Mammoth Steppe Ecosystem Restoration to Prevent Permafrost Carbon Emissions

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Melting Arctic Permafrost represents fundamental threat to global climate. Restoring “Mammoth Steppe” could help.

by Team Wooly Mammoth

Summary

Arctic permafrost contains ~1600 gigatons of carbon, approximately twice as much as the earths atmosphere (Tarnocai et al 2009). Due to accelerated warming at high latitudes this permafrost is beginning to melt. This will release large amounts of carbon into the atmosphere and create a positive feedback loop. Although many scientists are continuing to research the role permafrost carbon will play in global climate, Russian scientist Sergey Zimov, the discoverer of this “carbon bomb” (Zimov et all 1997) has an unusual, and rather poetic, plan to mitigate this effect. He believes that by restoring the “Mammoth Steppe” ecosystem, a grassland that once stretched from Spain to Canada and harbored tremendous herds of roaming ungulates – like the Serengeti but woollier – he can prevent permafrost from thawing. Not waiting for the rest of the world to

take action, he has started, in the most remote corner of north east Siberia, a project he calls Pleistocene Park which will be a proof of concept for his vision.

What actions do you propose?

Introducing large numbers of herbivores to the arctic will stimulate an ecological transformation from the current tundra and taiga ecosystems back to the "Mammoth Steppe" — a grassland ecosystem maintained by large numbers of herbivores that existed up until the end of the last ice age. Recent research (Zimov 2012) has shown that even during the last glacial maximum this ecosystem was able to maintain herbivore densities to the order of 11 tons per square kilometer. In Pleistocene Park animals introduced so far include Yakutian horses, muskoxen, European bison, reindeer, elk, and moose. Additional candidate species include Canadian wood bison, American plains bison, yak, Prezivalski's horse, Bactrian camel, sagia antelope, Yakutian goats, and llamas. This ecosystem can be created and maintained by cold adapted animals that currently live on the earth. Cloning a wooly mammoth is not necessary for the success of this project. However, when a ecologically meaningful population of mammoths derived from currently underway mammoth cloning projects are available they will also be included.

During the ice age the Mammoth Steppe was able to support such high herbivore densities because these animals, via physical disturbance and rapid nutrient cycling, maintained a grassland ecosystem that operated near it's photosynthetic maximum capacity. This ecosystem was so productive in fact that it pulled large quantities of Co2 from the earth's atmosphere and added it to the soil where it froze. Year by year, over tens of thousands of years, this soil built up to create the permafrost carbon deposits we find in the arctic today.

Restoring this ecosystem will effect global climate in three ways: 1) A meter of winter snow is a very effective thermo insulator. The ground absorbs heat during the summer but due to the layer of snow is unable to radiate this heat back into the atmosphere during the long and very cold arctic winter. This leads to a net increase in soil temperature. Millions of herbivores will spend the winter with one thought on their minds: finding enough food to not starve to death. In their search they will dig through or trample every inch of arctic snow looking for every last blade of grass. This will radically decrease the insulitave effect of the snow and cause a net temperature drop in the soil – preventing it from thawing even in a warmer climate. Early experimental results have show a net 4 degrees C drop in soil temperature in locations where herbivores are present (Sergey Zimov, personal communication). If permafrost stays frozen all that carbon stays where it is rather then releasing into the atmosphere. 2) A grassland ecosystem will have much higher albedo then the current tundra and taiga ecosystems. The scope of this effect is currently impossible to quantify but it could in theory be quite large. 3) In the very long term (thousands of years) this high productivity ecosystem will began drawing carbon out of the atmosphere and once again sequester it in frozen arctic soils.

Who will take these actions?

Initial proof of concept will be demonstrated by Sergey Zimov and his son Nikita Zimov at their research site Pleistocene Park. They will need funding from external partners to expand their project from it's current status. Full implementation will be carried out by the governments of Russia, The United States, and Canada as well as international organizations.

Where will these actions be taken?

Project locations are Russia, Alaska, and Canada. Although permafrost covers approximately 25% of the northern hemisphere land mass the largest concentrations of carbon are in a few relatively small locations in north east Siberia, central Alaska, and the Yukon Territory of Canada. Pleistocene Park, Sergey Zimov's experimental pilot project is located near the town of Cherski in the republic of Yakutia in the Russian Federation.

How much will emissions be reduced or sequestered vs. business as usual levels?

Projected emissions from thawing permafrost are not currently included in climate models and great uncertainty exists on the scale and time frame of these emissions. Sergey Zimov estimates that within 20 years methane and Co2 emissions from one relatively small region of Siberia will equal ~2 gigatons carbon per year (7.32 gigatones Co2) or ~20% of total anthropogenic emissions. Due to anaerobic decomposition some portion of this permafrost carbon will be converted to methane rather then Co2. Predicting the ratio of Co2 to Methane emitted from thawing permafrost is currently very difficult.

Because of the time frames necessary to implement Zimov's plan at a meaningful scale, even if initiated very soon, significant emissions of permafrost carbon are inevitable. However, by the second half of this century a restored mammoth steppe ecosystem could be preventing the emission of ~6 gigatons of Co2 per year, possibly a lot more.

What are other key benefits?

In addition to preventing large Co2 and methane emissions this project will significantly increase arctic albedo and over the long term began drawing carbon out of the atmosphere and sequestering it in the ground.

At the end of the last ice age human hunters pushing into the arctic overhunted the large herbivores that maintained the grassland ecosystem. Because it appears probable that the collapse of the Mammoth Steppe ecosystem was due not to climate change but to human hunting, restoring this ecosystem to it's former function would correct the largest human caused environmental tragedy prior to the modern era.

On a pragmatic note this ecosystem could provide a large amount of high quality protean for human consumption.

What are the proposal's costs?

Because northeastern Siberia has such a low human population density direct negative economic consequences would be quite low, especially when compared with the direct economic benefits to local residents (meat production, tourism). It is important to note that project calls ecosystem conversion from the current tundra and taiga to Mammoth Steppe grassland on a massive geographic scale. It is possible that there will be unintended consequences.

Time line

The short term will be dedicated to experimenting, data gathering, and expanding Pleistocene Park — the proof of concept. This period is also seeing the establishment of seed populations of herbivores in places other then Pleistocene Park, for example the 2015 reintroduction of Canadian Wood Bison to the Yukon river delta in Alaska and the 2006 (re?)introduction to Yakutia in Siberia.

The medium term will see large scale implementation by the governments of Russia, America, and Canada working with international organizations like the UN.

Because wild ecosystems are self sustaining the primary long-term action will be managing human impacts on the ecosystem – for example enforcing anti-poaching regulations and managing hunting for sustainability.

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