CARIBBEAN FOOD CROPS SOCIETY

47

Forty-Seventh
Annual Meeting 2011

Bridgetown, Barbados
Volume XLVII – Number 1
T-STAR Invasive Species Symposium

PROCEEDINGS
OF THE
47th ANNUAL MEETING

Caribbean Food Crops Society
47th Annual Meeting
July 3–8, 2011

Lloyd Erskine Sandiford Centre
Bridgetown, Barbados

"Assuring Caribbean food and nutrition security in the context of climate change"

United States Department of Agriculture,
T-STAR Sponsored Invasive Species Symposium

Toward a Collective Safeguarding System for the Greater Caribbean Region:
Assessing Accomplishments since the first Symposium in Grenada (2003)
and Coping with Current Threats to the Region

Special Symposium Edition
Edited by
Edward A. Evans, Carlton G. Davis, and Fredy Ballen

Published by the Caribbean Food Crops Society

ISSN 95-07-0410

Copies of this publication may be received from:

Secretariat, CFCS
c/o University of the Virgin Islands
USVI Cooperative Extension Service
Route 02, Box 10,000
Kingshill, St. Croix
US Virgin Islands 00850

Or from

CFCS Treasurer
P.O. Box 506
Isabella, Puerto Rico 00663

OPENING ADDRESS: DOUBLE JEOPARDY—CLIMATE CHANGE AND INVASIVE SPECIES

Ray Huffaker, Chair, Food and Resource Economics Department, University of Florida, PO Box 110240, Gainesville, FL 32611 USA. Telephone: 352-392-1826 x204; Email: rhuffaker@ufl.edu.

INTRODUCTION

The negative impacts of climate change on global water resources, agriculture, land resources, biodiversity, and ecosystem services are well known (e.g., temperature increases, increasing carbon dioxide levels, and altered patterns of precipitation). Lesser publicized is how climate change reinforces another key transformational driver: invasive species. The interactive dynamics of both drivers greatly magnify the devastating impacts of each on ecosystem services essential to human life and productive activities. This paper discusses how the academic literature has conceptualized the relationship between climate change and invasive species.

A BROAD CONCEPTUAL FRAMEWORK

The literature links climate change and invasive species with the concept of a bioclimatic envelope. Burgiel and Muir (2010: 6-7) define the bioclimatic envelope as "the particular set of ecological and climatic conditions or parameters necessary for a species' survival…the range of suitable habitats," and conclude that "it is therefore necessary to look at the full suite of variables relevant to a particular species' bioclimatic envelope, as well as its broader symbiotic relationships and trophic webs."

Figure 1 depicts the bioclimatic envelope within this broad context. There are three major interrelated drivers: climate, humans, and ecosystems. In the upper portion of Figure 1, ecosystem provides services essential for human life and productive activities, and feedback from these activities impacts the quality of ecosystem services. Climate provides essential resources sustaining ecosystem productivity, especially water and viable temperatures, and ecosystem provides services mitigating negative climate shifts, including carbon sequestration. In the lower portion of Figure 1, climate determines the scope of human activities; while humans can affect climate through activities increasing global warming.

Figure 1 depicts the ecosystem dynamics regulating interspecies interactions (i.e., symbiotic relationships and trophic webs) with a conventional generalized Lotka-Volterra model. In this example, there are two interacting species, X_t and Y_t, where t represents time. The population of each species (X_{t+1} and Y_{t+1}) is measured as the population in the preceding time period (X_t and Y_t) plus a net proportional growth rate (second term, right-hand side). The net proportional growth rate for each species depends on the current populations of each. An incremental increase in one species that generates a marginal increase (decrease) in the net proportional growth rate of the other represents a symbiotic (competitive or predatory) relationship.

The bioclimatic envelope generalizes the conventional concept of 'carrying capacity' by explicitly accounting for the impacts of climate and human activities on the range of suitable habitats. Consequently, similar to the way in which carrying capacity enters into Lotka-Volterra models, Figure 1 models the bioclimatic envelopes for *X* and *Y* (BCE_X and BCE_Y) as co-determinants of the net proportional growth rate for each species. As recommended by Burgiel and Muir (2010), Figure 1 offers a broad framework for conceptualizing the impact of climate change on invasive species.

ILLUSTRATION: WESTERN US MOUNTAIN PINE BEETLE

The US Mountain Pine Beetle preys on species of pine trees in the western United States and Canada. Warmer winter temperatures in the region have reduced mortality of the pest, resulting in population outbreaks and significant mortality of pine trees. Dying pines may be replaced by less desirable competitors, contributing to undesirable changes in fire regimes and other ecosystem characteristics (Burgiel and Muir 2010).

Figure 2 analyses this situation within the broad context of Figure 1. There are three interrelated species: pine trees (*X*), pine-tree competitors (*Y*), and pine-tree predators (*Z*). Warmer winters result in a bioclimatic envelope for pine beetles (BCE_Z) that increase the predator's net proportional growth rate. This results in increased predation of pine trees represented by the line connecting the *Z-equation* with the *X-equation*. Since pine beetles benefit from preying on pine trees, there is a 'plus sign' at the end of the line next to the *Z-equation*. Alternatively, since pine-tree mortality increases as a result, there is a 'negative sign' at the end of the line next to the *X-equation*. The next potential ecosystem linkage is that the weakened pine population may be outcompeted by less desirable plant species for vital resources such as sunlight and water. This is represented by the line between populations *X* and *Y*, with the 'negative sign' next to the population suffering competitive losses (*X*).

Identifying these broad interspecies relationships raises a set of complex issues requiring empirical analysis and more extensive ecosystems modeling. For example, what type of predator-prey relationship exists between pine beetles and pine trees? Is it a predator-prey cycle in which the pine beetle population crashes due to the lack of prey? Or, do pine beetles drive pine trees to extinction while switching to another prey? Does predatory pressure on pine trees result in a competitive relationship with other plant varieties that switches from *competitive co-existence* to *competitive exclusion*?

Consider now potential broader impacts among the three drivers (humans, ecosystem, and climate). Reduced pine populations potentially reduce timber profits, ecosystem resilience, and carbon sequestration. Reduced carbon sequestration and increased susceptibility of the region to wildfires could contribute to global warming to the further detriment of humans. As above, determining the extent to which these negative impacts occur would require extensive empirical analysis and ecosystems modeling.

CONCLUDING REMARKS

The framework developed in this paper formalizes the general discussion of climate change and invasive species in the literature, and facilitates the hypothesis formulation of potential interactions. The framework illuminates the substantial interdisciplinary collaboration that will be required to test these hypotheses, and to apply the resulting knowledge to avert the deleterious impact of climate change in increasing the abundance and spread of invasive species.

REFERENCES

Bugiel, S. and A. Muir, 2010. Invasive Species, Climate Change, and Ecosystem-Based Adaptation: Addressing Multiple Drivers of Global Change. Global Invasive Species Programme (GISP), Washington, D.C. (United States) and Nairobi (Kenya). http://data.iucn.org/dbtw-wpd/edocs/2010-054.pdf

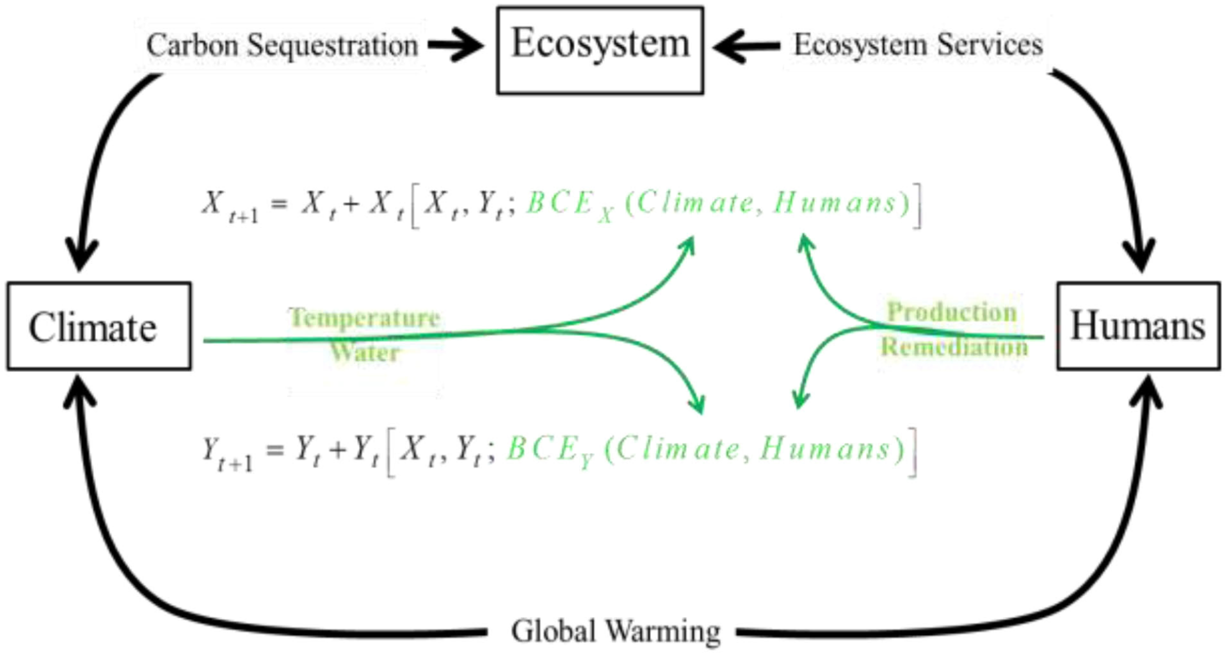

Figure 1. Conceptual framework linking climate change and invasive species

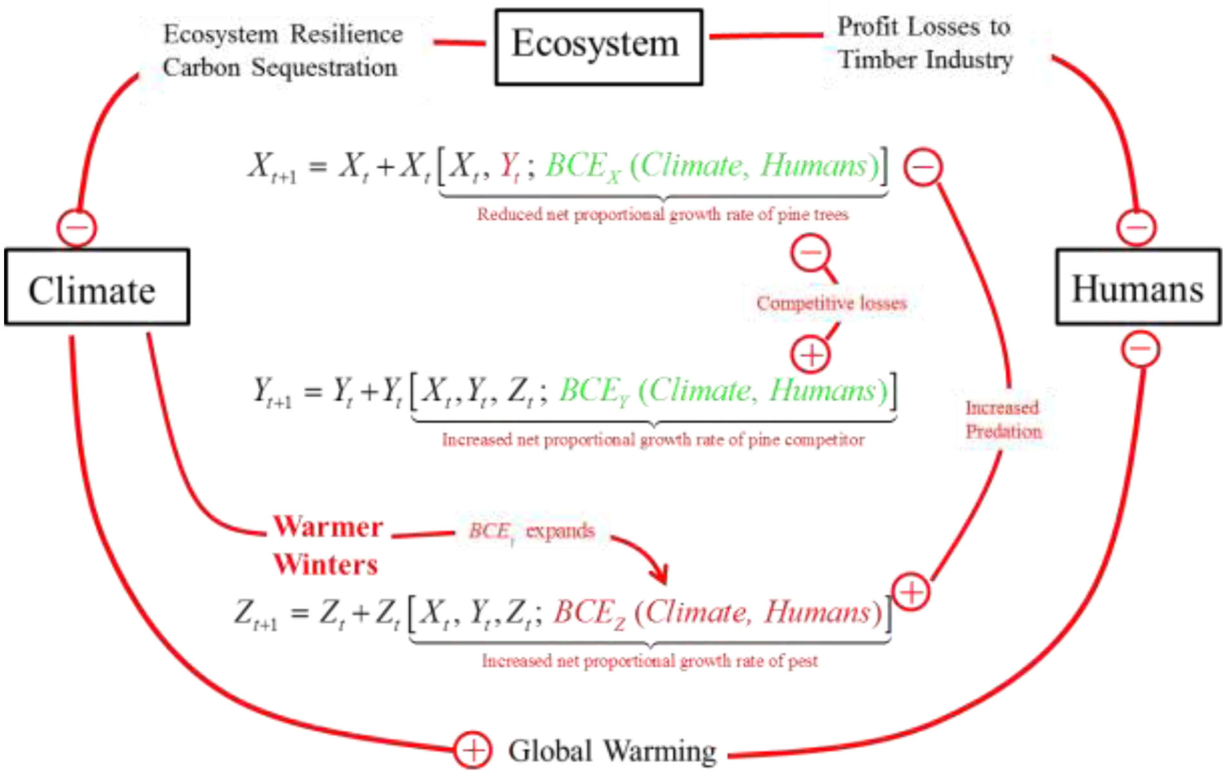

Figure 2. Illustration: Western US Mountain Pine Beetle