**Ecosystems of Rocky Mountain National Park**

Use the “*Ecosystems of RMNP”* handout to answer the following questions.

1. Identify the four distinct ecosystems of RMNP.
2. Describe the relationship between elevation and temperature.
3. Identify the factors that determine plant distribution.
4. Identify the tree species found in the montane ecosystem of RMNP and describe the environmental conditions in terms of elevation, temperature, moisture/precipitation, and general landscape characteristics.
5. Identify the tree species found in the subalpine ecosystem of RMNP and describe the environmental conditions in terms of elevation, temperature, moisture/precipitation, and general landscape characteristics.

|  |  |
| --- | --- |
|  | Using the information from your answers to the questions on page one and the “*Ecosystems of RMNP”* handout, illustrate and label the diagram below with as much detail as possible. |

**Tree Species Identification Lab**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1. Tree species name:   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Needles | Flat  (two-sided) | Spreading almost at right angles in two rows; crowded and curved upward; 1” — 1¾” long; dark green with whitish lines | Subalpine fir | | Spreading mostly in two rows, though often appear whorled around stem; ¾ — 1¼” long; flattened, rounded at tip, **flexible**, dark yellow-green or blue-green, very short; twisted leaf stalk (look closely where needle meets stem) | Douglas fir | | Square  (four-sided) | ⅝ — 1” long; spreading on all sides of twig (whorled) 4-angled; **sharp-pointed**, dark blue-green with whitish lines; disagreeable skunk like odor when broken or crushed | Engelmann spruce | | Bundles | 5 in bundle; 2 — 3½” long; slender, long-pointed | Limber pine | | 2 or 3 in bundle; 4 — 8” long; stout, stiff, dark green | Ponderosa pine | | 2 in bundle; 1¼” — 2¾” long; slightly flatten often twisted; yellow green to dark green | Lodgepole pine | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1. Tree species name:   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Needles | Flat  (two-sided) | Spreading almost at right angles in two rows; crowded and curved upward; 1” — 1¾” long; dark green with whitish lines | Subalpine fir | | Spreading mostly in two rows, though often appear whorled around stem; ¾ — 1¼” long; flattened, rounded at tip, **flexible**, dark yellow-green or blue-green, very short; twisted leaf stalk (look closely where needle meets stem) | Douglas fir | | Square  (four-sided) | ⅝ — 1” long; spreading on all sides of twig (whorled) 4-angled; **sharp-pointed**, dark blue-green with whitish lines; disagreeable skunk like odor when broken or crushed | Engelmann spruce | | Bundles | 5 in bundle; 2 — 3½” long; slender, long-pointed | Limber pine | | 2 or 3 in bundle; 4 — 8” long; stout, stiff, dark green | Ponderosa pine | | 2 in bundle; 1¼” — 2¾” long; slightly flatten often twisted; yellow green to dark green | Lodgepole pine | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1. Tree species name:   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Needles | Flat  (two-sided) | Spreading almost at right angles in two rows; crowded and curved upward; 1” — 1¾” long; dark green with whitish lines | Subalpine fir | | Spreading mostly in two rows, though often appear whorled around stem; ¾ — 1¼” long; flattened, rounded at tip, **flexible**, dark yellow-green or blue-green, very short; twisted leaf stalk (look closely where needle meets stem) | Douglas fir | | Square  (four-sided) | ⅝ — 1” long; spreading on all sides of twig (whorled) 4-angled; **sharp-pointed**, dark blue-green with whitish lines; disagreeable skunk like odor when broken or crushed | Engelmann spruce | | Bundles | 5 in bundle; 2 — 3½” long; slender, long-pointed | Limber pine | | 2 or 3 in bundle; 4 — 8” long; stout, stiff, dark green | Ponderosa pine | | 2 in bundle; 1¼” — 2¾” long; slightly flatten often twisted; yellow green to dark green | Lodgepole pine | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1. Tree species name:   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Needles | Flat  (two-sided) | Spreading almost at right angles in two rows; crowded and curved upward; 1” — 1¾” long; dark green with whitish lines | Subalpine fir | | Spreading mostly in two rows, though often appear whorled around stem; ¾ — 1¼” long; flattened, rounded at tip, **flexible**, dark yellow-green or blue-green, very short; twisted leaf stalk (look closely where needle meets stem) | Douglas fir | | Square  (four-sided) | ⅝ — 1” long; spreading on all sides of twig (whorled) 4-angled; **sharp-pointed**, dark blue-green with whitish lines; disagreeable skunk like odor when broken or crushed | Engelmann spruce | | Bundles | 5 in bundle; 2 — 3½” long; slender, long-pointed | Limber pine | | 2 or 3 in bundle; 4 — 8” long; stout, stiff, dark green | Ponderosa pine | | 2 in bundle; 1¼” — 2¾” long; slightly flatten often twisted; yellow green to dark green | Lodgepole pine | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1. Tree species name:   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Needles | Flat  (two-sided) | Spreading almost at right angles in two rows; crowded and curved upward; 1” — 1¾” long; dark green with whitish lines | Subalpine fir | | Spreading mostly in two rows, though often appear whorled around stem; ¾ — 1¼” long; flattened, rounded at tip, **flexible**, dark yellow-green or blue-green, very short; twisted leaf stalk (look closely where needle meets stem) | Douglas fir | | Square  (four-sided) | ⅝ — 1” long; spreading on all sides of twig (whorled) 4-angled; **sharp-pointed**, dark blue-green with whitish lines; disagreeable skunk like odor when broken or crushed | Engelmann spruce | | Bundles | 5 in bundle; 2 — 3½” long; slender, long-pointed | Limber pine | | 2 or 3 in bundle; 4 — 8” long; stout, stiff, dark green | Ponderosa pine | | 2 in bundle; 1¼” — 2¾” long; slightly flatten often twisted; yellow green to dark green | Lodgepole pine | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | 1. Tree species name:   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | Needles | Flat  (two-sided) | Spreading almost at right angles in two rows; crowded and curved upward; 1” — 1¾” long; dark green with whitish lines | Subalpine fir | | Spreading mostly in two rows, though often appear whorled around stem; ¾ — 1¼” long; flattened, rounded at tip, **flexible**, dark yellow-green or blue-green, very short; twisted leaf stalk (look closely where needle meets stem) | Douglas fir | | Square  (four-sided) | ⅝ — 1” long; spreading on all sides of twig (whorled) 4-angled; **sharp-pointed**, dark blue-green with whitish lines; disagreeable skunk like odor when broken or crushed | Engelmann spruce | | Bundles | 5 in bundle; 2 — 3½” long; slender, long-pointed | Limber pine | | 2 or 3 in bundle; 4 — 8” long; stout, stiff, dark green | Ponderosa pine | | 2 in bundle; 1¼” — 2¾” long; slightly flatten often twisted; yellow green to dark green | Lodgepole pine | |

|  |  |
| --- | --- |
| **Tree Species Descriptions**  For each of the following tree species:   * Identify at least three distinguishing characteristics of the following tree species. * Describe the relevant adaptations, habitat requirements, and life strategy/history information.   🡪 **Use the “*Ecosystems of RMNP”* handout** and the *tree species identification lab* for help. | |
| **Ponderosa pine**   * Adaptations, habitat requirements, and life strategy/history: | **Douglas fir**   * Adaptations, habitat requirements, and life strategy/history: |
| **Lodgepole pine**   * Adaptations, habitat requirements, and life strategy/history: | **Subalpine fir**   * Adaptations, habitat requirements, and life strategy/history: |
| **Engelmann spruce**   * Adaptations, habitat requirements, and life strategy/history: | **Limber pine**   * Adaptations, habitat requirements, and life strategy/history: |
| **Aspen**   * Adaptations, habitat requirements, and life strategy/history: | |

**Discuss existing scientific literature, examine data, and make hypotheses**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

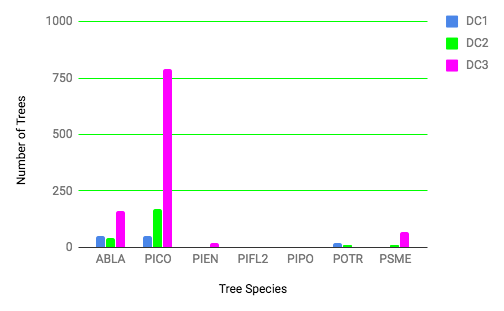
**Examine data**

Analyze the data in Figure 1 and Figure 2, in terms of *species diversity*, *evenness*, *dominance, age structure*.

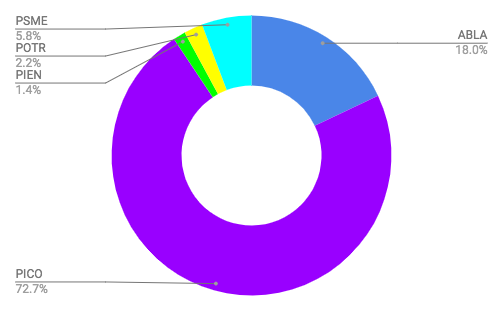
Refer to Figure 1 for abbreviations and size class ranges.

****

**Figure 1.** Species codes and diameter class size ranges

****

**Figure 2.** Tree frequency by diameter class at site 5 in 1972

****

**Figure 3.** Species composition of site 5 in 1972

**Analyze baseline data**

Describe site-5 (1972) in terms of species diversity, evenness, dominance.

Describe site-5 (1972) in terms of age structure.

**Comparative Questions, Predictions, and Hypotheses**

**Comparative Questions-** Use this format: *“How has the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ changed from 1972 to 2018”*

* 1. Species composition of the subalpine forest
  2. Age structure of the subalpine forest

**Predictions-** Your predictions are answers to your comparative questions.

Write three predictions each based on the preceding comparative questions.

**Hypotheses**- Using the *if, then, because* format write two hypotheses based on your predictions.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Understanding the Big Idea**

How do forest inventories help us learn about an ecosystem’s:

1. age structure (e.g. size by diameter class)?
2. species diversity?

How do forest inventories help us to track change over time in an ecosystem?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Applying knowledge**

1. How would knowing the time since the last disturbance change your understanding of a study site?
2. What tree species would you expect to see increase their abundance following a fire?  Following Beetle Kill? Why would there be a difference?
3. How can data from forest inventories be used to inform management decisions to such to mitigate fire intensity and beetle outbreaks?
4. If you were going to collect seed and grow trees in a greenhouse, which you would later plant to revitalize the forest, from where would you collect seed? (Hint: refer to *Adaptation, migration or extirpation: climate change outcomes for tree populations*)

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Using the CitSci.org database**

Go to the APES Daily Agenda page to find the link to the CitSci.org database.

For this activity you will analyze data for several sites and make inferences based on the ecological principles you have learned.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site 44** | | | | | | | | | |
|  | **1972** | | | **2013** | | | **2016** | | |
|  | DC1 | DC2 | DC3 | DC1 | DC2 | DC3 | DC1 | DC2 | DC3 |
| ABLA |  |  |  |  |  |  |  |  |  |
| PICO |  |  |  |  |  |  |  |  |  |
| PIEN |  |  |  |  |  |  |  |  |  |
| PIFL2 |  |  |  |  |  |  |  |  |  |
| PIPO |  |  |  |  |  |  |  |  |  |
| POTR |  |  |  |  |  |  |  |  |  |
| PSME |  |  |  |  |  |  |  |  |  |
| **Total Stems** |  |  |  |  |  |  |  |  |  |

1. Describe this site in terms of age structure and species diversity (evenness, and dominance) over time.
2. Describe your observations and explain any notable trends in the data.
3. To what ecological drivers or disturbances can you attribute the observed trends in the data?
4. Based on the data and your knowledge of mountain ecosystems, which type of ecosystem exists within this site? (montane, subalpine, ecotone, lodgepole, or aspen forest)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Site 218 — 2013** | | | | | | Species | DC1 | DC2 | DC3 | Total | | ABLA |  |  |  |  | | PICO |  |  |  |  | | PIEN |  |  |  |  | | PIFL2 |  |  |  |  | | PIPO |  |  |  |  | | POTR |  |  |  |  | | PSME |  |  |  |  | | **Total Stems** |  |  |  |  | | |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Site 5A — 2013** | | | | | | Species | DC1 | DC2 | DC3 | Total | | ABLA |  |  |  |  | | PICO |  |  |  |  | | PIEN |  |  |  |  | | PIFL2 |  |  |  |  | | PIPO |  |  |  |  | | POTR |  |  |  |  | | PSME |  |  |  |  | | **Total Stems** |  |  |  |  | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Site 75 — 2013** | | | | | | Species | DC1 | DC2 | DC3 | Total | | ABLA |  |  |  |  | | PICO |  |  |  |  | | PIEN |  |  |  |  | | PIFL2 |  |  |  |  | | PIPO |  |  |  |  | | POTR |  |  |  |  | | PSME |  |  |  |  | | **Total Stems** |  |  |  |  | | **Complete the data table below**  Using the RMNP Shannon diversity index calculator determine the H’ value for each site.  Based on the data and your knowledge of mountain ecosystems, determine the type of ecosystem that exists within each this site. (montane, subalpine, ecotone, lodgepole, or aspen forest)   |  |  |  | | --- | --- | --- | | **Site** | **H’** | **Ecosystem** | | **5A** |  |  | | **75** |  |  | | **218** |  |  | |

1. Describe each site in terms of age structure, species diversity (evenness and dominance), and explain the evidence that justifies your choice of ecosystem for each site.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Results**

In this section you will complete a data table and construct a graph for the site that your group inventoried.

Go to the APES Twitter page and find the latest CitSci.org tweet to navigate to the CitSci.org database.

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

|  |  |
| --- | --- |
| Diameter Class 1 (DC1): | < 2.5 cm |
| Diameter Class 2 (DC2): | 2.5 - 7.5 cm |
| Diameter Class 3 (DC3): | > 7.5 cm |

Use the CitSci.org database to organize and analyze the data from your site and complete the following table.

**Table 1.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Site: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** | | | | | | |
|  | **1972** | | | **2018** | | |
|  | DC1 | DC2 | DC3 | DC1 | DC2 | DC3 |
| ABLA |  |  |  |  |  |  |
| PICO |  |  |  |  |  |  |
| PIEN |  |  |  |  |  |  |
| PIFL2 |  |  |  |  |  |  |
| PIPO |  |  |  |  |  |  |
| POTR |  |  |  |  |  |  |
| PSME |  |  |  |  |  |  |
| **Total Stems** |  |  |  |  |  |  |

Using graph paper, Microsoft Excel, or Google Sheets, construct a bar graph or series of bar graphs that presents the data in Table 1. 🡪 Include your graph in the appendix of your report.

**Analyzing data to track change over time**

In this section you will analyze the data from your site to answer the following questions:

1. Did any species decline significantly in abundance during the study period?
2. Did any species increase substantially in abundance during the study period?
3. Is the species composition more or less diverse now than in 1972?
4. Did species composition change within the subalpine forest and do these changes suggest tree species migration?
5. Were there any shifts in abundance of trees between size classes? (i.e. changes in age structure; in other words, is the forest getting older, younger, or is it an even-aged stand?)

*Use the space below to record your observations.*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Writing scientific explanations**

In this section you will write two to three scientific explanations to answer the question: *“What are some possible ecological and environmental drivers responsible for the changes in the forest communities over time?”* A **driver** is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem (Nelson, G. C., 2005).

**Components of a scientific explanation:**

* Make a claim about the question.
* Provide evidence for the claim.
* Provide reasoning that links the evidence to the claim.

**Definitions:**

* Claim: An assertion or conclusion that answers the original question
* Evidence: Data that supports the claim.
* Reasoning: Reasoning is the justification that links the claim and evidence. Your reasoning explains *why* the data counts as evidence to support the claim, and is strengthened by relevant ecological principles.

\*Adapted from McNeill & Krajcik (2008)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Conclusion**

Write a conclusion, based on the data, that accepts or rejects your hypothesis (Do not say *“I was right or I was wrong”*, instead say *“the data support my hypothesis”* or *“the data do not support my hypothesis”*).

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**Report Guidelines**

This report is basically a lab report, only you conducted your lab in Rocky Mountain National Park.

The *length requirement* is only five-paragraphs. Both typed or hand-written reports will be accepted. Your report should be well-written with correct spelling, punctuation, grammar, and sentence structure.

Use the following format:

1. **Introduction**

* Explain what you did and why. For help with this, consider incorporating the answers to the questions you answered in the section *“Understanding the big idea”* on page 10.
* Close this paragraph by stating your *research questions (comparative questions).*
* Paragraphs 1 & 2 are related, describe similar information, and may flow from one to the other.

1. **Introduction**

* Next, you will need to explain some of the background information. For help with this, refer to the information you wrote on page 1 of this worksheet *“Ecosystems of Rocky Mountain National Park”* and pages 6 – 7 *“Discussing existing scientific literature”*.
* Finally, close the introduction by stating the predictions and hypotheses that you wrote on page 9.

1. **Results**

* Report the data collected from the forest inventory.
  + For help with this section refer to the information you wrote on page 14, *“Analyzing data to track change over time”.* Put your graph in the appendix (at the end of the paper), but refer to it within this section.

1. **Discussion**
   * + The purpose of this section is to interpret the results; i.e. to explain why the forest did or did not change during the study period. For help with this, refer to the information you wrote on page 15, writing scientific explanations.
2. **Conclusion**
   * + Accept or reject your predictions and hypotheses. For help with this, refer to the conclusion that you wrote on this page.
     + Finally, describe the significance of the study. For example:
       - Why is preserving biodiversity of forests important?
       - How can the data from this study and similar studies be used to help to preserve biodiversity in forest ecosystems of Rocky Mountain National Park and other National Forests, and Wilderness areas? For help with this, refer to questions 3 and 4 in the section *“Applying knowledge”* on page 10.
       - Finally, consider writing a *“call to action”.* For help with this, refer to the information you wrote in the section *“Discussing existing scientific literature” on* pages 6 – 7.

**References**

McNeill, K. L., & Krajcik, J. (2008). Scientific explanations: Characterizing and evaluating the effects of teachers' instructional practices on student learning. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 45(1), 53-78.

Nelson, G. C. (2005). Drivers of ecosystem change: summary chapter. *Ecosystems*.