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PROBLEMS IN ASSESSMENT

J. D. Longstreth

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Pacific Northwest Laboratory
Richland, Washington 99352

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Health Effects of Global Warming: Problems in Assessment

Janice Longstreth
Pacific Northwest Laboratory*
901 D Street, SW, Suite 900
Washington, DC 20024

ABSTRACT

Global warming is likely to result in a variety of environmental effects ranging from impacts on species diversity, changes in population size in flora and fauna, increases in sea level and possible impacts on the primary productivity of the sea. Potential impacts on human health and welfare have included possible increases in heat related mortality, changes in the distribution of disease vectors, and possible impacts on respiratory diseases including hayfever and asthma. Most of the focus thus far is on effects which are directly related to increases in temperature, e.g., heat stress or perhaps one step removed, e.g., changes in vector distribution. Some of the more severe impacts are likely to be much less direct, e.g., increases in migration due to agricultural failure following prolonged droughts. This paper discusses two possible approaches to the study of these less-direct impacts of global warming and presents information from on-going research using each of these approaches.

INTRODUCTION

As a health scientist interested in the risk assessment of global environmental change, I often feel a bit like the Connecticut Yankee in King Arthur's court; the "real" wizards think your ideas are crazy, while you know that you are just ahead of your time. I continue to persist in my foolish interest in this subject, content to point out that the only way to make progress from one paradigm to another is to challenge the accepted scheme of things. Not surprisingly, the constant feeling of Sisyphus pushing a large rock uphill is now quite familiar. I hope to use this opportunity to persuade you that scepticism is not the appropriate way to view the likely impacts of global warming on human health but rather that what health scientists face are problems in assessment brought about by the fact that the end-point which they study is a complex one which may be impacted by climatic change in myriad ways.

Clearly, it is likely to be easier to ameliorate the impacts of global warming on humans than the other fauna (or the flora) which inhabit the ecosphere; nevertheless, the complexity of human interactions with their environment is such that I believe that it is specious to conclude that human populations are at little or no risk from the changes which are likely to occur. However, predicting the potential risks is highly problematic in that the causative pathways will probably not show direct links to changes in climate. Indeed, if we categorize the potential impacts of global warming into primary, secondary and tertiary**, then current information

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**Primary effects are those directly related to changes in weather, e. g., heat stress; secondary effects are those one step removed from a direct effect. e.g., climate change results in crop failures leading to death from starvation; tertiary effects are two steps removed, e.g., climate change results in crop failures resulting in malnutrition which in turn leads to increased

indicates that the effects humans are likely to encounter are heavily weighted towards the those which are less direct.(1) Of course the ability to predict effects varies inversely with the directness of their relationship to weather so that it is very difficult to determine what proportion of an adverse indirect effect should be attributed to climate change and what should be attributed to other factors.

I believe that one can attack this problem in two ways. The first is to take a high-level, "top-down" or systems approach and evaluate the impacts of climate change on the system of human health and welfare. The second is a "bottom up" approach by starting with an end-point and tracking it back to changes in climate via an analog study or possibly a targeted investigation. This discussion presents an overview of the work we have done to date to explore the health (and welfare) impacts of global warming using each of these approaches. The top-down approach is demonstrated through a fairly detailed account of the work we are doing to develop a health and welfare model predicated on effects on children. For the bottom up approach, preliminary information is presented on an analog study currently underway to explore the relationship between human migration and environmental change in the form of drought.

Top Down Approach: Child Health and Welfare Index (CHWI)

The goal in developing the child health and welfare index was to craft a model which could be used to assess (rank) the health and welfare status of nations both under current conditions and the changing conditions associated with global warming. The ulterior motive for developing this index was to ensure that health and welfare information is included in the information being used by decision makers to evaluate the potential impacts of global warming and the likely policy options for responding to this threat. The approach taken comprised the following three steps:

Step 1: Develop a simple index composed of a series of potential indicators of child health and welfare which could be used to develop a base-case ranking of nations using current data. We have called this the Child Health and Welfare Index (CHWI).

Step 2: Link elements of the CHWI to the outputs of an econometric model being developed to help identify and evaluate policy options available for coping with the likely impacts of global climate change. The econometric model is the second generation of the Edmonds-Reilly model, also known as the SGM.

Step 3: Evaluate changes in the world index associated with changes in the SGM.

The focus on children was occasioned by our belief that children are the most susceptible sub-population; if children are not impacted by global change, it is unlikely that other age groups will be. This choice also limited the number of data elements which needed to be considered.

The first step in the development of this model was to identify candidate data. We drew heavily on information from the World Resources Institute, UNICEF, and the World Bank. We investigated the literature to discover if anything similar to this had been done, and found two metrics used by the development community, a United Nations Development Programme

susceptibility to disease.

(UNDP) metric and one from the World Bank, both of which were trying to create a better metric than GNP to reflect a nation's status in providing for its people and environment.

The focus on children led to consideration of a number of data elements related to mortality, education, nutrition and access to clean water and health care. The current CHWI is composed of the following 9 elements:

- Adult Female Literacy
- Percent of Age Group Enrolled in Primary Education
- Infant Mortality
- 1- to 5-Year-Old Mortality
- Maternal Mortality
- Low Birth Weight
- Daily Protein Available
- Access to Health Care
- Access to Safe Care

The data were normalized to the best value for each element using the following calculation:

$$V(M_1)_j = \frac{[HighestM_1 - (M_1)_j]}{HighestM_1 - LowestM_1} \quad (1)$$

The CHWI is calculated for each country, j , using the following simple equation:

$$CHWI_j = [(W1 \times IM1_j) + \dots + (W9 \times IM9_j)] / 9 \quad (2)$$

where

W1-W9 are the weights of each measure, all currently held at one.

In a number of instances, values for certain data elements were missing for some countries. In such cases, countries were divided into quartiles based on gross national product (GNP), and the mean value of the missing data element for that quartile was used to develop the intermediate value described above. This allowed us to calculate the index for 156 countries. Figure 1 presents the distribution of CHWI scores for these countries. The ten best and the ten worst in this ranking are presented in Table 1. These CHWI scores represent the base case for the health and welfare status of these nations.

In the second step of this process, we intend to link the inputs of CHWI to the outputs of the SGM. In order to do that we need to explore what linkages make sense empirically. Since the only module of the SGM that is currently populated with data is that for the US, and since we needed to explore the robustness of any relationships we develop, we decided that rather than exploring these connections over several regions, we would explore the connections temporally with US data. That led us to evaluate CHWI in the United States (US) over time using data from 1920 to 1990. Data for two of the data elements, access to drinking water and access to health care were not available over that time span, so we excluded these elements from the USCHWI and calculated changes in USCHWI over time based on the other 7 data elements. Currently the data are normalized to the best US value, which is generally the most recent information. After giving this some more thought, we have decided instead to normalize to the best world value or an idealized value, e.g., 100% for adult female literacy. Using the current normalization process, the change in the USCHWI with time is shown in Figure 2.

Note that the USCHWI goes up steadily with time with a more marked increase during the period of World War II. In reviewing the inputs of the various components, one appeared to be the major contributor to this finding as shown in Figure 3. Although the finding that female literacy has a significant impact on child health and welfare makes intuitive sense, this observation probably indicates that the index is reasonably sensitive to modifications in any of its parameters. These and other issues will be explored using sensitivity analysis and several other forms of exploratory data analysis. Current plans to continue include 1) an evaluation of weighting schemes in order to possibly compensate for the fact that some of the elements are strongly correlated with one another and thus may represent the same information, 2) evaluation of the female literacy element, particularly around WWII because of the concern that the observed sharp change may be an artifact of the assessment method rather than a real shift in status, and, 3) evaluation of connections to the econometric model, focusing first on the agricultural output portion and how it may link to the protein parameter.

Bottom-up Approach: Analog Study of Migration and Droughts in the Midwest

The bottom-up approach focuses on a particular effect and evaluates the linkages between this effect and primary impacts of climate change, e.g., changes in weather patterns, tracking the relationship back up the chain of events. This work is just beginning; we have decided to investigate the connection between droughts and human migration, using the events of the Dustbowl era in the US Great Plains as a possible analog for current events in Mexico. Migration was targeted as a critical issue in global climate change because it represents a sizeable human impact, not only in the disruption of the lives for those who emigrate but also on the populations of those lands where immigration has occurred. In the US and in Europe, social support systems are already being stressed by flows of people driven out by changes in their environment such as desertification; these populations have been given the title "environmental refugees." (2) Sea level rise will undoubtedly displace additional populations, and additional crop failures, arising as the result of the added climate stress due to global warming, are also likely to have an impact. However, analysis of the impact of global climate change on migration is highly problematic; not only is migration a tertiary effect of climate change, but it is also an ongoing phenomenon with root causes (absent global climate change) which are highly complex. Thus, we may be searching for the proverbial "straw that breaks the camel's back" by looking for it in haystack. Nevertheless, this issue appeared to be a good one to test the bottom-up approach.

The objectives of this study are to: 1) develop a tool with which to explore the connection between ecosystem changes and modifications to human health or welfare; 2) Understand better the links between global environmental change and migration; 3) Evaluate options for intervention; and 4) Develop policy options for responding to the associated impacts. Our approach to this project involves first evaluating the drought-driven migration out of the US Great Plains during a series of droughts between 1890 and 1980, looking at the change in migration over time and the concomitant changes in US farm policy. At the same time the current situation in Mexico will be evaluated, identifying what factors are driving migration. The basic premise of this investigation, which needs to be examined in more detail, is that much of what is driving emigration from Mexico to the US is loss of jobs in the Mexican agricultural sector. If this is true, then by exploring the link between drought, current Mexican agricultural policy and migration into the US we can also evaluate whether targeted aid to Mexico which modifies the current agricultural policy might be an instrument by which to reduce the flow of immigrants across the border.

Currently gathering time trend data are being gathered for both Mexico and the US in four areas: climatic/ agricultural factors, e.g., duration and severity of droughts, loss of productivity; economic factors, e.g., number of farm foreclosures; governmental activities, e.g., loan programs, irrigation development; and, demographic factors, e.g., population size, percent of the population in farming, source of immigrants. In the process of gathering this information, a number of issues have surfaced which will need to be dealt with in any final conclusions. These include significant differences in the structure of the agricultural system between the US Great Plains of the "Dust Bowl" era, and Mexico in the last 30 years, the passage in the US of the Immigration Reform Control Act of 1987 (IRCA), and the heavy use of "guest workers" by the US agricultural system. The information thus far gathered suggests that this approach shows promise, despite the complexities involved.

Conclusions

We believe that both of these approaches are useful tools in the exploration of the likely implications of global climate change for human health and welfare. The top-down approach has progressed further; it is being developed in parallel with a major econometric modeling effort in order to bring human health and welfare impact information to the policy makers along with economic impact information. It is, however, designed to produce very high level, big picture information which needs to be supplemented with the more detailed, highly focused information which can come out of a bottom-up approach.

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Table 1: The Best and the Worst of CHWI

BEST	WORST
Iceland	Mali
France	Afganistan
Spain	Somalia
New Zealand	Ethiopia
Ireland	Guinea
GerDemRep	SierraLeone
Italy	Bhutan
Greece	Guinea-Bissa
Canada	Niger
Switzerland	Mozambique

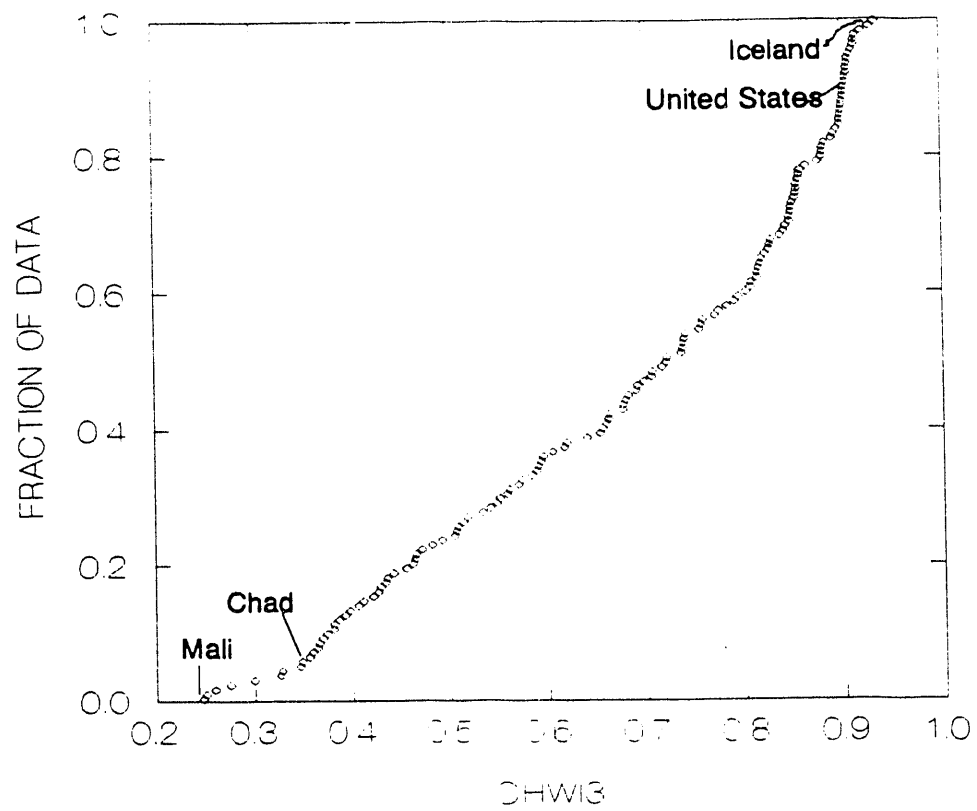


Figure 1 Child Health and Welfare Index

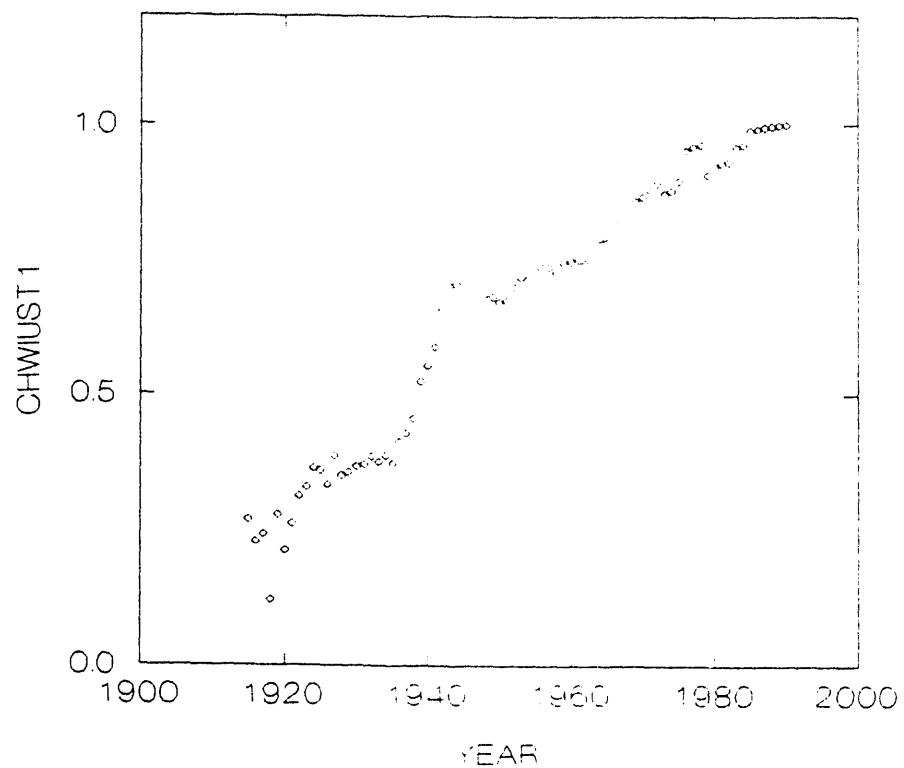


Figure 2 Temporal Variation in CHWI for the US, 1920-1990

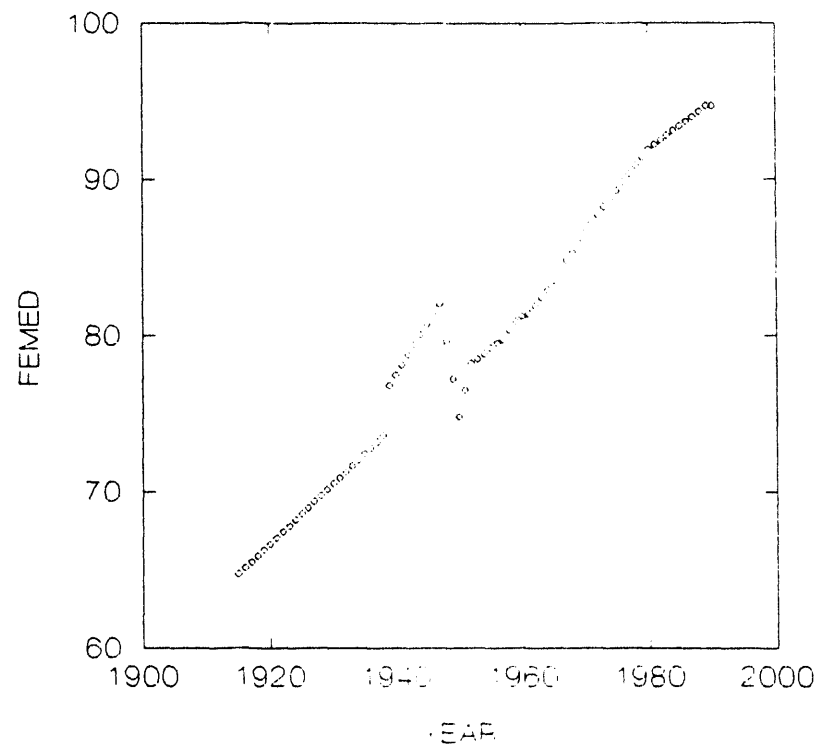


Figure 3 Temporal Variation in Female Literacy in the US, 1920-1990

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