SOUTHEAST ALASKA

DROUGHT

Low water reveals the exposed banks of a reservoir near Ketchikan.
Photo by Jeremy Bynum

January 2023

ABOUT THE DROUGHT

Although southeast Alaska is one of the wettest areas in North America, it was plagued by a long-lived drought from October 2016 to December 2019. "Extreme drought" was declared by the U.S. Drought Monitor in summer 2019. This designation, based on intensity and impacts, is a national rating.

The drought intensified in late 2017 garnering significant attention in Alaska as water restrictions and reservoir levels were too low for hydropower generation to meet capacity. Over the following 18 months, the drought waxed and waned with additional impacts, especially during the hot summer of 2019. This coincided with increasing national interest in Alaska drought, with a workshop sponsored by the USDA Northwest Climate Hub held in May 2019 in Juneau.

Who contributed to this project?

When normal levels of rain returned in autumn 2019, the Alaska Center for Climate Assessment and Policy (ACCAP) at the UAF International Arctic Research Center started a comprehensive review of drought to help serve as a reference of what happened for Tribes, communities and agencies. Early in this process, Britt Parker with National Integrated Drought Information System approached Rick Thoman at ACCAP about collaborating on the drought project. Soon they were joined by Andy Hoell from the NOAA Physical Sciences Laboratory. These groups partnered to create the Southeast Alaska Drought project which studied the drought causes, impacts and the likelihood of future droughts like it.

This final report provides easy to access information on:

- Weather and climate during the 2016-2019 drought in a temperate rainforest
- Temporal and spatial variability of the drought
- Wide array of observed impacts to society and the ecosystem

Who is this report for?

This report provides comprehensive information on the 2016-2019 drought that will be of value to a wide audience. For organizations and agencies outside of southeast Alaska but with an interest in the region, this will provide a look at a very "non-traditional" drought in one of the wettest parts of the world. For Tribes, communities and decision makers in southeast Alaska, this report will provide ready access to "what happened" and can inform planning, adaptation and mitigation activities.

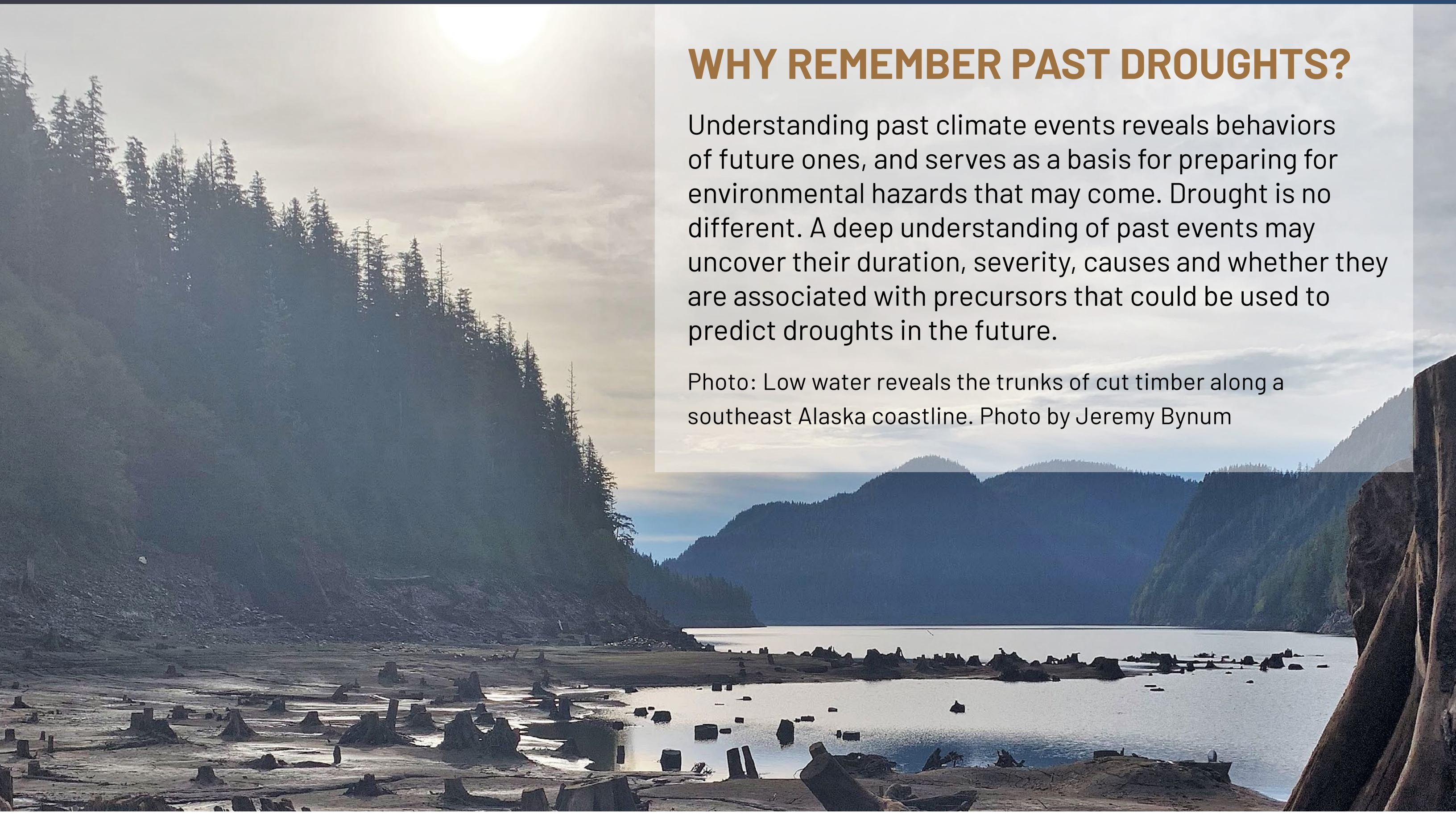
Cite this report

Hoell, A., Thoman, R., McFarland , H. R. & Parker, B. 2022. Southeast Alaska drought [report]. International Arctic Research Center, University of Alaska Fairbanks.

Take a look inside

Photo by Brian Logan/USFWS

DROUGHT **HISTORY**



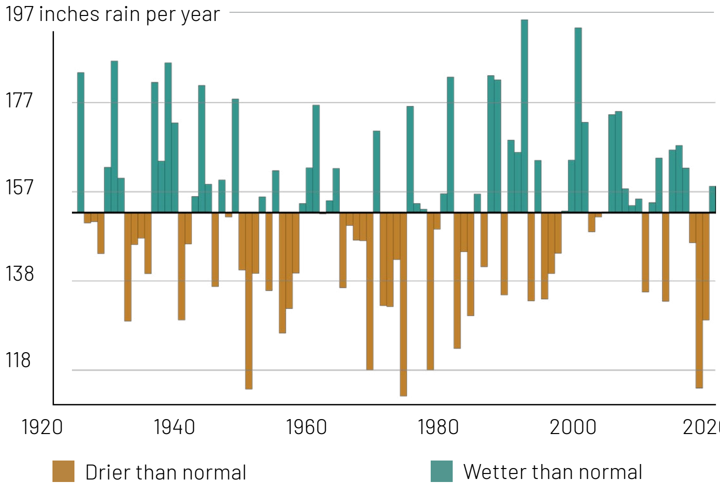
WHY REMEMBER PAST DROUGHTS?

Understanding past climate events reveals behaviors of future ones, and serves as a basis for preparing for environmental hazards that may come. Drought is no different. A deep understanding of past events may uncover their duration, severity, causes and whether they are associated with precursors that could be used to predict droughts in the future.

Photo: Low water reveals the trunks of cut timber along a southeast Alaska coastline. Photo by Jeremy Bynum

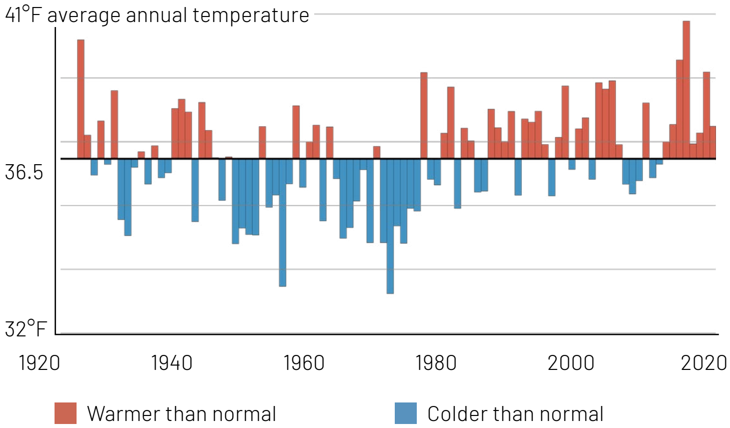
100 years of precipitation data

Dry spells are not unusual in southeast Alaska. This graph shows prolonged dry periods in the 1950s, 70s, and 90s. Some of these past droughts were longer and had years with even less rain, but the 2016–2019 drought was particularly jarring to those experiencing it because it followed a decade of much wetter conditions.



100 years of temperature data

Starting in the 1980s, there was a clear trend toward warmer temperatures in southeast Alaska. Conditions have been warmer than normal every year since 2013, but prior to 2016, these warm conditions were paired with more rain than normal. 2016 was the warmest year on record for southeast Alaska.



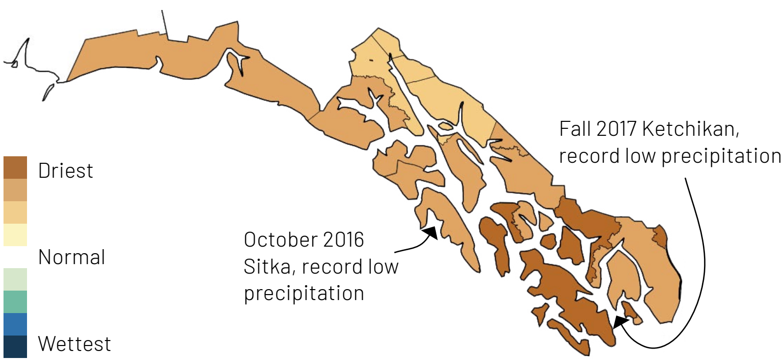
RANKING DROUGHTS

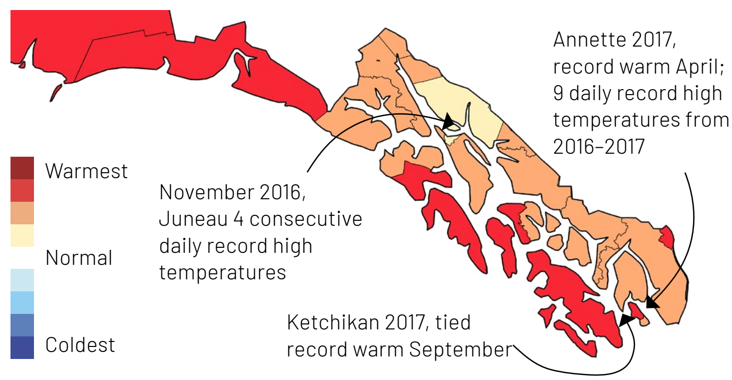
How dry and warm was southeast Alaska during the recent drought and how did that drought compare to past droughts in the region? The maps on the next two pages rank temperature and precipitation during four past droughts to the long-term (1925–2020) average.

2016–2019 drought compared to normal

The October 2016–September 2019 drought period was much drier than normal, especially in the southern Panhandle. This dryness was persistent in both winter and summer. Even so, there were periods of wetness; for example, summer 2017 was notably wetter than normal.

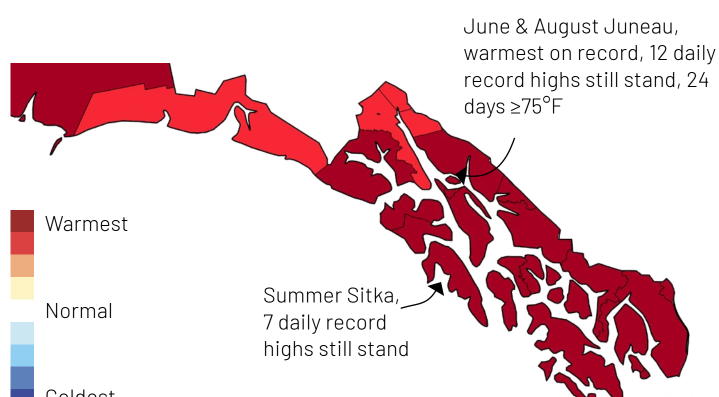
The recent drought was also considerably warmer than normal, but not always record breaking. Summers were consistently warmer than normal except for a few months of normal temperatures near Haines. Summer 2019 stood out as exceptionally warm across all of southeast Alaska. Winter temperatures during most of the drought were near normal, until winter 2018–2019 when temperatures throughout the Panhandle were far above normal.





2004 drought was short and extremely hot

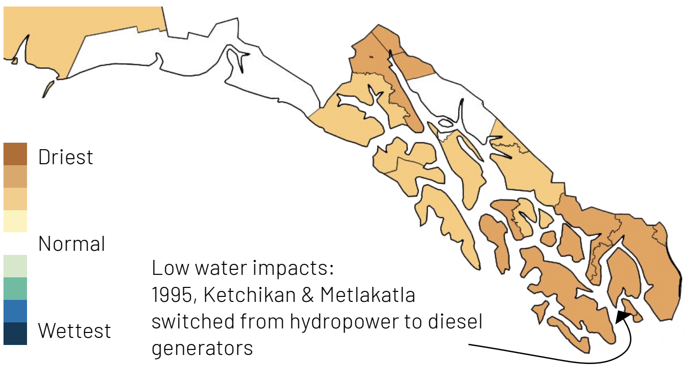
In summer 2004, southeast Alaska experienced a short duration but very impactful drought. In parts of central and northern southeast, 2004 still holds the record for warmest summer ever. Conditions grew so hot and dry that Tongass National Forest banned timber harvest from noon to 8 p.m. to avoid igniting wildfires when daily humidity was low and temperatures high.

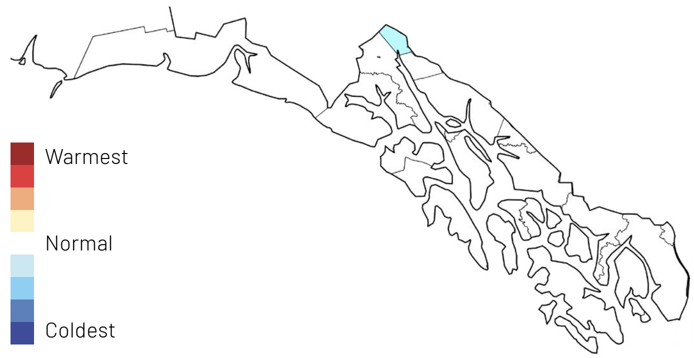


*Maps cover June, July & August

1990s drought was longer

In 1989, a short but intense drought caused a temporary closure of the Ketchikan Pulp Mill. A longer duration drought took place from 1994–1997. Conditions were drier than normal, but not all regions of the Panhandle were impacted. Yakutat and Juneau borough had normal amounts of rain. Unlike the recent drought, the 1990s drought had some warm years, but a cooler than average year mixed in. When looking at the entire period, temperatures were near normal.

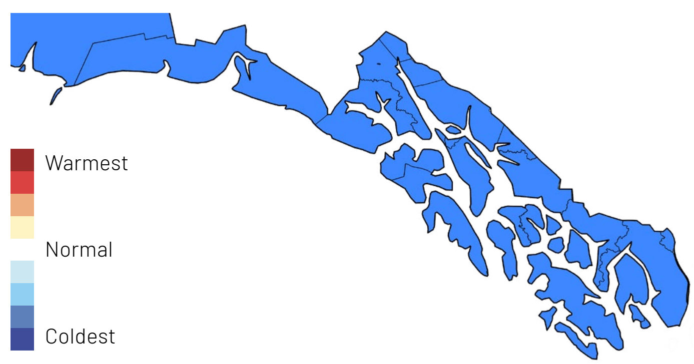




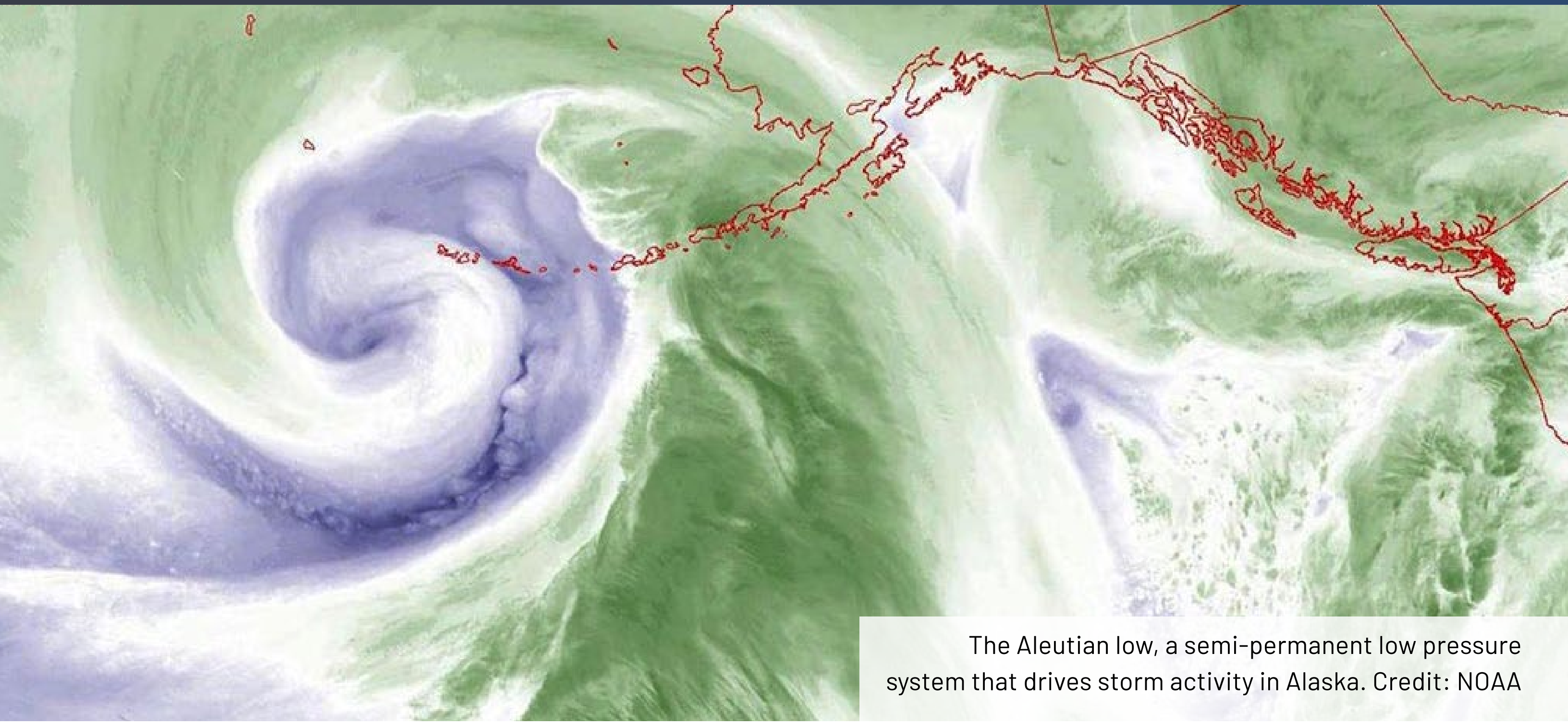
1970s drought was dry, but very cold

Have all droughts in southeast Alaska been warmer than normal? No, some past droughts in the region were accompanied by near to below-average temperatures. An example of such a three-year drought occurred in 1971–1974, when precipitation was about as low as during 2016–2019. However, temperatures during the 1971–1974 drought were well below the long term average. This starkly contrasts 2016–2019 in which temperatures were the warmest of any three-year period. Given the ongoing human-driven warming and the increasing importance of evaporation during southeast Alaska droughts, the 2016–2019 drought serves as a cautionary tale of what future droughts may bring and provides forewarning of the impacts associated with them.

When drought conditions are cooler than normal, there is often less evaporation into the air and during plant growth. The elevation where precipitation is likely to appear as snow is often lower. Mountain snowpack melts more slowly in spring and summer which helps keep stream temperatures lower. Each of these factors contribute to fewer impacts compared to warm droughts.



DROUGHT **CAUSES**

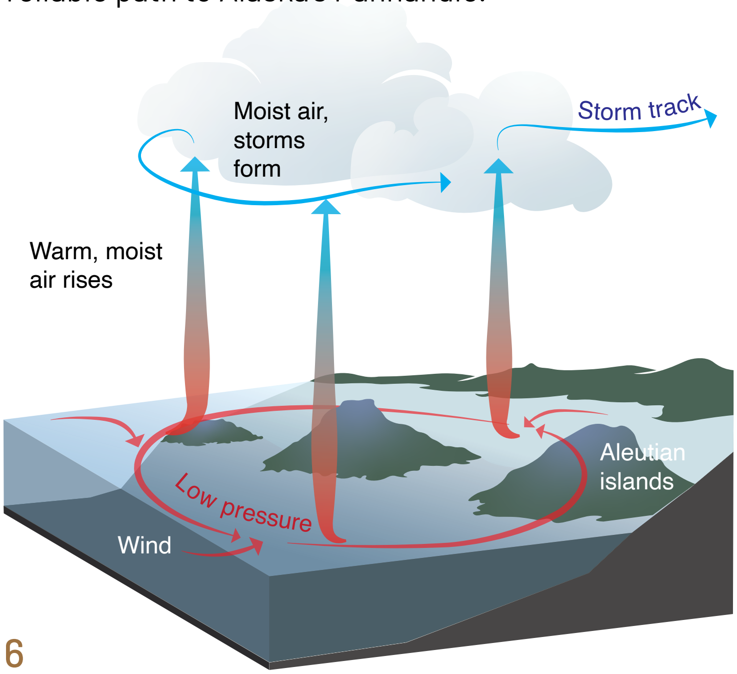


The Aleutian low, a semi-permanent low pressure system that drives storm activity in Alaska. Credit: NOAA

SOUTHEAST STORM MOVEMENT

Storms in southeast Alaska typically originate in the Aleutian Islands where there is usually a strong low pressure system, especially in winter.

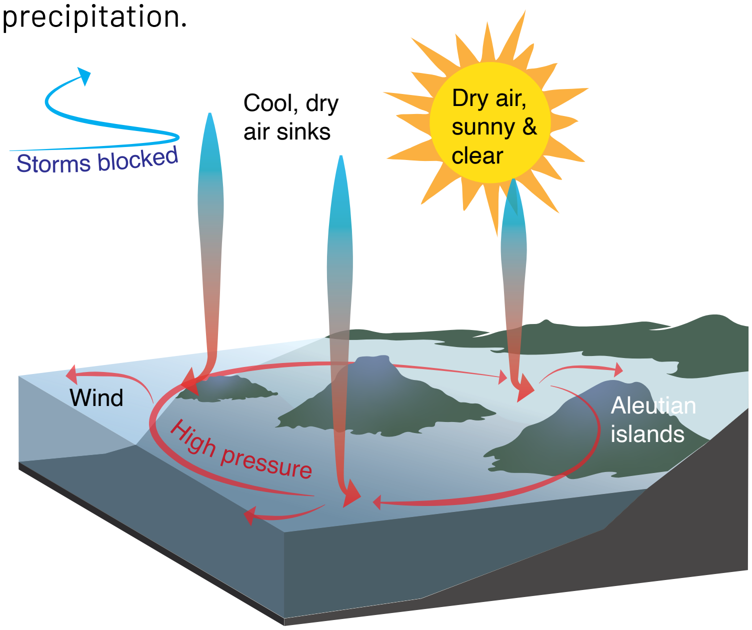
This system has lower pressure at its center than the surrounding areas. Winds blow toward the low pressure, which forces air at the center upward. As air rises, moisture condenses, forming clouds and precipitation. Storms from this "Aleutian Low" travel a reliable path to Alaska's Panhandle.



What made the 2016–19 drought different?

From 2016–2019 there was a persistent high pressure system over the Aleutians. This type of system has higher pressure at its center than the surrounding area. Winds blow away from the high pressure, creating a "void" that draws air down. As the air sinks it dries out. High pressure blocks other weather systems from moving into the area.

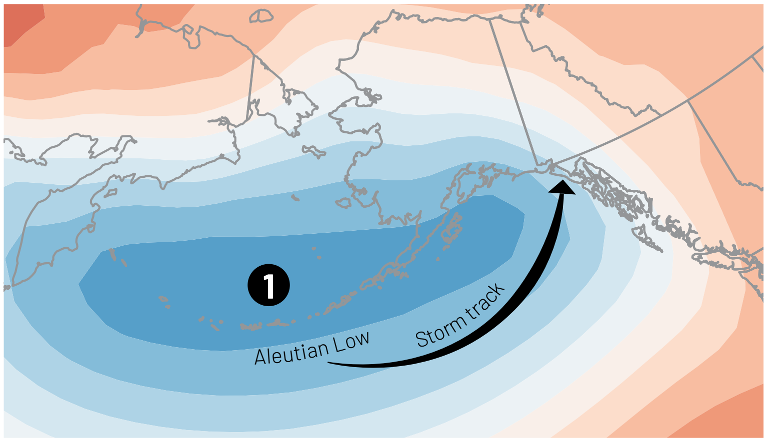
The 2016–2019 high pressure over the Aleutians pushed storms further north through Interior Alaska, leaving southeast with clear weather and low precipitation.



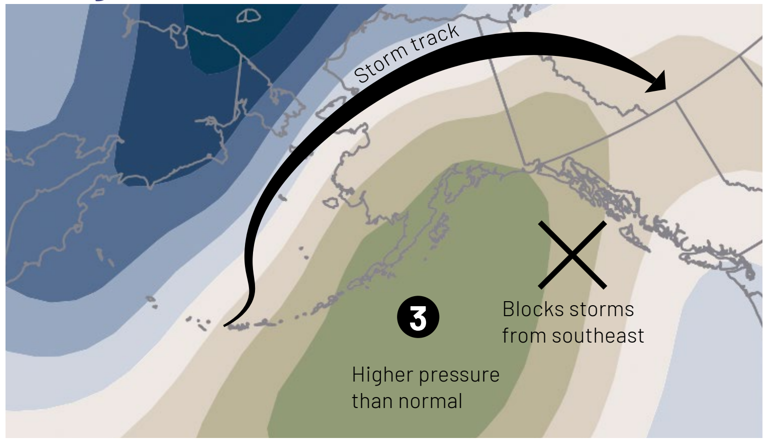
NORMAL STORM TRACKS VERSUS THE DROUGHT YEARS

These maps compare normal sea level pressure over Alaska to the drought period, 2016–2019. In winter, we expect to see low pressure (represented by the blue color) over the Aleutians and into the Panhandle. The green on the 2016–2019 drought maps shows that there was higher than normal sea level pressure over the Aleutians and Panhandle during the drought winters.

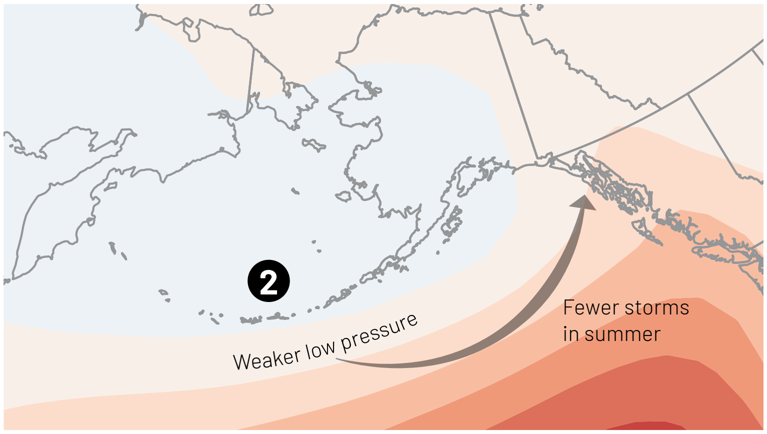
Normal winter



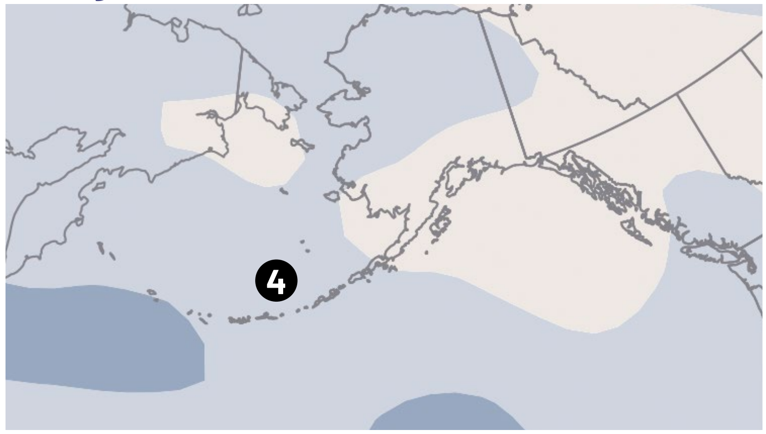
Drought winter



Normal summer



Drought summer



Low sea level pressure — High sea level pressure

Lower sea level pressure **than normal** — Higher sea level pressure **than normal**

1 Normal low pressure

Aleutian Low (dark blue because it has low sea level pressure) is very strong in winter, sending storms and precipitation into southeast Alaska.

2 Much higher pressure

The Aleutian Low is much weaker in summer, so there are usually fewer and less intense storms. This makes summer the dry season in southeast Alaska.

3 Weak Aleutian low normal

The Aleutian Low in winters 2016–2019 was weaker than normal, and further west. Higher pressure than normal (green) blocked storms, or reduced their intensity, from bringing precipitation to southeast Alaska.

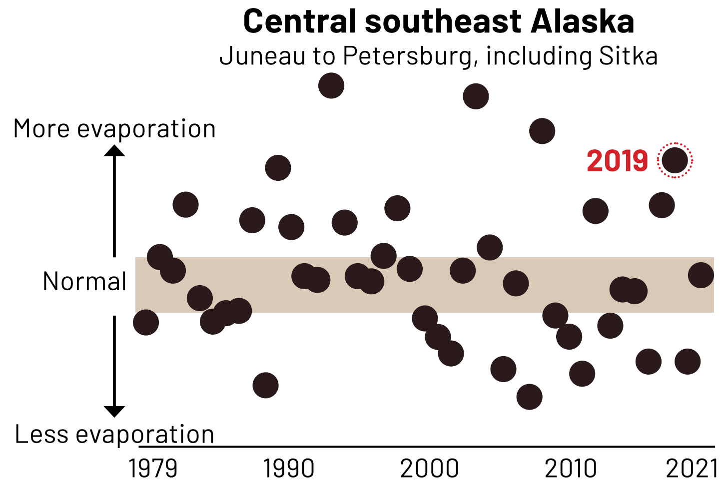
4 Not much difference

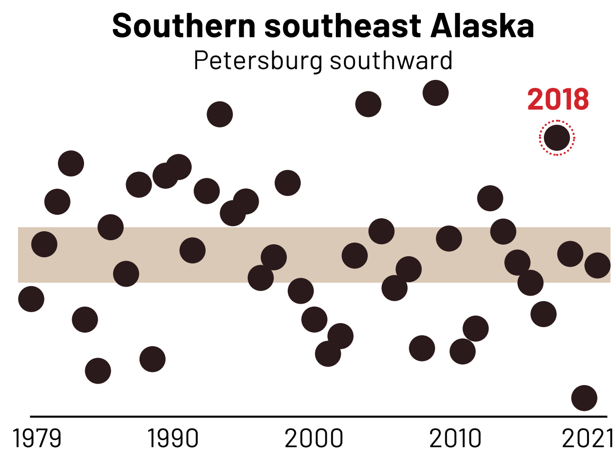
Sea level pressure was not much different in summer 2016–2019 than in a normal year, and there were few summer storms.

MORE EVAPORATION

Evaporation combines the effects of temperature, wind, and sunshine (or lack thereof) into a single value. High evaporation reduces surface water and dries out soils and vegetation, making drought impacts more severe.

In summer 2018, southern southeast Alaska was warm and dry with high evaporation. The following summer, this area was wetter with lower evaporation, but central southeast Alaska was warm and dry with high evaporation.





SNOW DROUGHTS

Snow droughts happen when there is little mountain snowpack. They affect water levels and stream temperatures when snow melts in spring and summer. Snow droughts can occur when precipitation is significantly below normal or even if it is near or above normal but snow accumulates at a higher elevation because only higher than usual areas reach freezing.

Southeast Alaska mountain snowpack was below normal during spring 2018 and 2019, due mostly to lower than normal precipitation. Prior to the start of the drought in 2015 and 2016, below normal mountain snowpack was due to the freezing point occurring at only very high elevations.

DROUGHT **IMPACTS**

LOW WATER LEVELS

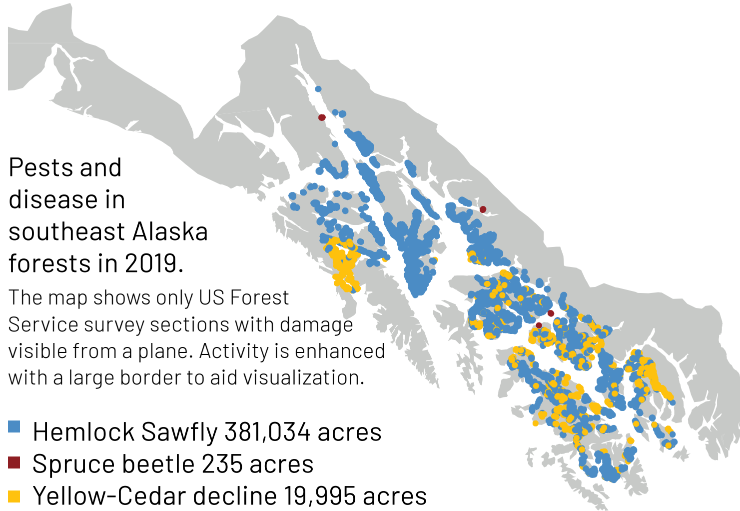
Lakes and reservoirs across southeast Alaska reached record lows during the 2016–2019 drought. Several communities experienced water restriction. Others that rely on local hydroelectric companies for power switched to diesel generators. Electricity costs rose in Juneau as Alaska Electric Light & Power was unable to produce enough electricity for "interruptible customers"—those who can make their own energy but purchase it when available, therefore offsetting the amount other customers pay.

Warm water and low stream flows in 2019 kept salmon in deeper, cooler offshore waters and delayed their movement into streams to spawn. At least one salmon mortality event was recorded when pre-spawning fish moved into a slough that later dried up. Late in the drought, hatcheries struggled to supply enough fresh, cool water to incubators. These salmon impacts were much less severe than other parts of Alaska where 2019's unprecedentedly warm river and ocean surface waters caused massive die-offs.

Though disguised by lush vegetation, a partially dried stream bed is visible near Juneau in August 2019. Photo by Molly Tankersley

INSECT OUTBREAKS

A hemlock sawfly outbreak across southeast Alaska began in 2018, ultimately defoliating 530,000 acres of forest. The warm and dry conditions in 2018 and 2019 were indirectly tied to the outbreak. Sawfly are always present in southeast Alaska, but in normal, cool, and wet summers, fungal diseases keep sawfly numbers down. The drought limited this fungal growth, allowing sawfly larval populations to grow to outbreak status.



Pests and disease in southeast Alaska forests in 2019.

The map shows only US Forest Service survey sections with damage visible from a plane. Activity is enhanced with a large border to aid visualization.

- Hemlock Sawfly 381,034 acres
- Spruce beetle 235 acres
- Yellow-Cedar decline 19,995 acres

WILDFIRE AND SMOKE

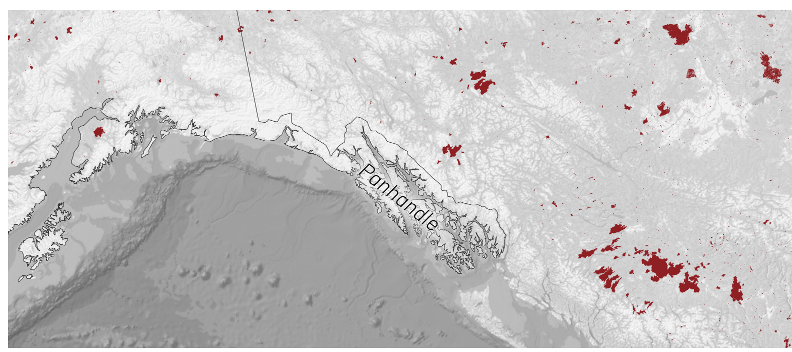
Wildfire in southeast Alaska has not been a significant concern historically because of the lack of dry fuels and ignition sources (typically lightning). However, regional drought conditions and warming temperatures not only increase the risk of wildfire in southeast Alaska but also in nearby portions of the southeast Interior of Alaska, the Yukon Territory and northern British Columbia. Smoke from wildfires in these regions regularly moves over southeast Alaska, and high pressure commonly associated with drought conditions helps trap smoke near the ground, worsening air quality and visibility.

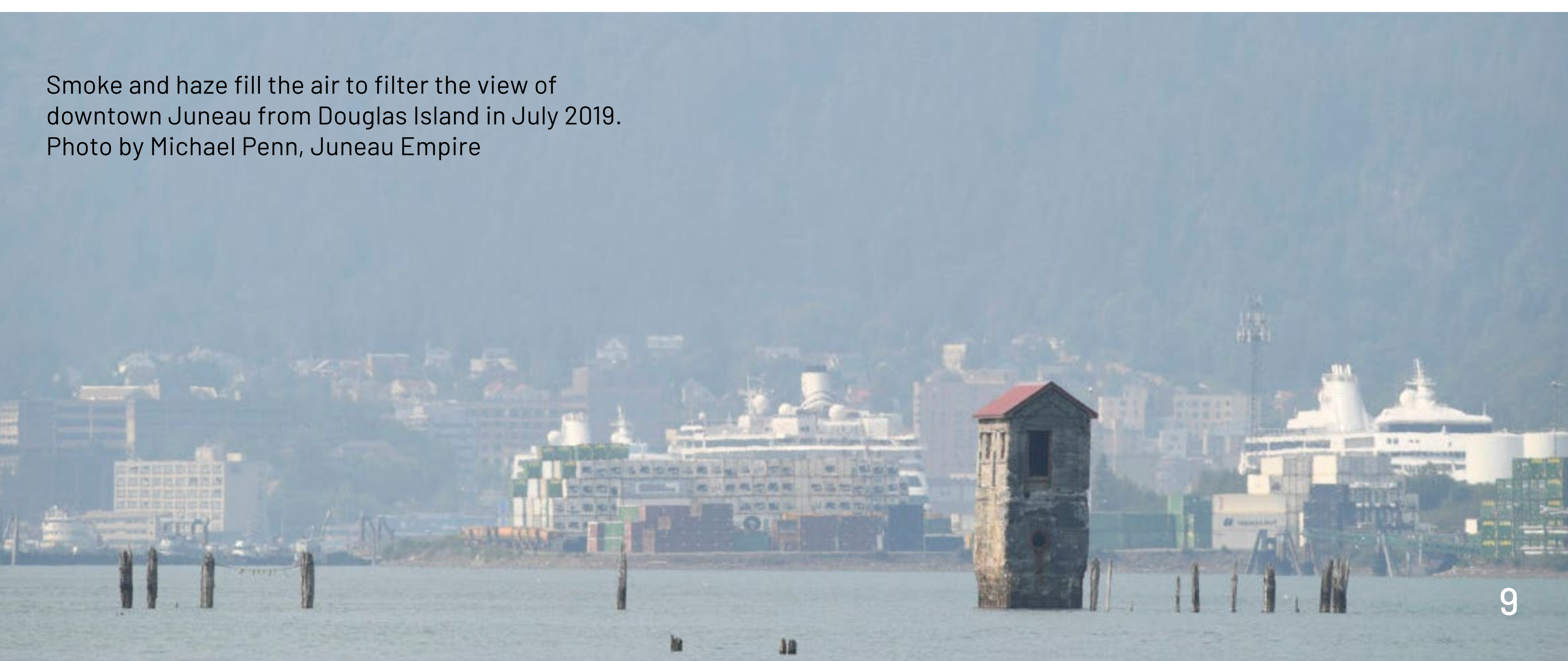
The Lynn Canal region of northern Panhandle is especially at risk because of the orientation of the mountains and the proximity to areas in the Yukon Territory susceptible to wildfires and smoke. Because of the importance of tourism to southeast Alaska, even moderate levels of smoke can significantly impact visibility on otherwise clear days, negatively impacting the tourism experience.

During the 2016-2019 drought, residents of southeast Alaska reported more smoke than usual. Juneau had three days in July 2019 with dense smoke that reduced visibility to six miles or less. Most years Juneau experiences no dense wildfire smoke.

Wildfires bordering southeast Alaska

The map below shows the wildfires surrounding southeast Alaska that burned during the drought summers of 2016–2019. Several large fires especially in Yukon and British Columbia sent smoke into southeast Alaska. Map credit Zav Grabinski





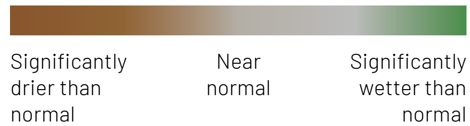
Smoke and haze fill the air to filter the view of downtown Juneau from Douglas Island in July 2019. Photo by Michael Penn, Juneau Empire

HOW LONG TILL DROUGHT IMPACTS OCCUR?

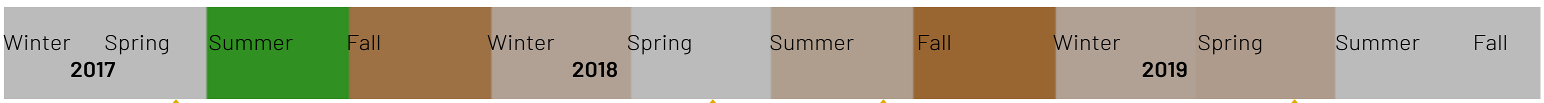
Drought in southeast Alaska looks very different from other parts of the world. Despite receiving less than half of the normal winter precipitation during the 2016–2019 drought, communities like Ketchikan still saw 100 inches of annual precipitation. Human and natural systems in southeast Alaska's rainforest are adapted to persistently wet conditions. Some plants and animals are unable to survive prolonged dry periods. Likewise, water-related infrastructure may not be designed to withstand low rain or snow.

Short-term impacts

Some impacts occur after only a short period of dryness. For example, surface soils and ground cover can dry out rapidly, which can increase wildfire risk and cause vegetation to wilt. Communities like Wrangell, with limited water storage capacity, can run low on water after only a few months.



When did short-term impacts hit during the drought?



1 • Water restrictions

Wrangell declared a water emergency several times when the reservoirs feeding their water supply dropped too low. Outside water use and consumption were limited, leak repairs were prioritized.

2 • Wildfire

Tongass National Forest responded to 32 wildfires in 2018. 15–20 fires/year is normal in the forest.

3 • Bug outbreak

A sawfly outbreak hit the southern Panhandle in summer 2018, spreading to the central Panhandle in 2019.

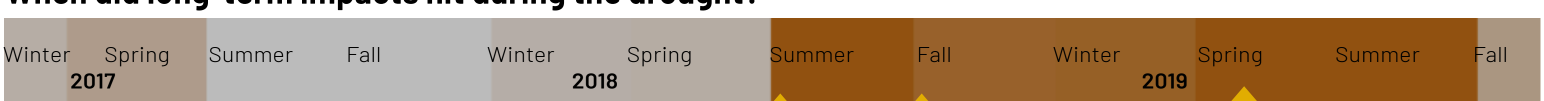
4 • Water restrictions

Haines issued water restrictions when Lily Lake, which supplies 80% of their water, reached a record low. Water no longer flowed by gravity and had to be pumped, reducing the amount of water reaching the community by ~half.

Long-term impacts

Other impacts take a year or more to materialize. Once these long-term impacts are triggered, short periods of wetness have little effect, and recovery can be slow. For example, it took two years of drought for the massive Snettisham reservoir feeding Juneau to drop low enough to restrict power to certain users.

When did long-term impacts hit during the drought?



5 • Subsistence

A poor berry crop limited subsistence at Metlakatla.

6 • Reduced energy

Low Crater & Long lake levels forced Juneau's Snettisham Hydroelectric Facility to cut off power to Greens Creek Mine.

7 • Hatcheries

Macaulay Salmon Hatchery in Juneau moved juvenile Chinook out to salt water months earlier than usual due to insufficient cool water.

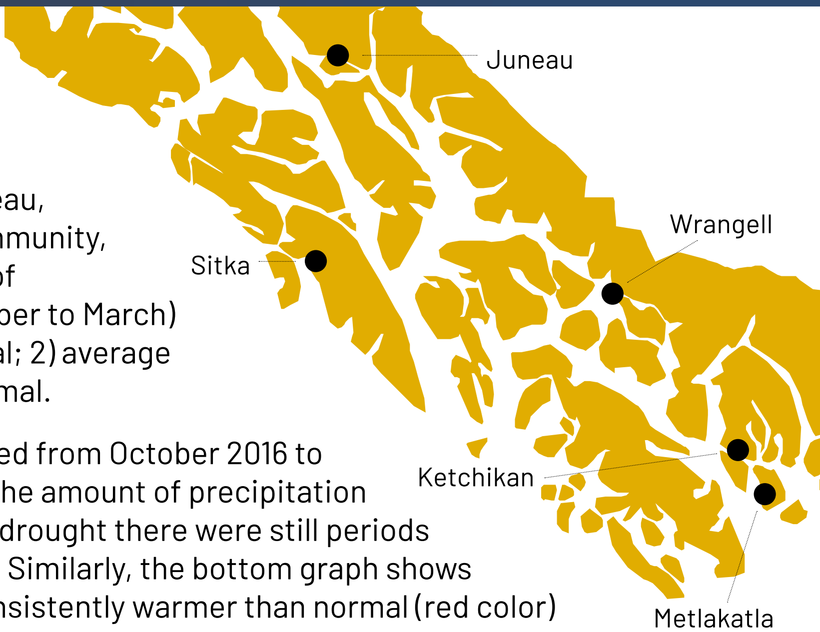
8 • Diesel energy

Reservoirs feeding Ketchikan & Metlakatla hydropower dropped too low, communities switched to mostly diesel generators.

**Selected examples represent only a few of the impacts southeast experienced during this drought.*

COMMUNITY CLOSE-UP

UNDERSTANDING THE DROUGHT IN INDIVIDUAL COMMUNITIES



The next three pages share impacts and data from Juneau, Sitka, Wrangell, Ketchikan and Metlakatla. For each community, we share summary statistics of, 1) the average amount of precipitation received during the drought winters (October to March) and summers (April to September) compared to a normal; 2) average temperature increase in both seasons compared to normal.

The graphs on the right show how the drought progressed from October 2016 to October 2019 in each community. The top graph shows the amount of precipitation compared to the 1925–2020 average. Despite being in a drought there were still periods of wetness (green color), especially early in the drought. Similarly, the bottom graph shows temperatures compared to normal. Conditions were consistently warmer than normal (red color) in all communities after mid 2018.

JUNEAU

- Temperatures were exceptionally high in 2019 while precipitation was lowest in 2018.
- Electrical power was restricted to some large users with the ability to generate their own power.
- Fish hatchery released some fry early because of warm water temperatures.

Photo of Juneau's Greens Creek Mine which received limited power during the drought. Photo by Hecla Mining Company

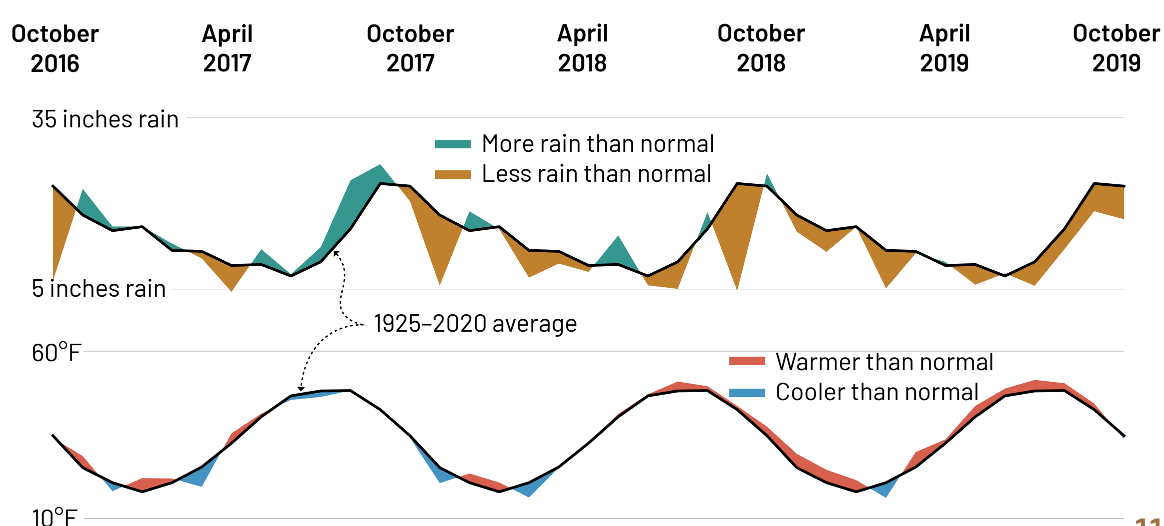
Summary statistics

14 inches less rain each winter

7 inches less rain each summer

0.5° warmer in winter

1.2° warmer in summer



Summary statistics

20 inches less rain each winter

4 inches less rain each summer

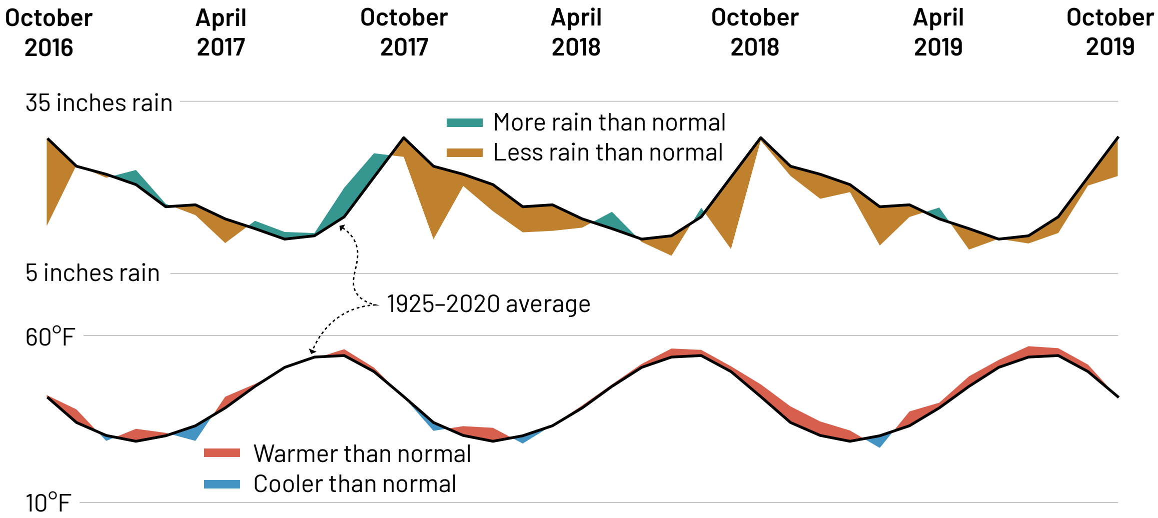
1.2° warmer in winter

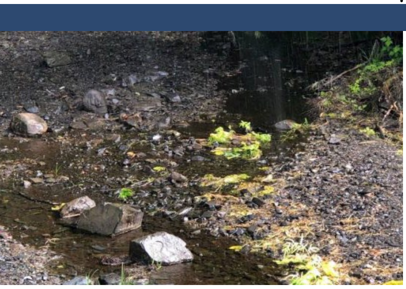
1.6° warmer in summer

SITKA

- 2018 was very dry and temperatures were highest compared to the long term average in 2019.
- Sitka experienced fewer drought impacts than other communities because of their infrastructure. The expansion of the Blue Lake Dam, completed in 2014, allowed for much greater water storage. This highlights the importance of having robust infrastructure in place to bolster resilience.

Sitka's Blue Lake Dam. Photo by Lance Ewers





Summary statistics

21 inches less rain each winter

5 inches less rain each summer

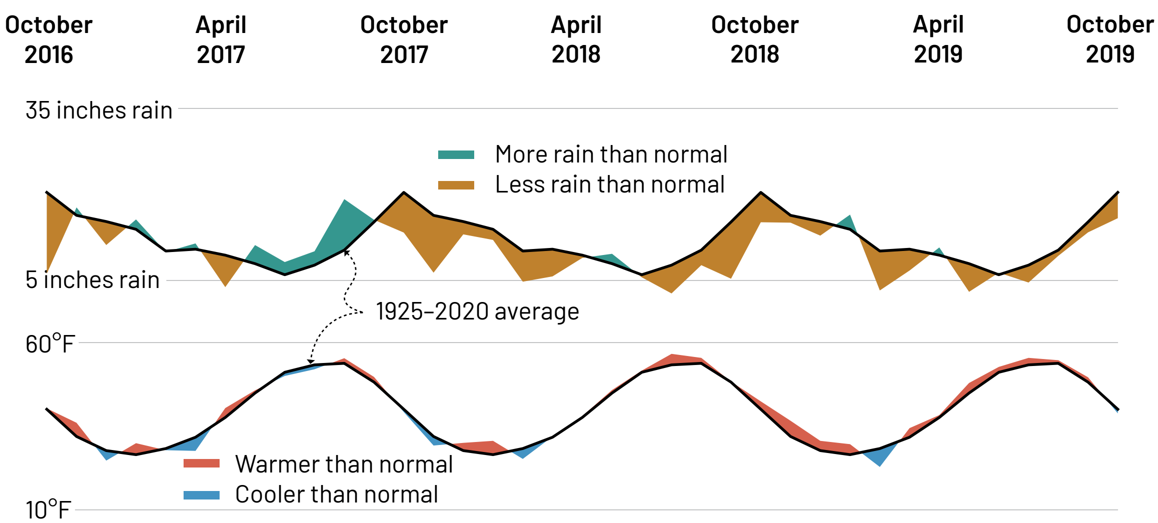
0.6° warmer in winter

1.2° warmer in summer

WRANGELL

- All three winter seasons were unusually dry while temperatures were highest compared to the long term average in 2019.
- Repeated water use restrictions due to low reservoir levels.

Photo of low stream flow feeding a Wrangell reservoir. Photo by City of Wrangell



KETCHIKAN

- Precipitation deficits were largest in 2018 while temperatures were highest compared to the long term average in 2019.
- Increased and repeated reliance on diesel for electricity.

Photo of low water exposing the banks of a reservoir near Ketchikan. Photo by Jeremy Bynum

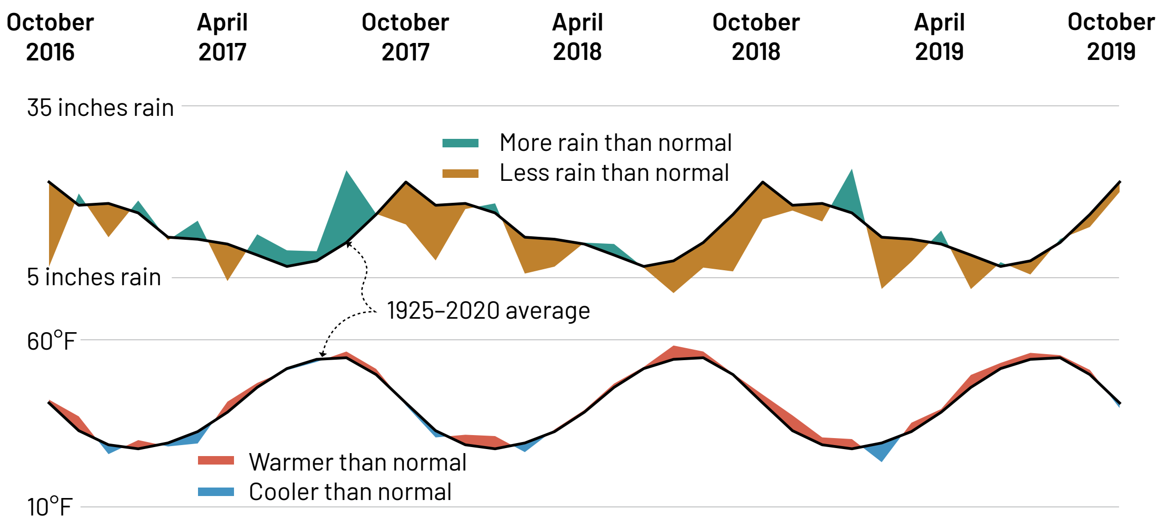
Summary statistics

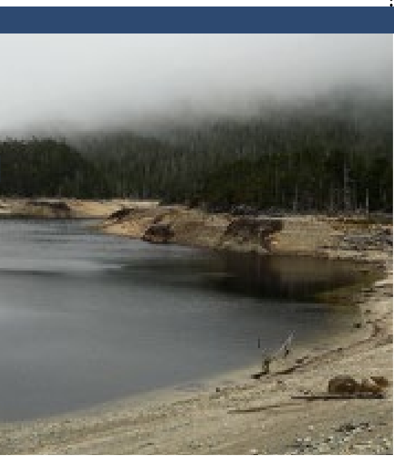
19 inches less rain each winter

3 inches less rain each summer

0.6° warmer in winter

1.4° warmer in summer





METLAKATLA

- Precipitation was below the long term average almost every month starting in late 2017, while temperatures were highest in 2019.
- Water use restrictions.
- Power was produced by diesel electric generators due to low reservoir levels.

Photo of low water levels at Purple Lake, the source of Metlakatla's water supply. Photo by Genelle Winter, Metlakatla Indian Community

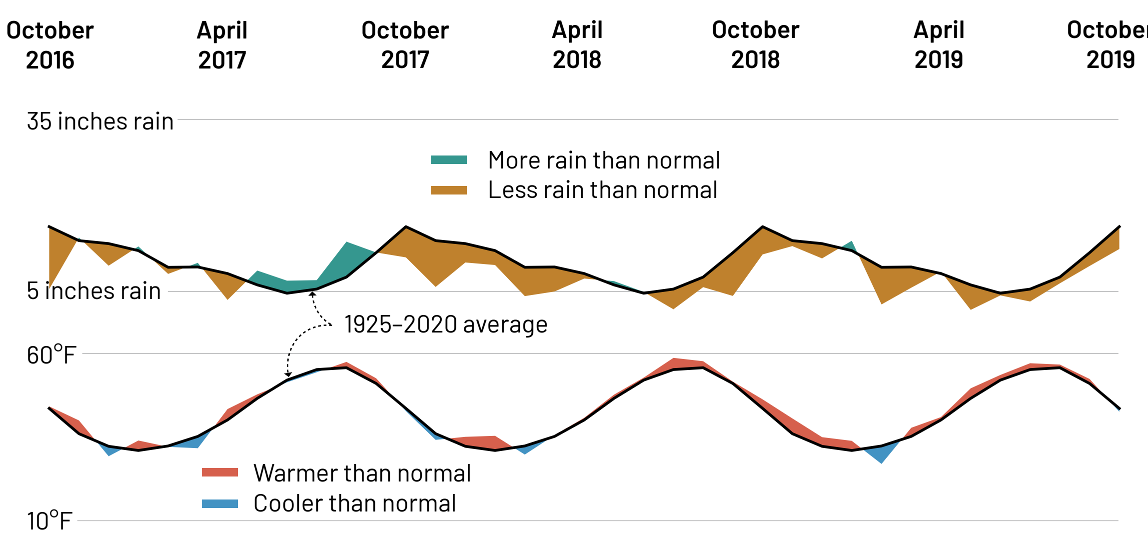
Summary statistics

20 inches less rain each winter

5 inches less rain each summer

0.7° warmer in winter

1.4° warmer in summer



DROUGHT **FUTURE**

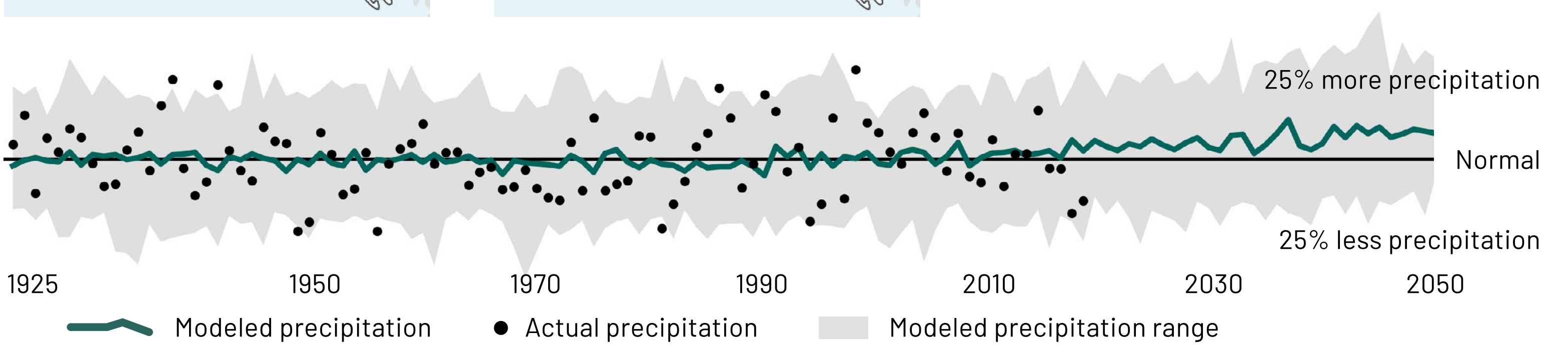
THE FUTURE IS SLIGHTLY WETTER

Using climate models, scientists explored whether precipitation is likely to increase, decrease, or remain the same in southeast Alaska. There likely won't be a noticeable change in the next few decades, but by 2050 precipitation may increase by as much as 14% in some areas. The change will occur in both summer and winter. Even so, there will continue to be years with less rain or snow than the past, and years with much more.

Precipitation in 10–20 years

Precipitation in 20–30 years

"Normal" for 1925–2020
5%
10%
15% wetter than normal



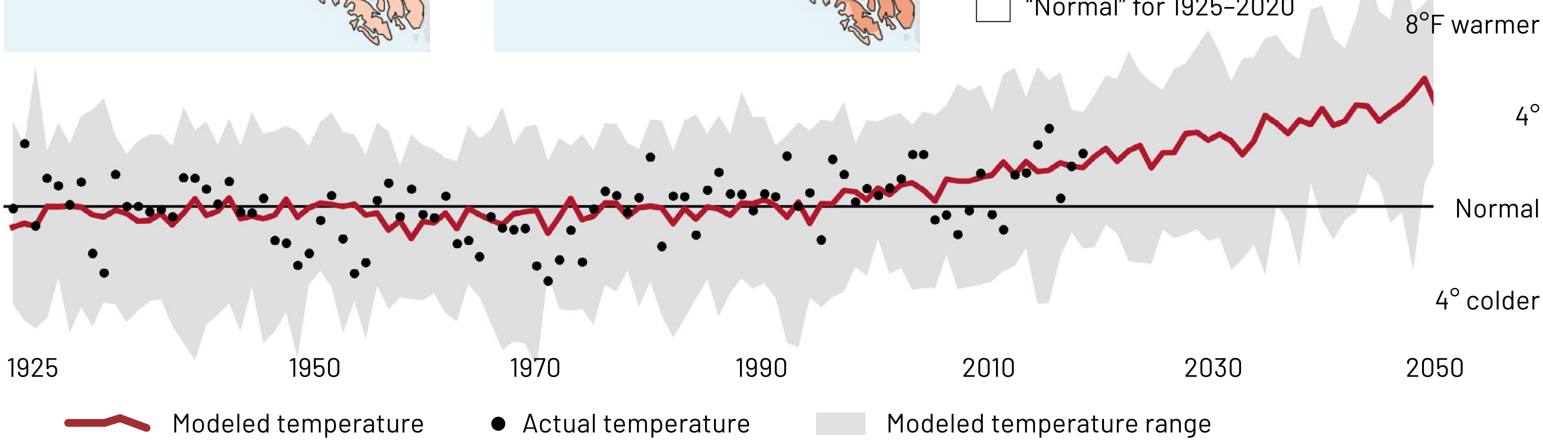
THE FUTURE IS A LOT WARMER

Climate models also indicate that southeast Alaska may get up to 6 degrees warmer by 2050. All regions of southeast Alaska are expected to warm in both summer and winter. Winter temperatures will warm slightly more than summer, and there will likely be more year-to-year variability in winter.

Temperature in 10–20 years

Temperature in 20–30 years

6°F warmer than normal
4°
2°
"Normal" for 1925–2020



 **All maps and graphs on this page show annual precipitation or temperature.*

WHAT'S THE FUTURE RISK OF DROUGHT?

Scientists assessed whether the risk of drought in southeast Alaska is likely to increase or decrease in the future. The analysis examined the future risk of a low precipitation event like what drove the 2016–2019 drought. Based on this proxy, there is a declining chance of drought in the next three decades. In both summer and winter, drought will become about half as likely to occur by 2050, compared to the risk of a similar precipitation event during 1925–2020.

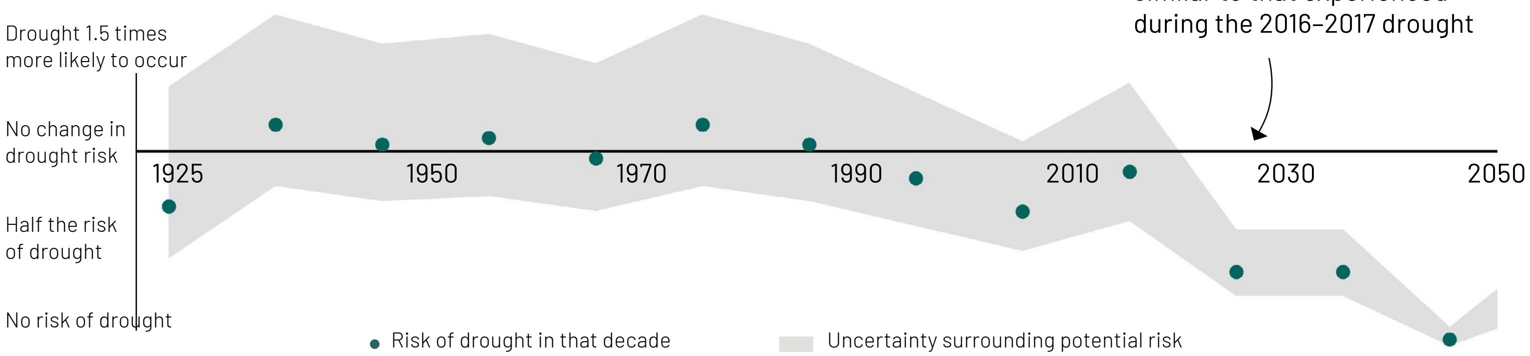
Model uncertainty is declining

Along with the projected risk of drought conditions (dots on the graph below), the model shows the level of uncertainty surrounding each estimate (grey shaded areas). The uncertainty is shrinking, likely because southeast Alaska is getting significantly wetter (see front side). This means that future estimates of low precipitation, like those that caused the 2016–2019 drought, are very accurate.

It's not all about precipitation

Despite this clear trend, other factors contribute to drought. Because southeast Alaska is also expected to get warmer, there will likely be more evaporation in summer, which could increase the chance of drought.

Drought risk is declining *This graph uses low precipitation as a proxy for drought



Did climate change cause the drought?

Scientists also used 38 global climate models to explore whether climate change aided precipitation and temperature changes in southeast Alaska. They found that although the low precipitation was not caused by climate change, the warmth was.

Tongass National Forest. Photo by Amy Li

DROUGHT **SOURCES**

A grassy field near Thunder Mountain in Juneau's Mendenhall Valley in September 2019. Photo by Molly Tankersley

HOW DID WE GATHER THE INFORMATION IN THIS REPORT?

The information in this report was compiled using various data sources, including news reports of drought impacts, community listening sessions about the drought and other personal anecdotes. The analyses, figures and maps were creating using the publicly accessible data sets listed below.

Observed precipitation and temperature (pages 3–5, 11–13)

NOAA/NCEI County and County Equivalent Data

Available at • **ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv/**

Observed atmospheric circulation (page 7)

NCEP/NCAR Reanalysis 1

Available at • **https://psl.noaa.gov/data/reanalysis/reanalysis.shtml**

Climate model simulations (pages 14–15)

Coupled Model Intercomparison Project Phase 6 (CMIP6)

Available at • **https://esgf-node.llnl.gov/projects/cmip6/**