What if Going Backwards Is the Solution? How De-Extinction of the Woolly Mammoth Might Help Mitigate Global Warming

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Documentaries are one of my preferred ways of learning. As college students, we are constantly trapped in the dichotomy of having an immense curiosity, fueling our wishes to solve the world's most complex problems while being incredibly limited in time due to deadlines and exams. Hence, documentaries are usually my dear companions as I go through my daily tasks, allowing me to learn new things while I do the dishes, clean my room, or go for a walk. Nevertheless, there are instances where learning is not as enjoyable for me. An example of this is regarding environmental issues. Every time I learn about environmental issues, I am reminded of the damage that human greed has caused to this planet. Being so focused on my mundane immediate problems, I forget that our quality of life has increased at our planet's expense. The annual increase in temperature, endangered species, thawing of the permafrost, and more are Earth's cries for help; requests most of us have remained deaf towards. Learning about environmental issues usually leaves me with a feeling of hopelessness and fear. Therefore, I decided to search for possible solutions that researchers are proposing to address one of the most concerning environmental issues: permafrost thaw.

Permafrost thaw and its impact on the environment

You might have heard about permafrost being a physical record of some extinct species (e.g., woolly mammoths, prehistoric horses) that were preserved almost intact for thousands of years. Strictly speaking, permafrost is ground that remains at or below 0°C for at least two consecutive years and is comprised of two components. The first one is the active layer, whose thickness can reach a few decameters in the Arctic coast. The active layer is the surface layer of soil that thaws in the summer and freezes back in the winter. Beneath this layer is the main body of permafrost, which is permanently frozen ground, shifting only over long timescales (Salzmann & Gärtner-Roer, 2017). Permafrost has quite a large extension, underlying about a quarter of the Northern Hemisphere. Its function is to maintain the structure of the soil, not only allowing for houses and roads to be built but also for ecosystems to remain stable. The stability of permafrost makes the ground less susceptible to wildfires and erosions (Waldrop et al., 2021).

Increasing temperatures from global warming deepen the active layer's thaw, allowing for heat to reach the underlying permafrost. As mentioned earlier, permafrost is important for the stability of the ground. When it thaws, the infrastructure built on top becomes less stable, contributing to erosions on the Arctic coast and increased loss of ground that can be dangerous for people living in those areas (Salzmann & Gärtner-Roer, 2017). However, the consequences of permafrost thaw are not only regional but can also be dangerous on a global scale. Permafrost is quite old, some of it dating from around 700,000 years ago (Waldrop et al., 2021). Over time, it has accumulated a significant quantity of organic material derived from dead plants, animals, and other organisms trapped in the soil before decomposing. Researchers believe that permafrost holds more than twice the amount of carbon dioxide currently in the atmosphere. Permafrost's frozen state locks the carbon up by stopping microorganisms from degrading the organic material stored in the ground. Nevertheless, when permafrost thaws, microorganisms become active again and start breaking down the organic material, releasing carbon dioxide and methane into the atmosphere as byproducts. The release of these gases into the atmosphere act as greenhouse gases, trapping heat in Earth's atmosphere and thus increasing the effects of global warming (Salzmann & Gärtner-Roer, 2017; Waldrop et al., 2021).

A possible solution: Bring the Woolly Mammoth back?

Although this idea sounds like science fiction, Ben Lamm and Harvard geneticist George Church, founders of Colossal, hope to make this claim come true. Colossal plans to identify the genes coding for mammoths' resistance to cold temperatures by analyzing well-preserved DNA samples from woolly mammoth remains in Alaska and Siberia. Then, they hope to add these genes to the woolly mammoth's closest relative alive today, the Asian elephant, through gene editing technology like CRISPR. The nucleus of the modified Asian elephant cells can theoretically be fused to an Asian elephant egg and finally be implanted into an Asian elephant surrogate, resulting in an elephant calf that looks and behaves like a woolly mammoth (Colossal Laboratories & Biosciences, 2023).

However, we still must determine if the de-extinction of the woolly mammoth would even be relevant to the current environment. McCauley et al. (2016) suggest guidelines to make de-extinction ecologically meaningful: selecting a species with low functional redundancy (i.e. their roles in their ecosystem are not being fulfilled by other species) that recently went extinct so that the ecosystem is akin to when they left, and that the species can be restored in large enough numbers to have an ecological impact. Let us assess then if the woolly mammoth fits those criteria. Regarding the last guideline, it is unclear since I do not know the exact number of woolly mammoths that Colossal labs are planning to achieve. Therefore, I will focus mainly on the other two points. As to low functional redundancy, the Colossal team argues that the woolly mammoth can aid the environment by using them as ecosystem engineers in order to reverse the current moss-dominating Arctic tundra into the ancient mammoth steppe, which is better equipped to combat climate change and preserve permafrost from thawing (Colossal Laboratories & Biosciences, 2023). This view is supported by Macias-Fauria et al. (2020), who proposed the reintroduction of large herbivores to the Arctic as a viable alternative to restore grasslands in the Arctic. It is thought that megafauna such as mammoths, oxen, and bison kept the grasslands stable during the Pleistocene through grazing and trampling. Since these animals required a significant amount of food, they would eat most of the moss and shrubs, allowing for more grass to grow, which was important as it reflected more sunlight, reducing the amount of soil warming (Macias-Fauria et al., 2020). Mammoths would knock trees and shrubs down, contributing to the prevalence of fast-growing grass and forbs (Colossal Laboratories & Biosciences, 2023). In addition, large herbivores trampling on the snow would compress it, making it denser and thus impeding it from insulating the ground as much, thereby keeping the ground cooler (Macias-Fauria et al., 2020). Given that the woolly mammoth's closest relative (the elephant) is now inhabiting warmer areas, it is clear that the idea of resurrecting the woolly mammoth is not redundant at all, but what can we say about the similarities in the mammoth's ecosystem in today's world?

The Russian ecologist Sergey Zimov founded the Pleistocene Park near the town of Chersky in northeastern Siberia. Along with his son Nikita, he aims to demonstrate how introducing herbivores can help protect permafrost and restore the grasslands that dominated the Arctic during the Pleistocene. Modern herbivores that resemble those of the Pleistocene (e.g., reindeer, musk oxen, yaks, Yakutian horses) can be studied for their behavior and any changes inside the fenced park (Kintisch, 2015). Beer et al. (2020) had sensors installed at various depths in the ground, both inside and outside the park, to monitor the temperature. Additionally, they had researchers record changes in vegetation and snow thickness. The findings showed that the average soil temperature was 1.9°C colder inside the park than outside. They also saw thinner, more compact snow due to the trampling of the animals and the start of a vegetation shift from moss to grasses and forbs, resembling the mammoth steppe vegetation (Beer et al., 2020). Although these findings have only occurred in a restricted smaller area like the Pleistocene Park, they suggest that perhaps with greater numbers of animals (and being quite optimistic, with Colossal's hybrid elephants), way more resources, and some more time, the reconstruction of the mammoth steppe might help slow down the thaw of permafrost and therefore help mitigate the effects of climate change.

Conclusion

Even though I feel inspired by these scientists' creativity to come up with all those fantastical and ambitious solutions for a problem as real and serious as permafrost thaw, the truth is that nothing is certain yet.

Moreover, these solutions are filled with ethical dilemmas. Are we trying to cross lines we should not cross? Could all the resources used in the Colossal project be better used in more realistic solutions? What do the people living in the affected areas think about this project? To this, I have no answer. However, it is evident that permafrost thaw is an issue that concerns all of us and we must do our best to find ways to combat it.