From Forest Nursery Notes, Summer 2009

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Forest Ecology and Management 257 (2009) 1566–1576

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Climate change impact predictions on *Pinus patula* and *Pinus tecunumanii* populations in Mexico and Central America

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ARTICLE INFO

Article history:
Received 29 July 2008
Received in revised form 19 December 2008
Accepted 22 December 2008

Keywords:
Adaptive ability
Climate change
Climate envelope models
Model validation
Provenance trials
Species distribution ranges

ABSTRACT

Climate change is likely to have a negative impact on natural populations of *Pinus patula* and *Pinus tecunumanii*, two globally important tree species in plantation forestry. The objective of this work was to evaluate the impact of climate change on the persistence of the natural populations of these species at their actual locations in order to take appropriate conservation measurements. A common approach to assess the impact of climate change on species natural distributions is climate envelope modeling (CEM). CEMs suggest significant impacts of climate change on the natural distribution of the two pine species, but their predictions contain considerable uncertainty related to the adaptive ability of tree populations to withstand future climate conditions. We assessed the adaptive ability of the two pine species based on the evaluations of provenance trials and used the results of these field trials to validate CEM impact assessment studies on provenance collection sites in the wild. The two pine species performed well in a wide range of climates, including conditions that were recorded by CEM as unsuitable for natural pine occurrence. The climate conditions where the two pine species naturally occur are predicted to become in the future more similar to the present climate of some areas where they are successfully established in field trials. These findings suggest that these pine species are in their natural habitat better adapted to climate change than CEM predicts. For the most vulnerable species, *P. tecunumanii*, human disturbances such as fragmentation from urbanization and conversion to agriculture that are occurring today are more urgent threats requiring action compared to the threat from climate change.

1. Introduction

The scientific basis of climate change is now well established. Climate change has occurred in the past century and is likely to continue into the future (IPCC, 2007). Changing climate will most probably affect the geographic range of native trees and the locations where they can be grown in plantations as exotic species. The possible negative impacts on natural populations of important tree species should concern the forestry sector, as these are the source of genetic diversity (seeds) used to sustain and improve plantation productivity under both present and future conditions (Dvorak et al., 2008). Despite the importance of alterations in global temperature and precipitation patterns, considerable uncertainty still exists on how tree species will respond to changes in climate (Hamrick, 2004; Botkin et al., 2007; Kremer, 2007). It is therefore important and relevant to better understand the threats of climate change to natural populations of tree species.

Many studies have used climate envelope models (CEMs) to assess the potential impact on ecosystems from climate change by using their current geographic distribution to develop a model of most suitable climate conditions for natural species occurrence, and projecting this into the future on the basis of results from general circulation models (GCMs). Their predictions show significant impacts and shifts in the actual distribution of many tree species (e.g. Gómez-Mendoza and Arriaga, 2007; Leng et al., 2008; Iverson et al., 2008). The extent to which trees can withstand environmental changes at their actual locations remains understudied in CEM-based climate change impact studies (Thuiller et al., 2007).

Although CEM modeling techniques have proved to be a valuable tool in the prediction of natural species distribution and the impact of climate change on their abundance (Guisan and Thuiller, 2005; Dormann, 2007), they face serious restrictions (Thuiller et al., 2004, 2007; Araújo et al., 2005; Dormann, 2007). One major problem with these approaches when applied to climate change research is that validation is difficult as the results

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doi:10.1016/j.foreco.2008.12.027