1. What words, definitions, and ideas come to mind when you think of an urban center?

In studies of geography, an urban center is often defined by a high amount of impervious surfaces, or surfaces such as paved roads, roofs, and sidewalks, which do not allow water to penetrate to the soil layer.

2. How would you predict a high concentration of impervious surfaces affecting…
   a) The living conditions for people?
   
   b) The living conditions for plants and animals?
   
   c) The air quality and temperature?
   
   d) The waterways?

3. In your group, you have the data for the field sites that was collected by a team assigned to a particular urban center. This data includes the distance from the urban center, the current number of native species, the current number of invasive species, and the number of native species present when the urban center was first settled over two centuries ago. **Calculate the averages of each column of the data and write them in the empty space provided on the data sheet.**

4. In order to have useful data, it is important to be consistent in taking experimental data. The results of your analysis are only valid if they can be replicated and the same conclusions can be reached in many different instances using well-planned steps. An international community of scientists communicate to learn from each others’ research, so the information needs to be helpful to others’ understanding. For instance, international science uses Celsius to discuss temperature instead of Fahrenheit. **Convert the temperature data from Fahrenheit to**
Celsius in the space provided on the data sheet. \((C = (F - 32) \times \frac{5}{9})\)

a) In taking this data, what are some ways researchers could have made sure they have reliable measurements? Think about the physical set-up of the data measurement (equipment, plot set-up, time of day, etc.).

Your site is one of three sites that were near a piece of urban land used for one of the following primary purposes:

- **coal-burning factory operations**
  * Traits: high air pollution in the area immediately around the factory, low human traffic anywhere besides the roads to the factory, noisy operations throughout the day, few to no people living in the surrounding area. Land is used for the factory, factory parking lot, and shipping services.

- **suburban neighborhoods**
  * Traits: moderate air pollution in the area immediately around the neighborhoods, moderate level of human traffic throughout, heavy seeding and watering of lawns, home gardens, and indoor and outdoor house plants, moderate density of people living in the area. Land is used for houses, parking lots, lawns and gardens, and community meeting spaces such as basketball courts or playgrounds.

- **main street of a downtown area to a mid-sized city**
  * Traits: moderate to high air pollution in the area immediately around downtown, high level of human traffic throughout, low seeding of balcony and street plants, high density of people living in the area. Land is used for offices, storefronts, restaurants, entertainment venues, condominium buildings, and parking lots.

Assume the data for each of the three sites was taken in exactly the same way and can be reliably compared.

**Data Analysis**

5. Since North Carolina was settled in the 1600s, the process of urbanization has changed the piedmont region to have more roads and buildings and services associated with an increase of people in urban and rural centers. With the increase of globalization, more travel and interactions across the globe has inevitably brought invasive species and physical destruction of some vegetated areas.

a) What is the difference between native and invasive/nonnative species?

b) What are some ways that invasive/nonnative plant species are introduced to an area? Think of what humans, plants themselves, and animals can do to introduce organisms.

c) Why may some scientists consider invasive species to be disadvantageous for the ecological health of an area?
The first question the group of researchers wishes to answer is whether the number of native species before settlement and the number of native species after settlement has a statistically significant difference. The data can be considered continuous as the abundance counts account for the maturity of each organism.

d) Do you predict there will be a significant difference in the number of native species before and after settlement? Why?

e) What kind of statistical test would you use for this? (circle one)

Chi-squared test of variance  T-test  Chi-squared test of goodness of fit

f) What needs to be true (or assumed to be true) about the data in order to use this statistical test?

g) Why are the other statistical tests not appropriate for answering this research question?

h) What are the hypotheses in this test?

Null hypothesis $h_0$:

Alternate hypothesis $h_1$:

i) Show your calculations (use a separate paper if necessary) with $\alpha = 0.05$.

j) What does the $p$ value mean? What did you find out about the number of native species before settlement versus after settlement? Does this surprise you? Why or why not?
6. Some plant species have been proven to be more sensitive to air pollution, with visible physical damage (often in the form of unusual spots on leaves, as shown in the pictures here – right: a healthy milkweed plant; left: a milkweed plant affected by ozone damage, NPS Photos) in early generations of plants that experience air pollution and loss of abundance in later generations of plants. Scientists recorded the number of each of 5 pollution-sensitive species at the urban center – their results are included on your data sheet.

Find out if there is a significant difference in the abundance of plant species that are sensitive air pollution at your urban center:

a) Which of the three of urban centers (from page 2) would you expect to have the most extreme air pollution? Why?

b) Using the provided data, what kind of statistical test would you use for this? (circle one)

- Chi-squared test of variance
- T-test
- Chi-squared test of goodness of fit

c) What needs to be true (or assumed to be true) about the data in order to use this statistical test?

d) Why are the other statistical tests not appropriate for answering this research question?

e) What are the hypotheses in this test?

Null hypothesis $h_0$: 

Alternate hypothesis $h_1$: 

f) Show your calculations (use a separate paper if necessary) with $\alpha = 0.05$.

g) What did you find out about the abundance of air pollution-sensitive plant species at your site?
7. There are other correlations that may exist in this data. The team’s first interest was in the relationship between the average yearly temperature of a site and the distance that site is from the urban center. They plotted the following graph using their data.

![Average Yearly Temperature vs. Distance from Urban Center](image)

\[ R^2 = 0.28578 \]

a) Is this correlation positive or negative? Strong or weak?

b) What does the correlation between the distance of a site from an urban center and the average yearly temperature of that site tell you about these factors?

c) What are other factors that may influence the temperature of a site? How would you expect these factors to correlate with temperature?
8. **Discussion**

a) Compare your findings with the other groups in the class. From which type of urban center do you think your data was taken? Justify your answer.

b) What are other possible correlations to explore in trying to understand the effects of urbanization on the plant ecology of an area? List as many as possible.

c) Write how you would design an experiment to test one of your possible correlations in question 8b (above).

Hypothesis:

Procedure:
### Plant Species Information Sheet: Urban Center A

<table>
<thead>
<tr>
<th>Site</th>
<th>distance to urban center (m)</th>
<th># of invasive species in 2013</th>
<th># of native species in 2013</th>
<th># of native species at settlement</th>
<th>1993-2013 yearly average temperature (F)</th>
<th>Convert the yearly average temperature to Celsius here:</th>
</tr>
</thead>
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Column averages:

(circle one) T value / $X^2$ value = ____________

$df = _______ < \alpha < _______ \quad \text{p-value: p} \quad 0.05$

Air pollution-sensitive plants:

<table>
<thead>
<tr>
<th>Species</th>
<th>Expected Abundance</th>
<th>Recorded Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer rubrum (red maple)</td>
<td>25</td>
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<tr>
<td>Rubus canadensis (thornless blackberry)</td>
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<tr>
<td>Liquidambar styraciflua (sweetgum)</td>
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<td>33</td>
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<tr>
<td>Cornus florida (flowering dogwood)</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>Platanus occidentalis (American sycamore)</td>
<td>19</td>
<td>16</td>
</tr>
</tbody>
</table>

(circle one) T value / $X^2$ value = ____________

$df = _______ < \alpha < _______ \quad \text{p-value: p} \quad 0.05$
Plant Species Information Sheet: Urban Center B

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<tr>
<th>Site</th>
<th>distance to urban center (m)</th>
<th># of invasive species in 2013</th>
<th># of native species in 2013</th>
<th># of native species at settlement</th>
<th>1993-2013 yearly average temperature (F)</th>
<th>Convert the yearly average temperature to Celsius here:</th>
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Column averages:

(circle one) T value / $X^2$ value = ______________

$\text{df} = \underline{\hspace{2cm}} < \alpha < \underline{\hspace{2cm}}$ p-value: $p\underline{\hspace{2cm}} 0.05$

Air pollution-sensitive plants:

<table>
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<td>Platanus occidentalis (American sycamore)</td>
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(circle one) T value / $X^2$ value = ______________

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### Plant Species Information Sheet: Urban Center C

<table>
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<tr>
<th>Site</th>
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</table>

**Column averages:**

(circle one) $T$ value / $X^2$ value = ______________

df = __________  _____ < $\alpha$ < _____  
p-value: p _____ 0.05

### Air pollution-sensitive plants:

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(circle one) $T$ value / $X^2$ value = ______________

df = __________  _____ < $\alpha$ < _____  
p-value: p _____ 0.05