

Causation, Correlation and Dying Arizona Alders

"I" = Interviewer, "G" = ChatGPT AI

I: Hi G. It's been a while, and I've been thinking about the difference between correlation and causation. Does that seem like something worthy of discussion?

G: Hello! Sure, I'd be happy to discuss the difference between correlation and causation with you.

In statistics, correlation and causation are often used interchangeably, but they are not the same thing. Correlation refers to a statistical relationship between two variables, whereas causation refers to the relationship between cause and effect, where one event or action (the cause) leads to another event or outcome (the effect).

In other words, correlation is a measure of how two variables are related to each other, while causation is a statement about how one variable affects another.

For example, suppose we observe that there is a positive correlation between the amount of ice cream people eat and the incidence of sunburn. That is, people who eat more ice cream tend to have more sunburn. However, this does not necessarily mean that eating ice cream causes sunburn. There may be other factors at play, such as the fact that people who eat more ice cream are more likely to spend time outdoors in the sun.

To establish causation, we need to conduct experiments or carefully controlled studies to isolate the effect of one variable on another. This can be challenging, as there may be many other variables that could be influencing the outcome.

In summary, correlation is a statistical relationship between two variables, while causation is a statement about how one variable affects another. While correlation can provide evidence of a possible causal relationship, it is important to establish causation through careful experimentation and analysis.

I: So, the relationship between an ecosystem's decline and global warming could be either causation or correlation, right? If so, how can we decide which it is?

G: Yes, the relationship between an ecosystem's decline and global warming could be either causation or correlation. In fact, it's quite likely that there is some causal relationship between these two phenomena, but it's important to be careful in how we interpret the data.

To determine whether there is a causal relationship between ecosystem decline and global warming, we would need to carefully examine the evidence and conduct experiments or controlled studies to isolate the effect of one variable on the other. This is not always possible in ecological studies, as it can be difficult or even impossible to manipulate variables in the field.

One way to establish causality is through a randomized controlled trial, where we randomly assign study participants to different treatments (such as different levels of ecosystem protection) and

measure the effect on the outcome variable (such as species diversity). However, such experiments may not be feasible in ecological studies due to the complexity and scale of the systems being studied.

Another way to infer causality is through a strong theoretical framework that explains the mechanisms by which one variable influences the other. In the case of ecosystem decline and global warming, there are several plausible mechanisms that could link the two phenomena, such as the direct impact of rising temperatures on species survival and the indirect effects of changes in habitat and food availability.

Ultimately, determining whether there is a causal relationship between ecosystem decline and global warming may require a combination of empirical data and theoretical understanding. It is important to be cautious in drawing conclusions and to continue gathering and analyzing data to improve our understanding of these complex ecological systems.

I: For instance, the decline of a river's riparian forest may coincide with the installation of a factory upstream, but we would need to have very good baseline data gathered before the installation as well as a theoretical framework for how a factory can cause riparian decline?

G: Yes, that's correct. To determine whether the installation of a factory upstream caused the decline of a river's riparian forest, we would need to have baseline data gathered before the installation of the factory, as well as a theoretical framework that explains how the factory could cause the decline.

Baseline data is important because it allows us to establish a "before-and-after" comparison of the ecosystem, which is essential for identifying any changes that occur after the installation of the factory. Ideally, the baseline data should include information about the riparian forest's composition and structure, as well as information about other potential stressors that could affect the ecosystem, such as changes in land use or climate.

In addition to baseline data, we would need a theoretical framework that explains how the factory could cause the decline of the riparian forest. This could involve identifying specific pollutants or stressors associated with the factory's operations, such as chemicals that are released into the water or changes in the flow regime of the river. Theoretical frameworks can be developed based on existing knowledge about the ecosystem or through experimental studies that test specific hypotheses.

Once we have baseline data and a theoretical framework, we can use statistical analyses to test whether the installation of the factory is associated with changes in the riparian forest. However, it's important to remember that correlation alone does not prove causation, and other potential factors could be influencing the ecosystem. Therefore, it's essential to use a variety of approaches, such as statistical modeling, controlled experiments, and expert judgment, to build a robust understanding of the causes of ecosystem changes.

I: Here's an example from Arizona's Verde River: The river experienced a very large flood in 2021. The floodwaters originated from a recent fire scar of a large forest fire, and it brought a heavy load of ash and silty downstream. Within 3 weeks, trees along the river downstream from the fire scar began to sicken and die. Can you help me design an experiment that might clarify whether these trees were dying because of the new silt and ash?

G: Sure, here's an experiment that could help clarify whether the trees along the Verde River were dying because of the new silt and ash or for some other reason:

1. **Site selection:** Choose several sites along the Verde River downstream from the fire scar, both where the trees are dying and where the trees are healthy. Ideally, the sites should be similar in terms of environmental conditions, such as soil type and moisture.
2. **Sampling:** Collect soil and water samples from each site, both where the trees are dying and where they are healthy. The samples should be analyzed for nutrients, heavy metals, and other potential contaminants that may be associated with the fire scar.
3. **Plant measurements:** Measure key indicators of plant health, such as leaf chlorophyll content, leaf area, and stem diameter, for both the dying and healthy trees at each site. These measurements can be used to assess the overall health of the trees and to compare the trees at the different sites.
4. **Experimental treatment:** Select a subset of the dying trees and apply an experimental treatment to them, such as removing the silt and ash from around their roots or providing them with additional nutrients. Alternatively, a control group of trees that are left untreated can be established.
5. **Monitoring:** Monitor the health of the trees over time, both for the trees that receive the experimental treatment and those that do not. Take regular measurements of plant health indicators, such as leaf chlorophyll content and stem diameter, to assess whether the trees are recovering or continuing to decline.

By comparing the soil and water samples from the healthy and dying trees, we can determine whether there are any differences in the levels of nutrients or contaminants that may be associated with the fire scar. By measuring the health of the trees at different sites, we can assess whether the decline is occurring only in areas where there is high silt and ash deposition, or if other factors are also contributing to the decline. Finally, by applying an experimental treatment to a subset of the dying trees, we can determine whether the treatment has any effect on tree health, which can help to clarify the cause of the decline.

I: It could be that all the trees along the river that became sick or died were exposed to high levels of silt and ash, but trees that were not sick or dead were not. Or there may be trees in the zone that experienced high silt and ash that did not get sick or die. Or the trees that did get sick or die may have been a weak set of trees that were already compromised by some other factor, such as fungal infection, poor nutrition, or insect damage. In that case, the trees that succumbed were a subset of the forest that may have eventually died anyway, but the flood, silt and ash just hastened their demise.

G: You raise some good points, and it's important to consider these different possibilities when interpreting the results of any experiment. Here are some additional considerations that may help to clarify the cause of the tree decline:

1. Tree species: It may be useful to identify the species of trees that are affected by the decline, as different species may have different tolerances to silt and ash deposition. For example, some species may be more sensitive to changes in soil pH or nutrient availability than others.
2. Tree age and size: It may also be useful to consider the age and size of the trees that are affected by the decline. Older and larger trees may be more vulnerable to stressors like silt and ash deposition, as they require more resources to maintain their health.
3. Timing of decline: The timing of the decline may provide clues as to the cause. If the decline occurs shortly after the flood, silt, and ash deposition, this suggests that these factors may be contributing to the decline. On the other hand, if the decline occurs gradually over time, this may indicate that other factors, such as fungal infection or insect damage, are playing a role.
4. Comparison to control sites: As you mentioned, it's important to compare the affected trees to nearby trees that are not experiencing decline. This can help to determine whether the silt and ash deposition is the primary cause of the decline, or if other factors are also contributing.
5. Long-term monitoring: Finally, long-term monitoring of the affected trees can help to determine whether the decline is temporary or permanent. If the trees are able to recover over time, this suggests that the silt and ash deposition may have been a temporary stressor. However, if the decline is permanent, this suggests that the trees were not able to tolerate the stressor and may have been weakened by other factors.

I: In the case I'm citing, the trees are Arizona Alders, *Alnus oblongifolia*. Does that give you any clues?

G: Yes, knowing that the affected trees are Arizona Alders, *Alnus oblongifolia*, provides some additional context. Here are a few things to consider:

1. Habitat: Arizona Alders are riparian trees, which means they grow along the banks of rivers and streams. Riparian ecosystems are particularly sensitive to changes in hydrology and water quality, so the silt and ash deposition may be having a larger impact on these trees than it would on other tree species.
2. Tolerance to silt and ash: It's unclear how tolerant Arizona Alders are to silt and ash deposition. Some tree species are able to tolerate high levels of sediment and ash in their root zone, while others are more sensitive. This is an area where further research may be needed.
3. Relationship to fire: Arizona Alders are known to have some adaptations to fire, such as the ability to resprout after being top-killed by a fire. However, it's unclear how the trees may be affected by the combination of fire, flood, and silt and ash deposition.

Overall, knowing that the affected trees are Arizona Alders provides some useful information, but more research may be needed to determine how the trees are being impacted by the flood and silt and ash deposition.

I: Could the fact that the trees are situated at the very northern and western edge of their distribution be a factor?

G: Yes, the fact that the affected trees are located at the very northern and western edge of their distribution could be a factor. Trees growing at the edge of their distribution are often more vulnerable to environmental stressors than those growing in the center of their range. This is because they may be experiencing suboptimal environmental conditions, such as colder temperatures, more extreme weather events, or different soil types, that limit their ability to grow and reproduce. Additionally, trees growing at the edge of their distribution may have less genetic diversity than those in the center of their range, which can make them more susceptible to disease and other stressors. Therefore, it's possible that the Arizona Alders growing at the edge of their distribution may be more vulnerable to the effects of the flood and silt and ash deposition than those growing in more favorable conditions.

I: You've given us a lot to think about, G. Thanks for the chat!

G: You're welcome! I'm glad I could help. If you have any more questions or want to discuss anything else, feel free to reach out to me again.