RED BUTTE GARDEN BOTANY BINS

PATTERNS & PARTNERSHIPS: UTAH MOUNTAIN ECOLOGY

Lesson 7: Beetles and Trees
Stability and Change

SEEd Alignment: 6.4.4 – *suggestions for acclimating to phenomenon education in italics*		
Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.		
Disciplinary Core Ideas	**Crosscutting Concepts**	**Science and Engineering Practices**
• LS2.C : Ecosystem dynamics, functioning, and resilience	• Stability and Change	• Construct Explanations • Engage in Argument from Evidence
Vocabulary: vocabulary is underlined		
population stability		
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.		
50 – 100 minutes (2 classes) , 35-45 minutes, and 100+ minutes (2-3 classes).		

Lesson Summary

Beetles, and dead trees, and population instability, Oh My! As you've likely heard on the news, or perhaps seen with your own eyes, there has been a drastic change to the ecosystems of most of Utah's Mountains and forests across the Western U.S. and Canada. Millions of acres of evergreen forests across the West have faded from brilliant greens to alarming shades of orange and finally to dull, dead browns as trees have succumbed to the current bark beetle outbreak. This color gradient acts as a map of populations that have become destabilized. Bark beetles are a native and natural part of western forests and of many tree's life cycles, but over the last few decades their numbers have exploded. Abiotic factors destabilized the bark beetles' populations, and the swarms of bark beetles in turn destabilized and decimated the population of most evergreen populations in the West.

Your students begin their investigation of this phenomenon by getting a look at the problem from afar, through drone footage, and then zeroing in on individual trees and the insect found inside. They will then break into teams and move through three stations where they will analyze data centered on the three main components of this outbreak; the bark beetles, the trees, and the climate. As they rotate the stations, they are tasked with constructing an argument about what has happened in that ecosystem and how populations were affected. Arguments are presented and debated with the goal of students creating an argument that makes sense to the class as a whole. Students further explore real world scientific problems, namely missing and incorrect data, and how to work with those limitations. Lastly, student investigate patterns of ecosystem changes and potential effects on populations through other ecosystems.

Essential Questions

- How can changes in abiotic factors in an ecosystem affect its organisms?
- How can differing organisms' populations affect one another?
- What is stability in an ecosystem?

Enduring Understanding

- Organisms are closely linked to their ecosystems.
- Changes to an organism's ecosystem can affect individuals and entire populations
- Changes in the populations of one organism can have an effect on populations of other organisms.

Previous Knowledge

Understanding that the stability of populations is tied to ecosystems, and that a change in ecosystems can affect population stability is typically not a hard concept for students. They've spent the last few lessons investigating the flow of energy and matter and the interconnected nature of ecosystems, and perhaps even experienced how abiotic factors could affect their energy/matter web. Students have also likely had some real-world experience with abiotic factors affecting populations in their ecosystems, or even populations having an effect on one another. Perhaps they've experienced a population explosion of fruit flies after food was left out too long, and seen that the increase in a food source lead to a change in the population of fruit flies. Or they may have noticed that a cold snap lead to an increase in the number of spiders in their homes, and a subsequent reduction in the number of other bugs.

Background Information

There is an incredible amount of background, studies, and reports available online about the current bark beetle outbreak, and one could easily go down a seemingly never-ending rabbits' hole on the subject! For this lesson, the background information is going to focus on four main topics: bark beetles as a native species, the effect of climate on beetles, the effect of climate on trees, the effect of beetles on trees, and the current bark beetle outbreak. The Lesson 7 folder on the USB contains many different resources if you would like to explore the subject more deeply, including the reports and studies that this background section was drawn from. This background presents a broad and generalized coverage of an incredibly intricate and diverse topic.

It would be easy to assume that bark beetles are an invasive species that invaded our forests, but that is not the case. Bark beetles have been in Utah, and part of the tree's lives, for nearly as long as the forests. When populations are stable, the bark beetles act as a typical predator. They predominantly attack and kill old and sick trees. This benefits the forest and the tree population as a whole by removing the weakest members of the population and freeing up resources for younger and stronger trees. The old trees are typically the tallest and create a shady canopy, blocking much of the sun from reaching the younger trees below. The old trees also have the largest root systems, and the most resource requirements, taking up soil minerals and water that younger trees need to thrive. When the old trees are attacked by bark beetles and die, they stop taking up the soil resources and eventually fall, opening up the canopy and allowing light through. Forests are no different than any other population, or the ecosystem as a whole, in that they are healthier when more biodiversity is present. When there is a range of ages and sizes of trees, they are more equipped to survive challenges that might wipe out one size or age class of a tree population. Bark beetles are one part of creating a tree population with a healthy diversity of size and age, culling the old and sick, while other factors control an overabundance of other classes. Fire, herbivory, fungi & bacteria, bark beetles, and other factors all work to create a diverse and healthy tree population.

Bark beetles are surprisingly hardy considering their size, and have a stunning reproductive rate. Their numbers are typically kept in check mainly by the climate that they, and their associated trees have adapted to over time. To understand their mortality, it's necessary to understand their life cycle. In summer (historically around early July) bark beetles emerge from trees and fly off in search of uninfected trees, where they can mate and lay eggs. They follow pheromone messages, that advertise that a tree is open or already full of beetles. Once the bark beetles find an open tree, they land and find a mate. Once fertilized the female beetles dig chambers under the bark of the tree to lay their eggs. Those eggs hatch and move through the sapwood as larvae, creating galleries as they consume the sugars and water the tree is transporting (historically in late August.) The beetles overwinter under the bark as larva, then pupates into pupa in the spring, and metamorphizes into adult beetles by summer. Since the beetle spends the vast majority of its life under the bark of trees, it is largely shielded from predators and pesticides. Woodpeckers do eat bark beetles, but are typically not considered a major component in controlling their populations. The beetles are shielded by the bark of the tree, but are still susceptible to extremes in temperatures, especially when transitioning from one form to another. Historically, there have been deep freezes during the fall and spring when bark beetles are the most delicate. These deep freezes lead to massive die-offs of the bark beetles, and kept their populations at stable levels. Over the last few decades, especially starting in the late 1990's, there have been fewer and fewer years when these deep freezes have occurred and so many, many more beetles are surviving the winter. Beetles had adapted to the yearly die-offs by having a large number of offspring during what was typically a two-month long summer or growing season. On average, a female bark beetle lays 60 eggs at one time. Many bark beetles only have one generation a year, but some have up to five. But those are historical numbers, as winters have not only lost their deep freezes over the last few decades, but summers have also started earlier and lasted later. What was once a two-month growing season, is now averaging four months. That is a doubling of the number of generations that any given bark beetle is generating. A beetle that typically has one generation of 60 beetles per growing season, is now having one generation of 60 beetles that are each having 60 beetles. This means that beetle populations are not just doubling but growing exponentially. A bark beetle that had been generating one generation of 60 previously, is now generating 3,600 beetles in the longer growing season. A beetle that had been generating 2 generations per year before for a total of 3,600 offspring from the original mother could now be generating 12,960,000 beetles during the doubled growing season. So beetle populations are not only exploding due to longer growing seasons, but also not experiencing typical massive die-offs. As the populations have exploded the bark beetles very quickly run out of old and sick trees, and move on to the young and healthy.

Trees are not immune from the climatic changes of the last few decades, which has further exacerbated the bark beetle outbreak. Like all organisms, when trees are dealing with restricted resources they become weaker and less able to fight off attacks, be them on a macro or micro scale. The sun and soil mineral resources have largely remained unchanged, but the water and temperatures have not. A trees main defense against bark beetles is to physically push the beetles out with sap, which can be seen on the trunk of an attacked tree as "pitch tubes". In order to produce sap, the tree needs adequate water, and in order to produce enough sap to defend itself against a population explosion of bark beetles it needs a lot of water. When that water is not available, the trees are not able to defend themselves and the beetles can quickly infiltrate the tree and begin to kill it. A healthy tree, not dealing with water-stress, can fight off over 2,000 beetles, while a water-stressed tree can be killed by as few as twelve. The water-stress the trees are facing is due to a combination of issues. As you may note on the precipitation chart, there is not a striking reduction in the amount of precipitation, and there are even some wetter years during the current outbreak. You might also note that there has not been an increase in the amount of precipitation either. So, the average temperatures are rising, the summer season is getting longer, but there is not more water. As summers continue far past the typical return of fall and the time when trees and bark beetles typically become dormant, the trees are stranded without water and still facing the onslaught of the bark beetles. What was once a selective removal of the weakest of the forests trees has become a massacre, falling healthy trees along with the old and sick. But that is not the only problem for the trees! Over the last century the tree populations biodiversity of age has been greatly affected by land management techniques. Where forest populations were once naturally shaped into a range of ages and sizes, fire suppression and logging techniques have created many stands where tree populations are largely skewed to older ages. These stands of older and weaker trees create wonderful breeding grounds for the bark beetles, where nearly none of the trees can offer a defense. The bark beetles then spread out from these stands to the areas with younger and healthier trees in such numbers that even those that are not water-stressed are unlikely to survive. Fire suppression also prevented another bark beetle population reduction factor in that extreme heat from fires can also create large scale die-offs of beetles but many trees are adapted to fire and largely survive. The same abiotic factors that help the bark beetle, harm the trees.

Lastly (kudos if you made it this far!) is the current bark beetle outbreak. There have been other bark beetle "outbreaks", but all were on a much, much smaller scale. All populations wax and wane in a dance with the populations of their associated organisms, with one partner sometimes smashing the foot of the other, but the current situation is far different. Between 2000-2017 forest surveys have shown at least 55.6 million acres affected by the bark beetle outbreak just in the U.S. The affected areas have up to 90% death rate for the attacked trees, and the outbreak is happening throughout Western Canada as well. The potential results of this outbreak are up for debate. Some scientists have hypothesized that the forests will be revived with the loss of the upper canopy of the forest and younger stronger trees of the same species will thrive. Others predict that trees and plants more adapted to lower elevation, warmer, and drier areas will begin to spread up in elevation and take over areas once dominated by evergreens, namely the quaking aspen (which is facing its own issues.) The growing number of dead, dry trees across the forests likely mean that there will be larger, and more extreme, forest fires as there is so much more easily sparked fuel. Those fires could further alter the forest. There are many potential outcomes, but regardless of the actual outcome the effects of this bark beetle outbreak, those results will be seen for many decades to come.

A potential side discussion can be conducted with the data sheets in this lesson, based on the (sometimes frustrating) nature of data in science. The weather and precipitation data for this lesson was pulled from the Western Regional Climate Centers website, which pulls from the Forest Service and the Bureau of Land Management's Remote Automated Weather Station (RAWS) program. These stations are used to monitor forest fire conditions and record weather patterns and can be accessed at https://raws.dri.edu/ . In choosing data we looked for a station that was located within the mountain ecosystem where the bark beetle outbreak is occurring, and had records beginning before at least 1990 and ending at least after 2010. Whether due to equipment failure, retirement and moving of stations, changes in funding or organizational structure, there were very few data sets available. The Hewinta Guard Station data turned out to be the best choice, but did come with some issues which are not unlike the issues a scientist might encounter when attempting to compile data. The first issue was missing data for some of the months across a few of the years. This missing data could be fodder for a class discussion on how missing data may be skewing the overall data and the graph. The second issue was the precipitation data for the years of 1988 and 1989. Annual precipitation of 487 and 573 inches are far out of the realistic range, and demonstrate the possibility of erroneous data being present in data sets from trusted data sources. This is a great chance to discuss the importance of questioning data that seems faulty, and using critical thinking skills. While these data issues could be glossed over if time is not available, they do offer an opportunity for your students to hone their scientific skills.

Lesson Plan:
Beetles and Trees – Stability and Change

Materials	Location
Phenomenon Introduction	
Drone Footage	USB – L7 Folder
Equipment to Watch mp4 video	Classroom Supplies
Bark Beetle Damaged Log	Bark Beetle Specimen Bag
Bark Beetle Specimen (in vial)	Bark Beetle Specimen Bag
Station 1: Temperature & Precipitation	
Minimum Average Temperature Chart	Addendum Folder – L7 Tab
Maximum Average Temperature Chart	Addendum Folder – L7 Tab
Annual Precipitation Chart	Addendum Folder – L7 Tab
Station 2: Bark Beetle Data	
Bark Beetle Specimen (in vial)	Bark Beetle Specimen Bag
abla tree cookie (*Abies lasiocarpa*)	Tree Cookie Bag
Bark Beetle Data Sheet	Addendum Folder – L7 Tab
Bark Beetle Life Cycle Sheet	Addendum Folder – L7 Tab
Station 3: Forest Trees	
Bark Beetle Damaged Log	Bark Beetle Specimen Bag
pico tree cookie (*Pinus contorta*)	Tree Cookie Bag
Trees & Bark Beetles Sheet	Addendum Folder – L7 Tab
Tree Mortality Sheet	Addendum Folder – L7 Tab
Other:	
Student notebooks and pens/pencils	Classroom Supplies
White Board	Classroom Supplies

Preparation

- For the phenomenon introduction you will want the drone footage from the usb, and equipment to display it, along with the log and beetle specimens in the Bark Beetle Specimens bag.
    - We suggest previewing the drone footage, watching for seasonal changes and areas of more and less die-off.
    - The video is in mp4 format, which will play on most video players.
- For the activity stations, you will want to assemble the components as outlined in the materials section above.
    - Depending on your classroom, you can either set up the stations ahead of time or distribute the components after the set-up. The log and beetle specimens will be used in the set-up and then can be distributed to the activity stations.
    - Students will have a chance to observe the log and beetle specimens at one of stations during the activity.

Set-up

- Explain that students will be exploring a phenomenon that is happening throughout Utah's forests, the Western U.S., and even into Western Canada.
- Show the drone footage.
    - Start by showing students the Winter Phenomenon Video and ask what they notice. Students may notice the lack of leaves, if so don't correct them and let them watch the following videos to give them a chance to notice that the trees remain leaf-less into the summer.
        - The goal for this section is to have students notice that a large number of the trees in the forest are dead and to wonder why. You could mention that these videos were taken at multiple locations in the Uinta Mountains, but that very similar scenes could be found in forests across Utah, the Western U.S., and Western Canada.
    - Show students the Fall and then the Summer Phenomenon Video's and again ask what they observe. The audio on the videos is actual recordings of the bark beetles eating/boring, mating, and communicating under the bark! It can give away the reveal of the beetle if you mention the audio at this point, but it can be a fun aside after showing the beetle.

- To save time you can show students only one of the clips, we suggest choosing the Summer Phenomenon Video as there isn't the issue of students assuming that the trees might have shed their leaves for fall/winter.

- Show students the log specimen.
  - The log will be at one of the stations, so your students will have a chance to handle and observe the log more closely at that time. The log specimen has two sides; one with the bark still intact, and the other with the bark removed. The bark side is to demonstrate the bore holes created when the beetles entered and exited the tree. The side with the bark removed is to show the galleries (wavy path the beetles chew through the sapwood) and frass (waste) left by the beetles.
  - Ask students to imagine that they've walked into the forest they saw in the drone footage. As they approach one of the dead trees they look closer at the bark (show students the bark side of the log, either through a projector, or walking through the class.) Ask them if they notice anything.
    - The goal is to have students notice the holes in the bark and wonder what created them.
  - Ask students to imagine that they've used a pocket knife to cut back the bark to see what might have made the holes. Show students the other side of the log, either through a projector, or walking through the class.) Ask them if they notice anything.
    - The goal is to have students notice the galleries and wonder what created them.
- Show students the bark beetle specimen, either through a projector or walking through the class.)
  - Tell students that the vial contains the beetles and larvae from the tree they were investigating.
- Briefly explain that starting around the year 2000 forests across the West have been decimated by the beetle they found.
- Explain that students will be creating teams and moving through three stations to learn about different aspects of the phenomenon and using that evidence to construct an explanation of what is happening in the forests and why.

Activity

- Break students into three teams.
  - To practice the scientific skills of Engaging in Argument from Evidence and Communicating Information later in the discussion. We suggest breaking the teams into

role, including Facilitator, Spokesperson, Timekeeper, and Devil's Advocate as outlined in the USB addendum folder document, "Suggested Group Discussion Roles."

- Ask students to collect a few sheets of paper or a notebook and pen for taking notes.
- Assign each team of students to one of the stations and have them investigate the station, discuss the components, and make notes.
  - We've had success giving students between 5-10 minutes per session, but suggest that you monitor students and rotate when they have stopped discussing the materials or based on your classroom time limits.
  - If you have more time: have your students do a quicker preliminary rotation through the stations where they only read/look at the materials (~3-5 minutes), followed by a second rotation where they discuss and construct arguments (~5-10 minutes.)
- Rotate the teams until they have visited all of the stations, checking in and encouraging scientific thought.
  - For the Precipitation & Temperature Station you could ask:
    - Do you see any patterns?
    - Do you think that any temperatures or precipitation levels are more significant than others to the organisms?
    - Do you see any trends in the temperatures or precipitation levels?
    - Do you think those trends will continue, and if so how might that affect organisms?
  - For the Beetle or Tree Station you could ask:
    - How is the beetle/tree attached in the energy and matter web?
    - What biotic and abiotic factors can affect the strands that attach the beetle/tree within the web?
    - What adaptations does the bark beetle/tree have to its environment?
    - What is different for the bark beetle/tree compared to the past (pre-2000)?
- When students have rotated through each of the three stations, have them discuss amongst their team what they think is happening in the forest.
  - Teams can be given a set amount of time to create an argument in class, or be given overnight or over a few days to create an answer or report.

- If you are using group discussion roles, this could be a good chance to have students create a short presentation on their findings or to remind students to utilize those roles in creating their answer.
- Remind students that they need to be able to tie their ideas back to the evidence they investigated in the stations.

Discussion

- Once the teams have finished constructing their arguments based on evidence, discuss them as a class.
  - If you used the group discussion roles, this would be the time to have the spokesperson present for each team. You can also model constructive argument, by having the other groups discuss each presentation and having the devil's advocate or spokesman ask questions or refute the claims of the other teams.
  - Monitor presentations for links between the argument and the evidence they studied.
- Ask students if the ecosystem they are studying (the forests attacked by the bark beetles) is healthy.
  - The goal is to have students understand that the ecosystem is unhealthy, students will typically say no, but if not lead the discussion to the fact that it is not a healthy ecosystem.
- Ask students what a healthy ecosystem version of this ecosystem would look like.
  - The goal is to have students understand the idea that a balanced ecosystem, one where predators are not completely overwhelming their ecosystem, is healthy.
  - Students typically come to this idea with little prompting, but if not, the following questions can help lead them to that conclusion:
    - How many more or fewer beetles would make the forest ecosystem healthy?
    - How many more or fewer trees would make the forest ecosystem healthy?
    - Would a change in temperature or precipitation affect the forests health?
    - What would you do to change the ecosystem to make it healthy?
- Introduce the concept/vocabulary of population stability: A population that is in balance, or equilibrium, with its ecosystem. A population having normal increases and decreases in number, but not completely overwhelming its predators, prey, or competition nor reducing in number to the point it dies-off or becomes endangered of dying-off.
- Ask students what makes a population stable or unstable.
  - List items on the board.

- **Choose a few of the most applicable items listed on the board and ask what would happen to a population in the ecosystem if that item increased or decreased.**
- **Ask students to come up with a statement that summarizes population stability and ecosystems, either as a team or as individuals, and discuss the results.**
    - **The goal is to create a statement that demonstrates an understanding of the concept that changes in an ecosystem can cause changes in population stability.**

Doubting Data – The Importance of Critical Thinking

Critical thinking is imperative to good science, and to understanding the information that surrounds and bombards us every day. Whether collecting data to understand a phenomenon, deciding who to vote for, or which news story to believe: having the ability to ask questions, evaluate sources, and think critically is the difference between finding facts and believing false-hoods. The data in this lesson is not perfect, there is missing and incorrect data. The data still paints a valid picture of climate trends, but could use some scrutiny.

- **Create copies of the precipitation and temperature data (available on the USB.) and distribute them to the students.**
- **Instruct students to review the data again, looking for anything of note.**
- **Ask students what they have noticed, if they haven't noticed the missing or incorrect data lead them to that conclusion.**
- **Focus on the Precipitation Chart, namely the years of 1988 and 1989.**
    - **Ask the students what they think is going on during those years.**
        - **Did those years really have exceptional amounts of precipitation?**
        - **Is that amount of precipitation within the realms of reason based on what they know about Utah?**
    - **On your computer navigate to http://prism.nacse.org/explorer/ (you may want to experiment with this site ahead of time, but it is fairly intuitive.)**
        - **Bring up the Annual Values for Precipitation for Summit County, Utah for the years of 1985 to 2017.**
        - **Ask your students what they notice.**
    - **Once the students have concluded that something was wrong with the data, ask them why they think it might be wrong.**
    - **Ask the students how they could verify or find false the rest of the precipitation data.**

- Focus on the Temperature charts.
    - Ask students how the missing data might affect the overall accuracy of the data.
    - Ask the students how much data is missing, is it different for different years?
        - Does missing more data have more of an effect?
    - What could the students do to mitigate the effect of missing data if there is no one source of weather data that covers the desired dates in the ecosystem in question?
- Have students explore the website http://prism.nacse.org/explorer/ or https://wrcc.dri.edu/ or others to investigate how they might try to create a data set for this activity (links available on the usb.)

Assessment

Students should demonstrate an understanding that changes in the abiotic or biotic components of an ecosystem, can cause changes in the stability of populations in that ecosystem. Students should further understand that data can and should be questioned, and understand some of the tools they have to question data. Informal observations and assessments of participation are most applicable for this lesson. If choosing to request presentations or written reports on the student's arguments, look for ties to evidence and critical thinking skills.

Extensions

The removal and reintroduction of wolves to Yellowstone National Park and the resulting effects on the ecosystem are wonderful subjects for further exploration into the subject of population stability. PBS has created a wonderful lesson plan based on this topic:

https://utah.pbslearningmedia.org/resource/331db173-a528-46ae-985c-e2432ebc6dc2/wolves-of-yellowstone-teacher-guide/

RED BUTTE GARDEN BOTANY BINS

Bark Beetles Data Sheet

Utah's Most Common Bark Beetles

Dendroctonus **species**

Attacks: Spruce, Pine, Fir

1 generation per year*

Ips **species**

Attacks: Fir, Elm

2 – 5 generations per year*

Scolytus **species**

Attacks: Spruce, Pine

1–3 generations per year*

Dendroctonus Gallery Pattern

Ips Gallery Pattern

Scolytus Gallery Pattern

Bark Beetle Facts

- Bark beetles are a natural part of almost all forests, including those in Utah.
- Just like a wolf typically kills the weakest deer, bark beetles usually attack old or sick trees. But if bark beetle populations are very large, they will attack healthy trees.
- Some bark beetles have multiple generations in a growing season (when temperatures stay above freezing, historically July and August.) *The generation info above is for the historic growing season of 2 months.*
- One female bark beetle can have 60 offspring at one time. Those 60 can each lay 60 eggs, leading to 3,600 in the second generation, 216,000 in the third generation, 12,960,000 in the fourth generation, and so on.
- The largest mortality agents of (things that kill) bark beetles are very cold temperatures, especially in the spring and fall. Temperatures of –30°F can kill over 50% of the bark beetle population.

Adapted from image by D.A. Leatherman, I. Aguayo, T.M. Mehall

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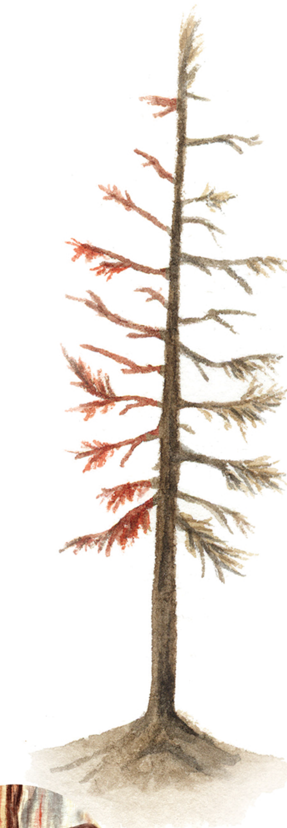
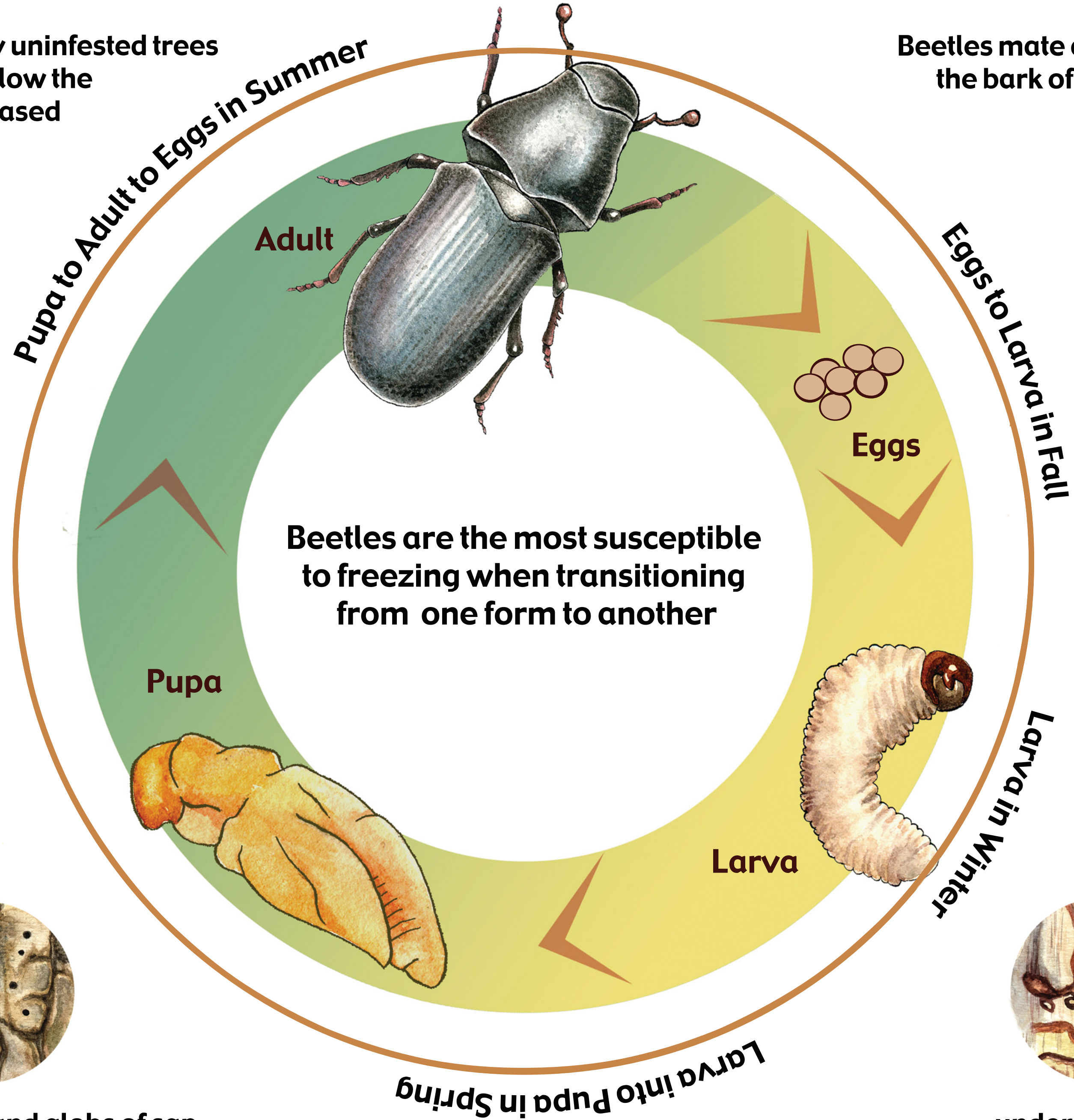
Bark Beetle Life Cycle

This life cycle is typical for most of the bark beetles found in Utah.

Beetles search out nearby uninfested trees and mates. They often follow the scent of pheromones released by other bark beetles.

Beetles mate and then burrow through the bark of the tree, depositing eggs in brood chambers.





Larvae pupate and leave the dying tree. Signs of an infested tree include small bore holes and globs of sap.

Adults and larvae create wavy paths called galleries under the bark as they burrow.

Tree Mortality (Death) Due to Bark Beetles

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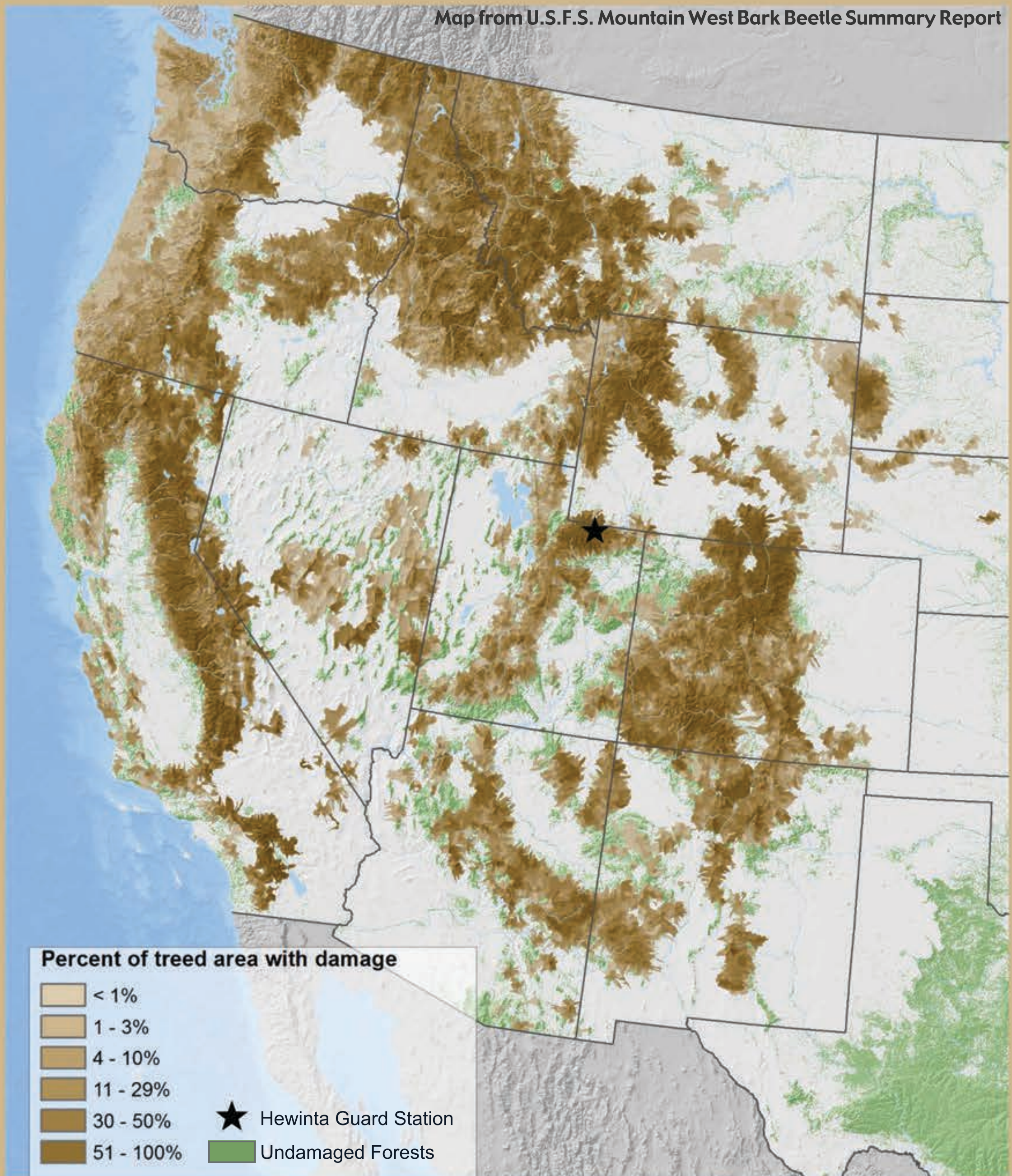
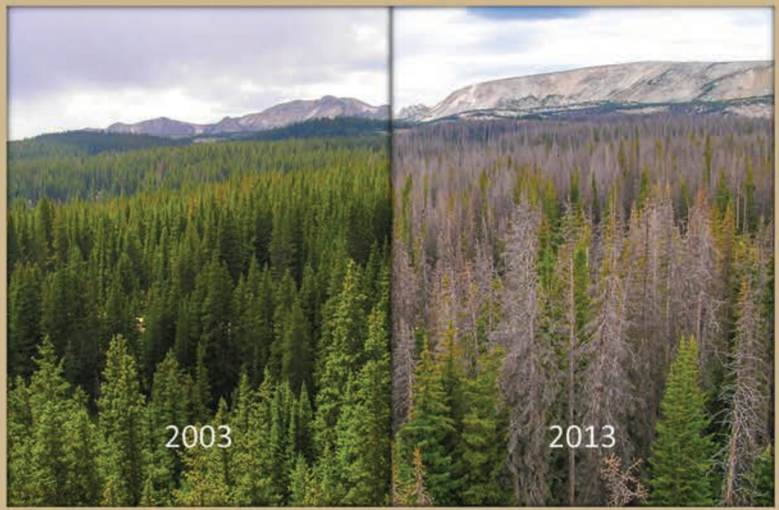


Percentage of Tree Mortality from Bark Beetles from 2000–2017

The Bark Beetle Outbreak



Before and after of area with bark beetle damage

- The current bark beetle outbreak in Utah, and across the Western U.S. and Canada, began in the year 2000.
- This is the largest bark beetle outbreak ever recorded. Between 2000–2017, at least 55.6 Million Acres of Western U.S. Forests have been damaged by the beetles.
- Up to 90% of the trees in damaged areas have died.
- Bark beetles are targeting younger and healthier trees, where before the outbreak they mainly attacked older and sicker trees.

Trees & Bark Beetles

Utah's Most Commonly Infested Trees

Spruce
Picea species

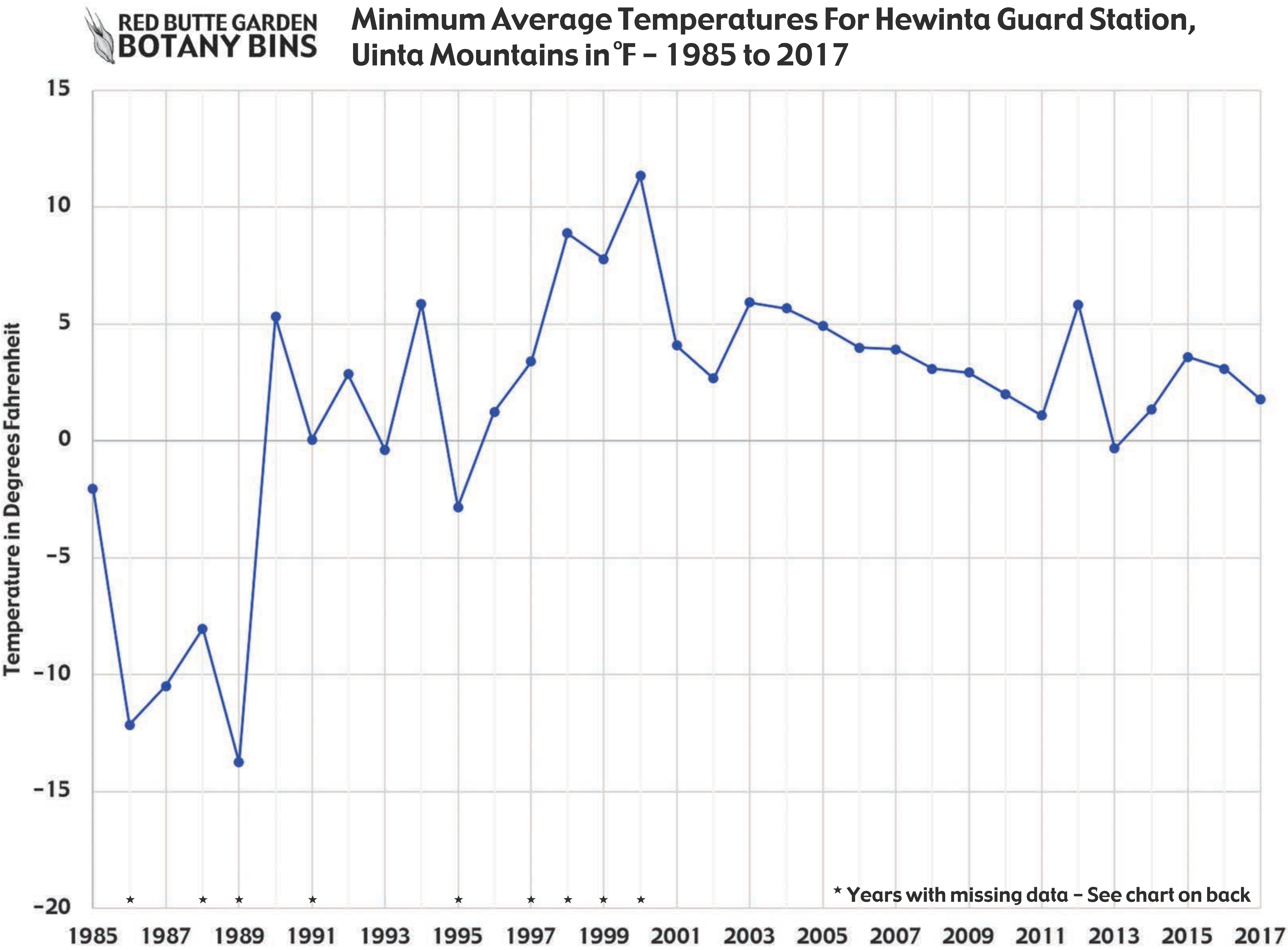
Fir
Abies & *Pseudotsuga* species

Pine
Pinus species

Pitch tubes on an infested tree trunk

Forest Tree Facts

- Trees in Utah are preyed on by many different organisms. The bark beetle has been their deadliest predator since the outbreak that began in the late 1990's to 2000.
- Trees have many ways to defend themselves. Against bark beetles, trees primary defense is to produce sap to physically push beetles out of the tree (called pitch tubes). A white pitch tube is a sign that a beetle was repelled, while a reddish-brown one shows a beetle was able to overcome the pitch tube and enter the tree.
- Healthy trees can withstand an attack of over 2000 bark beetles, producing huge amounts of sap to prevent their entry. Stressed trees can be killed by less than 20 bark beetles.
- Just like an ecosystem is healthier when it has a greater variety of organisms, tree populations are healthier when they have a greater variety of ages and sizes of trees.
- Bark beetles and forest trees have adapted over time with each other, and bark beetles are an important part of the tree populations life cycle. Bark beetles typically only attack old and stressed trees, creating space and freeing resources for younger and healthier trees and preventing forests where the tree population is mostly made up of old trees.
- Fire prevention and some logging techniques have lead to large areas where trees are all very close to the same age.
- Trees can survive extreme cold temperatures and low-grade fires that would kill many beetles.
- Some trees are also attacked by fungi that travels on the bark beetles bodies and are introduced inside the tree when the beetles bore in. The fungi can leave a blue stain on the wood.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Minimum Average Temperatures For Hewinta Guard Station, Uinta Mountains in °F – 1985 to 2017
Temperature in Degrees Fahrenheit
15
10
5
0
-5
-10
-15
-20
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
* Years with missing data – See chart on back

RED BUTTE GARDEN BOTANY BINS

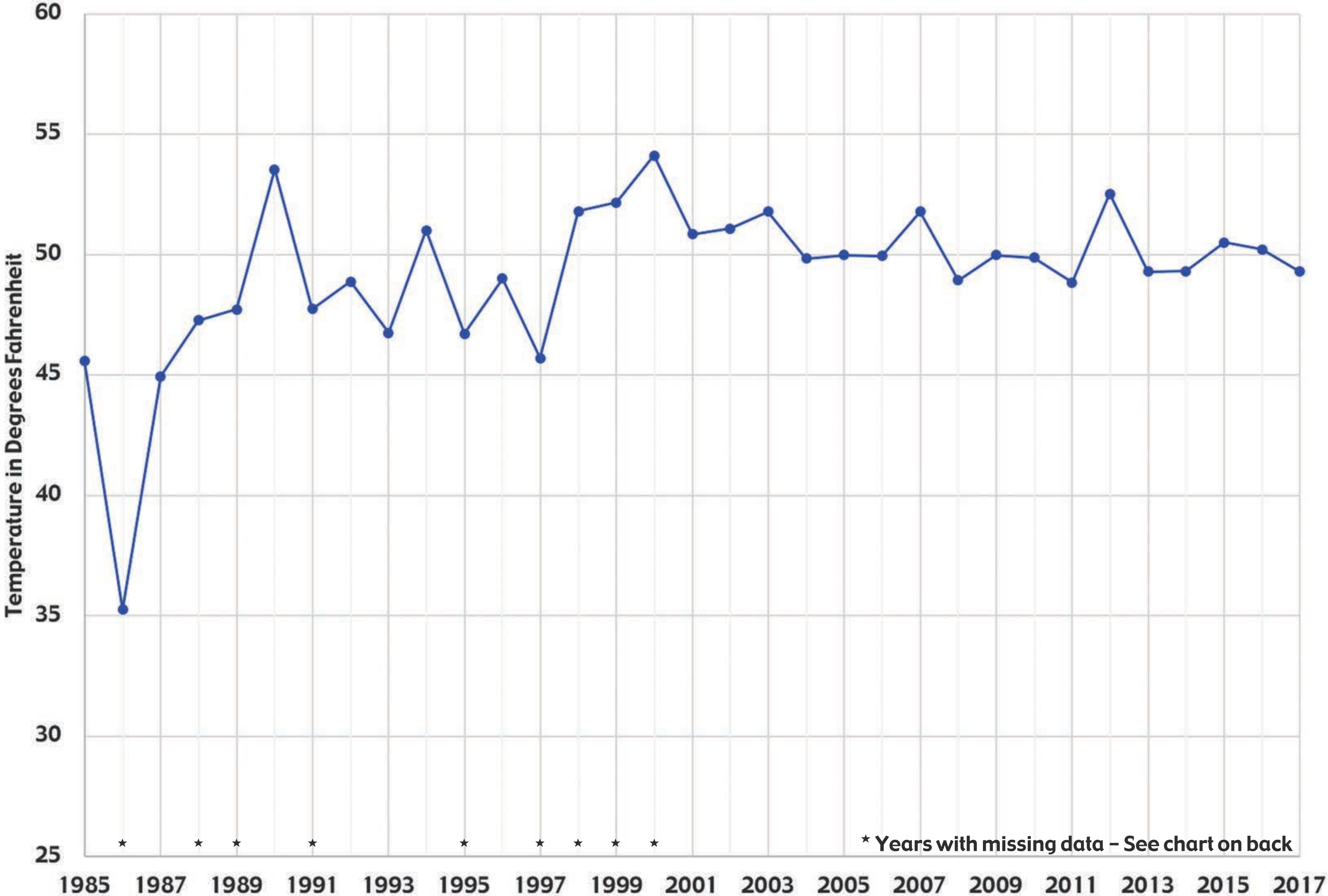
Minimum Average Temperatures For Hewinta Guard Station, Uinta Mountains in F - 1985 to 2017

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	-35.49	-41.09	-14.29	-0.2	8.3	23.1	28.8	23.9	5.5	6.2	-5.8	-23.39	-2.04
1986	-16.39	-27.59	-2.2	35.9	22.5					11.9	-5.8	-18.49	-12.14
1987	-24.09	-12.79	-18.49	-1.5	10.5	20.4	23.9	26	12.6	11.2	-12.09	-29.79	-10.49
1988	-21.29	-15.59	-12.79	-7.9	6.2		29.5	30.2	15.4	18.2	-57.99	-57.99	-8.02
1989	-57.99	-57.99	-57.99				42.9	20.4	21.1	-2.9	-5.1	-6.5	-13.75
1990						25.3	29.5	25.3	24.6	1.3	-13.49	-35.39	5.3
1991	-23.39	-10.69	-11.39	1.3	6.9	25.3	26	31.6	18.2	-15.59	-21.29	-26.19	0.06
1992	-15.59	-5.1	-7.9	2.7	22.5	23.9	26.7	16.8	20.4	9.8	-15.59	-24.79	2.85
1993	-8.6	-19.19	-3.6	0.2	10.5	18.9	25.3	19.6	12.6	2.7	-18.49	-44.59	-0.39
1994	-21.29	-14.89	-2.9	1.3	10.5	21.8	28.1	28.1	20.4	3.4	-9.99	-15.59	5.87
1995	-14.89	-10.69	-12.09	-0.1				26.7	12.6	-2.2	-3.6	-18.49	-2.83
1996	-16.39	-16.39	-2.9	-3.6	11.9	24.6	30.2	23.2	6.2	-5.1	-10.69	-26.19	1.24
1997	-12.79	-14.89	-9.99	-6.5				32	24	2	6	-16.99	3.39
1998	3	-13.99	32		17	29	36	27	26	5	-6	-19.99	8.88
1999	-13.99	-9.99	-9.99	-6	6	21	32	32	19				7.78
2000						27	29	34	18	9	-15.99	-6	11.34
2001	-15.99	-16.99	-7	-5	16	16	32	32	21	7	-14.99	-14.99	4.09
2002	-26.99	-19.99	-21.99	9	10	20	35	27	26	-3	-10.99	-11.99	2.67
2003	1	-23.99	-9.99	-2	12	28	29	32	13	11	-9.99	-9	5.92
2004	-12.99	-21.99	-6	0	21	29	35	25	18	10	-15.99	-12.99	5.67
2005	-9	-10.99	-5	4	15	21	29	21	17	10	-6	-26.99	4.92
2006	-15.99	-14.99	-14.99	-2	17	27	35	30	15	6	-18.99	-14.99	4
2007	-26.99	-14.99	-17.99	8	13	25	35	29	14	5	-4	-17.99	3.92
2008	-16.99	-13.99	-11.99	-14.99	9	23	29	28	23	1	-4	-13.99	3.09
2009	-29.99	-13.99	-10.99	-3	18	26	31	26	18	5	-9	-21.99	2.92
2010	-9.99	-14.99	-9.99	-1	-2	23	31	26	17	2	-15.99	-20.99	2
2011	-17.99	-34.99	-9	2	-4	16	32	31	26	2	-7	-22.99	1.09
2012	-10.99	-12.99	-7	6	13	17	35	32	22	-5	-5	-13.99	5.84
2013	-30.99	-20.99	-20.99	-1	1	20	37	32	16	0	-4	-31.99	-0.33
2014	-6	-20.99	-11.99	-5	-1	24	25	30	16	11	-17.99	-26.99	1.34
2015	-18.99	-18.99	-6	-4	18	29	23	29	20	13	-16.99	-23.99	3.59
2016	-17.99	-12.99	-11.99	6	7	26	28	27	20	4	-12.99	-24.99	3.09
2017	-26.99	-12.99	2	-5		27	26	32	11	4	-8	-10.99	1.78

Blank fields show that no data, or too little data, was collected

RED BUTTE GARDEN
BOTANY BINS

Maximum Average Temperatures For Hewinta Guard Station, Uinta Mountains in°F – 1985 to 2017



RED BUTTE GARDEN BOTANY BINS

Maximum Average Temperatures For Hewinta Guard Station, Uinta Mountains in F – 1985 to 2017

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	28.58	26.36	31.58	44.6	51.46	63.86	69.21	68.91	53.1	45.83	29.69	33.91	45.59
1986	38.01	29.61	38.02	37.3	23.2					41.41	37.24	33.42	35.26
1987	30.15	30.99	33.4	46.34	51.1	61.48	59.4	63.83	62.33	54.44	38.13	26.71	44.95
1988	27.03	35.28	32.37	44.97	50.79		73.55	71.87	60.01	57.13	34.14	32.9	47.28
1989	33.56	30.23	41.01				76.82	67.66	61.73	51.13	42.02	30.08	47.72
1990						68.19	70.73	68.79	64.26	50.65	39.8	26.95	53.53
1991	31.24	39.86	33.51	38.37	47.06	60.92	70.18	68.18	60.56	51.23	35.2	36.66	47.75
1992	35.49	35.91	39.48	49.48	53.54	61.34	67.2	70.56	62.09	53.46	33.67	29.02	48.88
1993	31.51	30.15	38.76	41.65	54.47	57.37	63.83	65.72	60.89	47.45	35.72	33.53	46.75
1994	31.83	32.34	42.23	43.53	55.69	67.53	74.22	72.6	63.16	46.15	31.98	40.54	51.02
1995	32.62	41.38	36.64	40.37				72.8	62.57	49.82	42.49	35.47	46.72
1996	28.74	35.67	39.98	42.76	51.43	66.41	72.95	71.6	58.26	50.45	40.45	29.46	49.01
1997	31.9	30.16	42.72	33.25				69.1	60.87	51.19	36.08	34.04	45.71
1998	37.5	33.32	35		49.33	68.6	72.48	70.71	63.5	49.39	40.9	34.87	51.81
1999	35.16	38.61	43.29	41.27	50.9	61.93	71.19	68.26	58.83				52.16
2000						66.36	74	71.39	61.3	48.45	33.13	36.39	54.11
2001	34.16	34.04	41.03	44.3	56.52	66	71.61	72.68	64.97	51.77	40.57	32.52	50.85
2002	31.1	36.18	36.84	46.73	53.1	68.47	77.55	72.23	61.57	49.48	43.5	36.19	51.08
2003	43.39	33.43	41.71	45.53	56.81	62.63	76.9	71.1	62.3	57.19	34.8	35.61	51.78
2004	34.29	32.59	47.52	43.97	52.9	62.6	70.88	67.32	59.63	47.65	41.7	37	49.84
2005	38.1	38.89	39.19	45.23	53.52	58.43	73.84	67.26	61.6	51.39	39.9	32.52	49.99
2006	33.48	34.46	34.77	46.37	55.13	67.63	74.74	69	58.23	48.65	40.73	36.1	49.94
2007	33.81	35.29	45.84	46.8	55.48	69.1	76.65	72.29	61.87	51.16	44.43	28.65	51.78
2008	28.13	34.62	36.35	41.17	49.61	63.13	74.68	71.35	62.1	52.48	42.57	31	48.93
2009	36.52	36.86	39.39	43.9	55.45	59.7	72.13	69.94	65.77	44.68	46.4	29.16	49.99
2010	37.23	33.36	41.39	44.33	47.9	63.33	71.71	68.52	67.9	51.87	35.4	35.48	49.87
2011	32.84	31.18	39.06	39.97	47.32	61.03	70.42	73.29	64.63	50.58	39.93	35.87	48.84
2012	38.77	31.9	45.94	48.57	56.58	70	71.71	74.23	65.13	51.97	45.93	29.65	52.53
2013	34.16	32.64	41.35	42.23	53.74	69.23	72.32	69.65	58.6	45.39	41.1	31.03	49.29
2014	35.23	32.39	40.77	44.23	52.55	62.13	71.94	64.48	62.37	54.32	38.4	33.06	49.32
2015	39.87	39.11	46.61	43.27	48.77	68.43	67	69	65.77	53.61	34.77	29.9	50.51
2016	33.97	39.52	39.61	44.13	48.77	68.93	72.19	70.03	60.8	52.06	43.17	29.35	50.21
2017	30.1	36.54	44.29	41.67		68.75	72.58	69.94	58.47	49.74	44.77	37.19	49.29

Blank fields show that no data, or too little data, was collected

RED BUTTE GARDEN
BOTANY BINS

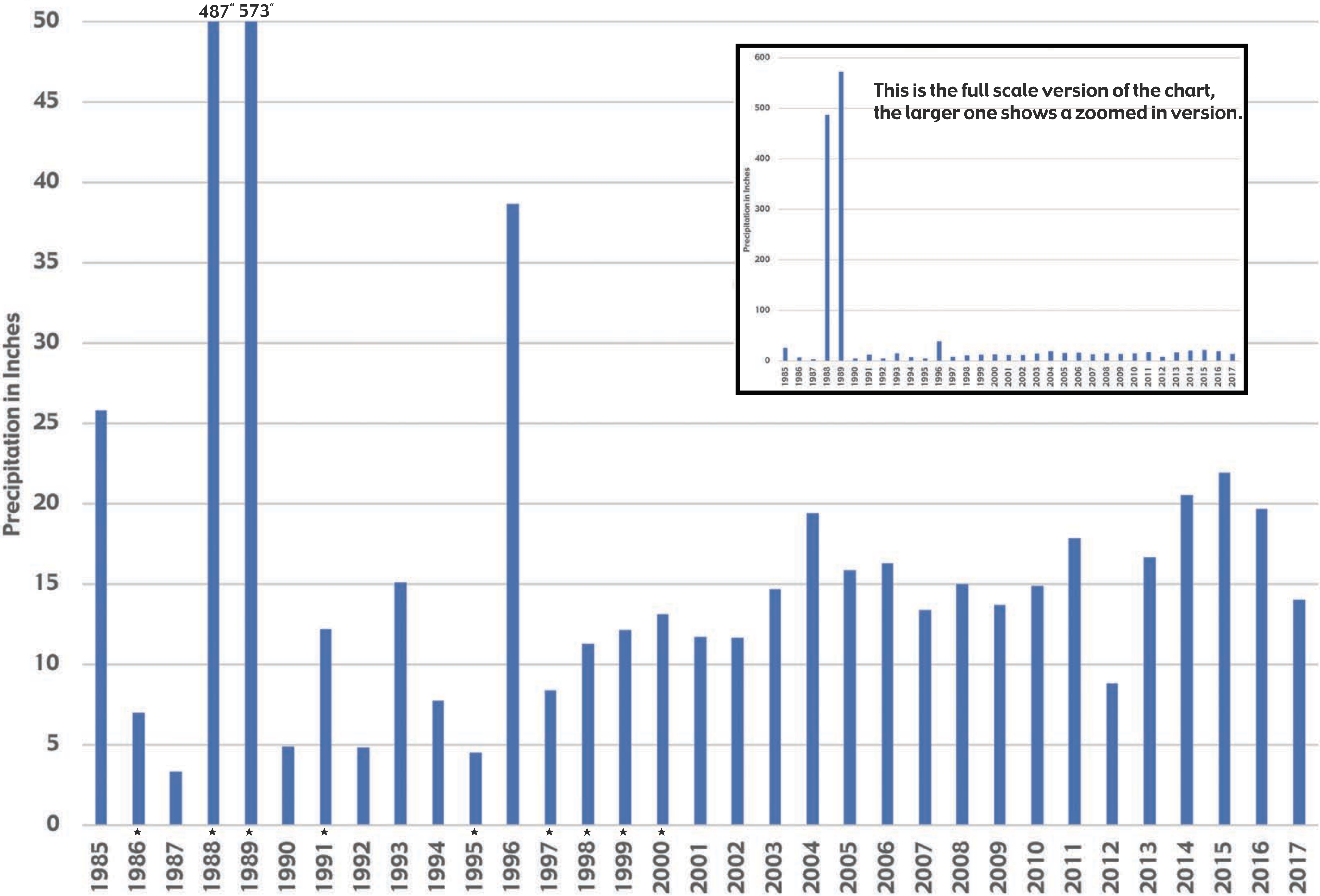
Monthly Precipitation For Hewinta Guard Station, Uinta Mountains in Inches – 1985 to 2017

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	0.08	0.49	0.91	1.59	2.01	13.39	2.46	0.66	1.49	2.21	0.13	0.42	25.84
1986	0.78	1.09	0.98	2.47	0.87					9.42	0.79	6.19	6.98
1987	0.27	0.4	1.1	1.17	2.17	1.07	1.39	1.16	0.4	0.31	0.73	0.13	3.34
1988	0.11	0.23	0.87	0.68	0.85		0.84	0.5	0.49	0.01	280.4	203.2	487.33
1989	390.1	150.3	0.4				0.2	0.78	1.46	0.05	30.45	30.24	573.14
1990						0.12	1.11	0.75	2.04	0.61	0.39	0	4.9
1991	0.16	0.22	0.44	0.58	2.2	1.33	2.61	2.47	1.79	0.02	0.42	0	12.24
1992	0.1	0.12	0.1	0.61	0.57	0.75	0.86	1.38	0.39	0.38	0.13	0.01	4.83
1993	0	0.04	0.44	7.61	1.8	1.08	1.36	0.8	0.54	1.18	0.23	0.05	15.13
1994	0.04	0.02	0.6	1.2	1.2	0.6	0.27	1.66	0.58	1.3	0.28	0.04	7.75
1995	0.02	0.2	0.67	0.22				1.6	0.92	0.48	0.6	0.04	4.53
1996	0.2	0.23	0.68	30.78	1.69	0.89	1.7	0.74	0.93	0.24	0.5	0.1	38.68
1997	0.12	0.02	0.28	0.48				3.37	3.12	1.49	0.66	0.22	8.4
1998	0.23	0.14	0.77		3.62	0	2.15	1.73	1.1	1.84	0.7	0.03	11.31
1999	0.11	0.89	0.6	2.24	1.88	1.25	2.22	1.4	1.56				12.15
2000						0.48	6.38	2.97	2.12	1.12	0.26	0.27	13.12
2001	0.35	0.15	0.86	1.56	1.56	0.53	1.66	2.04	1.47	1.09	0.41	0.05	11.73
2002	0.25	0.65	0.93	0.37	1.07	0.53	1.55	0.56	3.37	1.35	0.99	0.04	11.66
2003	0.78	0.24	1.33	1.42	1.44	3.49	0.53	3.24	0.78	0.15	0.82	0.46	14.68
2004	0.21	0.56	4.47	2.21	1.27	3.29	1.45	1.18	1.79	1.26	1.08	0.68	19.45
2005	0.64	0.52	0.9	1.76	3.06	2.39	1.16	1.45	1.28	0.81	0.89	1.01	15.87
2006	0.84	0.5	1.17	1.39	1.16	1.31	2.56	2.09	1.92	2.92	0.14	0.32	16.32
2007	0.36	0.64	1.09	0.99	1.65	0.17	0.66	1.88	2.42	3.21	0.1	0.24	13.41
2008	0.28	0.42	0.82	1.43	1.76	1.46	4.12	1.32	1.39	0.68	0.74	0.61	15.03
2009	0.51	0.44	0.42	2.26	1.3	3.14	1.69	0.79	1.36	1.01	0.59	0.2	13.71
2010	0.09	0.26	1.19	1.92	2.08	2.17	2.12	1.82	0.27	2.01	0.16	0.82	14.91
2011	0.46	0.06	1.33	3.25	4.3	1.04	3.43	1.86	0.62	1.2	0.17	0.15	17.87
2012	0.38	0.08	0.9	0.82	0.66	0.11	2.53	1.05	0.98	0.88	0.16	0.31	8.86
2013	0.13	0.08	1.31	1.14	1.11	0.09	3.6	2.14	3.62	1.98	0.75	0.76	16.71
2014	1.02	1.86	1.86	1.46	1.14	0.73	2.21	4.4	3.21	0.53	1.56	0.56	20.54
2015	0.88	1.36	0.95	1.6	5.4	1.61	3.06	2.34	0.94	1.5	0.97	1.32	21.93
2016	1.4	1.23	1.99	2.97	4.38	1.39	0.24	0.17	2.54	1.42	0.76	1.19	19.68
2017	1.67	1.11	2.6	0.64		4.07	1.69	1.97	2.46	0.46	1.28	0.79	14.03

Blank fields show that no data, or too little data, was collected

RED BUTTE GARDEN
BOTANY BINS

Annual Precipitation For Hewinta Guard Station, Uinta Mountains in Inches – 1985 to 2017



* Years with missing data – See chart on back