HNF-66047
Revision 0

# Hanford Site Bee Nest Box Monitoring Report for Calendar Year 2020

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
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HANFORD MISSION INTEGRATION SOLUTIONS
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# Hanford Site Bee Nest Box Monitoring Report for Calendar Year 2020

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# 1.0 INTRODUCTION

This report summarizes the results of the second year of monitoring bee nest boxes on the Hanford Site. Twenty bee nest boxes were installed as a component of compensatory mitigation for the installation of the L-894 water line between the 200-East and 200-West Areas of the Hanford Site in July 2019. The goal of this compensatory mitigation is to replace lost nesting habitat for above-ground nesting bees in a mature sagebrush ecosystem. Annual monitoring will track the condition and occupation of the bee nest boxes to determine if the compensatory mitigation was successful and to identify best practices when replacing nesting habitat for native bees.

## 1.1 PURPOSE AND NEED

Pollinators are vital to the health of native environments (Potts et al. 2010). By enabling successful plant reproduction, pollinators support the health of nearly all other organisms in the environment that rely on healthy plant populations. Bees are the most important group of pollinators worldwide (Kearns et al. 1998; Michener 2007) and are the primary pollinating species of the Columbia River Basin (Tepedino and Griswold 1995). Within the last century, rapid declines in both wild and managed bee populations have been recorded throughout the world (Kearns et al. 1998; Goulson et al. 2005; Biesmeijer et al. 2006). Declining bee populations put plant populations at risk of declining, which has the potential to affect the entire food web and disrupt ecosystems.

Habitat loss and fragmentation from human activities is one of the largest risks to pollinator populations. Habitat fragmentation reduces both pollinator abundance and diversity (Rathcke and Jules 1993). At the Hanford Site, human-caused habitat fragmentation most often occurs when vegetation is removed from natural areas to support project activities. This removal of vegetation results in the loss of both food and nesting resources for bees.

Replacing lost nest areas is vital to protect bee populations. Nesting area availability can be the driving factor in solitary bee population sizes (Steffan-Dewenter and Schiele 2008). Nesting resources for bees include hollow twigs, woody shrubs like sagebrush (*Artemisia tridentata*), and bare patches of ground. The removal of vegetative structures and disturbance of bare ground can kill nesting bees and eliminates potential nesting sites. The limited ranges of bees make local changes in habitat structure especially detrimental to population health; as the majority of wild, solitary bees have ranges of a few hundred meters (Gathmann and Tscharntke 2002).

The *Hanford Site Pollinator Study* (HNF-62689) identifies a number of best management practices to help support pollinator populations on the Hanford Site. In areas where vegetation is disturbed to support project activities, the study recommends replacing pollinator habitat by restoring with native flowering plants. This study also recommends additional restoration actions to replace bee nesting habitat.

Bee nest boxes are designed to replace lost nesting resources by providing areas for solitary bees to nest. Various styles of bee nest boxes have been installed throughout the Hanford Site in an effort to increase available nesting habitat in areas where natural habitat has been removed. The purpose of bee nest box monitoring is to collect data on bee usage of the nest boxes. These data will be used to determine if bee nest box installation is an effective way to replace lost bee nesting habitat in disturbed areas. In 2019, two different bee nest box styles were installed and will be monitored annually for 5 years. The data from this monitoring effort will be used to compare bee usage of the different styles of nest boxes and to determine if there is a preferred style. These styles also include different nesting materials; this monitoring effort will be used to determine if there is a preferred nesting material.

In addition to data collection, bee nest box monitoring will include checking the bee nest boxes for structural defects, ensuring the boxes are clean, and recording and developing an action plan for any issues with the boxes. The bee nest boxes will be monitored for 5 years after installation to determine their effectiveness; the boxes will be maintained or replaced, as needed. For additional information about pollinators found on the Hanford Site, see the *Hanford Site Pollinator Study* (HNF-62689).

## 1.2 REGULATORY DRIVERS

### 1.2.1 Federal Laws and Policy

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 DOE-RL compliance with an array of laws and policies. Ecological monitoring data provide baseline information about the plants, animals, and habitats under DOE-RL stewardship required for decision making under the *National Environmental Policy Act* and *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

#### 1.2.1.1 Presidential Guidance and Memoranda.

The 2014 presidential memorandum "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators" (79 FR 35903-35907) calls for immediate action to be taken by land-owning federal departments to prevent further pollinator population decline. This memorandum called for the establishment of a Pollinator Health Task Force that includes representatives from over 15 federal agencies, including the U.S. Department of Energy (DOE). This task force developed the *Pollinator Research Action Plan* (Pollinator Health Task Force 2015a) that outlines key priorities and goals to improve pollinator health. One of the goals of this plan is to restore or enhance 2.8 million ha (7 million ac) of pollinator habitat on federally-owned land (Pollinator Health Task Force 2015b).

Section II of the *Pollinator Research Action Plan* (Pollinator Health Task Force 2015a) is especially relevant to future pollinator habitat improvement work on the Hanford Site, as it addresses the need for increased and improved pollinator habitat. Current understanding of pollinator habitat requirements is limited. A key priority research theme of this section is "identifying viable approaches to restore and create pollinator habitat" (Pollinator Health Task

Force 2015a). Installing bee nest boxes and monitoring their effectiveness works toward the goal of restoring and creating pollinator habitat.

**1.2.1.2 U.S. Department of Energy Orders and Guidance Documents.**
The DOE Pollinator Protection Plan (Pollinator Health Task Force 2015b, Appendix E) directs the adoption of Best Management Practices (BMPs) for pollinator health. DOE is a land-owning agency and will assess each site to determine if implementing the BMPs is appropriate. As per the plan, the commitment to enhance, preserve, and protect pollinator habitat according to BMPs is consistent with Section 3, Subsection (a) of 79 FR 35903-35907, which calls for:

> "the development of a plan to enhance pollinator habitat and the implementation of a plan to manage lands and facilities under the auspices of the Department to enhance pollinator health on those lands."

Installing and monitoring bee nest boxes falls under this plan as it contributes to the creation and enhancement of pollinator habitat.

### 1.2.2 Hanford Site Management Guidance

DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, (BRMP) is identified by the DOE/EIS-0222-SA-01, *Hanford Comprehensive Land-Use Plan*, (CLUP) as the primary implementation control for managing and protecting natural resources on the Hanford Site. According to the CLUP, 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 that are either:

- Rare and/or declining (e.g., federal or state listed endangered, threatened, or sensitive species)
- Of significant interest to federal, state, or Tribal governments or the public.

Pollinators are of significant interest to the federal government, as demonstrated by the formation of the Pollinator Health Task Force. The health of pollinators, especially honeybees, is of public concern and has been the focus of increased media and public attention in the past 10 years.

The BRMP provides guidance regarding compensatory mitigation in scenarios where natural resources cannot be avoided, impacts cannot be minimized, and the resources cannot be rectified in place. Enhancing habitat quality can satisfy compensatory mitigation requirements if the mitigation is successful. The bee nest boxes monitored in 2019 were installed as a component of compensatory mitigation for the installation of a waterline (L-894) between the 200-East and 200-West Areas of the Hanford Site. Monitoring is a critical component in determining the success of compensatory mitigations.

### 1.3 GOALS AND OBJECTIVES

The specific objectives of this monitoring report are to:

- Provide second-year data for bee nest box occupation
- Determine the effectiveness of different bee nest boxes at replacing lost bee nesting habitat
- Recommend actions to increase bee nest box occupation.

This monitoring report is the second report in a multi-year effort to analyze the effectiveness of bee nest boxes replacing bee-nesting habitat. For the first report, see HNF-64747, *Hanford Site Bee Nest Box Monitoring Report for Calendar Year 2019*. The results of this effort will help inform future bee nesting habitat restoration and can be used in larger pollinator habitat restoration projects.

### 1.4 SCOPE OF MONITORING REPORT

The remaining sections of this monitoring report cover the following topics:

- **Section 2** summarizes the nesting biology of native bees in relation to the Hanford Site
- **Section 3** describes the location and installation of the bee nest boxes monitored in 2020
- **Section 4** defines the methods used to monitor bee nest box occupation
- **Section 5** describes the results from second-year bee nest box occupation monitoring
- **Section 6** discusses the results and provides recommendations for future monitoring
- **Section 7** lists the literature cited throughout this report.

## 2.0 NESTING BIOLOGY OF NATIVE BEES

Native bees are the primary insect pollinators of the Columbia River Basin and over 600 species are known to the region (Tepedino and Griswold 1995). Through pollination, these insects enable healthy plant reproduction and support organisms that rely on flowering plant populations for food and shelter. Bees are most abundant in arid environments similar to the environment of the Columbia River Basin (Linsley 1958; Koh et al. 2016). The *Hanford Site Pollinator Study* (HNF-62689), performed in 2017, found over 25 groups of bee on the Hanford Site. Habitat loss, alternation, and fragmentation are major threats to populations of native bees (Kearns et al. 1998). Removal of bee habitat includes both the removal of foraging resources and of nesting resources.

The majority of most solitary bee lifecycles are spent within the nest. Adult bees emerge in the spring and summer, and spend the time they are active mating, drinking nectar, collecting pollen, and provisioning their nests. Most bees lay eggs within individual nest cells and provision the cell with a pollen loaf that the larva will eat. After the nest cell is sealed, the egg undergoes a complete metamorphosis and develops into an adult. This process can be halted in the prepupal stage so that the bee does not develop too early and can emerge during the proper time in the spring or summer. Some bee species are bivoltine, meaning they can produce multiple generations in 1 year. Most bees only spend 3 to 6 weeks of their lives as active adult bees outside of the nest (Wilson and Messinger Carril 2016).

Bee nesting strategies vary depending on the species. Unlike European honeybees (*Apis mellifera*), native bees are typically solitary and do not nest in a colony. Native bee nests may be aggregated close together, but in most species this is likely due to availability of nesting resources rather than social behaviors (Mader et al. 2010). Native bees in the Columbia River Basin nest in an array of substrates, the two most common being soil and woody debris (Tepedino and Griswold 1995). Soil nesting bees found on the Hanford Site in the 2017 study included bees in the genera *Andrena*, *Perdita*, *Diadasia*, *Eucera*, *Melissodes*, *Anthophora*, *Hapropoda*, *Colletes*, *Halictus*, *Lasioglossum*, and *Agapostemon*, along with their associated cleptoparasites (HNF-62689; Wilson and Messinger Carril 2016). Above-ground nesting bees typically nest in open cavities or in holes bore into wood by other insects. Above-ground nesting bees found on the Hanford Site in a 2017 study included bees in the genera *Lithurgopsis*, *Osmia*, *Dianthidium*, *Paranthidium*, *Anthidium*, and *Megachile* (HNF-62689).

Above-ground nesting bees are known to nest in dead woody material, hollow stems, cracks in rocks, and in other substrates with pre-existing cavities (Murray et al. 2009). In shrub-steppe environments, big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), and spiny hopsage (*Grayia spinosa*) may provide nesting habitat. Ground nesting bees nest in bare patches of soil that are typically in exposed, sunny spots (Wilson and Messinger Carril 2016). With some exceptions, the type of soil that ground nesting bees prefer is largely unknown (Tepedino and Griswold 1995).

Nesting habitat is believed to be a limiting factor in the size and health of native bee populations and can determine overall bee community composition (Steffan-Dewenter and Schiele 2008; Potts and Roberts 2005). One of the greatest threats to bee populations is the removal of nesting material (Tepedino and Griswold 1995). Targeted habitat restoration combats this threat and is one of the tools most commonly used to help support bee populations. Taking a holistic approach to native bee habitat restoration means restoring both foraging and nesting resources.

# 3.0 BEE NEST BOXES INSTALLED IN 2019

In 2019, a waterline (L-894) was constructed between the 200-East and 200-West Areas of the Hanford Site. This waterline resulted in the removal of mature shrub-steppe habitat and subsequent loss of above-ground nesting resources for native bees. Though the area was replanted with native species, an access road spans the length of the waterline, resulting in permanent loss of shrub-steppe habitat. Twenty bee nest boxes were installed with the goal of replacing lost bee nesting habitat and studying the effectiveness of different bee nest box designs as a replacement habitat. This habitat restoration effort directly targeted above-ground and cavity nesting bees. Ground-nesting bee habitat was not targeted as little is known about the habitat requirements of ground-nesting bees apart from the availability of bare ground (Tepedino and Griswold 1995). Significant patches of bare ground were present throughout the replanted areas of the waterline.

The twenty bee nest boxes were installed the first week of July 2019. The boxes were spaced approximately 200 m (656 ft) apart along the waterline and located in the margin where the revegetation site met the natural habitat. Figure 1 shows the spacing of the bee nest boxes along the waterline.

Two differing designs of bee nest boxes were installed as part of 2019 efforts in order to study the effectiveness of different box designs. Design A contains both drilled holes and nest tubes as nesting habitat options. Design A had an average of 16 drilled holes and 67 nest tubes available per box when installed. Design B contains drilled holes, nest tubes, pinecones, wood pieces, and slots for butterfly use. Design B had an average of 64 drilled holes and 198 nest tubes available per box when installed. Both boxes were installed on U-Channel posts approximately 1 m (3.28 ft) off the ground and securely fastened so they did not move in the wind. The designs were installed in an alternating pattern from west to east, starting with Design A in the west. Ten boxes of each design were installed.

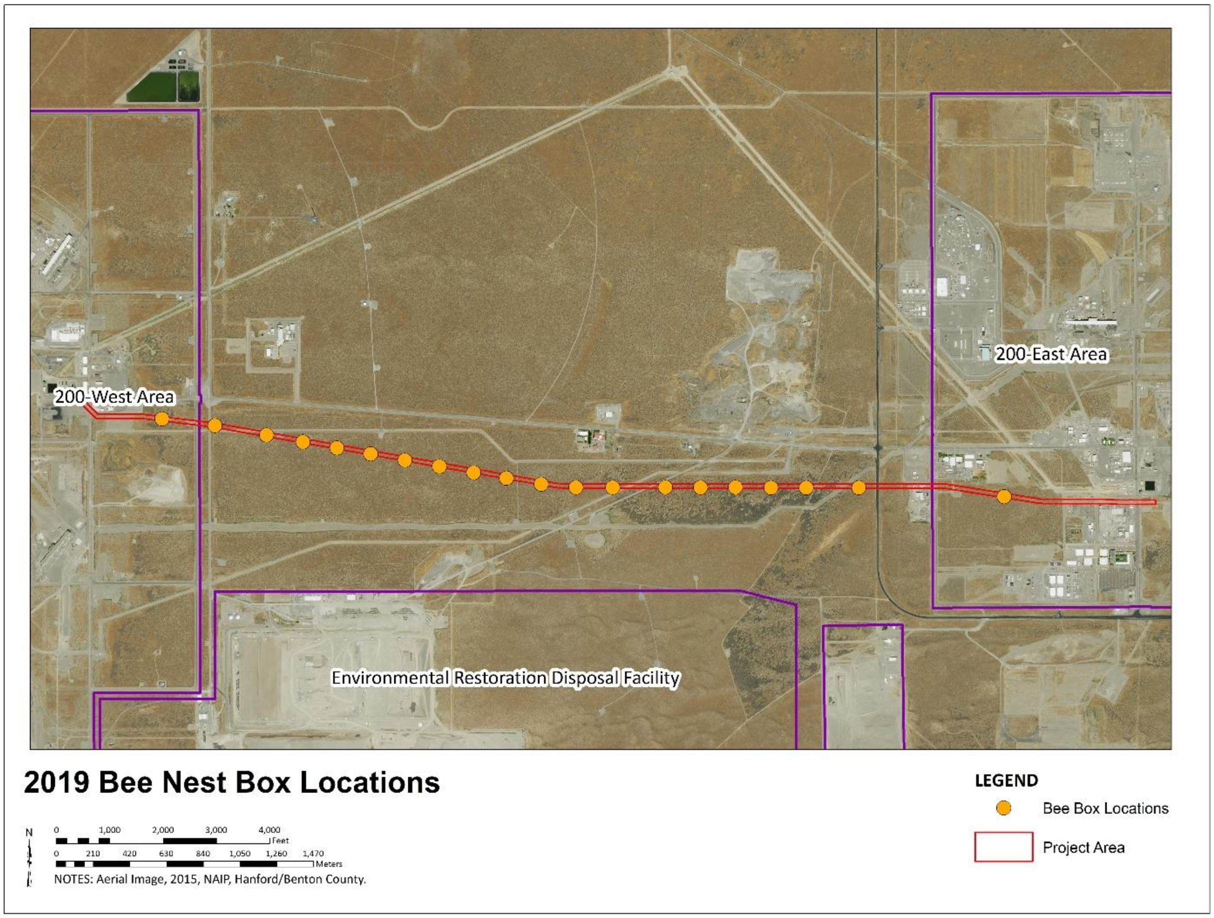


**Figure 1. Locations of Bee Nest Boxes Installed in 2019**

**Figure 2. Design A (Left) and Design B (Right) Bee Nest Boxes (Not to Scale)**

# 4.0 MONITORING METHODS

Nest box monitoring occurs after the active season for the majority of native bees has ended, approximately mid- to late-October at the Hanford Site (HNF-62689). The goal of bee nest box monitoring is to determine box occupation by counting the number of nests in each box. This relatively simple method allows researchers to determine box effectiveness, compare different styles of boxes and nesting material, and to compare variation in year-to-year occupation. Occupation monitoring involves visiting each box and counting the total number of nest tubes/holes and the number of occupied nest tubes/holes. Occupied nest holes are identified with the cut pieces of leaf or mud plugging the nest tubes/holes (Figure 3). This information along with a description of the box style, condition, and any noticeable changes were noted.

Some species of bees are bivoltine and can have multiple generations in 1 year. In some cases the nest cells that were created in the spring and early summer may have already produced offspring. These cells will have remnants of cut leaves or mud around the inside of the tube that will have a hole eaten through the middle (Figure 4). These cells will be counted as occupied during occupation monitoring to reflect their use earlier in the year. Second-year monitoring used photo comparisons to determine if the used nest cells were occupied in 2019 or 2020.

Design B includes nesting areas that are not tubes or drilled holes. These areas consist of stacked debris, pine cones, and slots. If there is evidence of bee nesting in these areas it is recorded on the field form. Evidence may consist of mud added to the area or leaves blocking an opening in the debris. If there is evidence of other insects using the nest box, it is recorded and the type of insect identified, if possible. Examples of this include finding a used wasp nest, cocoon, or chrysalis attached to or inside the box. Use of the box by other animals (such as finding bird excrement on top of the box or scratches on the side of the box) were recorded and signs of predation were looked for.

After the nest box was checked for insect and animal use, close-up pictures were taken of the nest boxes for documentation. The condition of the tube/hole openings was also recorded, as openings with splinters or other obstructions at the entrance may be less likely to be used by bees. Occupation monitoring will be repeated annually for 5 years following installation to determine success.

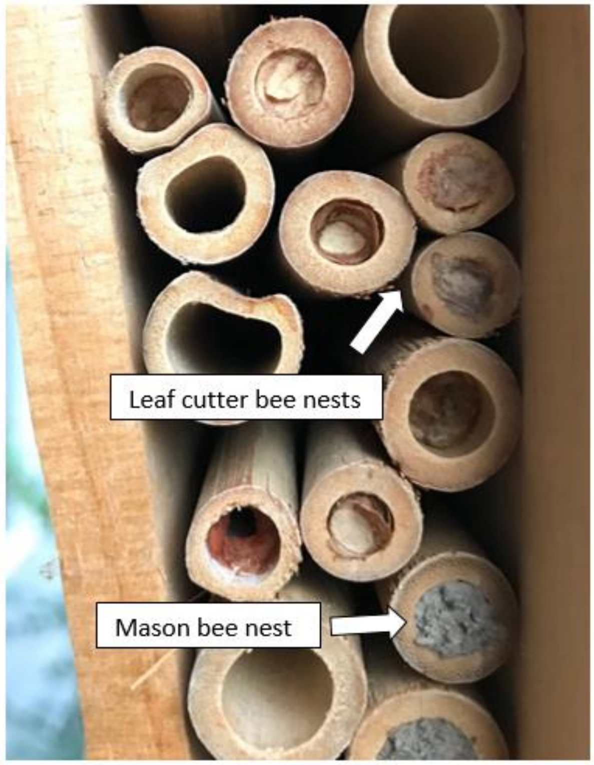


**Figure 3. Occupied Bee Nest Box Showing Leaf Cutter Bee and Mason Bee Nests**


**Figure 4. Occupied Bee Nest Box Showing Previously Occupied Nest Cell of Leaf Cutter Bee**

# 5.0 2020 MONITORING RESULTS

Quantitative data collected over multiple years is necessary to evaluate the effectiveness of bee nest boxes in recreating bee nesting habitat for above-ground nesting bees. The first year of monitoring for the bee nest boxes installed in July 2019 took place on December 9, 2019 (HNF-64747). The second year of monitoring for the bee next boxes took place on November 10, 2020, results from that monitoring are summarized below.

## 5.1 OCCUPATION DATA

Of the 20 bee nest boxes surveyed, 6 contained nests at the time of monitoring. The nests were split evenly between Design A and Design B, with three of each design containing nests at the time of monitoring. The nest boxes were numbered 1 through 20 from west to east; the occupied nest boxes were numbers 4, 6, 11, 13, 15, and 16 (Figure 5). None of the five boxes occupied in 2019 were occupied again in 2020. All of the nest cells that were used in 2019 had evidence of emergence, indicating that the nests created in 2019 successfully produced a new generation of bees.

Within the six boxes that were occupied, 20 nests[1] were recorded, which is an increase from the 15 nests recorded in 2019. Twelve of these nests were within drilled holes (60%) and eight were within the nest tubes (40%), similar to 2019 where the majority of nests were in drilled holes (87% compared to 13%). Of the 20 nests, 5 were created with leaves (25%) and 15 were created with mud (75%) (Figure 6). This is a higher proportion of mud to leaf nests than was detected in 2019 where 47% of nests were mud and 40% were leaf. No cellophane nests were found, unlike in 2019 where cellophane nests made up 13% of all nests documented. The majority of leaf nests were found in nest tubes (80%) as opposed to drilled holes (20%). The majority of mud nests were found in drilled holes (73%).

Of the 20 recorded nests, 10 were in Design A boxes and 10 were in Design B boxes. This is a change from 2019 monitoring where the majority of nests were in Design B boxes (60%). Within the Design A boxes, eight nests were in drilled holes and two were in tubes. Within the Design B boxes, four nests were in drilled holes and six were in tubes.

Though it appears the larger nest box design (Design B) provides far more nesting habitat, 2019 monitoring results noted that many of the Design B nest holes and tubes were obstructed by split wood or not properly drilled. The number of nest tubes and drilled holes per box changed in 2020 as a number of the boxes were damaged and lost tubes. The average number of unobstructed nest tubes per box was 66 for Design A and 77 for Design B. The average number of unobstructed drilled holes per box was 16 for Design A and 37 for Design B. The number of unobstructed tubes/hole was used when calculating occupation rates of the bee nest boxes.

[1] For the purposes of this monitoring effort, one nest refers to one occupied nest tube or drilled hole. Within each of these nests, one would expect to find multiple nest cells.

Monitoring in 2020 found that of the available nest spots 1.2% were occupied in Design A and 0.9% were occupied in Design B. Nest spot occupation increased for both designs from 2019 to 2020; the design with the highest nest spot occupation changed from Design B in 2019 to Design A in 2020.

When breaking nest spot occupation down by nest type, drilled holes had the highest occupation rate at 2.3% across all designs compared to a nest tube occupation of 0.6%. The most occupied substrate was the drilled holes in Design A, which had an occupation rate of 5.1%. This is similar to the results seen in 2019 where drilled holes in Design A had the highest occupation at 3.8%.

Of all the bee nest boxes, 30% contained bee nests in 2020, an increase from the 25% that contained nests during first-year monitoring in 2019. A total of 30% of Design A and 30% of Design B nest boxes were in use in 2020.

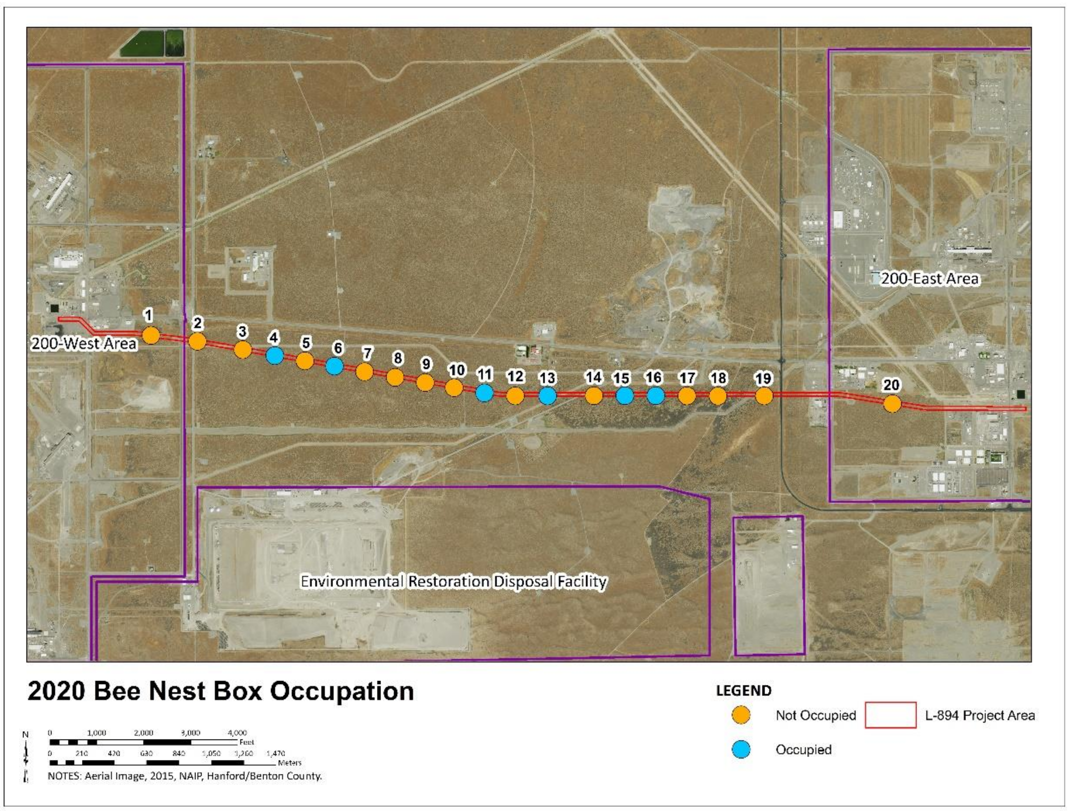


**Figure 5. The Occupied Bee Nest Boxes in November 2020**

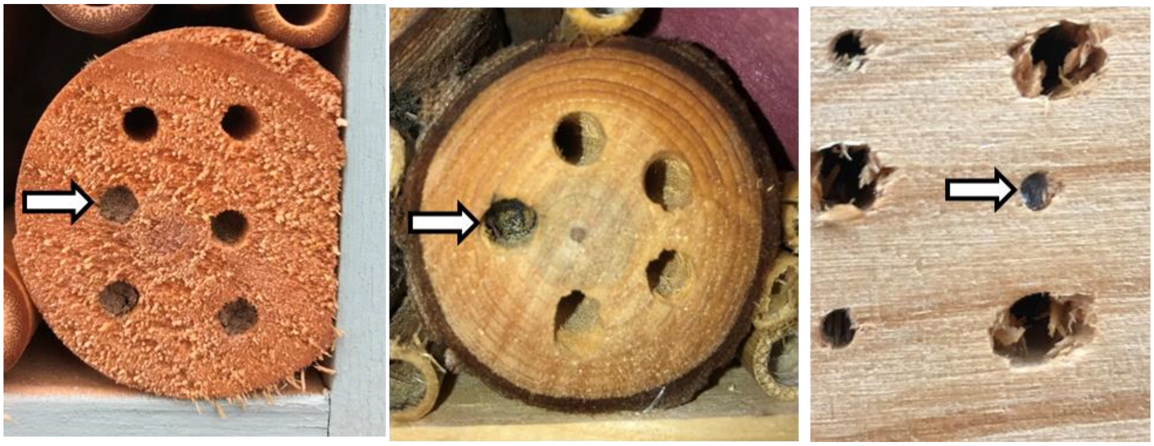

**Figure 6. Occupied Drilled Holes Filled with Mud (Left), Leaves (Middle), and a Cellophane-Like Substance (Right)**

## 5.2 CONDITION DATA

Though condition varied from box to box, all 20 of the bee boxes monitored for second-year monitoring require replacement in spring 2021. The Design B boxes were noted as having split roofs in 2019, most likely from weather damage. Monitoring in 2020 found that some Design B boxes were missing their roofs entirely, along with some nest tubes on the top of the box (Figure 6). Other Design B boxes had the sides splitting and coming apart from the main frame of the box, also likely due to weather damage. The majority of Design A boxes appeared to be structurally intact; however, mold in the form of black spots was noted on the nest tubes of all the Design A nest boxes (Figure 7). Mold was also detected in the wood debris substrate of some Design B boxes. Because of the damage and wear on both box designs, all of the 20 bee nest boxes are recommended for replacement in spring 2021.

All of the 20 nest boxes had been used as perches for birds, as indicated by bird excrement on the roofs of the boxes. One of the Design B boxes had a used wasp nest in the area intended for butterfly nesting, and one of the Design A boxes had a spider nest in the gaps in between nest tubes. The only other sign of animal use were two drilled holes in a Design A box that appeared to have been filled with small seeds, possibly as a cache for a bird or small rodent.

**Figure 7. A Weather Damaged Design B Nest Box Missing a Roof**

**Figure 8. A Design A Nest Box with Mold Growing on the Nest Tubes**

# 6.0 DISCUSSION AND RECOMMENDATIONS

First- and second-year monitoring of the bee nest boxes have provided data that can be used to analyze trends and the effectiveness of bee nest boxes in mitigating for lost habitat. First-year monitoring occurred after the nest boxes were installed in July 2019 and only covered the period from July to December 2019, missing the active spring and early summer season. Second-year monitoring in 2020 was the first year of monitoring that occurred after a full active season for bees.

One of the goals of analyzing bee nest box occupation was to determine if the nest boxes were effective at replacing bee nesting habitat. A complicating factor in first-year monitoring of the nest boxes was the timing of installation. The nest boxes were installed in July 2019, approximately 3 months after the active season for bees had begun. The majority of bee activity at the Hanford Site occurs in June (HNF-62689) and the late installation of these boxes may have resulted in lower occupation and skewed the results of first-year monitoring. Notably, in the Hanford Site Pollinator Study (HNF-6689) the majority of bees in the *Osmiini* (mason bee) and *Megachile* (leaf-cutter bee) groups were collected before July. These two groups of bee are specifically targeted by bee nest boxes and were likely missed in first-year monitoring due to the late installation of the nest boxes. First-year to second-year monitoring had a 20% increase in the number of nests, potentially due to the boxes being available for a longer period of time.

In 2019, 25% of the bee nest boxes were occupied and 0.8% of the available nesting spaces were used. This increased in 2020 when 30% of the bee nest boxes were occupied and 1% of available nesting space was used. Though this marks an increase in usage, the boxes were also available throughout more of the active season. In 2019, it was hypothesized that usage would increase annually as nesting bees returned to the same nest boxes to lay their eggs. Second-year monitoring found that no nest box used in 2019 was used again in 2020. The reason for this is unknown but it does not support the hypothesis that bees would return to the same nest box they emerged from to lay eggs. In 2019, three of the five occupied boxes were nearest to areas heavily impacted by human activity. In 2020, monitoring showed no clear pattern of bee nest box occupation and did not show higher use of bee nest boxes near areas of human activity. The six used nest boxes appeared to be randomly distributed across the available boxes. Figure 9 shows the bee nest boxes occupied in 2019 and those occupied in 2020.

Results from 2019 and 2020 monitoring show the drilled holes being used at a higher rate than the nest tubes. This could be due to a number of factors, including drilled-hole diameter, length, increased insulation, and/or the type of wood. With only 2 years of monitoring data, there is a possibility this perceived preference is due to chance. Leaf and mud nests have been found in both nest tubes and drilled holes. In 2020, 80% of leaf nests were found in nest tubes but only 17% were in 2019. There is not enough data to suggest that leaf or mud nesting bees prefer nest tubes or drilled holes. It is recommended that future monitoring measures the diameter of the occupied holes to determine size preference and inform future bee nest box designs.

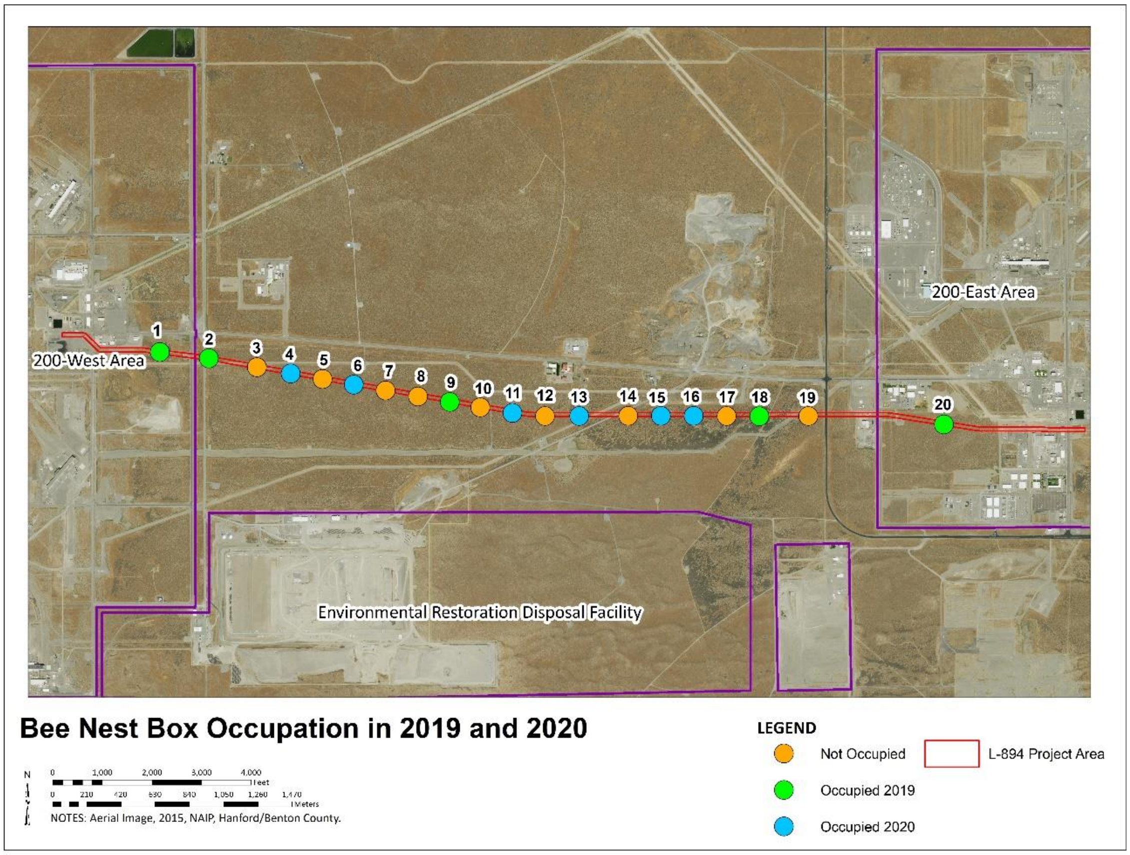


**Figure 9. Bee Nest Boxes Occupied in 2019 and 2020**

First-year monitoring found a fairly even distribution of leaf-filled versus mud-filled nests, while second-year monitoring detected a higher proportion of mud-filled nests. This suggests that more mud-nesting bees, likely mason bees in the family *Osmiini*, may utilize the nest boxes in the spring and early summer. The presence and distribution of leaf-filled and mud-filled nests may indicate the types of bees that are utilizing the nest boxes and can demonstrate which groups of bees are benefiting from the replacement habitat.

All of the 20 bee nest boxes installed in July 2019 needed replacement by second-year monitoring. In addition to weathering to the point of being unusable, many of the boxes had mold present on the nest tubes or other wooden structures. Introducing a potential pathogen via a nest box could increase harm to the bees and not achieve the goal of replacing pollinator habitat. All 20 boxes will be replaced in the early spring of 2021, and the boxes with nests will be placed in emergence boxes to allow the bees to emerge but not return to the used nest box. Certain designs of bee nest boxes can be cleaned and re-used, but replacement can be an easier and less labor-intensive option with reduced risk of introducing pathogens to nesting bees. The replacement boxes will be Design A and Design B, as additional information is needed before selecting a new design of bee nest boxes. Design A boxes will be replaced with Design B boxes and vice versa to remove any potential location bias.

Though 2019 data initially indicated that drilled holes were more commonly used than the nest tubes, 2020 data saw a higher percentage of nest tubes being used. Current data are not comprehensive enough to indicate if a certain nest style is utilized more than another. The "alternative" nesting substrates in Design B were unused by bees for both years and are not expected to be used in the future. Future nest boxes should only include nest tubes and drilled holes. Current data do indicate that nesting bees do not use tubes or holes that are blocked by splinters or wood fiber. Future nest boxes should include smoothed tubes and drilled holes that are not obstructed.

The 20 bee nest boxes monitored in 2020 were installed as a compensatory mitigation measure to compensate for lost nesting habitat. Bee nest box use appears to be increasing across all designs and nest types; however, second-year monitoring results did not follow patterns seen in first-year monitoring. Additional data from continued monitoring may allow researchers to see emerging patterns in nest box use, better informing future mitigation decisions. To this point, the bee nest box mitigation has been successful in replacing bee nesting habitat and in providing valuable data to researchers regarding pollinator habitat restoration.

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