



Gopher Tortoise Survey
at selected State Forests
in Northeastern Florida:
Ralph E. Simmons State Forest,
Cary State Forest,
Etoniah Creek State Forest,
Belmore State Forest,
Blue Springs Longleaf tract
of Twin Rivers State Forest,
and Welaka State Forest.



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Photo Credits:

Top: Gopher tortoise basking at the entrance of a burrow; Dan Hipes, FNAI

Middle: Sandhill at Blue Springs Longleaf Tract of Twin Rivers State Forest; Dan Hipes, FNAI

Bottom: Typical inactive tortoise burrow showing no recent sign of activity such as footprints or slide marks, but suitable for future use; Dan Hipes, FNAI

Acknowledgments

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Introduction

The Florida Natural Areas Inventory (FNAI) is part of the Florida Resources and Environmental Analysis Center at Florida State University. Our mission is to gather, interpret, and disseminate information that is critical to the conservation of Florida's biological diversity. To further this mission FNAI accepted a contract with Florida Department of Agriculture and Consumer Services, Division of Forestry (DOF) to conduct gopher tortoise surveys at six state forests in northeastern Florida: Ralph E. Simmons State Forest, Cary State Forest, Etoniah Creek State Forest, Belmore State Forest, Blue Springs Longleaf tract of Twin Rivers State Forest, and Welaka State Forest.

Methods

Potential gopher tortoise habitat for each state forest was selected from natural community and land cover maps in ArcGIS 9.3. A shapefile grid of 10 m x 10 m polygons was created using Hawth's Analysis Tools across the extent of potential habitat. Transects covering approximately 20 percent of the area were then selected systematically from this grid to evenly cover the area. The transects were unbiased with regard to placement within potentially suitable habitat. The transect file was loaded onto Trimble Nomad (with Pathfinder XB GPS) or Trimble GeoXT dataloggers, which have a map screen that allows the surveyor to see his/her location in relation to the preselected survey transects. GPS positions were corrected in real time using a WAAS satellite based augmentation signal. Each transect was searched for tortoise burrows. The path of each surveyor was recorded on the dataloggers to ensure full coverage of the entire survey transect. The location, size (juvenile < 14 cm; subadult 14-23 cm; adult >23 cm), and apparent activity status of all active, inactive, and recently abandoned burrows observed were recorded. Active burrows are characterized by open burrow entrances and clear signs of recent tortoise activity, such as tracks or slide marks in the sand (fresh digging alone may not be attributable to tortoises). Inactive burrows do not show clear signs of very recent tortoise activity but appear to have been maintained within the last few weeks to two months, as evidenced by a clean, passable, flat-bottomed entrance, with leaf litter either absent or appearing to have been deposited recently. Abandoned burrows represent a broad range of deterioration: Toward the inactive end of the spectrum, there may be decaying leaf litter in a burrow that otherwise retains functional shape (i.e., tortoise cross-sectional shape); there also may be erosion or evidence of digging by mammals (U-shaped or V-shaped bottom) at the mouth of the burrow. If a burrow showed evidence of armadillo use (higher dome, more rounded in cross-section), it was categorized as abandoned. Burrows that were not clearly made by a tortoise or old burrows that were filled by sediment or debris were not recorded.

Field data were downloaded and secondarily corrected (post processed) using base station data available from Florida Department of Environmental Protection to further improve the accuracy and precision of the locations recorded. The shapefiles depicting suitable habitat were edited to exclude areas of unsuitable habitat as determined during the field work. Transect shapefiles also were edited to exclude the unsuitable habitat. Tortoise burrows located outside of the transects were excluded from the data. Tortoise burrow densities were calculated for each habitat at each site. Burrow densities were then multiplied by acres of corresponding habitat to develop an estimate for the total number of active and inactive burrows for a site.

Results and Discussion

Ralph E. Simmons State Forest

FNAI staff surveyed 160 acres of transects within 819 acres of potential gopher tortoise habitat at Ralph E. Simmons State Forest. This habitat was predominately sandhill, but also included pine plantation on former sandhill, and ruderal areas (powerline ROW and cleared areas within the sandhill). Successional hardwood forest is present on former sandhill or in transitional areas from sandhill to upland hardwood forest along the slopes. Portions of transects were surveyed in these areas, but when determined to be unsuitable habitat, were excluded from the analysis. A total of 266 active, 98 inactive, and 234 abandoned tortoise burrows were observed. Of these there were 475 large, 91 medium, and 32 small burrows; this indicates recent reproduction and multiple age classes of tortoises. The high percentage of large burrows is typical for this long-lived animal. Table 1 summarizes the transect data for each of the three communities. Table 2 summarizes the activity status of burrows within the transects. Table 3 shows the calculated burrow density for each habitat. This density was then multiplied by the corresponding habitat acreage to calculate an estimate for the total number of active and inactive burrows for the state forest (Table 4). There was an unexpected result of a slightly higher density of both active and inactive burrow in pine plantation versus sandhill. This is the result of a large area within the pine plantation that has a sparse canopy of young trees and few midstory oaks allowing the herbaceous groundcover to flourish. The result is further explained by the fact that portions of the sandhill habitat are marginally suitable for tortoises because of a dense oak midstory. These areas are evident in Figure 1, which shows the habitat and the distribution of tortoises within transects at Ralph E. Simmons State Forest.

Table 1. Total gopher tortoise habitat and transect acreage at Ralph E. Simmons State Forest

Habitat	Total acres	Transect acres	Percent
sandhill	626.82	122.19	19.49
pine plantation	163.67	32.43	19.81
ruderal	28.86	5.41	18.75
Total	819.35	160.03	19.53

Table 2. Summary of burrow status by habitat within transects at Ralph E. Simmons State Forest

Habitat	Active	Inactive	Abandoned	Total
sandhill	180	70	185	435
pine plantation	65	21	43	129
ruderal	21	7	6	34
Total	266	98	234	598

Table 3. Summary of active and inactive burrow density within transects by habitat at Ralph E. Simmons State Forest

Habitat	Active	Density (per acre)	Inactive	Density (per acre)
sandhill	180	1.47	70	.57
pine plantation	65	2.00	21	.65
ruderal	21	3.88	7	1.29

Table 4. Total burrow estimates for active and inactive burrows by habitat at Ralph E. Simmons State Forest

Habitat	Acres of habitat	Active burrows per acre	Estimated active burrows	Inactive burrows per acre	Estimated inactive burrows
sandhill	626.82	1.47	921	.57	357
pine plantation	163.67	2.00	327	.65	106
ruderal	28.86	3.88	112	1.29	144
Total	819.35	--	1360	--	607

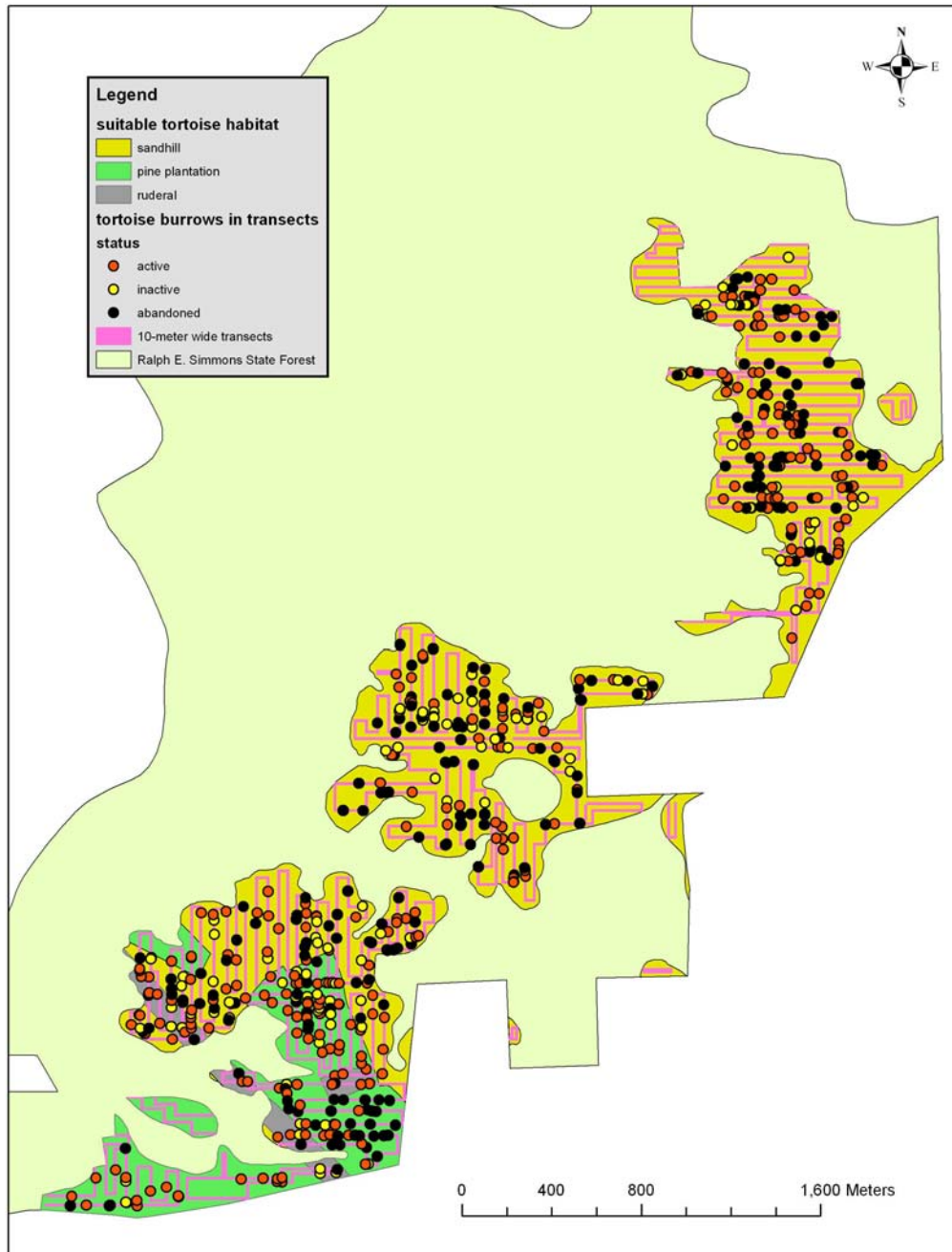


Figure 1. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Ralph E. Simmons State Forest

Belmore State Forest

FNAI staff surveyed 187 acres of transects within 921 acres of potential gopher tortoise habitat at Belmore State Forest. This habitat was predominately pine plantation, but also included clearcut pine plantation, and remnant sandhill or areas retaining enough natural sandhill characteristics to be mapped as such despite planted pines. A total of 84 active, 19 inactive, and 69 abandoned tortoise burrows were observed. Of these there were 142 large, 24 medium, and 6 small burrows; this indicates at least some recent reproduction and multiple age classes of tortoises. The high percentage of large burrows is typical for this long-lived animal. Table 5 summarizes the transect data for each of the three communities. Table 6 summarizes the activity status of burrows within the transects. Table 7 shows the calculated burrow density for each habitat. This density was then multiplied by the corresponding habitat acreage to calculate an estimate for the total number of active and inactive burrows for the state forest (Table 8). The tortoise density of active burrows in the sandhill (1.14/acre) is within the typical range of 1 to 2 per acre for a sandhill. Most of the pine plantation had a dense tree canopy with tortoises occurring in small infrequent openings where herbaceous plants persist. The result is a low density of burrows that are patchily distributed. The clearcut areas generally had a sparse to moderate herbaceous groundcover also resulting in a low burrow density. Figures 2 and 3 show the habitat and the distribution of tortoises within transects at Belmore State Forest.

Table 5. Total gopher tortoise habitat and transect acreage at Belmore State Forest

Habitat	Total acres	Transect acres	Percent
sandhill	85.62	17.49	20.43
pine plantation	571.99	112.45	19.66
clearcut plantation	263.36	57.14	21.70
Total	920.97	187.08	20.31

Table 6. Summary of burrow status by habitat within transects at Belmore State Forest

Habitat	Active	Inactive	Abandoned	Total
sandhill	20	4	18	42
pine plantation	35	12	37	84
clearcut plantation	29	3	14	46
Total	84	19	69	172

Table 7. Summary active and inactive burrow density within transects by habitat at Belmore State Forest

Habitat	Active	Density (per acre)	Inactive	Density (per acre)
sandhill	20	1.14	4	.23
pine plantation	35	.31	12	.11
clearcut plantation	29	.51	3	.05

Table 8. Total burrow estimates for active and inactive burrows by habitat at Belmore State Forest

Habitat	Acres of habitat	Active burrows per acre	Estimated active burrows	Inactive burrows per acre	Estimated inactive burrows
sandhill	85.62	1.14	97	.23	20
pine plantation	571.99	.31	177	.11	63
ruderal	263.36	.51	134	.05	13
Total			408		96

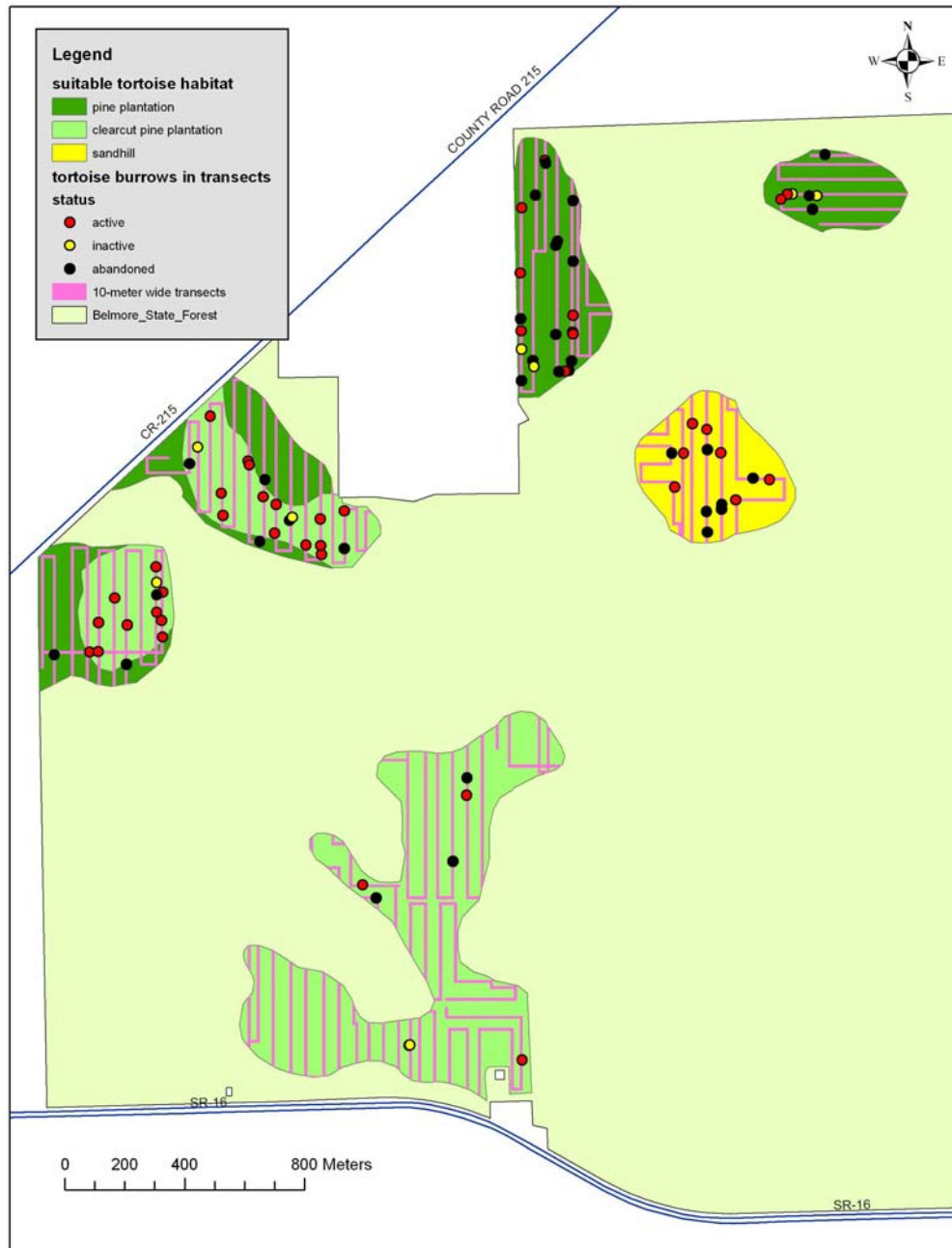


Figure 2. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Belmore State Forest (northwestern tract)

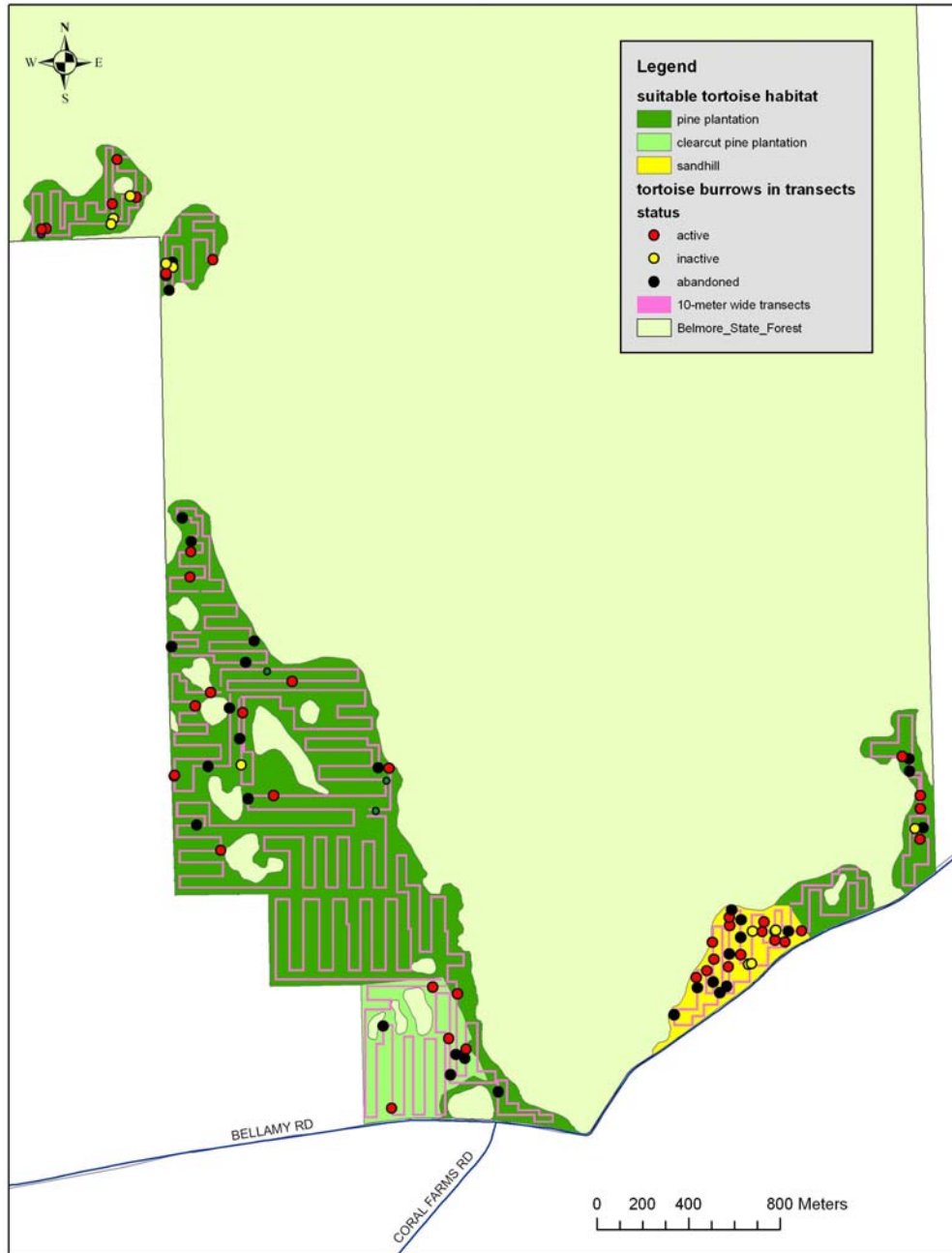


Figure 3. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Belmore State Forest (southeastern tract)

Cary State Forest

FNAI staff surveyed 214 acres of transects within 1003 acres of potential gopher tortoise habitat at Cary State Forest. This habitat was predominately pine plantation, but also included clearcut pine plantation, sandhill, mesic (dry) flatwoods and recently herbicided sites mapped as ruderal for this survey. A total of 281 active, 164 inactive, and 526 abandoned tortoise burrows were observed. Of these there were 834 large, 109 medium, and 28 small burrows; this indicates at least some recent reproduction and multiple age classes of tortoises. The high percentage of large burrows is typical for this long-lived animal. The number of abandoned burrows relative to active and inactive is higher than typical. This is often attributed to declining habitat conditions, but in this case is attributable in part to a recent die off of tortoises--evident from the many shells lying on the ground at one site. Table 9 summarizes the transect data for each of the three communities. Table 10 summarizes the activity status of burrows within the transects. Table 11 shows the calculated burrow density for each habitat. This density was then multiplied by the corresponding habitat acreage to calculate an estimate for the total number of active and inactive burrows for the state forest (Table 12). The tortoise density of active burrows in the sandhill (.38/acre) is below the typical range of 1 to 2 per acre for a sandhill. Most of the area mapped as pine plantation for this survey had a moderately open tree canopy allowing sufficient light for a moderate to dense herbaceous ground cover. The general result is a density of burrows comparable to natural sandhill. Some areas of pine plantation with a dense canopy, including most of the areas planted in sand pine, seemed to have a lower density of burrows, but these areas were not separated out for analysis. Figures 4 and 5 show the habitat and the distribution of tortoises within transects at Cary State Forest.

Table 9. Total gopher tortoise habitat and transect acreage at Cary State Forest

Habitat	Total acres	Transect acres	Percent
sandhill	171.69	37.28	21.71
pine plantation	651.63	139.38	21.39
clearcut plantation	42.89	7.19	16.76
mesic flatwoods	50.35	11.37	22.58
ruderal	86.62	18.81	21.71
Total	1003.18	214.03	21.34

Table 10. Summary of burrow status by habitat within transects at Cary State Forest

Habitat	Active	Inactive	Abandoned	Total
sandhill	14	25	52	91
pine plantation	225	134	444	803
clearcut plantation	8	2	2	12
mesic flatwoods	3	1	5	9
ruderal	31	2	23	56
Total	281	164	526	971

Table 11. Summary active and inactive burrow density within transects by habitat at Cary State Forest

Habitat	Active	Density (per acre)	Inactive	Density (per acre)
sandhill	14	.38	25	.67
pine plantation	225	1.61	134	.96
clearcut plantation	8	1.11	2	.28
mesic flatwoods	3	.26	1	.09
ruderal	31	1.65	2	.11

Table 12. Total burrow estimates for active and inactive burrows by habitat at Cary State Forest

Habitat	Acres of habitat	Active burrows per acre	Estimated active burrows	Inactive burrows per acre	Estimated inactive burrows
sandhill	171.69	.38	65	.67	115
pine plantation	651.63	1.61	1049	.96	626
clearcut plantation	42.89	1.11	48	.28	12
mesic flatwoods	50.35	.26	13	.09	5
ruderal	86.62	1.65	143	.11	10
Total			1318		768

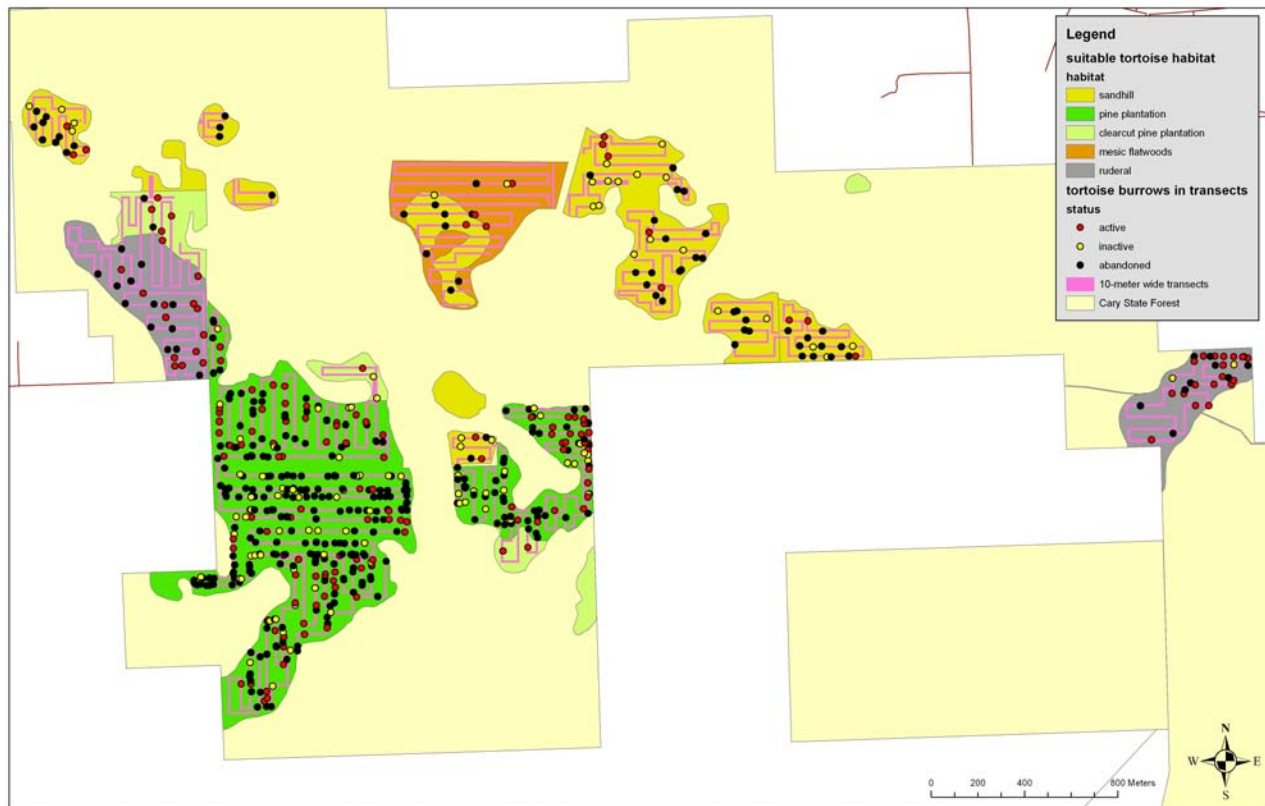


Figure 4. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Cary State Forest (northern tract)

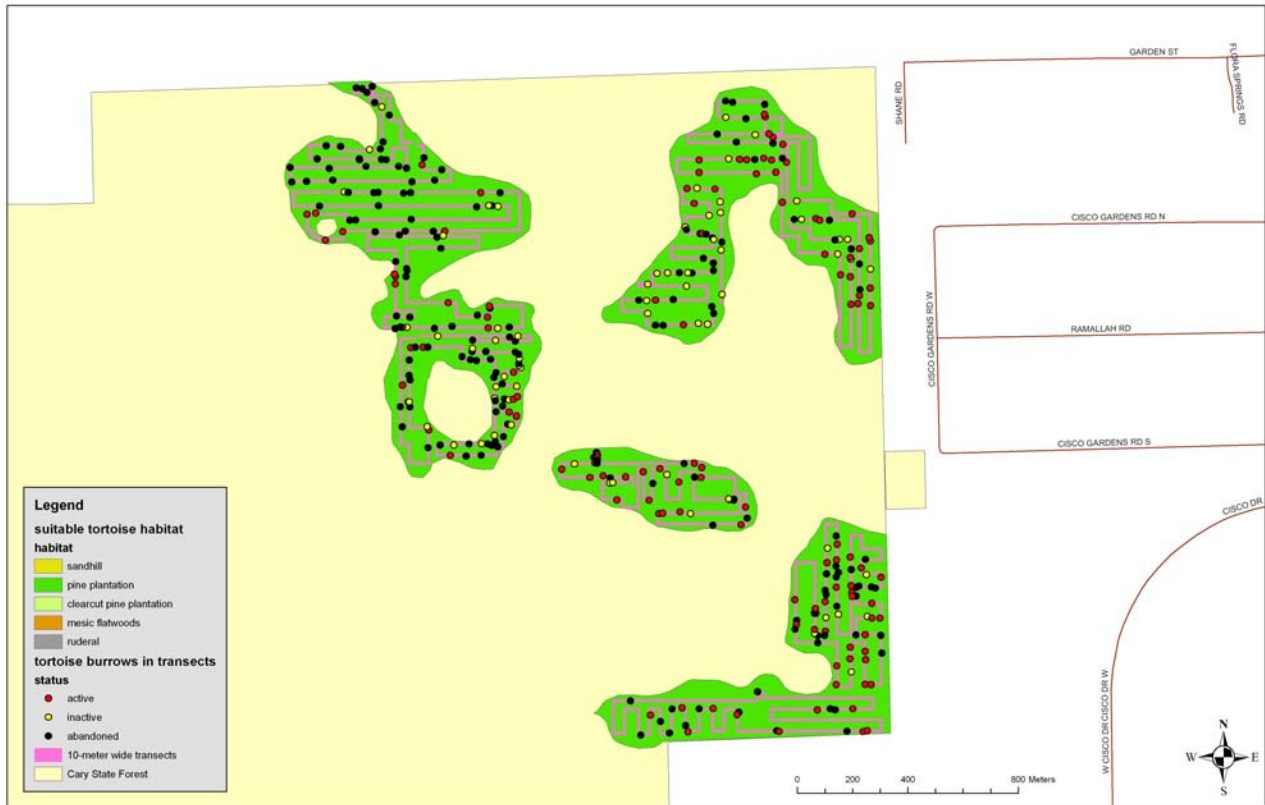


Figure 5. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Cary State Forest (southern tract)

Welaka State Forest

FNAI staff surveyed 128 acres of transects within 632 acres of potential gopher tortoise habitat at Welaka State Forest. This habitat was predominately sandhill, but also included scrubby flatwoods and xeric hammock. A total of 69 active, 14 inactive, and 40 abandoned tortoise burrows were observed. Of these there were 108 large, 13 medium, and 2 small burrows; this indicates at least some recent reproduction and multiple age classes of tortoises. The high percentage of large burrows is typical for this long-lived animal. The number of abandoned burrows relative to active and inactive is higher than typical. This is often attributed to declining habitat conditions, but is an unreliable indicator. Nevertheless, a large portion of the sandhill has not burned in several years. More frequent burning in sandhill (every 2 or 3 years) is necessary to improve and maintain habitat for gopher tortoises. Table 13 summarizes the transect data for each of the three communities. Table 14 summarizes the activity status of burrows within the transects. Table 15 shows the calculated burrow density for each habitat. This density was then multiplied by the corresponding habitat acreage to calculate an estimate for the total number of active and inactive burrows for the state forest (Table 16). The tortoise density of active burrows in the sandhill (.82/acre) is below the typical range of 1 to 2 per acre for a sandhill. The xeric hammock and scrubby flatwoods are marginally suitable to unsuitable because of dense shrub, midstory or canopy layers. Some of this area may have been historically unsuitable because its position on the landscape may have prevented regular burning. The larger tracts, however, appear to have been sandhill and could be managed to improve their suitability for gopher tortoises. Figure 6 shows the habitat and the distribution of tortoises within transects at Welaka State Forest.

Table 13. Total gopher tortoise habitat and transect acreage at Welaka State Forest

Habitat	Total acres	Transect acres	Percent
sandhill	372.88	78.96	21.18
scrubby flatwoods	166.81	30.11	18.05
xeric hammock*	92.08	19.32	20.98
Total	631.77	128.39	20.32

*xeric hammock includes historic sandhill and scrubby flatwoods

Table 14. Summary of burrow status by habitat within transects at Welaka State Forest

Habitat	Active	Inactive	Abandoned	Total
sandhill	65	14	38	117
scrubby flatwoods	4	0	2	6
xeric hammock*	0	0	0	0
Total	69	14	40	123

*xeric hammock includes historic sandhill and scrubby flatwoods

Table 15. Summary active and inactive burrow density within transects by habitat at Welaka State Forest

Habitat	Active	Density (per acre)	Inactive	Density (per acre)
sandhill	65	0.82	14	0.18
scrubby flatwoods	4	0.13	0	0
xeric hammock*	0	0	0	0

Table 16. Total burrow estimates for active and inactive burrows by habitat at Welaka State Forest

Habitat	Acres of habitat	Active burrows per acre	Estimated active burrows	Inactive burrows per acre	Estimated inactive burrows
sandhill	372.88	0.82	306	0.18	67
scrubby flatwoods	166.81	0.13	22	0	0
xeric hammock*	92.08	0	0	0	0
Total			328		67

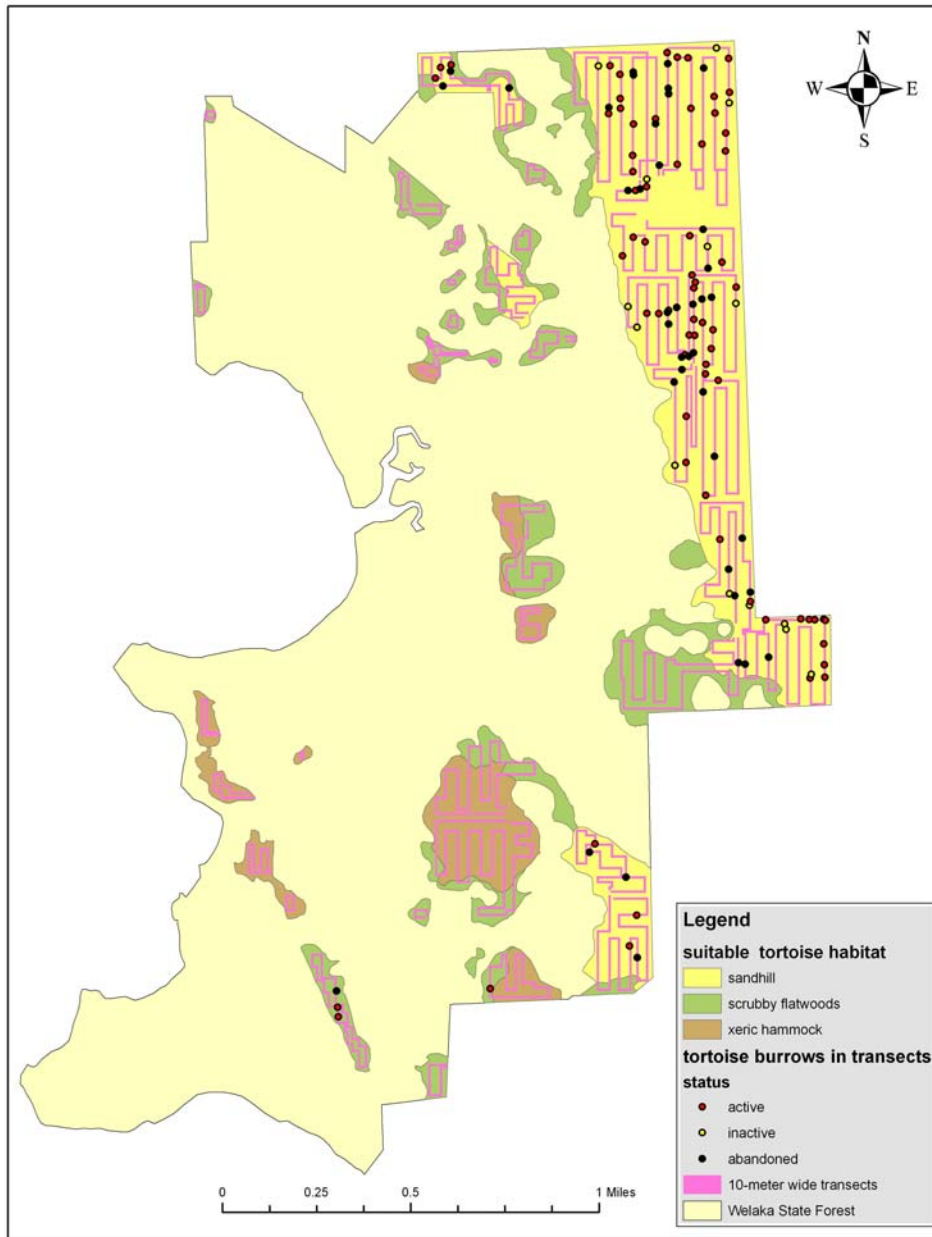


Figure 6. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Welaka State Forest

Etoniah Creek State Forest

FNAI staff surveyed 700 acres of transects within 3,830 acres of potential gopher tortoise habitat at Etoniah Creek State Forest. This habitat was predominately sandhill, pine plantation on well drained soils, and scrub, but also included successional hardwood forest on xeric and mesic soils, xeric hammock, mesic flatwoods, and scrubby flatwoods. A total of 231 active, 82 inactive, and 179 abandoned tortoise burrows were observed within transects. Of these there were 406 large, 65 medium, and 21 small burrows; this indicates at least some recent reproduction and multiple age classes of tortoises. The high percentage of large burrows is typical for this long-lived animal. Table 17 summarizes the transect data for each of the three communities. Table 18 summarizes the activity status of burrows within the transects. Table 19 shows the calculated burrow density for each habitat. This density was then multiplied by the corresponding habitat acreage to calculate an estimate for the total number of active and inactive burrows for the state forest (Table 20). The density of active burrows in the sandhill (.61/acre) is below the typical range of 1 to 2 per acre for a sandhill. This is attributable to a history of insufficient prescribed fire. Recent improvements (thinning and burning) to some of the sandhill tracts are evident. Areas mapped as pine plantation for this survey were variable in condition. Some areas have a dense cover of young sand pine; others had been recently cleared and roller-chopped. Nevertheless, areas within the plantations remain suitable for gopher tortoises. Figures 6, 7, and 8 show the habitat and the distribution of tortoises within transects at Etoniah State Forest.

Table 17. Total gopher tortoise habitat and transect acreage at Etoniah Creek State Forest

Habitat	Total acres	Transect acres	Percent
sandhill	1297.97	277.28	21.36
pine plantation	932.03	180.23	19.33
scrub	842.05	113.94	13.53
successional hardwood forest	287.02	46.91	16.34
xeric hammock	230.79	35.28	15.29
mesic flatwoods	125.41	25.58	20.40
scrubby flatwoods	114.76	20.76	18.09
Total	3830.03	699.98	18.28

Table 18. Summary of burrow status by habitat within transects at Etoniah Creek State Forest

Habitat	Active	Inactive	Abandoned	Total
sandhill	169	62	129	360
pine plantation	56	19	43	118
scrub	4	1	3	8
successional hardwood forest	2	0	2	4
xeric hammock	0	0	0	0
mesic flatwoods	0	0	1	1
scrubby flatwoods	0	0	1	1
Total	231	82	179	492

Table 19. Summary active and inactive burrow density within transects by habitat at Etoniah Creek State Forest

Habitat	Active	Density (per acre)	Inactive	Density (per acre)
sandhill	169	.61	62	.22
pine plantation	56	.31	19	.11
scrub	4	.04	1	.01
successional hardwood forest	2	.04	0	.00
xeric hammock	0	.00	0	.00
mesic flatwoods	0	.00	0	.00
scrubby flatwoods	0	.00	0	.00

Table 20. Total burrow estimates for active and inactive burrows by habitat at Etoniah Creek State Forest

Habitat	Acres of habitat	Active burrows per acre	Estimated active burrows	Inactive burrows per acre	Estimated inactive burrows
sandhill	1297.97	.61	792	.22	286
pine plantation	932.03	.31	289	.11	103
scrub	842.05	.04	34	.01	8
successional hardwood forest	287.02	.04	11	.00	0
xeric hammock	230.79	.00	0	.00	0
mesic flatwoods	125.41	.00	0	.00	0
scrubby flatwoods	114.76	.00	0	.00	0
Total			1126		397

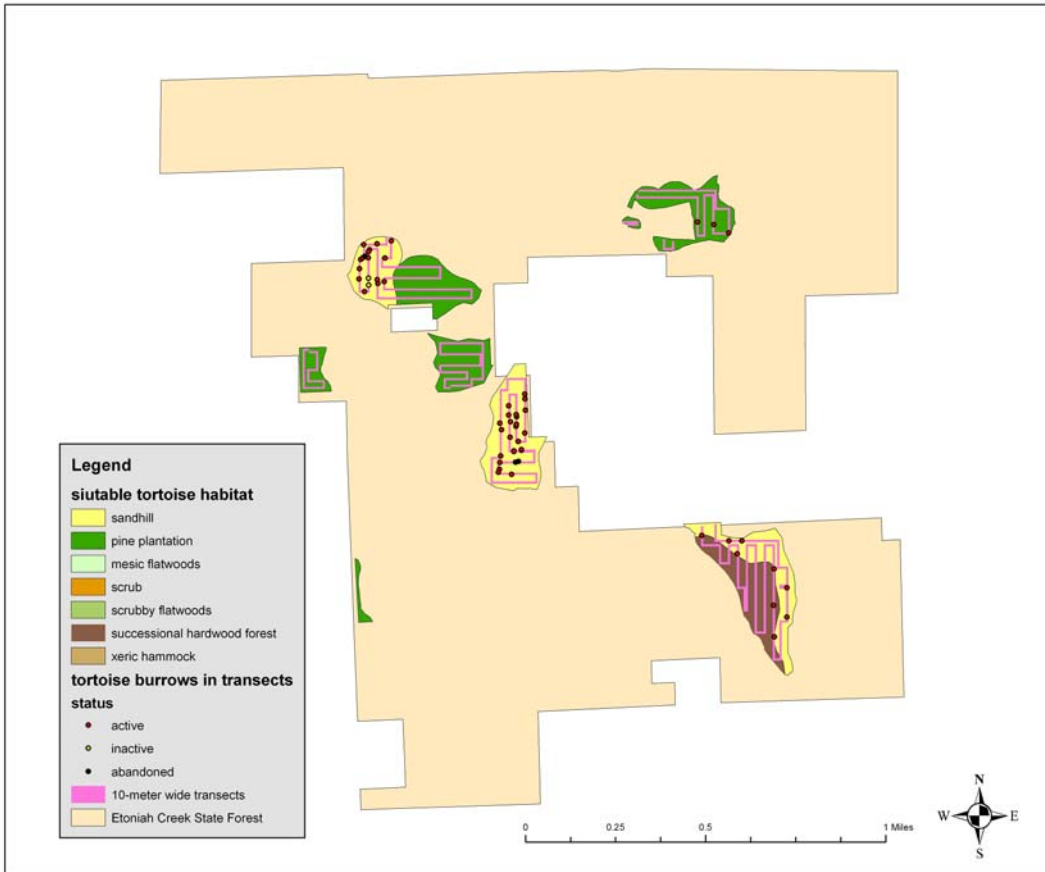


Figure 6. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Etoniah Creek State Forest (northeastern tract)

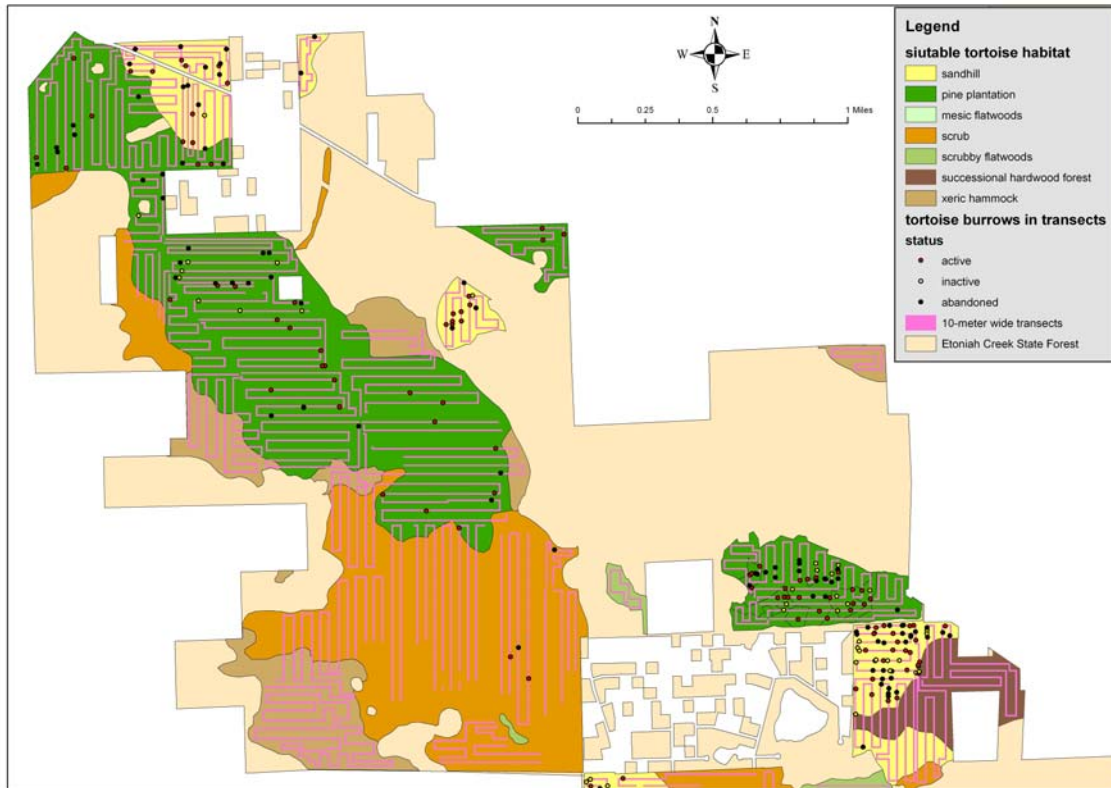


Figure 7. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Etoniah Creek State Forest (northwestern portion)

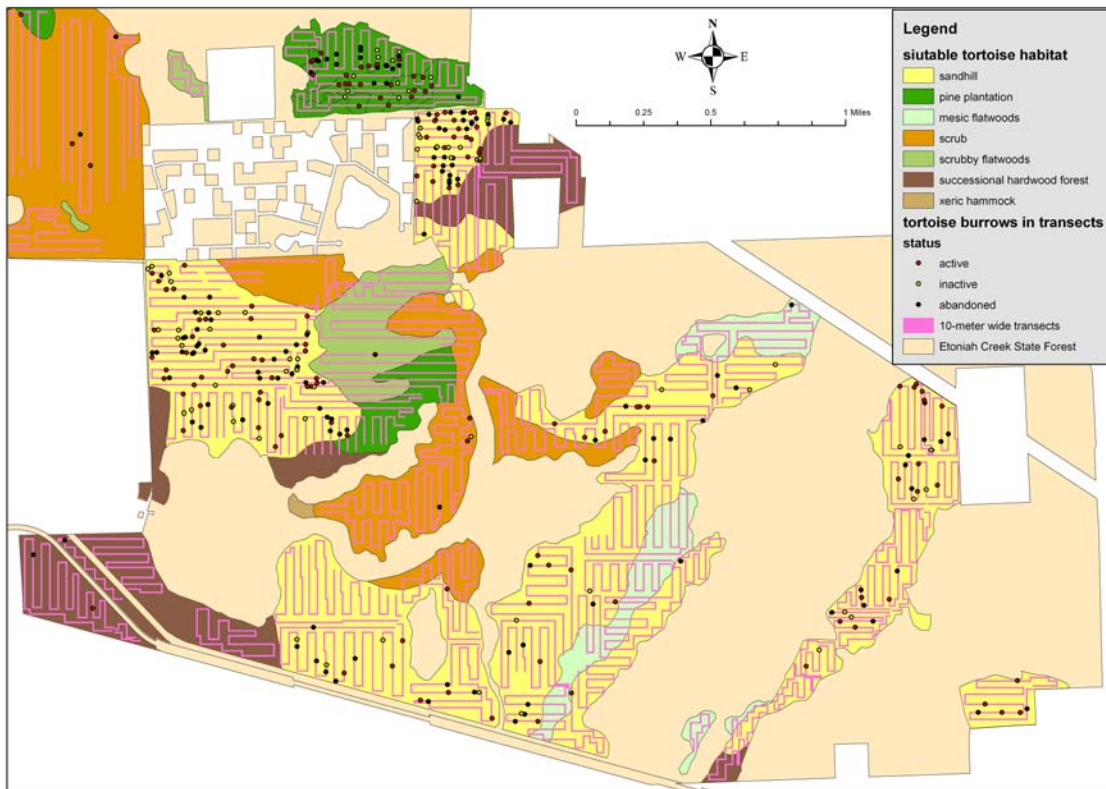


Figure 8. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Etoniah Creek State Forest (southwestern portion)

Twin Rivers State Forest

FNAI staff surveyed 413 acres of transects within 2,089 acres of potential gopher tortoise habitat at Twin Rivers State Forest. This habitat was predominately upland pine with inclusions of sandhill, and pine plantation. A total of 573 active, 261 inactive, and 304 abandoned tortoise burrows were observed within transects. Of these there were 955 large, 132 medium, and 51 small burrows; this indicates recent reproduction and multiple age classes of tortoises. The high percentage of large burrows is typical for this long-lived animal. Table 21 summarizes the transect data for each of the three communities. Table 22 summarizes the activity status of burrows within the transects. Table 23 shows the calculated burrow density for each habitat. This density was then multiplied by the corresponding habitat acreage to calculate an estimate for the total number of active and inactive burrows for the state forest (Table 24). The density of active burrows was greater than 1 per acre in all of the habitats surveyed on the state forest and within the typical range of 1 to 2 per acre for a sandhill in natural condition or other good quality habitat. Figure 9 shows the habitat and the distribution of tortoises within transects at Twin Rivers State Forest.

Table 21. Total gopher tortoise habitat and transect acreage at Twin Rivers State Forest

Habitat	Total acres	Transect acres	Percent
upland pine	1548.97	311.85	20.13
pine plantation	422.16	80.34	19.03
ruderal	118.26	21.20	17.93
Total	2089.39	413.39	19.79

Table 22. Summary of burrow status by habitat within transects at Twin Rivers State Forest

Habitat	Active	Inactive	Abandoned	Total
upland pine	463	226	262	951
pine plantation	82	31	37	150
ruderal	28	4	5	37
Total	573	261	304	1138

Table 23. Summary active and inactive burrow density within transects by habitat at Twin Rivers State Forest

Habitat	Active	Density (per acre)	Inactive	Density (per acre)
upland pine	463	1.48	226	.72
pine plantation	82	1.02	31	.39
ruderal	28	1.32	4	.19

Table 24. Total burrow estimates for active and inactive burrows by habitat at Twin Rivers State Forest

Habitat	Acres of habitat	Active burrows per acre	Estimated active burrows	Inactive burrows per acre	Estimated inactive burrows
upland pine	1548.97	1.48	2292	.72	1115
pine plantation	422.16	1.02	431	.39	165
ruderal	118.26	1.32	156	.19	22
Total	2089.39		2879		1302

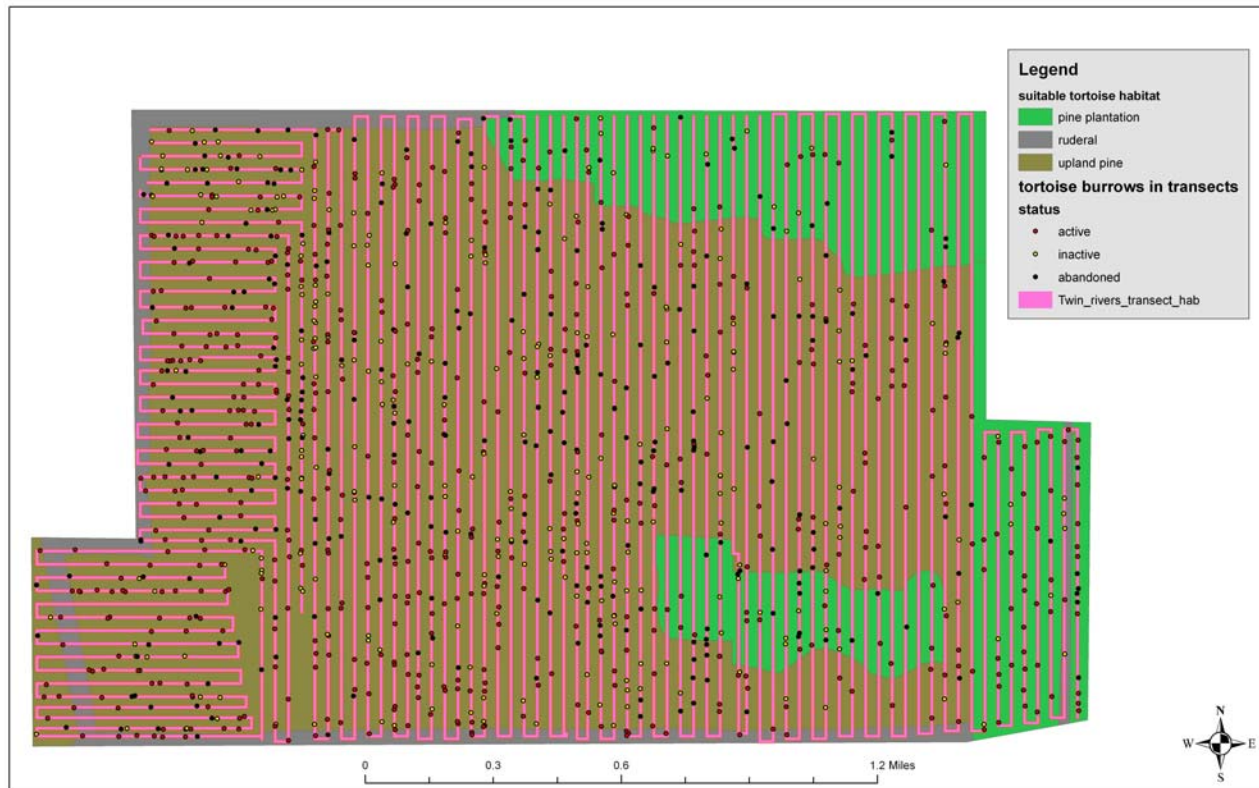


Figure 9. Distribution of suitable habitat and active, inactive, and abandoned burrows within transects at Blue Springs Tract of Twin Rivers State Forest