RMNP Forest Ecology Project- Historical Data Analysis

Directions:

- Write your name, today's date, and the class period on the upper right corner of a piece of loose-leaf paper.
- Write the heading *"RMNP Forest Ecology Project- Historical Data Analysis"* on the top left corner.
- Read all the of the background information and analyze all of the data tables and graphs.
- Answer all of the following questions on loose-leaf paper.
- You do not need to write the question. However, be sure to number each answer clearly.

Background Information

Rocky Mountain National Park (RMNP) is composed of a variety of mountain ecosystems. Mountain ecosystems are divided into life zones that change with elevation. The lowest of these, ranging from 5,600 – 9,500 feet, is the montane forest ecosystem. Ponderosa pine and Douglas fir characterize the montane forest ecosystem. Generally this life zone is adapted to dry sun-loving conditions. Above the montane is the subalpine forest life zone, which ranges from 9,000 – 11,000 feet. Subalpine forests are characterized by long-cold winters and short summers with large amounts of precipitation, mostly in the form of snow. Limber pine, subalpine fir, and Engelmann spruce distinguish the subalpine from other Rocky Mountain forests. From 11,000 feet to the summits of the high peaks advances the alpine tundra composed of ground hugging mosses, grasses, and shrubs.

1) What tree species characterize the montane forest ecosystem?
2) What tree species characterize the subalpine forest ecosystem?

Tree species migration in Rocky Mountain Forests

Essentially, ecological disturbance (fire, flooding, and climate change) have altered ecological factors causing forest tree species to migrate to more suitable habitat. In 1972 renowned forest ecologist Dr. Robert Peet, of the University of North Carolina at Chapel Hill, collected forest ecology data from 68 subalpine sites in RMNP for his research on elevation-vegetation gradients. Then in 2013 RMNP ecologist Scott Esser revisited all of Peet's sites to collect data to investigate his master's thesis on tree species migration. His research revealed that forest structure and species composition has changed in RMNP since 1972. The data show that most of the younger tree species are prevalent on north-facing moist and cool slopes. While warmer and dryer south-facing slopes are composed of mostly large old growth trees with fewer young trees, which means less regeneration. Overall, species have migrated to more suitable habitat, likely in response to climate change.[i]

3) Describe the changes in tree forest structure and tree species composition since 1972 observed by Esser.

Presently, the health of the Rocky Mountain forest is being seriously threatened by climate change. Globally, the average annual temperature has increased 1.4 degrees Fahrenheit, yet Rocky Mountain National Park's average annual temperature has increased 3.4 degrees Fahrenheit over the last 100 years.[ii] The 10 hottest years ever-recorded have all occurred since the year 2000 and this has impacted the forest[iii]. Rising temperatures in the Rockies has led to an overall reduction in spring snowpack and spring snowmelts now begin as much as three weeks early; this then is followed by an earlier peak stream flow".[iii & iv] Forest researchers Jason Funk and Stephen Saunders revealed, in their paper "Rocky Mountain Forests at Risk" that, due to increasingly hotter and dryer conditions, old-growth forests of the Rocky Mountains have experienced a doubling in tree mortality in the last few decades, with no recompensing increase in the amount of young trees.[iii]

4) Why is climate change such a concern for RMNP?
5) Describe the effect of changes in climate on Rocky Mountain forest ecosytems.

Forest researchers, David Bell, John Bradford, William Lauenroth showed, in their research on high-elevation tree species migration in the Rocky Mountains, that ecological factors and habitat suitability for high elevation tree species is expected to decrease. Not just in current subalpine habitat, but also in potential suitable unpopulated habitat where subalpine tree species could eventually migrate[iv]. This transformation will effectively facilitate the upslope migration of ponderosa pine and Douglas fir tree species; characteristic montane tree species that tolerate hotter dryer soils.[iv] Essentially, as Rocky Mountain forests become hotter and dryer, the Montane forest ecosystem will migrate upslope, slowly replacing the subalpine forest ecosystem. Since mountains taper off towards the top, the area of suitable subalpine habitat decreases the higher you go.[iv] This upslope migration could potentially result in habitat degradation, loss of biodiversity, and potentially, the loss of the subalpine forest ecosystem.

6) Describe the forecasted trends in upslope migration with respect to tree species and shifting mountain ecosystems.

We are working with Scott Esser to help the park gather useful data about the effects of climate change on subalpine forests in RMNP. As student/citizen scientists, your work may be used to help park scientists gain a greater understanding of the impacts of climate change on Rocky Mountain forests. With this information park scientists can then manage for resilience. Managing for resilience is a way to protect the forest by improving habitat through implementing forest management methods such as facilitated succession and adaptive migration. These methods essentially help to accelerate the natural process of ecological succession by ultimately helping the forest to adapt more quickly to changing conditions. This in turn will help to preserve biodiversity in Rocky Mountain forests.

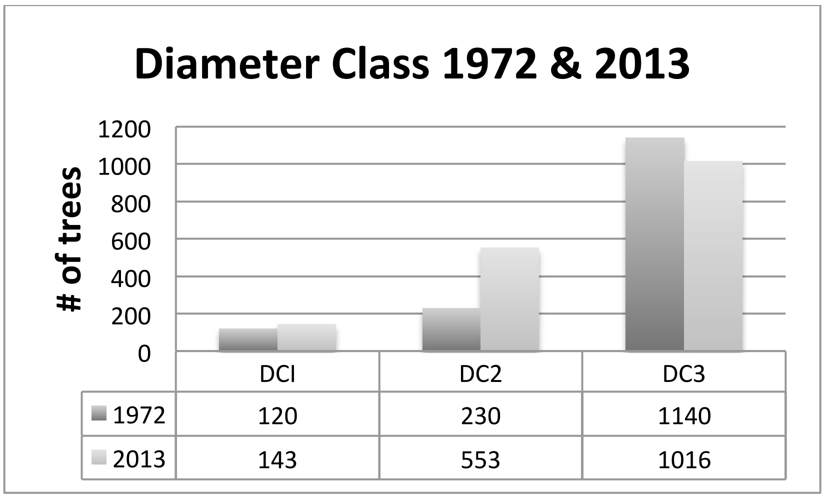
7) What does managing for resilience mean?
8) What are two methods that are used to manage for resilience?

Historical Data Analysis

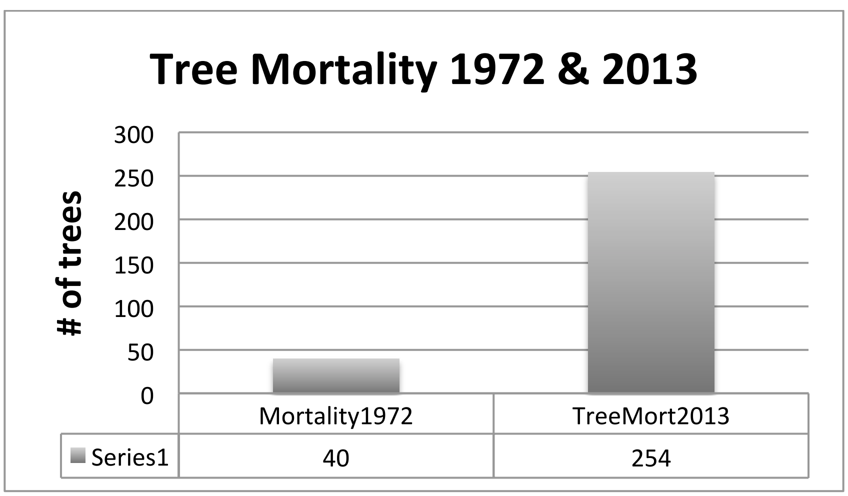
The process of science involves analyzing data, making predictions, and testing predictions through experimentation and/or research. Ecological research often involves natural experiments, which are based on collecting observational data and often asking comparative questions. In this case we will compare data collected from forest inventories between 1972, 2013, and 2016. As mentioned earlier, Dr. Robert Peet collected forest data from 68 subalpine sites and these sites were then re-inventoried in 2013 by RMNP ecologist Scott Esser. You and your classmates will analyze the data for one of these sites, site-5, and make predictions. Then you and your classmates and you will conduct the 2016 forest inventory of site-5. Site-5 is a subalpine site located on a north-facing slope at an elevation of 9,242 feet. The purpose of this activity is to analyze historical data for site-5 and make predictions, which you will test through research and observation. After conducting a forest inventory of site-5 and analyzing your results you will determine whether or not the data support your predictions. Then you will write-up your findings in a scientific paper. You will be doing real science from start to finish.

The data that follows was collected at site-5.

The graph below shows # of trees by Diameter Class (DC) (DC1 < 2.5 cm, DC2 2.5-7.5 cm, DC3 >7.5 cm)



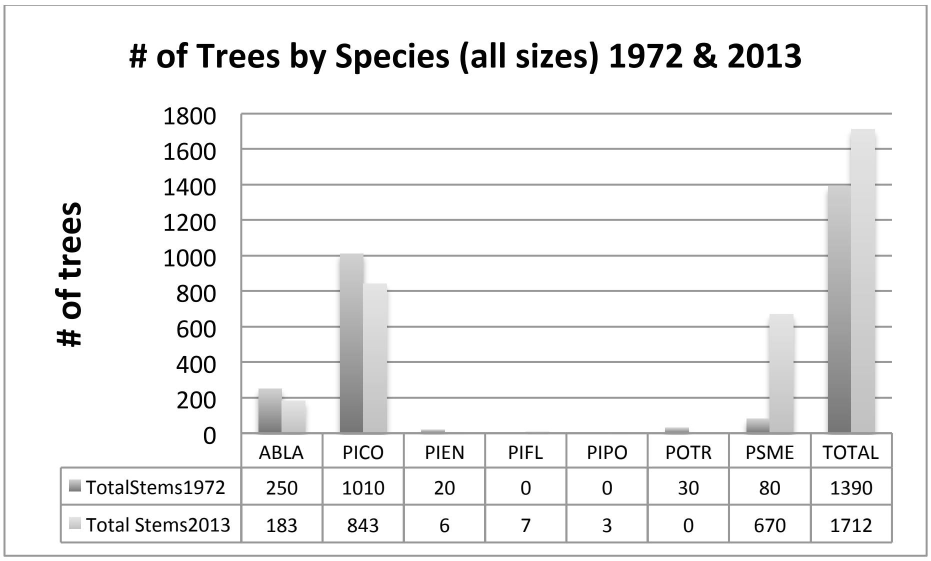
9) Describe the changes in # of trees by diameter class shown in the graph above between 1972 and 2013.
10) How does this data relate to changes in the age structure of the forest between 1972 and 2013?



11) Calculate the percent change in tree mortality at site-5 between 1972 and 2013?
12) What inferences can you make that may explain this change?

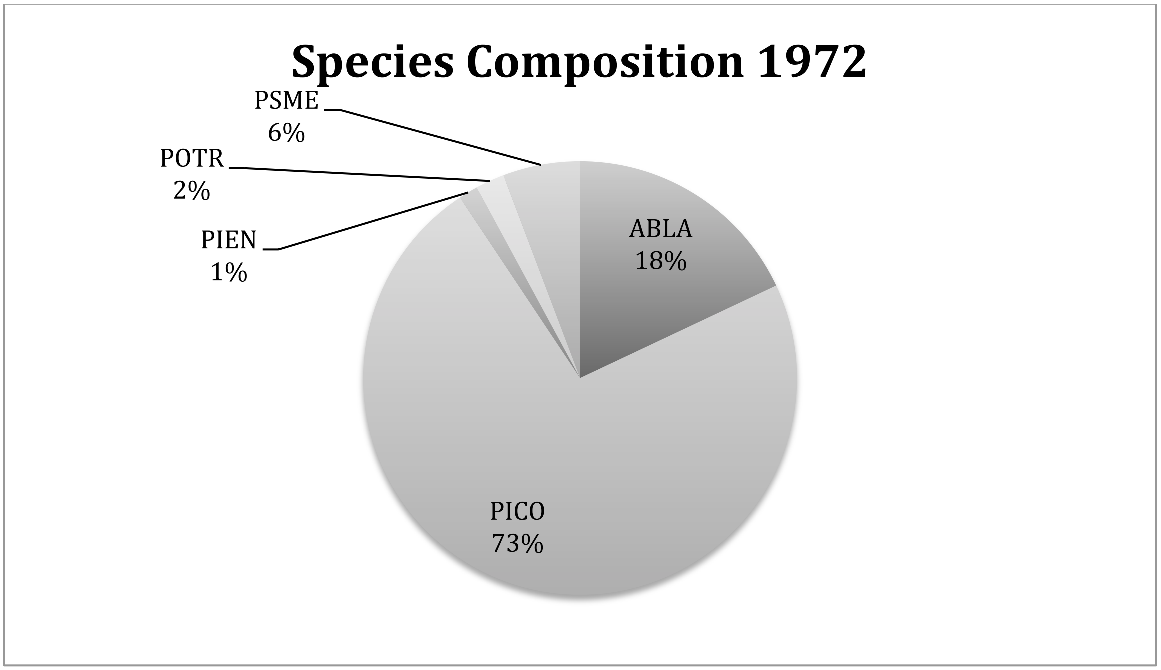
SPECIES CODES:

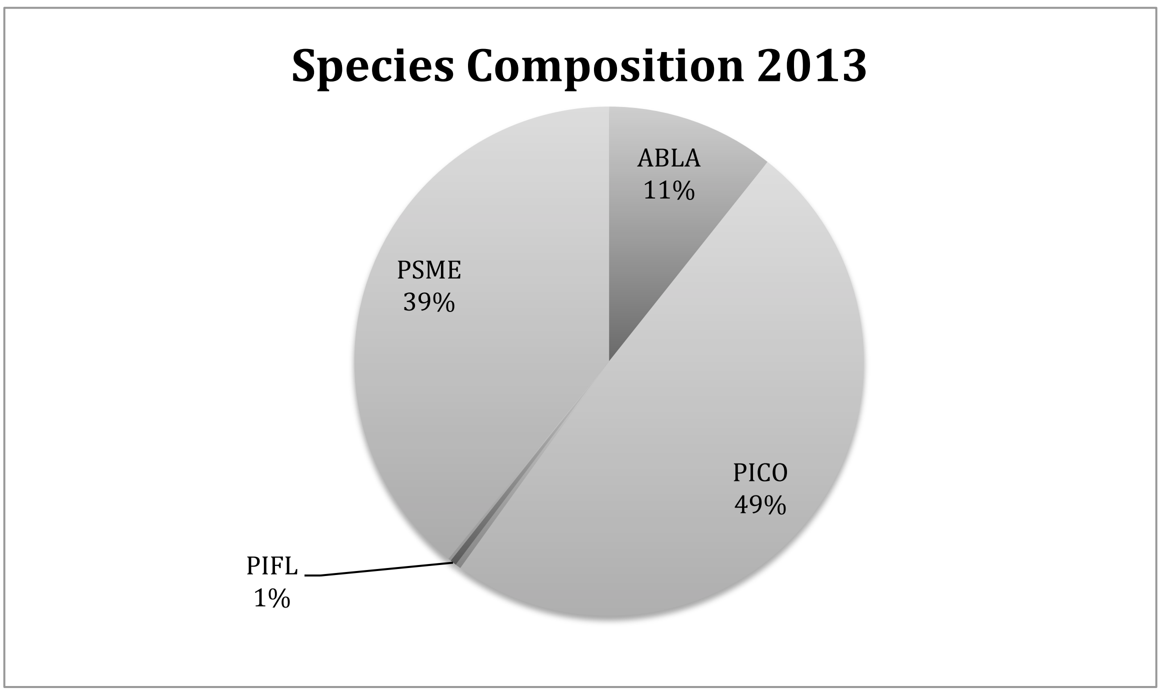
PICO – lodgepole pine, *Pinus contorta*
PIPO – ponderosa pine, *Pinus ponderosa*
PIFL2 – limber pine, *Pinus flexilis*
JUSC- Rocky Mountain Juniper, *Juniperus scopulorum*
PIPU- Colorado Blue Spruce, *Picea pungens*
ABLA – subalpine fir, *Abies lasiocarpa*
PIEN – Engelmann spruce, *Picea engelmanii*
PSME – Douglas fir, *Pseudotsuga menziesii*
POTR – aspen, *Populus tremuloides*



	ABLA	PICO	PIEN	PIFL	PIPO	POTR	PSME	TOTAL
TotalStems1972	250	1010	20	0	0	30	80	1390
Total Stems2013	183	843	6	7	3	0	670	1712

13) Describe the changes (increases and decreases of particular tree species), in terms of # of trees by species, that you can observe between 1972 and 2013.
14) Do these data support any ecological trends described in the background information? Explain.





15) Calculate the percent change in species composition for subalpine fir (ABLA) between 1972 and 2013.
16) What mountain life zone (ecosystem) is this tree species typically associated with?
17) Calculate the percent change in species composition for Douglas fir (PSME) between 1972 and 2013.
18) What mountain life zone (ecosystem) is this tree species typically associated with?
19) Does this data support any ecological trends described in the background information? Explain.
20) Write three predictions based on your data analysis; each based on the following criteria: 1) diameter class 2) mortality 3) species composition.

---

[i] Esser, S. M. (2015). Topography, Disturbance and Climate: Subalpine Forest Change 1972-2013, Rocky Mountain National Park, USA (Master's thesis, Colorado State University. Libraries).

[ii] United States. National Park Service. (2016). Climate Change. Retrieved April 19, 2016, from https://www.nps.gov/romo/learn/nature/climatechange.htm

[iii] Funk, J., S. Saunders, T. Sanford, T. Easley, and A. Markham. (2014). Rocky Mountain forests at risk: Confronting climate-driven impacts from insects, wildfires, heat, and drought. Report from the Union of Concerned Scientists and the Rocky Mountain Climate Organization. Cambridge, MA: Union of Concerned Scientists

[iv] Bell, D., Bradford, J., & Lauenroth, W. (2014). Mountain landscapes offer few opportunities for high-elevation tree species migration. *Global Change Biology*, *20*(5), 1441-1451.