Because the results reported by Fiorentini and Maffei were limited to cells whose receptive fields fell within 5° of the area centralis, we were initially concerned primarily with units whose receptive fields were in the central area of visual space. Although cells with more peripheral receptive fields were sampled, only those within the binocular segment were included in this report. Recordings were made at either 1 to 3 days after surgery (acute monocular paralysis) or at periods of more than 14 days (chronic monocular paralysis). These intervals were chosen to place our observations clearly on either side of the period reported previously to be critical for changes in simple cortical cells (*5*).

Of the 124 LGNd units which received visual information from the paralyzed eye, 119 could be classified with confidence as X or Y. The few units which could not be classified occurred with roughly equal frequency in both chronic and acute conditions and were excluded from the analysis. Figure 1 summarizes the data obtained from both conditions. As in other reports (*16*), in acutely paralyzed animals, X-units represent approximately 51 percent of the cells, while Y-cells constitute the remaining 49 percent. When recordings were made at more than 14 days after paralysis, these percentages were drastically altered. Only 7 percent of the units encountered were X-cells, while the remaining 93 percent were Y-cells.

In Fig. 2, the fraction of recorded units which were X-cells is displayed as a function of eccentricity. Although the X-cell loss appears to be present in all areas of the binocular segment, the small sample size in the most peripheral areas limits confidence with respect to our estimate of the loss in this region. Our estimate of the magnitude of the overall loss of X-cells is probably conservative because, in the chronically paralyzed cats, we sampled proportionately more from those regions of the LGNd which normally have a higher concentration of X-cells (*16*).

These results indicate that the number of functional X-cells in the LGNd was reduced by chronic monocular paralysis. The attrition of the X-cell population provides a new demonstration of neural plasticity in the adult visual system. The data are in large part consistent with the parallel processing model for connectivity within the visual system (*6*). Monocular paralysis simultaneously disrupts binocularity among simple cells in the visual cortex and produces loss of X-cells in the LGNd, while at the same time apparently leaving unaffected complex cells in the visual cortex and Y-cells in LGNd.

At the same time, however, the results raise a possibility which has not been considered in the parallel processing model (*6*). According to Fiorentini and Maffei (*5*), a certain proportion of simple cells continue to be driven by the paralyzed eye after chronic monocular paralysis. It seems unlikely that these cells receive their input from LGNd X-cells, since so few X-cells remain responsive to stimulation via the paralyzed eye. This suggests that after monocular paralysis, many simple cells in the visual cortex may be driven by Y-cells of the LGNd.

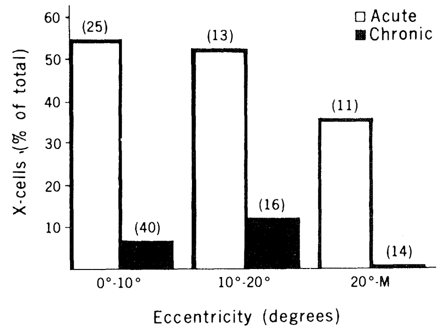

Fig. 2. Same data as in Fig, 1, expressed as a function of eccentricity of receptive field location. Eccentricities run from the vertical meridian (0°) to the beginning of the monocular segment (*M*). The frequency of X-units is expressed as a function of the total population (frequency of X fields plus frequency of Y fields) at each location. The numbers in parentheses refer to the total number of fields from which the percentage of X fields was calculated at each point. Following chronic monocular paralysis, X-cells in the LGNd were encountered with markedly diminished frequency at all retinal eccentricities in the binocular segment.

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References and Notes

1. T. N. Wiesel and D. H. Hubel, *J. Neurophysiol.* **26**, 1003 (1963).
2. D. H. Hubel and T. N. Wiesel, *J. Physiol. (Lond.)* **206**, 419 (1970).
3. T. N. Wiesel and D. H. Hubel, *J. Neurophysiol.* **28**, 1029 (1965); S. M. Sherman, K.-P. Hoffmann, J. S. Stone, *ibid.* **35**, 532 (1972); B. G. Wickelgren and P. Sterling, *Nature (Lond.)* **224**, 1032 (1969); P. Sterling and B. G. Wickelgren, *Brain Behav. Evol.* **3**, 1210 (1970); B. G. Wickelgren and P. Sterling, *J. Neurophysiol.* **32**, 16 (1969).
4. H. A. Buchtel, G. Berlucchi, G. G. Mascetti, *Brain Res.* **37**, 355 (1972).
5. A. Fiorentini and L. Maffei, *Vision Res.* **14**, 217 (1974).
6. J. S. Stone, *Invest. Ophthalmol.* **11**, 338 (1972).
7. J. Orem, M. Schlag-Rey, J. Schlag, *J. Exp. Neurol.* **40**, 784 (1973).
8. R. Fernald and R. Chase, *Vision Res.* **11**, 95 (1971).
9. C. Enroth-Cugell and J. G. Robson, *J. Physiol. (Lond.)* **187**, 517 (1966).
10. B. G. Cleland, M. W. Dubin, W. R. Levick, *ibid.* **217**, 473 (1971).
11. Y. Fukada, *Vision Res.* **11**, 209 (1971).
12. ——— and H. A. Saito, *ibid.*, p. 227.
13. B. G. Cleland, W. R. Levick, K. J. Sanderson, *J. Physiol. (Lond.)* **228**, 649 (1973).
14. J. S. Stone and K.-P. Hoffmann, *Brain Res.* **32**, 454 (1971).
15. M. W. Dubin, paper presented at the meeting of the Association for Research in Vision and Ophthalmology, Inc., Sarasota, Florida, 28 April to 2 May 1974.
16. K.-P. Hoffmann, J. S. Stone, S. M. Sherman, *J. Neurophysiol.* **35**, 518 (1972).

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Surface Albedo and Desertification

Otterman (*1*) has proposed that desertification in regions of marginal rainfall may be due to an increase in surface albedo caused by the removal of vegetation by overgrazing. He hypothesizes that, when high-albedo soils are denuded, the resultant increase in surface albedo causes lower surface temperatures, which in turn reduce the heat input to the lower atmosphere, decrease its temperature lapse rate, and hence somewhat reduce convective activity leading to rainfall. Over a period of several years we have measured albedos and surface temperatures of soils and plants in the Sonoran Desert climate of the southwestern United States, and, from the results of our investigations, we would predict that the denuded surface would be warmer than the vegetated one. Since the importance of correctly identifying the climatological mechanisms of desertification cannot be overemphasized in light of the devastation and human suffering caused by these processes in the Sahel (*2*), we believe that further analysis is warranted.

The primary data to be used in this context were obtained in May–June 1974 at Phoenix, Arizona. For about a week, we kept four different soils in 25-m^2 plots very wet by spraying them with water every morning, noon, and night. During this time, air temperature (T_A), surface soil temperatures (T_s), and albedos were measured every 20 minutes with fine-wire copper-constantan thermocouples and upright and inverted solarimeters. The soils were then allowed to dry. When the volumetric water contents of their upper 2 cm were between 2 and 4 percent, similar data were obtained for another week. Details of this work and closely allied experiments have been reported elsewhere (*3*).

Figure 1 shows the average difference between T_s and T_A for the four different soils when wet and when dry at 1400 local time as a function of their mean albedo at that time. When the soils are wet, T_s is nearly equal to T_A and is insensitive to albedo variations. When the soils are dry, however, T_s rises far above T_A and is very sensitive to albedo. Indeed, the predicted drop in T_s relative to T_A in traversing the postulated albedo range 0.25 to 0.37, suggested by Otterman (*1*) as representative of the vegetated and bare soils he investigated, is more than enough (13°C) to account for the apparent temperature differences he measured (3.5° to 5°C). However, Fig. 1 applies only to *bare* soil surfaces. When the land is covered by vegetation, relationships are very different. For nonstressed plants, leaf temperature tends to differ from air temperature by only a few degrees—leaf temperature is slightly above air temperature for air temperatures below 33°C and slightly below for air temperatures above 33°C (*4*). Even if water is severely limited, leaf temperatures generally rise less than 10°C above air temperature (*4*, *5*), particularly those of small-leaved plants (*6*) of the type Otterman mentions. Thus, since our data indicate that surface soil temperatures would still be 10°C above air temperature even at the highest albedo value he postulates, it is difficult to see how an area with an "appreciable vegetation cover" could become warmer than an adjacent bare soil area during midday.

Nevertheless, Otterman has presented temperature measurements indicating that the vegetated surface he studied was warmer than the adjacent bare soil. These temperature measurements were obtained by infrared thermometry. To use this technique successfully, the emissivity of the surface viewed over the spectral sensitivity region of the infrared thermometer must be known. Otterman reports that he assumed a value of 0.9 for both the bare and vegetated areas he compared. Emissivity measurements made by us (*7*) and others (*8*), however, indicate that for a desert soil of albedo 0.37 the emissivity could well be lower than 0.9 (≈ 0.88), and that for vegetated surfaces it is considerably larger

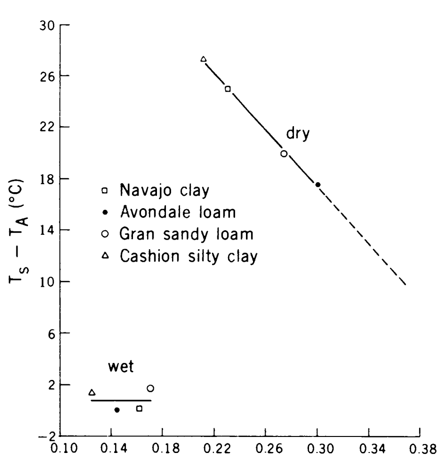

Fig. 1. Mean values of the surface soil temperature minus the air temperature ($T_S - T_A$) at 1400 local time for four different bare soils kept very wet (near saturation) for 1 week and very dry (2 to 4 percent water content by volume) for another week plotted as a function of the mean soil albedos for the same times.

(≈ 0.98). Using these values along with a representative value of the background sky radiation (*9*), we calculate that Otterman's approach could have introduced relative temperature errors as great as 8°C, considerably larger than the differences he reported for the bare and vegetated areas.

In light of these considerations, we believe that there is little justification for the desertification mechanism proposed by Otterman. Indeed, our analysis tends to indicate that the denuding of soil may have thermal and climatic effects just the opposite of those that he has postulated. Until actual on-site measurements of rainfall and of surface temperatures based upon correct surface emissivities show otherwise, the validity of the rainfall reduction mechanism Otterman postulates should be seriously questioned.

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References and Notes

1. J. Otterman, *Science* **186**, 531 (1974).
2. N. Wade, *ibid.* **185**, 234 (1974).
3. S. B. Idso, R. J. Reginato, R. D. Jackson, B. A. Kimball, F. S. Nakayama, *Soil Sci. Soc. Am. Proc.* **38**, 831 (1974); S. B. Idso, R. D. Jackson, R. J. Reginato, B. A. Kimball, F. S. Nakayama, *J. Appl. Meteorol.* **14**, 109 (1975).
4. E. T. Linacre, *Agric. Meteorol.* **1**, 66 (1964).
5. W. L. Ehrler and C. H. M. van Bavel, *Agron. J.* **59**, 243 (1967); J. H. Palmer, *Agric. Meteorol.* **4**, 39 (1967).
6. S. B. Idso, D. G. Baker, D. M. Gates, *Adv. Agron.* **18**, 171 (1966).
7. S. B. Idso and R. D. Jackson, *J. Appl. Meteorol.* **8**, 168 (1969); S. B. Idso, R. D. Jackson, W. L. Ehrler, S. T. Mitchell, *Ecology* **50**, 899 (1969).
8. K. J. K. Buettner and C. D. Kern, *J. Geophys. Res.* **70**, 1329 (1965); M. Fuchs and C. B. Tanner, *Agron. J.* **58**, 597 (1966).
9. S. B. Idso and R. D. Jackson, *Agron. J.* **60**, 388 (1968).
10. Contribution from the Agricultural Research Service, U.S. Department of Agriculture.

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Jackson and Idso's presentation of leaf temperatures versus air and bare soil temperatures (*1*) is consistent with a concise statement by Gates: "A dark, dry loam in full sunlight may have surface temperatures as high as 50°C when the air temperature at a height of 2 m is 30°C. A stand of vegetation nearby will have leaf temperatures near or below air temperature" (*2*). Indeed, these typical temperature characteristics of healthy leaves are a direct result of two factors. One of these is high albedo in the infrared: "the very abrupt increase in reflectance near 0.7 μ and the fairly abrupt decrease near 1.5 μ are present for all mature, healthy, green leaves" (*2*). The infrared radiation is 50 percent or more of the solar insolation at the ground (*3*), and the high albedo in this part of the spectrum reduces the radiation absorbed by the leaves. The second factor, which can be dominant, is evapotranspiration. This factor effectively causes the heat output to be significantly in the form of latent heat, reducing the temperature, but it can differ sharply between types of plants.

When the plant canopy covers only a portion of the ground, quite logically an increased infrared reflectance of the vegetated area is expected with increasing ground cover fraction, plant projection, height, and leaf surface index of vegetation (*4*). Accompanying this increased reflectance in the infrared is a decreased reflectance in the red portion of the spectrum.

The sharp contrast between the Sinai and the Negev was one of the preliminary "quick look" results of the Israeli ERTS-1 (Earth Resources Technology Satellite) program (*5*). The observed low reflectance in the MSS-7 (multispectral scanner) infrared band, 0.8 to 1.1 μm, of the area with "an appreciable vegetation cover" (*1*) in the western Negev was totally unexpected, and indeed can be referred to as the Negev infrared reflectance paradox. The measurements of the contrast between the Sinai and the Negev made with a microdensitometer scan were reported in *Science* (*6*). More accurate computation was recently carried out (*7*) directly from the ERTS-1 digital tapes, from pairs of points or small sampling areas on the two sides of the demarcation line [see figure 1 in (*6*)]. The contrast between the Sinai and the Negev in the MSS-7 infrared band ranges from 1.73 for a pair of points some 15 km from the Mediterranean to 1.27 for an inland pair where precipitation is less and the soil is more sandy. In the MSS-5 band, orange-red, the appropriate contrasts are 1.88 and 1.30, somewhat higher than in the infrared but not drastically so, as might be expected (*4*).

The studies, which began in the winter of 1972–1973, of temperature relationships on both sides of the demarcation line and of the possible meteorological-climatological effects were initiated only as a result of observing the Negev infrared reflectance paradox. I agree with Jackson and Idso that "it is difficult to see how an area with an 'appreciable vegetation cover' could be-

Fig. 1. Ground view of the western Negev (22 June 1974), showing vegetation growing in clumps. Tamarisk trees are only a rare occurrence.

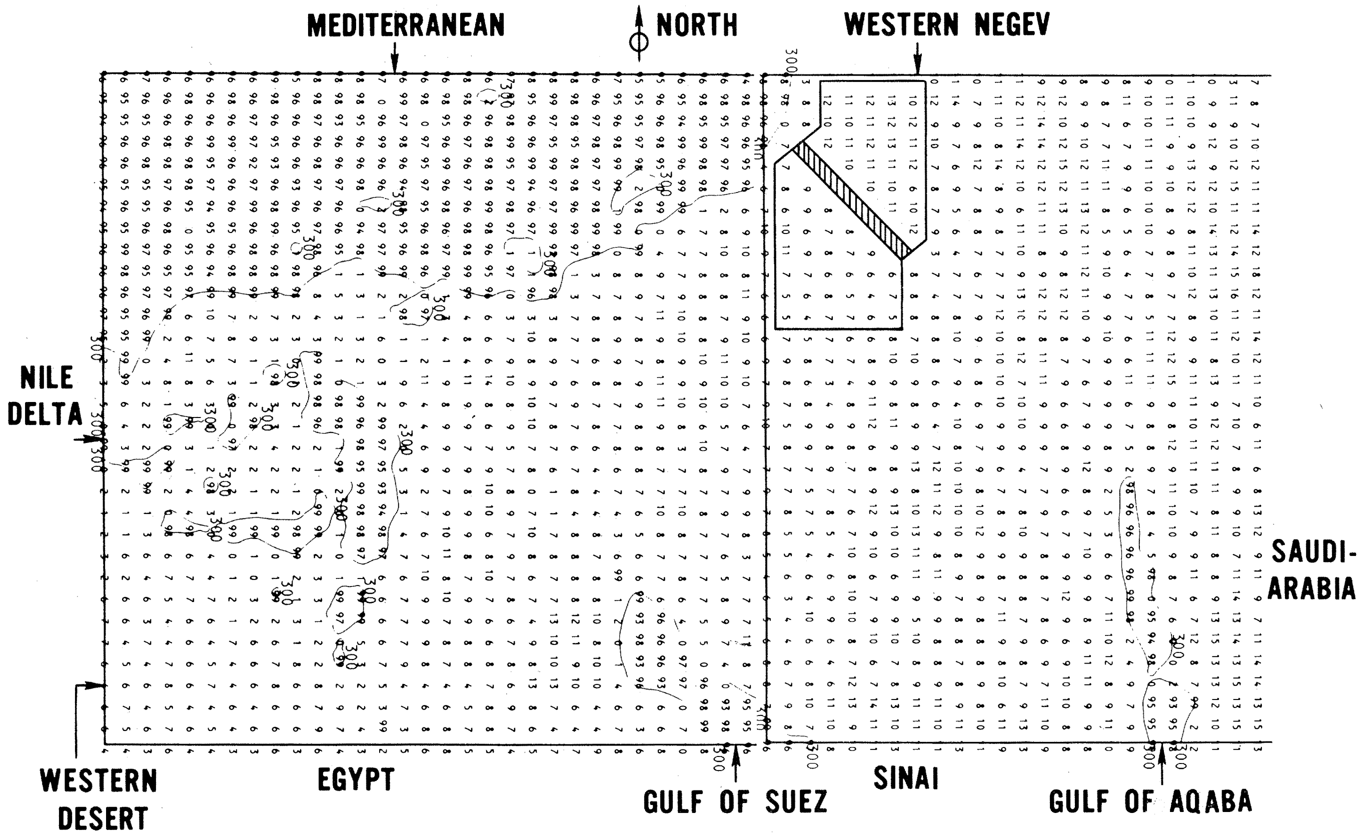

Fig. 2. Radiation temperature map of the area made by the scanning radiometer of the NOAA satellite at about 9:30 a.m. in mid-July 1974. The radiation temperatures are given as two-digit numbers either above 200°K or above 300°K.

come warmer than an adjacent bare soil area during midday" (*1*), but, for an area that does not exhibit the infrared reflectance paradox, it is downright *impossible*. In view of the paradoxically low reflectance of the Negev, the predominance of interstices between vegetation clumps imposed by the limitations in the available moisture, and the dry appearance of the vegetation (see Fig. 1), the question arose whether the usual temperature relations prevail for such dark areas "with an appreciable vegetative cover."

The existence of the temperature anomaly has been confirmed in a fragmentary way by one overflight (*6*) and the radiation temperature maps from satellites (see Fig. 2). The temperature anomaly shows that the radiation temperatures of the western Negev are higher by 4.1°K than those of the northern Sinai (the areas in the box in the upper center of Fig. 2), whereas the radiation temperatures of the cultivated areas of the Nile Delta are lower by some 10°K. Nighttime data for the Negev-Sinai area do not show any observable differences in radiation temperature. The fact that the thermal mountain of the western Negev (*6*) shows up in contrast to the Sinai only in the daytime strongly corroborates the viewpoint that the effect is caused by sensible temperatures due to albedo differences and not to emissivity differences.

Apparently, the explanation for the anomalous reflectance and temperature relations of the western Negev–Sinai area is that the vegetation covers only 25 to 35 percent of the ground surface in the Negev (as compared with some 10 percent or less in the Sinai) and that it is the interstices between the vegetation clumps that effectively control the reflectances and temperatures (*8*). In the Negev, the interstices show dark-gray plant debris littering the surface; in the Sinai the scant plant debris are trampled into the ground and covered by dust in the unstable soil environment of the overgrazed area. Thus, the high albedo of the Sinai is attributable to the bare unstabilized soil whereas in the Negev the more stable soil is covered by the plant debris. An additional effect is that the unstabilized soil has a higher reflectance than the more stable, partially crusted soil of the vegetation interstices (*9*).

There is an uncertainty in the emissivity which must be assumed in interpreting the radiation temperature data. I agree with Jackson and Idso (*1*) that the emissivity of the bare soil can be about 0.9 for the PRT-5 radiometer (Barnes precision radiation thermometer) measurements from 8 to 16 μm. The low emissivity value is, to a large extent, due to very low emissivity around 9 μm, the reststrahlen (residual rays) effect. The emissivity of the vegetation approaches unity, both because of a higher emissivity of the leaf surface and because of the multiple reflections in the canopy, which produce a cavity effect corresponding to nearly ideal blackbody emission. It is an open question to what extent the cavity effect applies to the clumps of vegetation in the Negev and the Sinai. Assuming an emissivity of 0.95 for the vegetative fraction of the ground cover and averaging linearly in emissivity in proportion to the ground cover, one obtains an emissivity of 0.905 for the Sinai with a 10 percent ground cover and 0.9175 for the Negev with a 35 percent ground cover. Under this assumption, the actually measured radiation temperatures of 45°C for the Negev and 40°C for the Sinai would correspond to sensible temperatures of 51.9°C for the Negev and 47.9°C for the Sinai, in other words, a 4°C temperature differential.

Even assuming an emissivity of 1.0 for the plant fraction of the ground cover, we would still find that the Negev is warmer than the Sinai by 3°C. The 8°C emissivity difference correction suggested by Jackson and Idso would apply, *at most*, if the Negev had a thick, 100 percent vegetative cover and the Sinai a 0 percent vegetative cover, which is not the case. The scanning radiometer of the National Oceanic and Atmospheric Administration (NOAA) satellite operates in a narrower band around 11 μm, effectively outside the reststrahlen band. A higher emissivity for soil would apply for Fig. 2, with probably a negligible difference of emissivity between the Sinai and the Negev.

The multifaceted study of possible desertification in this region is continuing and should in no way be regarded as definitive, not even for any of the subtopics. In spite of the efforts since the winter of 1972–1973 to study and analyze these phenomena, many uncertainties and questions remain. Specifically, appropriate mapping of radiation temperature differences from satellites will be available only in 1977, when LANDSAT-C (Land Satellite), with a thermal band in its scanner will offer a relatively high resolution and the coregistration of the thermal radiation measurements with the multispectral reflectance measurements. However, for most pertinent information, the operating time should be changed from 9:30 a.m. to about 10:30 a.m. (*10*). Further studies in a variety of disciplines are needed, and specifically I personally hope that Jackson and Idso will carry out detailed temperature measurements in an area of natural vegetation in the United States that does exhibit an infrared reflectance anomaly. Such reflectance anomalies have been found to exist in many parts of the world (*7*), including the Sahel.

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References and Notes

1. R. D. Jackson and S. B. Idso, *Science* **189**, 1012 (1975).
2. D. M. Gates, *Physical and Physiological Properties of Plants in Remote Sensing, with Special Reference to Agriculture and Forestry* (National Academy of Sciences, Washington, D.C., 1970), pp. 224–252.
3. H. H. Lamb, *Climate, Present, Past and Future* (Methuen, London, 1972), vol. 1.
4. J. E. Colwell, *Remote Sensing Environ.* **3**, 175 (1974).
5. J. Otterman, *Rass. 20th Int. Elettron. Nucl.* (1973), pp. 199–203.
6. ———, *Science* **186**, 531 (1974).
7. ———, L. Walter, T. J. Schmugge, paper VI.3.3 presented at the 18th plenary meeting of the Committee on Space Research (COSPAR), Varna, Bulgaria, 1975.
8. J. Otterman, Y. Waisel, E. Rosenberg, *Agro Ecosyst.* **2** (No. 1), 47 (1975).
9. N. H. MacLeod, personal communication.
10. J. Otterman, *J. Br. Interplanet. Soc.*, in press.
11. I thank T. Gray and J. Winston of the National Oceanic and Atmospheric Administration for the scanning radiometer data (Fig. 2).
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Fuel Savings by Lowering Thermostats

In criticizing Federal Energy Office (FEO) estimates of the fuel savings that would result from lowering thermostats 6°F, Ferrar and Nelson (*1*) appear to have erred. Their double-log regression showed fuel demand about proportional to the square root of heating degree-days, as derived from averages of individual state statistics. This relationship should not be used to estimate degree-day effects within a region. A time series regression, against observed degree-days within a state or region, must be used, and it should yield almost direct proportionality. Conduction heat losses from residences are proportional to the difference in temperature between inside and outside. Radiant heat losses, proportional to the fourth power of absolute temperature, also turn out to be nearly directly proportional to this temperature difference for small absolute reference shifts of 3°K (6°F). Using Ferrar and Nelson's tabulated data, a revised calculation yields a fuel saving of 24 percent of 1973 estimated demand; that is, 1.7×10^{14} Btu, or 840,000 barrels per day, which is close to the FEO estimate (900,000 barrels per day) that they quoted.

Comparison of per capita consumption between two areas shows only that architectural and life styles change in response to the local climatology of degree-days. A resident of the South Atlantic region who moves to New England, where more than twice as many degree-days are encountered, would not double his fuel consumption, because his new home would be better insulated and designed against this severity. The square root effect would apply. But if a particularly cold winter in the South Atlantic area caused doubled degree-days to be recorded, his fuel consumption there would indeed be doubled in response.

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References

1. T. A. Ferrar and J. P. Nelson, *Science* **187**, 644 (1975).

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Reed questions the use of cross-sectional data to estimate relationships between per capita fuel demand and degree-days. He argues that a time series regression should be used and asserts, on the basis of a thermodynamic argument, that such a regression should yield almost direct proportionality between the daily demand for heating oil and the degree-day variable. We contend that the thermodynamic solution, while relevant on a day-to-day basis, is not appropriate for forecasting the impact of a season-long policy.

A time series elasticity of unity implies a constant short-run return to that input. It is unrealistic to expect this constant unitary elasticity to prevail for longer than an extremely brief interval within a social system. The purpose of our study was to determine what one could reasonably expect from a policy implemented for a major portion of the heating season, during which time other social and economic forces were effective. The thermodynamics of the situation, while centrally relevant to the demand for heating fuel, should not be interpreted as the overriding effect in assessing an aggregate system demand.

At present we know of no time series studies which would alter the conclusions reached in our report. Moreover, in a time series study by Strout (*1*) on heating fuels, a degree-day elasticity of 0.468 was established. Similarly, Miller (*2*), employing data from December 1973 to May 1974 and September 1974 to May 1975, obtained results substantially similar to those presented in our work.

In the fuel oil heating industry a degree-day elasticity of unity is widely used as a base point, but correction factors are regularly applied, not only for geographic regions (Reed's point) but also for seasonal combustion efficiency changes. In attempting to forecast demand over a heating season, one must make sure that these correction factors are taken into account. Similarly, it is common in the heating industry to calculate relationships between consumption and degree-days for commercial establishments on a building-by-building basis. Again, this industry behavior calls into question the reliability of a unitary elasticity for forecasts of a seasonal duration.

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References

1. A. M. Strout, *Rev. Econ. Stat.* **43**, 185 (May 1961).
2. K. D. Miller, unpublished results.