**Trees and bushes, home sweet home for warblers**

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*Activity adapted for GEOS 536 from Data Nuggets*

Research Background:

The vast coniferous forests of the Pacific Northwest provide rich and diverse habitat types for birds. These forests are also a large source of timber, meaning they are economically valuable for people. Disturbances from logging and natural events result in a forest that has many different habitat types for birds to choose from. In general, areas of forest that have been harvested more recently will have more understory, such as shrubs and short trees. Old-growth forests usually have higher plant diversity and larger trees. They are also more likely to have downed trees or standing dead trees, which are important for some bird species. Other disturbances like wildfire, wind, large snow events, and forest disease also have large impacts on bird habitat.

At the Andrews Forest Long-Term Ecological Research site in the Cascade Mountains of Oregon, scientists have spent decades studying how the plants, animals, land use, and climate are all connected. In the past, Andrews Forest had experiments manipulating timber harvesting and forest re-growth. This land use history has large impacts on the habitats found in an area. Many teams of scientists work in this forest, each with their own area of research. Piece by piece, like assembling a puzzle, they combine their data to try to understand the whole ecosystem.

The researchers have been collecting long-term data on the number, type, and location of birds in Andrews Forest since 2009. To read the protocol for surveying, [click here](https://andrewsforest.oregonstate.edu/sites/default/files/lter/data/studies/sa024/HJ_Andrews_Point_Count_Protocol_2019_revised.pdf). Early each morning, starting in May and continuing until late June, teams of trained scientists hike along transects that go through different forest types. Transects are parallel lines along which data are collected. At specific points along the transect, the team would stop and listen for bird songs and calls for 10 minutes. There are 184 survey locations, and they are visited multiple times each year.

At each sampling point, the researchers carefully recorded a count for each bird species that they hear within 100 meters. They then averaged these data for each location along the transect to get an average number for the year. The scientists were also interested in the habitats along the transect, which includes the amount of understory plants and tall trees, two forest characteristics that are very important to birds. They measured the percent cover of understory vegetation, which shows how many bushes and small plants were around. They also measured the size of trees in the area, called basal area. Basal area is a common forestry term used to describe the average amount of an area (usually an acre) occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height and expressed as per unit of land area – typically square feet per acre. The larger the basal area, the greater amount of standing wood per acre. Using these data, the research team is looking for patterns that will help them identify which habitat conditions are best for different bird species. With a better understanding of where bird species are successful, they can predict how changes in the forest could affect the number and types of birds living in Andrews Forest and nearby.

**1. How do you think understory vegetation percent cover and coniferous basal area differ if you’re standing in an old growth forest vs. new growth forest (ie. one that may have just been logged)?**

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| Based on what they have learned in classes, hoping their answer will be understory percent cover would be expected to decrease as coniferous basal area increases – due to lower light conditions as basal area increases. But any answer that is supported by some ecological knowledge. |

***Research Question:* What are the habitat conditions where the most Wilson’s Warblers and Hermit Warblers are found?**



*LEFT: Wilson's warbler (male) (photo by Brad Imhoff, Macaulay Library); RIGHT: Hermit warbler (male) (photo by Ian Davies, Macaulay Library)*

Find out a little bit about the Hermit warbler and the Wilson’s warbler. Fill in the table below.[*All About Birds*](https://www.allaboutbirds.org/guide/) is a great first place to start.

|  |  |  |
| --- | --- | --- |
|  | **Wilson’s Warbler** | **Hermit Warbler** |
| **Habitat** | scrub | Forests |
| **Food** | insects | Insects |
| **Nesting** | ground | Tree |
| **Conservation status?** | Common bird in steep decline | Low concern |

**2. Based on what you found, what types of habitat do you think you’ll be more likely to find Wilson’s warbler?**

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| Because they are species that make their nests in the understory of forests, more of Wilson’s Warblers in forest areas with more understory than in forest areas with less understory |

**3. What types of habitat do you think you’ll be more likely to find Hermit warblers?**

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| Because they species that build their nests in dense foliage of tall coniferous trees and search for insects in the trees Hermit’s warblers would be more likely found in forest plots where there are larger trees. |

**Diving into the Data**

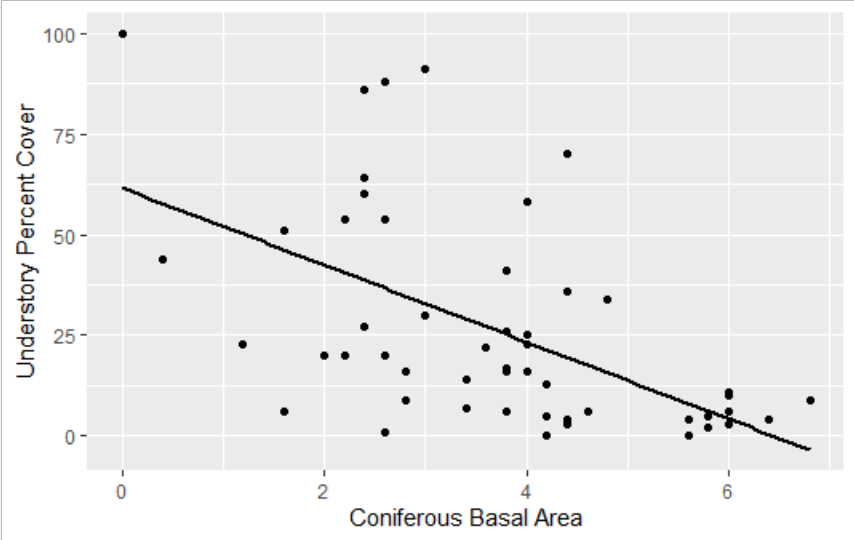
Let’s start looking at the data. I’ve simplified it for you. The Excel file shows the data from 20 study locations in Andrews Forest, averaged across 11 years of long-term data collection.

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| --- | --- |
| **Variable** | **Description** |
| Location | location along a transect - specific location where data were collected |
| Species | HEWA (Hermit warbler) or WIWA (Wilson’s warbler) |
| Num\_Indiv | the average number of individual warblers detected during 1 year – this is averaged over 11 years |
| Under\_per\_cov | Understory percent cover (%) of deciduous vegetation. Ranges from 0% (*no understory vegetation*) to 100% (*very dense understory vegetation – think: super challenging to walk through*) |
| Coniferous\_BA | The basal area is measured as square feet per acre, and expressed as 100 square feet per acre. So 4.4 in the data means 440 sq ft/acre. The amount of coniferous trees is strongly related to the size of the trees in a given area. |

Before getting into the main research question, let’s explore the relationship between coniferous basal area and understory vegetation cover.

**4. What do you expect the relationship to be between coniferous basal area and understory cover? Write in the box below and also add a graph sketch of your proposed relationship.**

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| --- |
| **As coniferous basal area increases, the understory cover will decrease** |



Now open the R code and load the data and libraries. Run the first chunk of code to create a scatter plot relationship between coniferous basal area and understory vegetation cover. And run the correlation code to get the R2 between the two variables. Copy and paste your graph below.

**5. Describe the data (*what is the graph telling you? Talk about the trends you see*) and then interpret it (*why do you think you see what you see in the graph?*). Include the R2 value in your summary.**

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| **Cor = -0.57** |

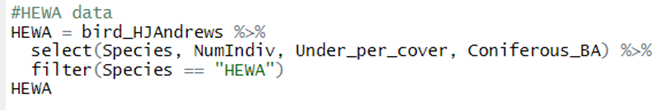
Now let’s dive back into the primary research question:

**What are the habitat conditions where the most Wilson’s Warblers and Hermit Warblers are found?**

By the end of this section you should have created **2 graphs**: 1. Relationship between understory vegetation cover and number of warblers and 2. Relationship between coniferous basal area and number of warblers. In addition, you will have **run 4 regressions** examining those relationships to determine if either of the variables is significant in predicting the two bird species presence.

I have given you the R code to examine the relationship between *understory vegetation cover* and *the number of warblers*. After creating this graph you will need to modify the code so that you create a graph to illustrate the relationship between coniferous basal area and the number of warblers.

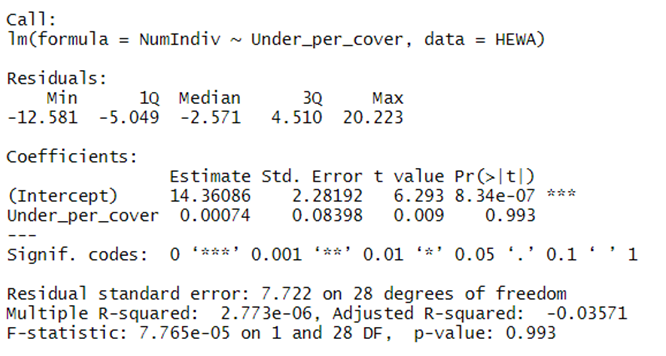
Run the R code for *understory vegetation cover and number of warblers.* On the graph you will see two linear regression lines. A linear regression line is one way to gauge the relationship between the variables. Each line has an associated equation. One way to get the equation for each of these lines, in other words to see if there is a significant relationship between the variables, is to run linear regressions using the lm() function. To get each equation you will need to create filtered datasets: one for the Hermit warbler and one for the Wilson’s warbler. I have given you the code to create a filtered Hermit warbler data set:



and to run the first linear regression – looking at the relationship between the number of Hermit warblers and understory percent cover.

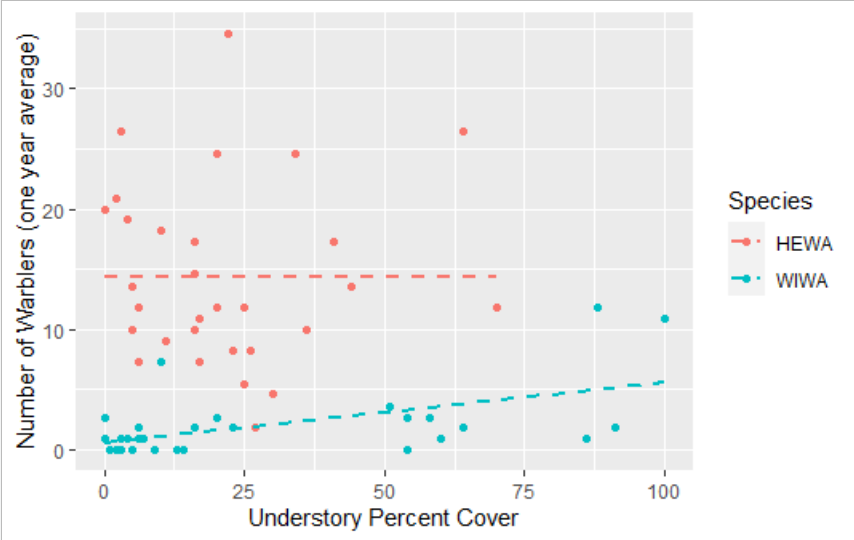


When you run summary(HEWA\_reg1), your output is:



**Two things to notice about this output.** 1. The p value (Pr(>|t|) for the understory percent cover data is 0.993, meaning that it is not a significant variable to predict the number of individual hermit warblers. 2. The multiple R2 is very low, and you saw this when you graphed the data – the line was nearly flat.

**FIGURE 1:**

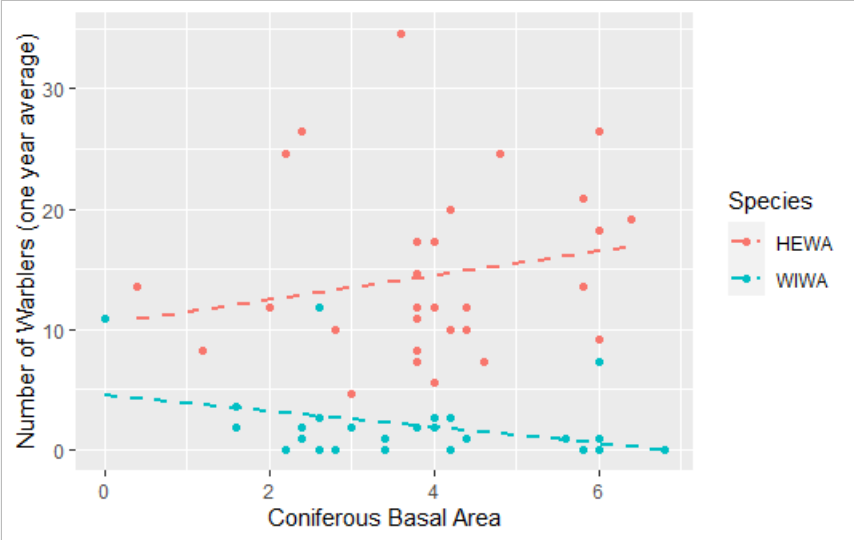


**6. Describe data and interpret the linear regression for Hermit warbler (include whether understory vegetation cover is significant and R2)**

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| Understory cover is not a good predictor for number of hermit warblers (p = 0.993). The multiple R2 is essentially 0, line is flat. |

**7. Describe data and interpret the linear regression for Wilson’s warbler (include whether understory vegetation cover is significant and R2)**

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| Understory cover is a good predictor of wilson’s warblers, where as understory percent cover increases, the number of wilson’s warblers increases, and this increase is significant (p = 0.00175). The multiple R2 does not show a very strong relationship however, at 0.2994. |

**FIGURE 2:** 

**8. Describe data and interpret the linear regression for Hermit warbler (include whether coniferous basal area is significant and R2)**

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| Coniferous basal area is not a good predictor for number of hermit warblers (p = 0.3043). The multiple R2 is also very low, 0.03, trending slightly as coniferous basal area increases the number of HEWA increases. |

**9. Describe data and interpret the linear regression for Wilson’s warbler (include whether coniferous basal area is significant and R2)**

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| Coniferous basal area is a good predictor of wilson’s warblers, where as coniferous basal area increases, the number of wilson’s warblers decreases, and this decrease is significant (p = 0.04278). The multiple R2 does not show a very strong relationship however, at 0.1386. |

**10. Make a claim that answers the scientific question: *What are the habitat conditions where the most Wilson’s warblers and Hermit warblers are found?***

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| From the 11 years of observations, Wilson’s Warblers detections were higher in forest areas with higher deciduous understory cover and lower in forests with greater amounts of coniferous trees.  Detection of Hermit Warblers, however, was not related to deciduous understory cover, but was higher in forest areas with greater amounts of coniferous trees. |

**11. What evidence was used to write your claim? For this answer I am looking for you to reference specific parts of the data, graphs, regression outputs, etc.. Then I’d like you to explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the two warbler species and their preferred habitats.**

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| ● The 11-year average detection of Wilson’s Warbler is lower in  plots with low understory cover and higher in plots with high  understory cover.  ● There is a positive relationship between Wilson’s Warbler  average detections and deciduous shrub cover. There is a  positive slope to the line of best fit for Wilson’s Warbler  average detection vs. deciduous shrub cover.  ● The number (average detections) of Hermit Warblers, in  contrast, does not vary with deciduous shrub cover. The slope  of the Hermit Warbler line is flat when plotted against shrub  cover.  ● The 11-year average detection of Wilson’s Warbler is higher in  plots with low conifer basal area and lower in plots with high  conifer basal area. Thus, there is a negative relationship  between Wilson’s Warbler average detections and coniferous  tree basal area (the amount of coniferous trees).  ● The 11-year average detection of Hermit Warblers is lower in  plots with low conifer basal area and higher in plots with  high conifer basal area. There is a positive relationship  between the number (average detections) of Hermit Warblers and conifer tree basal area  The number of Wilson’s Warblers were higher in areas with a  higher density of understory shrubs, and lower in areas where  there were fewer shrubs. Wilson’s Warblers need understory  plants for both nesting and access to food. It makes sense,  then, that they are more abundant in areas where there is higher  understory density.  Hermit Warbler numbers, on the other hand, did not vary in  accordance with the density of understory shrubs. This is  because they nest and find food in the upper canopy of dense  forests, and do not rely on understory shrubs for their food and  nesting. Thus, hermit warblers occur in high numbers in areas  where coniferous tree basal area is higher. |

**12. Your supervisor is looking over plans for future logging activities within the forest but first they want to know how it may impact these two warbler species. Given what you know from this study, what do you tell them? How will future logging impact these two species?**

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| Likely minimal impact – if shrubs are left intact in the understory, WIWA will still have nesting habitat. The HIWA wasn’t negatively impacted by the removal of large trees, but there were higher numbers in areas where the coniferous basal area was greater. |

**13. How might a wildfire affect the forest habitat differently than logging? I want you to think about both short term (immediately post fire) and longer term (a few years post fire). What do you think this might mean for habitat for each of these species?**

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| Many answers. In the most extreme, wildfire could remove both understory and large trees, reducing habitat for both species. A ground fire may remove shrubs, but leave tall trees, negatively impacting the WIWA in the short term but perhaps not impacting the HIWA. |

**Next steps**

**14. What are at least two additional questions and predictions that could be investigated by resource managers and applied ecologists to build on this research? Focus in on ecological questions that have a management based concern.**

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| Question 1 |  |
| Prediction 1 |  |
| Question 2 |  |
| Prediction 2 |  |

**15. What future data should be collected to answer Ques 1?**

Independent variable(s):

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|  |

Dependent variables(s):

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**16. What future data should be collected to answer Ques 2?**

Independent variable(s):

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Dependent variables(s):

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**17. For each variable you listed for #15 and #16, please describe how each could be measured/collected.**

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