OUT ON A LIMB:

DO HAZELNUT ORCHARDS PROVIDE HABITAT FOR CAVITY NESTING BIRDS?

by

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Approved: [redacted] ______________________________
Dr. Lauren Hallett

Cavity nesting birds are a group of high conservation concern in the U.S. They depend on areas with mature decaying trees in which cavities can be excavated, but few studies have examined the role of managed landscapes such as orchards in providing nesting habitat. This study assesses the suitability of hazelnut orchards for cavity nesting bird species in the Willamette Valley, where hazelnut farming is a major industry. Using field surveys, I measured the density of suitable tree cavities and size of tree limbs in four commercial hazelnut orchards, three experiencing heavy fungal decay, and one with limited decay. I used observations of birds in the same orchards to determine the abundance of all cavity nesting species. When comparing between orchards, cavity density increased with average tree diameter, but was much lower in the orchard with low levels of fungal decay. Black-capped chickadees were the most abundant cavity nesting birds observed, a smaller species dependent on nest sites with soft wood. These results suggest that orchards with mature trees experiencing fungal decay may be the most valuable for cavity nesting birds, but these qualities also make orchards vulnerable to diseases that reduce crop yield. To control key diseases, many older orchards are being replaced with new blight resistant trees, altering habitat connectivity for Willamette Valley birds. A regional management strategy

where some mature, decaying orchard are instead retained could benefit declining bird populations.

INTRODUCTION

Bird populations are declining worldwide, highlighting the need for novel conservation solutions. Approximately 18% of all bird species are cavity nesting and require a sufficient supply of tree cavities to support their reproduction (van der Hoek et al. 2017). This makes them particularly vulnerable to habitat loss, as they depend on mature forest stands with many dead and dying trees. In addition, they are heavily impacted by conventional management practices on working lands, such as private agriculture and managed forests, which limit the supply of tree cavities (Remm & Lõhmus 2011). Therefore, certain management practices which are necessary for economic productivity, like the removal of dead/dying trees and the suppression of fungal decay, may also actively deter cavity-nesting birds in agroecosystems.

Cavity nesting birds can be grouped into three main categories based on their method of cavity usage. Primary cavity nesters excavate their own cavities by digging an entrance hole and vertical chamber in the trunk or limb of a tree, often creating a new cavity nest each breeding season. Secondary cavity nesters cannot create their own cavities and must rely on those previously excavated by primary nesters. Primary cavity nesters are further subdivided into strong and weak excavators based on their size, foraging habits, and ability to penetrate wood. In the Pacific Northwest, strong excavators include the larger woodpeckers and sapsuckers, who are well adapted for drilling into hard wood for feeding and excavating cavities (Spring 1965). Weak excavators include chickadees, nuthatches, and smaller woodpeckers who are not as specialized for drilling into hard wood but can still excavate cavities in wood softened by decay (Bunnell 2013). While both strong and weak excavators prefer to excavate softer wood, weak excavators are more limited to trees that are experiencing heartwood rot and bark damage and will often renovate cavities initiated by strong excavators.

While cavity-nesting bird communities are well studied in North American forests (Wesołowski & Martin 2018), few studies have examined nesting in tree crops within agroecosystems. Some systems could have the potential to aid in the conservation of cavity nesting birds by providing habitat with high tree cavity density in landscapes where relatively few remnant forests remain. However, the extent to which native bird species utilize industrial orchards for nesting remains an open question for agroecologists. This is the case in the Willamette Valley of Oregon, where the majority of historical habitat has been replaced with hazelnut orchards and other agricultural operations (Schumaker et al. 2004). Today, the Oregon hazelnut industry is in a period of rapid growth. Oregon produces over 99% of domestic hazelnuts with approximately 8,000 acres entering production each year (Teel 2018). Simultaneously, many older orchards are being replanted with new disease resistant varieties, leading to more homogenous agroecosystems composed of newly planted orchards. These changes highlight the need to gather ecological data and develop novel management practices that could support biodiversity in hazelnut agroecosystems.

Tree diameter and level of decay are among the most important factors for the selection of nest sites by birds (Wesołowski & Martin 2018). A given tree must first be decayed to the point where a cavity can be excavated or naturally formed (a process often spurred by fungal infection, in conjunction with other factors such as weathering or boring insects). Second, the tree's limbs or trunk must be large enough to accommodate an interior chamber that can fit the cavity nesting species. Compared to trees in unmanaged forests, hazelnut trees likely lack the size required for nesting by larger species, but they may still provide habitat for many smaller cavity nesting species. Previous studies indicate that even the smallest cavity nesting species are unlikely to nest in limbs or trunks with diameters less than 12 cm (Bovyn et al. 2019), excluding young hazelnut orchards from providing cavity nests. Even in old hazelnut orchards limb size can be highly variable, therefore mean limb diameter may be an important limiting factor influencing habitat suitability.

In natural systems, most cavity-nesting birds favor mature forest patches with many dead and dying trees, and patches containing tree genera prone to heartwood rot, namely cottonwoods and oaks (Remm & Lõhmus, 2011). Similarly, older hazelnut orchards are highly susceptible to heartwood rot and bark damage and could be of greater importance to cavity nesting birds in hazelnut agroecosystems compared to younger orchards. As hazelnut trees age, they become more susceptible to fungal infection, eventually softening to the point where birds can excavate cavities. Much of the decay observed in Oregon hazelnut orchards is caused by a fungal pathogen known as Easter filbert blight (EFB). Introduced to Oregon in the mid-1970s, it has caused extensive damage to orchards in the region despite efforts to control its spread (Pscheidt 199). However, by causing heavy decay in hazelnut orchards, the presence of EFB and other wood-rotting fungi may be an important factor for cavity nesting birds.

By measuring bird abundance and tree cavity density across different orchards, I aim to sample the baseline habitat quality of hazelnut farms for cavity-nesting bird communities. The guiding questions for this study were the following: (Q1) how does tree diameter and the presence of fungal decay influence tree cavity density in hazelnut orchards? and (Q2)

What types of cavity nesting bird species are present in hazelnut orchards during the breeding season?

METHODS

For this study I selected four hazelnut orchards with different ages, management histories, and levels of decay. All orchards surveyed were subject to the regular pruning of decaying limbs, and application of pesticides. All orchards were planted before the development of blight resistant hazelnut cultivars and are susceptible to Eastern Filbert Blight. Two orchards were located on Dorris Ranch in Springfield Oregon, a hazelnut farm established in 1892, and considered the longest operating commercial hazelnut farm in the United States (Fig 1). Goat orchard is 65 years old while Clump orchard is 75 years old. Both orchards surveyed at Dorris Ranch are heavily damaged by EFB, particularly Goat orchard which has many trees that have lost primary limbs or have been reduced to stumps. A qualitative assessment revealed that most trees in the Dorris Ranch orchards had canopies that were 25-50% dead, with areas of stripped bark and fungal growth on most trees. The trees in both orchards have a shrubby, multi-stemmed structure because they were not trained to have a single trunk during development.

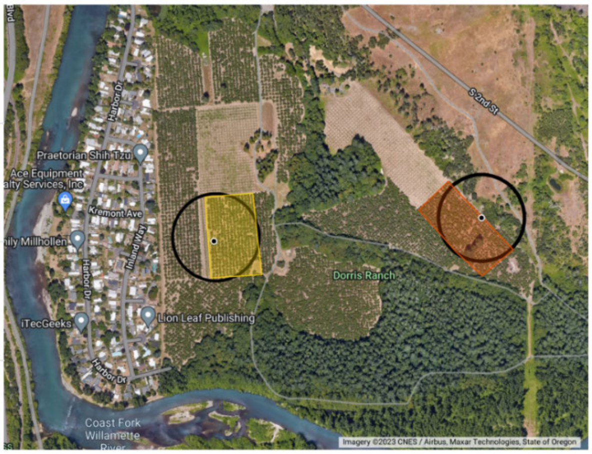

Figure 1 – Satellite view of Dorris Ranch. Colored rectangles indicate cavity survey area and points with circles indicate bird survey areas. Yellow is Clump Orchard and Orange is Goat Orchard. Goat orchard is adjacent to restored oak woodland, while Clump orchard is adjacent to young orchards that were replanted in 2022, and nearby residential area.

The Howell and Wheatland orchards are located on Lane-Masse Farms in Kaiser Oregon. Wheatland orchard is 60 years old, and also infected by Eastern Filbert Blight, with most trees having a canopy that is 25-50% dead, stripped bark, and fungi on most limbs. The trees in Wheatland orchard are trained to have a single trunk and a wine cup shaped structure, resulting in a few large limbs.

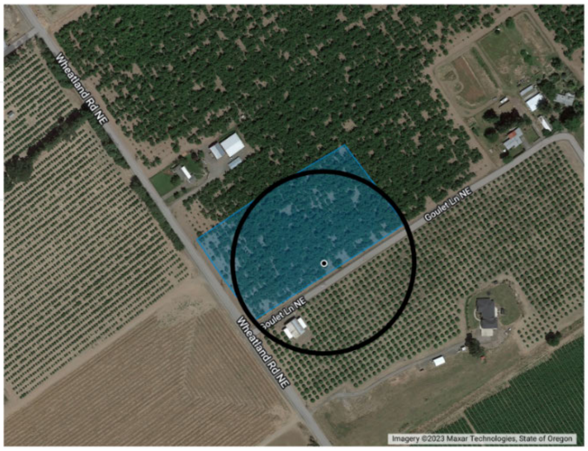

Figure 2 – Satellite view of Wheatland Farm. Colored rectangle indicates cavity survey area and point with circle indicates bird survey area. Wheatland is adjacent to agricultural areas including other hazelnut orchards and hops.

Howell orchard is the youngest orchard at 45 years old and as a result is not extensively damaged by eastern filbert blight. It shows the least signs of decay, with the canopy of most trees being 0% dead, and few trees experiencing stripped bark or signs of eastern filbert blight, although most trees still hosted other species of fungi.

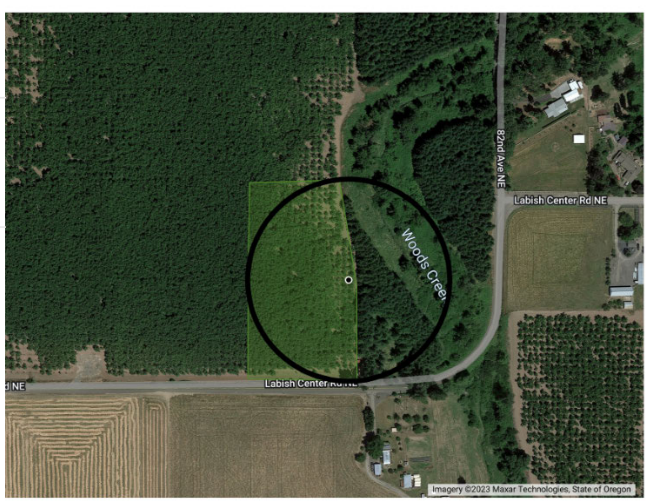

Figure 3 – Satellite view of Howell Farm. Colored rectangle indicates cavity survey area and point with circle indicates bird survey area. Howell orchard is adjacent to a Douglas fir stand and agricultural areas.

For each orchard, I surveyed for tree cavities and measured tree diameter within a 4-acre area. Surveys were performed in early December 2022 after trees became defoliated, but before winter weather damaged tree limbs, thus potentially removing cavities present during the 2022 breeding season. I organized orchards into tree rows and columns, and systematically surveyed approximately 260 trees per orchard for suitable cavities sampling evenly across the survey area. During surveys I scanned the trunks and primary limbs of the target tree with binoculars while walking 360 degrees around it to observe from every angle. I recorded the presence of any presumably usable cavities, using the following criteria adapted from Andersson et al. (2018) to determine suitability: (1) cavity entrance hole diameter ≥2.3 cm; (2) horizontal cavity depth ≥6.0 cm (3) closed cavity bottom; (4) cavity located above ground level; (5) cavity entrance not facing upward, and (6) cavity fully roofed. Unable to reach and directly measure most cavities, I instead confirmed these criteria qualitatively by observing with binoculars from the ground. I used diameter tape to measure diameter at breast height (DBH) for 130 trees per orchard, and for every cavity-bearing tree. Multi-stemmed hazelnut trees are very common, complicating DBH measurement. Following the recommendations of the New York State Department of Environmental Conservation DBH was calculated for multi-stemmed trees by measuring the diameter of all stems, then taking the square root of the sum of all squared stem diameters.

To better understand how tree diameter and the presence of decay influences the supply of tree cavities across different hazelnut orchards (Q1) I calculated average tree diameter for each of the four orchards and categorized each orchard as experiencing either “heavy decay” or “limited decay” based on my qualitative assessments of the sites. I compared these variables to the density of suitable cavities that I observed in each orchard. To demonstrate the relationship between tree size and the presence of cavities, I also compared the diameter of trees containing different numbers of cavities, drawing from all trees surveys regardless of orchard. Statistical analysis and data visualization was performed using R studio.

To answer the question of which cavity nesting bird species are present in hazelnut orchards (Q2) I utilized bird abundance data collected in the same 4 orchards in spring 2022 as part of a separate study on farm bird diversity. This data was collected using point-count survey methods, with points placed at the interface between orchards and adjacent habitat, overlapping with the same areas where I later surveyed for tree cavities. Each point was surveyed for 5 minutes every 2 weeks throughout the 2022 breeding season (April to July). During surveys, researchers recorded the number and species of all birds seen or heard within 100 meters. I calculated the average weekly density of each cavity nesting species observed in each of the four orchards Using R studio. I also categorized the bird species based on their cavity usage type (strong excavator, weak excavator, or secondary excavator). I used ANOVA tests to identify significant differences in the abundance of both individual species and types of cavity users.

RESULTS

During cavity surveys I found a total of 84 suitable tree cavities across the four orchards. The vast majority of suitable cavities were excavated by birds as opposed to being formed naturally via decay alone, implying the presence of primary excavators in recent breeding seasons. Mean tree diameter was significantly different between orchards (P value = <2e-16) and orchards with higher diameter trees contained more cavities (Fig 4). The exception to this was Howell Orchard, where despite having an equivalent mean tree diameter to

Clump Orchard, only three cavities were found. When comparing between all individual trees, trees with zero cavities had significantly lower diameter compared to trees with one or more cavities (Fig 5). Anecdotally, most cavities were located in large decaying limbs directly below where the limbs had been pruned.

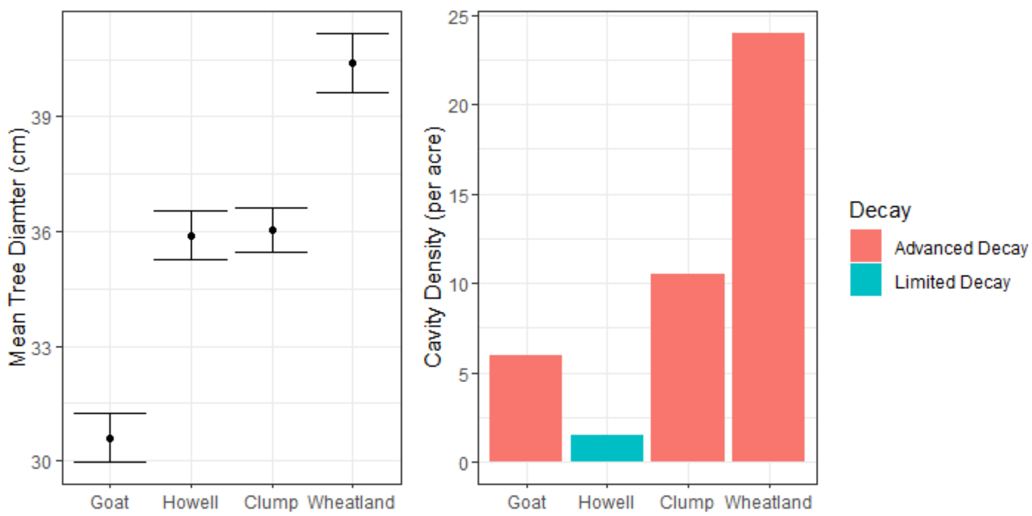

Figure 4 – Mean tree diameter and cavity density for each orchard. Orchards are categorized by decay level in right panel. Orchards are ordered by increasing tree diameter.

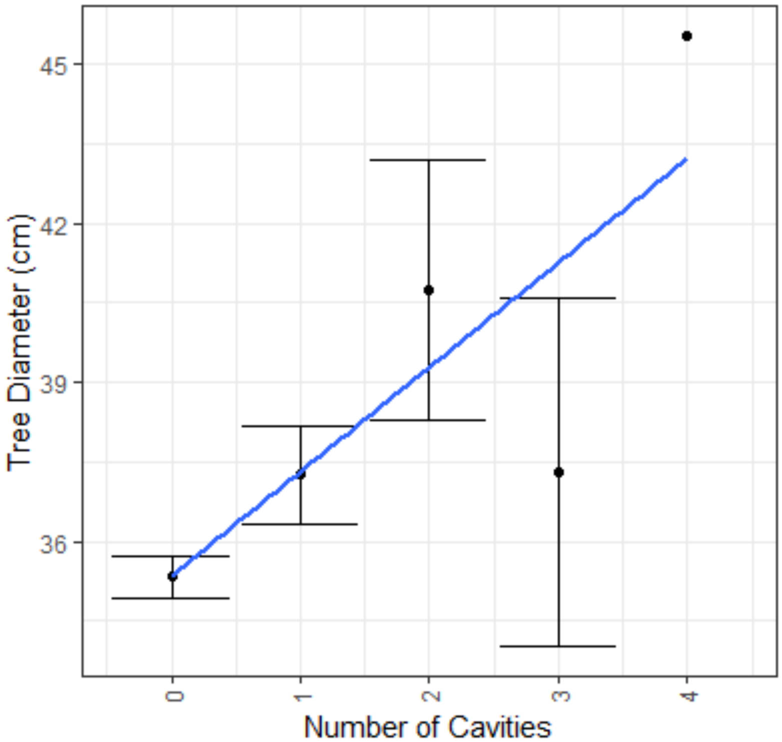

Figure 5 – Diameter of hazelnut trees with different numbers of cavities.

The abundance of individual cavity nesting bird species, and the abundance of different types of cavity users was significantly different between orchards (P values = 0.003328 and 0.0457 respectively) and within orchards (P values = 0.0011 and 0.07). Weak excavators were the most abundant group, in particular Black-capped chickadees (Fig 6). Other weak excavators included Red-breasted nuthatches, White-breasted nuthatches and Downey woodpeckers. Northern flickers were the only widely observed strong excavator, sampled in all orchards. A single Red-breasted sapsucker was found in Clump orchard. Secondary cavity nesters were absent from Clump and Howell, while Bewick's wrens were observed in Goat orchard, and Wheatland orchard had a high abundance of European starlings.

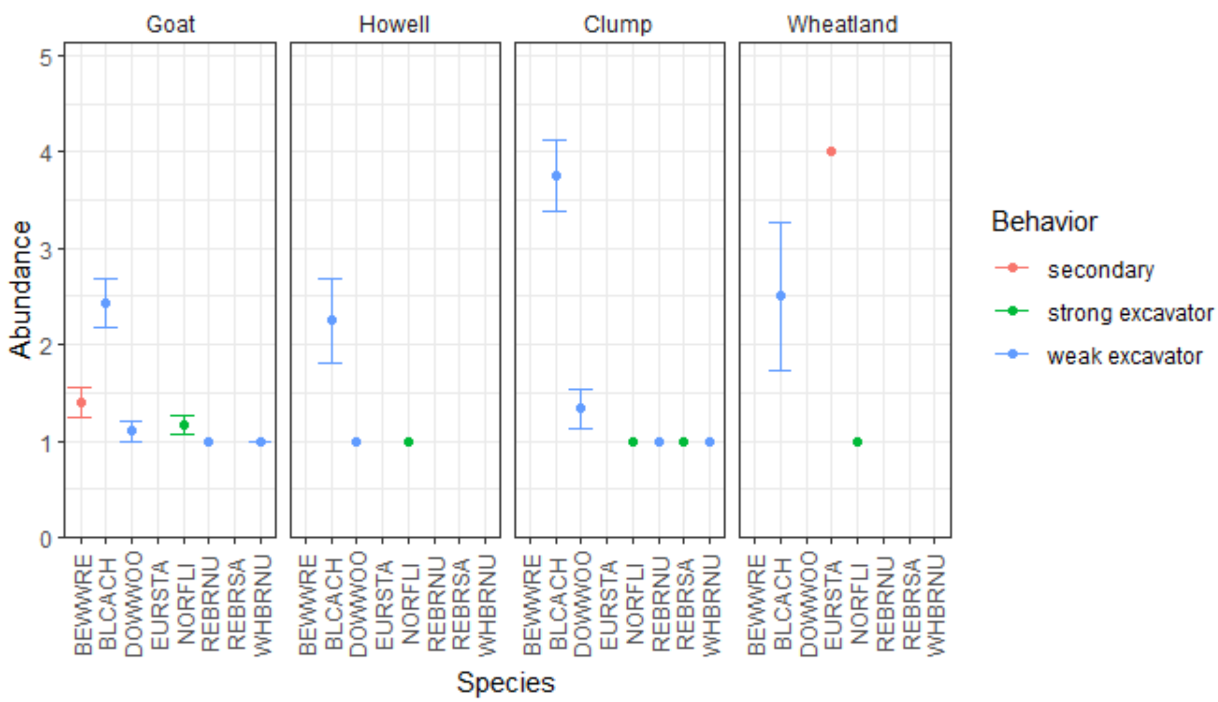

Figure 6 – Average weekly abundance of cavity nesting birds observed in each orchard during the 2022 breeding season, organized by species and cavity usage type.

DISCUSSION

The results of my tree cavity survey indicate that cavity density increases with tree diameter and the presence of fungal decay in hazelnut orchards (Q1). Higher limb diameter resulted in a higher number of cavities at both the orchard scale and individual tree scale, while the low density of cavities in Howell Orchard can be explained by the lower levels of Eastern Filbert Blight infection. This could indicate that the presence of fungal decay is a prerequisite for tree cavity excavation in hazelnut orchards, even when tree diameter is high.

Much of the observed variation in orchard structure can be explained by the differences in management history found at the four sites. For example, it seems that tree training during development (single trunk vs multi-stemmed) has a strong influence on tree diameter and as a result, cavity density. This is evident when comparing trees at Wheatland orchard, which were trained to grow with a single trunk and a few large limbs, to those at Goat and Clump orchards where many trees lack a single trunk and have smaller, crowded limbs. Despite being close in age and experiencing similar levels of fungal decay, Wheatland had a significantly higher average tree diameter and higher cavity density. These training practices are performed by growers to maximize nut production, but also increase tree diameter, representing a case where maximizing hazelnut productivity aligns with promoting habitat for cavity nesting birds.

The observation that most cavities were located a few inches below the tip of clipped limbs may represent another way in which cavity nesting birds respond to management actions. This pattern can be explained by previous research which indicates that birds will excavate cavities that are both as high as possible from the ground and in the softest available wood (Bunnell 2013). Hazelnut limbs are most often clipped to remove branches infected with EFB or wood rot, while leaving the healthy portion of the limb intact. But by exposing the heartwood of the limb this may also accelerate rot in the portion of the limb that remains, making them ideal sites for excavation by birds. Because of this, the pruning of trees infected with EFB may not be as detrimental to cavity nesting birds as it seems, so long as the clipped limbs that remain are large enough to support cavities.

However, by demonstrating the importance of decaying orchards to cavity nesting birds, these results also reveal potential conflicts between the goals of high hazelnut productivity and avian conservation. Eastern Filbert Blight and other fungal infections represent existential threats to many hazelnut farms, and their spread is limited as much as possible. Decaying orchards are regularly sprayed with fungicides, and heavily decayed trees are removed and replanted. At the regional scale, there are ongoing efforts to replant mature orchards in-masse with new blight resistant cultivars. These actions, although important for the expansion of the hazelnut industry, may limit the supply of tree cavities for birds. Given that very few cavities were found in the orchard with low levels of infection by EFB, along with the fact that hazelnut trees take decades to reach sufficient size for cavity nesting birds, this rapid replanting of old, decaying orchards could result in few hazelnut farms providing suitable nesting habitat in the near future.

As for which cavity nesting birds are most likely to reproduce in hazelnut orchards, weak excavators and smaller species were the most abundant groups observed during the 2022 breeding season (Q2). This makes sense when considering that they are 1.) able to utilize the small diameter of hazelnut limbs, and 2.) more restricted to trees experiencing fungal decay when compared to strong excavator species. The Black-capped chickadee, by far the most abundant species observed across my study sites, epitomizes this trend. It is the smallest cavity excavator in the Pacific Northwest and is a weak excavator that depends on nest sites with heavy decay (Foote et al. 2020). Habitat change models of the Willamette Valley predict a decrease in Black-capped chickadee population size by 2050 (Schumaker et al. 2004). The White-breasted nuthatch is another species of conservation value that was observed at several of my study sites. It is listed as a sensitive species in Oregon due to the loss of closed canopy oak woodland for foraging and nesting (Altman & Stephens 2012). Based on my results, managing old hazelnut orchards as breeding habitat could be a way to buffer these population declines in the region.

Many strong excavator species, and secondary cavity nesting species were notably absent from the study sites, implying that hazelnut orchards are unlikely to provide nesting habitat for these groups. Most large woodpecker species (for example Acorn woodpecker and Pileated woodpecker) require trees with much higher diameters than those found in orchards, have strong preferences for specific species of host trees, or have other nest site requirements that hazelnut orchards simply cannot provide (Bunnell 2013). The Northern Flicker is an exception to this, excavating cavities in a wide diversity of habitats and tree species, although strongly preferring trees experiencing heartwood rot (Wiebe & Moore 2020). This could explain why Norther flickers were observed at all four sites, while other strong excavators were absent. In Interior British Columbia, Northern flickers act as a keystone species, providing cavities for reuse by secondary nesters and initiating excavation for weak excavators (Martin et al. 2004). It is possible that they play a similar role in Oregon hazelnut orchards, even when present at the low abundance that I observed.

The lack of secondary cavity nesting species may be explained by the small size of hazelnut trees, as well as the ephemeral nature of nest sites in decaying hazelnut orchards. While cavities in larger tree species can persist for several years or decades (Edworthy et al. 2017) hazelnut orchards experience frequent limb breaks and pruning by growers. This may result in few suitable tree cavities remaining between breeding seasons for secondary cavity nesters to reuse. European Starling, observed at high abundance in Wheatland orchard, are known to steal recently excavated cavities from primary excavators (Cabe 2020). This may allow them to nest in hazelnut orchards while other secondary cavity nesters cannot.

Although these results are interesting, there are limitations to assessing habitat quality based on bird abundance alone, because abundance and reproduction within a local habitat are not necessarily correlated (Johnson 2007). Many of the birds observed for this study may have been foraging in the orchards while breeding in other nearby habitats, in fact the placement of the observation points at the edge of orchards was originally designed to measure the effect of adjacent wildland habitat on bird abundance within orchards as part of a separate project. Measuring the number of tree cavities containing active nests during the breeding season would provide more persuasive evidence that hazelnut orchards are valuable as breeding habitat for cavity nesting birds. In May 2023 I attempted this on a limited scope by making a single visit to each orchard and using a pole-mounted camera to observe the interior of tree cavities. I identified 2 breeding pairs of Black-capped chickadees, and 1 pair of Red-breasted nuthatches, all in the incubation stage of nest development. A similar survey performed weekly throughout the breeding season could provide valuable data on the abundance, species, and success of cavity nesting birds utilizing hazelnut orchards specifically for reproduction.

In lieu of such data, the results of this study still provide evidence that several bird species excavate tree cavities in hazelnut orchards, in particular Black-capped chickadees and other species that can take advantage of low diameter trees prone to fungal decay. Furthermore, birds seem to excavate more cavities in orchards with higher diameter trees and avoid orchards with lower levels of Eastern Filbert Blight infection. This has implications for hazelnut farm management in the region. Specifically, farmers might consider retaining portions of their old, blight susceptible orchards and/or replanting their decaying orchards in phases rather than all at once. By managing hazelnut agroecosystems as bird habitat, we may be able to buffer some of the population declines impacting bird species in the Willamette Valley and works towards reconciling agriculture and wildlife conservation.

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