Abandoned cropland helps make Europe cooler

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If you've ever sat in the cool shade of a tree on a hot summer day, you already know that shaded areas are cooler than open fields. But is that kind of cooling enough to make a difference in the hotter world of the

future?

When a team of researchers looked at more than 20 years of recent land use changes for Europe and combined that with a climate model to provide information on temperatures during the same period, they found the answer to this question is a clear yes.

"When we put all the land cover changes together and looked at how these affected climate, we found a widespread seasonal cooling—up to one degree C in the summer—in western Europe," said Francesco Cherubini, the senior author of a newly published paper on the findings in *Nature Communications* and head of the Industrial Ecology Programme at the Norwegian University of Science and Technology.

Cherubini and his colleagues say this kind of information is vital to helping Europe plan policies that will encourage the right kind of land use for a warmer future.

"We can couple the global challenge of mitigation with the local need for climate adaption if we choose the right combination of land uses," he said.

The article is titled "Predominant regional biophysical cooling from recent land cover changes in Europe."

More than just CO_2

Cherubini was one of the lead authors of an ICC special report on Climate Change and Land published last autumn, so he's well aware of the role that land use plays in determining local and regional climate.

The 2019 IPCC land report demonstrated that land use can help stabilize temperature rises to a relatively low level, he said.

For example, the IPCC study showed that decreasing the amount of land used for grazing animals can free up land for growing forests, which soak up CO_2 as they grow.

The new study goes beyond looking at how land can help store CO_2, however, by looking at other ways in which land cover affects the climate.

"Usually we look at carbon in or carbon out," Cherubini said. "But here we assess the other effects through which the land interacts with climate systems, not just carbon."

These other effects include how different kinds of land cover reflect or absorb sunlight—which clearly affects surface temperature—along with humidity levels and evapotranspiration. Evapotranspiration is a term that describes both water losses due to evaporation from water bodies, and water losses when trees lose water through their leaves, which is called transpiration.

All these factors are important, he says, because policy makers need to look at all the different pieces of the climate puzzle, not just carbon dioxide.

"By having policies that only focus on carbon, you completely overlook these other effects, which are important from a regional climate perspective," he said.

"The ambition here is to have land management planning, where you can tackle the global challenges of carbon storage through land management, combined with strategies that have local cooling benefits," he said.

Climate model and satellite data

The researchers relied on the European Space Agency's satellite information on land cover, which has data on changes in vegetation cover from 1992 to 2015.

This incredibly detailed dataset allowed the researchers to map land use cover for the 24-year period under eight broad categories: evergreen needleleaf forest, deciduous broadleaf forest, open shrubland, cropland, urban and built-up, cropland/natural vegetation mosaic, wetland, and grassland.

They then combined these maps of vegetation changes with a regional climate model that simulated the climate for the same 24-year period.

"The model used actual observed atmospheric conditions," said Bo Huang, a postdoc at the Industrial Ecology Programme and first author of the paper. "This gave us realistic information about how the changes we saw in land cover also affected changes in climate over the period."

They were also able to compare their results with other empirical studies from different parts of Europe, which confirmed their findings.

Area of cropland loss the size of Switzerland

The researchers found that approximately 25 million hectares (Mha) of agricultural land was abandoned in Europe during the 24 years for which they had data, although cropland expansion elsewhere in Europe of about 20 Mha meant that the net loss of cropland was 5 Mha. That's a loss that is a little larger than the area of Switzerland.

When cropland was abandoned, it was mostly taken over by forests, and to a lesser extent, urban settlements. Cherubini said the main reason that cropland was abandoned was because of socioeconomic factors.

"People might have gotten tired of living in the countryside, or they don't want to work on their farm anymore," he said. "We saw this especially in the former Soviet Union after the fall of the (Berlin) Wall, because farmers were exposed to agricultural trade and international markets."

As a consequence of agriculture abandonment, forested areas in Europe increasedby about 23 Mha, with about 7 Mha of net gain. Some of these gains in forest area resulted when trees colonized wetlands and peatlands that had dried out over the period due to warmer summers and less precipitation. This last change—the drying out of wetlands in eastern Europe—also had significance for temperatures in eastern Europe, especially in the summer.

Cooler in western Europe, warmer in eastern Europe

When the researchers put all their data together, they saw that cropland abandonment in western Europe was associated with a regional cooling of roughly 1 degree C. in the spring and summer, and lesser amounts of cooling in the autumn and winter.

But eastern Europe, especially in the northeast, showed the opposite trend with warming of up to 1 degree C in some areas during the spring and summer.

The reason for this warming is partly because wetlands in this region are drying out, said Xiangping Hu, a researcher at NTNU's Industrial Ecology Programme and one of the paper's contributing authors.

"When the sun shines on a 'wet' wetland, much of the energy from the sun goes to evaporating the water in the wetland rather than heating the surface of the wetland," he said. "In a 'dry' wetland, most of the sun's energy goes to heating the surface of the wetland, so the air above it also warms."

The researchers saw this clear trend in their temperature modelling of the area.

One of the main outcomes of the study was the different climate response to vegetation growth in eastern versus western Europe, Cherubini said, because of different local conditions.

For example, eastern Europe is drier than western Europe, so when trees revegetate cropland, they don't have access to as much soil water for transpiration as their counterparts in western Europe. That difference is enough to overcome the benefits of cropland abandonment in eastern Europe, which is another reason why the researchers' analysis showed warming in eastern Europe but cooling in western Europe with cropland abandonment.

In contrast to both eastern and western Europe, however, Scandinavia showed relatively little change in temperatures linked to land use cover changes over the period. That's because there was little change in land use, the researchers found.

Creating win-win situations

An awareness of these local and regional effects can allow European policymakers to create incentives that will help mitigate temperature increases to come.

For example, in northern Europe, policymakers could find ways to prevent wetlands from drying out as a way to limit temperature increases, Cherubini said. In western Europe, he said, policymakers could have "specific planning and incentives for revegetation of open land, considering the local cooling benefits as a synergy of global climate change mitigation," he said.

By lowering food waste in general and promoting more efficient agriculture on land that is being farmed, less land will be needed for primary agricultural production.

Cherubini pointed out that warming is occurring much faster over land than compared to the global average level.

"We are already at a mean warming of about 1.8 degrees C on the land, and we will be about 3 degrees on the land even if we are successful at stabilizing the average global temperature at 1.5 degrees C," he said. "That means we need to take action to adapt to a warming climate, and land use planning is one action that can bring local cooling benefits."

"The message is quite clear," Cherubini said. "Abandoned cropland—or land cover change more generally—and its role in regional climate can help to us adapt and mitigate the effects of climate change. And by improving agricultural systems, we can free up land for multiple uses."

More information: Bo Huang et al. Predominant regional biophysical cooling from recent land cover changes in Europe, *Nature Communications* (2020). DOI: 10.1038/s41467-020-14890-0

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