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LA12 Fall 2022:
Environmental Science for Sustainable Development

Lab Week 6:
Urban Forestry

This post lab assignment has five parts. Parts I and II are based on the measurements you conducted during lab for four tree species (Fig. 1 and Fig. 2). In part III, you use a modeling tool called ***i-tree*** to assess tree benefits through land cover classification at a one-hectare location on campus assigned to each of you. In part IV, we provide you with results from *i-tree* land cover classification and ask you to make assessments of tree benefits based on the data provided.

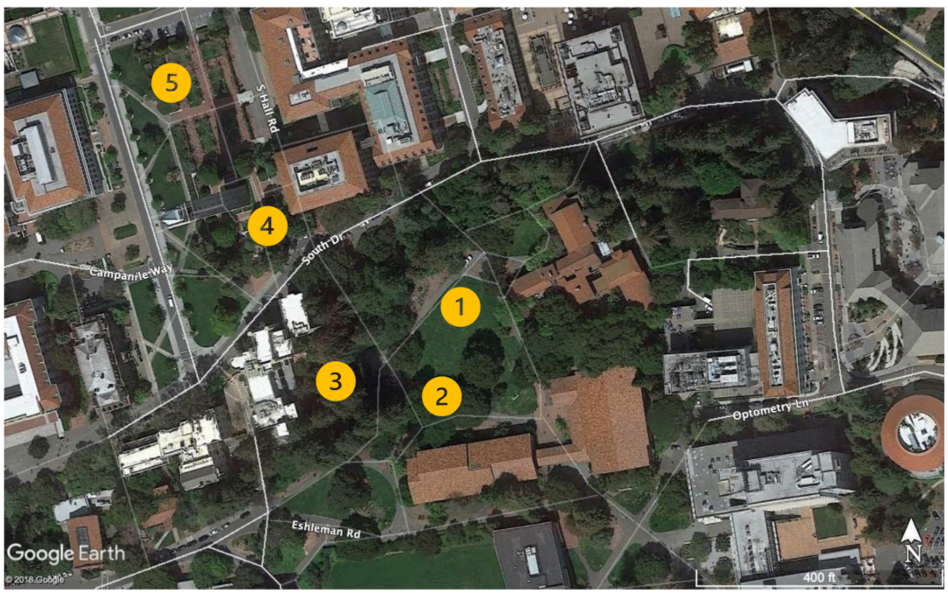

Fig. 1 Microclimate research sites on UC Berkeley Campus. numbers represent the following: 1=Lawn (control); 2=Coast Live Oak; 3=Redwood; 4=Canary Island Pine; 5=London plane tree

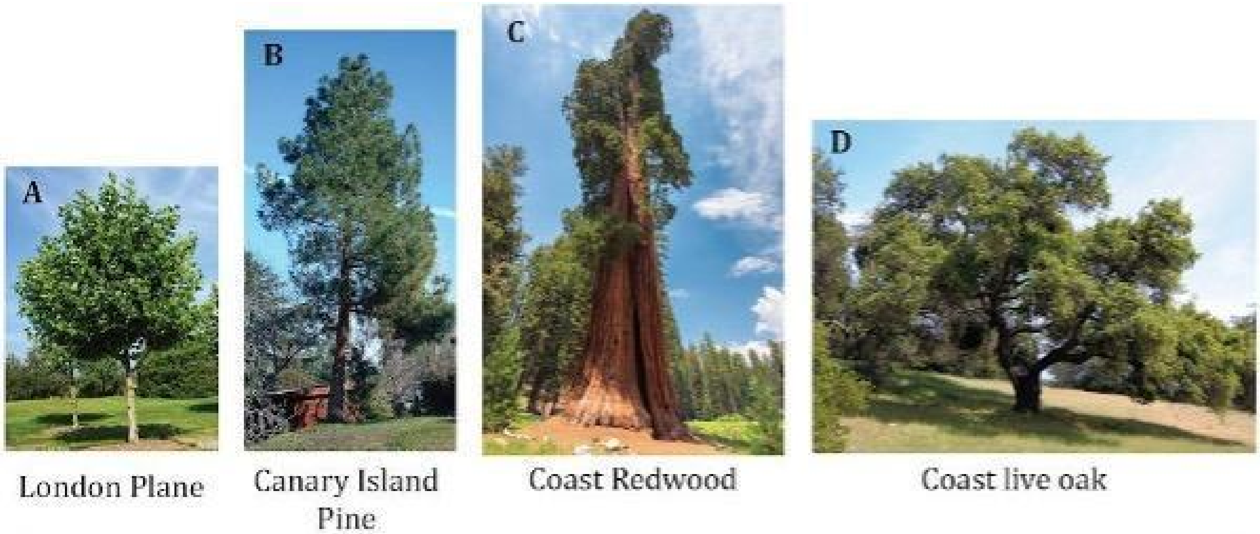

Fig. 2: Tree species under study.

Part I: Bioclimatic Chart

1. Enter air temperature and relative humidity data, from the shaded and non-shaded spots, your group measured during lab, in the corresponding spreadsheet named with your lab section. Spreadsheets are linked in this week's assignment prompt in bCourses. Also enter your name. **[1 point]**

2. The purpose of having at least two measurements per site is to validate measurements. Do a Control Assessment and Quality Control (QA & QC) of those measurements. This means you can make an average of those if they are in a close range. But if you have odd outliers do not include those in the validated data in the table below.

3. Enter the validated average of air temperature and relative humidity in table 1. **[2 points]**

4. Use the 'Olgyay Bioclimatic Chart', Figure 3, to plot the data measurements from table 1. You can either hand draw the data points on the chart and embed it as an image or you can use editing tools in Microsoft Word or Powerpoint to plot the data points. Code your graphic (use different colors or symbols) so that data from different tree types (locations) can be distinguished. Remember you are plotting air temperature vs. relative humidity for shaded and non-shaded spots for each of the four tree species plus the control site (lawn). Include a legend in your chart. Make points and legend legible. **[2 points]**

Table 1. Air Temperature and Relative Humidity measurements by students at the Urban Forestry Lab

Location #	Tree Species	Shaded Spot			Non-shaded spot		
		Air Temp (ºF)	Relative Humidity (%)	Ground Temp (ºF)	Air Temp (ºF)	Relative Humidity (%)	Ground Temp (ºF)
1	Control (lawn)	**NA**	**NA**	**NA**	**81° F**	**74%**	**77° F**
2	Coast Live Oak	**76° F**	**51%**	**68.8° F**	**81° F**	**60%**	**82.3° F**
3	Redwood	**72° F**	**60%**	**73.1° F**	**65° F**	**51%**	**114° F**
4	Canary Island Pine	**78° F**	**57%**	**74.6° F**	**82° F**	**45%**	**114° F**
5	London Plane Tree	**78° F**	**60%**	**72.8° F**	**79° F**	**61° F**	**89.4° F**

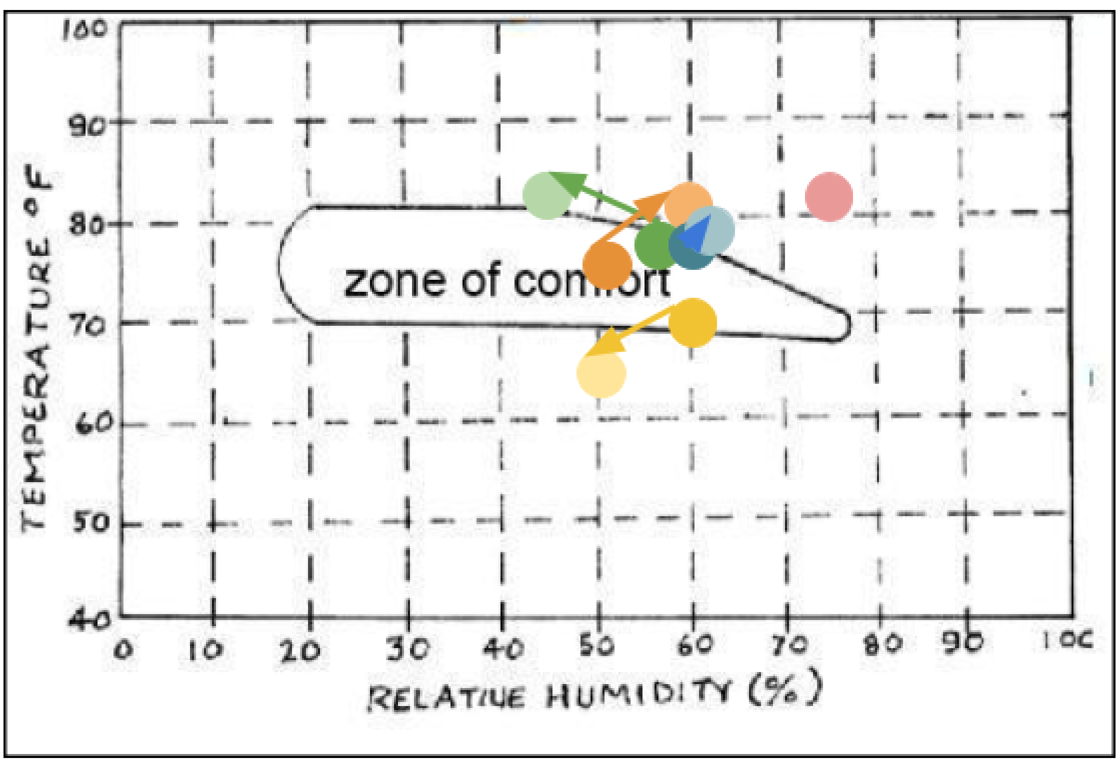

Figure 3. Olgyay's zone of human comfort

5. Interpret your plot. Please write in full sentences

a. How many of the data points fall into the microclimatic comfort zone (the solid shape in the middle of the graph) at the time of the readings? How many of the data points do NOT fall into the microclimatic comfort zone at the time of readings? **[1 point]**

Four data points fall into the microclimatic comfort zone–all four are the shaded areas. When measuring the relative humidity and air temperature of the other 5 non-shaded regions, these points fell outside of the microclimatic comfort zone.

b. Based on the data for the entire lab section, and the field observations, what tree grove characteristics appear to have the greatest influence on whether points fall into the human comfort zone? Explain plausible reasons. **[1.5 points]**

Tree cover has probably the most significant influence on whether points fall into the human comfort zone. When the branches are closer to the ground and there are wide leaves that cover most of the ground below, the temperature and humidity stay at comfortable levels. For example, the Coast Live Oak has long branches that extend far out from the trunk. This tree guarantees its comfort and falls solidly in the comfort zone due to this reason.

6. Based on the temperature measurements reported in table 1,

a. How does ground temperature change between shaded-spots in comparison to non-shaded spots for each of the tree-species locations? **[1.5 points]**

For all the tree species, ground temperature increases when going from shaded areas to non-shaded areas.

b. Does relative humidity, ground temperature, and air temperature in shaded spots under trees compare to the control site (lawn)? You can answer this question with a table of the differences and explain significant changes. **[1.5 points]**

Relative humidity, ground temperature, and air temperature do not directly compare to lawn control site because the lawn has no shade while the shaded spots do. But, all shaded areas fall within the comfort zone based on humidity and air temperature while the control site falls well outside of this zone, which makes sense since there is no tree cover to make the lawn comfortable. Ground temperature of the lawn is also similar to the ground temperature of the shaded areas

c. Track measurement differences between air temperature and ground temperature for each of your measurements from table 1. Is ground temperature different than air temperature? If so, where is that difference larger? What can explain the difference? Use your observations of ground cover to explain this answer. **[1.5 points]**

Between the shaded and the non-shaded areas, the difference between air temperature and ground temperature is the largest in the non-shaded areas. With the only exception being the Coast Live Oak, the non-shaded areas has large differences because the ground freely absorbs the heat from the sky and increases the temperature. When leaves and branches almost completely cover the ground from direct sunlight, the ground temperature stays relatively low.

Part II. Solar Heating

1. Extract the *Raw Solar Radiation* measurements from your lab section spreadsheet for each site.
2. Conduct a QA and QC. Calculate the mean value and write those in Table 2.
3. Using the guidance below, calculate solar heating for the raw solar radiation data collected for each observations' site.
4. Show your work for at least one location. **[1 point].** Provide final answers in table 2.

Solar heating Guidance

- Divide raw data by 525 to convert the measure into cal/cm2/min.
- Determine the albedo for your site based on the table provided in the lab handout
- Use this link: https://www.suncalc.org/ to get the sun angle for the time of data collection. The sun angle is technically a combination of altitude and azimuth angle, but for simplicity use the **"Altitude" angle** (in degrees) for the solar heating calculation.
- Based on eq. 1, calculate solar heating (SH)

$$Solar\ Heating\ =\ (Solar\ Radiation\ ^*)\times(1\ -\ albedo)\sin\ (sun\ angle\ with\ ground) \qquad \text{(eq. 1)}$$

Table 2: Solar heating **[Complete table and correct solar heating values total 3 points]**

Site #	Tree Species	Solar Radiation Raw		Solar Radiation* (cal/cm^2/min)		Solar Heating	
		Shaded	**Non-Shaded**	**Shaded**	**Non-Shaded**	**Shaded**	**Non-Shaded**
1	Control (lawn)	**NA**	**70,000**	**NA**	**133.333**	**NA**	**76.086**
2	Coast Live Oak	**960**	**31,000**	**1.829**	**59.048**	**1.323**	**42.681**
3	Redwood	**710**	**76,000**	**1.352**	**144.762**	**0.875**	**93.622**
4	Canary Island Pine	**2000**	**84,000**	**3.810**	**160.000**	**1.594**	**66.956**
5	London Plane Tree	**660**	**75,000**	**1.257**	**142.57**	**0.717**	**81.521**

5. Compare solar heating differences between each of the locations, and explain the reasons for it. What differences did you observe differences in Solar Heating between different locations and tree types? Which types of vegetation provide the greatest reduction in Solar Heating? **[2 points]**

In the shade, the solar heating is below 1.6 for all the locations all within .8 of each other. When compared to the non-shaded areas they all skyrocket to over 42 and max out at 93.6.

The differences would be the amount of sunlight that reaches the ground from direct sunlight compared to indirect sunlight. I noticed that when the shaded area for solar heating is higher the lower the non-shaded area is for solar heating and the same goes for shaded areas that have smaller solar heating the higher the non-shaded area is for solar heating. Shade provides the greatest reduction in solar heating because it lowers the surface and air temperatures in areas covered by shade.

6. In 2-3 sentences, define and explain the importance of a) the ground angle with the sun and b) the albedo used in the calculation of solar heating. You may have to do some literature research for this. USE YOUR OWN WORDS. (use MLA, APA or Chicago style citations if needed). **[2 points]**

When calculating solar heating, the ground angle with the sun is important because the light rays that travel from the sun hit the trees at a specific angle. That specific angle determines how much of that light will actually travel through the leaves and cause solar heating. That's also why the other factor, (b) the albedo, is roughly what percentage of light that gets absorbed into the leaves. When you calculate, you do (1-albedo), which is the percentage of light that will go through the leaves.

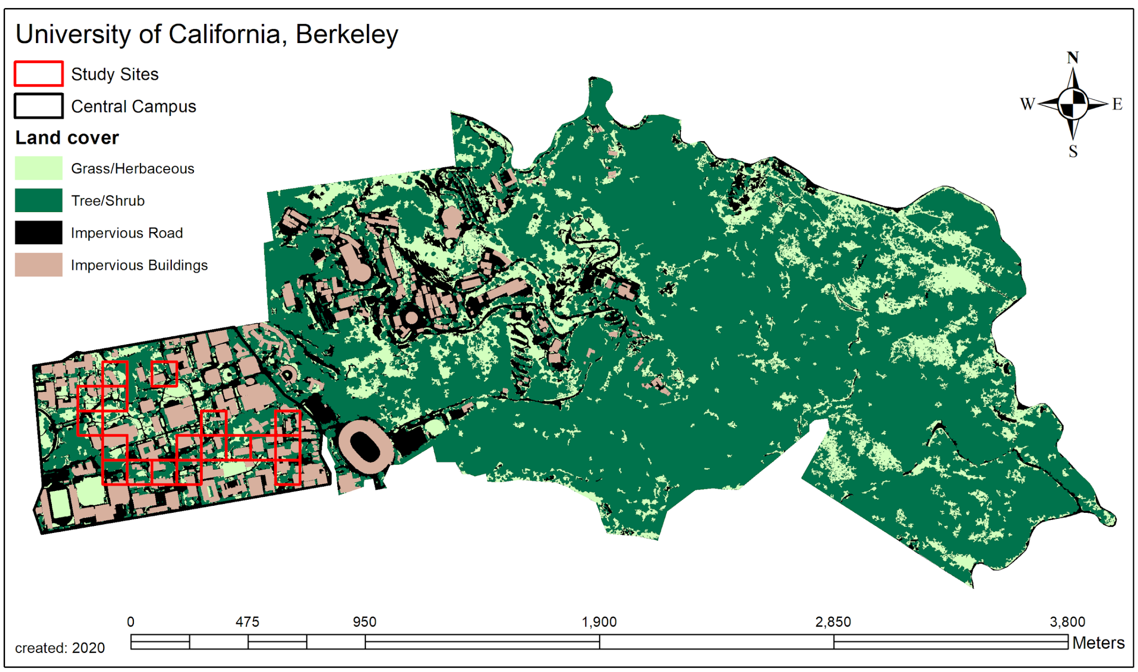

Figure 4. Land Cover Classification of UC Berkeley campus and students' study sites.

Part III. i-Tree Cover Assessment and Tree Benefits Report - For a given 1 hectare site on Campus

i-Tree is a peer-reviewed software suite produced by the USDA Forest Service. Users can specify location, species, and tree size inputs to get an understanding of the environmental and economic value that different tree types provide in their area of interest.

You will use this web-based land cover tool, *iTree Canopy*, to estimate tree cover for a designated study site of 1 Ha within UC Berkeley's campus. Each student will sample and classify at least 25 land cover points for their study site. Each study site is a randomly selected quadrat (square area) from a grid of the entire campus (Figure 4). You will submit your classification data and i-tree report as part of your lab report assignment and answer questions a to e, below in this page. **[i-tree report is 2 points]**

See the step by step instructions 1 to 10 (pp. 6-8) to generate the report and obtain the information to answer those questions:

a. What is the estimated % cover of trees/shrubs for your site? **[0.75 points]**
b. What is the standard error (reported as +/- SE) for the tree/shrub classification? **[0.75pts]**
c. How much $C0_2$ equivalent (in tons) is sequestered annually by trees in your site?**[0.75pts]**
d. What is the total annual pollutant adsorption capacity (in grams/yr and lbs/yr) of the trees on your site? [Note: This is the total amount in grams of the six pollutants (CO, NO2, O3, SO2, PM10, PM2.5)] **[0.75 pts]**
e. What is the estimated volume of avoided runoff (in kilolitters (Kl)) by the trees on your site? Convert the volume of runoff to cubic feet and report it. [1kl = 1m^3 = 35.3147 ft^3] **[0.75 pts]**

Instructions for using i-tree and generate report:

1. Prepare your study site data.

Identify your site number in this spreadsheet. Download the following three data files) corresponding to your site, from bCourses/Files/3_Assignments/LabWk6_UrbanForestry/Data_itree/site_#

1. Shapefile (site_XX.shp),
2. Projection file (site_XX.prj), and
3. Benefits setting file (benefits_settings).

The shapefile and projection files store information about the location and dimensions of your site. The benefits setting file stores the i-Tree analysis parameters. *Do NOT modify this data.*

2. Navigate to i-Tree Canopy in your web browser: https://canopy.itreetools.org/.

This web-based land cover tool allows users to classify land cover (e.g., trees, grass, building, roads, etc.) within a well-defined study area. The tool randomly selects points within the study area and displays the point as a cross-hair (or target) on Google Earth imagery. For each point, the user looks at the image and classifies the cover at the center of the cross-hair.

Based on this sampling, iTree estimates the area for each land cover classification and estimates the annual amount of air pollutants removed through deposition on trees. The six, regulated air pollutants (by the Clean Air Act) in the analysis include:

1. carbon monoxide (CO)
2. nitrogen dioxide (NO2)
3. ozone (O3)

4. sulfur dioxide (SO_2)
5. particulate matter (PM), includes $PM_{2.5}$ and PM_{10}

3. Read the i-Tree Canopy summary and then click the blue "**Get Started**" button.

4. Load your site boundary (**configuration step 1 of 3**). In the panel on the right, click "**Load Shapefile Boundary**" and load the corresponding shapefile (site_#**.shp**) and projection (site_#**.prj**) you unzipped for your site...OK. Then click **Next** on the right side of the screen.

5. Read the Basic Land Cover types that you will be using to classify point data:

- Tree/Shrub
- Grass/Herbaceous
- Impervious Buildings
- Impervious Road
- Impervious Other
- Water
- Soil/Bare Ground

No parameters are changed in this window (**configuration step 2 of 3**). Click **"Next"**.

6. Click "Load" and select the **benefits_setting** file from your bCourses download (configuration step 3 of 3). Click "**Next**".

Note: If you clicked next without loading the **benefits_stettings** file, you need to go to "Project" -> "File" -> "New/Start Over", and repeat steps 2 to 4. There is not "back" button. So be sure to upload your file before clicking "Next".

7. You should now see the **red boundaries of your study site** atop a recent Google satellite image. Your site is one hectare of UC Berkeley's campus. Observe the landscape, potential habitat, and key ecological features within your site.

8. i-Tree generates randomly located points inside your study area for you to classify. You will need to classify 25 samples. Click the "+" in the panel (on bottom right) to create your first point. This point has an ID shown in the panel. Use your best judgment to classify the point and select the appropriate class from the Cover Class drop-down option. If it looks like a tree over a road, select Tree/Shrub. If the point lands on a cover type you are not sure about or is not adequately represented by the classification, you may choose "Impervious Other" as your default unknown class. Then click "Save & Create New" to generate a new point.

Based on this sampling, i-Tree "learns" how to classify the entire site through statistical pattern recognition from the satellite image.

9. After creating 25 points, save your project. Beneath the panel on the right is a "**Save**" button, under **"Save your project".** Use the following file name convention:
"Site_#__LastNameFirstName" (replace # with your site number) The project will be saved on

your computer or hard drive. It is recommended to save your progress frequently. Then, you can overwrite it, or add a new version to your file.

10. Click the blue “Report” button. Go to the top of the window and click on “Report”-> “Print”… to save a copy of your report as a PDF. Attach that report as a separate PDF in you bCourses submission.

Part IV i-Tree Land Cover Assessment and Tree Benefits on UC Berkeley campus. Standard Data Given

The map in Figure 4 and land cover data in Table 3 show the area for each cover class for the entire campus (including the hill area, which includes mostly the watershed of Strawberry Creek) versus central campus (outlined in black on Figure 5). You will use the estimated per hectare benefits of tree cover in Table 4 to estimate the carbon and air pollution benefits of “tree/shrub” cover for the entire campus.

Table 3. Area of UC Berkeley Land Cover Classes

	Area (ha)		
Land cover	**Central Campus**	**Upper Campus**	**All of Campus**
Grass/Herbaceous	11	65	76
Tree/Shrub	20	294	314
Impervious Road	18	45	63
Impervious Other	23	15	38
Total	72	419	491

Table 4. Estimated annual benefits of urban tree cover per hectare in Berkeley

Tree Cover Benefit Type	Rate accumulated per year
Carbon sequestration	30.6 metric tons/ha/yr
CO_2 equiv. sequestration	112.2 metric tons/ha/yr
PM10 removal rate	25,410 g/ha/yr
Rainwater Interception	1,577 cubic feet/ha/yr

(sources: Nowak and Crane 2006, Nowak et al 2006, EPA)the

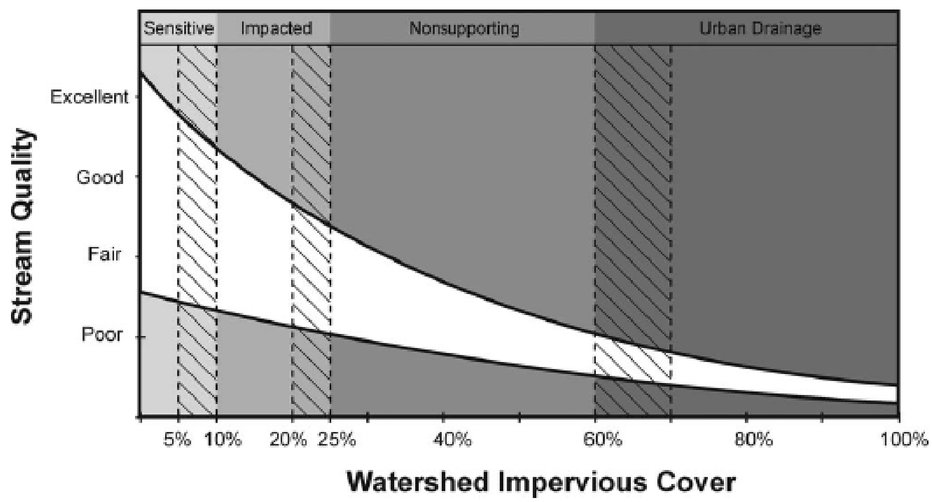

Figure 5. Stream quality impacts from watershed urbanization and impervious cover (Impervious Cover Model (Source: Schueler et al., 2009).

Answer the following questions based on Table 3, Table 4, and Figure 5:

1. How does the percentage cover of tree/shrub cover compare between central campus versus the upper campus in Strawberry Creek canyon? **[1 point]**

   Percentage of tree/shrub cover in central campus is 28% and percentage of cover in upper campus is 64%

2. How much $C0_2$ equivalent (in metric tons/yr) can be sequestered annually by tree/shrub cover between central campus versus the upper campus in Strawberry Creek canyon? Use information in Table 4. **[1 point]**

0.28 * 112.2 = 31.416 metric tons/yr, 0.64 * 112.2 = 71.808 metric tons/yr. In central campus, 31.416 metric tons/yr can be sequestered while 71.808 metric tons/yr can be sequestered in upper campus. that is about 40 metric tons/yr more on the northern side of campus.

3. What is the annual PM10 adsorption capacity (in grams and pounds) of the trees/shrubs for central campus vs upper campus? **[1 point]**

(central campus) 0.28 * 25,410 = 7114.8 g

(upper campus) 0.64 * 25,410 = 16262.4 g

4. What is the percent cover of all impervious surfaces for central campus versus upper campus? **[1 point]**

For central campus, the percent cover is 56.94%. For upper campus, the percent cover is 20.57%.

5. Calculate and consider the annual runoff avoided (in terms of cubic feet) due to tree cover for each area of campus. **[1 point]**

(central campus) 0.28 * 1,577 = 441.56 ft^3

(lower campus) 0.70 * 1,577 = 1103.90 ft^3

(upper campus) 0.64 * 1,577 = 1009.28 ft^3

6. Based on the percent impervious cover estimates for central campus and upper campus, and referring to Figure 5 (stream quality vs watershed impervious cover), describe your expectation of stream quality in the upper versus lower watershed of Strawberry Creek? **[1pt]**

I expect central campus to be fair stream quality and I expect upper campus to be good to fair stream quality.

Post-Lab Final Submission

Submit the following:

a) Your answer to the lab assignment questions in this document. [30 points]

b) i-Tree Canopy Cover Assessment and Tree Benefits Report. [2 points]

c) The data you collected in the field. [3 points]

List of References

Schueler, T.R., Fraley-McNeal, L. and Cappiella, K., 2009. Is impervious cover still important? Review of recent research. *Journal of Hydrologic Engineering*, *14*(4), pp.309-315.