Florissant Fossil Beds
Climate Change

National Park Service
U.S. Department of the Interior

Florissant Fossil Beds
National Monument
Colorado

Changes in the Earth's climate have occurred since the planet formed 4.5 billion years ago. Eocene Florissant was at the threshold of one of the most significant climate changes since the extinction of non-avian dinosaurs—a massive cooling event that affected life around the globe. Modern Florissant faces a similar challenge from climate change today. How can fossils help us understand climate change of the past, and how does this knowledge help us make decisions in response to modern climate change?

What was Florissant like 34 million years ago?

At the end of the Eocene Epoch, the time when plants and insects were falling into Lake Florissant to be preserved as fossils, Florissant was wetter and much warmer than it is today:

	Mean Annual Temperature	Mean Annual Precipitation
Modern	4°C (39°F)	38 cm (15 in)
Eocene	11–18°C (52–64°F)	50–80 cm (20–31 in)

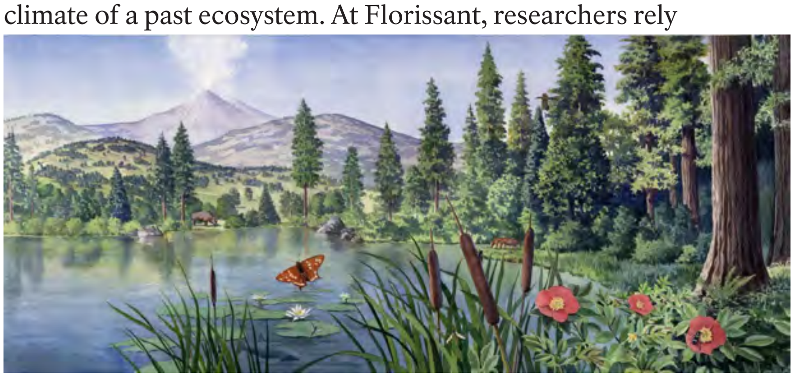
Today Florissant has a cool temperate climate and primarily evergreen coniferous vegetation, like pines and spruces. During the Eocene, Florissant had a warm temperate or even subtropical climate with deciduous broadleaved plants and exotic tall conifers. Although modern and Eocene Florissant had comparable summer temperatures, winter temperatures are much colder now, restricting the types of plants that can live here.

How do we know what past climates were like?

There are many methods that scientists can use to reconstruct the climate of a past ecosystem. At Florissant, researchers rely primarily on plant fossils to determine what Eocene Florissant was like. Unlike animals, which can migrate with the seasons, plants are rooted to the ground and have specific adaptations for survival in a particular climate.

One way to infer climate from fossil plants is to look at the nearest living relatives of the fossil species and the climates those plants live in today. A modern plant probably lives in a climate similar to the one its Eocene relative lived in. Another method involves considering the physical form of the fossil plant. Many plants have physical adaptations, especially in their leaves, which help them survive more successfully in certain climates than others. The size, shape, texture, and teeth of a leaf are all features that reflect the climate a plant inhabits.

A combination of multiple methods must be used when reconstructing climate because no single method is flawless. When reconstructing Eocene Florissant's climate, scientists consider the physical features of fossil leaves, the climates that the fossils' nearest living relatives live in, and other methods like analyzing the tree rings in Florissant's petrified redwood and hardwood stumps.



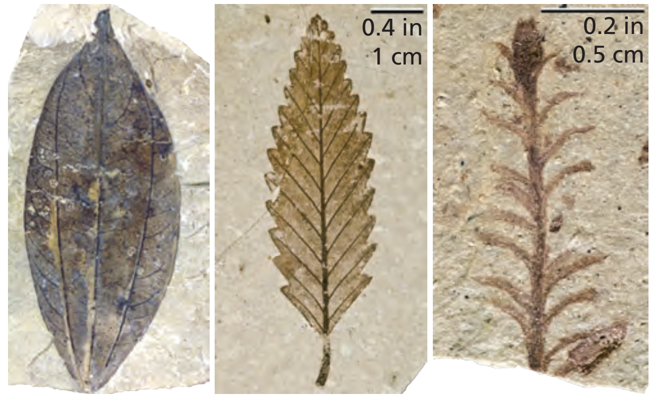
What happened after Eocene Florissant?

As the Eocene transitioned into the Oligocene Epoch 34—33 million years ago, global climate cooled significantly and rapidly. This was the result of new cold ocean currents created by continental plate movement around Antarctica. Studies have found that the North American climate cooled by as much as 8—10°C (14—18°F) in less than a million years.

Florissant is one piece of the fossil record that spans the Eocene-Oligocene transition and shows how plant communities and climate changed during this time.

Late Eocene Florissant had a warm temperate climate at high elevation, as shown by the dominance of broadleaved plants with a few conifers. In contrast, a nearby and slightly younger early Oligocene site at comparable elevation had a cool temperate climate, indicated by a dominance of conifers such as pine, fir, and spruce.

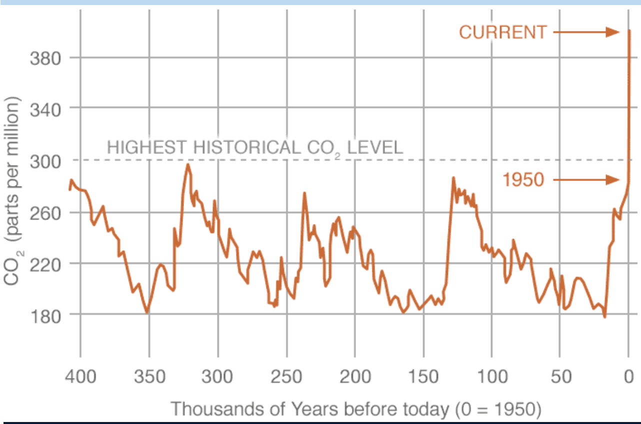
A similar change is evident from fossil floras in the lowlands of the west coast, where the subtropical forests of the late Eocene gave way to temperate deciduous forests in the Oligocene. These lowland Oligocene floras share many types of plants with Eocene Florissant, such as pines, firs, redwoods, oaks, hickories, elms, maples, and roses, indicating that these types of plants dispersed from higher to lower elevation as climate cooled. The shift from subtropical to temperate at low elevations and from warm temperate to cool temperate at high elevations is evidence of the effect global climate change can have on terrestrial ecosystems.



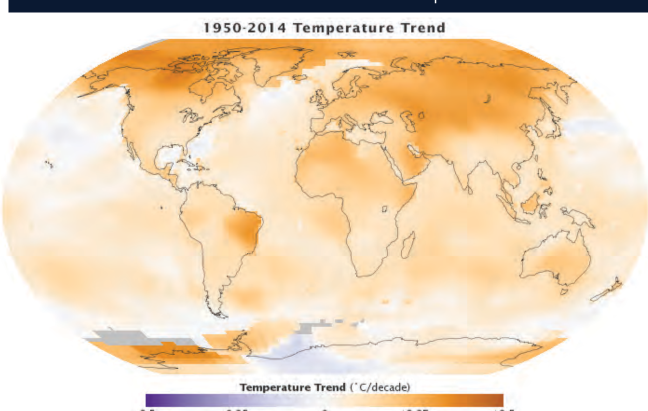
Fossil leaves from subtropical, warm temperate, and cool temperate climates. Left to right: *"Cinnamomum dilleri"* (UCMP-735), *Fagopsis longifolia* (FLFO-11513), *Sequoia affinis* (FLFO-6488). UCMP image courtesy of the University of California Museum of Paleontology.

What causes climate change?

Data from scientific studies prove that climate is changing, as it has changed since the Earth formed, but why is this climate change concerning? Most past global climate changes are attributed to variability in solar output, the Earth's orbit and tilt, volcanic activity, and plate tectonics. The rapid warming occurring on Earth today is caused not by any of these natural variations, but by human augmentation of the atmosphere's natural greenhouse effect. By burning fossil fuels like coal and oil, we increase the concentration of carbon dioxide (CO_2) in the atmosphere. As a result, the atmosphere is able to trap more heat, raising global temperature.



Ice cores show that CO_2 levels have oscillated naturally between 180 and 300 ppm for the past 400,000 years. Since 1950, CO_2 levels have risen above 400 ppm and are still rising. From NASA's Global Climate Change website, data from the National Oceanic and Atmospheric Administration.



Temperatures have increased more rapidly in some regions of the Earth than others. The greatest warming between 1950 and 2014 has been near the poles. From the NASA Goddard Institute for Space Studies.

How is climate change affecting us?

In addition to direct effects, such as melting ice sheets and rising sea level, global warming changes the way water is evaporated into and released by the atmosphere, intensifying hurricanes, droughts, and other weather phenomena. In our national parks, climate change has a variety of effects:

- Species ranges are shifting northward and upward in elevation
- Species interactions within communities are changing as species respond differently to shifting seasons and subsequent changes in the timing of flowering, breeding, and migration
- Storms are becoming stronger and more frequent
- The ranges of animal-carried diseases are growing
- Rising water levels are threatening park lands and buildings
- Wildfire activity is increasing

At Florissant, native species as well as petrified stumps and shale fossils are at risk from shifting seasons, changing weather patterns, and wildfires.

How do fossils help us understand climate change?

If CO_2 emissions were stopped altogether, global temperature would continue rising as the CO_2 already in the atmosphere trapped more heat. Climatologists can study ancient climates to see how the planet responds to sustained changes in CO_2 and how long it might take to recover.

Paleontologists can study fossils to see how past life responded to climate change, such as in the Eocene-Oligocene transition. In the past, populations have responded by moving to more favorable climates, adapting to the new climate, or going extinct. Ancient climates changed over thousands to millions of years, providing time for populations to respond. Modern climate is changing over the course of decades. Like ancient populations, living organisms can migrate or adapt in response to change, but they must respond much more quickly to avoid extinction.

By reducing our impact on the atmosphere and by using the history of ancient climate change to predict how our planet and the life on it will be affected, we can help provide a more stable climate in the future and protect our natural resources today.