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Hanford Site Raptor Nest Monitoring Report for Calendar Year 2016



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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Mission Support Alliance

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The cover photo is of a Swainson's Hawk, taken by John Nugent.

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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, [USDOE 1999](#)), which is the Environmental Impact Statement that evaluates the potential environmental impacts associated with implementing a comprehensive land-use plan for the Hanford Site for at least the next 50 years, ensures that DOE-RL, its contractors, and other entities conduct activities on the Hanford Site in compliance with NEPA.

The vision for the DOE-RL managed portion of the Hanford Site focuses not only on the clean-up of nuclear facilities and waste sites, but on the protection of groundwater and the Columbia River and the restoration of Hanford lands for access and use. To reach these goals Hanford is working closely with partners, such as the U. S. Fish and Wildlife Service (USFWS) and National Park Service (NPS), to enable use of the Hanford land consistent with the CLUP. As the Hanford Site moves toward accomplishing this vision, understanding of the ecological resources present and whether there is a need for conservation and/or protection of any resources will be critical for making informed decisions for responsible site stewardship.

The *Hanford Site Biological Resources Management Plan* (BRMP, [USDOE 2013a](#)) is identified by the CLUP as the primary implementation document 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 places priority on monitoring those plant and animal species or habitats with specific regulatory protections or requirements; or 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) based on the level of concern for each resource. A Washington State threatened species, the Ferruginous Hawk (*Buteo regalis*) is ranked as a Level 4 resource in the BRMP, along with the Bald Eagle (*Haliaeetus leucocephalus*), a Washington State-listed sensitive species and a federal species of concern. Level 4 resources are considered essential to the biological diversity of the Hanford Site and the Columbia Basin Ecoregion. The management goal of Level 4 resources is preservation, with a high level of status monitoring.

Nesting raptor surveys fulfill the obligations described in the Memorandum of Understanding between DOE and USFWS *Regarding the Implementation of [Executive Order 13186](#), “Responsibilities of Federal Agencies to Protect Migratory Birds”* ([USDOE and USFWS 2013](#)) by conducting research and other activities for the preservation and enhancement of habitat for migratory birds, maintenance of bird populations, and minimization of human impacts on native species.

1.1 Background

Raptors are apex predators that can significantly change the dynamics of an ecosystem by controlling prey species’ populations. As top-level predators, raptors are also much more susceptible to negative environmental stressors such as toxins, habitat loss or degradation, and human disturbance. The number and diversity of nesting raptors in an area can be an indicator of environment health.

The Hanford Site supports a large and diverse community of raptorial birds ([Fitzner et al. 1981](#)), with 26 species of raptors observed on the Hanford Site. Thirteen raptor species have been recorded nesting on the Hanford Site, including eight species of diurnal raptors and five species of owls (Table 1). Several of these species are on state and federal threatened and endangered species lists ([WDFW 2016](#)). The Ferruginous Hawk is a Washington State-listed threatened species, and the Bald Eagle is a Washington State sensitive species and a federal species of concern. The Burrowing Owl (*Athene cunicularia*) is a Washington State candidate species, and the Swainson’s Hawk (*Buteo swainsoni*), Prairie Falcon (*Falco mexicanus*), and Osprey (*Pandion haliaetus*) are Washington State monitored species. Raptor species on the Hanford Site are also afforded protection under the Migratory Bird Treaty Act ([MBTA](#)). Because of the status of these species and their protection under the MBTA, DOE-RL documents and protects nest locations to avoid disturbance during the nesting season and tracks populations over time to determine potential impacts of Hanford operations on these species.

Table 1. Status of Nesting Raptors of the Hanford Site

Species		Species Status*	
Common Name	Scientific Name	Washington State	Federal
Ferruginous Hawk	<i>Buteo regalis</i>	Threatened	None
Swainson’s Hawk	<i>Buteo swainsoni</i>	Monitored	None
Red-tailed Hawk	<i>Buteo jamaicensis</i>	None	None
Prairie Falcon	<i>Falco mexicanus</i>	Monitored	None
American Kestrel	<i>Falco sparverius</i>	None	None
Northern Harrier	<i>Circus cyaneus</i>	None	None
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Sensitive	Species of Concern
Osprey	<i>Pandion haliaetus</i>	Monitored	None
Great Horned Owl	<i>Bubo virginianus</i>	None	None
Long-eared Owl	<i>Asio otus</i>	None	None
Short-eared Owl	<i>Asio flammeus</i>	None	None
Burrowing Owl	<i>Athene cunicularia</i>	Candidate	None
Barn Owl	<i>Tyto alba</i>	None	None

* Species status retrieved from [WDFW 2016](#).

The creation of the Hanford Site has likely benefited many raptor species from restrictions on public access, livestock grazing, and agriculture for the past 73 years. Prior to European settlement, trees occurred only sporadically on the Hanford Site, along riparian zones. Species such as the American Kestrel (*Falco sparverius*), Great Horned Owl (*Bubo virginianus*), Long-eared Owl (*Asio otus*), Red-tailed Hawk (*Buteo jamaicensis*), Swainson's Hawk, Ferruginous Hawk, and Bald Eagle have benefited from the trees that people planted near now-abandoned homesteads, townsites, and previous army encampment sites. Human-made structures on the Hanford Site have also provided nesting habitat for a variety of raptors: Barn Owls (*Tyto alba*) in abandoned structures; Red-tailed Hawks and Great Horned Owls on the outside of decommissioned reactor buildings; and Red-tailed, Swainson's, and Ferruginous Hawks on transmission towers and wooden utility poles. Recent additions to the list of nesting raptors on the Hanford Site (first year 2000), ospreys have benefited from nest platforms built for their use ([Poston et al. 2001](#)).

Some species of raptors nest on the Hanford Site in low numbers due to the natural lack of suitable nesting habitats, food sources, or nesting substrates. For instance, Prairie Falcons nest primarily on cliffs, which on the Hanford Site are limited to Rattlesnake and Gable mountains, Gable Butte, and Yakima and Umtanum ridges. Northern Harriers (*Circus cyaneus*) nest primarily on the ground in wetland areas, which are also limited on the Hanford Site. Ospreys subsist on live fish and consequently are restricted to areas along the Columbia River.

Short-eared Owls (*Asio flammeus*) are common winter visitors to the Hanford Site but rarely nest on site. This species nests on the ground in marshes, grasslands, and tundra areas supporting dense cyclic populations of small mammals ([Wiggins et al. 2006](#)). Short-eared Owls have also been found nesting around Benson Ranch on the Fitzner/Eberhardt Arid Lands Ecology Reserve ([Fitzner et al. 1981](#)) but no other areas on site.

Bald Eagles appear on the Hanford Site primarily during the winter months when they congregate to feed on post-spawned fall Chinook salmon (*Oncorhynchus tshawytscha*) carcasses that wash up along the shores of the Columbia River and waterfowl that winter in the area. Prior to 2013, some pairs of Bald Eagles attempted to nest on the Hanford Site, but most left the area in the spring when their food sources diminished without successfully raising young ([USDOE 2013b](#)). In 2013, the first successful Bald Eagle nest was documented on the Hanford Site; this nest was again successful in 2014 and 2015 ([Cranna et al. 2015a](#); [Cranna et al. 2015b](#)).

Since 1973, nesting raptor surveys have been conducted on the Hanford Site by DOE-RL and the Washington Department of Fish and Wildlife (WDFW; [Olendorff 1973](#); [Fitzner et al. 1977](#); [Fitzner 1978](#), [1980a](#), [1980b](#); [Fitzner et al. 1981](#); [Poole et al. 1988](#); [Fitzner and Newell 1989](#); [Nugent 1995](#); [Leary 1996](#); [Dirkes and Hanf 1998](#); [Leary et al. 1998](#); [Dirkes et al. 1999](#); [Poston et al. 2000](#), [2001](#); [Clayton 2005](#)). However, these surveys were not conducted systematically and were not consistent in the area chosen for monitoring: depending on the year, surveys included either the entire area or a small section (i.e., only the DOE-RL managed portion) of the Hanford Site, or only known nest locations. The previous surveys were not conducted every year, and the species documented during those surveys included different subsets of raptors. A consistent approach for long-term monitoring of nesting raptors was finally initiated

in 2012 for the portions of the Hanford Site managed by DOE-RL and has been reproduced annually since that time ([Nugent et al. 2013](#); [Nugent et al. 2014](#); [Nugent et al. 2015](#); [Nugent et al. 2016](#)).

1.2 Objectives

The focus of this annual report is to document the distribution and abundance of nesting raptors on the DOE-RL managed portions of the Hanford Site. Annual surveys provide land managers with specific locations of nest sites so that the nests can be avoided and disturbances minimized during the nesting season. Long-term trends in nesting raptor populations also allow for the assessment of potential impacts from Hanford Site operations.

1.3 Scope

The scope of this work is to document the distribution and abundance of as many nesting raptors species as possible on the DOE-RL managed portions of the Hanford Site using the survey methods described in Section 2.0. These methods are likely to detect the majority of species of nesting raptors on the Hanford Site but with varying degrees of success (Table 2) and with some highlights summarized below.

Table 2. Nest Site Selection of Raptors on the Hanford Site and Likelihood of Detecting Nests during Annual Surveys

Species	Nest Site Selection	Likely to Detect Nests if Present?	Likely to Detect Most Nests?
Ferruginous Hawk	Trees, Cliffs/Rock Outcrops, Utility Structures	Yes	Yes
Swainson's Hawk	Primarily Trees, but also Utility Structures	Yes	Yes
Red-tailed Hawk	Trees, Cliffs/Rock Outcrops, Utility Structures, Buildings	Yes	Yes
Prairie Falcon	Primarily Cliffs	Yes	Yes
American Kestrel	Primarily Secondary Cavities in Tree	Yes	No
Northern Harrier	Primarily on Ground in Wetland Vegetation but also Dry Grasslands	No	No
Bald Eagle	Large Trees, Nest Platforms, Cliffs	Yes	Yes
Osprey	Large Trees, Nest Platforms, Cliffs	Yes	Yes
Great Horned Owl	Primarily in Trees in Nests Built by Other Species	Yes	Yes
Long-eared Owl	Primarily in Trees in Nests Built by Other Species	Yes	Yes
Short-eared Owl	Primarily on Ground in Dry Sites	No	No
Burrowing Owl	Primarily in Burrows Dug by Other Animals but also Human-made Structures (e.g., Culverts, Artificial Burrows)	Yes	No
Barn Owl	Existing Cavities in Trees, Cliffs/Rock Outcrops, Caves, Buildings	Yes	Yes

The survey methods are likely to detect a majority of individual nest sites for Red-tailed, Swainson's, and Ferruginous Hawks; Prairie Falcons; Bald Eagles; Ospreys; and Great Horned and Long-eared Owls.

- The species noted below nest in less conspicuous areas, and a high proportion of individual nest sites for these species are not likely to be detected using the described methods.

- Burrowing Owls nest in burrows in the ground, and the survey methods described are not optimal for documentation of this species' nest sites.
- Northern Harriers and Short-eared Owls are ground-nesting birds with difficult to detect nests and are thus not likely to be assessed accurately using the defined survey methodology. Short-eared Owls may not nest within the current survey area.
- American Kestrels are secondary cavity nesters and most nest sites are not detected using these survey methods.
- The most conspicuous raptors nesting on the Hanford Site are the three species of *Buteo* Hawks: Red-tailed, Swainson's, and Ferruginous. These species build large stick nests on trees, cliffs, rock outcrops, utility poles and transmission towers and sometimes buildings. The largest number of raptor nest sites detected with these methods belong to *Buteo* Hawks.
- Common Ravens (*Corvus corax*) also build large stick nests that are difficult to distinguish from *Buteo* Hawk nests without the presence of the birds. Although Common Ravens are not considered raptors, they perform a similar ecological role and are protected under the MBTA. The majority of Common Raven nests are detected with the prescribed survey methods and are included in this report.

Raptor nesting season on the Hanford Site extends over 6 months, generally from March through August. Fitzner et al. ([1981](#)) found that Great Horned Owls were the earliest in season nesters on the Hanford Site with an average egg laying date of March 15. In 2015, Great Horned Owls were discovered tending a nest with one egg on the 105KE Reactor on January 14; however, this nest was observed depredated on January 22. Fitzner et al. ([1981](#)) also found that American Kestrels were the latest in season nesters with an average laying date of May 25. First-egg dates for raptor species known to nest on the Hanford Site are provided in Table 3. Although these data are limited and dated, survey timing can be inferred. To detect the greatest number of raptor nests, surveys were conducted in late May and early June, during which time all species occupy their respective nesting territories.

Table 3. First-egg Dates for Raptor Species Known to Nest on the Hanford Site

Species	Hanford Site*			Statewide†		
	Number of Records	Earliest First-egg Date	Latest First-egg Date	Number of Records	Earliest First-egg Date	Latest First-egg Date
Ferruginous Hawk	-	-	-	23	Mar 28	Apr 30
Swainson's Hawk	39	Apr 28	May 20	28	Apr 28	May 31
Red-tailed Hawk	19	Mar 30	Apr 20	46	Feb 23	May 09
Prairie Falcon	3	Apr 15	May 24	126	Mar 09	May 18
American Kestrel	4	May 08	Jun 18	30	Mar 26	Jun 20
Northern Harrier	2	Apr 07	Apr 25	14	Mar 26	May 24
Bald Eagle	-	-	-	26	Mar 01	May 10
Osprey	-	-	-	26	Apr 16	Jun 21
Great Horned Owl	5	Mar 05‡	Apr 27	28	Feb 11	Apr 28
Long-eared Owl	7	Mar 20	May 21	41	Mar 06	Jun 03
Short-eared Owl	-	-	-	7	Mar 18	May 30
Burrowing Owl	6	Apr 08	-	12	Mar 23	Jun 08
Barn Owl	-	-	-	6	Mar 04	May 14

* [Fitzner et al. 1981](#)

† [The Burke Museum](#), University of Washington

‡ In 2015, Great Horned Owls were observed tending a nest with one egg on January 14; however, the egg was found depredated on January 22.

2.0 Methods

2.1 Nest Surveys

Nests were located using foot and vehicular surveys. Surveys were conducted on the DOE-RL managed lands of the Hanford Site excluding an area south of 200 East Area (BC Controlled Area and Central Landfill) (Figure 1). DOE-RL managed lands include the central Hanford, McGee Ranch, Riverland, dunes areas, and the southern shoreline of the Columbia River. All elevated substrates in the surveyed areas were searched for nests. Suitable nesting structures included trees, cliffs and rock outcrops, utility poles and transmission towers, abandoned buildings, and nest platforms. The distribution of nesting substrates on DOE-RL managed portions of the Hanford Site is provided in Figure 2. Surveys completed in 2012 to 2015 did not include a portion of the Central Plateau (containing the 200 Areas) due to the high number of elevated structures and restricted areas (Figure 1). A concerted effort was made to survey this area in 2016.

Nest searches occurred in late May and early June, during which time all species occupy their respective nesting territories. Some nest sites were also recorded during other unrelated ecological surveys. A nest was considered occupied if adult birds were tending a recently built nest or eggs, or young were present. A Trimble Global Positioning System (GPS) with sub-meter accuracy was used to record nest site coordinates. Areas in which nest sites were not easily accessible in the field such as high cliffs were later adjusted on maps in a Geographic Information System (GIS). Field personnel spent as little time as possible at each nest site to avoid disturbing the birds. Nest searches were not conducted during inclement weather. During cold or wet weather, field personnel avoided flushing incubating adult birds. Flushing adult birds at these times may cause nest failures.

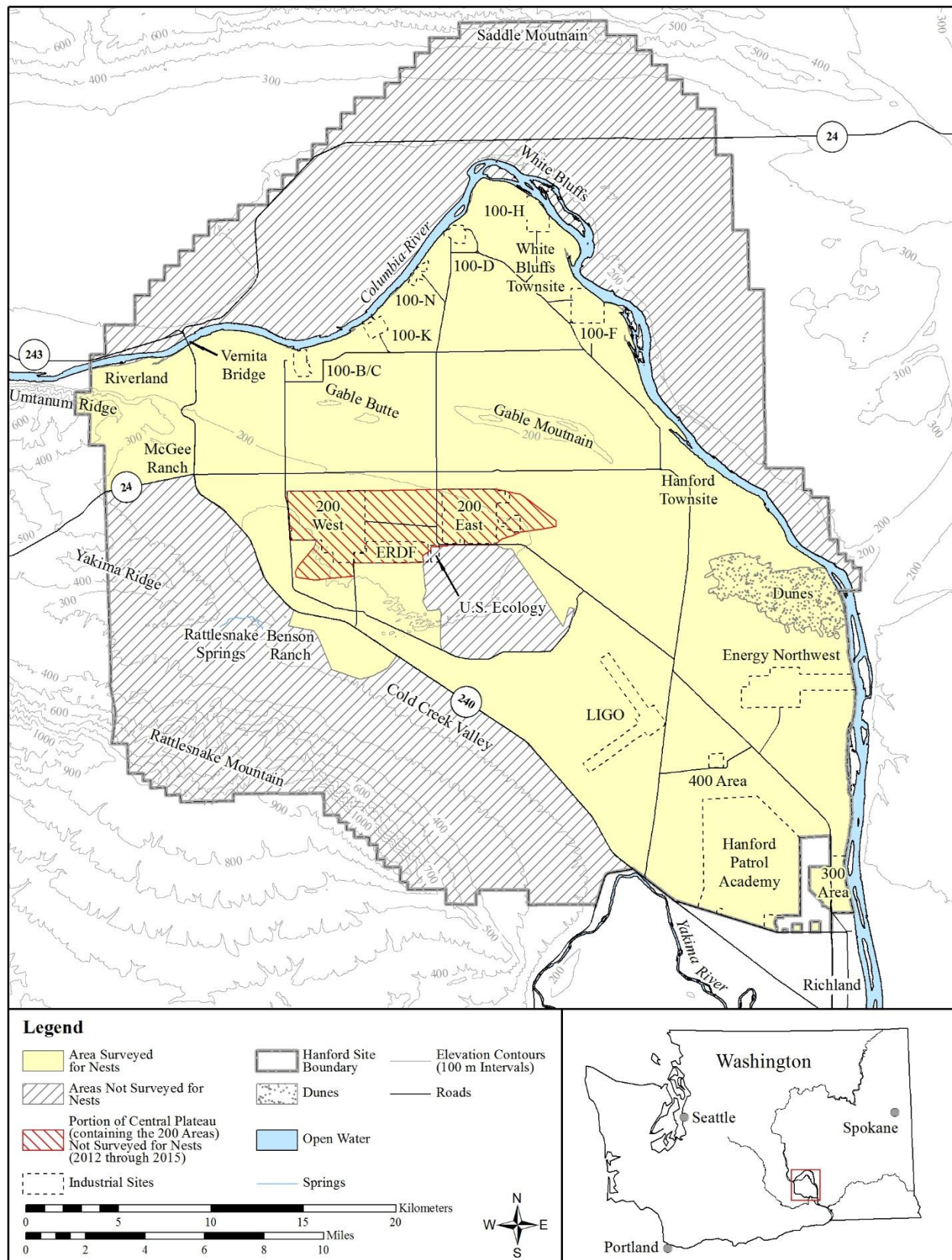


Figure 1. Area Surveyed for Raptor and Raven Nests on DOE-RL Managed Lands of the Hanford Site in 2016

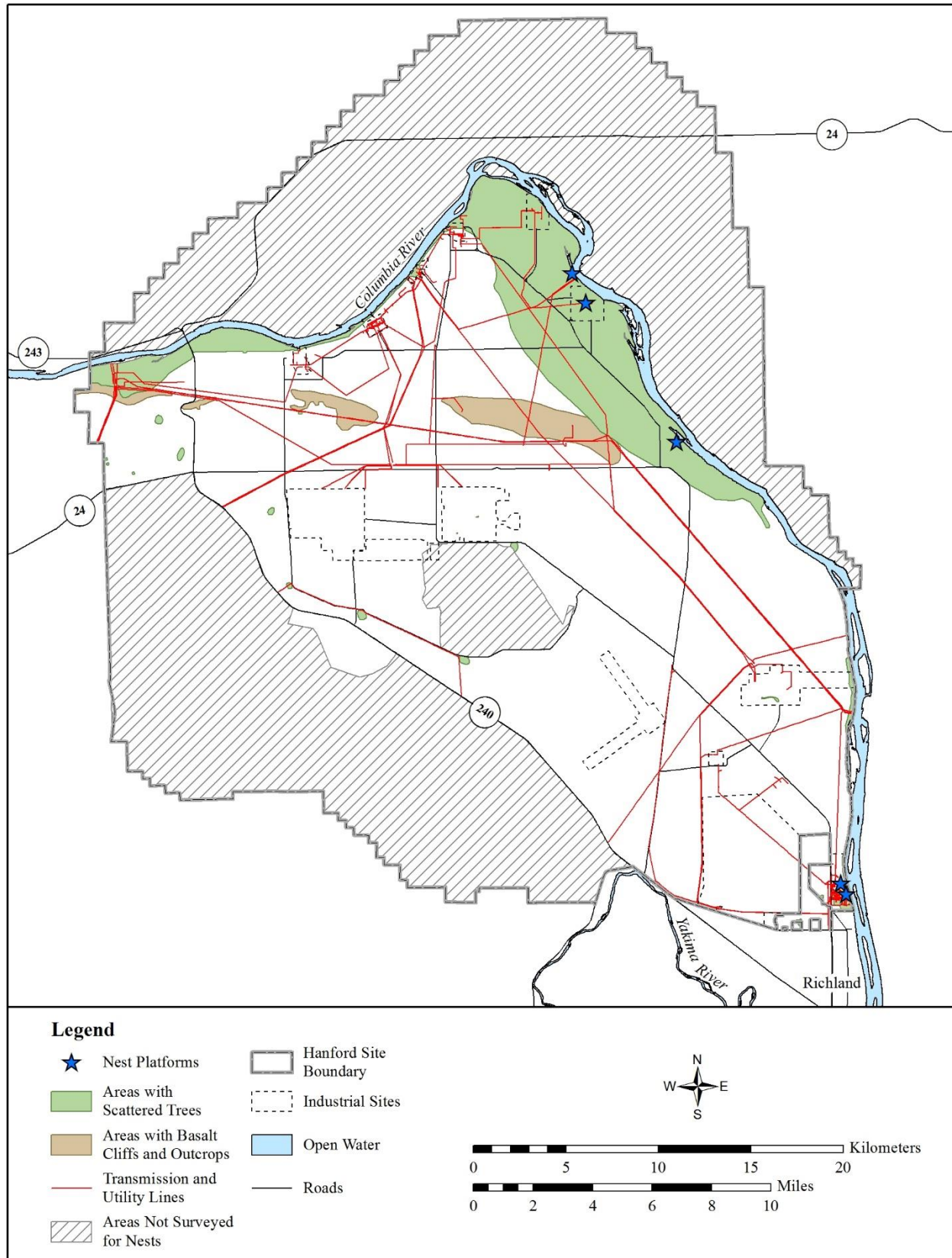


Figure 2. Distribution of Nesting Substrates on DOE-RL Managed Lands of the Hanford Site

2.2 Ferruginous Hawk Nesting Territory Occupancy and Productivity Surveys

In addition to the annual survey of nesting raptors on the Hanford Site, DOE-RL coordinated with WDFW to determine occupancy and productivity of all traditional Ferruginous Hawk nesting territories on the DOE-RL managed lands of the Hanford Site. WDFW is required to report on the status of Ferruginous Hawks every five years to verify whether the species' current listing of threatened is justified or whether a reclassification is needed ([WAC 232-12-297](#)).

WDFW nest survey protocol for the Ferruginous Hawk was used in the surveys (Hayes and Watson 2015). The definition of a nesting territory used in the protocol "is an area that contains, or historically contained, one or more nests of a mated raptor pair and where no more than one pair is known to have bred at one time" ([Steenhof and Newton 2007](#)). Seventeen traditional Ferruginous Hawk nesting territories have been identified on the DOE-RL managed lands of the Hanford Site (Figure 3). Three surveys were conducted in 2016, 2 occupancy surveys and 1 productivity survey. The first occupancy survey took place between March 15 and April 5 when birds reside on territories and many have initiated incubation ([Smith et al. 2010](#)). All 17 traditional Ferruginous Hawk nesting territories were visited and assessed for occupancy. The occupancy surveys included visiting historical nests, scoping all potential nest structures in the vicinity of historical nests, scanning ground and elevated perches for adult birds and hiking through territories to elicit defensive behavior of adults that may otherwise not be detected. The duration of an occupancy survey was 2 hours per territory unless occupancy by Ferruginous Hawks was detected sooner. Occupancy of a territory by species other than Ferruginous Hawks (e.g., Red-tailed Hawks, Prairie Falcons, Common Ravens) was also recorded. An occupancy survey was discontinued early if another species was found occupying a territory. A second occupancy survey was conducted ≥ 2 weeks after the first occupancy survey, and before May 15, the mean hatch date. Only the territories not confirmed to be occupied on the first survey were visited and again assessed for occupancy. A nesting territory was classified as "unoccupied" if no evidence of occupancy was detected after 2 properly timed, 2-hour surveys at least 2 weeks apart. The productivity survey was performed between June 1 and June 15 when most young are 2 to 5 weeks old. Surveyors visited the occupied territories, counted the young at each nest and aged them based on plumage ([Moritsch 1985](#)).

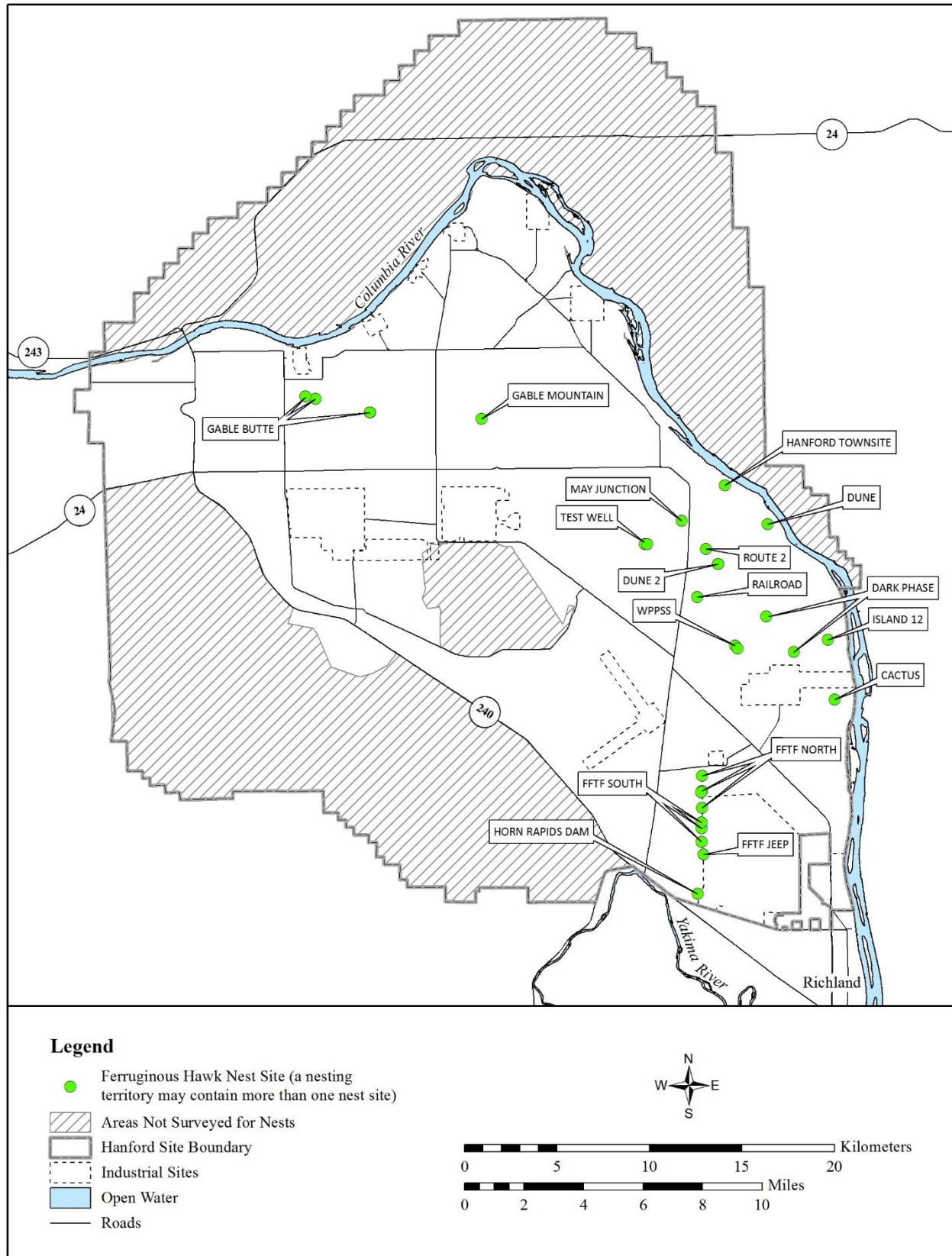


Figure 3. Traditional Ferruginous Hawk Nesting Territories on DOE-RL Managed Lands of the Hanford Site

3.0 Results

3.1 Nest Surveys

Nest surveys were conducted on 10 days from May 16 through June 1, 2016 (specifically, May 16-19, May 23–26, May 31, and June 1). Nests observed during other ecological monitoring efforts are also presented here. A total of 111 nest sites were recorded in 2016. Nest substrates used by raptors and ravens on DOE-RL managed lands in 2016 are shown in Table 4. Approximately 10% of the raptor and raven nests located in 2016 were on naturally occurring substrates such as cliffs and naturally established trees (5 of the 40 nest trees) along the Columbia River. All raptor nest sites located in 2016 are displayed in Figure 4, and Common Raven nest sites found in 2016 are shown in Figure 5.

Table 4. Nest Substrates Used by Raptors and Ravens on DOE-RL Managed Lands of the Hanford Site in 2016

Species	Tree	Cliff	Transmission Tower	Utility Pole	Meteorological Tower	Nest Platform	Traffic Sign	Building (Chimney)	Irrigation Pipe	Total
Ferruginous Hawk			3							3
Swainson's Hawk	18		1	1						20
Red-tailed Hawk	3	2	4							9
Prairie Falcon		2								2
American Kestrel*	2	1						1		4
Bald Eagle	1		1							2
Osprey						5				5
Great Horned Owl	4									4
Long-eared Owl	2									2
Burrowing Owl*									1	1
Common Raven†	4	1	48	4	1		1			59
Total	34	6	57	5	1	5	1	1	1	111

* Nests of American Kestrels and Burrowing Owls are difficult to find; therefore, nest numbers likely represent minimums.

† Common Ravens are technically not raptors but occupy a similar ecological niche and are protected under the MBTA.

3.2 Ferruginous Hawk Nesting Territory Occupancy and Productivity Surveys

Three Ferruginous Hawk nesting territories (Dune 2, Dark Phase, and FFTF Jeep) were occupied on DOE-RL managed lands of the Hanford Site in 2016 and all three territories were successful. Two young were produced at each nest for a total six young.

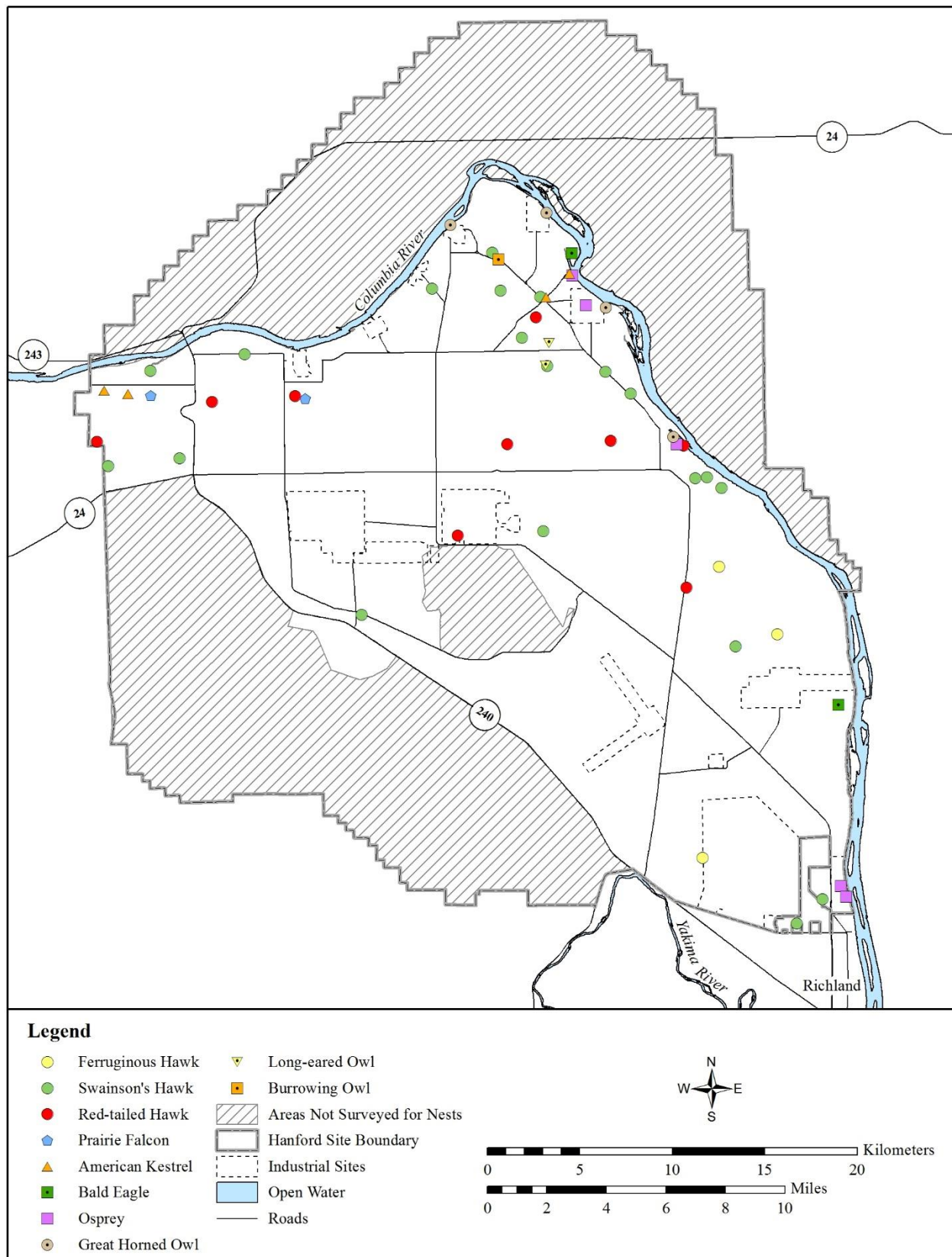


Figure 4. Raptor Nests Located on DOE-RL Managed Lands of the Hanford Site in 2016

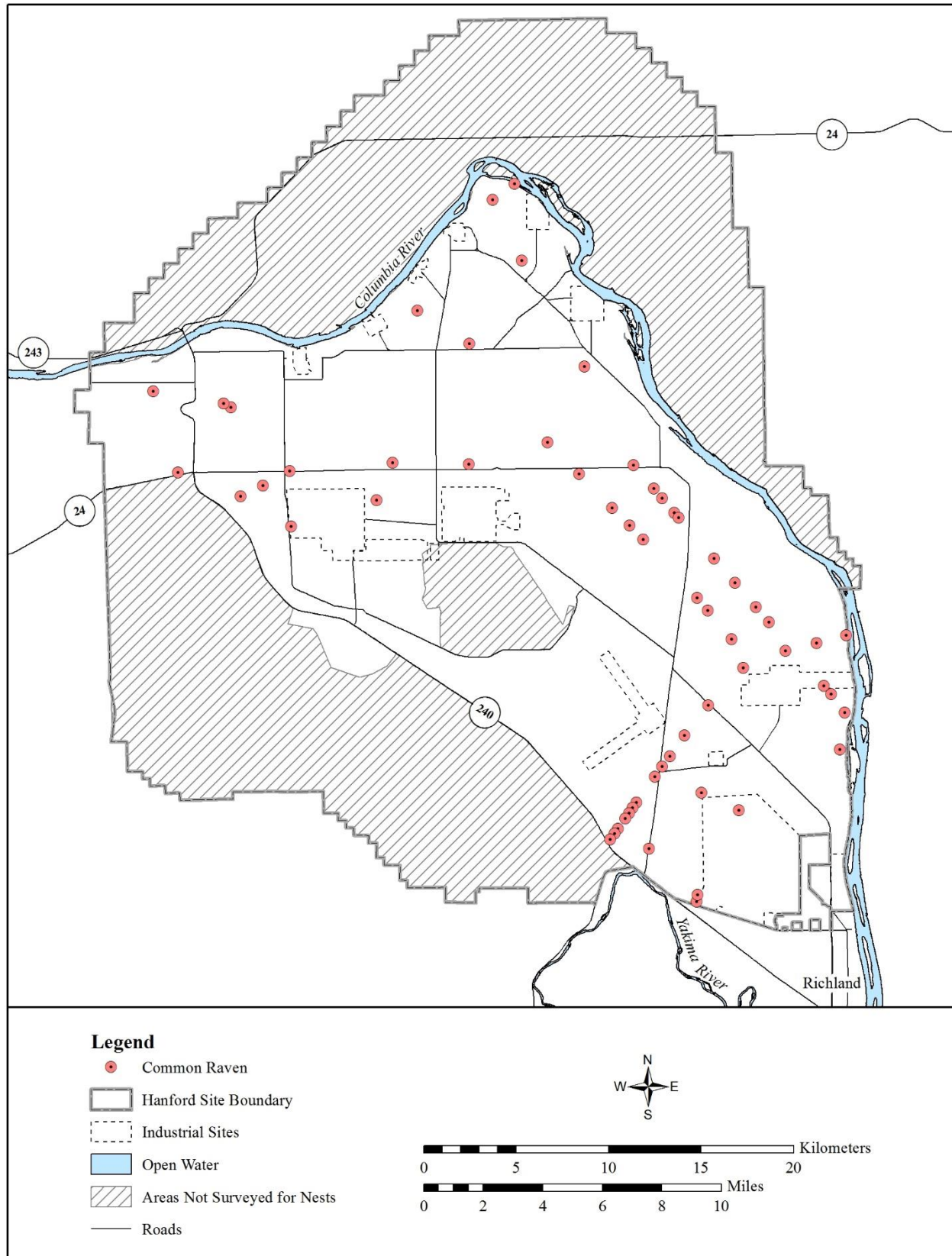


Figure 5. Common Raven Nests Located on DOE-RL Managed Lands of the Hanford Site in 2016

4.0 Discussion

Survey methods used in 2016 were consistent with the methods used in 2012 through 2015 ([Nugent et al. 2013](#); [Nugent et al. 2014](#); [Nugent et al. 2015](#); [Nugent et al. 2016](#)); with the exception of a portion of the Central Plateau (containing the 200 Areas) was surveyed for the first time in 2016. Two Common Raven nests and a Red-tailed Hawk nest were observed in this portion of the Central Plateau. There have been incidental sightings of Common Raven nests in this area from 2012 through 2015 (Figure 6). Thus, systematic survey data from 2016 have provided similar data as incidentally recorded data from previous years.

Nests of 10 raptor species (Ferruginous, Swainson's, and Red-tailed Hawks; Prairie Falcons; American Kestrel; Bald Eagles; Ospreys; and Great Horned, Long-eared, and Burrowing Owls) as well as Common Ravens were located in 2016. With the exception of American Kestrels and Burrowing Owls, it is likely that all or most of the nests on the DOE-RL managed portions of the Hanford Site were detected during the 2016 survey. A comparison of the number of raptor and raven nest sites located in 2012 through 2016 is presented in Figure 7, and a summary of the number of raptor and raven nest sites reported on the Hanford Site from the years 1973 through 2016 is provided in Table 5.

The first known successful Bald Eagle nest was documented on the Hanford Site upstream of Wooded Island in 2013; the nest site was successful again in 2014 and 2015 ([Cranna et al. 2015a](#); [Cranna et al. 2015b](#)). Two Bald Eagle nests were documented in 2016. A pair of Bald Eagles built a nest on a transmission tower near the Bonneville Power Administration's (BPA) Benton substation approximately 1100 meters northwest of the upstream Wooded Island nest site. It appeared that the pair used nesting materials from the upstream Wooded Island nest. This pair successfully fledged 2 young. The second Bald Eagle nest was constructed on the White Bluffs peninsula in the same location as in 2015 ([Cranna et al. 2015b](#)). Like the nest built on the peninsula in 2015, the success of the nest in 2016 could not be determined due to increased foliage on the trees obscured the view of the nest. However, an adult Bald Eagle was observed on the nest on May 12, past the date of the recorded latest first-egg date (May 10) for Washington State, and a pair of adult Bald Eagles were seen at the nest on July 6 by field personnel conducting an electrofishing project in White Bluffs Slough.

Ferruginous Hawks occupied 3 nest sites on the Hanford Site in 2016 which was comparable to the previous 4 years (2 to 4 nests per year). The 3 nest sites were located on 230 kV transmission towers and were all previously known WDFW nesting territories. A total of 6 young were produced on the Hanford Site, 2 at each nest (Figure 8). Preliminary results (final results are expected out in early 2017) from WDFW state-wide Ferruginous Hawk nesting territory surveys indicate that the Hanford Site is an important refuge for the survival of the species in the region. In the past, Ferruginous Hawk nests have been found in 12 eastern Washington counties with the largest concentrations in Benton and Franklin Counties (Richardson 1996). In 2016, WDFW recorded 5 total nests (4 successful including the 3 nests on the Hanford Site and 1 abandoned) in Benton County and 7 total nests (4 successful, 2 failures, and 1 unknown outcome) in Franklin County (Fidorra, pers. comm. 2016).

Nesting Ferruginous Hawks were uncommon on the Hanford Site prior to 1987, with only 1 or 2 pairs nesting each year on basalt outcroppings on the side hills of Rattlesnake Mountain ([Fitzner and Newell 1989](#)). In 1987, 4 pairs of Ferruginous Hawks were observed nesting on the relatively new 230 kV transmission towers associated with the Washington Public Power Supply System reactors (now known as Energy Northwest). Construction of the transmission towers began in 1976, and lines were energized between December 1976 and July 1981. In 1988, 7 Ferruginous Hawk nests were observed on 230 kV transmission towers, and 1 in a tree. In 1991, 1992, and 1993, 11 active Ferruginous Hawk nests were reported each year on the entire Hanford Site (8 to 10 active nests in the survey area) ([Fitzner et al. 1994](#); [Nugent 1995](#)). The majority of these nests were located on the newly built transmission towers. A decrease in the number of nesting Ferruginous Hawks on the Hanford Site has occurred since the 1990s. Clayton ([2005](#)) reported 4 nesting pairs on transmission towers in 2005 and WDFW (Livingston, pers. comm. 2012) documented 2 nesting pairs on transmission towers in 2010.

Ferruginous Hawks are especially sensitive to human disturbance and incursion into their nesting areas. On the Hanford Site, nesting Ferruginous Hawks are protected using WDFW guidelines ([WDFW 2004](#)). Buffer zones of 1000 meters (m) [3281 feet (ft)] are established around active nests. Road closure signs are placed in the roads where they intersect with the 1000 m (3281 ft) buffers. Nest areas are protected from all human disturbance within 250 m (820 ft) between March 1 and May 31, and within 1000 m (3281 ft) for prolonged (>0.5 hour) activities during the entire nesting and fledging season (March 1 to August 15). The identification of active nests sites during this survey allows for the protection of nesting Ferruginous Hawks.

Twenty Swainson's Hawk nests were observed in 2016, which is within the range of nests found in the past 4 years (15 to 20 nests per year), and on the higher end of the range of nests found in the past 43 years (9 to 23 nests per year). Nine Red-tailed Hawk nests were observed in 2016, which is within the range of nests found in the past 4 years (9 to 14 nests per year), and on the lower end of the range of nests found in the past 43 years (7 to 19 nests per year).

Two Prairie Falcon nests were found in 2016, which was similar to the past 4 years (2 to 5 nests per year). Nests were found on the basalt cliffs on Gable Butte and Umtanum Ridge. The number and location of Prairie Falcon nests documented on the Hanford Site has remained relatively constant over the years.

Four American Kestrel nests were located in 2016, and this is likely an underrepresentation of the actual number of nests on the Hanford Site. American Kestrels nest in holes and crevices on trees, cliffs, buildings, and other structures. The Hanford Site provides nesting habitat for the kestrels, but their cavity nests are difficult to detect using the methods of this survey. Similarly, Northern Harriers are ground nesters, and although they likely nest on the Hanford Site their nests are difficult to detect using these methods. No Northern Harrier nests were detected in 2016, however, an adult female harrier was observed showing nest defensive behaviors on May 17 in White Bluffs Slough just south of 100-H Area.

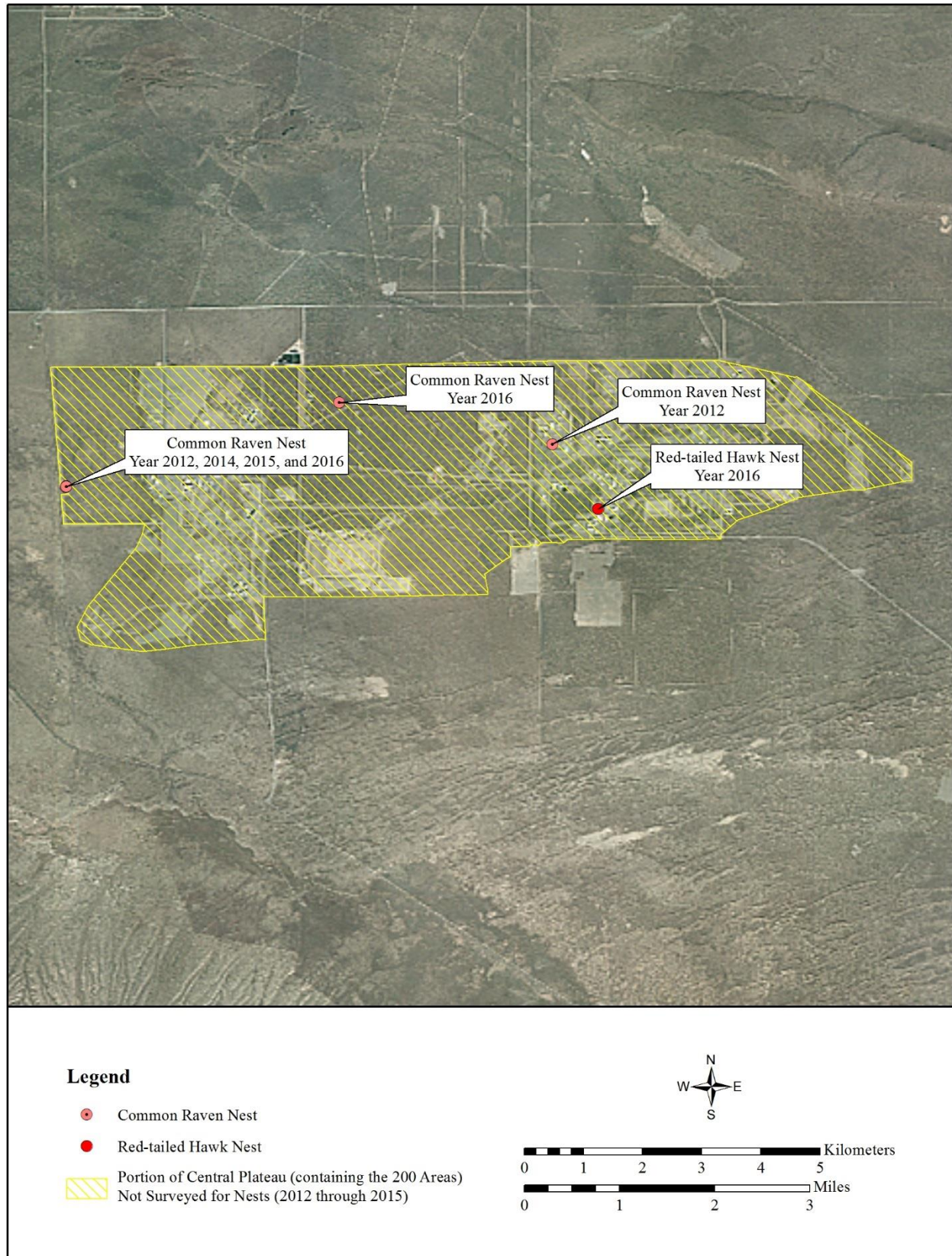


Figure 6. Raptor and Common Raven Nests Recorded in the 200 Area from 2012 through 2016

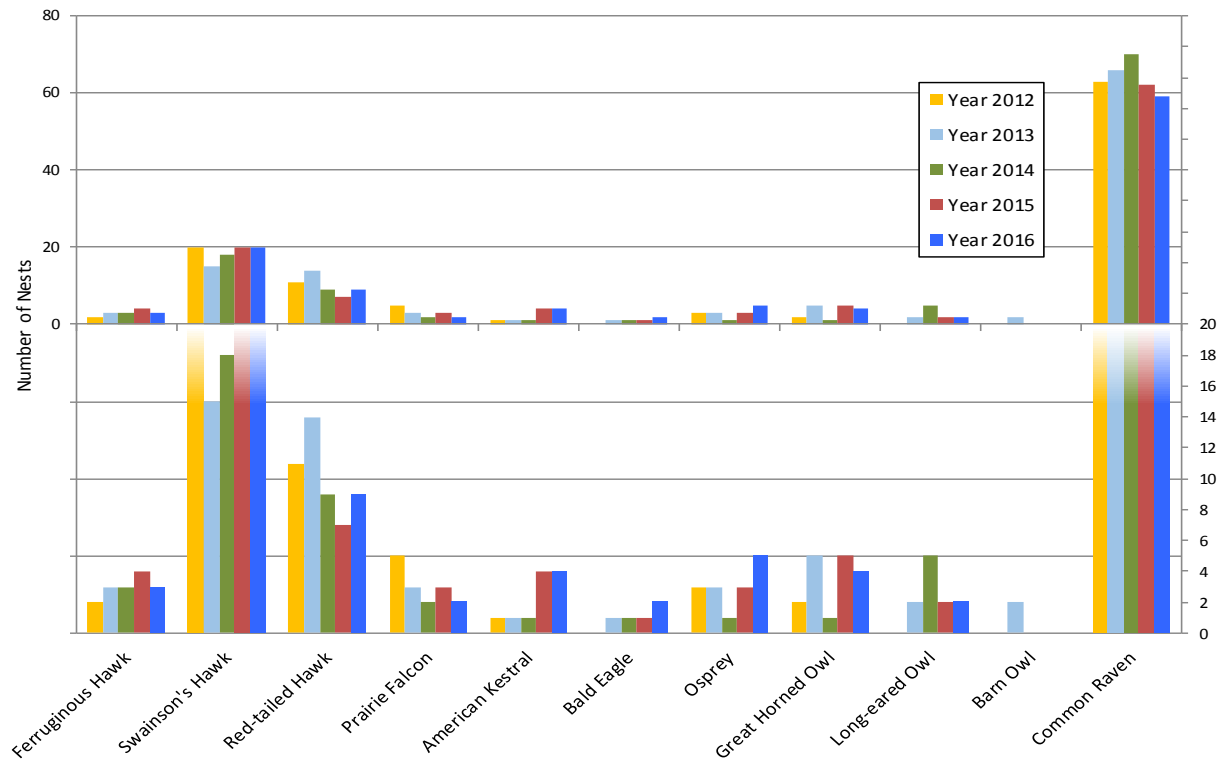


Figure 7. Number of Raptor and Raven Nest Sites Located on DOE-RL Managed Lands of the Hanford Site in 2012 through 2016



Figure 8. Two Ferruginous Hawk Nestling (~32 days old) at Dune 2 Nesting Territory

Table 5. Number of Raptor and Raven Nest Sites reported on the Hanford Site from the Years 1973 through 2016

Survey Years Source		Species													
		Ferruginous Hawk	Swainson's Hawk	Red-tailed Hawk	Prairie Falcon	American Kestrel	Northern Harrier	Bald Eagle	Osprey	Great Horned Owl	Long-eared Owl	Short-eared Owl	Burrowing Owl	Barn Owl	Common Raven
1973	Olendroff (1973)		10 [10]	9 [12]	2 [2]					7 [7]	1 [1]				
1975 to 1978	Fitzner (1980b) and Fitzner et al. (1981)	[1]	14 to 16	7 to 19	[4]	[10]*	[5]*			2 to 4 [3 to 5]	2 to 6 [3 to 8]	[1 to 2]*	13 to 22* [20 to 26]*	1 to 2 [2]	[9 to 11]
1981 and 1982	Thompson-Hanson (1984)						[15]* 4 to 6*								
1987	Poole et al. (1988)		23 [36]												
1987 and 1988	Fitzner and Newell (1989)	4 to 7													
1991 to 1993	Nugent (1995)	8 to 10 [11]	14 [22 to 25]	13 [20 to 25]											
2000	Poston et al. (2001)								1						
2005	Clayton (2005)	4	9	14											45
2007 and 2008	Larson (2009)												[16 to 17]*		
2010	WDFW (2012)	2													
2010	Wilde (2010)												27†		
2012	Nugent et al. (2013)	2	20	11	5	1*			3	2					63
2012	Wilde et al. (2013a)												39†		
2013	Nugent et al. (2014)	3	15	14	3	1*		1	3	5	2			2	66
2013	Wilde et al. (2013b)												50†		
2014	Nugent et al. (2015)	3	18	9	2	1*		1	1	1	5		11*		70
2015	Nugent et al. (2016)	4	20	7	3	4*		1	3	5	2		11*		62
2016	This Report	3	20	9‡	2	4*		2	5	4	2		1*		59‡

Number in brackets is the number of nests found in those years on the entire Hanford Site. Number not in brackets is the number of nests found in those years in the area of our survey which comprises the DOE-RL managed lands of the Hanford Site excluding a portion of the Central Plateau (containing the 200 Areas) (Figure 1).

* Nests of American Kestrels, Northern Harriers, Short-eared Owls, and Burrowing Owls are difficult to find; therefore, nest numbers likely represent minimums.

† Number of active burrows, including nest and satellite burrows.

‡ A portion of the Central Plateau (containing the 200 Areas) excluded in previous years was surveyed in 2016 (Figure 1). One Red-tailed Hawk and two Common Raven nests were recorded.

Osprey nests on the Hanford Site have increased since the building of nest platforms. The highest number of Osprey nests (5) were recorded on the Hanford Site in 2016. This was a marked increase from the 1 to 3 nests observed in the past 4 years.

With the exception of Burrowing Owl nests, owl nest numbers have remained relatively constant in the last 43 years. The number of Great Horned Owl and Long-eared Owl nests were within historical ranges. Four Great Horned Owl nests were found in 2016 which is within the range of 1 to 7 nests per year. Two Long-eared Owl nests were located in 2016 which is within the range of 1 to 6 nests per year. No Barn Owl or Short-eared Owl nests were detected in the survey area in 2016. Barn Owls are not frequently observed nesting on the Hanford Site and Short-eared Owls rarely nest on the Hanford Site. Only one Burrowing Owl nest was incidentally observed in 2016 but it is assumed that more nests exist on the site. The Burrowing Owl is a Washington State candidate species and a more extensive survey of Burrowing Owl nests will be completed in 2017.

Common Raven nest site numbers decreased on the Hanford Site in 2016. The amount of Common Raven nests observed during nest surveys had been increasing since the 1970s, reaching a peak number of 70 nests in 2014. The 2015 and 2016 surveys showed a drop in the number of raven nests with 62 and 59 nests respectively. Ravens often flourish in areas where humans have altered the natural environment. The majority of raven nests found on the Hanford Site are on transmission towers or utility poles. Increased numbers of nesting ravens can have detrimental impacts to sensitive species in the area, in particular, ravens prey on eggs and nestlings of other birds nesting on the Hanford Site. A decrease in Common Raven nests may benefit the health and survival of other birds nesting on the Hanford Site.

5.0 References

- Burke Museum. 2016. *Washington Birds Breeding Phenology Project*. University of Washington. Accessed October 10 at: <http://www.burkemuseum.org/ornithology/phenology>.
- CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act of 1980, [42 U.S.C. 9601-9675](#). (P.L. 96-510).
- Clayton, K. M. 2005. *Breeding Population Status and Nest Site Characterization of Hawks (Buteo spp.) and Common Ravens (Corvus corax) on the Hanford Site, Southcentral Washington*. PNNL-SA-46396. Pacific Northwest National Laboratory, Richland, Washington. Online at: https://claytonkelly.files.wordpress.com/2007/06/hawkreport_clayton.pdf.
- Cranna, K., C. Lindsey, J. Nugent, and J. Wilde. 2015a. *Hanford Site Bald Eagle Monitoring Report for Fiscal Year 2014*. HNF-58547, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: <http://www.hanford.gov/files.cfm/HNF-58547 - Rev 00.pdf>.
- Cranna, K., C. Lindsey, J. Nugent, and J. Wilde. 2015b. *Hanford Site Bald Eagle Monitoring Report for Fiscal Year 2015*. HNF-59488, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: <http://www.hanford.gov/files.cfm/HNF-59488 - Rev 00.pdf>.

- Dirkes R. L. and R. W. Hanf. 1998. *Hanford Site Environmental Report for Calendar Year 1997*. PNNL-11795. Pacific Northwest National Laboratory, Richland, Washington. Online at: http://msa.hanford.gov/files.cfm/PNNL-11795_1997.pdf.
- Dirkes R. L., R. W. Hanf, J. R., and T. M. Poston. 1999. *Hanford Site Environmental Report for Calendar Year 1998*. PNNL-12088. Pacific Northwest National Laboratory, Richland, Washington. Online at: http://msa.hanford.gov/files.cfm/PNNL-12088_1998.pdf.
- Executive Order 13186. *Responsibilities of Federal Agencies to Protect Migratory Birds*. Online at: <http://energy.gov/nepa/downloads/executive-order-13186-responsibilities-federal-agencies-protect-migratory-birds>.
- Fidorra, J. 2016. Personal communication with this WDFW staff member.
- Fitzner, R. E., D. Berry, L. L. Boyd, and C. A. Rieck. 1977. "Nesting of Ferruginous Hawks (*Buteo regalis*) in Washington 1974-75." *The Condor* 79:245-249. Online at: <https://sora.unm.edu/sites/default/files/journals/condor/v079n02/p0245-p0249.pdf>.
- Fitzner, R. E. 1978. *The Ecology and Behavior of Swainson's Hawk in Southcentral Washington*. PhD thesis. Washington State University. Pullman, Washington.
- Fitzner, R. E. 1980a. *Behavioral Ecology of the Swainson's Hawk in Southeastern Washington*. PNL-2754. Pacific Northwest Laboratory, Richland, Washington. Online at: <http://www.osti.gov/scitech/servlets/purl/6600005-A1Pjcp/>.
- Fitzner, R. E. 1980b. Impacts of a Nuclear Energy Facility on Raptorial Birds. In *A Workshop on Raptors and Energy Development*, ed. R. P. Howard and J. F. Gore. Bonneville Power Administration, U. S. Fish and Wildlife Service, Idaho Power Company, and the Idaho Chapter of the Wildlife Society. Boise, Idaho. January 25-26, 1980. Online at: <https://wild.nrel.gov/node/560>.
- Fitzner, R. E., W. H. Rickard, L. L. Cadwell, and L. E. Rogers. 1981. *Raptors of the Hanford Site and Nearby Areas of Southcentral Washington*. PNL-3212. Pacific Northwest National Laboratory, Richland, Washington. Online at: <https://wild.nrel.gov/node/722>.
- Fitzner, R. E., and R. L. Newell. 1989. Ferruginous hawk nesting on the U.S. DOE Hanford Site: case history of a recent invasion caused by transmission lines. In *Proceedings IV: Issues and technology in the management of impacted wildlife*. Pp. 125-132. Thorne Ecological Institute, Boulder, Colorado. Online at: http://www.fs.fed.us/rm/pubs_other/rmrs_1989_davis_p001.pdf.
- Fitzner, R. E., S. G. Weiss, and J. A. Stegen. 1994. *Threatened and Endangered Wildlife Species of the Hanford Site Related to CERCLA Characterization Activities*. WHC-EP-0513. Westinghouse Hanford Company, Richland, Washington. Online at: <http://pdw.hanford.gov/arpir/pdf.cfm?accession=D196075970>.
- Hayes, G. and J. Watson. 2016. *Survey Protocol for Ferruginous Hawk, 2016*. Washington Department of Fish and Wildlife, Olympia, Washington. 6 pp.

- Larson, K. B. 2009. *Nest Habitat Selection of Burrowing Owls in Relation to Soils, Burrow Availability, and Burrow Temperature*. MS Thesis. Washington State University, Pullman, Washington. Online at: http://www.dissertations.wsu.edu/Thesis/Summer2009/K_Larson_072409.pdf.
- Leary, A. W. 1996. *Home Ranges, Core Use Areas, and Dietary Habits of Ferruginous Hawks in Southcentral Washington*. MS Thesis. Boise State University, Boise, Idaho.
- Leary, A. W., R. Mazaika, and M. J. Bechard. 1998. "Factors Affecting the Size of Ferruginous Hawk Home Ranges." *Wilson Bulletin* 110(2):198-205. Online at: <https://sora.unm.edu/sites/default/files/journals/wilson/v110n02/p0198-p0205.pdf>.
- Livingston, M. 2012. Personal communication with this WDFW staff member.
- MBTA – Migratory Bird Treaty Act of 1918, [16 U.S.C. 703, et seq.](#)
- Moritsch, M. Q. 1985. *Photographic Guide for Aging Nestling Ferruginous Hawks*. Published Report. U.S.D.I., Snake River Field Station, Boise, Idaho. Online at: <https://archive.org/details/photographicguid26mori>.
- NEPA – National Environmental Policy Act of 1969, [42 U.S.C. 4321, et seq.](#) (P.L. 91-190).
- Nugent, J. J. 1995. *Nest-Site and Habitat Selection of Buteo Species in Southeastern Washington and the Use of Geographic Information Systems to Model Nest Habitat Quality*. MS Thesis. University of Montana, Missoula, Montana. Online at: <http://scholarworks.umt.edu/cgi/viewcontent.cgi?article=7568&context=etd>.
- Nugent, J., C. Lindsey, and G. Malin. 2013. *Raptor Nest Monitoring Report for Calendar Year 2012*. HNF-53073, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-53073_-_rev_00_No_Coversheets.pdf.
- Nugent, J., C. Lindsey, and J. Wilde. 2014. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2013*. HNF-56769, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-56769_-_Rev_00.pdf.
- Nugent, J., K. Cranna, C. Lindsey, and J. Wilde. 2015. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2014*. HNF-58717, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-58717_-_Rev_00.pdf.
- Nugent, J. J., K. J. Cranna, J. W. Wilde, and J. E. Grzyb. 2016. *Hanford Site Raptor Nest Monitoring Report for Calendar Year 2015*. HNF-59755, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-59755_-_Rev_00.pdf.
- Olendorff, R. R. 1973. *Raptorial Birds of the U.S.A.E.C. Hanford Reservation, South-Central Washington*. BNWL-1790. Battelle Pacific Northwest Laboratories, Richland Washington. Online at: <https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/BNWL1790.xhtml>.
- Poole, L. D., N. V. Marr, and S. M. McCorquodale. 1988. *Productivity, Mortality, and Response to Disturbance of Nesting Swainson's Hawks on the Hanford Site*. PNL-6496. Pacific Northwest National

- Laboratory, Richland, Washington. Online at: <http://www.osti.gov/scitech/servlets/purl/5212015-QfXHA6/>.
- Poston T. M., R. W. Hanf, and R. L. Dirkes. 2000. *Hanford Site Environmental Report for Calendar Year 1999*. PNNL-13230. Pacific Northwest National Laboratory, Richland, Washington. Online at: http://msa.hanford.gov/files.cfm/PNNL-13230_1999.pdf.
- Poston T. M., R. W. Hanf, R. L. Dirkes, and L. F. Morasch. 2001. *Hanford Site Environmental Report for Calendar Year 2000*. PNNL-13487. Pacific Northwest National Laboratory, Richland, Washington. Online at: http://msa.hanford.gov/files.cfm/PNNL-13487_2000.pdf.
- Smith, J. P., S. J. Slater, and M. C. Neal. 2010. *Recommendations for Improved Raptor Nest Monitoring in Association with Oil and Gas Development Activities*. U.S. Department of the Interior, Bureau of Land Management. Online at: <https://www.blm.gov/nstc/library/pdf/TN436.pdf>.
- Steenhof, K., and I. Newton. 2007. *Assessing Nesting Success and Productivity* in D. M. Bird and K. L. Bildstein, Editors. *Raptor Research and Management Techniques*, Hancock House Publishers, Blaine, Washington. Online at: http://www.raptorresearchfoundation.org/files/2015/10/Raptor_Research_all.pdf.
- Thompson-Hanson, P. A. *Nesting Ecology of Northern Harriers on the Hanford Site, South-central Washington*. MS Thesis. Washington State University, Pullman, Washington.
- USDOE – U. S. Department of Energy. 1999. *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. DOE/EIS-0222-F. U.S. Department of Energy, Washington, D.C. Online at: <http://energy.gov/nepa/downloads/eis-0222-final-environmental-impact-statement-0>.
- USDOE – U. S. Department of Energy. 2013a. *Hanford Site Biological Resources Management Plan*. DOE/RL-96-32, Rev. 1. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: <http://www.hanford.gov/files.cfm/DOE-RL-96-32-01.pdf>.
- USDOE – U. S. Department of Energy. 2013b. *Bald Eagle Management Plan for the Hanford Site, South-Central Washington*. DOE/RL-94-150, Rev. 2. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: <http://www.hanford.gov/files.cfm/Hanford%20Bald%20Eagle%20Management%20Plan%20Rev.%20%20-%20FINAL.PDF>.
- USDOE – U.S. Department of Energy and USFWS – U.S. Fish and Wildlife Service. 2013. *Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service: Regarding Implementation of Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds."* September 12. Online at: <http://energy.gov/sites/prod/files/2013/10/f3/Final%20DOE-FWS%20Migratory%20Bird%20MOU.pdf>.
- WAC 232-12-297. *Endangered Threatened, and Sensitive Wildlife Species Classification*. Washington Administrative Code. Online at: <http://apps.leg.wa.gov/wac/default.aspx?cite=232-12-297>.

- WDFW – Washington Department of Fish and Wildlife. 2004. *Management Recommendations for Washington's Priority Species – Volume IV: Birds*. Washington Department of Fish and Wildlife, Olympia, WA. Online at: <http://wdfw.wa.gov/publications/00026/wdfw00026.pdf>.
- WDFW – Washington Department of Fish and Wildlife. 2016. *Species of Concern in Washington*. Washington Department of Fish and Wildlife. Online at: <http://wdfw.wa.gov/conservation/endangered/>.
- Wiggins, D. A., D. W. Holt and S. M. Leasure. 2006. "Short-eared Owl (*Asio flammeus*).” The Birds of North America Online, Ed. A. Poole. Ithaca: Cornell Lab of Ornithology. Retrieved from the Birds of North America Online at: <http://bna.birds.cornell.edu/bna/species/062/>.
- Wilde, J. 2010. *Active Burrowing Owl Burrows on the Hanford Site in 2010*. Unpublished Raw Data.
- Wilde, J. W., C. T. Lindsey, and J. J. Nugent. 2013a. *Burrowing Owl Monitoring Report for Calendar Year 2012*. HNF-54294, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: <http://www.hanford.gov/files.cfm/HNF-54294 - Rev 00 Cleared Public.pdf>.
- Wilde, J. W., C. T. Lindsey, J. J. Nugent, and M. S. Filan. 2013b. *Hanford Site Burrowing Owl Monitoring Report for Calendar Year 2013*. HNF-56531, Rev. 0. Mission Support Alliance, Richland, Washington. Online at: <http://www.hanford.gov/files.cfm/HNF-56531 - Rev 00.pdf>.