Modelling climatic change impacts on sleeper and alert weeds

John K. Scott, Kathryn L. Batchelor and Paul B. Yeoh
CSIRO Entomology, Private Bag 5, PO Wembley, Western Australia 6913, Australia
Email: john.k.scott@csiro.au

Summary Changes in climate will also change the status of existing and potential weeds depending on where they are found in Australia. Two examples are presented showing the predicted distributions of alert species, *Acacia catechu* and *Cynoglossum creticum*, threats to northern and southern Australia respectively. Models forecasting the suitability for the plant's growth under two climate predictions for 2070 were generated by using CLIMEX with OzClim overlays. *Acacia catechu* shows the potential for considerable southern spread following climate change, while *C. creticum* retracts further to the south, but with a higher level of potential threat on the southern coast of Victoria. In both cases the models indicate a considerable change in the regions most threatened by the weeds.

Keywords Climate change, alert weeds, sleeper weeds.

INTRODUCTION

We expect our climate will change in the coming decades. For this reason some weeds will have greater potential to spread in the future, whereas others might become less damaging than they are today. In addition, the impact of weeds on the environment and agriculture will also change.

Our current project aims to predict the impact of climate change on Australia's 28 environmental alert and 17 agricultural sleeper weeds. Using models of growth indices for these species under several climate change scenarios projected to the years 2030 and 2070, we will develop a risk map for Natural Resource Management regions in Australia. Two alert species, cutch tree *Acacia catechu* (L.f.) Willd. (Leguminosae) and blue hound's tongue, *Cynoglossum creticum* Mill. (Boraginaceae), were chosen for this paper to illustrate our methods and show the potential response of a tropical and temperate Australian weed.

MATERIALS AND METHODS

CLIMEX growth indices models (Sutherst *et al.* 2004) were developed for the two species based upon their world distribution (excluding Australia) and their biology, temperature and moisture requirements. These models were then combined with OzClim (CSIRO 2007) to forecast potential future growth indices. For this paper we depict data for future climatic predictions in the year 2070 using the IPCC 'high emissions' global warming scenario taken from the Intergovernmental Panel on Climate Change assessment of the scientific basis for climate change (IPCC 2000). This scenario is modelled using both the Hadley Centre Mark 2 (HadCM2) and the Echam Mark 3 (ECHAM3) global change models (IPPC 2001). These climate predictions are representative of the range of predictions for temperature and rainfall across Australia. In general Australia will experience an overall increase in temperature associated with increased monsoonal rainfall in the north and decreased winter rainfall the south. The HadCM2 model predicts relatively large decreases in rainfall whereas the ECHAM3 model predicts relatively large increases in rainfall (Kriticos 2006, Ruosteenoja *et al*. 2003).

Acacia catechu A native of the Indian region, it is introduced in south east Asia, including Darwin in Australia. It is found in tropical savannah and arid steppe environments, but not tropical rainforest (Chakrabarty and Gangopadhyay 1996).

The CLIMEX model was set to maximise the Ecoclimatic Index (EI) values over India with growth favoured around 30°C. Optimal and limiting moisture levels were set to ensure a positive Growth Index (GI) over the wet season for Indian sites so that growth (GI) matched the phenology given in Singh and Kushwaha (2006). Stress factors of cold and dry were used to define the distribution in Indian subcontinent from the north and west respectively. Hot-wet stress was used to define the absence from tropical rainforest areas.

Cynoglossum creticum *Cynoglossum creticum* is native to the Mediterranean origin (Greuther *et al.* 2007). It has established in southern NSW. Despite extensive searches, there are no data on the phenology, ecology, temperature and moisture requirements of this species. Consequently the model is entirely based on its world distribution (excluding Australia).

A Mediterranean climate template was used as the starting CLIMEX model. The cold stress and cold-wet stress were adjusted to increase the distribution northwards from the Mediterranean region to better match the plant's native distribution, in particular the presence of the plant in the southern half of France (Tela Botanica 2007) and the introduced presence in

Germany. It was only possible to include the latter by also including the southern part of the United Kingdom, where the plant is not recorded (Royal Botanic Garden Edinburgh 2007).

The plant is introduced into the middle regions of Chile (Regions V to X), Robinson Crusoe Island in the Juan Fernández Archipelago (Nelis 2006) and Argentina (at a site near the border with Chile) (Missouri Botanical Garden 2007). The CLIMEX model based on the European distribution predicts that these sites in South America, as well as Robinson Crusoe Island, would be suitable for growth of *C. creticum*; consequently the model was not modified further.

An explanation of the parameter terms and variables used in the CLIMEX models is found in Sutherst *et al.* (2004).

RESULTS

Acacia catechu Parameter values for the *Acacia catechu* CLIMEX model were: TI0 18; TI1 25; TI2 37; TI3 45; MI0 0.0405; MI1 0.15; MI2 1.7; MI3 2; Cold Stress Temperature Threshold 1.8; Cold Stress Temperature Rate −0.2; Heat Stress Temperature Threshold 45; Heat Stress Temperature Rate 0.05; Dry Stress Threshold 0.036; and Dry Stress Rate −0.085. The results for Australia using these parameters are shown in Figure 1a. The predictions of future suitability under the two climate change models are shown in Figures 1b and 1c. The most suitable future environment for *Acacia catechu* is predicted to be the NSW and Queensland coast and hinterland. The remainder of Australia, including its current distribution, is predicted to be unfavourable for growth of this weed.

Cynoglossum creticum Parameter values for the *Cynoglossum creticum* CLIMEX model were: TI0 10; TI1 16; TI2 24; TI3 28; MI0 0.1; MI1 0.4; MI2 0.7; MI3 1.5; Cold Stress Temperature Threshold 0; Cold Stress Temperature Rate −0.015; Heat Stress Temperature Threshold 30; Heat Stress Temperature Rate 0.002; Dry Stress Threshold 0.02; Dry Stress Rate −0.05; Wet Stress Threshold 1.6; Wet Stress Rate 0.0015; Cold-Wet Degree-day Threshold 6; Cold-wet Moisture Threshold 1; Cold-wet Stress Rate 0.05; Hot-wet Temperature Threshold 23; Hot-wet Moisture Threshold 0.5; and Hot-wet Stress Rate 0.075. The results for Australia using these parameters are shown in Figure 2a. The predictions of the two climate change models are shown in Figures 2b and 2c. The prediction for the current climate is for the weed to be only found in southern Australia. Under climate change this distribution will contract towards the southern coast. However, the EI values in CLIMEX are not high and it is doubtful that this species will be a real threat except for localised coastal areas in Victoria and Tasmania.

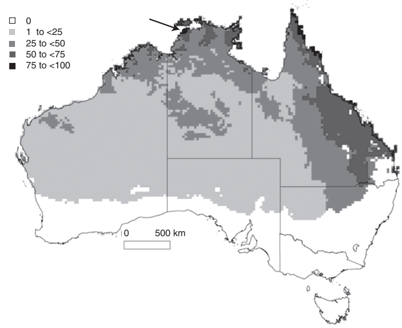

Figure 1a. Predicted distribution (EI) of *A. catechu* based on current climate. The arrow points to the current distribution. High EI values (75–100) are the most suitable for growth and survival.

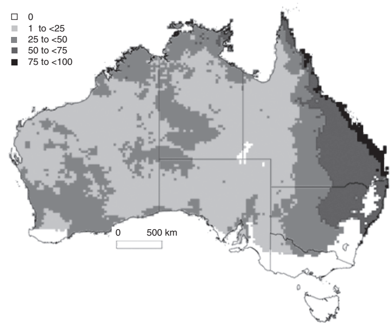

Figure 1b. Predicted distribution of *A. catechu* based on the Echam mark 3 high model for 2070.

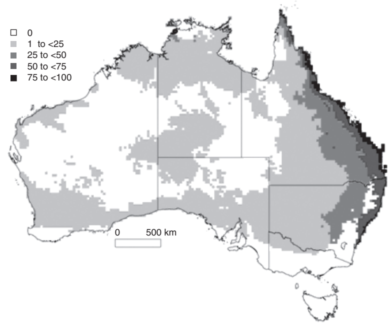

Figure 1c. Predicted distribution of *A. catechu* based on the Hadley M2 high model for 2070.

DISCUSSION

On a national scale, the CLIMEX model identifies a limited area (coastal Qld) of high EI for *A. catechu* for both the predicted current and future distributions. The differences in the two climate change models are

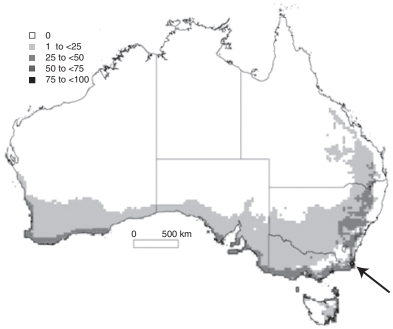

Figure 2a. Predicted distribution (EI) of *C. creticum* based on current climate. The arrow points to the current distribution. High EI values (75–100) are the most suitable for growth and survival.

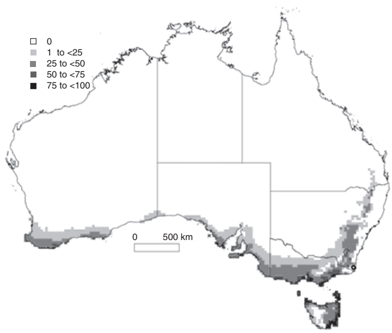

Figure 2b. Predicted distribution of *C. creticum* based on the Echam mark 3 high model for 2070.

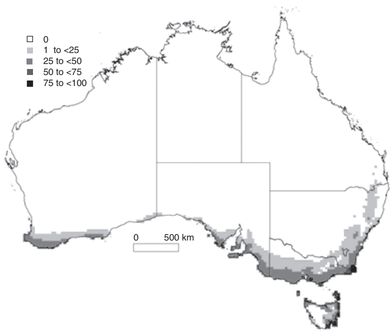

Figure 2c. Predicted distribution of *C. creticum* based on the Hadley M2 high model for 2070.

clearly shown for central Australia, reflecting the different rainfall predictions (Figures 1b and 1c).

Only two climate change predictions for two weed species can be shown here, but they illustrate the general effects expected due to climate change. Tropical species will spread further south, while southern species will contract towards the coastline, but with increased suitability for the weed.

ACKNOWLEDGMENTS

This project was funded by CSIRO and the Research and Development component of the Defeating the Weeds Menace program.

REFERENCES

Chakrabarty, T. and Gangopadhyay, M. (1996). The genus *Acacia* P.Miller (Leguminosae: Mimosoideae) in India. *Journal of Economic and Taxonomic Botany* 20, 599-633.

CSIRO (2007). (http://www.cmar.csiro.au/ozclim/index.html).

GBIF (2007). http://www.gbif.org/. Access date: 8 August 2007.

Greuther, W., Burdet, H.M. and Long, G. (2007). Med-Checklist. A critical inventory of vascular plants of the circum-Mediterranean countries. http://ww2.bgbm.org/mcl/home.asp. Access date: 8 August 2007.

IPPC (2000). Special report on emissions scenarios. www.grida.no/climate/ipcc/emission/index.htm.

IPPC (2001). Climate change 2001: the scientific basis. (Cambridge University Press, Cambridge UK).

Kriticos, D. (2006). Release notes for Ozclim Australia Climate Change Scenarios for use in CLIMEX. Ver.1.0. Unpublished report, CSIRO.

Missouri Botanical Garden (2007). Current specimen list for *Cynoglossum creticum*. http://mobot.mobot.org/cgi-bin/search_vast. Access date: 16 Jan 2007.

Nelis, L.C. (2006). Plantas introducidas de la Isla Robinson Crusoe. Access date: 16 Jan 2007.

Royal Botanic Garden Edinburgh (2007). Flora Europaea. http://rbg-web2.rbge.org.uk/FE/fe.html. Access date: 16 Jan 2007.

Ruosteenoja, K., Carter, T.R. Jylhä, K. and Tuomenvirta, H. (2003). Future climate in world regions: an intercomparison of model-based projections for the new IPCC emissions scenarios. The Finnish Environment 644, Finnish Environment Institute, 83 pp.

Singh, K.P. and Kushwaha, C.P. (2006). Diversity of flowering and fruiting phenology of trees in a tropical deciduous forest in India. *Annals of Botany* 97, 265-76.

Sutherst, R.W., Maywald, G.F., Bottomley, W. and Bourne, A. (2004). CLIMEX V2 CD and user's guide. (Hearne Scientific Software Pty Ltd, Melbourne).

Tela Botanica (2007). Flore électronique. http://www.tela-botanica.org/page:eflore?module=fiche&nvp=25&nn=20584. Access date: 8 August 2007.