# **Plants in the Human-Altered Environment (PHAE) Research Project**

**Background Worksheet**

This semester, we will be contributing to a national research project led by Dr. Jason Kilgore (Washington & Jefferson College) and Dr. Karen Kuers (University of the South). This is a project to compare effects of a continuum of landscape alteration intensities on plant diversity, biomass, and ecosystem services, and to explore human socioeconomic connections to plants in the environment.

**Introduction**

Humans have had an inordinate effect on the biosphere, creating a continuum of landscape alteration intensities that impacts the potential abundance, diversity, and productivity of plants (Galvani et al. 2016). While human impacts are often associated with biodiversity loss (Ceballos et al. 2015), resulting in reduced resistance to invasion by non-native species, reduced productivity, and reduced carbon sequestration (Cardinale et al. 2012), plantings in urban areas have also been shown to increase woody species richness (Blood et al. 2016). The human alterations of the landscape have changed the ways that we interact with and use plants and the environment (Cadenasso et al. 2007; Isbell et al. 2017), and, consequently, people have lost touch with many ways that we have historically interacted with plants.

The learning outcomes for this project are to:

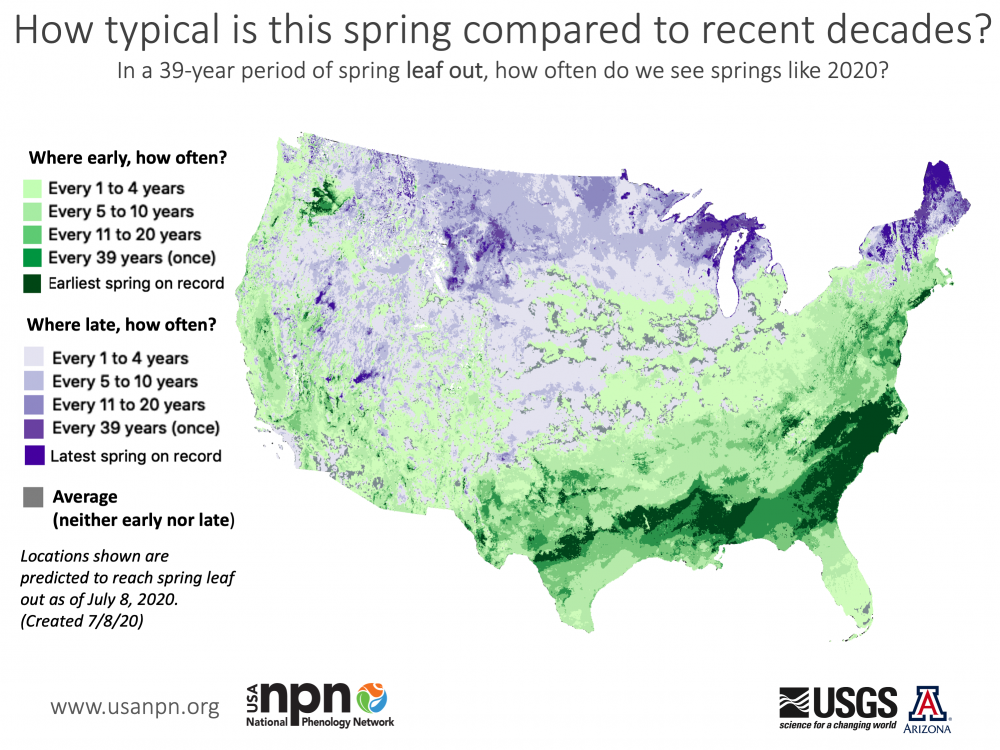
* Recognize a continuum of natural and human-altered landscapes
* Identify an appropriate study site and plot within a range of landscapes
* Classify landscape features, identify woody and non-woody plants, and measure plant abundance and cover
* Improve data management skills by collecting, sharing, and analyzing data using defined variables in spreadsheets
* Analyze spatially relevant data within and across project sampling locations to address local, regional, and continental scale research questions related to local landscape features and plant abundance, diversity, and size
* Become familiar with continental-scale ecological research through EREN and NEON and the importance of long-term ecological monitoring across time and space

**Throughout this worksheet and subsequent modules, there are spaces for you to answer questions and record data. These will be in blue text. Make sure you answer all of these.**

|  |
| --- |
| **Food for thought: answer this question before reading further.**   1. What is the value of measuring and recording environmental conditions and the organisms living in a particular location over a long period of time? |

**Long-term ecological monitoring** is the process of taking repeated empirical (i.e., quantitative) measurements of the environment and the organisms within that environment over a period of decades or longer ([Lindenmayer and Likens 2010](https://www.sciencedirect.com/science/article/pii/S0006320710000522?casa_token=A3-ohUk0GuAAAAAA:s1Ks0CxqCW5hnZeRW4Wdh3S7ZiYytnNMpEtTiWLWW-cBXc5VDfP4yO8bw08T522pgPXtzCALgg)). While humans have taken note of changes in their environment for a long time, only in the last century have we been more careful about these measurements. Henry David Thoreau filled dozens of journals with observations on the environment, plants, and animals ([Foster 2002](https://www.jstor.org/stable/827568?seq=1#metadata_info_tab_contents)), such as when certain bird species arrived north in the spring, when they nested, when they fledged, etc. These life history stages tend to be synchronous with certain changes in the seasons; we call these stages [phenophases](https://www.usanpn.org/taxonomy/term/16#:~:text=An%20observable%20stage%20or%20phase,are%20present%20on%20a%20plant.) and the study of life history stages [phenology](https://www.usanpn.org/about/why-phenology). However, changing climate creates early (or late) arrival of spring conditions that affect when deciduous trees produce leaves (Figure 1), which can in turn affect those animals that depend on those leaves.

What is the value of these observations? By closely monitoring key life history stages, abundances, presence/absence, and diversity, and tying these data in with environmental data, we can better understand how organisms respond to their environment. We can better understand fluctuations in population sizes, in diversity, and in community change. We can make more informed management decisions that affect the land and the organisms that live there. We can also better understand the “bigger picture” across the landscape in how environmental change, including climate change, is affecting organisms on this planet.



**Figure 1: Early vs late spring compared to 2020 for the contiguous United States.** Map from USA - National Phenology Network.

However, a long-term ecological monitoring program must contain certain elements to make it functional, effective, and efficient ([Lindenmayer and Likens 2010](https://www.sciencedirect.com/science/article/pii/S0006320710000522?casa_token=A3-ohUk0GuAAAAAA:s1Ks0CxqCW5hnZeRW4Wdh3S7ZiYytnNMpEtTiWLWW-cBXc5VDfP4yO8bw08T522pgPXtzCALgg)). For example, the program should be question driven; that is, the program should be guided by a conceptual model and by a rigorous study design that will test *a priori* predictions. To be most useful, these predictions should be related to contrasting management alternatives. In addition, data management should be clear, transparent, and user-friendly, therefore the program should rely on key personnel with data management skills. And the program should provide relevance for its customers ([Vander Naald et al. 2019](https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.2875#ecs22875-bib-0032)).

### **Examples of long-term ecological monitoring programs**

The **Long Term Ecological Research (LTER) Network** was established in 1980 with funding from the National Science Foundation (NSF) to monitor the environment and its organisms across six different types of ecosystems. The LTER Network now has [28 sites](https://lternet.edu/site/) throughout the U.S. and Antarctica, offers standardized protocols for measuring key variables, and data from their [online portal](https://portal.lternet.edu/nis/home.jsp). This [website](https://lternet.edu/how-we-work/) provides a good overview of how the LTER works.

The **USA National Phenology Network (**[**USA-NPN**](https://www.usanpn.org/home)**)** was established in 2007 by an NSF grant to monitor and record phenology data, develop an accessible [database](https://www.usanpn.org/data), and motivate [citizen scientists](https://www.usanpn.org/partner/volunteer-scientists) to contribute phenology data from across the U.S.

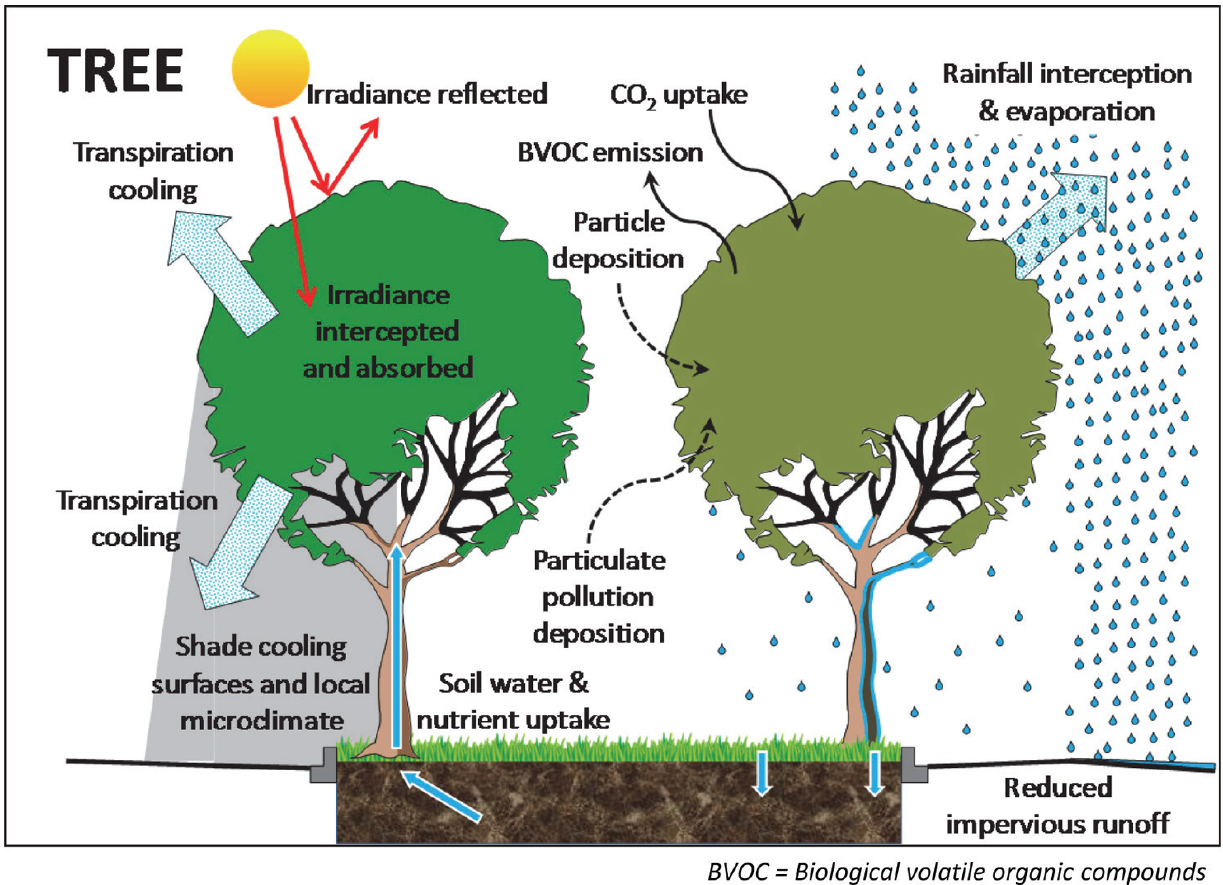
The **National Ecological Observatory Network (**[**NEON**](https://www.neonscience.org/)**)** was established in 2011 by an NSF grant and became operational by 2019 to collect environmental data and archival samples that characterize plant, animals, soil, nutrients, freshwater, and atmosphere from 81 field sites strategically located in terrestrial and freshwater ecosystems across the U.S. [Data are gathered](https://www.neonscience.org/data-collection) through *in situ* automated instruments (mounted on towers), observational sampling, and airborne remote sensing surveys and are available through a [data portal](https://www.neonscience.org/data).

|  |
| --- |
| **Question:**   1. What do the green areas in the map above mean? What do the purple areas mean? What could be the implications of the lighter colors for other organisms? Provide an example. |

**Research questions**

Given the experimental design of PHAE, you could develop a variety of research questions, but we will focus on one research question related to the importance of woody plants in human-altered environments. We know that woody plants (trees and shrubs) provide structure and function in ecosystems, including urban ecosystems. They provide habitat for a myriad of other organisms, including animals, fungi, bacteria, lichens, and even other plants. Woody plants also moderate low and high temperatures, creating a more favorable environment for other organisms. Especially in urban ecosystems, woody plants are important for a variety of ecosystem services, like water uptake, air quality improvement, and ultraviolet (UV) radiation reduction, as well as human health and well-being. However, despite providing over $18 billion annually in ecosystem services, tree cover in urban areas is declining in 44 of the 50 states in the U.S. (Nowak and Greenfield 2018).

Woody plant cover can vary in structure and composition, which affect the services that they provide to other organisms. For example, shrubs are typically shorter, have foliage (leaves) closer to the ground, and lower biomass than trees, especially mature trees. Also, some species are native to a region and are thus likely to be better acclimated to surviving in its climate and interacting with other native species. Other species are introduced from other areas into the region. Some of these non-native species can become invasive by regulating the growth and/or reproduction of other organisms through chemicals that they produce or by excessive competition for limiting resources like light, water or nutrients. Invasive species typically have fast growth rates, reproduce relatively early in their life cycle, have high reproduction, widely disperse their propagules (e.g., seeds, rhizomes), and affect community composition, structure, and function. While urban forests are often viewed as degraded, lower quality, and less diverse than native forests, some evidence suggests that the urban forests are more biodiverse (Pregitzer et al. 2019), important in maintaining ecosystem services (Figure 2; Livesley et al. 2016), and more prepared to respond to climate change (Swanston et al. 2016).



**Figure 2. Examples of ecosystem services provided by trees.** Image from Livesley et al. (2016).

The question that we will investigate in PHAE is the importance (e.g., density, size, cover, ecosystem services) of woody plants across a range of intensities of human alteration of the environment. As humans obtain resources from the environment and convert the land to our use, we change the composition, structure, and function of its living components. In this project, we characterize local patches of landscape (“plots”) through quantitative measures of anthropogenic influence, such as proportion of impervious surface area and human-made viewshed, and land cover type classification. Within each patch of landscape, woody plants (shrubs and trees) are identified, mapped, and measured. We then compare these data across sites from participating institutions and online data from EREN and NEON.

Within geographic regions capable of supporting trees, we predict that the intensity of human alteration of the environment is negatively related to the importance of woody plants in local landscape patches. While most studies are specific to a region (Blood et al. 2016) or community (Pregitzer et al. 2019), PHAE leverages the spatial power of students distributed across the entire continent, as well as existing online data, to investigate fine-grain phenomena at the large-extent scale.

|  |
| --- |
| 1. Generate or draw a plot illustrating one prediction for this project. Choose one type of landscape alteration (e.g., impervious surface area (%) or human-made viewshed (%)) as your independent variable for the x-axis. Choose one measure of the importance of woody plants (e.g., number of trees, total crown cover of woody plants) in local landscape patches as your dependent variable for the y-axis. Be sure to label the axes with your variables (units). Annotate the graph with a short note to explain the mechanism for the pattern that you predict in your graph.   https://docs.google.com/drawings/u/0/d/s_Uns7QPJ91IVLnrvyxbRDQ/image?w=425&h=301&rev=38&ac=1&parent=1_X8vqgflKw08XFoNBLPogb0MGBdywo3yMHXTcBdUt8I |