HNF-59911
Revision 0

Hanford Site Ground Squirrel Monitoring Report for Calendar Year 2015

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

P.O. Box 650
Richland, Washington 99352

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Hanford Site Ground Squirrel Monitoring Report for Calendar Year 2015

K. Cranna and J. Nugent
Mission Support Alliance

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1.0 Introduction

The U.S. Department of Energy, Richland Operations Office (DOE-RL) conducts ecological monitoring on the Hanford Site to collect and track data needed to ensure compliance with an array of environmental laws, regulations, and policies governing DOE activities. Ecological monitoring data provide baseline information about the plants, animals, and habitats under DOE-RL stewardship at Hanford required for decision-making under the *National Environmental Policy Act* (NEPA) and *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). The *Hanford Site Comprehensive Land Use Plan* (CLUP, DOE 1999), which is the Environmental Impact Statement for Hanford Site activities, helps ensure that DOE-RL, its contractors, and other entities conducting activities on the Hanford Site are in compliance with NEPA.

The *Hanford Site Biological Resources Management Plan* (BRMP, DOE 2013) is identified by the CLUP as the primary implementation control for managing and protecting natural resources on the Hanford Site.

> The BRMP provides a mechanism for ensuring compliance with laws protecting biological resources; provides a framework for ensuring that appropriate biological resource goals, objectives, and tools are in place to make DOE an effective steward of the Hanford biological resources; and implements an ecosystem management approach for biological resources on the Site. The BRMP provides a comprehensive direction that specifies DOE biological resource policies, goals, and objectives.

DOE-RL prioritizes monitoring those plant and animal species or habitats with specific regulatory protections or requirements; that are rare and/or declining (federally or state listed endangered, threatened, or sensitive species); or are of significant interest to federal, state, or tribal governments or the public. The BRMP ranks wildlife species and habitats (Levels 0–5), providing a graded approach to monitoring biological resources based on the level of concern for each resource. The Townsend's ground squirrel (*Urocitellus townsendii*) is listed as a "State Candidate" by the Washington Department of Fish and Wildlife (WDFW; WDFW 2012) and is ranked as a Level 3 resource in the BRMP. The management goal for Level 3 resources is conservation and requires a moderate level of status monitoring.

Ground squirrels are important to the shrub-steppe ecosystem for many reasons. They serve as a food source for many mammals such as badgers and coyotes and fall prey to predatory birds such as hawks, falcons, and owls. The ground squirrel diet consists of a variety of foods including seeds, which contributes to native plant seed dispersal. The process of digging burrows helps to aerate the soil and provides burrows for other species, including burrowing owls (Sato 2012). Their decline is due to the loss of suitable habitat and isolation of their communities through fragmentation as well as control programs involving poisoning and shooting that were widely practiced in the past (WDFW 2012).

Ground squirrels are underground for much of the year for hibernation and estivation, making it crucial to monitor during the correct time frame. The ground squirrels' lifecycle consists of several seasonal components. During mid- to late January, squirrels emerge from their burrows after hibernation. They spend the next month breeding, followed by gestation and rearing of young. The young become active outside the burrow by mid-April. They become dormant again starting in late May to late June, entering a type of torpor called estivation that is used to avoid the hot and dry portion of the year (WDFW 2012). After estivation, ground squirrels may spend late September and October foraging in preparation for hibernation.

The crucial window to observe and monitor these ground squirrels is between late January, after hibernation and before late May when estivation begins. These months are the longest active period for ground squirrels and thus are the best time for monitoring. Ground squirrels breed and rear young during this time, and age determination is easier because the juveniles are significantly smaller than the adults. Protective maternal alarm calls are also used at this time, maximizing the likelihood of detecting occupied colonies (Figure 1).

Figure 1. Townsend's Ground Squirrel Performing Maternal Alarm Call

1.1 Ground Squirrels on the Hanford Site

Townsend's ground squirrels are found in Washington State only within the Columbia Basin and west of the Columbia River. Two subspecies of Townsend's ground squirrels are known to occur, *U. townsendii nancyae* and *U. townsendii townsendii*. *U.t. nancyae* is found north and east of the Yakima River, which includes the Hanford Site, and *U.t. townsendii* occurs south and west of the Yakima River (Yensen and Sherman 2003). The predicted distribution of Townsend's ground squirrels from WDFW's Washington

GAP Analysis Program is shown in Figure 2. Ground squirrels on the Hanford Site are known to consume mostly Sandberg's bluegrass (*Poa secunda*), followed by a variety of forbs, including western tansymustard (*Descurainia pinnata*), lupine (*Lupinus* spp.), and long-leaf phlox (*Phlox longifolia*; Rogers and Gano 1980).

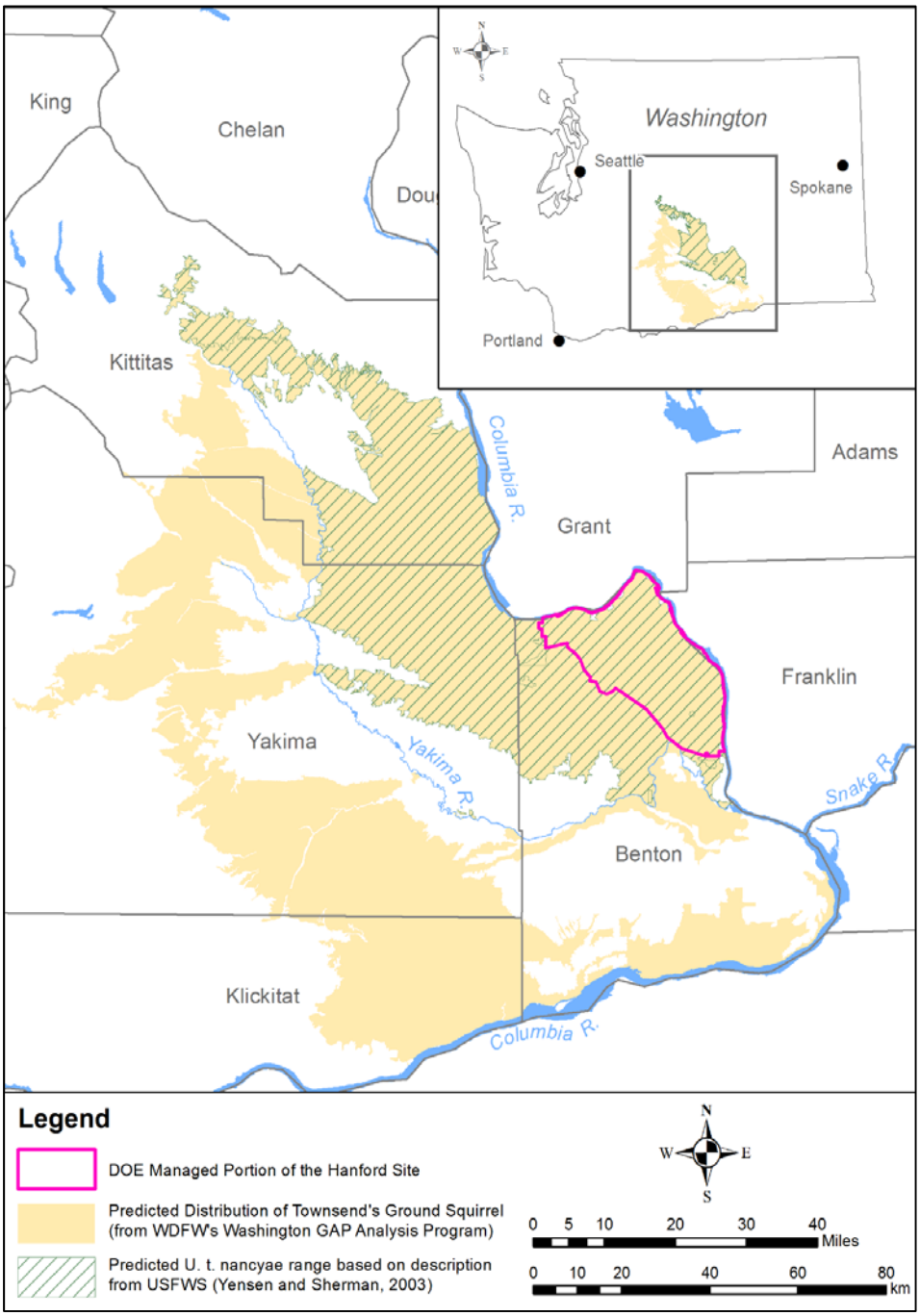

Figure 2. Predicted Townsend's Ground Squirrel Distribution with Overlay of the Subspecies *U.t. nancyae*'s Predicted Range in Relation to the DOE Managed Portion of the Hanford Site

The central portion of Hanford Site managed by DOE encompasses ~815.8 km^2 (315 mi^2). Prior to 2012, six Townsend's ground squirrel colonies were documented on the Hanford Site within this area. During 2012 and 2013, Mission Support Alliance (MSA) surveyed 45 "diamond" transects totaling 108 mi (173 km), covering 2565 ac (1038 ha) and documented the status of the previously known colonies (Lindsey et al. 2012; Lindsey and Nugent 2013). No new colonies were detected during the transect surveys; however, seven previously undocumented colonies were identified during surveys focused on areas where ground squirrels were incidentally encountered by other Hanford Site biologists performing compliance reviews and other surveys. One of the six colonies documented prior to 2012 (300 Area colony) was found to be occupied during the 2013 surveys (Figure 3).

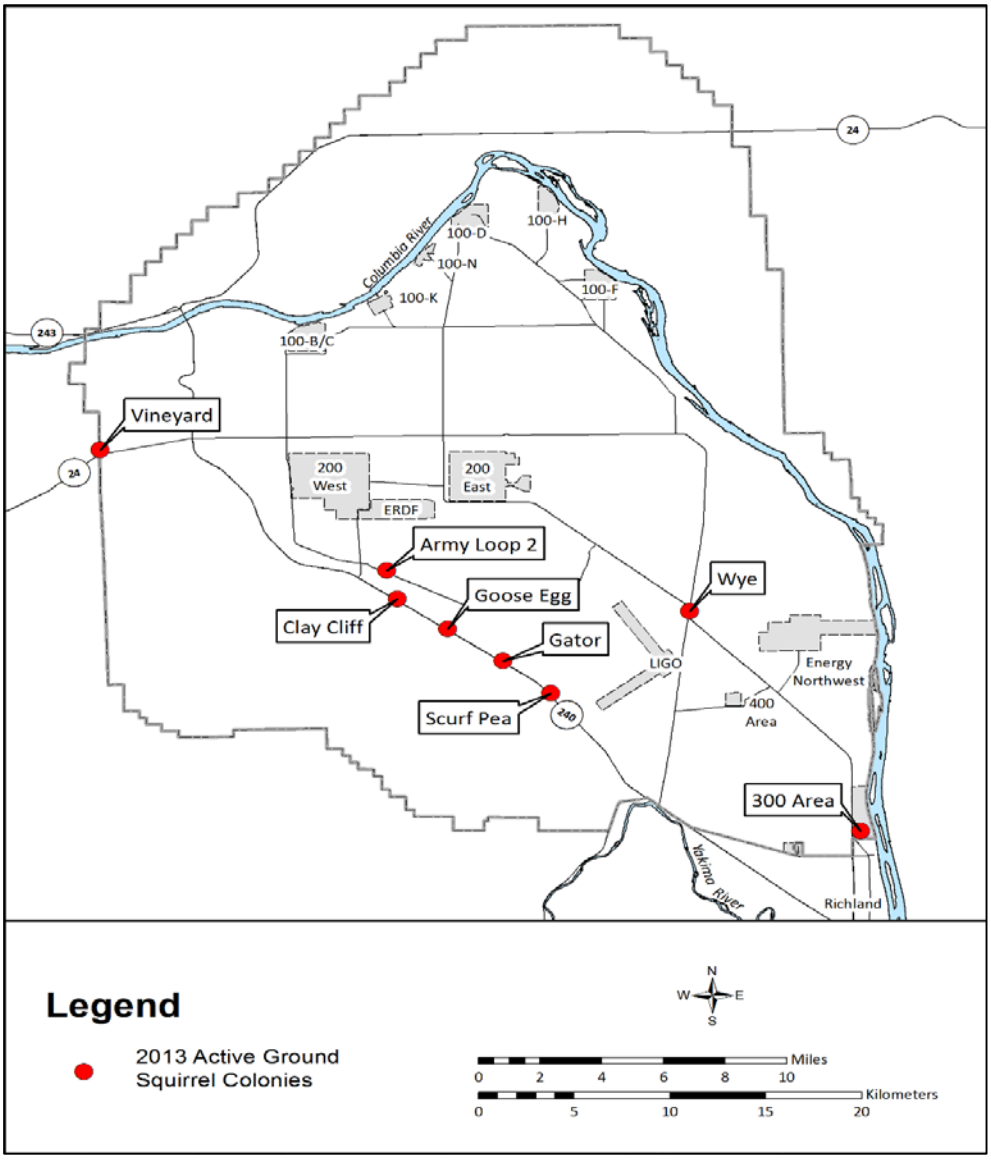

Figure 3. 2013 Active Townsend's Ground Squirrel Colonies on the DOE Managed Portion of the Hanford Site

1.2 Habitat Suitability Modeling of Townsend's Ground Squirrels

Townsend's ground squirrels were chosen as a focal species in the Washington Wildlife Habitat Connectivity Working Group's (WHCWG) Connected Landscapes Project analysis specific to the Columbia Plateau Ecoregion (WHCWG 2012). Specifically, the Washington WHCWG is a partnership composed of federal and state agencies, tribes, and universities co-led by the WDFW and Washington State Department of Transportation. The habitat connectivity study consisted of analyzing distribution, habitat associations, and sensitivity to several anthropogenic factors together in a Geographic Information System (GIS). The study modeled habitat concentration areas, habitat resistance, cost-weighted distance, and connectivity linkages. The data used to develop the model were regional, state, or national datasets. The output of the model is a valuable tool for assessing connectivity of the Hanford Site with surrounding habitats; however, a finer scale model using Hanford Site-specific data layers could provide more meaningful data on a site-wide scale.

1.3 Objectives

The goal of this study is to develop a habitat suitability model for the Townsend's ground squirrel on the Hanford Site that can be used by managers and planners to make informed decisions regarding the strategies and management actions such as mitigation, restoration, and habitat improvements necessary to sustain Hanford's biological resources. The identification of key Townsend's ground squirrel habitat also provides information necessary to address several of the DOE resource management objectives for Hanford:

- Protect species and habitats of state and federal concern
- Maintain and preserve native biological diversity
- Where and when feasible, improve degraded habitats in a strategic manner to increase landscape connectivity and native diversity
- Reduce and minimize fragmentation of habitats
- Maintain landscapes that provide regional connectivity to habitats surrounding Hanford.

Additionally, habitat suitability models can delineate important habitats on the Hanford Site to assess the impacts of proposed Hanford Site activities during ecological compliance reviews as well as provide focus areas for more efficient biological resource monitoring in the future.

2.0 Methods

The Townsend's ground squirrel habitat suitability model was developed in three phases. During the initial phase, active ground squirrel colonies were surveyed in 2013 to document occupancy, and the extent of all currently active colonies were mapped. In the second phase, vegetation and soil were characterized at the sites that were determined to be occupied. The final phase involved developing the

GIS raster data layers and using the information collected at the current sites along with literature review to construct a habitat suitability map of the Hanford Site.

2.1 Documenting the Status of the Townsend's Ground Squirrel Colonies on Hanford

Surveyors used a Global Positioning System (GPS) capable of sub-meter accuracy to navigate to the previously identified Townsend's ground squirrel colony locations. Active ground squirrel burrows were identified as holes ~7 cm (2.8 in) in diameter absent of vegetation covering the entrances, lacking spider webs at the opening, and with tracks and/or signs of herbivory near the opening (Figure 4). Surveyors also documented visible individuals and audible alarm calls. Each colony was determined to be inactive or active based on these criteria. Any burrows identified outside of the previously defined polygons that were generated by connecting the coordinates of the outermost burrows in the colony were flagged, and the polygons were extended to include those new burrows.

Figure 4. Example of Active Townsend's Ground Squirrel Burrow with Signs of Herbivory

2.2 Vegetation Characterization at Active Sites

Vegetation at all occupied ground squirrel colonies was surveyed using a non-permanent variation of the Daubenmire method (Daubenmire 1959; Figure 5). Surveyors navigated to the centroid of each occupied ground squirrel colony polygon and stretched out a 100 m tape, placing the 50 m mark at the centroid. The orientation of each transect was determined randomly. Surveyors then systematically placed a rectangular 20 × 50 cm Daubenmire frame (Daubenmire 1959) perpendicular to the tape every 5 m along

the transect for a total of 20 quadrats per transect. Percent cover was estimated for each species of plant that fell within each of the quadrats. Percent cover was then summarized for each species encountered at each transect.

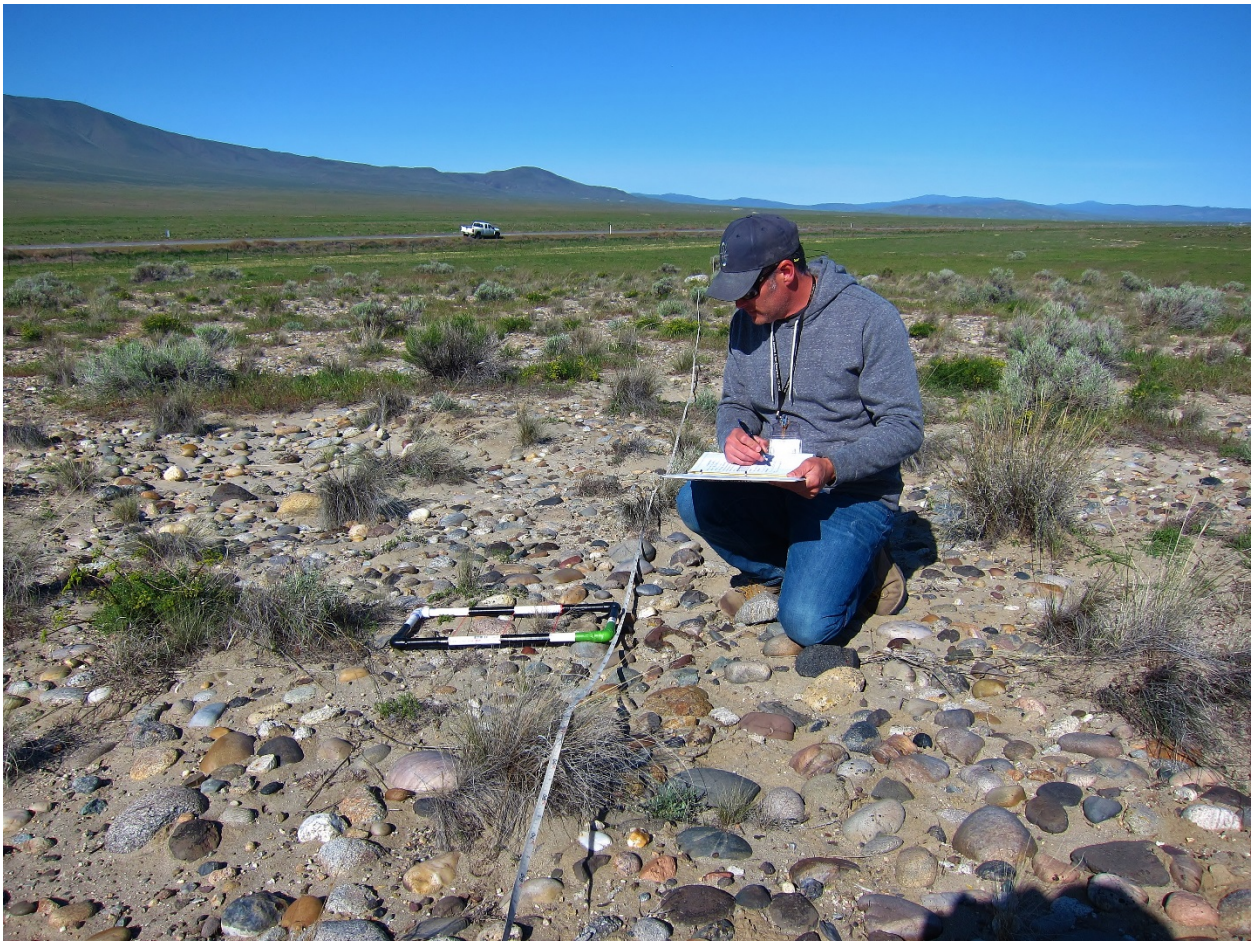

Figure 5. Estimation of Vegetation Canopy Cover Using the Daubenmire Method

2.3 Soil Characterization at Occupied Sites

Surveyors performed the "feel method" technique of determining soil texture at each occupied colony (Thien 1979). Surveyors also performed push-rod tests to determine relative soil depth. A 1.0-m metal rod was pushed as far as possible into the ground at three random locations near the centroid of the occupied colony.

2.4 Habitat Suitability Analysis

Habitat suitability models assess the quality of habitat for a species within a study area based on known and assumed habitat associations for several different factors which, specific to this model, were soil, land cover, slope, and distance to roads, railroads, and power transmission lines. Classifications of each factor were ranked and assigned a suitability value from 0.00 (unsuitable habitat) to 1.00 (optimal habitat). The

rankings were based primarily on the model developed for the Washington Connected Landscapes Project's analysis specific to the Columbia Plateau Ecoregion (Washington WHCWG 2012), with the exception of soil and land cover. The Hanford Site data layers for these factors are of a much finer resolution and contain many more classifications; therefore, these factors were ranked using a literature review and the results of the soil and vegetation characterization performed at each of the occupied sites. ArcGIS software was used to combine raster layers for each factor and produce a final suitability map resulting in a suitability score for each pixel. All raster layers used or developed were 5 m resolution. The extent of the model encompasses central Hanford and the Arid Lands Ecology (ALE) Reserve to assess connectivity with the surrounding areas. Rankings for each factor are described below.

2.4.1 Soil Type

Ground squirrels require soils that are easily excavated yet provide stability for their burrow networks. Soil texture strongly influences the ability of a burrow to remain stable, the nutrient-holding ability of a soil, the amount of water the soil can store, the amount of this water that is available to plants, how fast water moves through the soil, and many other properties. Soil depth is also important for ground squirrels as deeper burrow networks can provide insulation from extreme temperatures. Regional studies have shown that ground squirrels may select sites based on soil characteristics more than other variables and have a preference for deep silt loam soils (Greene 1999). The soil types found on Hanford were ranked for both texture and depth class and assigned a habitat value rating as shown in Table 1.

Table 1. Soil Type Ranking

Soil Name	Habitat Value
Riverwash	0.00
Burbank loamy sand	0.60
Quincy sand	0.60
Ephrata sandy loam	0.80
Ephrata stoney loam	0.80
Pasco silt loam	1.00
Kiona silt loam	0.70
Warden silt loam	1.00
Ritzville silt loam	1.00
Esquatzel silt loam	1.00
Hezel sand	0.60
Dunesand	0.00
Koehler sand	0.30
Scooteney stoney silt loam	0.60
Lickskillet silt loam	0.30

2.4.2 Land Cover/Vegetation

Townsend's ground squirrels consume green vegetation during their active period from early winter into late spring, then shift their focus to the seeds of grasses and forbs to prepare for estivation (Yensen et al. 1992). A study on the diets of Townsend's ground squirrels on the ALE Reserve showed that their intake

was primarily Sandberg's bluegrass followed by a variety of forbs, including western tansymustard, lupine, and long-leaf phlox (Rogers and Gano 1980). In areas where fire destroyed the native shrub and bunchgrasses, cheatgrass (*Bromus tectorum*) can be an important food source; however, wild fluctuations in productivity due to year-to-year changes in precipitation can cause populations in these areas to be much less stable (Yensen et al. 1992). While shrubs could potentially offer cover and some level of burrow stability, ground squirrels can detect predators at a greater distance in areas with little-to-no shrub canopy, and it is believed that line-of-sight availability prevails in site selection (Sharpe and Van Horne 1998). The rankings of habitat value for the vegetation classifications on Hanford are listed in Table 2.

Table 2. Land Cover/Vegetation Type Ranking

Vegetation Class	Habitat Value
Native bunchgrasses	1.00
Native bunchgrasses/Cheatgrass	1.00
Sparse and/or Half- shrub/Native bunchgrasses	0.70
Sparse and/or Half- Shrub/Native bunchgrasses/Cheatgrass	0.70
Dense shrub/Native Bunchgrasses	0.50
Dense shrub/Native bunchgrasses/Cheatgrass	0.50
Non-vegetated sand - bluffs - talus	0.00
Gravel/Industrial/Non-vegetated/Agricultural/Exotic weed	0.00

2.4.3 Slope

The rankings for slope were based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012) and are listed in Table 3.

Table 3. Slope Ranking

Slope (degrees)	Habitat Value
0 to 20	1.00
20 to 40	0.70
Greater than 40	0.00

2.4.4 Roads and Traffic

The ranking of the roads was based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012; Table 4). All known ground squirrel colonies on the Hanford Site are found adjacent to main roads (Figure 3). While it is obvious that detection of colonies near main roads is much more likely, it is also believed that the proximity to human activity provides some level of protection for the squirrel from predators such as badgers and raptors.

Table 4. Road Ranking

Roads	Buffer Distance (m)	Habitat Value
Highway centerline	0–5	0.00
Highway inner	5–500	1.00
Highway outer	> 500	1.00

Local roads centerline	0–5	0.00
Local roads inner	5–500	1.00
Local roads outer	> 500	1.00

2.4.5 Railroads

The ranking of the railroads layer was based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012; Table 5). All railroads on Hanford are now inactive, and ground squirrels could potentially use these rights-of-way as corridors for movement.

Table 5. Railroad Ranking

Railroads (inactive)	Buffer Distance (m)	Habitat Value
Railroad centerline	0–5	0.00
Railroad inner	5–500	1.00
Railroad outer	> 500	1.00

2.4.6 Transmission Lines

The ranking of the transmission lines layer was based on the Washington Connected Landscapes Project Townsend's ground squirrel-focused appendix in the Columbia Plateau Ecoregion (Sato 2012; Table 6); however, it is assumed that the availability for raptors to perch and nest on the towers has a stronger negative influence on ground squirrels than suggested. Therefore, rankings were downgraded for the regions closer to the transmission lines for the Hanford Site model.

Table 6. Transmission Line Ranking

Voltage	Transmission Lines	Buffer Distance (m)	Habitat Value
< 230 KV	One line inner	0–200	0.30
	One line middle	200–500	0.60
	One line outer	> 500	1.00
	Two or more lines inner	0–200	0.30
	Two or more lines middle	200–500	0.60
	Two or more lines outer	> 500	1.00
≥ 230KV	One line inner	0–200	0.30
	One line middle	200–500	0.60
	One line outer	> 500	1.00
	Two or more lines inner	0–200	0.30
	Two or more lines middle	200–500	0.60
	Two or more lines outer	> 500	1.00

2.4.7 Factor Weights

Each of the six factors was assigned a weight that reflects the assumed relative influence each have on the distribution of Townsend's ground squirrels in this region (Table 7). Weights were chosen using literature review and expert opinion.

Table 7. Factor Weights

Factor	Weight (%)
Soil type	30
Land cover/Vegetation type	20
Slope	20
Transmission lines	15
Roads and traffic	7.5
Railroads	7.5

Thus, the habitat suitability score for each pixel in the model was based on the following equation:

Habitat Suitability Score = 0.30 x Soil Type Value + 0.20 x Land Cover/Vegetation Type Value + 0.20 x Slope Value + 0.15 x Transmission Line Value + 0.075 * Roads Value + 0.075 x Railroads Value

Suitable habitat areas for the Townsend's ground squirrel were modeled using habitat values of ≥ 0.85, ≥ 0.90, and ≥ 0.95.

3.0 Results

3.1 Status of Ground Squirrel Colonies

Surveys at historic colonies were performed at all locations documented as occupied during 2013, with the results shown in Table 8. All occupied Townsend's ground squirrel colonies documented during 2015 are shown in Figure 6.

Table 8. Monitoring Results at Historic Townsend's Ground Squirrel Colonies

Location	Occupied 2015	Comments
Vineyard	Yes	Several individuals observed. Distress calls prevalent throughout survey.
Army Loop 2	No	Three burrows observed in area with vegetation and/or cobwebs in entrances. Location appears to be inactive.
Clay Cliff	Yes	Several individuals observed and heard.
Goose Egg	Yes	Several individuals observed and heard. Colony has extended east.
Gator	Yes	Several active burrows, and individuals observed and heard.
Scurf Pea	No	No burrows or individuals observed or heard.
Wye	No	A few inactive burrows observed with vegetation and/or cobwebs covering entrances.
300 Area	Yes	Two larger areas appear to be very active; other areas not. No animals observed; however, several burrows showed signs of herbivory.

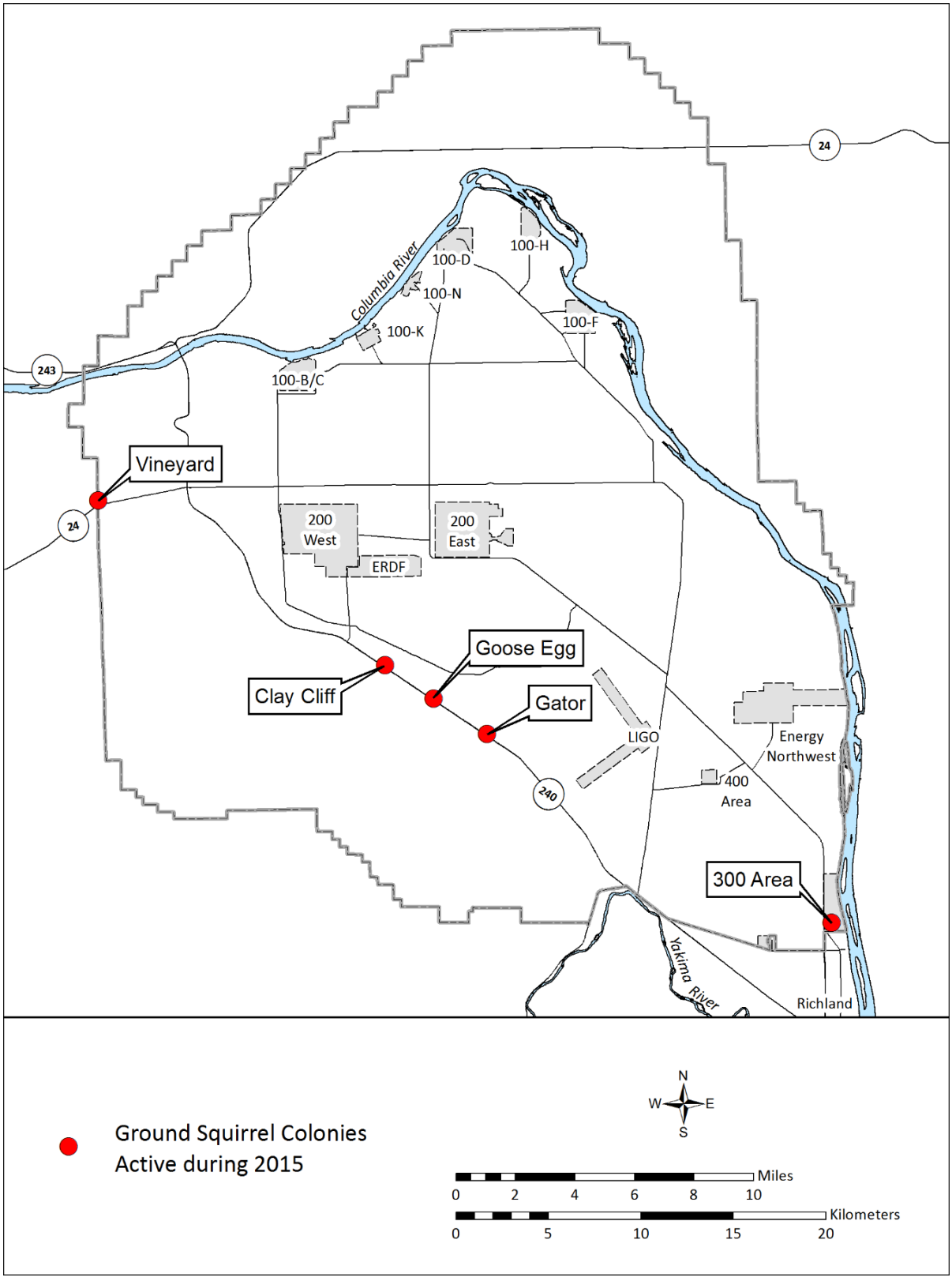

Figure 6. Active Townsend's Ground Squirrel Colonies on the DOE Managed Portion of Hanford Site in 2015

3.2 Vegetation Characterization

The greatest amount of vegetative cover was at the 300 Area (89.15%), followed by Goose Egg (61.51%), Gator (59.78%), Clay Cliff (50.39%), and Vineyard (42.52%; Table 9). Cheatgrass was the dominant species at all five locations. The 300 Area location is a highly disturbed area bounded by parking lots and buildings, with nearly all of the vegetative cover being cheatgrass (96.61%). The Goose Egg site is adjacent to Highway 240 and is located within a large flat expanse of land. The vegetative cover at Goose Egg is 94.71% cheatgrass, with the remainder being mostly introduced species. The Gator colony is adjacent to Highway 240. This location has a flat component of silty soils with small hills surrounding it comprised mostly of lithosols. The flat portion of this area is mostly cheatgrass; however, the site as a whole had one of the lowest percentages of cheatgrass cover at 61.27%. The remainder was mostly a mix of native species (27.17%) and Sandberg's bluegrass (4.40%). The Clay Cliff area resides on the northwest edge of the same flat expanse as Goose Egg. Much like the Goose Egg site, it is mostly cheatgrass (87.57%), with some Russian thistle (8.69%) and other introduced species (3.47%). The Vineyard site is on the western boundary of the Hanford Site north of Highway 240 adjacent to a dry creek bed and very rocky. This site had the lowest percentage cover of cheatgrass (61.74%) and the highest percentage of Sandberg's bluegrass (14.70%).

Table 9. Type and Percentage of Vegetation Cover at Each Colony Site

Type	300 Area	Gator	Goose Egg	Clay Cliff	Vineyard
Big sagebrush	0.00	0.00	0.00	0.00	0.38
Rabbitbrush	0.88	0.75	0.00	0.00	0.00
Needle-and-thread grass	0.00	1.00	0.00	0.00	0.00
Sandberg's bluegrass	0.13	2.63	0.00	0.00	6.25
Cheatgrass	86.13	36.63	58.25	44.13	26.25
Tumblemustard	1.75	0.13	0.75	0.00	1.50
Russian thistle	0.00	0.50	1.88	4.38	1.63
Other introduced	0.13	2.00	0.63	1.75	5.51
Other native	0.13	16.14	0.00	0.13	1.00
Total cover	**89.15**	**59.78**	**61.51**	**50.39**	**42.52**

3.3 Soil Classification

Soil texture was estimated using the "feel method" (Thien 1979) at all occupied colony locations. Surveyors also pushed a 1-m rod into the ground at three random locations near the centroid of each colony and averaged the recorded depths. Results of these field tests are shown in Table 10.

Table 10. Results of Soil Texture and Depth Tests Completed at All Occupied Colony Locations

Colony Name	Soil Texture	Soil Depth (cm)
300 Area	Sandy loam	17
Gator	Silt loam	40
Goose Egg	Sandy loam	54
Clay Cliff	Silt loam	100
Vineyard	Silt loam	15

3.4 Habitat Suitability Model

The model output is illustrated in Figures 7, 8, and 9, with three different qualitative ranges of habitat suitability. The model outputs include the ALE Reserve to illustrate connectivity with the areas surrounding the DOE managed portion of the Hanford Site. The suitability of ≥ 0.85 represents "good" habitat and mimics the output range used in the Washington Connected Landscapes Project's analysis specific to the Columbia Plateau Ecoregion (Washington WHCWG 2012; Figure 7). This output contains 281 polygons fairly evenly dispersed throughout the site and ranges from less than 1 ha to 8583 ha in size. Four of the five currently occupied sites are located within these areas. Mean size was 108 ha and the total area for all 281 polygons within the DOE managed portion of the Hanford Site was 30,451 ha (30% of the total area of Hanford). The second output range was all areas with a habitat suitability score of ≥ 0.90 and represents "better" ground squirrel habitat (Figure 8). The resulting map shows 83 polygons within the DOE managed portion of the Hanford Site, mostly found near Highway 240 adjacent to the ALE Reserve as well as some areas in the northern portion of the site and ranges from less than 1 hectare to 1858 ha. Four out of the five currently occupied sites also fall within these areas. Mean size was 99 ha and the total area for all 83 polygons was 8175 ha (10% of the total area of Hanford). The final output range represents all areas with a habitat suitability score of ≥ 0.95 and is considered "optimum" ground squirrel habitat (Figure 9). This output resulted in nine polygons within the DOE managed portion of the Hanford Site, located almost exclusively in areas adjacent to the ALE Reserve, with the exception of one area near 100-BC. Three of the five currently occupied sites are located within these polygons. One of the two sites not located within the polygons (Gator colony) is ~ 400 m from the nearest polygon. The resulting nine polygons range from 5 ha to 1700 ha, with a mean size of 354 ha and a total area of 3184 ha (4% of the total area of Hanford).

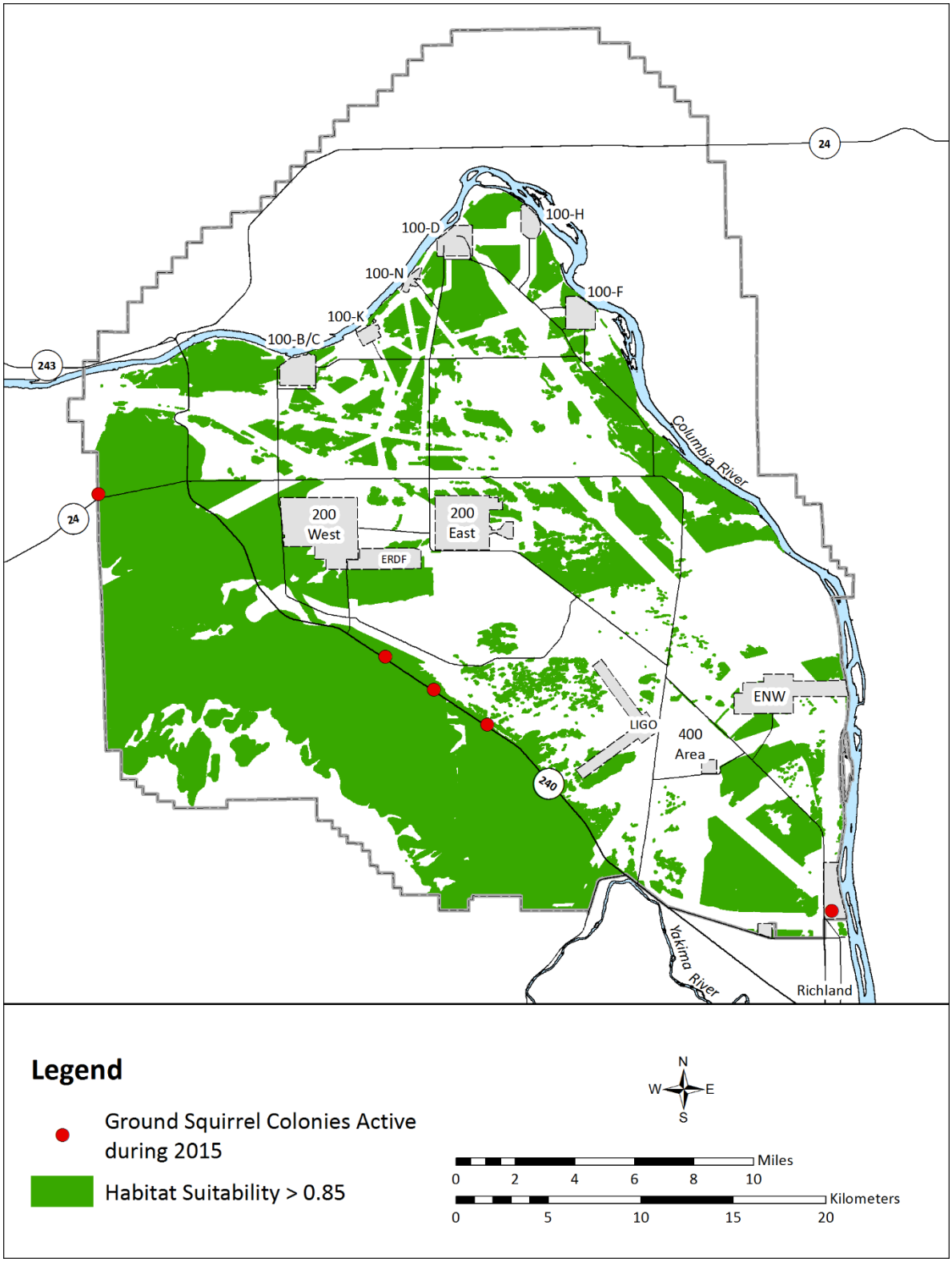

Figure 7. Habitat Suitability Map of the DOE Managed Portion of the Hanford Site and ALE Reserve with a Habitat Suitability Score of 0.85 and Greater

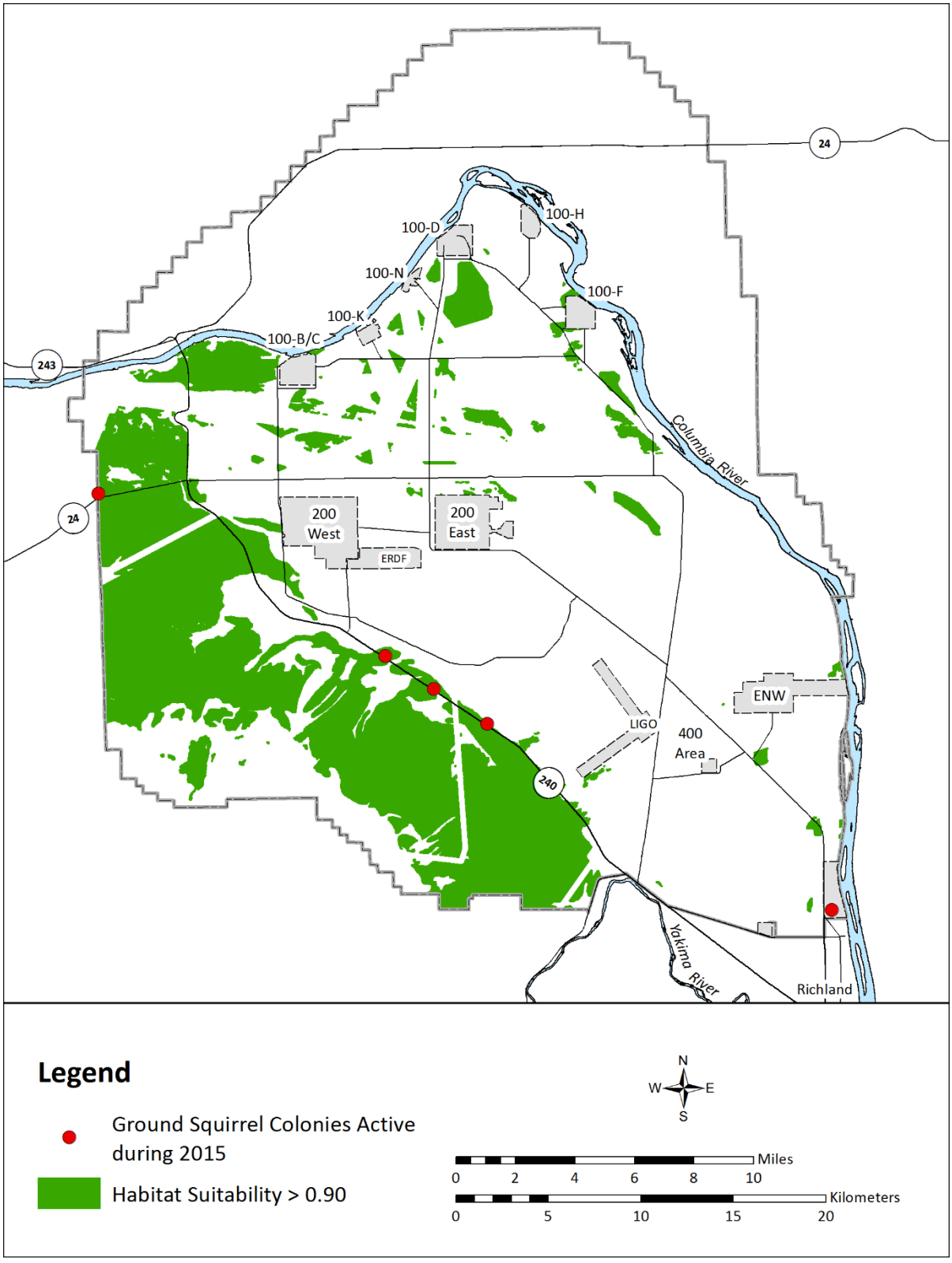

Figure 8. Habitat Suitability Map of the DOE Managed Portion of the Hanford Site and ALE Reserve with a Habitat Suitability Score of 0.90 and Greater

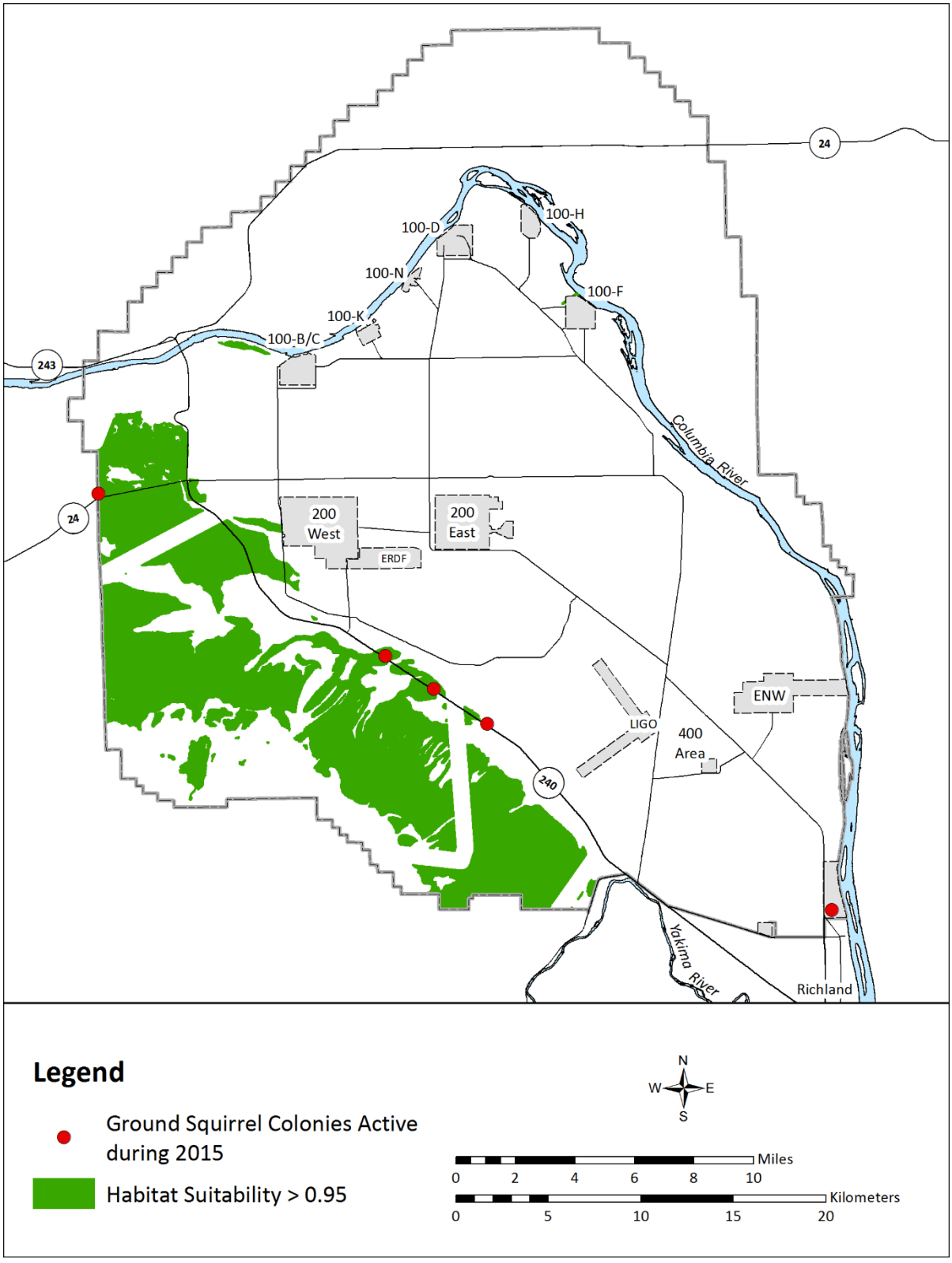

Figure 9. Habitat Suitability Map of the DOE Managed Portion of the Hanford Site and ALE Reserve with a Habitat Suitability Score of 0.95 and Greater

4.0 Discussion

The model presented in this report is based on the habitat associations of the five currently occupied sites for Townsend's ground squirrels on the Hanford Site, a literature review of several regional studies of ground squirrels, and an existing model of the Townsend's ground squirrel for the Columbia Plateau Ecoregion (Washington WHCWG 2012). Habitat suitability models are inherently limited by the quality and type of datasets available for the study area, the over- or under-estimation of the importance of the variables used in the model, and the omission of important habitat associations that are not accounted for. Therefore, this model is a prediction of species-habitat relationships that can be used to identify potential impacts on Townsend's ground squirrel habitat and management actions that may mitigate losses in habitat quality and/or quantity.

Four out of the five active ground squirrel colonies were located within the region designated by a habitat suitability score of ≥ 0.90. The 300 Area contains the only colony that resides in a habitat defined as "unsuitable" by the model. The human activity at this location most likely provides protection by deterring predators such as hawks and badgers that was not accounted for in this model. While modifications to the model could be made to capture this variable, the likelihood of detection – and thus the protection of colonies in habitats in close proximity to human activity on the Hanford Site – is very high. Roads and traffic may have a similar protective factor that is not necessarily accounted for in the model. Not enough data exist to place a higher value to areas near roadways; however, all currently active colonies do occur adjacent to major roads or high traffic areas.

To maintain a consistency with the existing model of the Townsend's ground squirrel for the Columbia Plateau Ecoregion, raptor nests were not included as a factor in this model. The Hanford Site has a dense population of raptors; the populations are bolstered by the prevalence of artificial nesting structures (e.g., transmission towers, planted trees) on which 89 percent of the raptor nests were found in 2014 (Nugent et al. 2015). It has been proposed that the high density of raptors on the Hanford Site may be negatively impacting prey species, including Townsend's ground squirrels (Nugent et al. 2015). In a study of the diet of raptors on the Hanford Site, the *Buteos*, including the ferruginous (*Buteo regalis*), red-tailed (*Buteo jamaicensis*), and Swainson's (*Buteo swainsoni*) hawks, were the primary predators of Townsend's ground squirrels (Fitzner et al. 1981). When the locations of the active ground squirrel colonies were compared to the active *Buteo* nests buffered by their typical relative home range sizes (6.21 km^2 for Swainson's hawks [Fitzner, 1978], 7.48 km^2 for red-tailed hawks [Peery, 2000], and 9.9 km^2 for ferruginous hawks [Peery, 2000]), it appeared that ground squirrel colonies were mostly present outside of these areas (Figure 10). The only exception to this is the 300 Area colony which, as mentioned, is most likely protected against predation by its proximity to human activity. The inclusion of active *Buteo* nests as a variable in the model could improve its functionality as a predictor of where mitigation, restoration, or habitat improvement activities would best suit ground squirrels and where the focus of future searches for new colonies should occur.

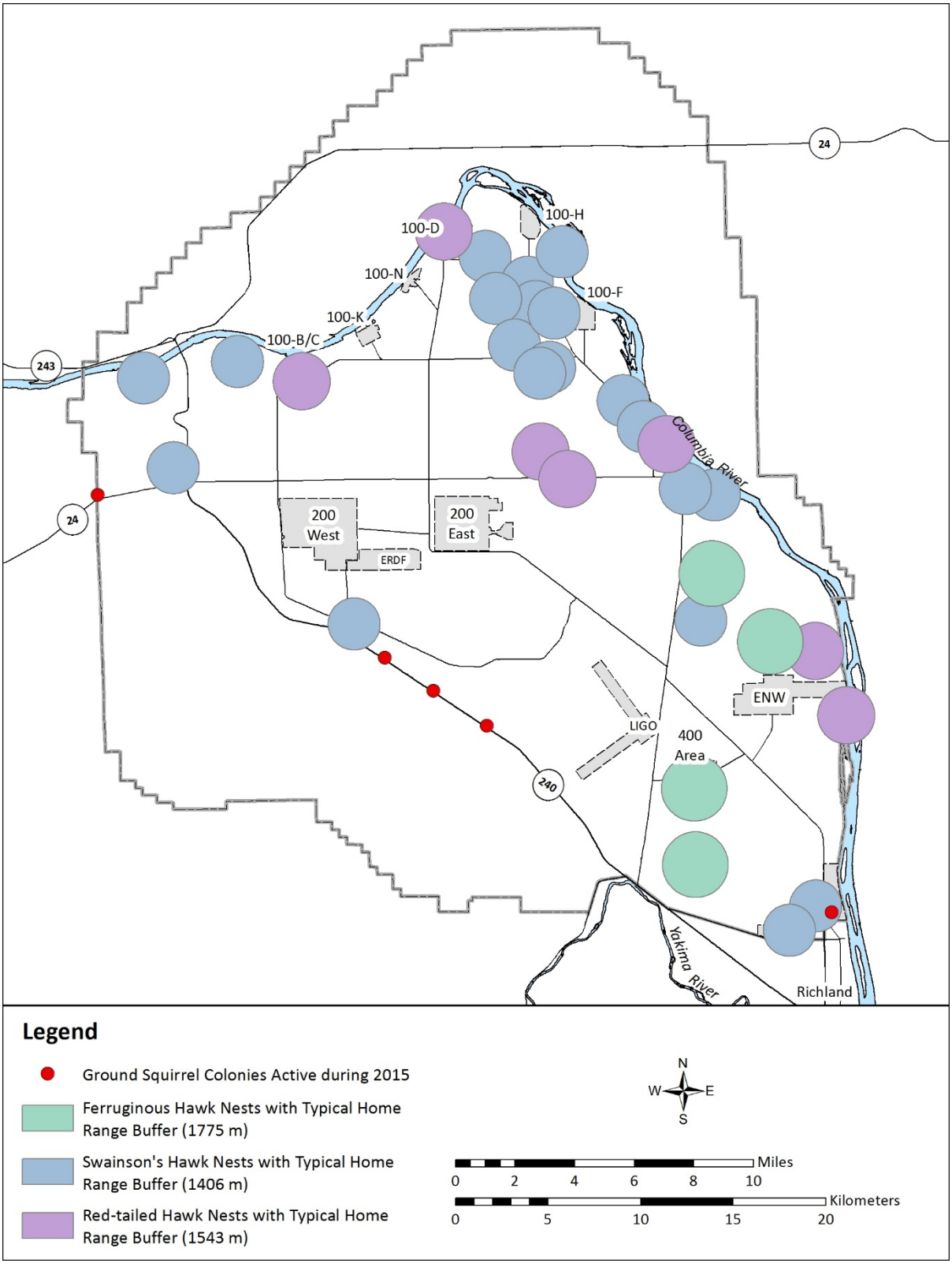

Figure 10. Townsend's Ground Squirrel Colonies in Relation to 2015 *Buteo* Hawk Nest Locations with Relative Typical Home Range Buffers

Validation of the model is planned for future ground squirrel monitoring efforts. Systematic searches for new colonies within the areas of high habitat suitability (≥ 0.90) will be performed, along with the continued monitoring of the status and size of identified ground squirrel colonies to determine trends in the ground squirrel population on the Hanford Site and ensure that ongoing Hanford Site cleanup activities do not impact existing Townsend's ground squirrel colonies.

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