Plants in the Human-Altered Environment (PHAE)

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Module 1. Identify and characterize your study site (online)[1,2]

Part I. Identify study site

Estimated time to complete: 30 minutes

Student learning outcomes:

- Identify study site using aerial images
- Use online mapping tools to select, delineate, and calculate area for a study site
- Use a random (stochastic) number generator to select sites

The **study site** is that space in the environment where your study will take place and should be carefully selected to address your research question and to minimize bias. In this project, we will use a flexible methodology to identify your study site to address a variety of research questions. The study site should range from 1000 to 5000 m^2, or 0.1 to 0.5 hectare. You could identify several study sites from which one could be randomly selected for your project.

Confer with your instructor on how you should select areas for consideration as study sites. Each area should be freely accessible or with permission of the owner, and each area should be relatively close to where you are staying. The environment could be very different, from forested to agricultural to parkland to urban. For example, if you are taking a forest ecology course, you may have to choose areas with trees; however, if you are taking an introductory biology course, you may be interested in a range of landscape types. Regardless of the landscape type, even treeless, you will be able to participate in this project. You should have an idea of where your study site(s) will be located before you proceed.

Question:

[1] Version 13 August 2020. Contact eren.phae@gmail.com for questions, comments, or suggestions.
[2] This work was supported by the National Science Foundation under Grant No. DBI-2037827. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

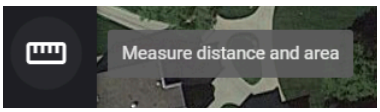
1) In what general area will you be locating your study site? Why are you choosing this area?

We will use GoogleEarth, a freely available online mapping system, to identify, measure, classify, and organize your study site(s). On the homepage, choose “Launch Earth”, which will take some time to load depending on your internet speed.

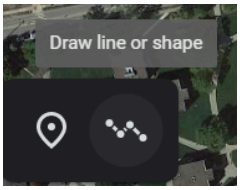
First, let’s create a new project. On the left panel, choose “Projects” and then select “Create project in Google Drive” in the “New Projects” dropdown menu. Name the project with your last name_first name - course number - institution, unless your instructor provides a standardized naming system for your Project name.

Question:
2) What is the name for your Google Earth Project?

Second, we will identify and delineate your study site(s). From your project page, click the “New Feature” dropdown menu, select “Search to add place”, enter your place name or zip code, and navigate to your study area. Within your study area, choose an area that could be used as your study site to address your research question. For example, you might be interested in an area bounded by sidewalks on your campus, or you could delineate a particular section of forest bounded by a fence line on one side. To check the area of your potential study site, select the ruler icon on the left panel, choose units of “Meters” from the dropdown menu, and then delineate a closed polygon around your study site. A measured area will appear on your screen once the polygon is closed. Your sampling frame should be between 1000 m^2 (0.1 hectare, ha) and 5000 m^2 (0.5 ha) in area.



If this polygon meets the area criterion, then choose the “Draw line or shape” tool to create your first study site. If your site has a wide boundary (e.g., sidewalk or road), consider whether the polygon should follow the inside, outside, or middle of the boundary. Choose an appropriate name for this site. You will need to remeasure the area for your final study site by choosing the ruler function, as above, and then copying the area value by clicking the copy icon on the right side of the area dialog box.



Edit the features of your study site by drifting over the frame's name and then clicking "Edit features". You can change the site's name, as well as boundary and fill colors, in this dialog box. You can also note the latitude and longitude (in decimal degrees, dd) for the polygon center. In the text box below the study site's name, paste the area value with units (Figure 1).

Questions:

3) What is the name (e.g., TechCtr Quad) of your study site (variable "nameSite")?

4) What is the area (m^2; e.g., 2,383.96 m^2) of this study site?

5) What are the latitude (dd; e.g.,40.171065°) and longitude (dd; e.g., -80.2389528°) for the approximate center to your study site?

Latitude:

Longitude:

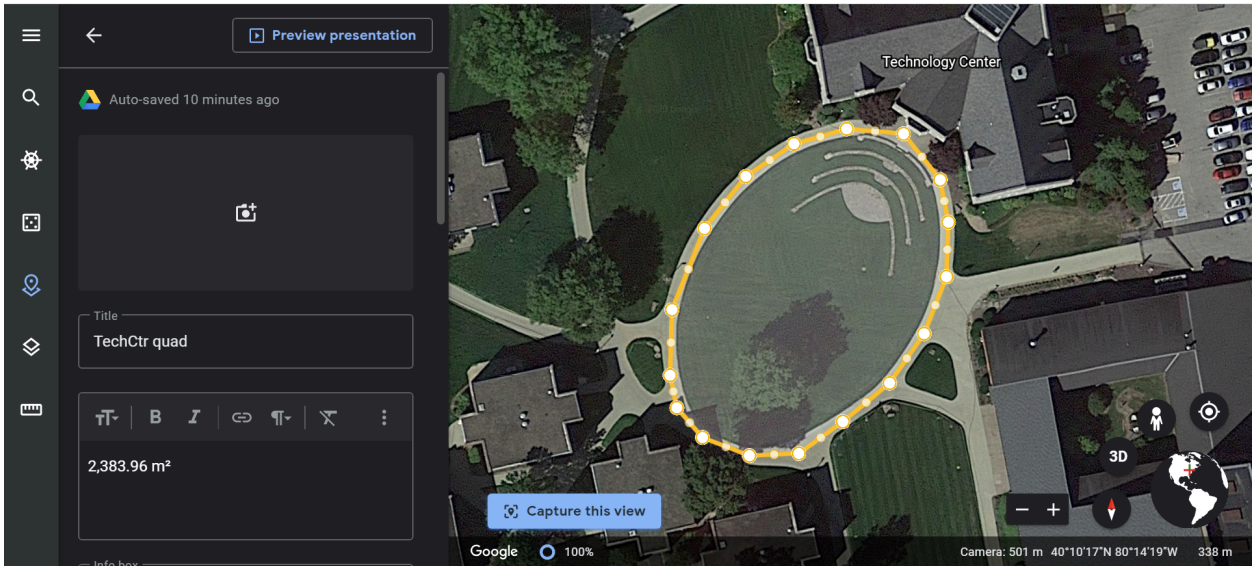


Figure 1. Example study site in GoogleEarth. The study area has been delineated and the measured area has been pasted into the objects features. Onsite photographs of the study site can also be added to the object's features.

Choose additional study sites, and then view all of your sites using the "Present" icon. You may be asked by your instructor to present the sites for review; one way to share the sites is to

Ctrl-PrtScn and paste the screen showing the site's polygon and area, as in Figure 1. Depending on your research question(s) and instructor, you may choose to use only one of your study sites. Assign a number to each of your sites, and then use Random.org, or some other random (stochastic) number generator, to select the sites that you will use for this project. Give this site a relevant name (e.g., Tech).

Record the information for your selected study site(s), including its name (variable "nameSite"), area, latitude, and longitude, in the appropriate column (variable) and row (your project) in the copied version of the GoogleSheet (PHAE - Site Data) for your class.Once your class's data are entered and proofed, please share the data file with the PHAE gmail account so that we can add your data to the other sites, including sample data from EREN and NEON sites ("Compiled data" files).

Part II. Characterize your study site

Step 1. Characterize the climate of your study site (remote)

Estimated time to complete: 30 minutes

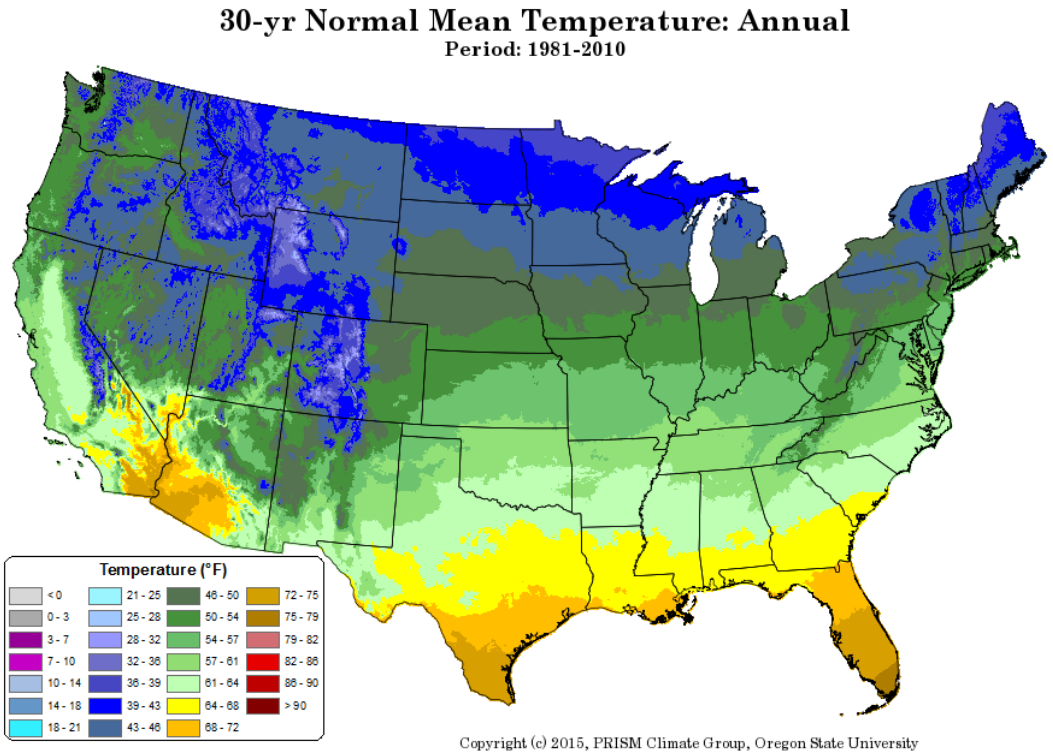
Student learning outcomes:

- Use online and local resources to determine climatic and geographic characteristics of the research site

You can easily obtain a wealth of information on the climatic and geographic characteristics of your study site from the internet. Most of these characteristics will vary across the continent and influence the potential for plant growth. For example, note the patterns in mean annual temperature and precipitation (Figure 2) for the 30-year period from 1981-2010 in the United States.

Questions:
1) What pattern(s) do you see in mean annual temperature (Figure 2)?

2) What pattern(s) do you see in mean annual precipitation (Figure 2)?



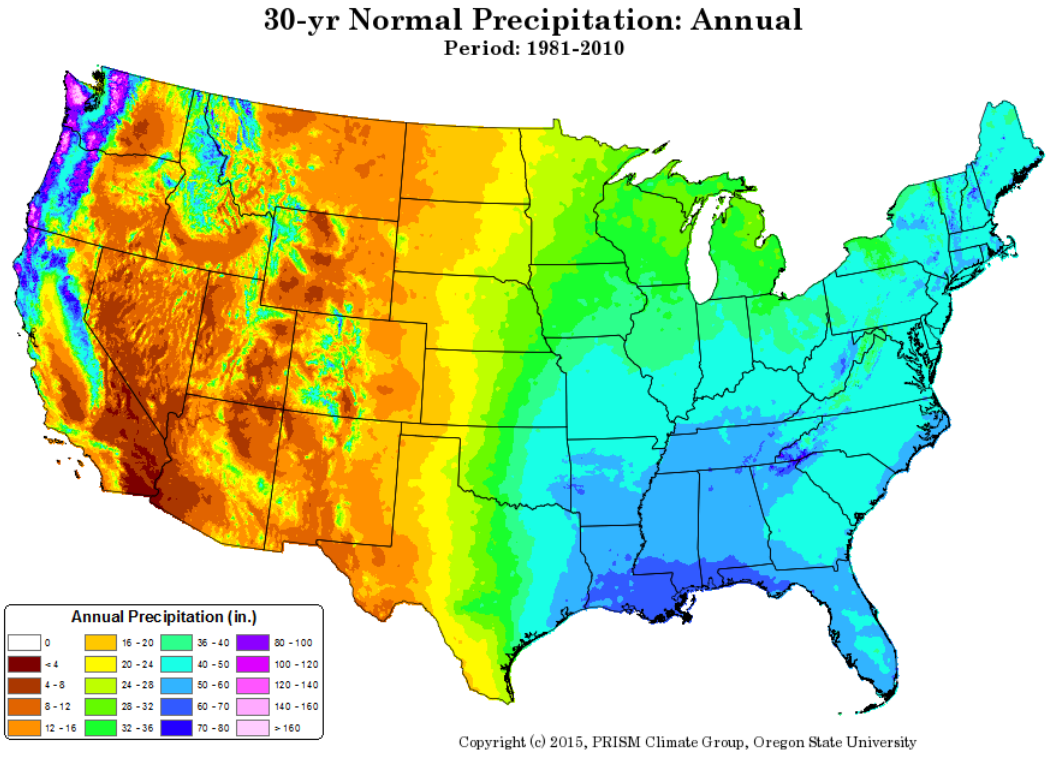


Figure 2. Mean annual temperature (*top*) and precipitation (*bottom*) (1981-2010) for the contiguous U.S. Map is from Northwest Alliance for Computational Science & Engineering (NACSE), Oregon State University.

Questions:
3) What effects might the combinations of these patterns have on the length of the growing season for plants?

4) What kinds of adaptations might you see in plants as a result of the combinations of these patterns of mean annual temperature and precipitation?

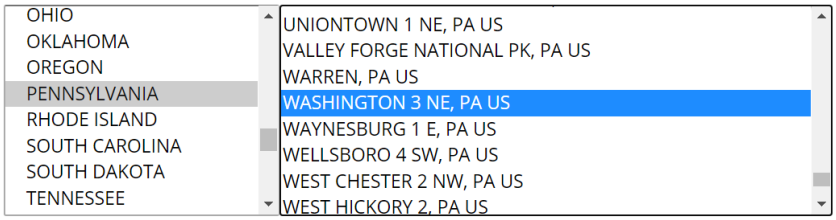
We typically use the most recent 30-year average for temperature and precipitation variables to get “mean annual” values. You can find the most recent set of these data, called U.S. Climate Normals, from the National Centers for Environmental Information (NCEI), a service of the National Oceanic and Atmospheric Administration (NOAA) of the US government. This dataset contains daily, seasonal, and monthly Normals of temperature, precipitation, snowfall, heating and cooling degree days, frost/freeze dates, and growing degree days calculated from observations at approximately 9,800 stations operated by NOAA’s National Weather Service.

Once you are on the U.S. Climate Normals website, select “Launch Quick Access” button, then the “Annual/Seasonal” tab; make sure that you are on the 1991-2020 tab on the right side. Select your state and then the city closest to your study site. You should get a table similar to what you see in Figure 3.

You can learn more about that particular weather station by clicking “View station details" or more information about the growing season (i.e., freeze-free season) by clicking “View station report”. Note that the weather station for this example has the name of “WASHINGTON 3 NE, PA US” and an ID of “USC00369318”. This station is located at an elevation of 396.2 m, latitude of 40.1789°, and longitude of -80.1889°. Thus, enter the weather station information into the appropriate variables of nameStn, IDStn, elevationStn, latitudeStn, longitudeStn in the **PHAE - Site data** Google Sheet.

Once you have entered the weather station information, then you need to convert the values given in Imperial units to metric units for mean annual precipitation (mm; multiply the value in inches by 25.4), mean annual minimum temperature (° C; subtract 32 from the value in ° F then multiply by 5/9), mean annual temperature (° C), and mean annual maximum temperature (° C).

These data are entered as appropriate for the variables pptMean, tempMinMean, tempMean, and tempMaxMean in the **PHAE - Site data** Google Sheet.



WASHINGTON 3 NE, PA US

View Station Details | View Station Report

SEASON	PRECIP (IN)	MIN TMP (°F)	AVG TMP (°F)	MAX TMP (°F)
Annual	38.87	38.1	49.0	60.0
Winter	8.21	19.1	28.3	37.5
Summer	11.04	56.7	68.4	80.1
Spring	10.51	36.0	47.8	59.5
Autumn	9.11	40.0	51.2	62.4

Figure 3. Mean annual and seasonal climatic variables from 1981-2010 U.S. Climate Normals when choosing "Washington 3 NE, PA, US" as the nearest weather station. Note that Imperial units must be converted to metric before entering the data into the GoogleSheet.

The growing season length is limiting to the types of and biomass production by vegetation and is generally regarded as that period during the growing season after which the last frost occurs in the Spring and before the first frost in the Fall (Figure 3). However, like most environmental factors, the growing season length is changing, with a 6-10-day increase in eastern North America and 16-19-day increase in western North America since 1991, relative to earlier in the 20th century (Walsh et al. 2014).

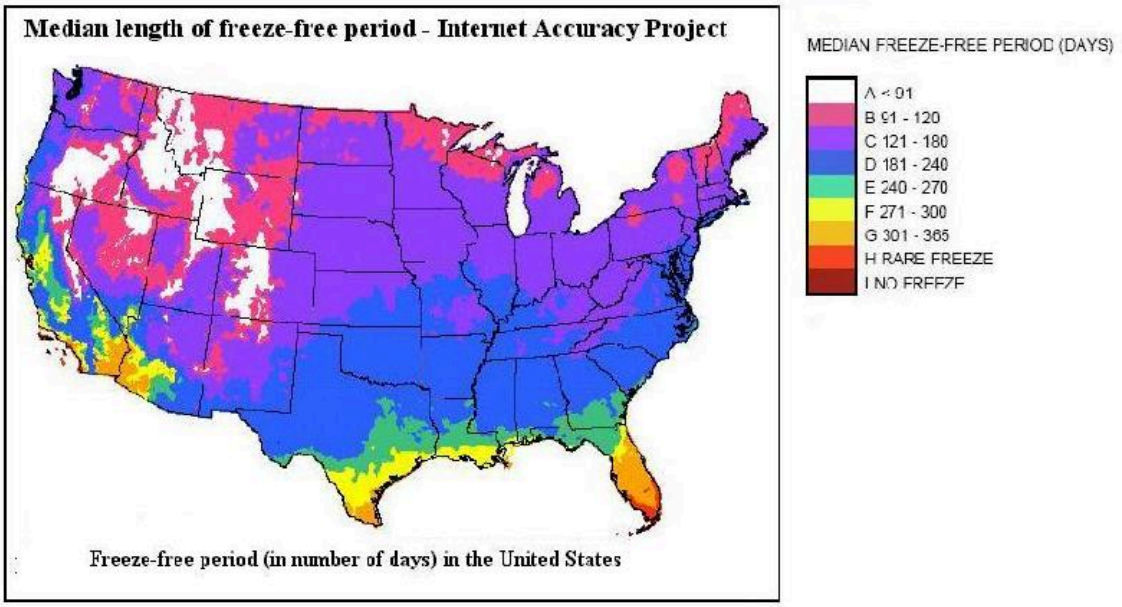


Figure 4. Median length of freeze-free period in the U.S. Map is based on National Weather Service data and produced by the Internet Accuracy Project.

Question:
5) What spatial patterns do you see in growing season length (Figure 4)? What factors drive these patterns?

We can obtain an approximate length of the growing season from several sources, including, surprisingly, Dave's Garden, which uses National Weather Service data to interpolate an estimated freeze-free growing season length. Once you are on the website, type in the ZIP code nearest your study site. Enter this variable, FFGS (days), into the **PHAE - Site data** Google Sheet.

Step 2. Classify the land cover of your study site

Estimated time to complete: 30-60 minutes

Student learning outcomes:

- Identify land cover types from aerial imagery
- Use online mapping tools to measure area for land cover types within study site

Potential applications:

- Compare surface areas of living to nonliving components across landscapes
- Gather socioeconomic and demographic data from other sources to relate to land cover types

We will classify and estimate the area of cover within your study site in two different ways.

Land cover types:

Return to your study site image in Google Earth, and zoom in to the frame to fill the screen. Identify and determine whether different types of land cover (Table 1) occur within your study site.

Table 1. Land cover type variables. Each land cover type has a variable code which is the abbreviated name used in the spreadsheets. All of these land cover types are measured in square meters (m^2) and must sum to the total area of the study site or plot, as directed.

Variable name	Variable code	Description
impervious hard surface	imper.hd.surf	hard surface that prevents water infiltration into the soil, such as cement/asphalt sidewalk, road, roof, industrial equipment, packed-soil trails/roads
semipervious hard surface	semiper.hd.surf	impervious hard surfaces with pervious gaps, such as brick sidewalks, gravel walkways/driveways/roads
managed lawn	man.lawn	lawn (grass) that is actively managed (mowed)
managed landscape (unmown)	man.landsc	managed landscape beds containing flowers, shrubs, small trees, and/or mulch
cropland - rows	man.crop	row crops, such as corn, wheat, lettuce, beets, vineyards
cropland - no rows	man.fld	animal pasture or field that is managed for hay
unmanaged nonwoody vegetation	unman.fld	early successional habitat that is formerly managed and dominated by nonwoody plants; fallow fields; recurrently disturbed areas; prairies
scrub-shrub	scr.shr	canopy cover by woody plants (shrubs, young trees) less than 5 m in height, including regenerating forest
tree	tree	canopy cover by trees greater than 5 m in height
exposed soil	exp.soil	soil barren of any substantial vegetation
exposed rock	exp.rock	bare rock barren of any substantial vegetation
water	water	open water barren of emergent vegetation

Question:
1) What land cover types (Table 1) are present in your study site?

Use the Ruler tool to delineate and calculate areas for each of the land cover types. You may find this task easier if you measure the total area of the study site, then measure easily identifiable land cover types, like managed lawn (Figure 5) or tree canopy (Figure 6), sum the individual areas for each of these cover types, then subtract from the entire area for the most difficult cover type. You could record each of the parts of each land cover type in the above box, then sum them before entering the total area for each land cover type into the appropriate column (variable) and row (your site) in the **PHAE - Site data** Google Sheet.

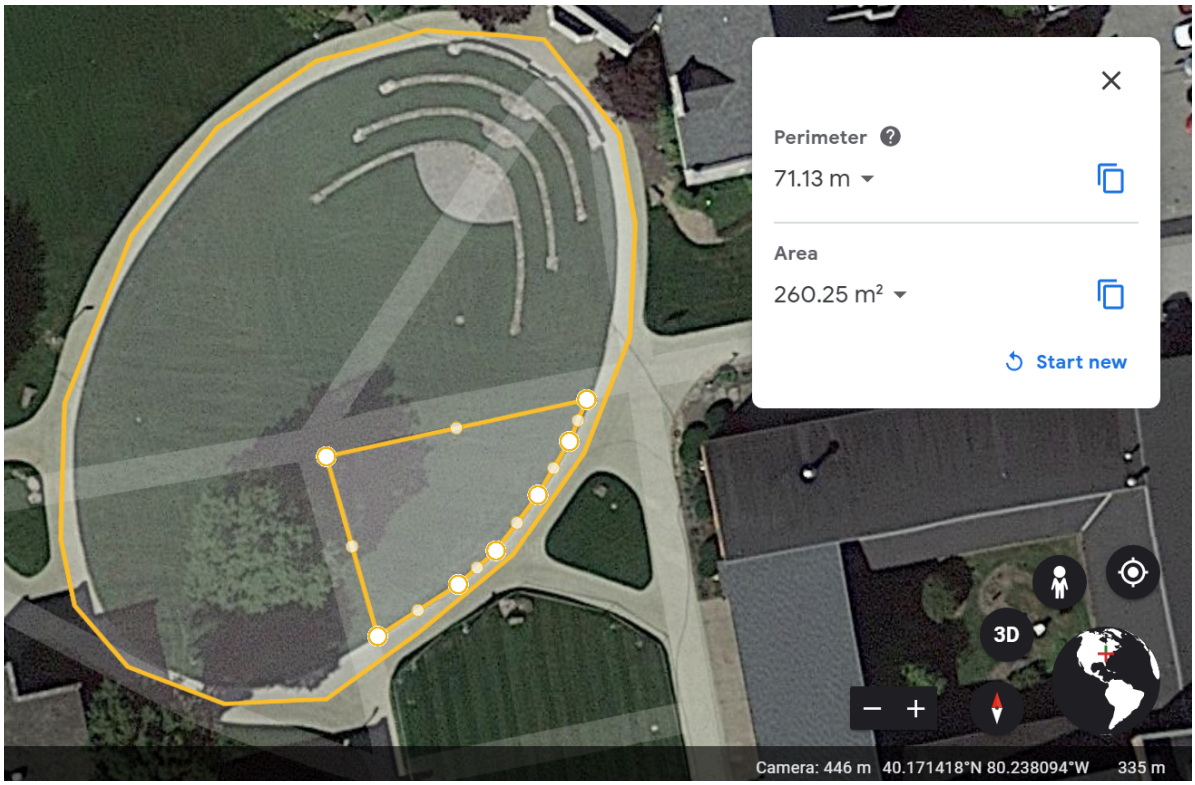


Figure 5. Delineated land cover type of "managed lawn" in the study site. The area for this section of "managed lawn" is shown in the dialog box; record this area, measure the other "managed lawn" segments, then sum them for the total area of "managed lawn." Enter this value into the GoogleSheet.

Within your study site, you may have vegetation that provides vertical structure, also called canopy, provided by shrubs, trees, and even vines. For this project, we are ignoring vines and defining trees as greater than five meters in height, and defining shrubs as less than five meters in height. While tree canopy can be visualized in aerial images taken during the growing season, estimating canopy area for deciduous trees from aerial images taken during the dormant season can be tricky. In addition, shrub canopy is difficult to see if any tree canopy exists. You will likely need to visit your study site to identify overlapping canopy areas or to differentiate shrub and tree canopy, and then do your best to estimate these areas in GoogleEarth.

Questions:
2) Is tree canopy clearly present in your delineated study site? Are the trees in leaf, whether evergreen or growing-season deciduous?

3) Is the shrub canopy clearly present in your delineated study site? Could shrub canopy exist under the tree canopy?

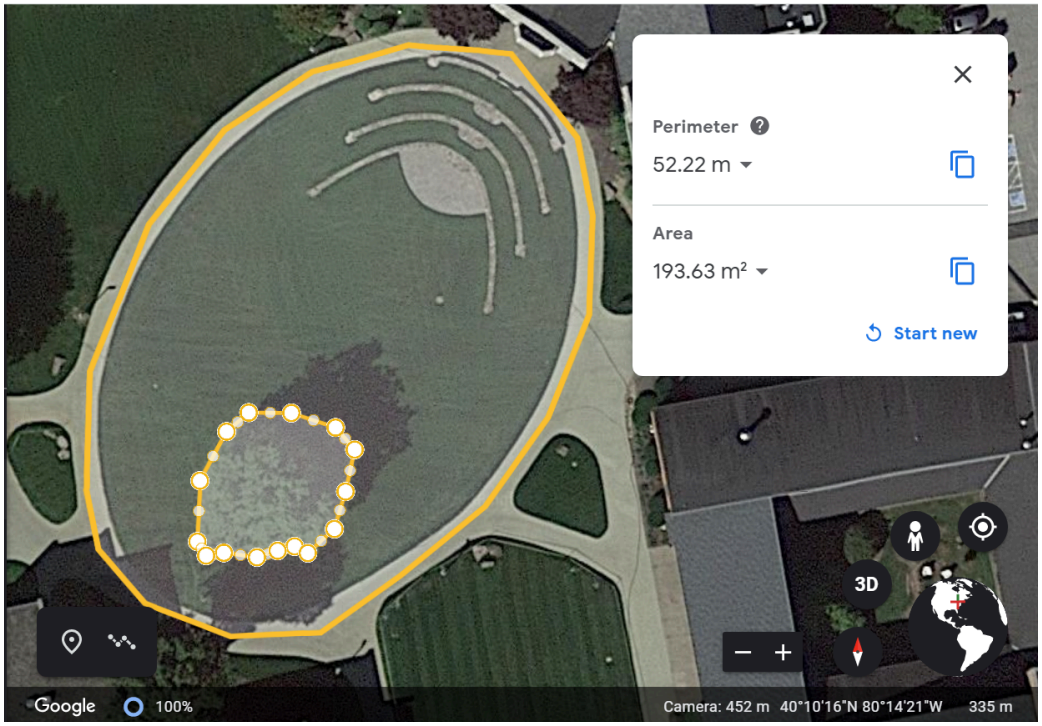


Figure 6. Delineated land cover type of "tree canopy" in the study site. The area for this canopy is shown in the dialog box; copy and paste this value into the PHAE - Site data GoogleSheet. Multiple locations for a given land cover type will require their areas to be summed before entering into the GoogleSheet.

Land cover type (NLCD 2016):

We will now determine the land cover type as interpreted by remotely sensed data (NLCD 2016). Go to the online MRLC Viewer; you may want to drag this tab off the browser to open a second browser just for the Viewer and to simultaneously view your study site on the first browser window.

On the left panel, choose the Contents tab, and check the boxes for “2016 CONUS Impervious Surface”, “2016 CONUS Tree Canopy”, and “2016” CONUS Land Cover”. You may already notice different colors on the map; click the Legend tab on the left panel to interpret the colors by land type (NLCD 2016). Use the pan and zoom features to zoom in to your study area. Click on the “Identify tool”, move your cursor so that the latitude and longitude in the upper right corner of the image match your study site’s location (from “Edit features"), and then click on the map (Figure 3). You will see the Impervious Surface (%), Tree Canopy (%), and Land Cover type indicated in the right panel. Transcribe these data to the appropriate column (variable) and row (your project) in the **PHAE - Site Data** GoogleSheet.

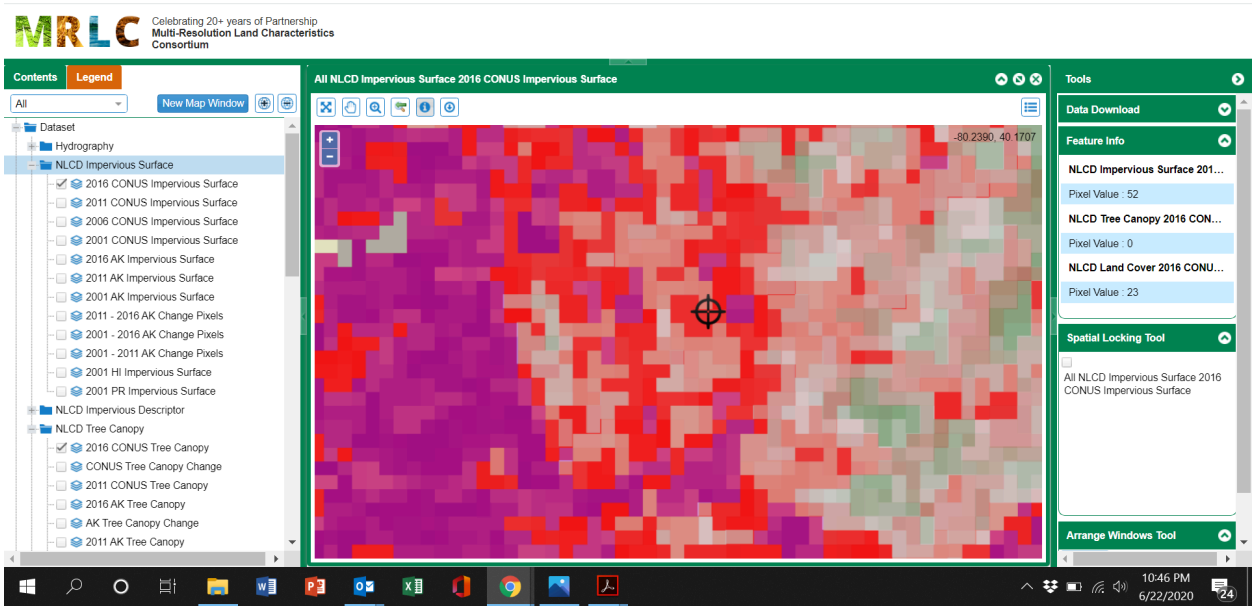


Figure 7. Example land cover type map from NLCD (2016). The “target” is located at the coordinates for the center of the study site polygon and sits on a 30-m x 30-m grid cell with 52% impervious surface, 0% tree canopy, and land cover type of 23, which is “Developed, Medium Intensity”.

Questions:
4) What values do you get for your study site for:

Impervious Surface (pixel value, %) -

Tree Canopy (pixel value, %) -

Land Cover Type (pixel value) -

5) What are the numerical value (e.g., 23) and the description for your study site's Land Cover Type (see Legend)?

Data entry and data sharing with EREN.PHAE

Students: Find the copy of the GoogleSheet (**PHAE - Site data**) provided to you by your instructor. Enter the data that you have collected. Double-check the data to see that the data were correctly entered. Be aware of the appropriate number of decimal places, and don't add any accidental spaces!

Instructors: Once your class's data are entered and proofed, please share the data file with the PHAE gmail account so that we can add your data to the other sites, including sample data from EREN and NEON sites ("PHAE - Compiled Data" Google Sheet).