The threat to New Zealand's plantation forests from four pests under a changing climate

Summary of the research report: Future proofing plantation forests from pests (contract reference CO4X0810)

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This fact sheet focuses on the possible impact of climate change on the threat that four key pests pose to New Zealand's plantation forestry resource. It outlines the potential distribution and economic impact of these invasive species (two currently in NZ and two potential problem species) under current and future climate in New Zealand.

What is the threat?

Current economic losses

The current direct economic impacts of pests and diseases on plantation forests of New Zealand has been estimated to exceed NZ$160 million per year. Additional costs associated with the fumigation of logs to remove insect pests from export timber are at least NZ$12 million per year. Not included in either of these figures are costs associated with lost opportunity because certain trees cannot be grown in New Zealand due to their vulnerability to pest attack.

Climate change resulting in warmer conditions may provide a more favourable habitat for many Mediterranean and tropical pests and diseases to establish, a wider potential habitat, greater rate of spread and/or greater severity of damage.

Four pests and diseases

Despite the considerable threat that pests pose to plantations under climate change, little research has investigated how climate change will influence the potential distribution and abundance of the key pests of the New Zealand plantation resource. The impacts of climate change on potential distribution of four high impact species were studied. However, tt should be noted that the changes in potential distribution of these species, described here, does not necessarily reflect how climate change will affect all pest species as a whole.

Four species that could potentially have or are already having a high detrimental economic impact on New Zealand plantations were selected in consultation with MAF, the Forest Research Biosecurity Council and the New Zealand Forest Owners Association. Selected species include two species that are currently in New Zealand namely, the weed Buddleja davidii and the disease Dothistroma needle blight caused by the pathogens Dothistroma spp. Two pests that are potential threats to New Zealand include the disease pitch canker (caused by the pathogen Fusarium circinatum) and Thaumetopoea pityocampa (pine processionary moth).

The process-based distribution model CLIMEX was used to project current and future distribution for the four pest species. CLIMEX is a dynamic climate model integrating weekly growth and survival responses of a species to temperature and soil moisture into an annual index of climatic suitability, the Ecoclimatic Index. The Ecoclimatic Index ranges from 0 for locations where the species cannot persist to 100 for optimal locations.

Six climate change scenarios were used to project the potential distribution of these four pests under climate change during the 2080s. These scenarios were developed from three contrasting Global Climate Models (GCMs) each run using two standard International Panel on Climate Change scenarios, representing medium (A1B) and high (A2) emissions, drawn from the set of standardised emissions scenarios. Selected GCMs included CSIRO Mark 3.0 (CSIRO, Australia), NCAR-CCSM (National Centre for Atmospheric Research, USA), and MIROC-H (Centre for Climate Research, Japan).

<u>Dothistroma needle blight</u>
Current status: Present in New Zealand

Dothistroma needle blight is a foliar disease of Pinus spp. that is characterised by red bands on needles. It causes defoliation of the tree and in extreme cases, mortality. The pathogen is present throughout New Zealand wherever suitable hosts are grown and is estimated to cause losses of $24 million per annum. Pinus radiata (radiata pine), which accounts for over 90% of all softwoods planted in New Zealand, is considered highly susceptible to the disease. Currently Dothistroma needle blight is controlled by spraying copper oxides and Dothistroma resistant P. radiata is often planted in areas where the disease is severe.

Although Dothistroma needle blight is present throughout New Zealand there are wide regional differences in severity. Research shows an air temperature of 16 to 20° C and continuously wet conditions to be optimum for infection and growth of the fungus causing Dothistroma needle blight. Consequently, the most severely affected regions are those with high rainfall and moderate temperatures. In the North Island, infection levels tend to be low in Northland, Hawke's Bay and the Wairarapa, whereas the central North Island, Waikato and Taranaki are the most severely affected regions. In the South Island, infection is most severe around Westland with low infection levels found throughout the remainder of the South Island.

Potential current range and future range under climate change

The potential distribution of Dothistroma needle blight in New Zealand included all plantations under both both current and future climate. The potential distribution determined here indicates the likelihood that Dothistroma needle blight will be able to become established and does not describe disease severity. This highlights the need for the development of finer scale models that can be used to account for variation in severity throughout New Zealand under climate change.

<u>Pitch Canker (Fusarium circinatum)</u>
Status: Not present in New Zealand

Fusarium circinatum, the causal agent of the disease known as pitch canker, has been considered one of New Zealand's most undesirable and unwanted pathogens. Because of the high risk this disease poses to New Zealand's forest industry, strict quarantine regulations have been put in place to help prevent this pathogen from being introduced to New Zealand. These restrictions include a complete ban on any pine species or Pseudotsuga menziesii (Douglas-fir) live plant material into New Zealand and restrictions on seed imported from countries known to have pitch canker.

Fusarium circinatum has been found to be pathogenic to, or reported on, over 60 species of pine and P. menziesii. Pinus radiata is the most susceptible species. As F. circinatum is a wound pathogen intact tissue is not vulnerable to invasion. In general, pitch canker has been associated with wounds created by insects, weather or mechanical damage.

Pitch canker disease in pines is characterised by exudation of large amounts of resin in response to an infection. All tissue of susceptible hosts can be infected by F. circinatum. Individual infections are unlikely to kill a tree but multiple infections can cause extensive dieback in the canopy and this may potentially lead to mortality. Pitch canker also affects seed and seedlings and thus, can be a serious nursery problem.

Distribution under current and climate change
The core range of the disease is humid subtropical and Mediterranean areas. The potential distribution under current climate included only 43% of New Zealand plantations. Most of these plantations were located in northern and coastal regions of the North Island and were projected to have a climate that was optimal for pitch canker. The extensive forests located in the central North Island generally had an unsuitable climate for pitch canker.

Under climate change, the potentially suitable areas in New Zealand increased by 108% to 134% depending on the model employed. Northern and coastal regions, with high humidity or subtropical climates would be expected to have more severe outbreaks.

All of the future climate change scenarios predict the majority of the North Island and northern coastal areas of the South Island will have suitable to optimal conditions for pitch canker. Under climate change most of the extensive forests located in the central North Island are projected to have a climate suitable for pitch canker.

The increased global distribution of F. circinatum worldwide is of concern to New Zealand and other pitch canker-free countries as it increases the risk that the pathogen could inadvertently be introduced to New Zealand. Continued vigilance and monitoring for this disease is essential for prevention or early detection of F. circinatum in the forestry sector.

Buddleja davidii
Status: Present in New Zealand

Buddleja davidii is a perennial, semi-deciduous shrub that readily establishes on disturbed sites predominantly in regions with temperate, Mediterranean, subtropical, and tropical climates. In the extensive plantations common in the central North Island of New Zealand, B. davidii retards tree growth more than any of the other major co-occurring weed species.

Potential current range and future range under climate change
Projections of potential distribution show most of the North and South Island to be suitable for B. davidii. Regions that are unsuitable for B. davidii are located at high altitude adjacent to the main axial ranges in the South Island. There are large tracts of land suitable for B. davidii within the south-east of the South Island where B. davidii is currently scarce.

Although the potential distribution of B. davidii increased under all future climate scenarios these increases showed marked regional variability within New Zealand. As the entire North Island currently ranges from suitable to optimal for B. davidii, no further potential range expansion occurred under the future climate scenarios. However, in the South Island, model projections show considerable potential range expansion particularly in high country areas adjacent to the Southern Alps.

The risk of B. davidii expanding its range into eastern and southern regions of the South Island of New Zealand is likely to be increased by planned changes in land use. As B. davidii predominantly colonises disturbed areas, substantial increases in plantation forest area within this region are likely to exacerbate the rate of spread of B. davidii. Under future forest scenarios considered, these regions show the greatest potential for further afforestation, with estimates of between 0.7 to 2 million ha that could be potentially converted from pasture to trees.

Within New Zealand, B. davidii has a high impact on plantation species, as it exhibits fast growth, broad environmental tolerance and a short juvenile period, after which it produces an extremely large number (up to 3 million seeds per plant) of wind dispersed seed. As a result, invasion by B. davidii is likely to more detrimentally affect plantations than competition from the current local suite of weeds that presently colonise plantations on the South Island.

Pine processionary moth (Thaumetopoea pityocampa)
Status: Not present in New Zealand

Should this pine defoliator become established in New Zealand, outbreaks are likely to occur at a high frequency because P. radiata, a preferred host, is highly susceptible to attack and because T. pityocampa would experience freedom from natural predators. Consequently, the damages resulting from an establishment of T. pityocampa are expected to be significant.

The risk of arrival of this species is relatively low as T. pityocampa is considered to be a poor disperser and has not yet become established anywhere outside its native region. Although pathways exist such as shipment of egg masses with containers originating from infested regions, or accidental transport by tourists, there have not been any recorded arrivals in New Zealand of any life stage of the pine processionary moth.

Potential current range and future range under climate change
Under current climate 60% of the total plantation area within New Zealand was projected to be suitable for T. pityocampa. By region, the percentage of plantation area suitable for T. pityocampa declined with latitude from 100% in Northland and Auckland to 0% in most South Island regions

Under climate change there were marked increases in climatic suitability for T. pityocampa and projections show between 82% and 90% of the plantation estate was suitable under future climate scenarios.

Over an entire rotation the modelled impact of T. pityocampa on both total and merchantable stem volume was predicted to be substantial. Under current climate the dispersal of T. pityocampa throughout New Zealand was predicted to result in average reductions of 16% in both merchantable and total stem volume. Under future climate these reductions were more severe ranging from 29% to 33% under different models.

Under the assumption that T. pityocampa will become established and is fully dispersed throughout New Zealand, projected losses in net present value (NPV) of the plantation resource, over the course of one rotation (28 years) were $1,306 M under current climate and ranged from $2,239 M – $2,493 M under climate change.

At lower rates of dispersal, NPV losses under current climate ranged from between $500 M to $167 M, assuming respective linear spread rates of 2.53% of the plantation resource year^{-1} (equivalent to 30 km year^{-1}) and 0.84% year^{-1} (equivalent to 10 km year^{-1}). Potential reductions in net present value for these two spread rates were markedly higher under all climate change scenarios.

At lower probabilities of establishment all losses in NPV were reduced in proportion with the diminished probability of establishment. For instance, under a probability of establishment of 1%, NPV losses under current climate ranged from $5M to 1.67M, assuming respective linear spread rates of 2.53% and 0.84% of the plantation resource year^{-1}, respectively.

Losses in NPV made under the assumption that T. pityocampa is controlled using aerial application of an insecticide (Bacillus thuringiensis (Bt)) were reduced but still relatively high. When expressed as a proportion of the reductions in NPV assuming no control, values under current climate were 47%, 80% and 83%, respectively, assuming T. pityocampa, is fully dispersed (throughout suitable areas) and dispersed at a rate of 2.53% and 0.84% per year. Under future climate, these proportions averaged 38%, 46% and 46%, of the no control option, respectively, assuming full dispersal and dispersal at rates of 2.53% and 0.84% per year.

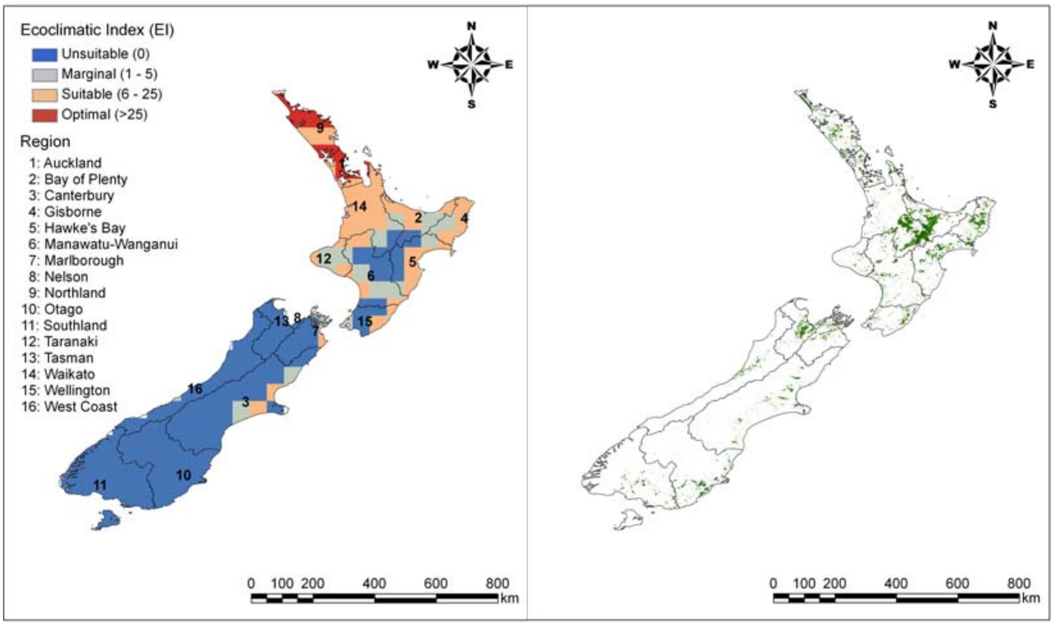

Figure 1. New Zealand map showing: (a) ecoclimatic suitability, by region, under current climate for *T. pityocampa* and (b) existing (green) pine plantations.

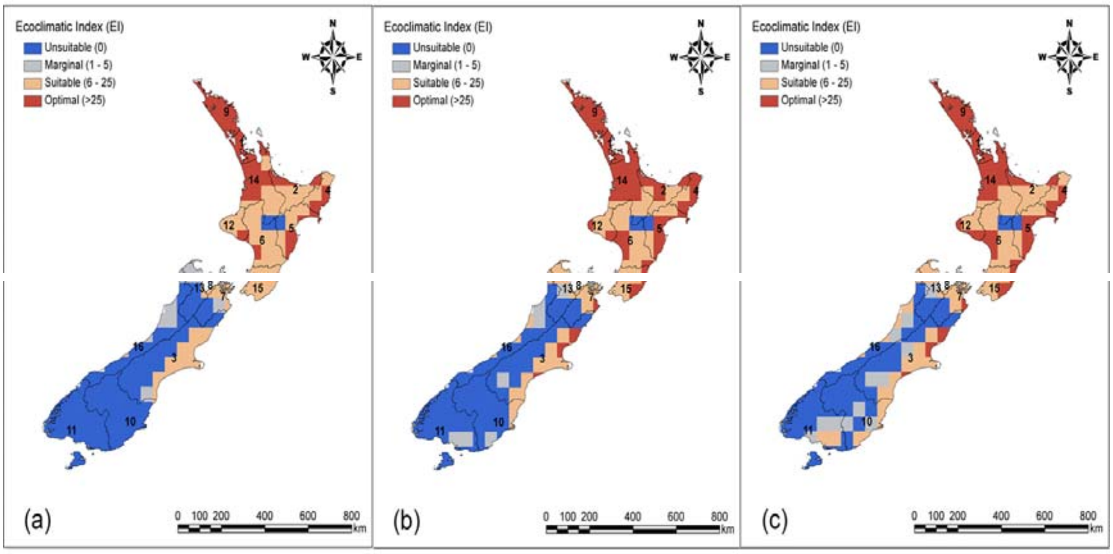

Figure 2. New Zealand map showing ecoclimatic suitability for *T. pityocampa* under climate scenarios (during the 2080s) derived from (a) CSIRO Mark 3.0, (b) MIROC-H and (c) NCAR-CCSM. All models were run with the AIB emissions scenario.

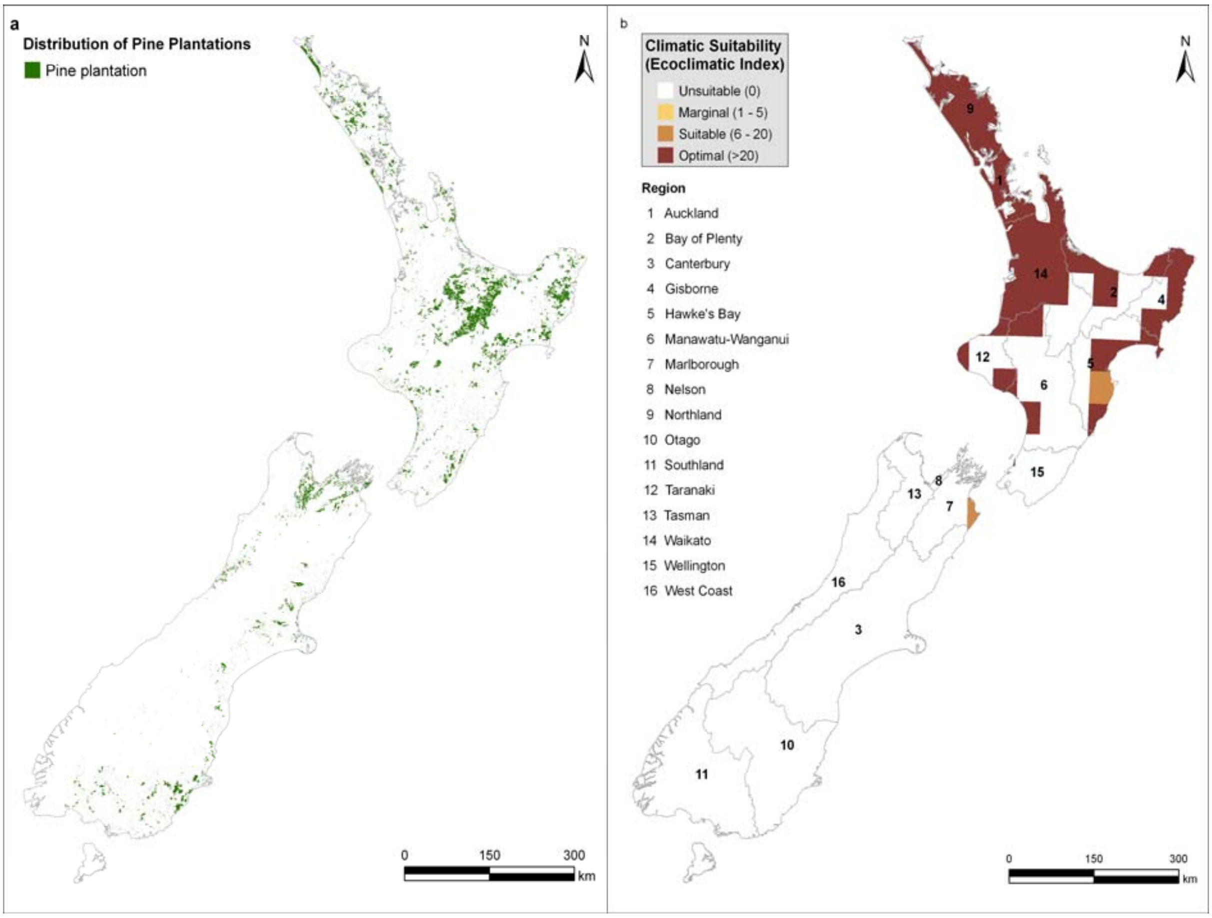

Figure 3. New Zealand map showing (a) location of existing *Pinus* spp. plantations and (b) ecoclimatic suitability, by region, for pitch canker, under current climate.

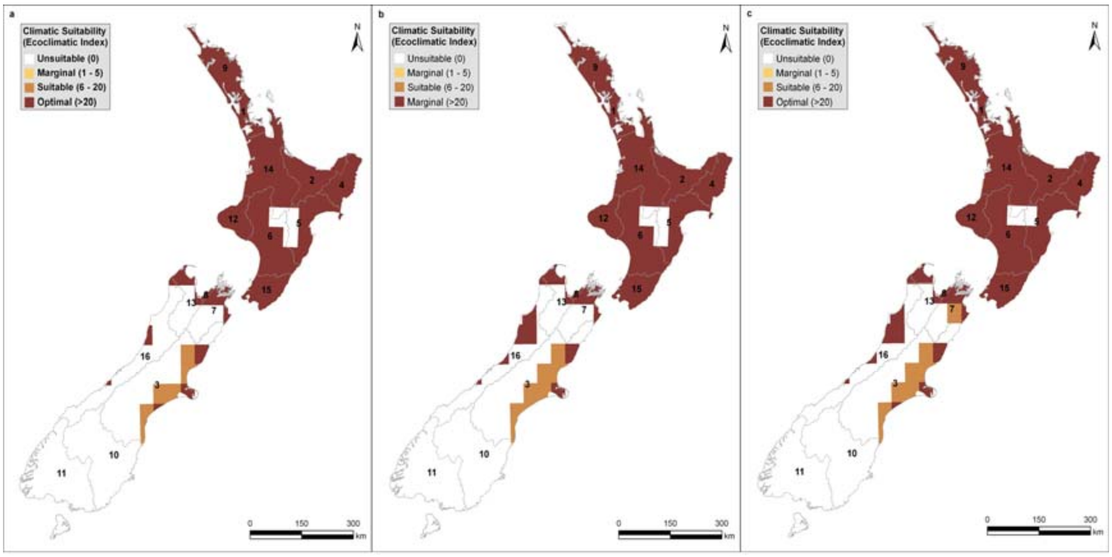

Figure 4. New Zealand map showing ecoclimatic suitability for pitch canker under climate change scenarios (during the 2080s) derived from (a) CSIRO Mark 3.0, (b) NCAR-CCSM and (c) MIROC-H. All models were run with the AIB emissions scenario.