

Ozarks Environmental and Water Resources Institute (OEWRI)
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**Pre- and Post-Harvest Activity Assessment using the
U.S. Forest Service Forest Soil Disturbance Monitoring
Protocol (FSDMP), Mark Twain National Forest,
Missouri (2022-2023)**

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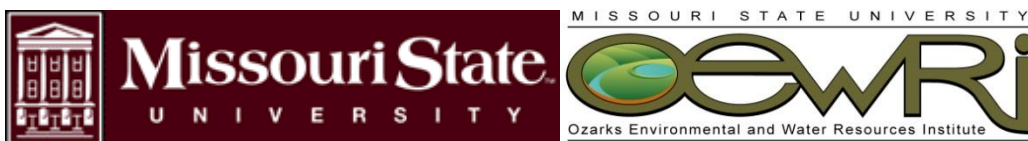
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PURPOSE AND SCOPE

The United States Forest Service (USFS) has contracted the Ozarks Environmental and Water Resources Institute (OEWRI) to perform the Forest Soil Disturbance Monitoring Protocol (FSDMP) within the Mark Twain National Forest (MTNF) in southern Missouri. The FSDMP is a national monitoring program designed to assess the extent of ground disturbance during timber harvest activity and to quantify changes to the landscape that may affect long-term sustainability of the site (Page-Dumroese et al. 2009¹). The first time this type of monitoring has been performed within the MTNF was in 2018 and results of this study were used to refine the FSDMP to adequately assess the impact of timber harvest on variable Ozarks landscapes. The overall goal of this project is to use the FSDMP to monitor different areas within the MTNF and assess the effectiveness of the FSDMP as a monitoring tool.

Specific objectives of Year 5 monitoring activities are:

1. Implement FSDMP on MTNF lands based on forest management units selected by MTNF soils program manager.
2. Complete post-harvest activity data collection at **eight** timber sale sites in 2022-2023.
3. Enter pre- and post-activity data into FSDMP database and provide a quality control review.
4. Provide a photo location representative for each transect line and spatial data associated with transects and points along transects.
5. Summarize findings, results, and analysis.

STUDY AREA

The MTNF is located in the southern Missouri Ozarks region that is characterized by a dissected plain grading from broad, gently rolling uplands to steep, highly dissected hillslopes when closer to major river valleys (USDA 2006). In general, the region is underlain by soluble Ordovician and Mississippian age cherty limestone and dolomite, with remnant Pennsylvanian age sandstone and shale along ridgetops (Adamski et al. 1995). The area is a karst landscape where sinkholes, losing streams, and springs are common. Upland soils are formed from cherty residuum and colluvium capped by a thin layer of loess, fragipans are common on the broad,

flat divides (USDA 2006). The forest is dominated by Oak and Oak-mixed hardwood forest communities with smaller areas of native shortleaf pines (Nigh and Schroeder 2002).

The MTNF consists of six ranger districts in southern Missouri (Figure 1). For the Year 5 Assessment sites were located in the Doniphan/Eleven Point, Ava/Cassville/Willow Springs, and Poplar Bluff districts. The five sites in the Ava/Cassville/Willow Springs District were, Fox Hollow, Hellroaring Springs, Tabor Cave, Garner Hollow, and Huckleberry Ridge. Wild Coyote was the only site assessed in the Poplar Bluff District in the Year 5 Assessment. Warthog and Monterey were assessed in the Doniphan/Eleven Point Ranger District. Two sites in the Year 4 Report (Owen et al., 2022), Swayback and Sterling Hollow, were not evaluated as there were no longer disturbance indicators identified at these locations.

METHODS

Geospatial Methods

USFS staff selected sites for the FSDMP and provided maps highlighting several payment units at each site. The maps were rectified in ArcGIS and each payment unit was digitized to create polygon areas of each unit. For each unit, a best-fit “zig-zag” transect including 68 total sampling points at equally spaced intervals was created by visual judgement to cover all areas of the payment unit (see layout patterns of sampling points in Figures 2-11). The uniform use of 68 total sampling points at each site, regardless of differences in payment unit area, is based on criteria to collect the maximum number of points needed to quantify the maximum variability at the 90% confidence limit with a margin of error at +/- 10% (Page-Dumroese et al. 2009²). These points were transferred to ArcGIS FieldMaps app on a tablet and a Bad Elf GNSS Surveyor was used for navigation in the field (Photo 1).

Field Methods

For the Pre-Activity (Pre-Survey) and Post-I Activity (Post-I) survey, each transect was sampled by starting at monitoring point #1 and performing the FSDMP at every other sample point (odd numbers). As data were entered into the Excel-based FSDMP datasheet, site variability is updated continuously by the software. The FSDMP spreadsheet specifies the minimum number of points to be evaluated based on the chosen confidence interval. For this project a 90% confidence limit with a margin of error at +/- 10% was chosen. Therefore, if there was low variability in the data, a total of 30 locations would be enough to satisfy the minimum number of sampling locations needed per the assessment. Alternatively, if the unit was highly variable, a total of 68 sampling locations would be needed to satisfy the chosen confidence interval at the maximum. If this occurred, the evaluators would backtrack along the transect and fill in

with more sampling locations at the even numbered monitoring points to meet the requirement. For this project, a minimum of 34 points were evaluated, which exceeds the minimum required, to make sure the entire site was assessed.

At each sampling location, a 6" ring was laid down at the predetermined location and a photo was taken to capture the condition of the forest floor to include the surrounding landscape (Photo 2). Forest floor depth was measured using a folding ruler and any notes of surrounding vegetation, woody debris, surface rocks, or bare earth were also recorded (Photo 3). Any ruts were noted at each sampling location based on the depth of rutting. A pit was then dug to a depth of 6-12" (15-30 cm) (Photos 4 and 5). The exposed soil was then evaluated using the FSDMP protocol using soil morphology indicators such as compaction, platy, massive, or puddled structure (Photo 6). Results of the assessment were entered into the Excel spreadsheet on site using an iPad (Photo 7). Finally, a photo of the pit was taken for later reference. Starting in Year 5 all subsequent Post-Harvest assessments (after Post-I) were only conducted at disturbed sample locations from the previous assessment.

Additionally, a mapping component of the protocol was added to assess disturbance spatially across the sites. The mapping component was added to sites during the Post-I assessment to evaluate the impact of logging practices immediately after harvest. ArcGIS FieldMaps and a Bad Elf GNSS Surveyor were used to delineate landings, and primary and secondary logging roads/trails. Once the field data was collected, ArcGIS was used to create maps of the disturbance at the sites and calculate the area of disturbance. Polygons of the landings were delineated by walking around the landing and recording the perimeter. Primary and secondary roads were delineated as lines by walking down the center of the roadway. The width of the road was recorded, and the average width was used to buffer the roads in ArcGIS to create an area of road/disturbance.

Data Storage and Visualization

All photos and datasheets were joined with each evaluated location and stored in an ArcGIS Geodatabase. These data can then be brought into ArcMap and the photo, and the data collected at the individual sample points can be observed by using the HTML Popup Tool to click on each point on the screen.

YEAR 5 ASSESSMENT RESULTS

Post-I Evaluation (< 1-year from harvest)

Tabor Cave and Huckleberry Ridge were assessed for the first time after timber harvest (Post-I). Tabor Cave was assessed on December 1, 2022, approximately three months after timber harvesting was completed (Table 1). Huckleberry Ridge was assessed on March 6, 2023, approximately three months after harvest completion.

Tabor Cave

Tabor Cave was moderately disturbed through timber harvesting practices. Of the 40 observed sample points, 30% were disturbed – Class “1” and Class “2” – and 70% were undisturbed – Class “0” (Table 2). Average forest floor depth (4.1 cm) remained the same as pre-harvest conditions (Table 1, Figure 2). The percentage of sample points with coarse woody debris increased, while fine woody debris and live plants decreased slightly (< 10%) from pre harvest conditions (Table 3, Figure 2). Rutting was observed at twelve of the forty sample points. Four points were also compacted (Table 3, Figure 2).

Mapping of the landing sites, primary and secondary roads was conducted to further identify the spatial distribution of disturbance areas (Figures 3 & 4). In most cases, landings were considered the most impacted by logging and equivalent to a class “3” or “2” disturbance, primary roads were equivalent to a class “2”, secondary roads were equivalent to a class “1” and all other areas were considered undisturbed (class “0”). By area, 91% of the Tabor Cave site was undisturbed and 9% was disturbed by the timber harvest activity (Table 4). In comparison the sample point evaluation found 70% of the points undisturbed and 30% disturbed (Table 2).

Huckleberry Ridge

Huckleberry Ridge was one of the more impacted sites in Post Activity-I surveying. Fifty-five sample points were observed with 38% of them classified as disturbed (Table 2). Average forest floor depth (3.8 cm) decreased by nearly half compared to the pre-activity survey (Table 3, Figure 2). The percentage of sample points with coarse woody debris (53 %) more than doubled pre-activity levels. Fine woody debris remained similar to the pre-activity survey and the percentage of live plants observed at the points decreased to 50 % (Table 3, Figure 2). Rutting was observed at 21 points, two of those were also compacted (Table 3, Figure 2). Overall, 34 points (62 %) were class “0” (undisturbed), 12 points (22%) were class “1” (rutting with soil “O” horizon in place), and 9 points (16%) were class “2” (rutting, “O” horizon missing, compacted less than 30 cm) (Table 2).

By area, 86% of the Huckleberry Ridge site was undisturbed (Table 4, Figures 5 & 6). Landings, primary roads, and secondary roads made up 14% of the area. In comparison to the distribution of evaluated sample points, the disturbance by area (14%) was less than in the evaluated points (38%) (Tables 2 & 4, Figure 6). This indicates that the sample points were distributed more along the disturbed areas than in the undisturbed areas, despite the random nature of the sample point creation.

Post-Activity Evaluation (> 1-year after harvest) – Assessing Disturbed Points

Six sites were reassessed for disturbance indicators following the completion of Post-I surveys. Each subsequent survey after Post-I represents an additional year of surveying after the timber harvest was completed. For example, Post-II surveys were completed one year after the initial post-harvest assessment, Post-III – two years after, Post-IV – three years after, and so on. During the fifth year of OEWR performing the FSDMP for the U.S. Forest Service, Garner Hollow and Hellroaring Springs were assessed in Post-II surveys, Monterey was assessed in Post-III surveys, and Warthog, Wild Coyote, and Fox Hollow were assessed in Post-IV surveys (Table 5). This evaluation was the first year in which only disturbed points were reassessed. In all previous reports the minimum number of sample points was 34 for all surveys past Post-I. Owen et al. (2022) found that in surveys completed after the Post-I survey the only points that remained disturbed were those that were disturbed in Post-I surveys. Thus, only the disturbed points were necessary to monitor for recovery from disturbance.

Post-II Evaluation

Garner Hollow

The Post-II survey of Garner Hollow shows the site is slowly recovering from timber harvest with 19% of observed sample points being disturbed compared to 21%. The average forest floor depth was 6.3 cm with 9 points evaluated (Table 3, Figure 7). Coarse woody debris (22%) and fine woody debris (89%) presence decreased since the Post-I survey. However fine woody debris presence is now similar to what it was during the preassessment before logging. Live plants were found at 100% of the sample points, increasing from the Post-I survey and returning to preassessment levels (Table 3, Figure 2). Rutting and compaction increased as a percentage of the evaluated points, however since only the disturbed points were assessed, the number of points with rutting decreased (9 to 8) while compaction remained similar (3) to the Post-I surveys (Table 3, Figure 2). Overall, one point was class “0”, three points were class “1”, and five points were class “2”. Therefore, only one point had recovered from rutting, compaction, and other disturbance in the year between Post-I and Post-II surveying. Combined with the undisturbed points from the previous post-assessment survey, the site is 81% undisturbed (Table 2).

Hellroaring Springs

The Post-II survey of Hellroaring Springs shows the site is also recovering from timber harvest with 16% of observed sample points being disturbed compared to 19%. Average forest floor depth was 2.1 cm in the 7 points evaluated (Table 3). Coarse woody debris (29%), fine woody debris (71%) and live plant (71%) presence decreased compared to Post-I surveys (Table 3, Figure 2 & 8). However, this could be because of a smaller sample size. Bare soil and rock were not observed in any of the surveys at Hellroaring Springs thus far (Figure 2). Rutting was observed at six of the points and compaction was observed in one both decreasing slightly since the Post-I survey (Table 3). Overall, one point was a class "0", five were class "1" and one was class "2". Combined with the previous post-assessment survey the site is 84% undisturbed (Table 2).

Post III Sites

Monterey

Post-III surveying of Monterey shows the site is continuing to recover from timber harvest however, overall the same number of disturbed points was detected (12%). Average forest floor depth was 1.5 cm for the 4 sample points evaluated, similar to the previous survey (Post-II) (Table 3, Figure 9). Coarse woody debris (50%), fine woody debris (100%), and live plant (75%) presence remained similar to Post-II surveys (Table 3). Bare soil and rock were not observed in the last two surveys (Post II & III). Rutting was observed at all four of the sample points and compaction was observed at one (Table 3, Figure 2). Rutting did not decrease since the Post-II survey but compaction was no longer present at one of the disturbed points. Overall, one point was class "1" and three points were class "2", combined with the undisturbed points of the previous survey, this site is 88% undisturbed (Table 2).

Post IV Sites

Fox Hollow

Although this is the fifth year of surveying Fox Hollow (Post-IV) and only disturbed points from the Post-III surveying were to be evaluated, further logging disturbance was observed and a complete evaluation of the sample points was performed. Additionally, since recent logging impacts were visible, mapping of landing, primary roads, and secondary roads was also performed. In total 47 sample points were evaluated. Average forest floor depth (2.6 cm) has remained within 0.4 cm across the five surveys completed at Fox Hollow (Table 3, Figure 2). In the Post-IV assessment, coarse woody debris (64%) and fine woody debris (98%) presence was increased compared to previous surveys (Table 3, Figure 2). Live plant presence (79%) was slightly less than the Post-III survey. The increase in coarse and fine woody debris and decrease

in live plant presence since the Post-III survey indicate that the site has been further impacted. Further, rutting was observed in 36% of sample points, an increase by over four times the Post-II survey (Table 3, Figure 2). Compaction was observed in 6% of the sample points (Table 3, Figure 2). Overall, thirty points were class “0”, eight points were class “1”, nine points were class “2”, and no points were class “3” (Table 2).

The majority (86%) of the site area was found to be relatively undisturbed through mapping of logging landings and primary and secondary roads (Table 4, Figures 10 & 11). The disturbed areas were broken into three classes, landings (class “3” – most disturbance), primary roads (class “2”), and secondary roads (class “1”). Landings composed 6%, primary roads composed 2%, and secondary roads composed 6% of the total area at Fox Hollow (Table 4, Figure 11). Landing areas and more disturbance overall was located on the east side of the site. Primary roads were located around the perimeter and along central ridges. Secondary roads sprouted from primary roads to the boundary of the unit (Figure 11). In comparison, 36% of the sample points were disturbed while 64% were undisturbed (Table 2). Thus, greater disturbance was found in the point evaluation compared to the delineation of logging areas and roads.

Warthog

The post-IV survey of Warthog shows the site has completely recovered from timber harvest activity. Only two points remained disturbed in the Post-III surveying of Warthog in 2022 (Owen et al., 2022). Thus, only two points were evaluated in the Post-IV survey (Figure 12). Both points were no longer found to be rutted, compacted, or impacted by logging practices. Average forest floor depth was 1.5 cm and live plants and fine woody debris were present at the sample points (Table 3, Figure 2). Coarse woody debris was not observed at either point (Table 3). Both points are now class “0” undisturbed. Since the sample points were the last remaining disturbed points and are now no longer disturbed, it is recommended that this site be retired from monitoring.

Wild Coyote

The post-IV survey of Wild Coyote shows the site nearly recovered from timber harvest activity. Only one point remained disturbed in Post-III surveying of Wild Coyote in 2022 activity (Owen et al., 2022) (Figure 13). In Post-IV surveying the floor depth was 4 cm, and live plants and fine woody debris were present at the point. No coarse woody debris was observed (Table 3, Figure 2). The point was found to still be impacted by logging practices as rutting was still visible and the forest floor was still impacted as there was no topsoil present (Tables 2 & 3). However, compaction was no longer observed at the point (Table 3). The disturbance class for this point remains class “2” as rutting is still visible, and the topsoil is displaced.

OBSERVATIONS AND RECOMMENDATIONS

There are three main findings of the Year 5 Assessment conducted in 2022-2023.

1. Modification of the protocol to better assess disturbed points resulted in monitoring of only the disturbed points identified in Post-I surveys. This modification allowed for less time to be spent reevaluating undisturbed points and focused on the monitoring of disturbed points and their recovery.
2. A mapping component was added during the Post-I assessment. The mapping component included delineation of the logging landings and primary and secondary logging roads at their most disturbed extent – less than one year after timber harvest. Comparison of the disturbed area percent to the percent of disturbed sample points showed that the mapping protocol consistently found 21-24% less disturbance. Despite differences in total disturbance, disturbed points typically aligned with disturbed areas from the mapping protocol. The differences come from points found to be disturbed where mapping did not show logging roads or landings. This may also be due to errors from GPS units in remote forested areas. Also, the mapping exercise includes the entire payment unit to the boundary, while sample transects do not extend to the boundary and therefore accounts for some of the difference in total disturbance.
3. Forest recovery was observed at several points at sites evaluated in Post-II – IV assessments. Disturbance indicators (rutting, compaction, impacted soil) were found to decrease at all sites since the previous survey. Evaluated points at the Warthog site no longer show disturbance indicators, therefore the forest floor has recovered from logging activity.

CONCLUSIONS

Year 5 Assessment

OEWRI implemented the USFS FSDMP at eight post-activity payment units within the Mark Twain National Forest in southern Missouri in 2022-2023 during leaf-off conditions. The following sites were evaluated more than two years after the timber harvest activities, Monterey, Wild Coyote, Warthog, Garner Hollow, and Hellroaring Springs, with only the disturbed points from the previous survey monitored. Disturbance indicators (rutting, compaction, forest floor impacted) at these sites have reduced in presence since the previous survey indicating forest floor recovery. Warthog no longer had any disturbance indicators remaining and Wild Coyote only had one disturbed point remaining. The other sites had less

than 10 disturbed points each. Fox Hollow, Tabor Cave, and Huckleberry Ridge were assessed in Post-I surveying. Although this is the fifth year of monitoring the Fox Hollow site, timber harvesting of trees damaged in storms four years after the initial harvest caused further disturbance to the site – with the most rutting observed at the site thus far. Tabor Cave and Huckleberry Ridge were found to be disturbed at logging landing sites, and along primary and secondary logging roads. Mapping of disturbed areas at Fox Hollow, Tabor Cave, and Huckleberry Ridge showed less overall disturbance compared to the sample point protocol.

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TABLES

Table 1. Summary of sites evaluated for this project.

Site	MTNF District	County	Area (ha)	Pre-Assessment Date	Harvest Date	Year 5 Survey	Year 5 Survey Date
Fox Hollow	Ava/Cassville/Willow Springs	Douglas	38.6	Aug. 2, 2018	Sept. 9, 2019	Post-IV	April 10, 2023
Monterey	Doniphan/Eleven Point	Oregon	27.8	Dec. 16, 2019	Dec. 9, 2020	Post-III	Jan. 11, 2023
Sterling Hollow	Ava/Cassville/Willow Springs	Howell	7.9	July 31, 2018	Sept. 23, 2019	Retired	NA
Swayback	Poplar Bluff	Butler	5.8	Sept. 26, 2018	April 25, 2019	Retired	NA
Warthog	Doniphan/Eleven Point	Carter	22.3	April 5, 2018	Dec. 28, 2018	Post-IV	Jan. 11, 2023
Wild Coyote	Poplar Bluff	Wayne	6.4	Sept. 27, 2018	Aug. 20, 2019	Post-IV	Jan. 11, 2023
Hellroaring Spring	Ava/Cassville/Willow Springs	Douglas	5.2	Feb. 3, 2021	Aug. 16, 2021	Post-II	Nov. 8, 2022
Huckleberry Ridge	Ava/Cassville/Willow Springs	Barry	9.7	March 4, 2021	Nov. 25, 2022	Post-I	March 6, 2023
Garner Hollow	Ava/Cassville/Willow Springs	Barry	7.2	March 24, 2021	Sept. 30, 2021	Post-II	Dec. 6, 2022
Tabor Cave	Ava/Cassville/Willow Springs	Howell	16.6	Feb. 10, 2022	Aug. 25, 2022	Post-I	Dec. 1, 2022

Table 2. Number of Year 5 Assessment Sample Points Evaluated by Disturbance Class.

Site	Total	Class 0		Class 1		Class 2		Class 3	
Fox Hollow	47	30	64%	8	17%	9	19%	0	0%
Monterey	34	30	88%	1	3%	3	9%	0	0%
Warthog	34	34	100%	0	0%	0	0%	0	0%
Wild Coyote	34	33	97%	0	0%	1	3%	0	0%
Hellroaring Springs	37	31	84%	5	14%	1	3%	0	0%
Huckleberry Ridge	55	34	62%	12	22%	9	16%	0	0%
Garner Hollow	42	34	81%	3	7%	5	12%	0	0%
Tabor Cave	40	28	70%	10	25%	2	5%	0	0%

Table 3. Year 5 Assessment Survey Results.

Site	Year 5 Assessment Survey							
	Present in Sample Point Observations (%)							
	Avg. Forest Floor Depth (cm)	Live Plants	Coarse Woody Debris (>7 cm Dia.)	Fine Woody Debris (<7 cm Dia.)	Rock	Bare Soil	Rutting	Compaction
Fox Hollow	2.6	78.7	63.8	97.9	0.0	0.0	36.2	6.4
Monterey	2.0	75.0	50.0	100	0.0	0.0	100	25
Warthog	1.5	100	0.0	100	0.0	0.0	0.0	0.0
Wild Coyote	4.0	100	0.0	100	0.0	0.0	100	0.0
Hellroaring Springs	2.1	71.4	28.6	71.4	0.0	0.0	85.7	14.3
Huckleberry Ridge	3.8	49.1	52.7	94.5	0.0	0.0	38.2	3.6
Garner Hollow	1.2	100	22.2	88.9	0.0	0.0	88.9	33.3
Tabor Cave	4.1	82.5	57.5	95.0	0.0	0.0	30.0	10.0

Table 4. Year 5 Assessment Mapping Results by Disturbance Class.

Site	Disturbance Class by Area							
	"0" Undisturbed		"1" Secondary Road		"2" Primary Road		"3" Landing	
	Acres	%	Acres	%	Acres	%	Acres	%
Fox Hollow	82.0	86	5.8	6	2.1	2	5.6	6
Huckleberry Ridge	20.8	86	2.3	9	0.6	2	0.5	2
Tabor Cave	37.1	91	2.2	5	0.9	2	0.7	2

Table 5. Number of Evaluated Points by Year and Assessment.

Site	Number of Points Evaluated				
	2019	2020	2021	2022	2023
Fox Hollow	34	52	40	37	47
Monterey		34	53	34	4
Sterling Hollow	34	34	40	34	
Swayback	34	60	34	34	
Warthog	34	40	34	34	2
Wild Coyote	34	34	34	34	1
Garner Hollow			34	42	9
Hellroaring Springs			34	37	7
Huckleberry Ridge			34		55
Tabor Cave				34	40

Pre-Survey	Post-I	Post-II	Post-III	Post-IV
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FIGURES

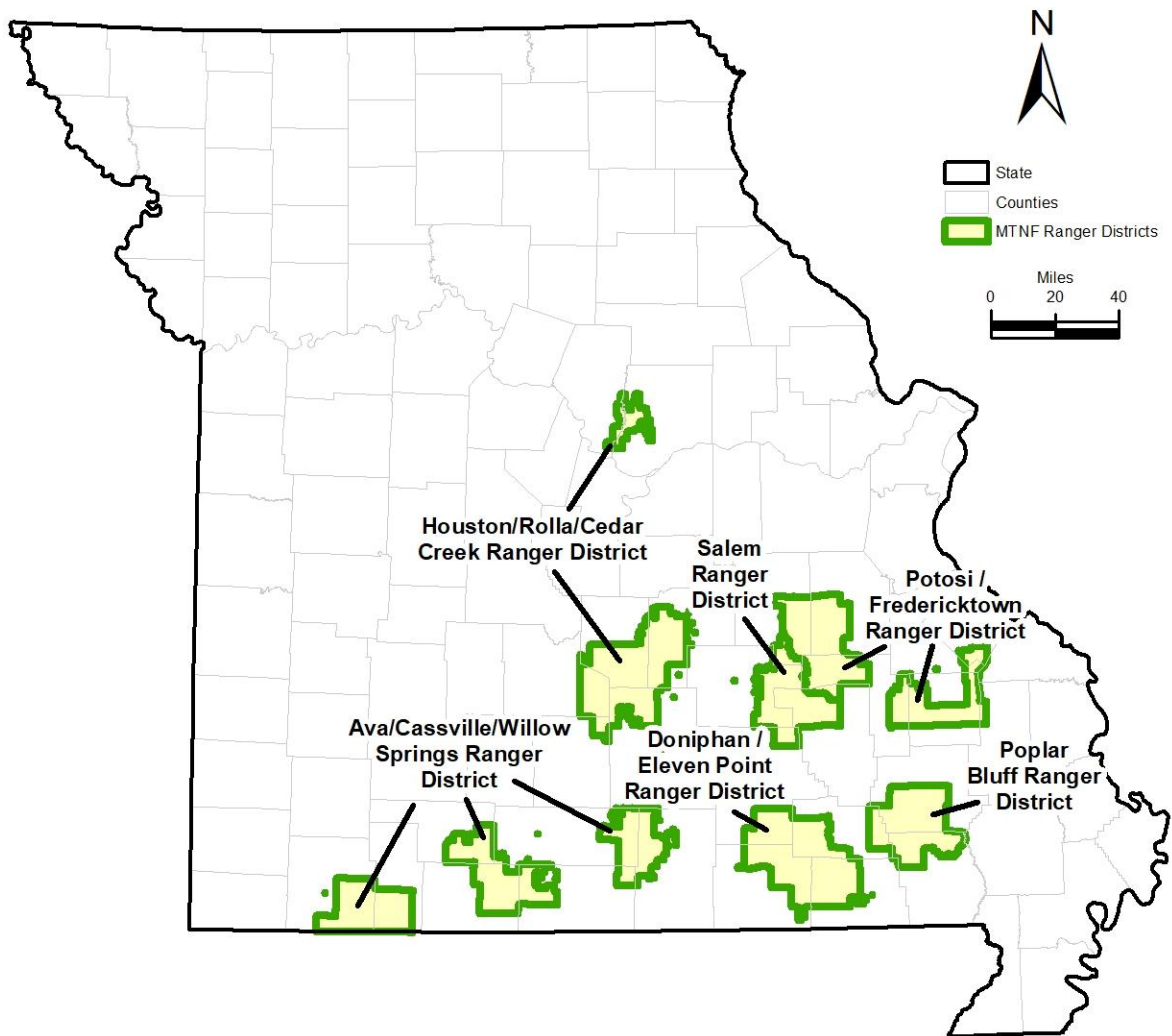


Figure 1. Mark Twain National Forest (MTNF) Ranger Districts in Southern Missouri.

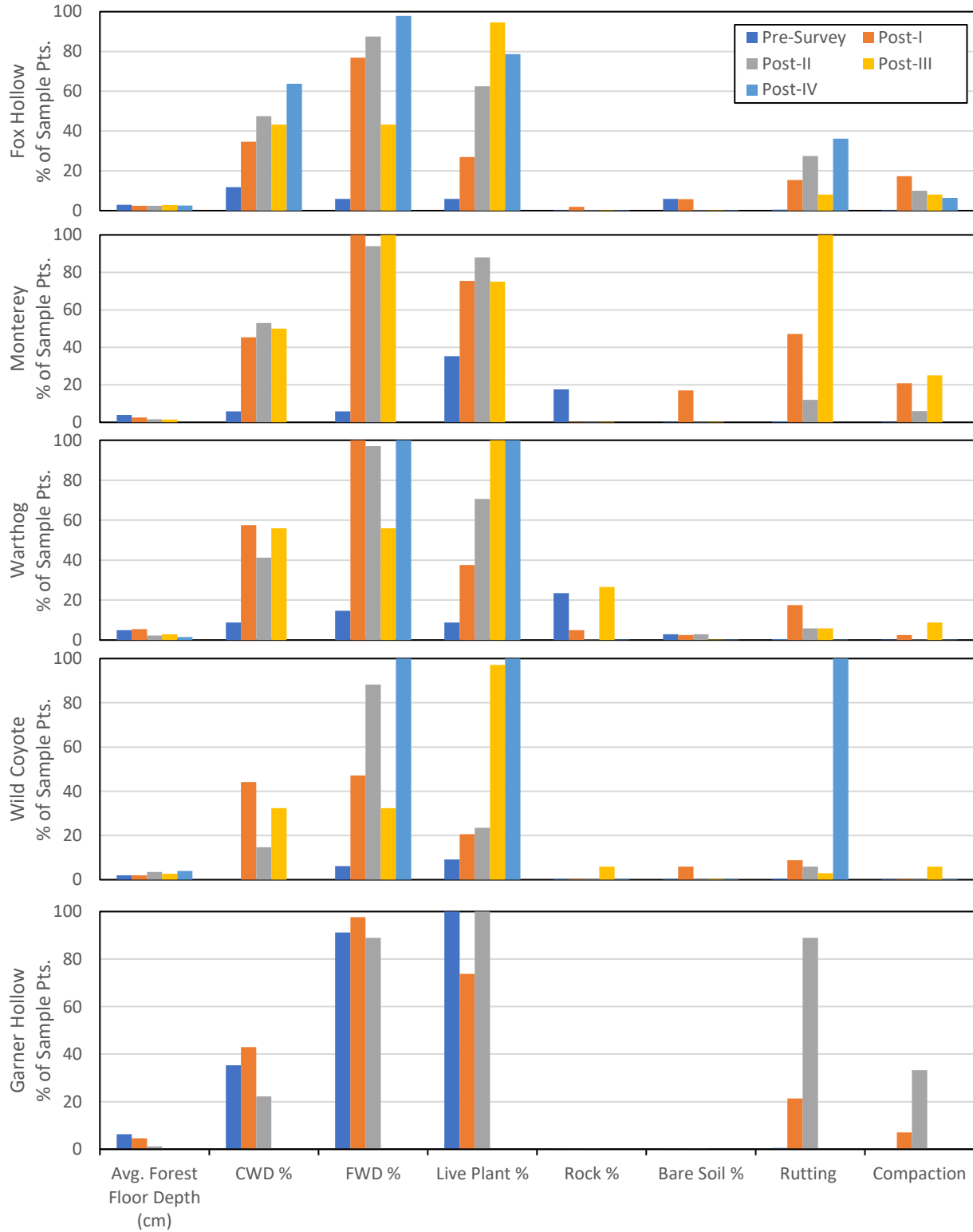


Figure 2. Observed temporal changes in site characteristics since 2018.

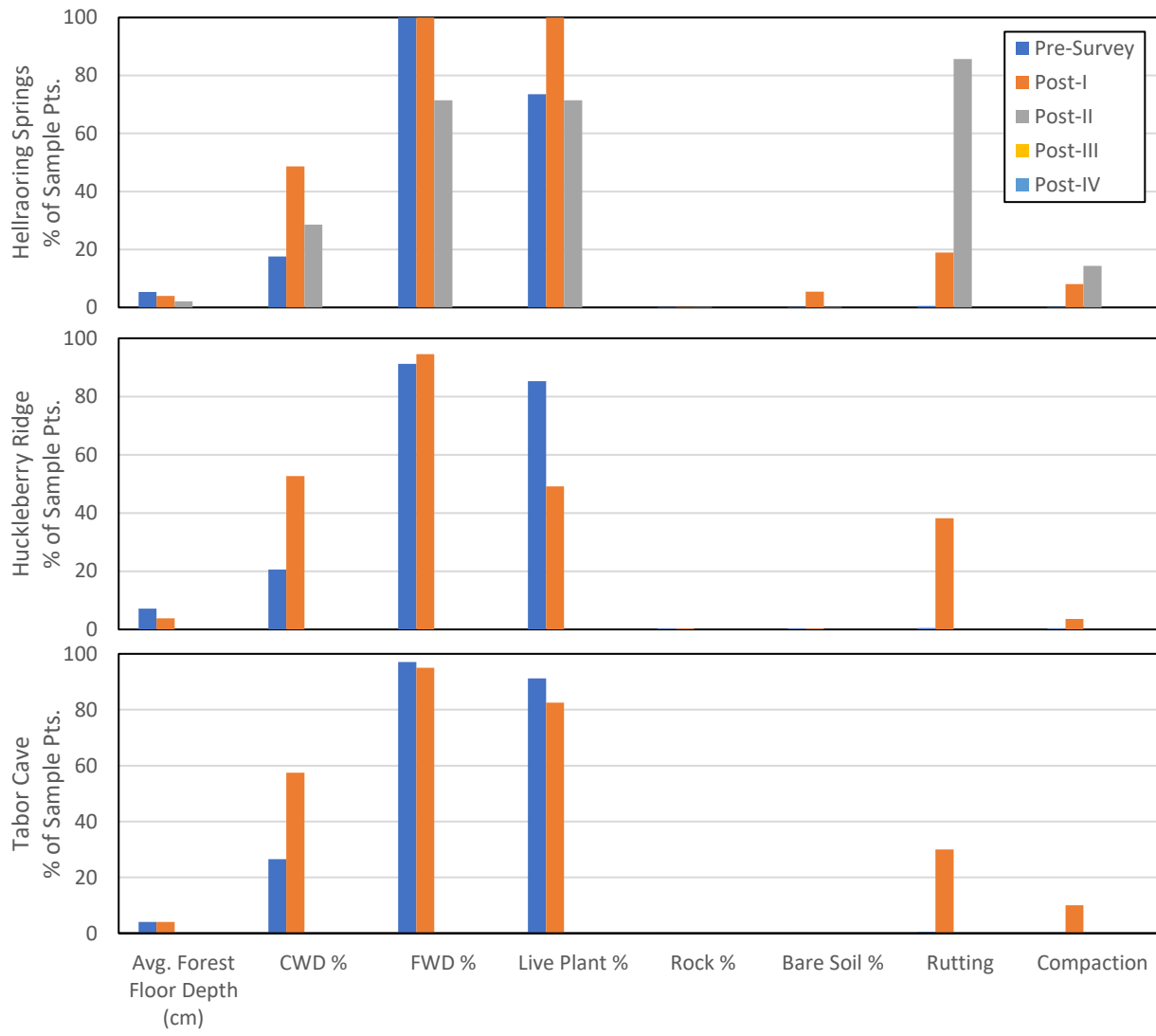


Figure 2 Continued. Observed temporal changes in site characteristics since 2018.

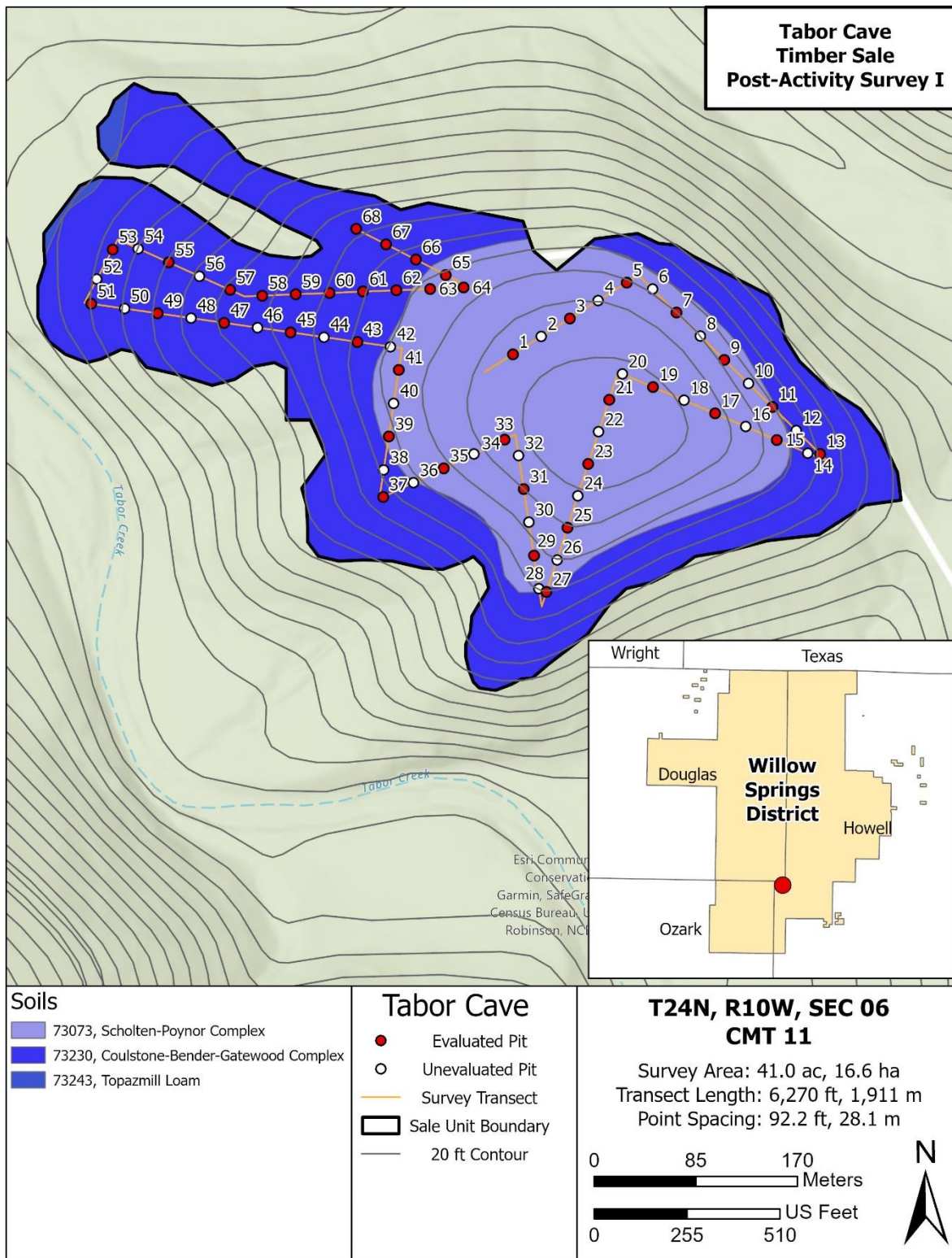


Figure 3. Tabor Cave Site Map.

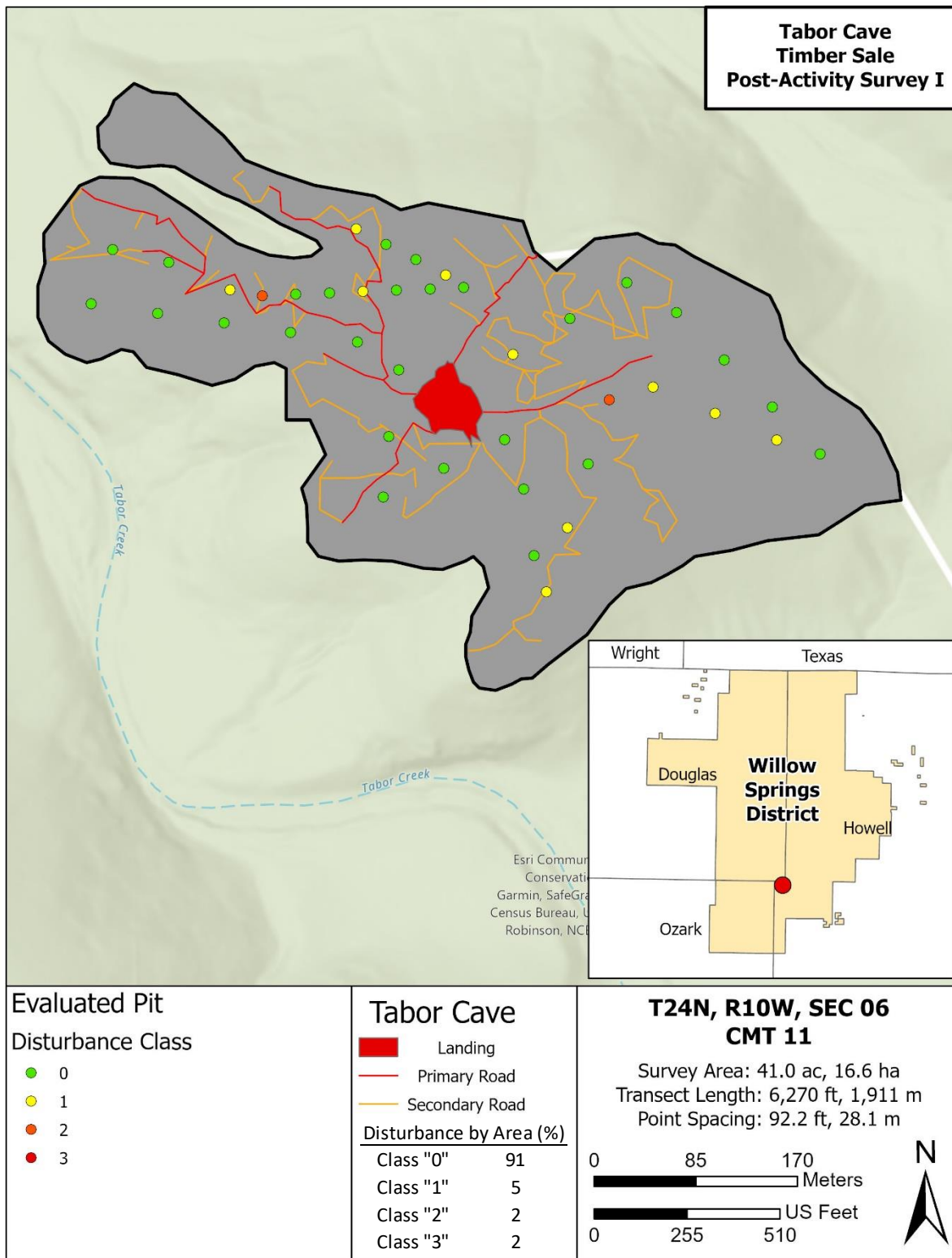


Figure 4. Tabor Cave Disturbance.

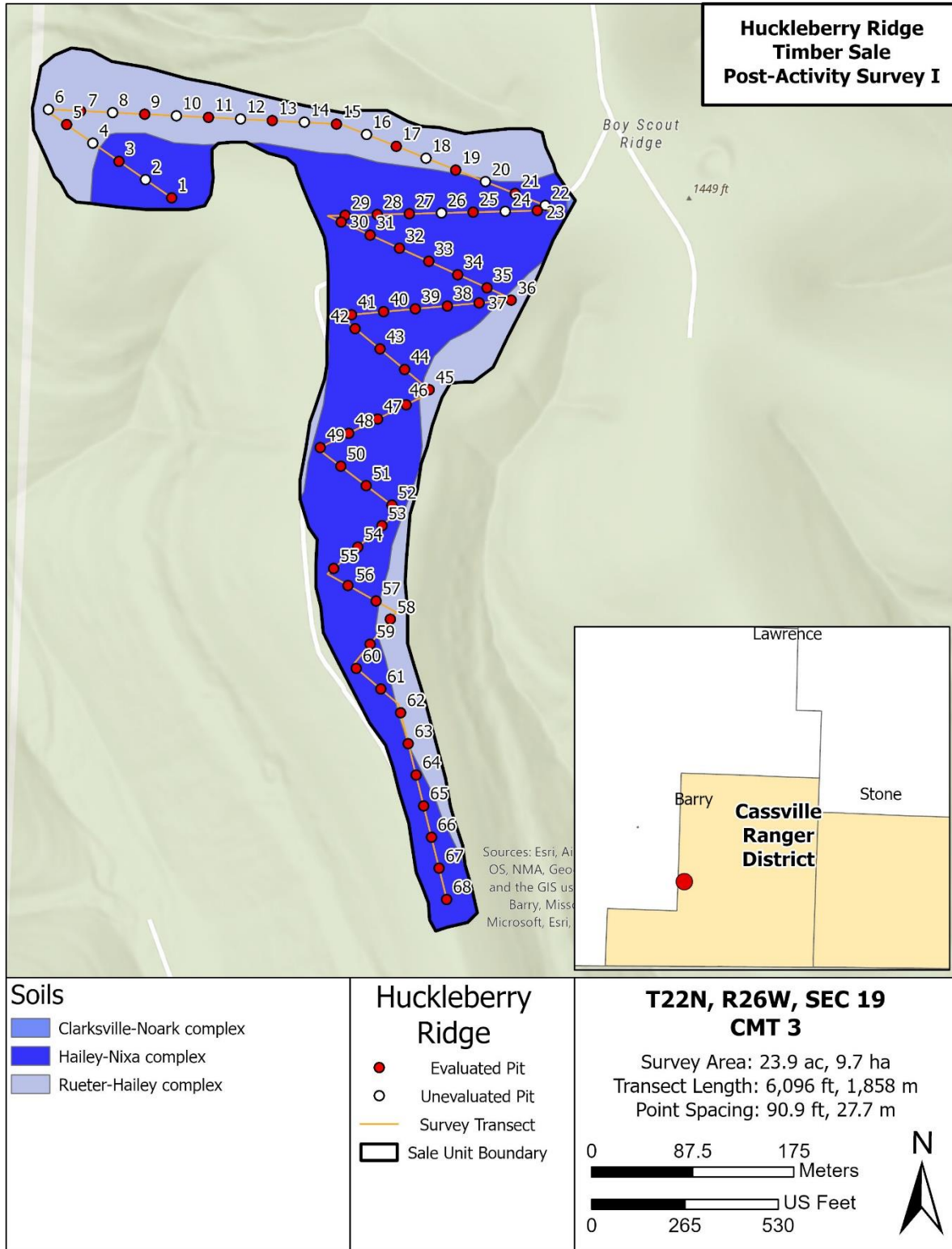


Figure 5. Huckleberry Ridge Site Map.

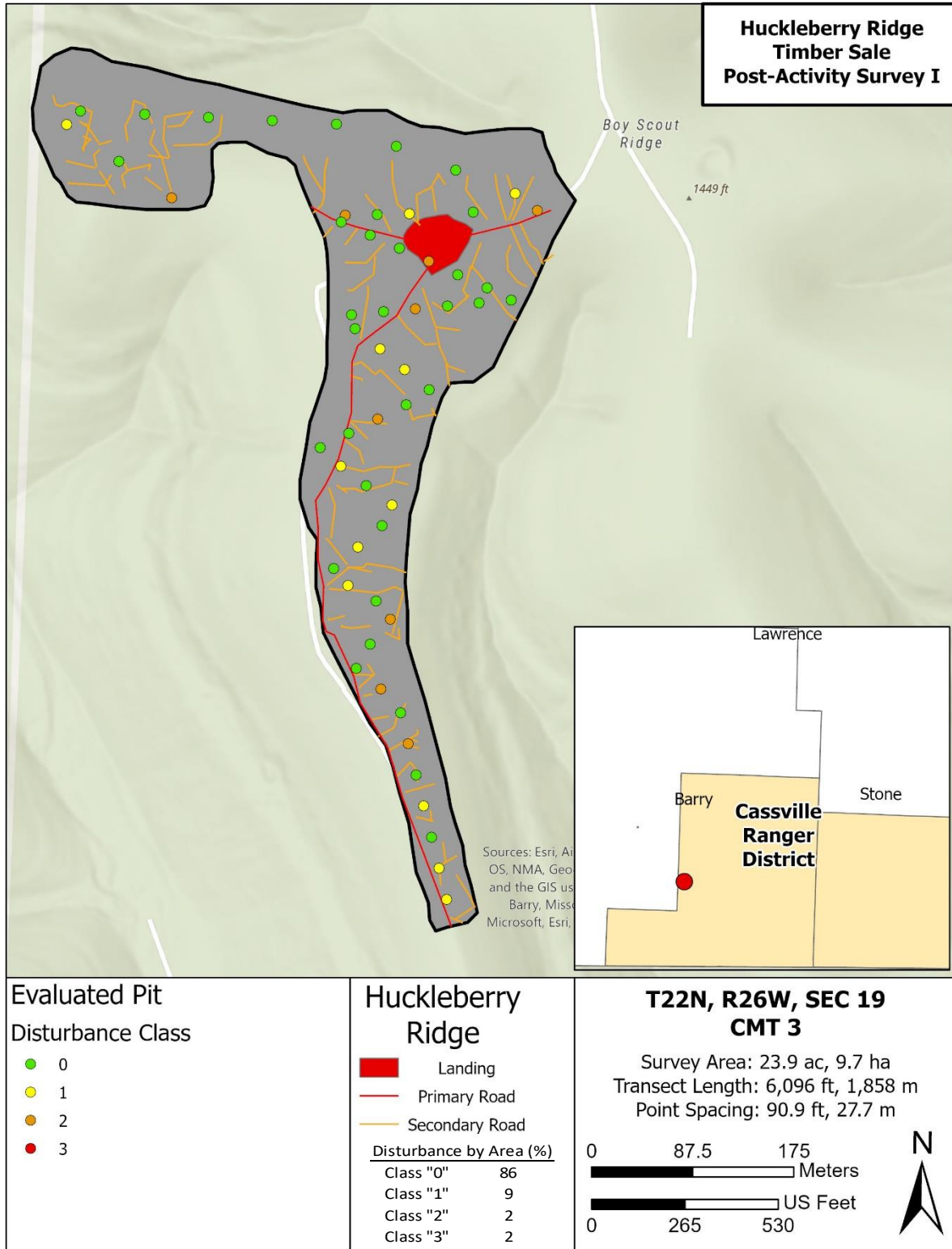


Figure 6. Huckleberry Ridge Disturbance.

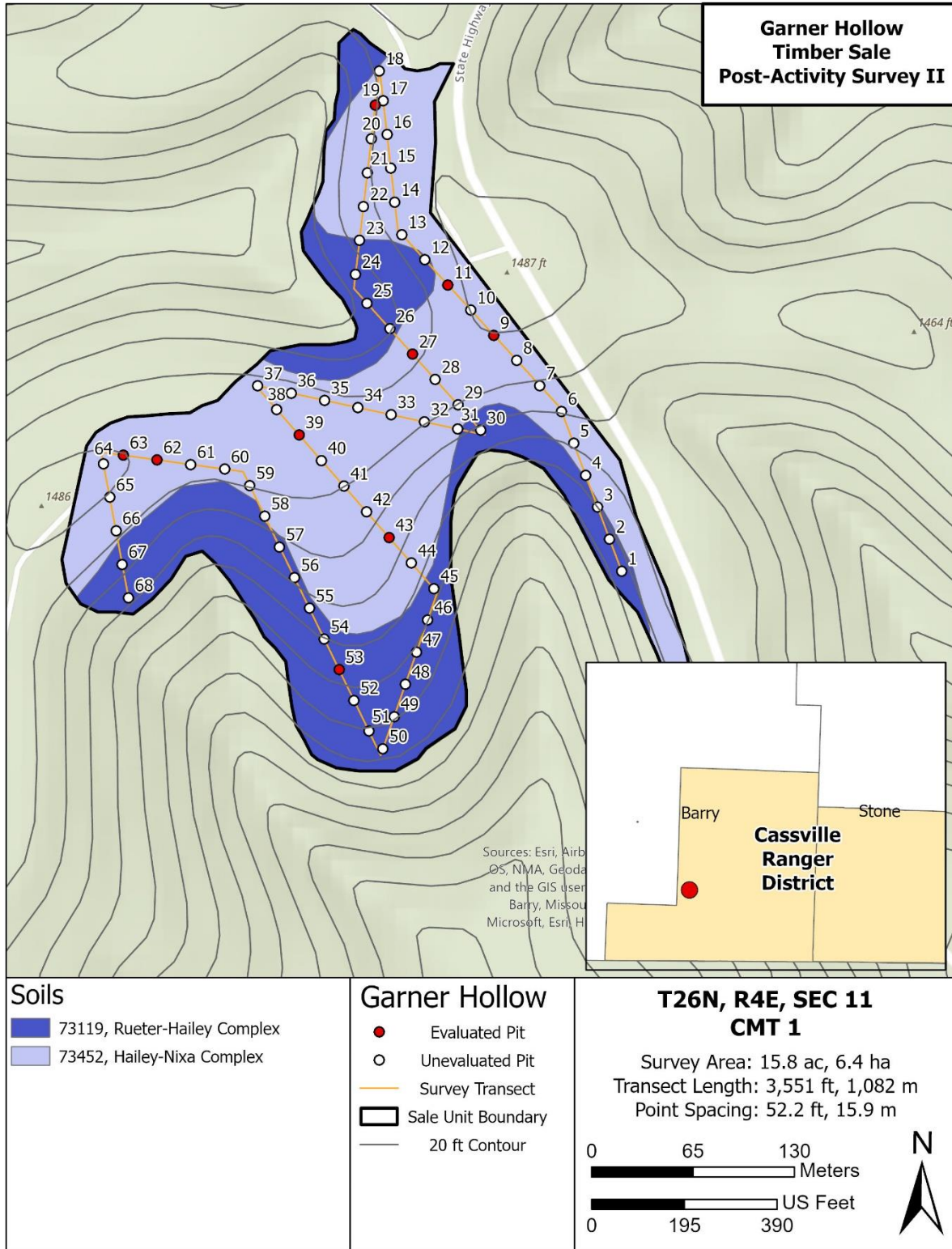


Figure 7. Garner Hollow Site Map.

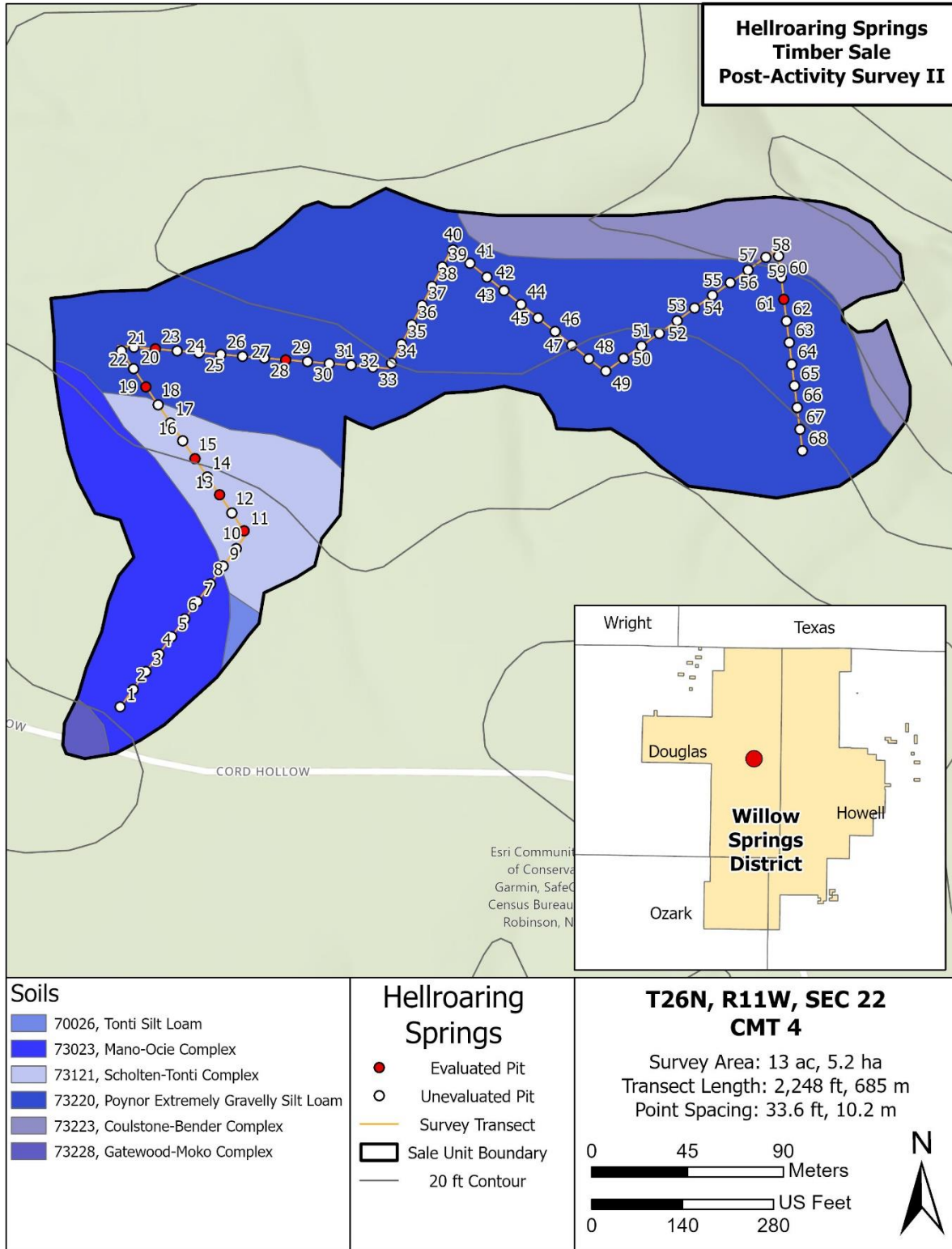


Figure 8. Hellroaring Springs Site Map.

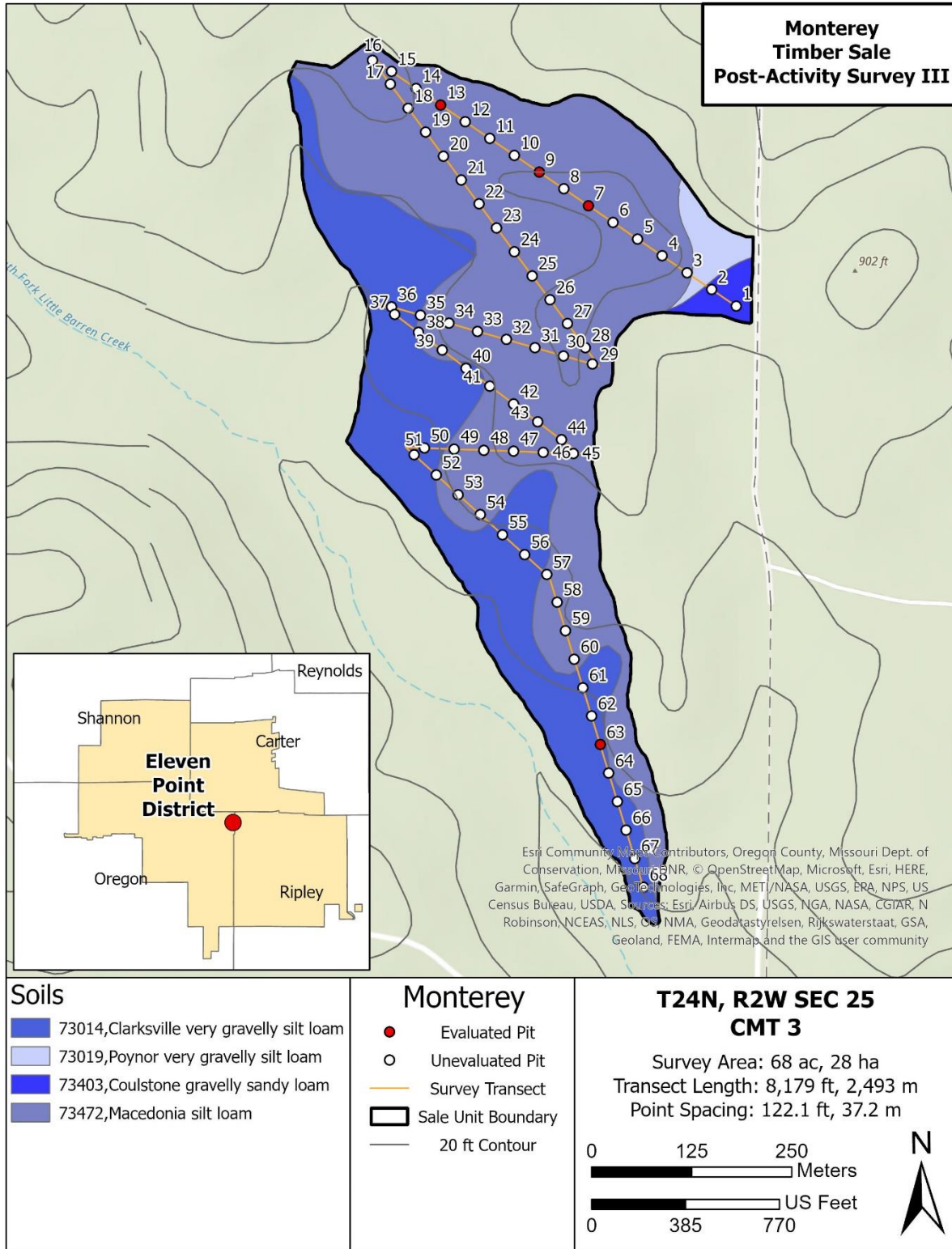


Figure 9. Monterey Site Map.

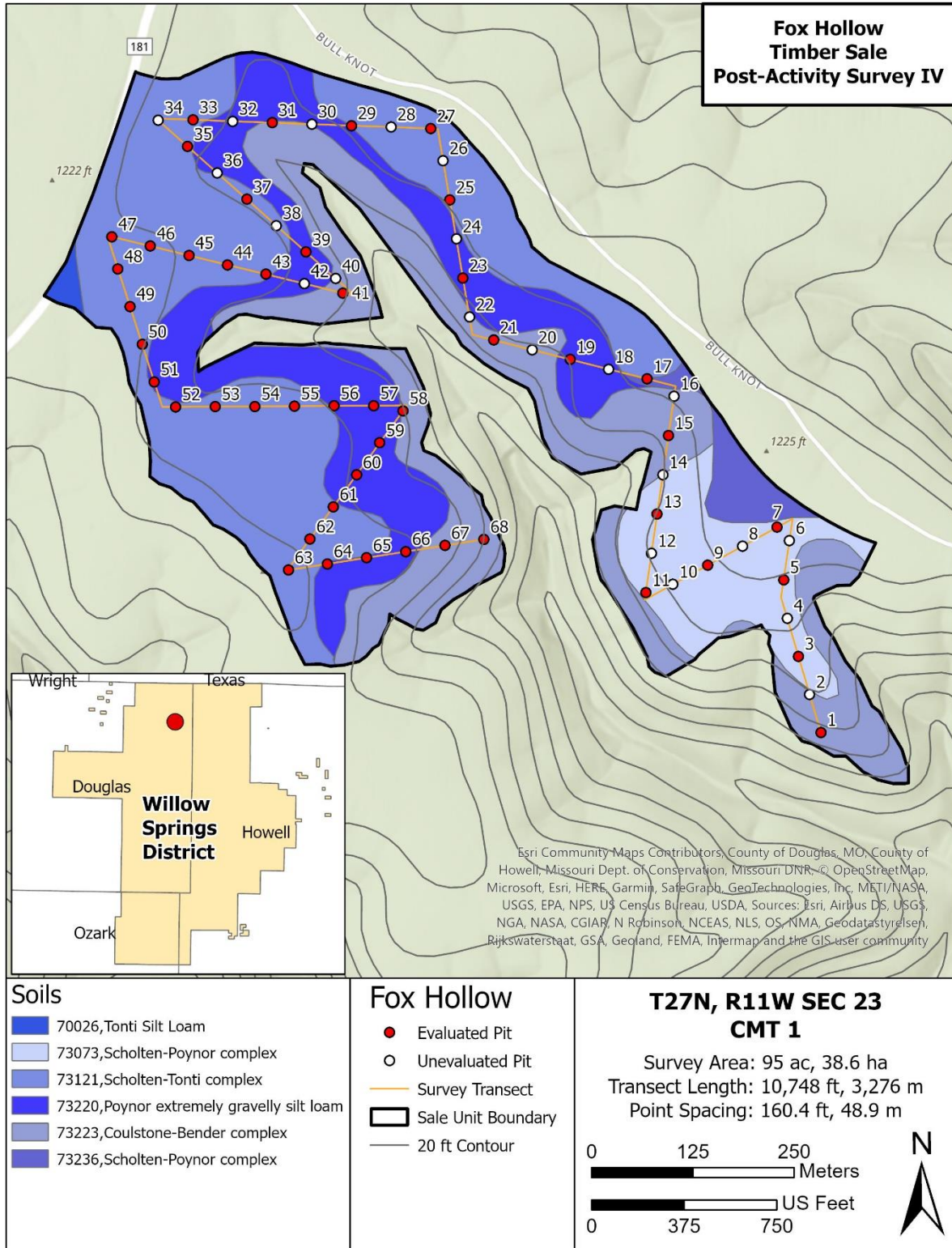


Figure 10. Fox Hollow Site Map.

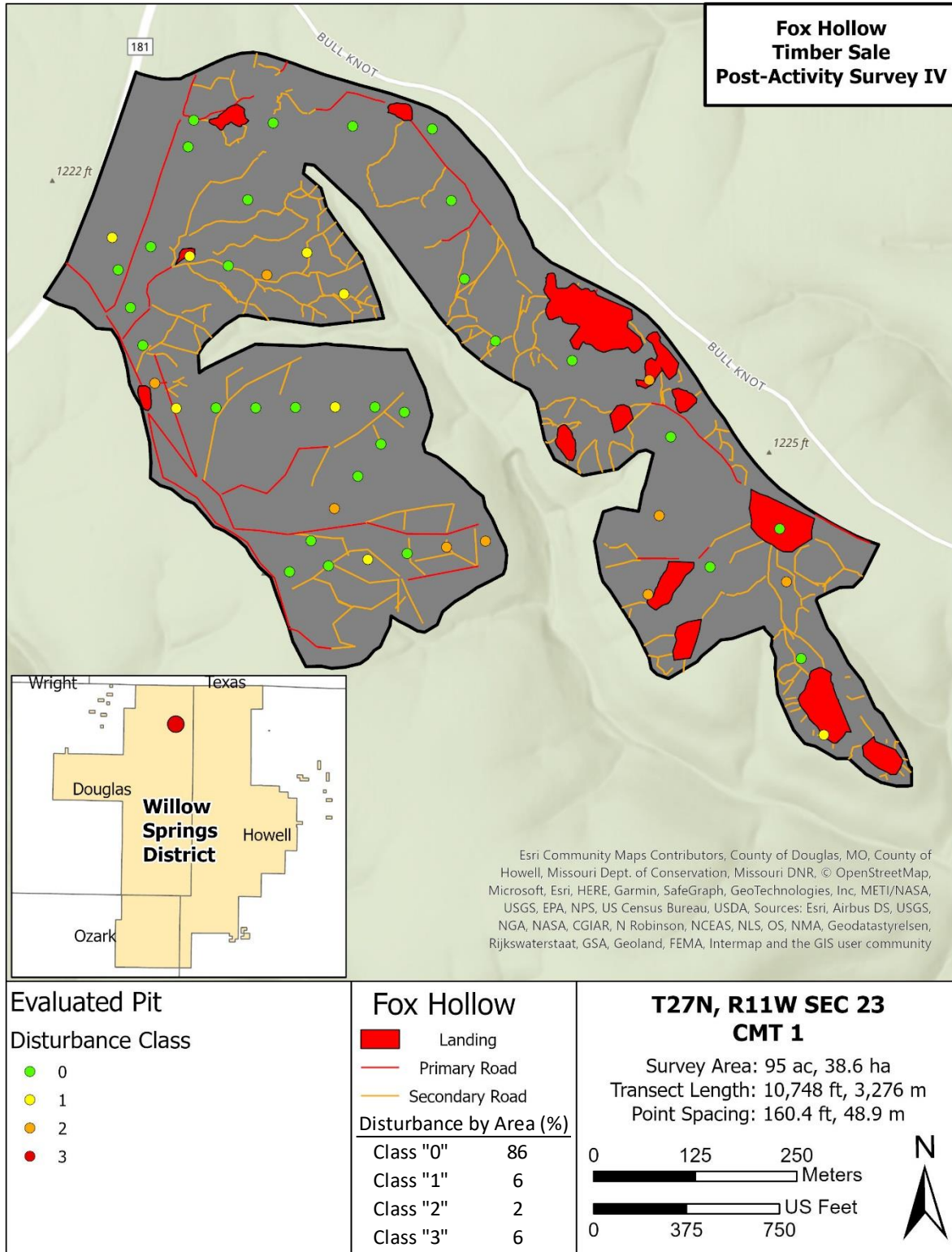


Figure 11. Fox Hollow Disturbance.

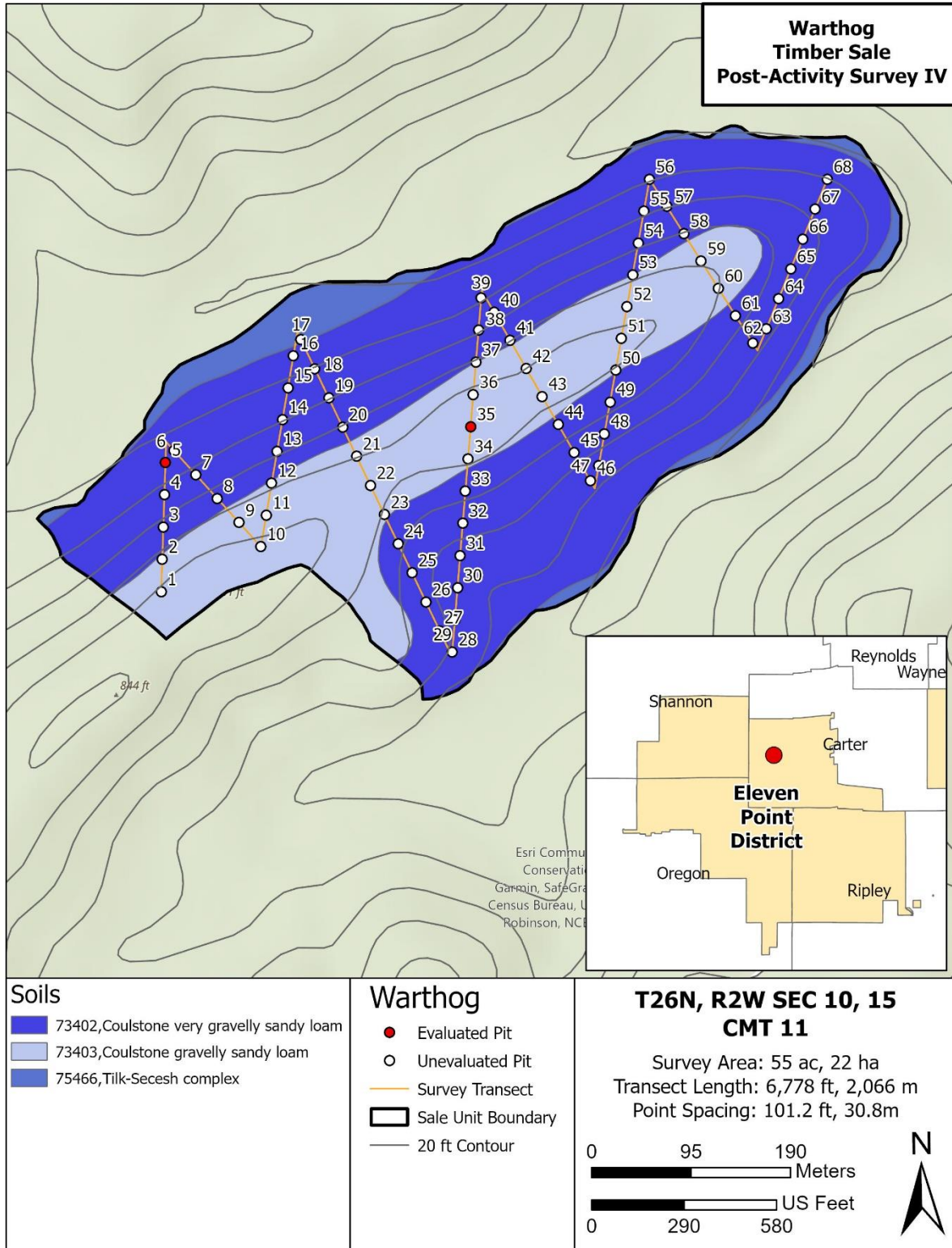


Figure 12. Warthog Site Map.

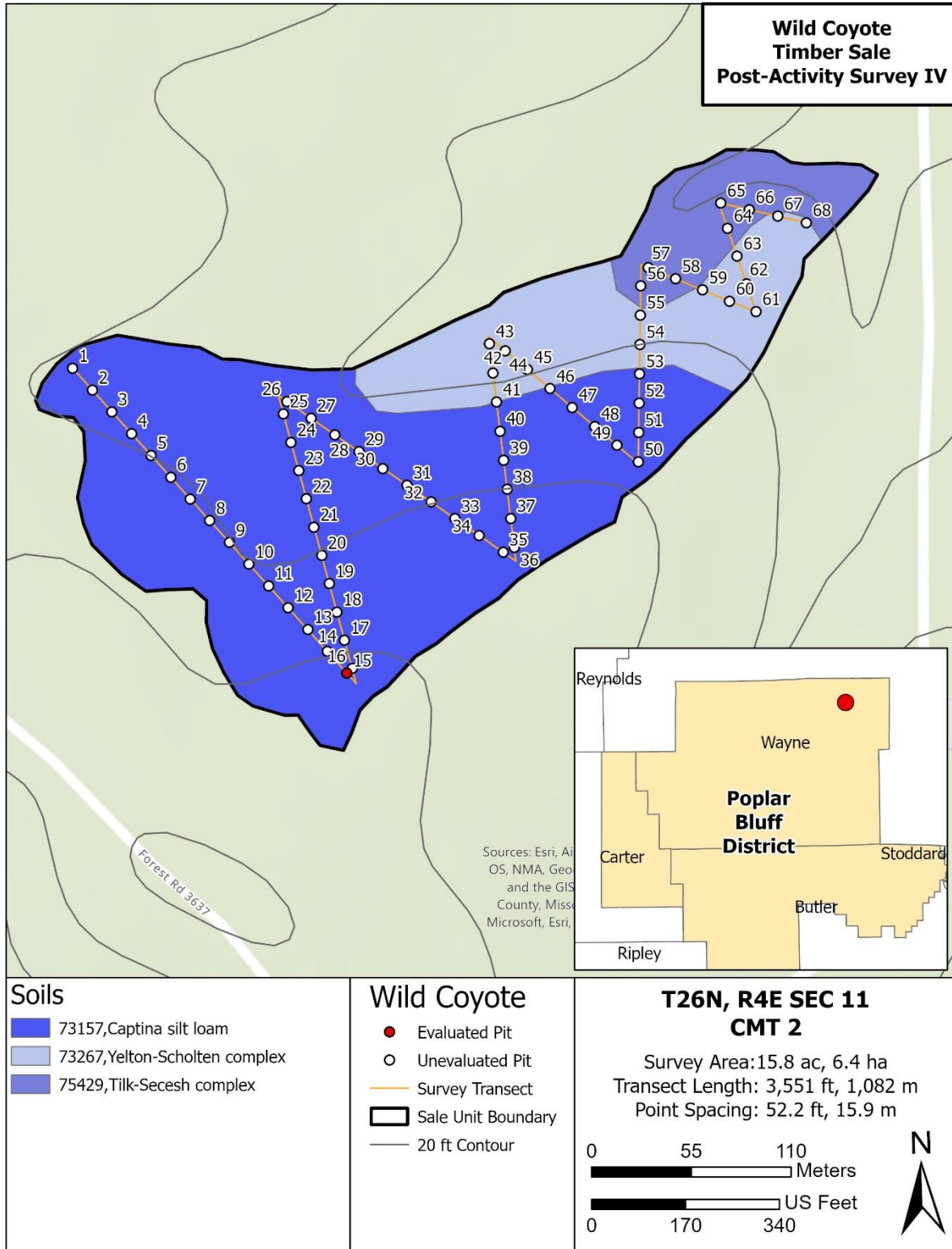


Figure 13. Wild Coyote Site Map.

PHOTOS



Photo 1. Using GPS navigation to locate pre-selected point locations (Swayback: Sept. 26, 2018).



Photo 2. Point location and ring where forest floor is evaluated prior to digging a pit (Monterey: May 11, 2018).



Photo 3. Measuring forest floor depth (Sterling Hollow: July 31, 2018).



Photo 4. Pits are dug to a depth of 15-30 cm (Warthog: April 5, 2018).



Photo 5. Measuring pit depth (Coyote: Sept. 27, 2018).



Photo 6. IPADs are used to enter data to FSDMP datasheet (Coyote: Sept. 27, 2018).



Photo 7. Using an example of platy structure to help field workers identify it in the field (Monterey: May 11, 2018).