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in two distinct belts, one of them being in the cereal-producing mid-latitudes. The world could ill-afford diminishing productivity in its wheatfields!

Still Many Unknowns

What we need, surely, is a sound appraisal of the gains and losses that could result from a major increase in atmospheric CO_2. Several world organizations and many national institutions are attempting such an appraisal, but labour in an atmosphere that is made heated by absurd over- and under-statements of what may lie before us. In my own judgement, we are still some years away from any kind of decision as to the most desirable change in the direction of public policy: there are too many unknowns. Among the aspects that disturb me most are the following:

(i) Dire uncertainty as to the future course of fossil-fuel consumption. It is from burned coal, oil, and gas, that the extra CO_2 mainly comes. Only a few years ago it seemed reasonable to assume a continuing 4–5% per annum increase in such consumption. Now, after the rise in oil-prices, and in the midst of a slump, expectations of even 2% per annum growth seem excessive to some.

(ii) We are also quite unsure as to the magnitude of biomes' and soils' carbon losses to the atmosphere. Hence our estimates of future CO_2-levels in it are highly suspect, to say the least, and can constitute at best a very poor basis for prognostication of what may amount to a major fraction of the global equation.

(iii) The models which we used to predict the climatic response of rising CO_2 concentrations now seem inadequate. In spite of prodigious efforts, these models still do not properly simulate the so-called 'transient' effect—the delay in climatic response due to the heat-absorption capabilities of the intermediate waters of the oceans. Nor do they adequately model the geochemistry of the ocean at its floor, or the poleward heat-transports.

(iv) We cannot yet deal effectively with the possible changes in cloudiness and precipitation, especially as regards the latter's longitudinal distribution. Even if we did know accurately the future atmospheric CO_2-levels, we should have trouble in predicting their consequences for such aspects of climate.

(v) To an even greater extent than the consequences of climate, we should find it hazardous to predict the potential impact of future changes in CO_2-levels through their effects on the world's ecosystems, though there are some grounds for optimism. Most plants using the C-3 photosynthetic pathway—many crops and tree species, for example—seem to profit in growth and water-use efficiency from sharp increases in ambient CO_2-levels. But C-4 plants, such as maize and sugar-cane, are less affected. However, this is a judgement based on laboratory experiments: in the field, warmer-than-accustomed temperatures may induce more widespread disease, and/or more fire-damage in forests, than has normally been experienced. Moreover, the huge question of how complete ecosystems will respond has hardly been seriously broached.

None of the above considerations should seem strange to those who are close to the problem; indeed, most of them are already being actively pursued in internationally-coordinated ways. Obviously, one can visualize potential changes; but one can also see opportunities. Certainly, pessimism is not a duty for the environmentalist!

Some Opportunities

One attractive set of opportunities are those that I mentioned first: there may be major gains in agriculture, transportation, and energy consumption. I see more of these gains than I see threats, though I do not discount the dangers.

Another opportunity is the huge challenge that this operation presents to the environmental scientist. It absolutely demands the cooperation of physical scientists, studying the ocean and atmosphere, with the biologists who look at ecosystems (of which, after all, the ambient climate is a part). It demands, too, that behavioural and social scientists think out the possible consequences for mankind. And it demands that statesmen—an appellation now too little heard—should rise to the challenge wherever political measures are needed to redress imbalances and meet unwelcome change.

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National Characteristics and the Establishment of National Parks in Sub-Saharan Africa

National parks and equivalent reserves are important conservation tools, but the proclivity of nations to establish them varies considerably. Such variation may be explained, at least in part, by the variation in social and physical conditions among countries, though this fundamental proposition has received little research attention. Wilkinson (1978) explored the relationship of national park establishment with socio-economic variables for 127 nations. Although significant relationships were discovered, he reported confusing findings, including the contradictory implication that park area *per caput* is related to increased industrialization and decreased energy consumption. This finding could have resulted if the nations studied included two or more groups undergoing opposing processes. Under these circumstances, greater insight might be achieved by applying Wilkinson's techniques to a smaller group of nations possessing greater regional similarity.

To accomplish this we have conducted step-wise multiple regression analyses relating 26 independent socio-economic and physical variables to national parks and reserves established (IUCN, 1980) in 33 sub-Saharan African nations. Three independent variables were used: Total national park/reserve area per country (TParks), national park/reserve area as a percentage of national area (PParks), and national park/reserve area *per caput*

of human population (ParksPC). A summary of the most important predictors which were entered in the models is presented in Table I.

Implications

Residuals—cases demonstrating great differences between the actual and predicted values of the dependent variable in one or more of the models—include Zambia, Benin, Botswana, and Lesotho. This calls attention to these countries and suggests them as possible subjects for further investigation. Yet the small number of residuals, and the lack of discernible spatial and statistical pattern, reveal no subregion of sub-Saharan Africa as warranting separate investigation.

Use of variables that are descriptive of the physical environment is somewhat unusual in quantitative modelling of development processes, but is justifiable in this case. The physical variables which were included, certainly interacted with both dependent variables and other independent variables—but in ways that render their interpretation most difficult. Taken together, they at best suggest that national parks are more prevalent in countries where the environment is more amenable to grasslands—including savanna—and to large grazing species than elsewhere. Though difficult to interpret, the mere emergence of these variables implies that closer scrutiny of the physical setting of sub-Saharan national parks may reveal much about their use as a conservation tool. The place of the physical variables in the models also brings additional attention to a recurring conservation question: are national parks and reserves appropriately balanced across biome types?

The positive relationship of population density of PParks is surprising, and a seeming contradiction to the negative relation in the TParks model. As a greater percentage of the total population located in the largest city of a nation also enters the PPark model positively, it may be that those countries with greater centrality have a sufficiently low rural population-density to permit devotion of a relatively higher proportion of the nation's area to national parks. A high urban population may cause a country's total population density to appear high, though the rural population-density will often, in fact, be low. Greater centrality, and perhaps urban crowding, may also contribute to a social psychology that is conducive to environmental conservation.

The ParksPC model is somewhat disturbing. Its level of explanation is essentially the same as that for PParks, but the model is more complicated. Wilkinson's worldwide *per caput* model, however, has a higher r-squared value with fewer variables included. The lack of complete data for African nations, or a suitable means to estimate missing values for the variables used by Wilkinson (1978), may have been important in the lower r-squared and more complicated nature of our model. However, it may be that African parks, with their strong resource-bases, are much less likely to be adjusted to some degree of equality of parkland per person than are parks in the world overall.

The importance of history to the understanding of national parks in sub-Saharan Africa is evident in the models. The longer a nation has been associated with the management of at least one national park, the greater are the chances that the experience will have led to the creation of other parks.* Further, the different imperial powers which most recently dominated areas that have become modern African nations, have left their marks as attitudes or procedures which have influenced the course of national park establishment. Understanding conditions leading to the use of national parks in sub-Saharan Africa may require laborious and detailed individual national investigations of the history of national parks— a type of study that is now widely available in the developed world, particularly in the USA, but is rare and inadequate for the Third World generally, and in sub-Saharan Africa specifically.

Table I. *National Parks of Sub-Saharan Africa: Three Models.*

TParks	= 1.3459 + (0.0428) YrsPark + (0.3694) Tractors – (1.2886) Fr – (0.0389) PopDen + (4.0714) Bel + (0.0404) Pop80 r^2 = 0.79
PParks	= –0.2159 + (0.0837) YrsPark + (0.0121) PopDen – (0.0004) HighEl + (0.1742) LgstCity + (1.4196) Brit – (0.0023) WmPrecip r^2 = 0.64
ParksPC	= –3.7012 + (0.0312) Assist – (0.1427) CoolTemp + (0.2000) WarmTemp + (0.0424) LifeEx – (0.6003) Fr – (0.0124) PMP – (0.0344) ParWater r^2 = 0.64

Definition of Variables:

Assist: Average annual foreign assistance, 1975–77.
Bel: Formerly under Belgian rule.
Brit: Formerly under British rule.
CoolTemp: Average temperature in coolest month, capital city.
Fr: Formerly under French rule.
HighEl: Highest elevation in the country.
LgstCity: Percentage of national population in the largest city.
LifeEx: Life expectancy at birth, 1978.
ParksPC: Park area *per caput*, 1980.
ParWater: Percentage of area under inland water-bodies.
PMP: Percentage of area in permanent meadows and pastures.
PopDen: Persons per square kilometre, 1980.
Pop80: Population, 1980.
PParks: Percentage area in parks, 1980.
TParks: Total park area, 1980.
Tractors: Tractors in use per 1,000 population, 1977.
WarmTemp: Average temperature in warmest month, capital city.
WmPrecip: Average precipitation in wettest months, capital city.
YrsPark: Years since establishment of the first national park.

* This seems to us particularly gratifying to note. Ed.