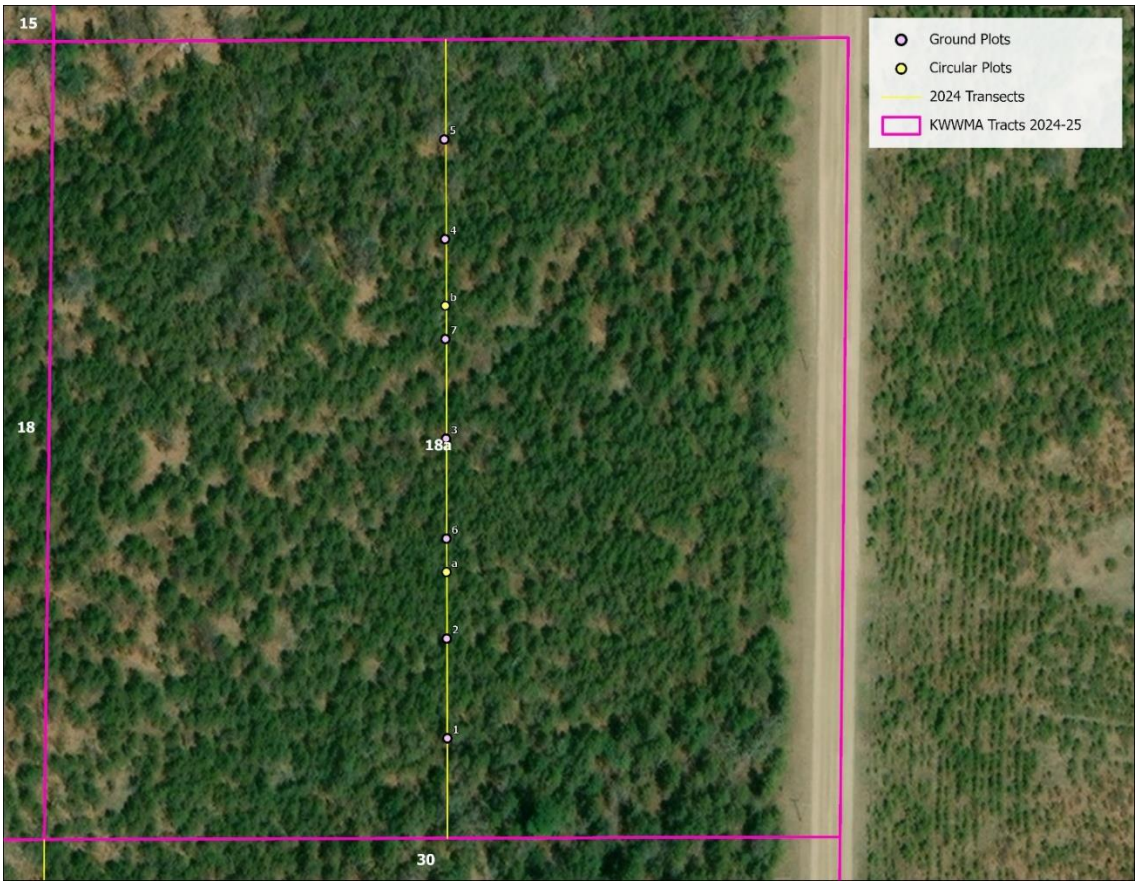

Figure 10. Tract 18a in Ogemaw County.

This tract had a dense canopy largely dominated by young jack pine as a result of regeneration following the Perry Holt Fire of 1998. The subcanopy was extremely sparse with only a few individuals of red oak (*Quercus rubra*) documented. The shrub layer was similarly sparse, represented by only a handful of jack pine and red oak saplings. A few jack pine snags were noted in the canopy and in the shrub layer. Common species included bracken fern, Pennsylvania sedge, low sweet blueberry, feathermosses, and reindeer lichen. Some moderately conservative species included big bluestem, little bluestem (*Schizachyrium scoparium*), bastard-toadflax (*Comandra umbellata*), and rattlesnake-weed (*Hieracium venosum*). Highly conservative species included rice-grass, common frost weed, and bearberry. The ground flora was variable but the presence of species like bracken fern, wintergreen, rice-grass, huckleberry, and cow-wheat suggest continuity with dry northern forest. Small openings

contained mostly species that are generalists in the jack pine plains such as little bluestem, rattlesnake weed, and poverty grass.

Tract OG19

Natural community: Dry northern forest

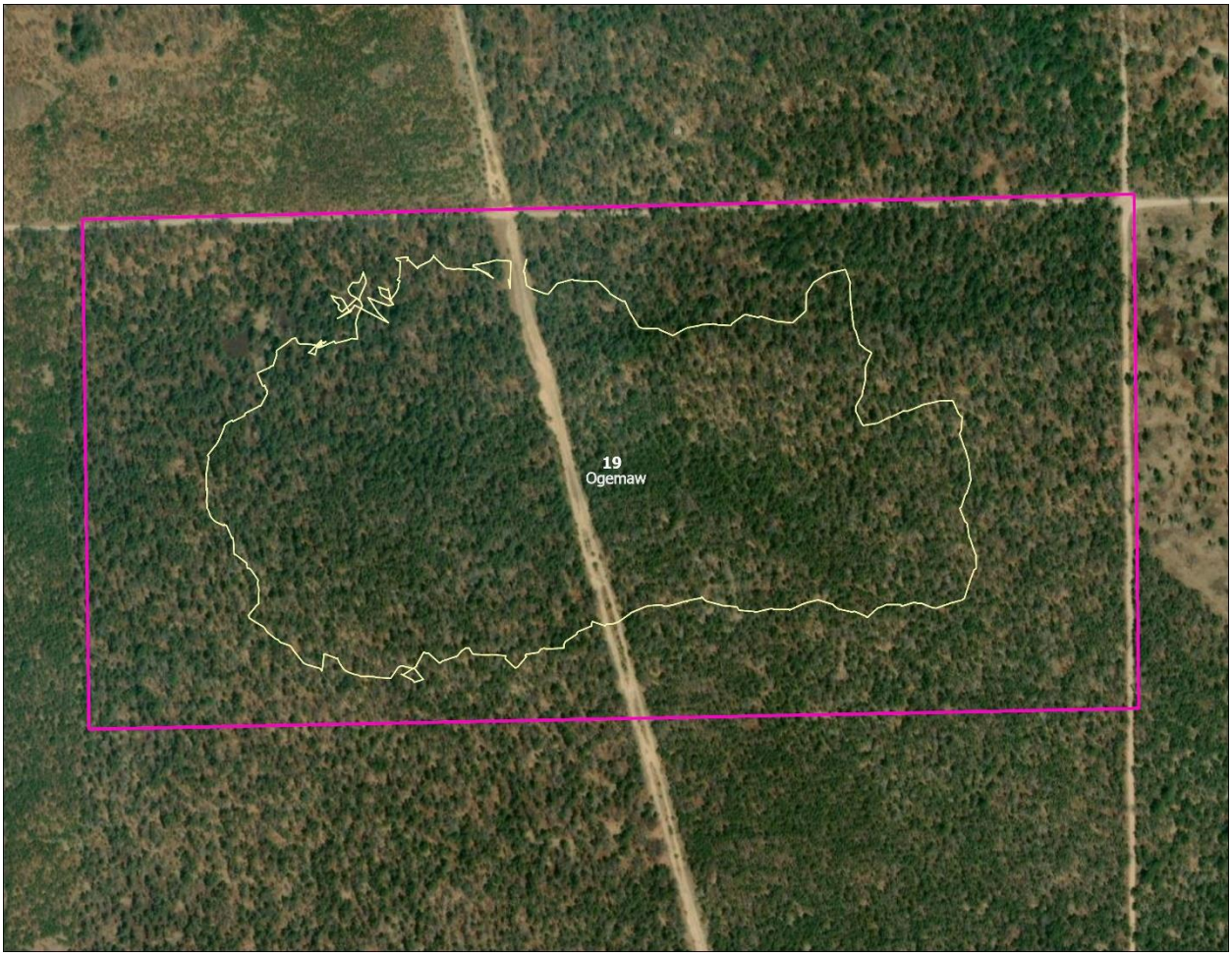

Figure 11. Tract 19 in Ogemaw County, with survey track from 9/3/2025.

This tract is a degraded but recoverable dry northern forest. The moderately dense canopy (~80% cover) was strongly dominated by jack pine, including two cohorts estimated at approximately 60 and over 100 years old, respectively. Hill's oak and red pine were occasional in the canopy and white pine was uncommon to rare. Jack pine snags and coarse woody debris were locally abundant. All species that were dominant to occasional in the canopy were present in the subcanopy, and tall shrub layers were composed of all canopy species plus hardwood species black cherry and white oak (*Quercus alba*). The eastern 1/5th of this tract was characterized by a more open canopy and structure consistent with pine barrens as well as dense Hill's oak regeneration which is likely a response to the Damon Fire of 1996. The ground

layer was mostly dominated by low shrubs although bracken fern, feather mosses, and reindeer lichen were common. The low shrub layer was dominated by low sweet blueberry and locally by huckleberry (Figure 12), while sweet fern and wintergreen were frequent and bearberry was common. The prevalence or presence of highly to moderately conservative species like huckleberry, wintergreen, pink lady's-slipper (*Cypripedium acaule*), and trailing-arbutus are indicative of dry northern forest rather than a pine barrens community. Ant mounds formed by *Formica* spp. were occasional. Non-native common St. John's-wort was rare in this tract but should be monitored for population growth every two to three years.

Figure 12. Huckleberry was locally dominant in the low shrub layer of tract OG19.

Tracts OG30/31

Natural community: Dry northern forest

Figure 13. Tracts 27, 30, 31, and 39 in Ogemaw County. Tracts 30 and 31 were sampled together, as were tracts 27 and 39.

These tracts had a canopy strongly dominated by jack pine. The subcanopy was thin and also dominated by jack pine, while white pine was uncommon. White oak was rare in the subcanopy and snags were occasional in both the canopy and subcanopy. The shrub layer was very thin with infrequent occurrences of jack pine and Hill's oak. The ground layer was composed of roughly equal proportions of vegetation and leaf litter (43.75% and 38.13%, respectively; Figure A4) with abundant bracken fern throughout. Also present were spreading dogbane (*Apocynum androsaemiifolium*), Pennsylvania sedge, and red oak seedlings. Moderately conservative plants included cow-wheat and low sweet blueberry while highly conservative included rice-grass, trailing-arbutus, and sand cherry. Composition suggests continuity with dry northern forest as indicated by the presence of species like bracken fern, cow-wheat, and trailing-arbutus. No species were observed that are representative of high-quality barrens communities and zero non-native invasive species were documented within the surveyed areas. Much of tracts 30 and

31 appear to have been in the path of the Perry Holt Fire of 1998. The northwestern portion of tract 30 in particular shows evidence of recent fire as it was dominated by young jack pine regeneration.

Tract OG35

Natural community: Dry or dry-mesic northern forest

Figure 14. Tract 35 in Ogemaw County.

This tract was likely pine barrens historically but is undergoing mesophication (shifting from drier to more mesic ground layer conditions). As such, tract 35 appears to be on a successional trajectory toward dry-mesic northern forest (Cohen 2010a). The canopy was moderately dense and dominated by big-tooth aspen (*Populus grandidentata*), perhaps a response to the Perry Holt Fire of 1998. The lack of dense jack pine regeneration, as seen in other tracts affected by the Perry Holt Fire, may be due to a locally limited seed source of jack pine. Red maple (*Acer rubrum*) was also very common in the canopy while red pine was rare in the west but increasingly common toward the east. The subcanopy was thin and composed of white pine.

The shrub layer was more dense than other tracts and was dominated by witch-hazel (*Hamamelis virginiana*) while also containing a mix of living and dead red maple and white pine. The ground layer was strongly dominated by leaf litter (82.5%; Figure A4) and floristically more representative of dry-mesic northern forest than pine barrens or dry northern forest (Cohen 2010a, Cohen 2010b, Comer 2010). This tract contained several species that are more likely to occur in dry or more often dry-mesic northern forests, such as witch-hazel, prince's-pine, pinesap, star-flower, and rough-leaved rice-grass (*Oryzopsis asperifolia*). No species restricted to high-quality barrens were observed. Common ground layer species included bracken fern, Pennsylvania sedge, wintergreen, and red maple seedlings. Moderately conservative species included low sweet blueberry, star-flower (*Trientalis borealis*), pinesap (*Hypopitys monotropa*), bristly greenbrier (*Smilax hispida*), and rough-leaved rice-grass. The highly conservative species observed in this tract were prince's-pine (*Chimaphila umbellata*), low bindweed (*Calystegia spithamaea*), and round-leaved pyrola *(Pyrola americana*). No non-native invasive species were documented.

Tracts OG39/27

Natural community: Dry northern forest

The maturing canopy in these tracts (Figure 13) was composed of jack pine with rare occurrences of red and white pine. The subcanopy was dominated by jack pine while white pine, white oak, red oak, and red maple were rare. Jack pine snags were frequent in both the canopy and subcanopy. The shrub layer was composed of red maple and, less frequently, white oak. The ground layer was dominated by a low diversity community of vascular plant species, although non-vascular species were also abundant. Common plant species included Pennsylvania sedge, low sweet blueberry, reindeer lichen, feathermosses, hair moss (*Polytrichum* spp.), and red oak seedlings. Big bluestem was one of the few moderately conservative species observed. No highly conservative species were documented. These tracts contained mostly species that occur across the forest-barrens matrix in the jack pine plains, with no portion of the flora strongly indicating dry northern forest or pine barrens as a management target. No non-native invasive species were recorded.

Tract OG52

Natural community: Dry northern forest

Figure 15. Tract 52 in Ogemaw County.

This tract supports pine barrens structure but the preponderance of species such as trailing-arbutus, wintergreen, huckleberry, witch-hazel, and cow-wheat suggests continuity with dry northern forest (Figure 16). The current successional trajectory indicates mesophication toward oak-pine barrens or dry-mesic northern forest. The canopy was thin to maturing, dominated by big-tooth aspen, and with infrequent occurrences of white oak and red maple. The subcanopy was much denser than the canopy and was comprised of white oak as the dominant species with some occurrences of big-tooth aspen, red maple, white pine, and red oak. The shrub layer was also dense and dominated by white pine with white oak, red maple, and witch-hazel occurring infrequently. Aerial imagery indicates that the canopy in this tract is dense in the northeast quadrant while other areas are thinner and homogenous, a pattern possibly influenced by the Perry Holt Fire of 1998. Common species included Pennsylvania sedge, bracken fern, and seedlings of oak and maple. Moderately conservative species included

wintergreen, cow-wheat, and low sweet blueberry. Highly conservative species included trailing-arbutus and huckleberry. No non-native invasive species were documented.

Figure 16. Trailing-arbutus is a species more commonly associated with dry northern forests or large, closed-canopied portions of pine barrens.

Oscoda County Tracts

We conducted plot sampling in five portions of tract OS11, which occupies 315 hectares (780 acres) and supports multiple cover types (Figure 17). The dominant cover types in this tract are a small lake and submergent marsh surrounded by conifer swamp and emergent marsh. Bassett and Lincoln (2024) described evaluations of some of the natural communities in this tract based on meander surveys. For the current study, we delineated and conducted plot sampling in five upland portions (Figures 18-23).

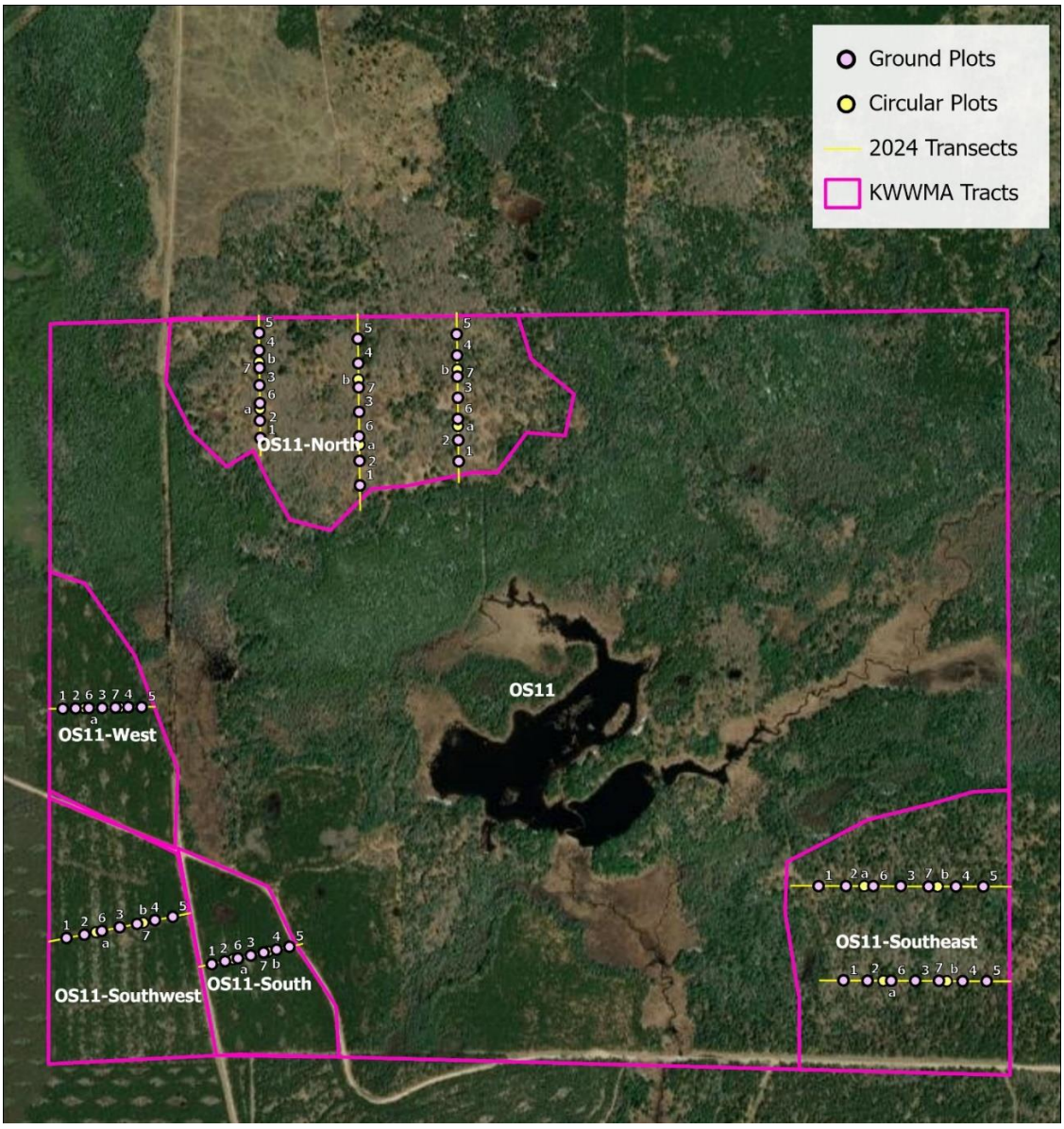

Figure 17. Tract 11 in Oscoda County containing individual sampling areas 11-North, 11-South, 11-Southeast, 11-Southwest, and 11-West. Note large wetland complex in center, surrounded by uplands supporting pine barrens and other communities.

Tract OS11-North

Natural community: Oak-pine and pine barrens, dry-mesic northern forest
Rare species: Hill's thistle (*Cirsium hillii*, Special Concern)

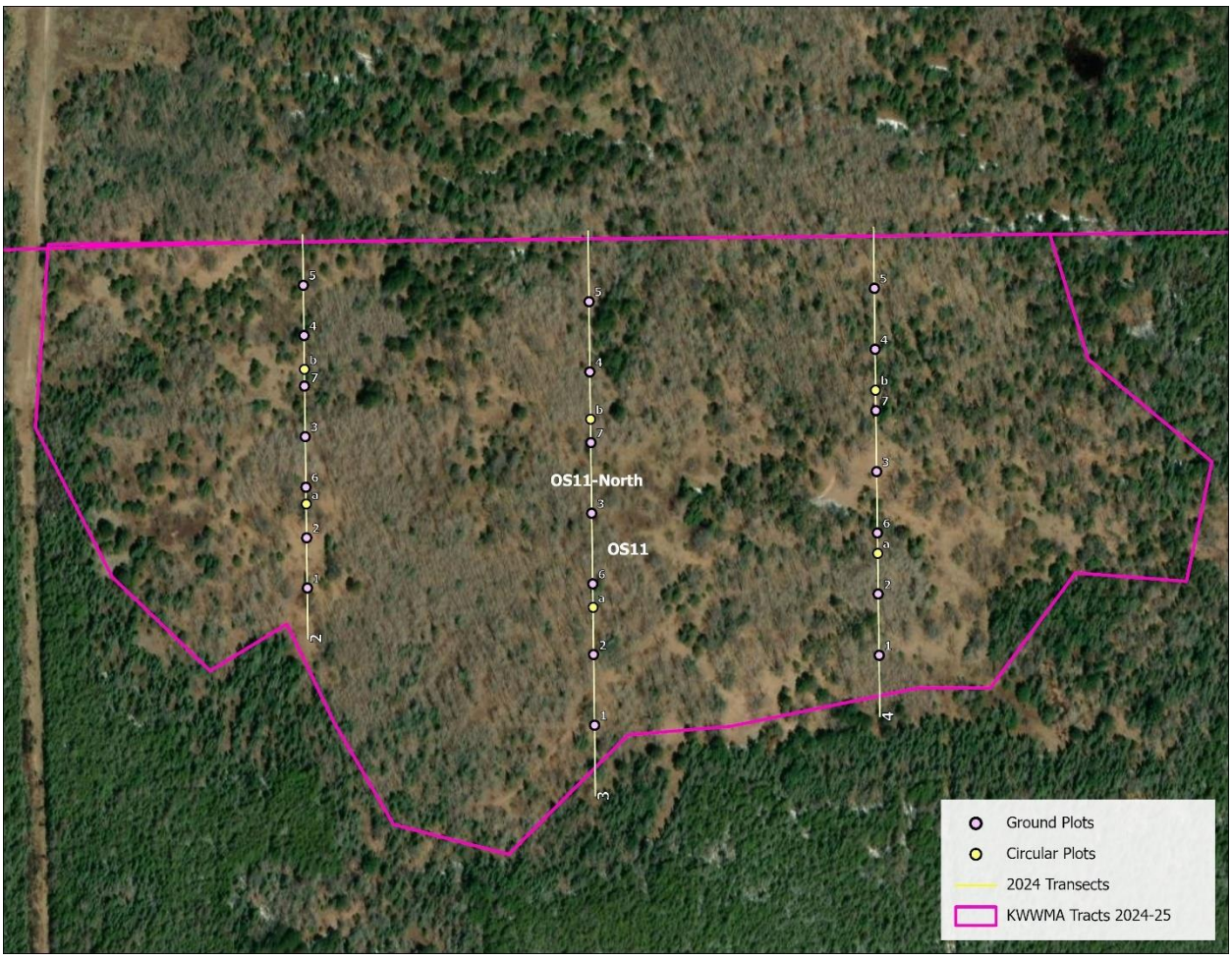

Figure 18. Tract 11-North in Oscoda County.

This tract is a mix of oak-pine and pine barrens undergoing mesophication toward dry-mesic northern forest and portions which appear to be degraded dry-mesic northern forest with openings. Indicators of this complex condition include the dominance of quaking aspen (*Populus tremuloides*) (Figure 19), with infrequent to rare occurrences of big-tooth aspen, balsam fir (*Abies balsamea*), and paper birch (*Betula papyrifera*). Mesophication, to the extent it is occurring, is a result in part of the dispersal of mesophytic tree species from conifer swamps on the south and west. The subcanopy was moderately dense and dominated by black cherry but also included quaking aspen, jack pine, red maple, balsam fir, and red pine. The shrub layer was also moderately dense and composed of black cherry and balsam fir with infrequent occurrences of red pine, jack pine, and big-tooth aspen. Common species in the ground layer included bracken fern, running ground-pine (*Lycopodium clavatum*), and

Pennsylvania sedge. Moderately conservative species included rattlesnake-weed, false melic (*Schizachne purpurascens*), sweetfern, and low sweet blueberry. Highly conservative species included Gillman's goldenrod, northern shorthusk (*Brachyelytrum aristosum*), bearberry, and rice-grass. Bassett and Lincoln (2024) described this tract as including primarily degraded dry-mesic northern forest, with elements of dry northern forest and isolated barrens openings. Consistent with this, species recorded during 2024 plot sampling included many that occur with similar frequencies in both barrens and forest habitats such as Pennsylvania sedge, low sweet blueberry and reindeer lichen. Several species were observed that are indicative of forests including northern shorthusk, trailing-arbutus, and wintergreen as well as some indicative of barrens including prairie brome (*Bromus kalmii*) and Gillman's goldenrod. This tract had the highest species richness of all tracts surveyed in 2024-2025 (Table 1), likely due to this habitat diversity. The distribution of species was uneven to moderately even with bracken fern and Pennsylvania sedge being the most abundant. We documented eight non-native species including some that may be management concerns such as common St. John's-wort and Canada and Kentucky bluegrass (*Poa compressa* and *P. pratensis*). We documented Hill's thistle during 2023 surveys (Bassett and Lincoln 2024).

Figure 19. Dry-mesic portion of tract OS11-North dominated by quaking aspen.

Tract OS11-South

Natural community: None – Weave plantation

Figure 20. Tract 11-South in Oscoda County.

The canopy of this tract was a dense monoculture of planted jack pine. The subcanopy was composed only of rarely observed black cherry. The shrub layer was thin and dominated by jack pine with some rare occurrences of black cherry. Leaf litter accumulation was high in the ground layer (mean depth 2.8 cm; Figure A4) and mosses and lichens were abundant. Common ground layer species included bracken fern, Pennsylvania sedge, hairgrass, sand cherry, hair mosses, and feather mosses while openings in the weave were dominated almost exclusively by Pennsylvania sedge. Some moderately conservative species included cow-wheat, Canada mayflower (*Maianthemum canadense*), and rough-leaved rice-grass. Highly conservative species included bearberry, prairie brome, and rice-grass. Occasional to frequent species such as Canada mayflower, bracken fern, wintergreen, and starflower are more likely to occur in dry northern forests. A small wetland inclusion occurs in the northern central end of the tract. Invasive orange hawkweed (*Hieracium aurianticum*), a common non-native species, was recorded in this tract.

Tract OS11-Southeast

Natural community: Dry northern forest

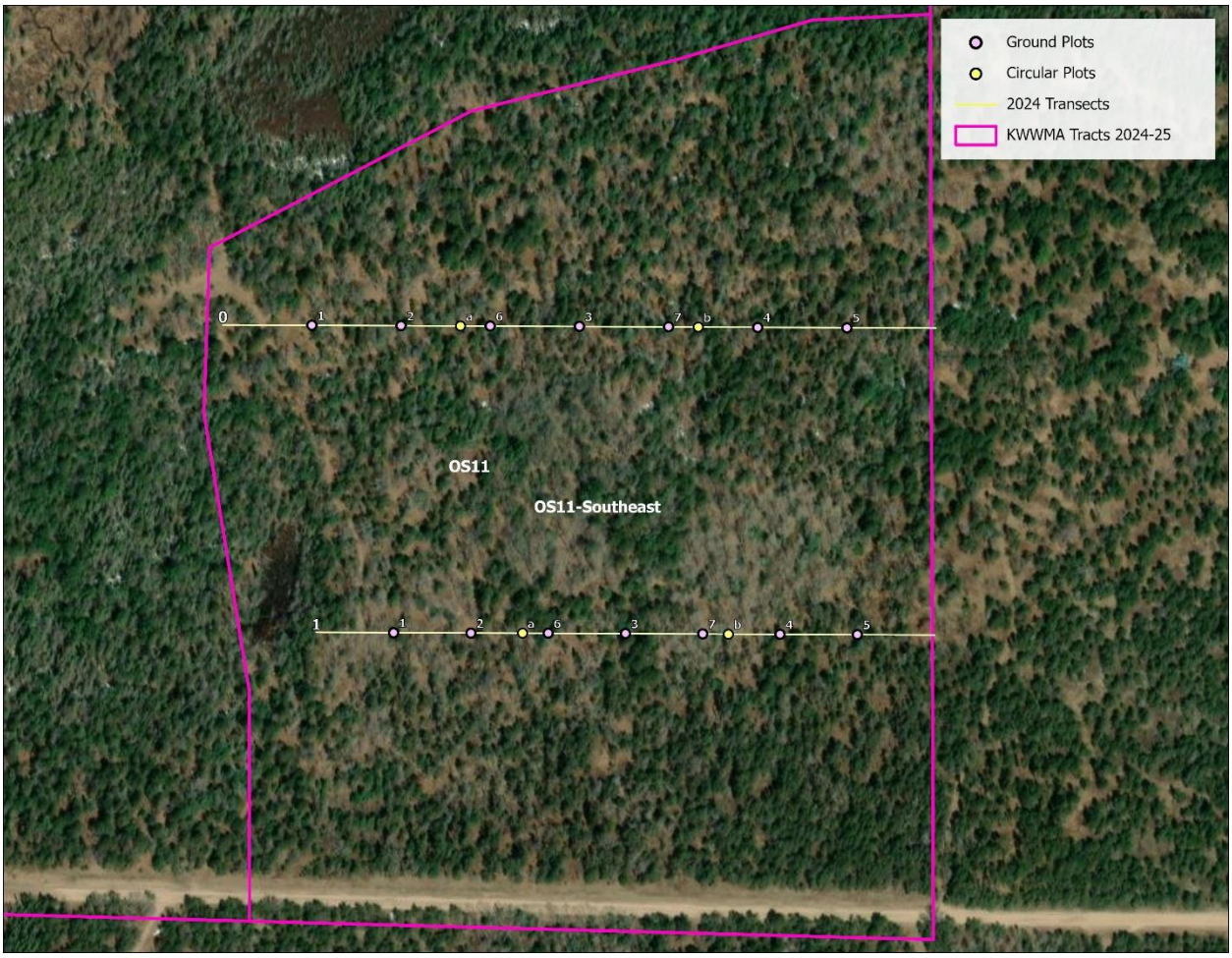

Figure 21. Tract 11-Southeast in Oscoda County.

This tract had a patchy canopy dominated by quaking aspen with frequent white pine and balsam fir and infrequent red maple and Hill's oak. Quaking aspen was also the most common species in the subcanopy with frequent occurrences of balsam fir and less frequent occurrences of red maple, jack pine, white pine, and red pine. Snags of jack pine and red pine were noted in the canopy and white pine in the subcanopy with a sparse shrub layer. Common species included bracken fern, Pennsylvania sedge, huckleberry, and wintergreen. Moderately to highly conservative species included big bluestem, rough-leaved rice-grass, sweet fern, and false melic. Bassett and Lincoln (2024) described a fire-suppressed barrens in the south along Farrington Road, grading into dry to dry-mesic northern forest to the north. In 2024, we mostly observed species restricted to high-quality forests including wintergreen, Canada mayflower, huckleberry, and star flower in addition to generalist species that occur with similar probability in barrens and forests. No non-native species were documented. This tract is heterogenous in

canopy density and structure, with some small openings throughout that could harbor barrens species.

Tract OS11-Southwest

Natural community: None – Row plantation

Figure 22. Tract 11-Southwest in Oscoda County.

This tract had a dense canopy dominated by jack pine with some occurrences of black cherry and very few occurrences of red pine. The subcanopy was extremely sparse with just a few occurrences of black cherry. The shrub layer was moderately dense and included jack pine and black cherry. Most of the trees in these layers were alive with very few snags. Common species included hairgrass, low sweet blueberry, Pennsylvania sedge, and wintergreen. Highly conservative species included bearberry, rice-grass, rough-leaved rice-grass, and sand cherry. Composition was variable. Wintergreen, northern short husk, and trailing-arbutus were among species observed in 2024 that are more likely to occur in forests than the open portions of barrens. No species restricted to high-quality barrens habitat were observed, but several

species that are more representative of barrens were documented including hairy goldenrod (*Solidago hispida*), old-field goldenrod (*Solidago nemoralis*), and sand violet (*Viola adunca*). Bassett and Lincoln (2024) noted that small patches of moderately to highly conservative species occurred throughout this tract in areas not planted with jack pine, suggesting that pine barrens would be a reasonable management target. Non-native yellow hawkweed was also noted in this tract.

Tract OS11-West

Natural community: None – Weave plantation

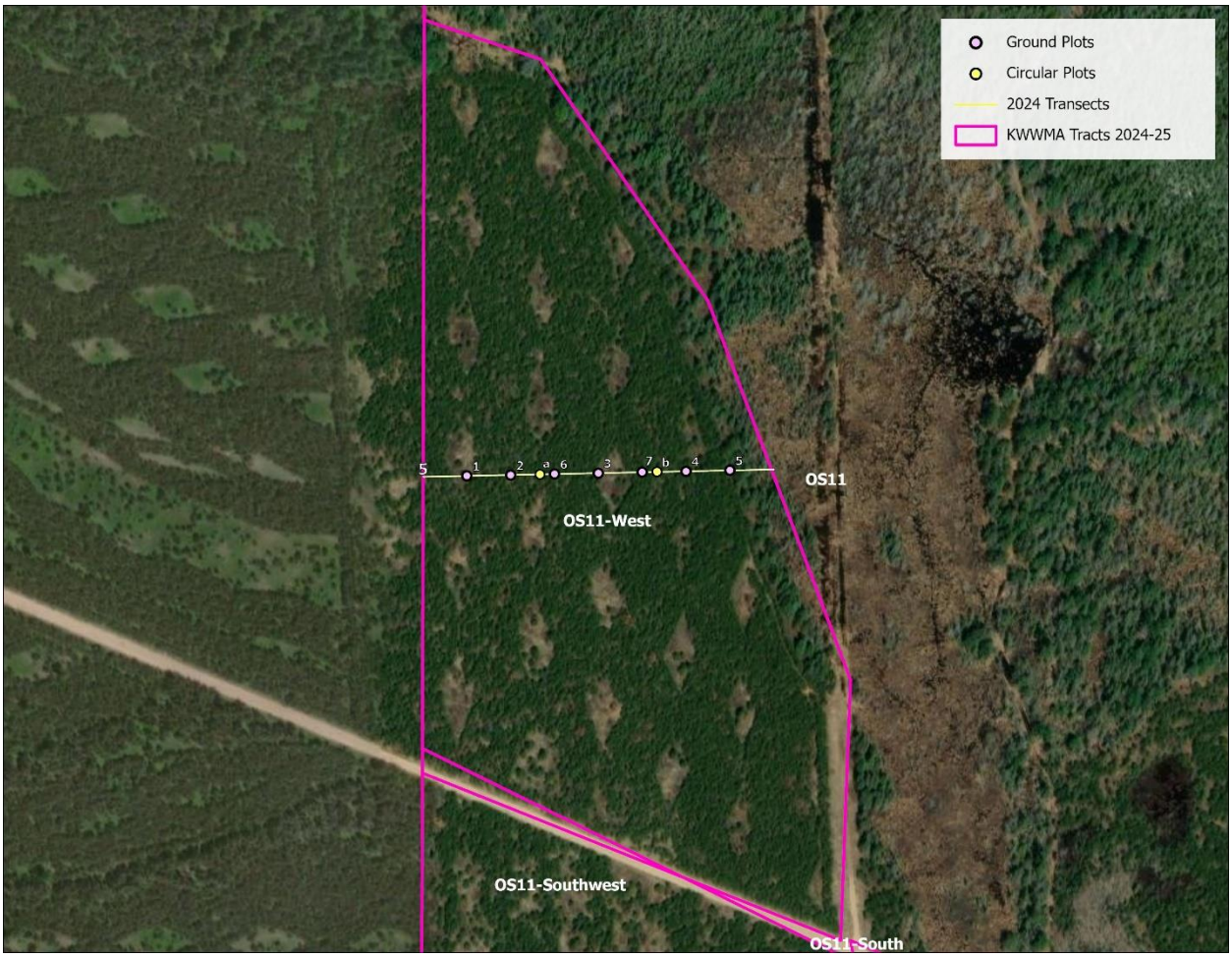

Figure 23. Tract 11-West in Oscoda County.

This tract is a traditional weave plantation with a canopy dominated by jack pine and locally co-dominated by red pine. The subcanopy was denser than the canopy and also dominated by jack pine with frequent occurrences of red oak. The shrub layer was moderately dense and was dominated by jack pine. Common species observed in this tract included bracken fern, sweet fern, Pennsylvania sedge, and feathermosses. Highly conservative species included melic grass,

harebell, and rice-grass. No species indicative of historical barrens communities were observed; however, a few species more likely to occur in forests were observed including bracken fern, wintergreen, and wood anemone (*Anemone quinquefolia*). The floristic composition suggests moderate continuity with a historical forested state despite the degrading effects of conversion to weave plantation. The non-native, invasive wood bluegrass (*Poa nemoralis*) was observed in this tract and should be treated and monitored in the event that this tract is managed.

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APPENDIX A: SELECT DATA SUMMARY FIGURES

Here, we include example figures, summarizing canopy density (Figures A1, A2), shrub and sapling density (Figure A3), groundcover metrics (Figure A4), and plant species richness (Figures A5, A6) for each tract. There were statistically significant differences between tracts for all metrics found below. See figure captions for more information.

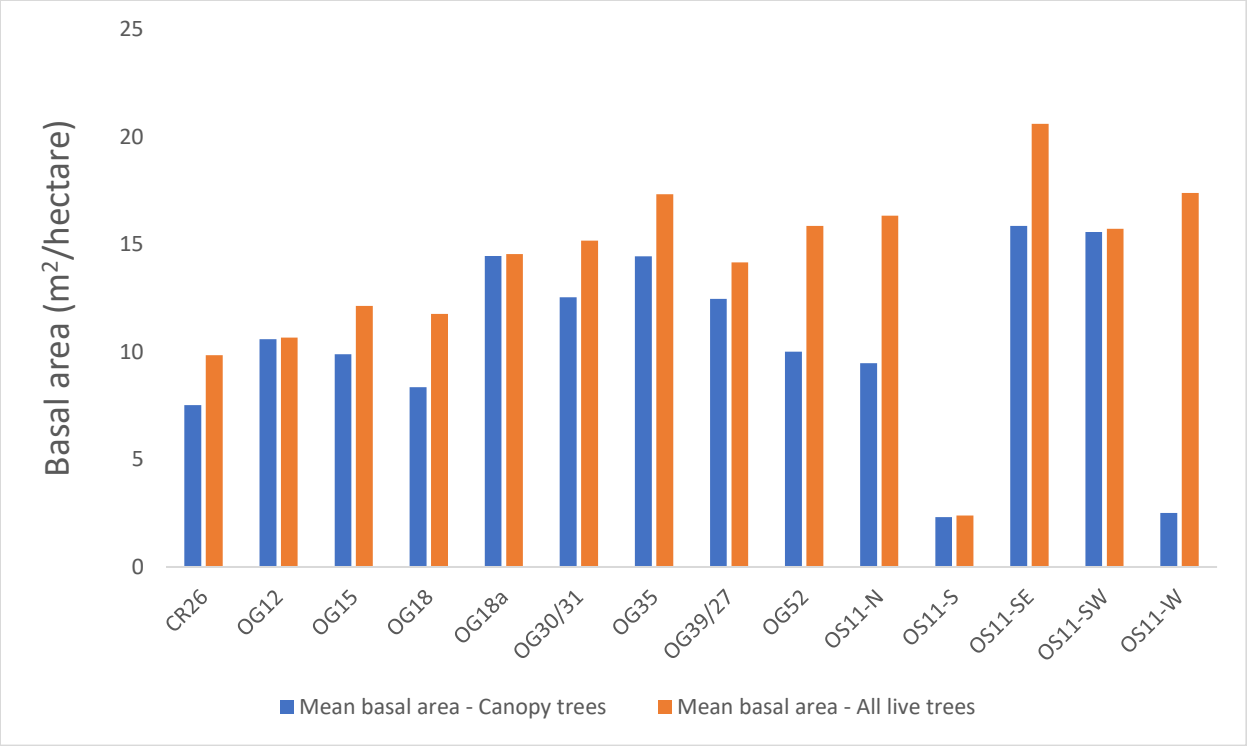

Figure A1. Mean stocking rates for all living trees, and for only canopy trees. Stocking rate for all live trees was significantly lower in Tract OS11-S than in all other tracts and both OS11-S and OS11-W had signifacntly lower basal areas for canopy trees than all other tracts.

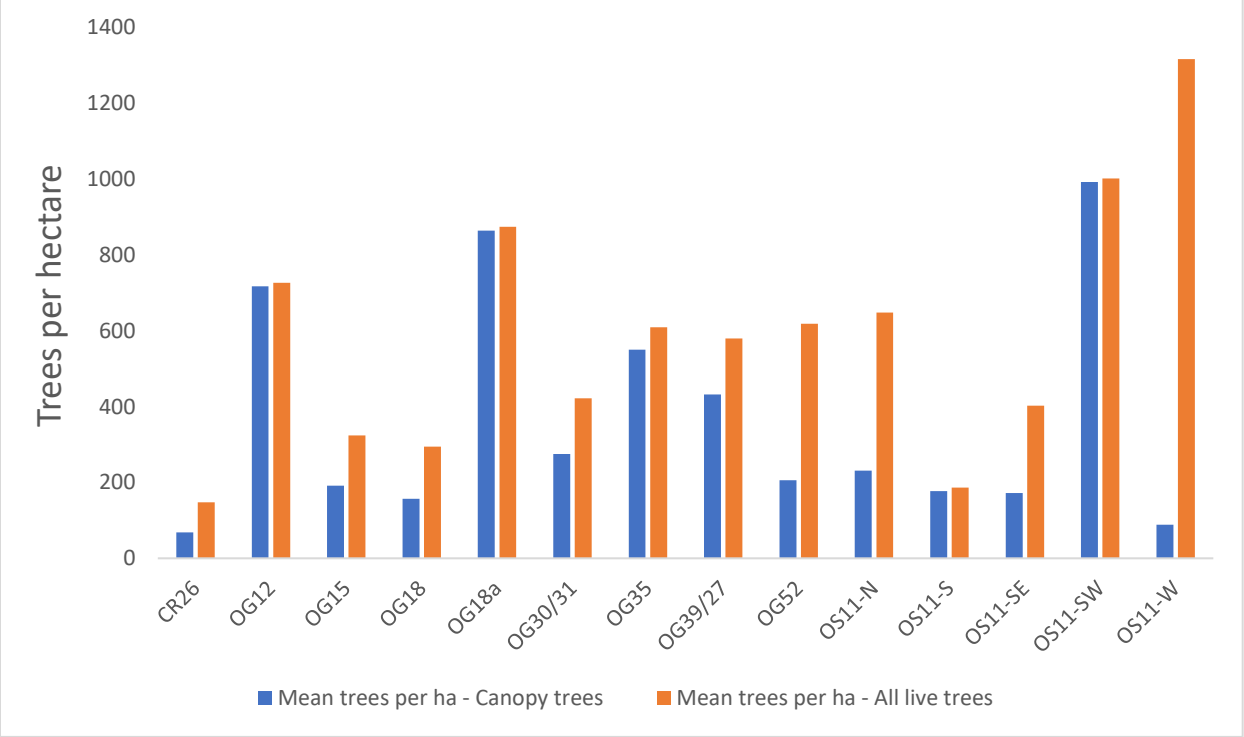

Figure A2. Mean tree density, for all living trees, and for only canopy trees. Tree density for all live trees was significantly higher in Tract OS11-W than in all other tracts.

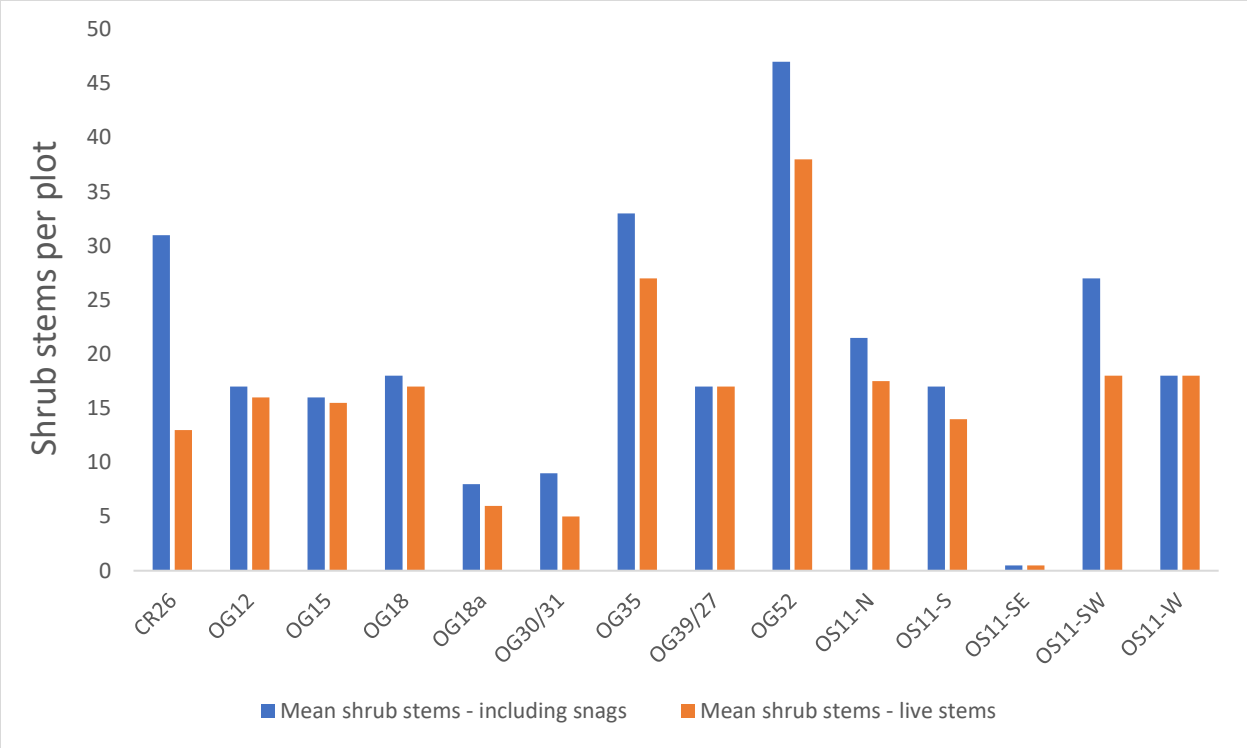

Figure A3. Mean shrub/sapling density, for all living stems, and living stems + snags. Tract OS11-SE had significantly lower stems per plot than all other tracts.

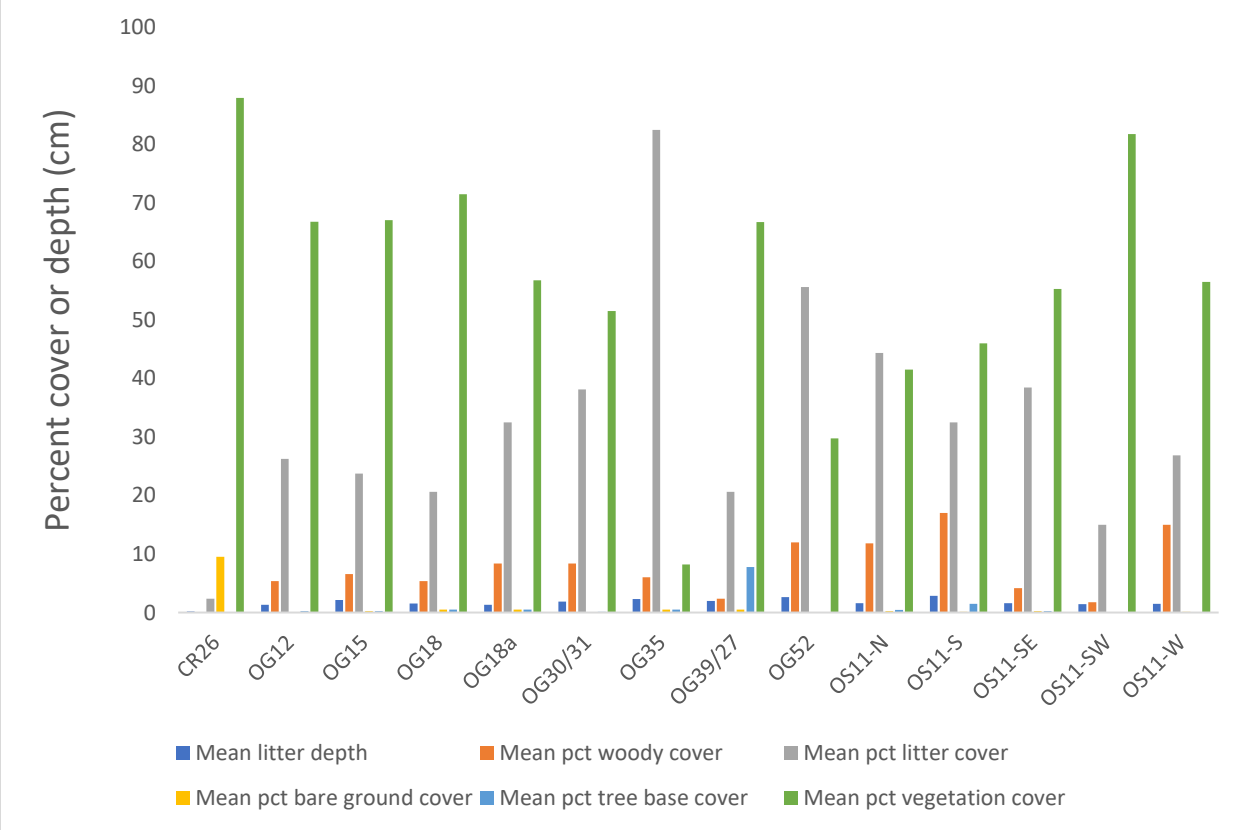

Figure A4. Mean abundance for types of ground cover, and mean depth of leaf litter.

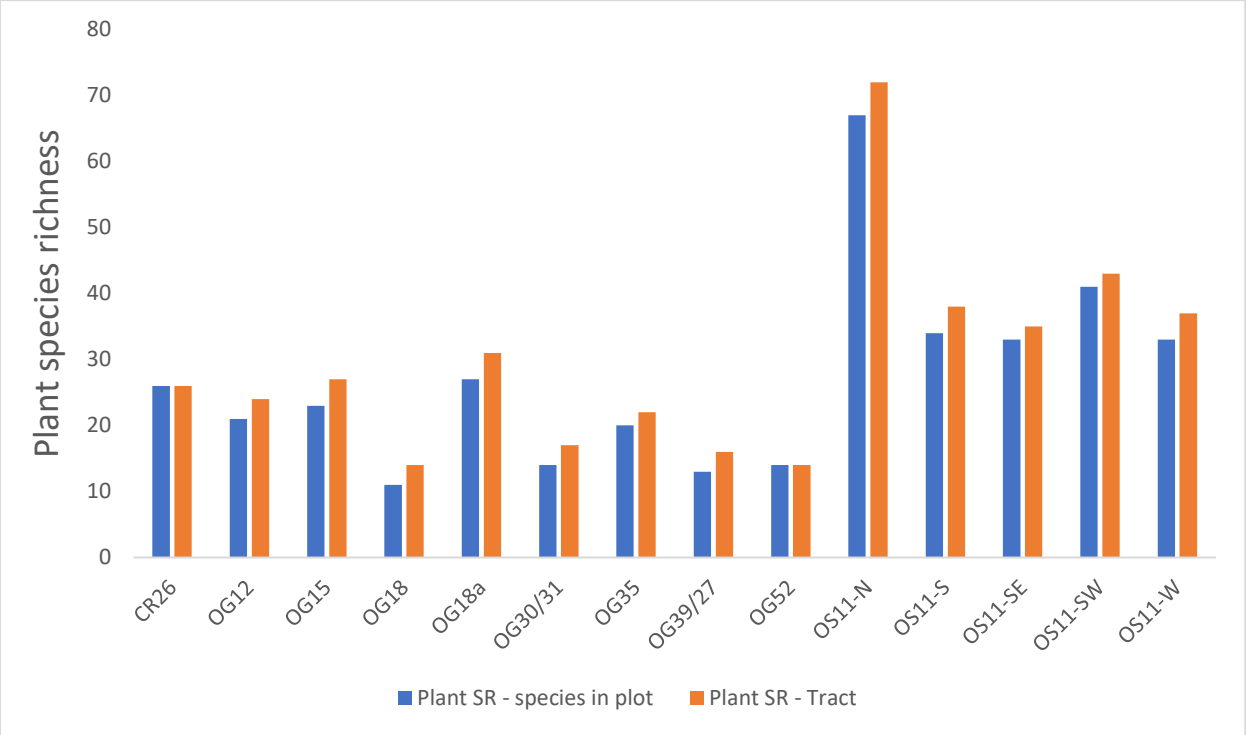

Figure A5. Plant species richness for all species and only those observed in circular plots. Tract OS11-N had significantly higher species richness than all other tracts for both variables.

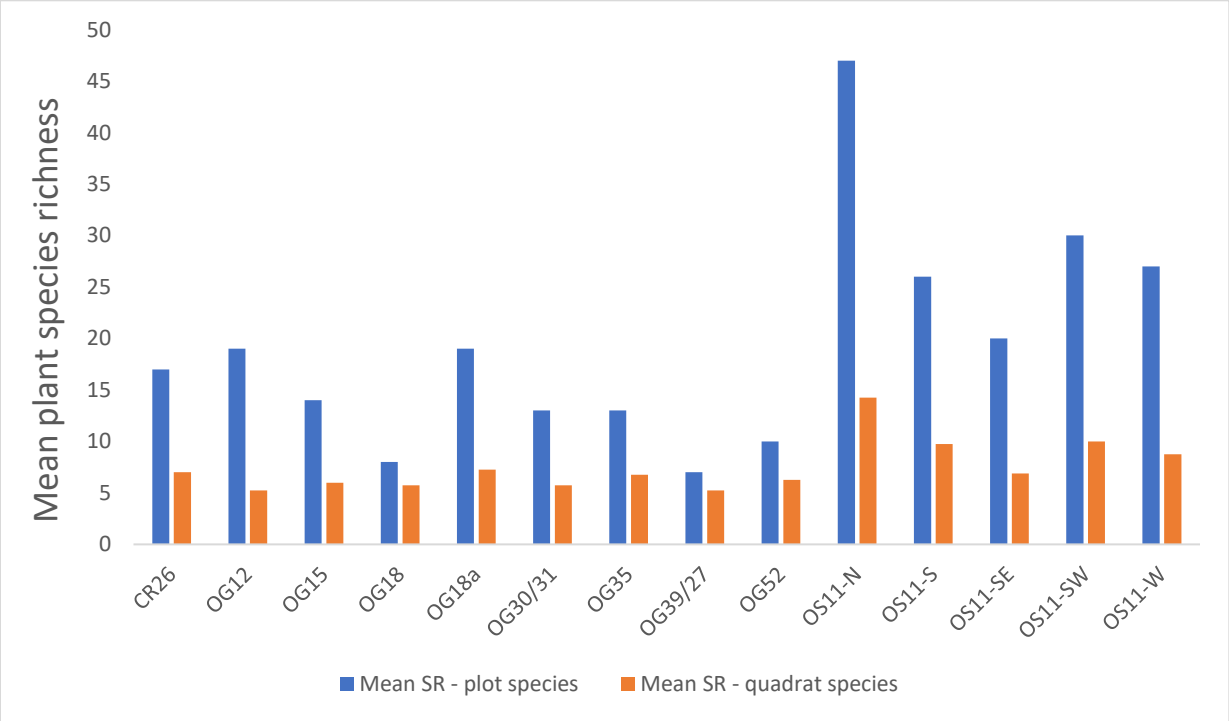

Figure A6. Mean plant species richness, for all species observed in circular plots, and for only those observed in ground layer quadrats (excluding frequency quadrats). Tract OS11-N had a signficantly higher mean species richness observed in circular plots than all other tracts.