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Published on *EOSDIS - Earth Data Website* (http://earthdata.nasa.gov)

Sowing the Seeds of Change? [1]

by Mike Meshek
Published in 1995

Model relates regional weather to historical land use changes in U.S.

For as long as people have practiced agriculture, we have been concerned about the effect of weather on crops. Lately, scientists have become interested in the potential impact of croplands on climate. Now, a regional modeling study suggests that summers in the United States may be different from 200 years ago as a result of large-scale land use changes.

The researchers tested the sensitivity of regional climates within the U.S. to vast vegetation changes by running the same model twice for a single summer month. In one simulation, Jeffrey Copeland and his colleagues used the indigenous vegetation of the conterminous United States as the model's driving force. In another model run, they forced the model with the land cover as modified by the last two centuries of human activity.

"What we found was that human disturbances of the landscape have had a very significant effect on the weather and climate," says Roger Pielke, a Colorado State University atmospheric scientist who worked on the project.

Among human disturbances of the landscape, agriculture in particular has significantly changed the vegetative face of the conterminous United States. Look at enough land in the lower 48 states and you will see that more than half of it is now covered by crops or something other than native vegetation.

In the central grasslands, crops have replaced almost all the tall grass prairie and much of the short grass prairie. Croplands have also supplanted native short grasses in California's Central Valley, mixed woodland along the Atlantic coast, and much of the deciduous forest in the Great Lakes region.

Humans direct the plow, but what we grow -- and the vegetation we plow under to plant our crops -- directs important exchanges between land and air. How the two trade water, for example, depends to a large degree on four land cover properties: aerodynamic roughness length, albedo, leaf area index, and fractional coverage.

Aerodynamic roughness length is a measure of the roughness of a given vegetation type and thus its resistance to air movement. Albedo is a measure of the amount of solar radiation a particular plant type reflects. Leaf area index (LAI) is a ratio of leaf surface area to ground surface area. Fractional coverage is a simple measure of the extent to which a vegetation type covers the land.

Copeland and his colleagues assigned numerical values for these four vegetative characteristics to all the indigenous vegetation and modified land cover types they used in their model. As indigenous vegetation in the model, they used data estimates of the vegetation types most likely to have occurred before European disturbance of the landscape. For the modified land cover, the modelers used the United States Geological Survey (USGS) land cover database, a derivation of an Advanced Very High Resolution Radiometer (AVHRR) data set distributed by the land processes DAAC at the USGS Earth Resources Observation Systems (EROS) Data Center.

With this input, the researchers ran the model. As model output, they evaluated four atmospheric parameters at the surface: temperature, precipitation, wind speed, and mixing ratio, the ratio of atmospheric water vapor to dry air.

When the modelers compared the input of the four vegetative characteristics with the output of the four atmospheric parameters, they found some close relationships. For instance, wind speed compared well with roughness length. In the East where taller trees were replaced by shorter crops, wind speeds at the surface increased, while in the West where short grasses were replaced by taller crops, wind speeds decreased.

The model results show only a slight increase (0.05 degrees Celsius) in temperature across the country. The

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temperature dipped in the West, but rose more in the East. The researchers relate the temperature variations to a combination of changes in albedo, leaf area index, and fractional coverage.

Daily precipitation rates increased in all regions except two. Overall, the precipitation rates increased by about five percent. However, because precipitation depends on a complex combination of temperature, winds, and mixing ratio, the modelers were unable to attribute the rise in precipitation to a single vegetative characteristic.

These results establish the sensitivity of summer weather patterns to land use change, say the researchers.

"We can say that there has been an effect," says Pielke. "I am only surprised that this hasn't been explored more because these changes have occurred globally -- in Asia, Africa, and now South America."

Reference(s)

Copeland, J. H., R. A. Pielke, and T. G. F. Kittel. 1996. Potential climatic impacts of vegetation change: A regional modeling study. Journal of Geophysical Research. 101(D3):7409-18.

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