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IPCC WORKING GROUP III
RESOURCE USE AND MANAGEMENT SUBGROUP

GENEVA, 30 OCTOBER - 1 NOVEMBER 1989

IPCC/WG3/RUMS/Doc. 1

(19.IX.1989)
ENGLISH ONLY

UNMANAGED ECOSYSTEMS - BIOLOGICAL DIVERSITY: ADAPTIVE RESPONSES TO CLIMATE CHANGE

(Submitted by the co-chairmen of the Resource Use and Management Subgroup of IPCC Working Group III)

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WASHINGTON, D.C. 20240

SEP 13 1989

Dear Colleague:

Attached is a working paper produced for the Resource Use and Management Subgroup of the Intergovernmental Panel on Climate Change's Response Strategy Work Group identifying various measures for adapting to the effects of climate change on natural ecosystems which focusses on biodiversity.

Similar to other papers, this does not address each measure's cost and effectiveness; its social, environmental and economic consequences; the legal and institutional hurdles to its adoption or methods to reduce these hurdles. Nevertheless, the measures identified in this draft paper seem reasonable options for further evaluation in the context of the U.S. Your comments -- especially on whether these options are suitable for evaluation in the context of other nations -- would be invaluable. I expect you would bring your comments to the scheduled October 30 - November 1 workshop in Geneva.

I may be contacted at the Department of the Interior, Mail Stop 4412, 18th and C Streets, NW, Washington, DC 20240 (telephone (202) 343-4951; fax (202) 343-4867).

Sincerely,

Indur M Goklany

Indur M. Goklany
Executive Director,
Departmental Working Group
on Climate Change

Attachment

UNMANAGED ECOSYSTEMS—BIOLOGICAL DIVERSITY: ADAPTIVE RESPONSES TO CLIMATE CHANGE

Working Paper
Prepared for the
Resource Use and Management SubGroup of
Working Group 3 of the
Intergovernmental Panel on Climate Change

Contents:

September 12, 1989

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Introduction

1. Climate change has the potential to significantly affect the world's biological diversity by: (a) altering the geographical extent of various habitats and ecosystems, (b) modifying the species composition *of* habitats and ecosystems, and (c) causing changes in the population sizes and distributions to species, leading in some cases to the extinction of species.

2. Generally, in terrestrial and coastal environments, global warming could result in regions of suitable climate. for given species shifting toward the poles and toward higher elevations. However, in practice, the pattern of change in the location of suitable climatic conditions for given species may be far more complex. Changes in patterns of precipitation, evaporation, and wind; and in the frequency of storms, tire, and other disturbances may have local and regional influences on the location and suitability of habitats following any change in climate. In addition, the ecological amplitude of various species will influence the extent to which they are affected by shifts in climate regime. Marine environments are expected to experience broadly similar changes to those found on land and in coastal area. The impact of these changes on species diversity and on the composition, distribution, and extent of habitats and ecosystem would depend upon the magnitude and rate *of* climate change on the effect *of* higher $C0_2$ concentrations on vegetation and on the capacity of species to respond to these changes through dispersal, colonization and, particularly in the case *of* corals, growth. Ecosystems are not cohesive assemblages of species that will "migrate" as a unit in response to climate change. Instead the species present in plant and animal communities will likely dissociate as a result of differences in thermal tolerance, habitat requirements, and dispersal and colonization abilities. They will then redistribute according to new environmental parameters to compose new communities under the new climatic conditions, though some communities will remain as relics.

3. In the temperate zone, if the magnitude of warming and, in particular, the rate of climate change approach the National

Academy of Science's (NAS) 1987 estimate[1], impacts on biodiversity might be severe. Under rapid climate change, the rate of the poleward shift in suitable habitat might significantly exceed natural dispersal rates. In tropical regions, differences in temperature and precipitation may not be as large, but potential changes in the seasonal timing *of* rainfall or in the frequency or intensity of disturbance (i.e., hurricane or fire frequency) could affect the species composition of tropical ecosystems. Rapid sea level rise may decrease coastal wetland habitat and may exceed the growth rate of corals, leading to loss or diminishment of many coral ecosystems.

4. This added threat of the impact of climate change on biological diversity could compound the existing problem of biotic impoverishment. Without an impact from climate change, in the next half century we could witness the extinction of relatively large fractions *of* the world's species, largely due to the size of tropical forest habitat. Furthermore, over the last century, many critical habitats, such as coastal wetlands, have already been degraded or significantly reduced in size throughout the world.

5. Two factors influence the capacity of species to shift their ranges in response to changes in suitable climatic regimes are 1) the ability of species to disperse to areas with suitable climate and 2) the availability of suitable habitat in those areas. As noted above (paragraph 3), a rapid rate of change in climate may exceed the dispersal and colonization capacities of many species. Dispersal may be further hindered by human land-use practices that have fragmented existing habitats. Much *of* the world's species diversity is contained in relatively small habitat patches (in both protected and unprotected areas) surrounded by agricultural or urban landscapes that impede the dispersal *of* most species.

6. In many cases even when species have the capacity to disperse to new sites suitable habitat may not be available due to either natural circumstance. (i.e., warming may lead to the loss *of* alpine habitats from many mountains), or human land-use practices. For example, the use of levees, dikes, and sea-walls to protect coastal development decreases the area that would potentially be available f*or* coastal wetland habitat as sea level rises. Although transportation corridors and landscape edges aid in the dispersal of many species, the presence of farms, roads, and settlements may hinder the migration of many terrestrial species to suitable habitats.

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[1] The 1987 NAS report, Current Issues in Atmospheric Change, concluded that a doubling in atmospheric $C0_2$ would most likely result in a 1.5-4.5^o C increase in global temperature.

7. Increased extinction rates could result in the loss of species of known value, the loss at species of potential future value, and the degradation of various ecosystem services that may occur when component species are lost. The potential loss at wild relatives of agricultural species could be particularly costly as these species may possess invaluable genes needed for efforts to breed varieties capable of growing under new climatic conditions. Many of these agricultural species are currently being cataloged and maintained in germplasm collections. Also required is adequate recording of the indigenous technologies for maintaining the wild roots of the world's food species.

8. Changes in the distribution and extent of various habitats and ecosystems could also entail costs in the form of lost services or in the provision *of* substitutes for those services. For example, the loss of coastal wetland habitat will mean the loss *of* its valuable services as a fish rearing habitat, a pollution tilter, and a source of nutrients for coastal ecosystems.

9. With competing financial and land-use demands that will result under conditions of global warming, the human response to the loss of biological diversity could be *tar* less than required to prevent significant biotic impoverishment. Overall response strategies to mitigate the impact of global warming can be expected to focus on the necessity of meeting immediate human needs in such sectors as agriculture, forestry, water resources, and protection of coastal development. Although the technical expertise is adequate, it is unlikely that financial resources will be available to undertake ecosystem restoration projects on a scale that could mitigate many of the potential impacts on biodiversity. Unless agriculture, forestry, animal husbandry, and human settlements become less land intensive, it is also unlikely that developed land will be converted into natural or semi-natural landscape., despite the benefits that may be entailed from conserving biological diversity. In comparison to the potential for responding to impacts in other sector, such as agriculture, the potential for mitigating the impact. of climate change on biological diversity is likely to be minimal (see 13, below).

10. Given these considerations, evaluations of response to slow the rate and magnitude *of* the change in climate must consider the potential impacts on biodiversity. In this regard, strategies chosen to slow the rate of climate change should also seek opportunities to mitigate the effects of climate change on biodiversity. For example, agro forestry schemes that increase C02 uptake may lessen the impact of climate change on biological diversity by lessening; people.' demands for wood and land from natural forests. This could be done through the provision *of* an alternative source of fuel wood, and through increased agricultural productivity. On the other hand, as noted below (in 14), certain

strategies adopted to prevent or slow qloba1 warming could, in tact, be detrimental to the conservation of biodiversity.

Response Strategies

11. **Enhance Ongoing Biodiversity Conservation Efforts.** Uncertainty rewarding the specific effects of global climate change on biodiversity will persist. Consequently, policies must embrace the uncertainty involved in such a manner that they will either yield no net cost or will result in benefits under any probable scenario of climate change and ecosystem response. Many biodiversity conservation policies that would be desirable under conditions of greenhouse warming would be advantageous under any circumstances. Policies designed to address the need for the long-term conservation of biodiversity must increase the ability of species to withstand both natural and human-caused perturbations. To meet thes8 objectives, populations must be maintained at sufficiently high levels, and opportunities for dispersal and colonization must be present or enhanced via human intervention in order for species to respond to changes in their environment, including natural climatic changes. Thus, protected areas large enough to maintain sizable populations of species corridors linking protected areas in order to increase effective population sizes and provide dispersal routes; policies designed to provide benefits of protected areas to people in surrounding lands; and so forth may make sense even in the absence of the forecasted climate change. The ongoing strategies that should be considered under any circumstances include:

Technologies

a) **Strengthen and enlarge protected areas.** Large areas of natural or semi-natural habitat will be better able to maintain viable populations of certain species. In many cases the most pressing need for protected areas involves the strengthening of the existing area through the provision of greater financial or managerial support. Protected area enlargement would be beneficial for the maintenance of biodiversity under any circumstances but, where possible, enlargement of protected areas with poleward or up-slope additions will be particularly beneficial under conditions of a warmer climate, especially in ecotone regions. However, the benefits of enlargement must be balanced against the expense and other societal goals.

b) **Provide local communities on economic stake in protected areas.** Establishing and/or enlarging protected areas i8 not a panacea. This is especially true in the developing world where immediate needs override long-term concerns. Local communities need to have an economic stake in protected areas, species protection, and sustainable management in order for conservation efforts to be successful. This may involve providing employment in staffing and managing protected areas providing services for tourists, or allowing a sustainable harvest of forest, fiber, and toddler products in some areas.

c) **Establish conservation corridors between protected areas.** Conservation corridors serve to increase the size of protected areas and thus increase the effective population size of the species involved. In addition, corridors could enhance the capacity for species to shift ranges along temperature and moisture regime. in response to climatic change. However, corridor establishment should be weighed against the purchase costs and foregone uses of land.

d) **Enhance <u>ex situ</u> capacity.** Whether used as a temporary "refuge" f*or* species extinct in the wild, or as a permanent conservation tool when wild habitat is lost, <u>ex situ</u> conservation (that is, maintenance of species in zoos, botanical gardens, seed banks and through other means of "off-site" storage) will become increasingly important with the added pressures of climate change. There is a need to substantially increase the capacity of zoos, botanical gardens, and germplasm banks. Such an increase in capacity will involve both the expansion or addition of facilities and research into storage techniques for species that can not currently be maintained <u>ex situ.</u>

<u>Ex situ</u> conservation is one of the few technological tools available for response strategies, but for several reasons it will only be capable of addressing a small portion of the need for species conservation under probable scenarios of climate change. Specifically, (a) It deals only with the maintenance of species and not with their role in ecosystems: (b) there is a relatively limited capacity for wild species in <u>ex situ</u> facilities for economic reasons; (c) for many species, technologies are not yet available for their maintenance <u>ex situ;</u> and, (d) <u>ex situ</u> conservation (such as seed/germplasm banks) removes species from natural evolutionary processes, thereby reducing their value as a source of genetic information (e.g., a wild crop relative will not continue to evolve resistance to its pest. when removed from their selective pressure), and reducing the likelihood of survival if suitable habitat becomes available *for* reintroduction. The most important role of <u>ex situ</u> conservation may be as an intermediary step for species that are threatened in their natural habitat and not yet able to colonize habitat in more suitable regions.

e) **Reduce other demands on land by increasing productivity of agriculture, animal husbandry, agro forestry, etc.**
One alternative to land purchase for the maintenance of natural and semi-natural land would be to reduce the

requirements for land and water use which compete with natural ecosystems. Worldwide, these include agriculture, grazing, the quest for fuelwood, and the expansion of human settlements. Dealing with these would also directly address many of the present causes of deforestation and loss of biodiversity. Such measures could include: (i) making agriculture, forestry and animal husbandry more efficient in term. of land and water use, e.g., by focusing research on developing appropriate new cultivars; (ii) reducing subsidies for agriculture, forestry and grazing; and (iii) planning development such that it minimizes impacts on biodiversity, maintains potential pathways for migration and encourages maximum intensity of land use consistent with environmental quality standards. (Goklany 1988).

f) **Increase research on conservation of biological diversity.** Current biodiversity conservation efforts are seriously hindered by the lack of knowledge of the basic identity and ecology of some of the world's species and by a lack of understanding of the requirements for maintaining small populations of species in fragmented natural habitats. Thus, under any future climate scenario, key research for the conservation of biodiversity includes:

i) increased research into species taxonomy, distribution, and habitat requirements

ii) increased research in conservation biology

iii) increased research in establishing an economic stake in conservation.

12. **Increase Flexibility of Land-use.** If global climate change occurs, many plant and animal species distributions will have to shift. Allowance for such shifts is not built into current systems of land-use and land tenure. For example, if upland sites are not available for colonization by wetland species following sea level rise the potential effects of global warming on coastal wetlands could b. exacerbated. Thus, it may be desirable to establish the boundaries of certain coastal protected areas using sea level as a reference in order to ensure that critical wetland habitat will remain available as sea level rises. However, the establishment at new forests or other plant and animal communities as the global climate change must also reconcile issues regarding changes in ownership of the land in question-- such a. fair and equitable compensation, and the best and highest socially desirable use of the lands in question. Policies could be explored whereby the options for the conversion of land to a natural state (e.g., on the coast) may be maintained should should conversion be deemed desirable.

13. **Develop New Technologies Suitable for Responding to the Impacts of Global Warming.** Where natural processes and changes in land management are insufficient to provide the desired response to the impacts of climate change on biodiversity, strategies to be considered include: (a) the temporary or permanent use of ex situ conservation techniques (see 11); and, (b) the use of community restoration and development techniques; specifically, the introduction of species unable to colonize new regions naturally, possibly including the approximate re-creation of entire ecosystems in areas of suitable climate. Such technologies should be explored and developed, and institutional mechanism. explored and devised to allow their effective use.

While some examples of successful development of habitat do exist, community restoration and/or development face substantial practical difficulties if they are to be undertaken on any large scale (multi-species or community scale). Apart from the expense involved, which 1s likely to be substantial, community restoration and development are hindered by the following factors. First, because ecosystems will not shift as cohesive units in response to climate change, it will only be possible to predict species composition of ecosystems following climate change in the most general terms. Second, while knowledge of community ecology can provide general guidelines for ecological restoration, the influence of many of the key factors influencing community composition, such as the nature *of* species interactions and soil chemistry, are highly site- and species-specific, and will be difficult to evaluate prior to actual attempts to establish a "new" community. Finally, the age-structure of populations in a newly created community may prevent the early establishment of many species (i.e., some species cannot be established in a newly established forest due to a dependence on more climax vegetation).

Essential research to enhance the capabilities of restoration ecology in response to climatic change includes:

a) **Effects.** Research into the patterns of species distribution expected at various times in the future under various success ional stages and with soil regimes that evolved under different moisture and temperature regimes.
b) **Colonization Capacity.** Research into the rates of natural colonization and dispersal, the ability of poleward ecotypes to persist/recruit under conditions found in more equatorial portion of the range, barriers to dispersal and colonization, etc.
c) **Human Intervention.** Research into techniques for the recreation of communities and habitats, with particular emphasis on species interactions and soil physics,

chemistry, and origin. Research into the costs involved in approaches involving direct intervention.

Institutional arrangements may be required that could promote and perform both anticipatory and reactive human intervention in patterns *of* dispersal, and colonization. For example, inter-agency and international working groups could be established to evaluate and promote response strategies dealing with land management. Because of the uncertainty involved in both climate change and ecolO9ical response, the role of anticipatory response activities (i.e. the establishment of forest. poleward of the current species distribution) may be severely limited, and most activities will probably be reactive. This again places a premium on mitigating global climate change and on developing institutional and policy structure. that grant maximal flexibility in land-use designation and management consistent with considerations *of* net social, environmental and economic consequences (paragraph 12, above).

14. **Avoid Response Strategies Detrimental to Biodiversity.** Many of the potential strategies available to either slow the rate of climate change or mitigate its impacts could be potentially hurtful to the conservation of the world's biological diversity. For example, the carbon sequestering role ft forests may be enhanced by replacing natural forests with plantations of fast-growing trees. Such a response may slow the rate of climate change, but at a significant cost in terms of the loss of biological diversity. Similarly, the construction of sea walls and levees to protect coastal development will decrease the area available for coastal wetland habitat. The effect of response strategies on biological diversity must be considered in the evaluation of the social, environmental and economic consequences prior to any decisions regarding their suitability in a particular context.

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