RED BUTTE GARDEN BOTANY BINS

PATTERNS & PARTNERSHIPS: UTAH MOUNTAIN ECOLOGY

Lesson 4: Reading Rings Resources and Survival

SEEd Alignment: 6.4.1 – *suggestions for acclimating to phenomenon education in italics*		
Analyze data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. Ask questions to predict how changes in resource availability affects organisms in those ecosystems.		
Disciplinary Core Ideas	**Crosscutting Concepts**	**Science and Engineering Practices**
• LS2.C: Ecosystem dynamics, functioning, and resilience	• Cause and Effect • Stability and Change	• Ask Questions • Analyze Data • Engage in Argument from Evidence
Vocabulary: vocabulary is underlined		
resource, ecosystem Optional: dendrochronology		
Time Commitment: These lessons are designed to provide flexibility in both length and depth. Plain text in black contains the middle-of-the-road option, while text in red contains time-saving options, and text in purple contains options to dive deeper into the subject matter.		
40-50 minutes, 25-30minutes, and 60+ minutes.		

Lesson Summary

Welcome to the wonderful world of dendrochronology! Studying the rings and markings on the cross-section of a tree trunk can reveal the life story of that tree, and give great insight to what is happening in the ecosystem the tree inhabits. Through investigation of "tree cookies" (cross sections of the entire trunk of the tree), you and your students will observe firsthand the effects of resource availability on an organism. Your observations can then be compared to climate data that covers the years the trees were alive. This investigation mimics the real-world work of dendrochronologists! The potential effects of greater changes in resource availability are then predicted on both an organism and population level by asking "what-if" questions to the class. Your students become dendrochronologists as you exit your classroom and explore the stories of the trees that exist in the ecosystem surrounding your school! Using the same tool as professional scientists (an increment borer), you can take core samples of your neighborhood trees and discover what secrets they hold. This is a great opportunity to create an ongoing project for your classroom that adds new core samples each year to chronicle the changes to your trees over time.

Essential Questions

- What happens when an organism has less or more resources?
- What happens when a population has less or more resources?
- Does a difference in resources affect all organisms equally?
- If one population is affected by a difference in resources, does that affect other populations?

Enduring Understanding

- Organisms/populations need resources to live.
- Different organisms have different resource requirements.
- Changes in available resources can affect organisms/populations.

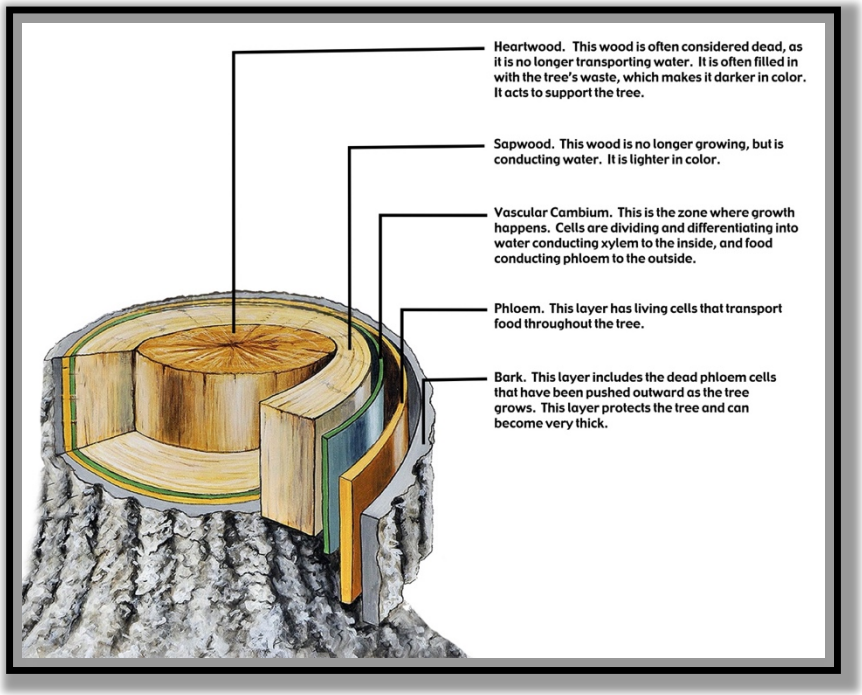
Previous Knowledge

Your students' have likely learned, and innately know, that all living things have requirements to live. Those requirements vary by the type and species of the organism, but with a little prompting your students can likely list out the main needs of a plant or animal. If they need a refresher, we suggest posing a few questions. To remind them that plants need sun, air, water, space, and nutrients/stability from soil, you could ask what would happen if a plant had too little or too much of any of those resources. The same could be posed for animals and their needs of food, water, shelter, air, and space.

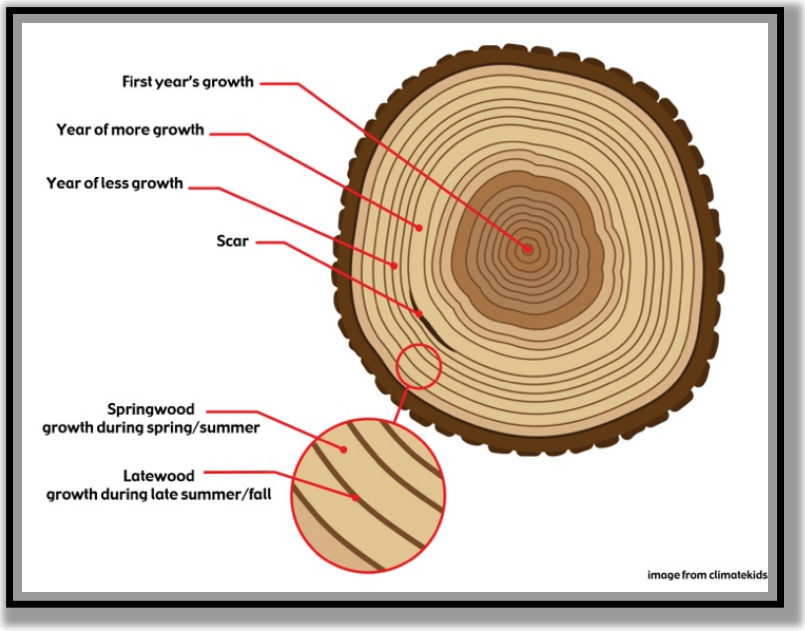
They will use their scientific skills of asking questions and analyzing data in this lesson. Luckily, most students are adept at questioning things. Combining their questioning powers with a good dose of pattern finding powers will help students to analyze the data. While it may take some work to polish their analyzing abilities, they have a firm foundation already laid to build on.

Background Information

Dendrochronology, the study of the rings and markings on the cross-section of a tree trunk, is rooted in knowing some basics about how a tree grows. Cell division and tree growth occurs in the vascular cambium (a layer just below the bark of a tree.) Every growing season, or year, a new layer of cells is added to the inside and outside of the vascular cambium. The cells growing on the inside create the wood and the annual rings. See the image below (also available as a blackline at the end of the lesson plan and on the USB).



The tree grows fastest during the spring/summer, and creates large cells with relatively thin cell walls. This is called springwood, and appears as lighter colored rings. As winter approaches, the tree grows more slowly and creates smaller cells with relatively thicker cell walls. This is called latewood, and appears as darker colored rings. One year's growth can be seen in a set of the lighter and darker rings.



The relative width of the tree's rings correlates to the resources available to the tree. During the spring and summer, the trees grow at their fastest rate, since they have the most resources in the form of water and sun along with the favorable temperatures. During the late summer and fall, the trees begin to grow more slowly since there is less water, less sun, and the temperatures begin to drop. Trees become dormant in the winter, with no discernable growth, since the water is often frozen and sunlight and temperatures are at their minimums. In years where more water is available, the tree can grow at a faster rate, leading to a wider ring of springwood. In years of drought, the tree cannot grow as much, leading to more narrow rings.

Teacher Note: As an aside, this does not hold true in areas outside of the temperate zone! In the temperate zone we have distinct growing seasons, but in the tropical zone growing seasons can last the entire year. The lack of seasons means a lack of rings!

As the tree grows it creates a pattern of wide and narrow rings. Dendrochronologists use these patterns to study climate, ecology, and history. Patterns in tree rings can be compared to modern climate data, or to corroborate climate models made from other sources such as ice cores. By overlapping and matching patterns in trees that lived during different times, you can create continuous timelines that span hundreds or thousands of years. The rings and markings on tree cookies can also tell us about the history of fires, insect invasions, herbivory, and when the tree has had to bend to compete for access to sun.

Trees are the keystone organisms for many of the forest ecosystems. Their presence or absence, health or weakness, can have a snowballing effect on the other organisms in the forest. Trees act as food in the form of leaves and bark for many organisms. They house insects, mammals, birds, fungi, and lichens which many other organisms rely on for food. Trees create shelter, shade, and camouflage for organisms big and small. They stabilize the soil and prevent runoff and flooding. An imbalance in their populations, whether as far more or far less trees, leads to significant changes in the resources available to all other organisms in the tree's ecosystem.

The tree cookies in the Botany Bin were collected in the Uinta Mountains or along the Wasatch Front in 2016 and 2017. They were all in areas of similar climate and precipitation. All of the trees were dead or dying when they were collected, and the dead trees had died between the years of 2014–2017. The trees are marked using the naming convention used by most government and scientific organizations. This naming convention is based on the scientific name for the plant and uses the first two letters of the genus and the first two letters of the species or specific epithet. For example; Quaking Aspen's scientific name is *Populus tremuloides* so it is marked with the letters "potr." The trees included are:

Common Name	Scientific Name	Marking
Quaking Aspen	*Populus tremuloides*	potr
Gambel Oak	*Quercus gambelii*	quga
Rocky Mountain Juniper or Utah Juniper	*Juniperus scopulorum or Juniperus osteosperma*	jusc or juos
Subalpine Fir	*Abies lasiocarpa*	abla
Lodgepole Pine	*Pinus contorta*	pico
Rocky Mountain Douglas Fir	*Pseudotsuga menziesii*	psme
Engelmann Spruce	*Picea engelmannii*	pien

You will likely notice that the rings vary greatly in size between the cookies. This is because, just like other organisms, different trees grow at different rates. Some grow very quickly, as can be seen by relatively much larger rings throughout the tree's life. These are considered softwoods as their wood is less dense. For example, the pine "pico." Others grow much slower, with relatively smaller rings. For example, the juniper, "juos" or "jusc." The denser wood creates hardwoods.

Lesson Plan:
Reading Rings – Resources and Survival

Materials	Location
Tree Cookies	Botany Bin
Hand Lenses	Botany Bin – Pull Out Compartment
Blackline: Precipitation Chart	Addendum Folder – Tab L4 OR USB – L4 folder
Blackline: Temperature Chart	Addendum Folder – Tab L4 OR USB – L4 folder
Blackline: Reading Rings – Resources and Survival	Addendum Folder – Tab L4 OR USB – L4 folder
Pencils or Pens	Classroom supplies
Projector	Classroom supplies
Optional:	
Increment Borer *Watch the instructional video BEFORE using the borer! The borer can easily get stuck in the tree if you do not follow the instructions!*	Botany Bin – Pull Out Container
Increment Borer Mounting Supply Bag	Botany Bin – Pull Out Container

Set-up

- To make this activity more phenomenon-based we suggest that you leave the Disciplinary Core Ideas until the discussion portion of the lesson.
- *If your students are still acclimating to phenomenon-based science you can preface the lesson by saying that you will be researching how resources effect organisms. You can also prime their thinking with the following questions:*
  - *What happens when an organism doesn't get enough food?*
  - *What happens when an organism gets more food?*
  - *What do plants need to live? How do they get their food?*
  - *What do animals need to live? How do they get their food?*
  - *What would happen if there were no more plants?*

- Explain that the students will be looking at tree cookies (cross sections of the trunk) that came from the Utah Mountain Ecosystem.
    - Introduce the students to the concept of an ecosystem (all of the interconnected living and non-living components of a given area). This can be done quickly to save time, or you can expand on this concept by giving examples of the biotic and abiotic components. We suggest specifically mentioning the abiotic components of water, climate, and rocks/soils.
    - Teacher Tip: If your students haven't recently covered the needs of organisms for survival, it can be helpful to include a brief reminder before introducing the ecosystems. We suggest the following: Plants need sun, air, water, space, and nutrients/stability from soil. Animals need food, water, shelter, air, and space.
- Break the students into teams. We suggest creating 3 or 4 teams.
    - This activity can be done as a class to save time, using the largest tree cookie and projecting it onto your whiteboard to observe.
    - To practice the scientific skills of Engaging in Argument from Evidence and Communicating Information; we suggest breaking the teams into roles, namely; Facilitator, Spokesperson, Timekeeper, and Devil's Advocate as outlined in the USB addendum folder document "Suggested Group Discussion Roles."
- Distribute the cookies to the teams.
    - Explain that the cookies are all from the same area, the Utah Mountain ecosystem (Uinta Mountains and Wasatch Front) and died between 2014 and 2017. They lived at different elevations but were subject to the same climate and weather.
    - Suggested cookie distribution:
        - 3 teams: 1) pico and juos, 2) abla and quga, 3) pien and psme.
        - 4 teams: 1) pico and juos, 2) abla and quga, 3) pien and psme, 4) large cookie
        - 5 teams: 1) pico, 2) abla, 3) pien, 4) psme, 5) juos
- Distribute the hand lenses to the students and explain that they will help the students observe the cookies.
    - Using the lenses does have a learning curve, so it can be helpful to familiarize yourself with using the lens ahead of time. Have your students practice using the lens to magnify their hands (the cuticle around the fingernail is ideal). There are links to videos and instructions on the USB, one of which is condensed below.
        - Hold the lens with your writing hand and move it as close to that same eye (right hand to right eye) as is comfortable (not touching the eye) resting the hand holding the lens on your face for stability.

        - Hold the specimen in the other hand and bring it towards the lens until it comes into sharp focus (typically within a few inches of the lens) or move your face with the lens in place towards the specimen until it comes into sharp focus.
    - Allow the students time to look at the specimens individually before proceeding. This can help them to create their own observations and practice using the hand lens. We suggest 2–5 minutes.
- Ask the students what they notice about the cookies and what previous knowledge they have about tree rings.
    - The most common previous knowledge is that the rings let you know the age of the tree.
    - Explain that the youngest ring is the outer most ring, using the largest tree cookie and your projector to point out the inner ring as the oldest and the outer ring just under the bark as the youngest. This is a great place to start the conversation about why the tree creates one ring per year. Using the blacklines "Basic Tree Anatomy" and "Tree Ring Diagram" as either a handout or projected on your board, lead the students through the ring creation process.
- Ask the students if they notice any difference between the rings found on the tree.
    - We suggest leaving the discussion at noticing that there are differences in the rings. *If you feel your class needs more guidance ask the students why there are thicker and thinner lines. Refer back to the questions about what happens if an organism gets more or less food, and how a plant gets its food if needed. The goal is to have the students correlate the size of the rings with how much food the plants have available that year.*
- Explain that the students will now work to see if they can find a reason for the difference of the tree rings.

Activity

- Give the teams a set amount of time to complete the activity. We suggest 5–10 minutes.
    - *If your students need guidance, encourage them to think about what the plants need to live and what challenges they are potentially facing in the ecosystems the plants are living in. Basically, what the plants need, what they have, and how they bridge any gaps between the two.*
- Ask the students to work as a team to come up with a hypothesis about why the tree rings have different widths.

- Have the students record their ideas and reasoning on the blackline "Reading Rings – Resources and Survival."
- The goal is to have students think about what makes an organism grow. As long as they can tie their observations together logically there is no "wrong" answer.

- Have each team share their observations.
  - You can use this time as an exercise in Engaging in Argument from Evidence when students have conflicting ideas on the why of the traits. If you had a Devil's Advocate, this would be a time for them to help assemble and voice their team's objections. The worksheet can help students record the results of that discussion.
- Distribute the blacklines showing the precipitation and temperature data. You can also let the students know that there were no significant differences in the amount of sun or air the trees received and that their soils didn't change.
- Ask the students to review the climate data and the patterns of the rings on their cookies to see if they can find any correlation or corroboration of their earlier claims.
  - Have the students record their ideas and reasoning on the blackline "Reading Rings – Resources and Survival."

Discussion

- Have each team share their results after comparing the tree cookies and climate data.
  - Streamline this step by merging it with projecting the tree cookie on your board. As a class, come up with a hypothesis on why the traits have different sizes and compare the peaks and valleys of the climate data with the relative thickness and thinness of the rings looking for patterns.
  - You can use this time as an exercise in Engaging in Argument from Evidence when students have conflicting ideas on the why of the traits. If you had a Devil's Advocate, this would be a time for them to help assemble and voice their team's objections. The worksheet can help students record the results of that discussion.
- Ask the class what they think would happen if the trees had far less or far more of the resources they need.
  - Have the students record their ideas and reasoning on the blackline "Reading Rings – Resources and Survival."
  - This and the rest of the discussion section can be done as homework by asking the students to complete the rest of the blackline "Reading Rings – Resources and Survival" if time is limited.

- As a class discuss a what-if scenario where all or most of the trees in a forest died due to lack of resources.
    - Would the change in the number of trees only effect the trees or would there be an affect to other organisms in the forest? Which organisms and why?
    - Have the students record the results of the discussion on the blackline "Reading Rings – Resources and Survival."
- Challenge the class to also imagine what would happen if there was an increase in resources and the tree population doubled.
    - Would an increase in trees have a positive or negative effect on the other organisms in the forest?
    - What would happen if there was a large reduction in resources the following year?
    - Have the students record the results of the discussion on the blackline "Reading Rings – Resources and Survival."

Dendrochronology at Your School

You and your students can now use the same tools and techniques as professional scientists in your own backyard! Please take a few minutes to watch the video linked on the USB (https://www.youtube.com/watch?v=jPJUewNcvqo) for instructions before using the increment borer!

- Once you've watched the video, head outside and try to locate 2-4 trees that appear to have different resources. For example, a tree in the school yard with regular watering has different resources than the tree growing wild on a dirt lot, or one growing along a stream.
- Take a core sample from each tree and bring it back to the classroom to mount and sand.
    - Be sure to note which core sample came from which tree. This is a great time to talk about the importance of documenting scientific samples. You can include the location and conditions the tree was found in, the type of tree, when the sample was collected, etc.
- Apply a line of wood glue to the channel on the wood blocks from the Increment Borer Mounting Supply Bag and then press the core sample gently into the channel. The glue will dry in a few hours.
    - Label the wood block with data you recorded in the field, including the date.

- Once the glue has dried, use the sandpaper to sand the core sample even (or nearly even) with the wood block.
- Depending on the samples, you found you can conduct a number of investigations on the core samples.
    - Compare the patterns of the rings from the different sites. Can you tell a difference between the trees found in areas with different resources?
    - Can you find other markings on the core sample? What might they be from?
    - If one of the trees was dead when you collected the sample, can you match the patterns to a living tree to identify when the dead tree died?
    - When comparing the trees with more resources versus those with less, look closely at the first few years of growth. Do you see a difference in the wild tree and the one from a garden? Why might those differences occur?

Assessment

Students should demonstrate an understanding that organisms, and populations, are dependent on resources. Students should also demonstrate an understanding that changes in the amounts of resources can have different effects on different organisms, depending on their needs. Informal observations can be made as students are working; observe how they participate in discussions, if they are engaged, etc. Make anecdotal notes of students' verbal responses during discussions. The worksheets can also be used as either a note of participation, understanding, or critical thinking.

Extensions

- The National Park Service has a great activity guide that can be combined with the wood cookies in the bin. This covers not only climate and dendrochronology, but also archeology. PDF copies are available on the USB along with hyperlinks.
  https://www.nps.gov/band/learn/education/upload/10TreeRingActivities.pdf

- This website allows students to build a tree ring model based on given ecosystem parameters.
  https://www.windows2universe.org/earth/climate/dendrochronology_build_tree.html

- NBC learn video on trees importance in their ecosystems.
  http://www.nbclearn.com/changingplanet/cuecard/54732

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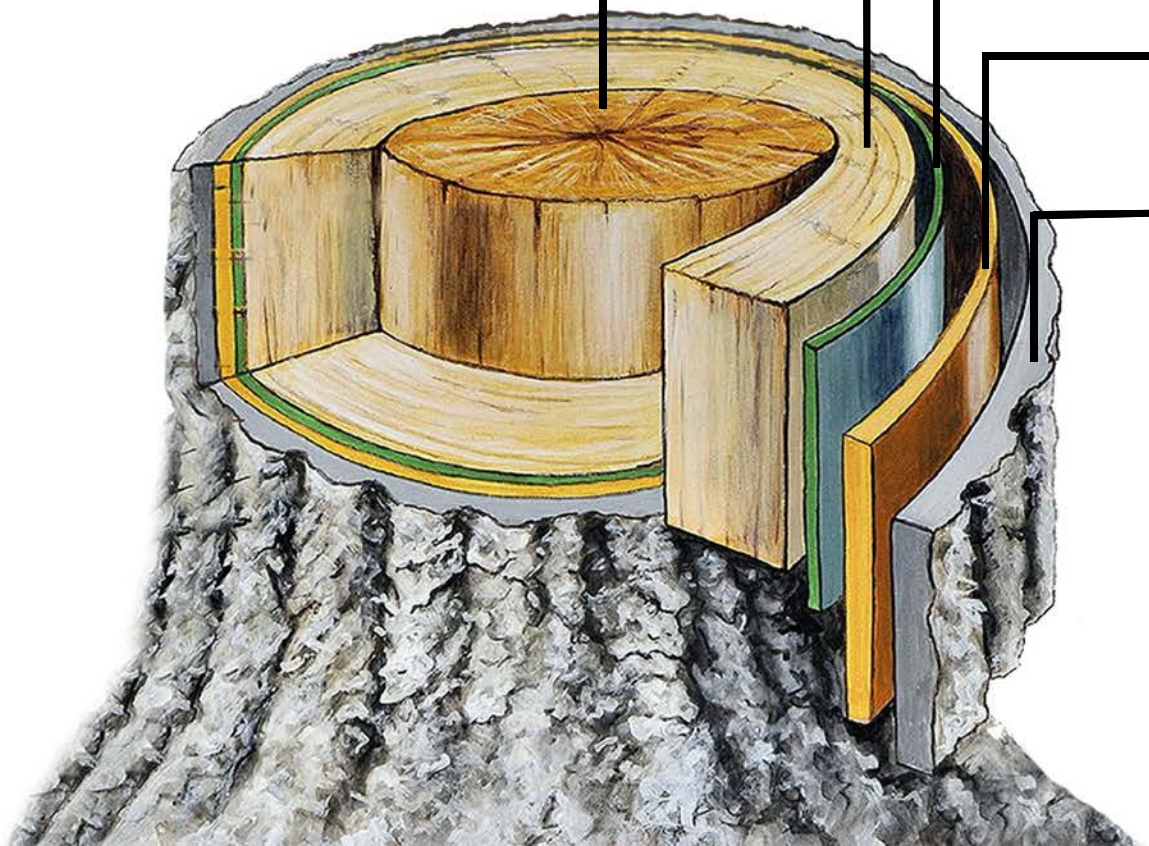
Basic Tree Anatomy



Heartwood. This wood is often considered dead, as it is no longer transporting water. It is often filled in with the tree's waste, which makes it darker in color. It acts to support the tree.

Sapwood. This wood is no longer growing, but is conducting water. It is lighter in color.

Vascular Cambium. This is the zone where growth happens. Cells are dividing and differentiating into water conducting xylem to the inside, and food conducting phloem to the outside.

Phloem. This layer has living cells that transport food throughout the tree.

Bark. This layer includes the dead phloem cells that have been pushed outward as the tree grows. This layer protects the tree and can become very thick.

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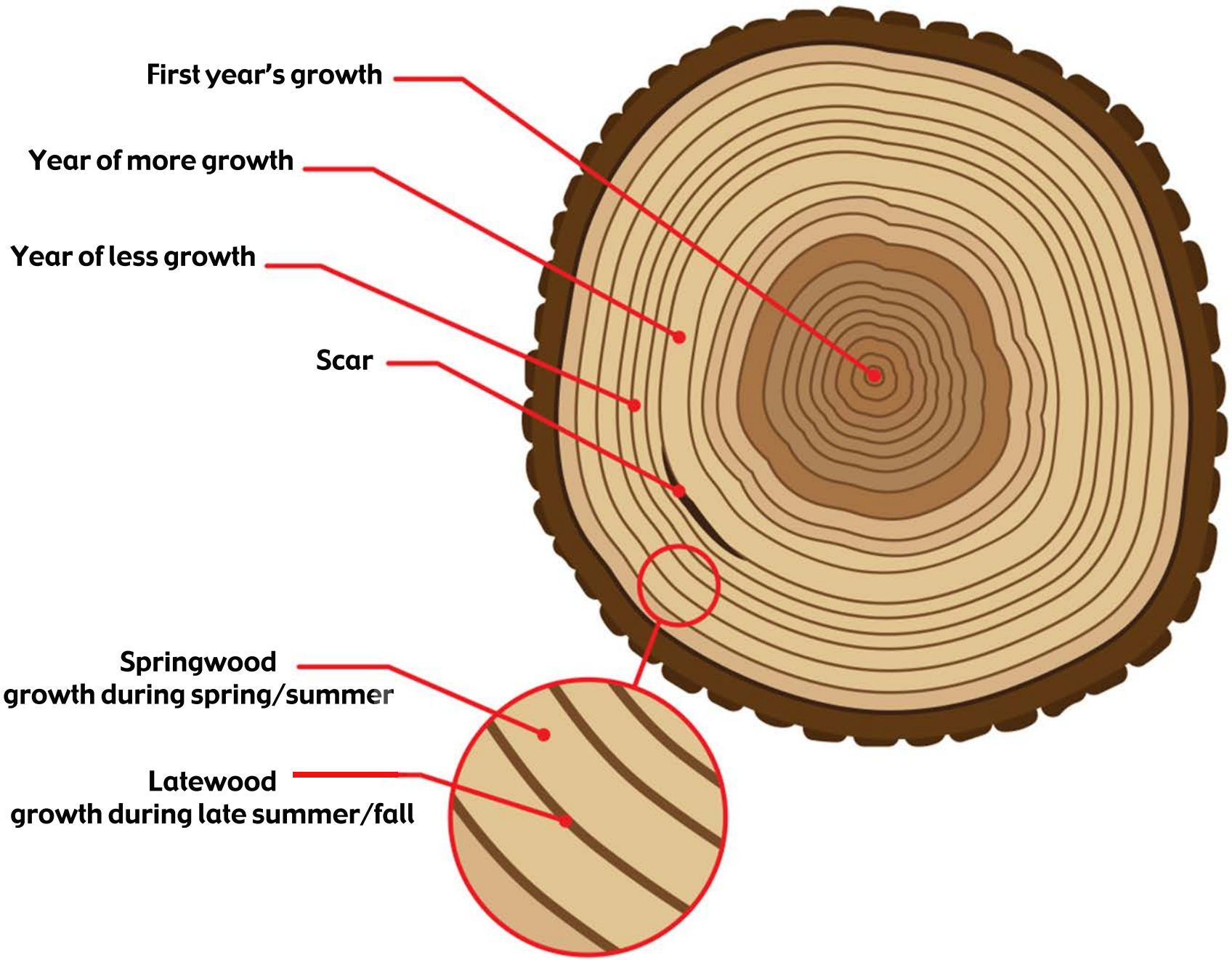
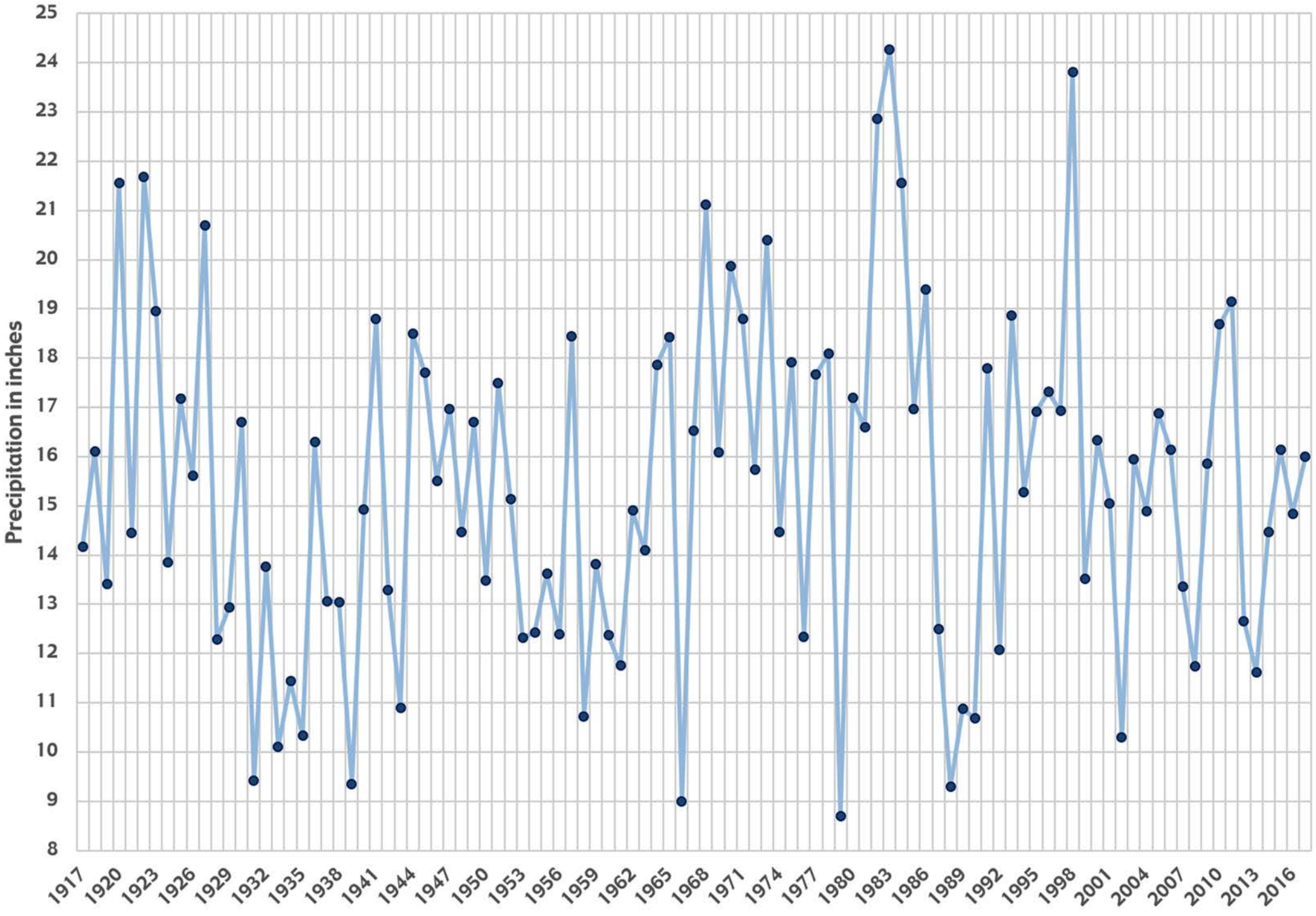
Tree Ring Diagram



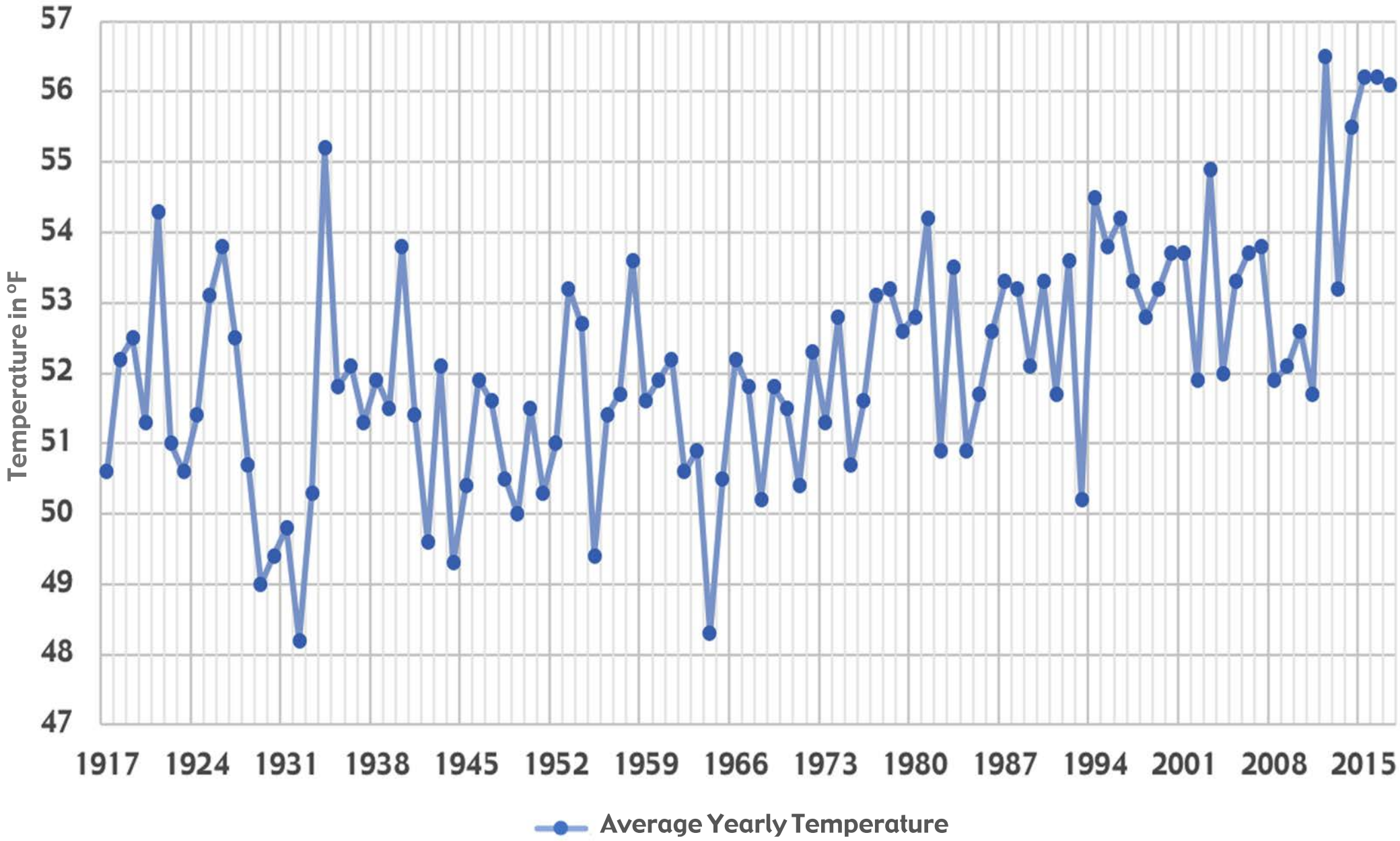
RED BUTTE GARDEN BOTANY BINS

1917–2017 Annual Precipitation in Inches for Salt Lake City, Utah



RED BUTTE GARDEN
BOTANY BINS

1917-2017 Annual Temperature in Fahrenheit for Salt Lake City, Utah



RED BUTTE GARDEN BOTANY BINS

Reading Rings – Resources and Survival

Name(s): _____ **Date:** _____

Specimen(s) Observed (tree code): _____

Organisms and Resources

Why do you think the rings on the tree have different widths? _____

_____

_____

Does the climate data support your claim? Why or why not? _____

_____

_____

_____

What resource seems to be limiting or increasing the trees growth? _____

Could any other ecosystem factors be affecting the trees growth? Which ones? _____

_____

How could you test the above claim? What data would you need? _____

_____

_____

Ecosystem and Resources

What would happen if there was an extreme change in the resources that the trees need?

_____

_____

_____

Write a paragraph or two on the back of this sheet about what you think would happen to the forest if the trees largely died off or if they doubled in number?