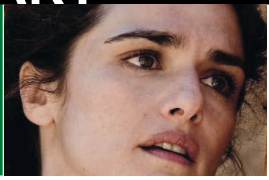

LETTERS

edited by Jennifer Sills

Forests and Climate: A Warming Paradox

E. ROTENBERG AND D. YAKIR ("CONTRIBUTION OF SEMI-ARID FORESTS TO THE CLIMATE SYSTEM," Reports, 22 January, p. 451) showed that forestation may not be an effective tool for climate change mitigation. They found that in a semi-arid landscape, the warming potential of a forest due to changes in the surface albedo and the longwave radiation emission far outweighs the cooling effect due to carbon sequestration. However, their analysis did not address the fact that the radiation balance of the surface is not the same as the radiation balance of the climate system. The atmosphere retains a significant portion of the longwave radiation emitted and the shortwave radiation reflected by the surface. Globally, only 10% of the surface longwave radiation escapes the atmosphere to the outer space (*1*). The escape fraction over Rotenberg and Yakir's site is probably higher due to low cloud cover, but not by much: The outgoing longwave radiation for a clear sky at the top of the atmosphere suggests a maximum of 20% (*2*). Similarly, because of atmospheric absorption and cloud reflection, the local albedo at the top of the atmosphere is lower than the surface value. By not taking into account this energy redistribution, Rotenberg and Yakir may have substantially overestimated the warming effect of forestation (and the cooling effect of desertification).

A deeper issue, also related to energy redistribution, is whether it is accurate to combine the CO_2 radiative forcing and the surface radiation change for the purpose of analysis. To help policy discussions, the greenhouse effects are often expressed as climate sensitivity (*3*), estimated at ~0.8°C increase in the surface temperature per W m^{-2} increase in the radiative forcing (*4*). The surface exchange process does not work that way. Rotenberg and Yakir's paradoxical result—that the forest, being an efficient convector, is much cooler despite more radiation loading than the shrubland—provides a powerful argument against combining the two quantities. In humid climates, forests also cool the surface by removing its latent heat, which is released above the atmospheric boundary layer by cloud condensation.

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Yatir forest. In their Report, Rotenberg and Yakir studied the semi-arid Yatir forest in Israel.

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Forests and Climate: The Search for Specifics

E. ROTENBERG AND D. YAKIR ("CONTRIBUTION of semi-arid forests to the climate system," Reports, 22 January, p. 451) demonstrate that dryland afforestation amplifies global warming and that desertification has resulted in net global cooling. However, the climatic impact of desertification warrants a more detailed analysis.

First, Rotenberg and Yakir's results from Yatir forest [located at the arid/semi-arid transition zone (*1*)] cannot be extrapolated to all areas undergoing desertification. Modeling the climatic effects of land-use change must account for diverse climate sensitivities dependent on various combinations of plant communities and climate (*2*).

Second, the spectral properties of infrared radiation reflected from green vegetation are fundamentally different from those of exposed soil (*3*). Unlike the radiation generated by soil, vegetation-derived shortwave infrared radiation (700 to 2000 nm) hardly interacts with the major absorption bands of CO_2, H_2O, and methane and dissipates substantial amounts of energy to space that are not accounted for by conventional analysis of albedo effects.

Third, common dryland ecosystems (open woodlands, savannas, and grasslands) differ from the pine forest analyzed by Rotenberg and Yakir. Such ecosystems have higher albedo than pine forest and produce an average 7 tons of biomass per hectare and year (*4*). Drylands support high biodiversity and provide livestock fodder, woody biomass, or high-value agricultural products (*5*, *6*). Desertification may have benefits in terms of increasing albedo, but those come at a cost: fossil fuel use, progressive further land degradation, and a shift to intensive irrigation agriculture that will result in high additional energy costs and greenhouse gas emissions.

We must address these questions before rendering final judgment on the climate sensitivity of desertification processes.

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Response

WE AGREE WITH LEE THAT TRANSLATING OUR radiative forcing (RF) results into temperature change is complex. In our Report, we warned that "[t]he *RF* values in this context should be interpreted with caution and are used here as a convenient way [a metric] to compare the magnitude of biogeophysical and biogeochemical forcing."

It is clear that RF alone does not have a direct relation to temperature change at Earth's surface (*1*–*4*). Temperature sensitivity to RF associated with atmospheric CO_2 can be three times that associated with albedo (*5*). Temperature can also change in response to nonradiative effects, such as evapotranspiration efficiency or surface roughness (*3*, *4*). Indeed, the massive sensible heat flux generated in the semi-arid forest could, if associated with sufficiently large forested area, modify atmospheric circulation and consequently local-to-regional climate more than any of the RF parameters [such as by influencing the depth of the planetary boundary layer, development of convective conditions, and cloud cover (*6*, *7*)].

Regardless of the uncertainty in translating RF to temperature change, the results from the semi-arid site showed large and robust effects. The local RF associated with the semi-arid land cover changes is about 50 W m^{-2} (divided mainly between short- and longwave radiation effects). This is important when considering that as much as ~20% of the thermal radiation (or ~5 W m^{-2}, which is further enhanced by shortwave reflected light) can radiate straight out to space under the mostly cloudless conditions in this region, contributing to the planetary climate system. Although a local effect, it is still significant compared to the global top-of-atmosphere RF associated with doubling of atmospheric CO_2 concentrations, estimated at about 4 W m^{-2}.

Whereas we estimated local RF on the basis of field measurements, the intricate translation of such RF estimates into temperature change (or even just into top-of-atmosphere RF) must rely on models and satellite observations. At present, it is still a challenge, even for the best models, to sum up measurable RF and other nonradiative effects and provide a reliable climate-change forecast (*8*). The continuous exchange between models and observations is critical to advancing the field and ultimately providing useful information for policy discussions (*4*).

Leu highlights the difficulties in developing appropriate and reliable metrics to assess factors that influence the climate system. Referencing a paper by Pielke *et al*. (*9*), Leu points out that surface temperature differs depending on the presence of different land use and plant communities. Our use of the RF metric cannot be directly related to Pielke's arguments on the suitability of surface temperature to assess climate change. We indicate the large impact on surface RF of the primary conversion of mostly bare surface to vegetated land cover, and vice versa, in the semi-arid zone. This research, in turn, should motivate more detailed investigations, including the consideration of different plant communities, soils, and geographical characteristics, as suggested by Leu.

The additional issue of unique plant reflectivity in the near-infrared (NIR) range, which may have climatic consequences, clearly deserves further investigation. But this effect can be assessed using our existing experimental setup because reflectivity measurements in this study included shortwave radiation (S) (305 to 2800 nm), complemented by photosynthetic active radiation (PAR) [400- to 700-nm range (*10*, *11*)], with the difference predominantly representing the NIR range (700 to 2800 nm). The results indicated that in going from sparse shrubs to open canopy forest, reflectivity decreased on average to 0.55, 0.53, and 0.57 for the S, PAR, and NIR, respectively. Although some enhanced reflectivity in the NIR range is indeed indicated, this is a relatively small effect and would be further diluted because of the overall higher atmospheric absorption in this spectral range (*12*), and the general increase in the diffusive nature of reflected radiation.

Finally, as pointed out by Leu, desertification and afforestation in the semi-arid and other dry regions have wide range of implications, including economic, societal, and climatic, all of which should be considered in management, policy- and decision-making processes.

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CORRECTIONS AND CLARIFICATIONS

News of the Week: "Five questions on the spill" by R. A. Kerr *et al*. (21 May, p. 962). The third author of the story was Lauren Schenkman, not Laura Schenkman. The name is correct in the online HTML version.

News Focus: "Animal communication helps reveal roots of language" by M. Balter (21 May, p. 969). The chimpanzee Washoe, who learned to communicate using American Sign Language, was mistakenly referred to as a male. Washoe was a female.

TECHNICAL COMMENT ABSTRACTS

Comment on "Deep-Sea Temperature and Ice Volume Changes Across the Pliocene-Pleistocene Climate Transitions"

Jimin Yu and Wally S. Broecker

Sosdian and Rosenthal (Reports, 17 July 2009, p. 306) used magnesium/calcium ratios in benthic foraminifera from the North Atlantic to reconstruct past bottom-water temperatures. They suggested that both ice volume change and ice-sheet dynamics played important roles during the late Pliocene and mid-Pleistocene climate transitions. We present evidence that their record of deep ocean temperature is not reliable, thus raising doubts about their conclusions.

Full text at www.sciencemag.org/cgi/content/full/328/5985/1480-c

Response to Comment on "Deep-Sea Temperature and Ice Volume Changes Across the Pliocene-Pleistocene Climate Transitions"

S. Sosdian and Y. Rosenthal

Yu and Broecker argue that the paleoceanographic interpretation of our 3.2-million-year record of North Atlantic deep-sea temperature hinges on the determination of whether temperature or carbonate saturation is the primary driver of benthic foraminiferal magnesium/calcium ratios from the North Atlantic. Here, we present evidence supporting our argument that bottom-water temperature variability is the primary control on benthic foraminiferal Mg/Ca at our site.

Full text at www.sciencemag.org/cgi/content/full/328/5985/1480-d

Published by AAAS

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Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 3 months or issues of general interest. They can be submitted through the Web (www.submit2science.org) or by regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

Call for Science to Clear Whaling Confusion

NEGOTIATIONS ON THE FUTURE OF THE International Whaling Commission (IWC) may culminate in a decision at the annual meeting in Morocco from 21 to 25 June that would suspend the current moratorium on commercial whaling and allow commercial catches of fin, minke, sei, and Bryde's whales in the North Atlantic, Southern Ocean, and North Pacific. Proposals from the Chair for a consensus decision to allocate ad hoc catch quotas close to current levels of whaling for a 10-year period have been criticized for sidelining science ("Deal to legalize whaling would sideline science," V. Morell, News of the Week, 30 April, p. 557). In response, a press release issued 7 May (revised 11 May) expressed the intention that catches would be within limits calculated according to the IWC's agreed, science-based, and "extremely conservative" Revised Management Procedure (RMP) (*1*). Unfortunately, this intent is not reflected in the wording of the actual proposal, which allows sufficient room for interpretation to potentially allow much higher catches than would be considered sustainable in the long term according to the agreed and published specification of the RMP (*2*). This confusion can only be resolved by explicit adoption of the published procedure into the IWC Schedule and instructions to the IWC Scientific Committee to perform the relevant calculations. Calculations of sustainable catch levels using the procedure and performed by the Scientific Committee, which includes scientists nominated by both whaling and non-whaling governments in addition to a number of independent experts, would be transparent, documented, and verifiable. Without such advice from the Scientific Committee, many of the 88 member nations of the IWC will not have the scientific resources themselves to assess the validity of the proposed catches amid the inevitable claims and counterclaims that are being made.

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