Impact of Climate Conditions and Adaptation on Southern Pine Beetle Infestations

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ABSTRACT

This study investigates the relationship between climate factors and southern pine beetle (SPB) (*Dendroctonus frontalis* Zimmermann) risk using the generalized linear model (GLM). The GLM approach alleviates some disadvantages of the traditional linear model. The estimated model is then used to predict SPB infestations under different future climate change scenarios from 2020 to 2099. We find that mean spring and summer temperatures and minimum winter temperature have a positive impact on SPB risk whereas spring and winter precipitation and mean fall temperature have a negative impact. In addition, removals of infested trees via timber salvage tend to reduce subsequent SPB risk. Because the insect life history or population level process is largely related to climate factors, climate change could alter SPB outbreak patterns. However, the risk of SPB outbreaks would not move in one direction because the SPB population largely depends on complex interactions between temperature and precipitation. Even though the mean temperature in the U.S. South in general is projected to rise by various Global Climate Models (GCMs), precipitation also is likely to increase at least in some parts of the region and/or in some time periods. Thus, in some areas, the positive impact of rising mean temperatures will be compensated by the negative impact of rising precipitation on SPB risk. Overall, future SPB risk would vary with location, time, and climate conditions predicted by GCMs.

INTRODUCTION

Insect outbreaks are a major disturbance southern U.S. forests, and the southern pine beetle (SPB), *Dendroctonus frontalis* Zimmermann, is the most destructive insect to southern pine forests. Climate factors such as temperature and precipitation affect SPB infestations (Gan 2004), and ongoing global climate change could enhance SPB risk.

This study aims to understand a) which climate factors and to what extent they contribute to SPB infestations in the southern U.S. (Fig. 1) and b) the potential impact of future climate change on SPB risk in the region. Such an understanding would help develop strategies to mitigate SPB damage under climate change.

OBJECTIVES

1) To estimate the relationship between climate factors and SPB infestation risk;

2) To predict future SPB risk under climate change.

METHODS

1. **Estimation of the relationship between climate factors and SPB infestations**

   The generalized linear model (GLM) approach (Papke and Wooldridge 2008) with a probit link function was employed to investigate the relationship between various climate factors and SPB outbreaks using historical data.

2. **Projection of future SPB risk**

   Future SPB risk was projected based on the future climate (IPCC 2014) projected

   by two Global Climate Models:
   HADCM3 from the Hadley Centre for Climate Prediction Research
   CCSR from National Institute for Environmental Studies

   under two IPCC emissions scenarios:
   A2 and B2.

RESULTS

Estimated regression model

Table 1. Marginal effect from GLM

Independent variable	Coefficient (Marginal effect)	Delta-Method S.E	P-value
USV (unsalvaged volume in current year)	0.1032	0.0091	0.000
lnSPT (log spring temperature in current year)	0.0154	0.0052	0.003
lnFLT (log fall temperature in current year)	-0.0141	0.0053	0.008
lnSPP1(log spring precipitation one year ago)	-0.0010	0.0004	0.006
lnWNP1(log winter precipitation one year ago)	-0.0011	0.0003	0.000
lnMin_WINTER1 (log min winter temperature one year ago)	0.0047	0.0017	0.007
lnSPT2 (log spring temperature two years ago)	-0.0096	0.0049	0.049
lnSMT2(log summer temperature two years ago)	0.0218	0.0100	0.030

•Mean spring temperature (overall) and minimum winter temperature have a positive impact on SPB infestation.

•Mean fall temperature has a negative impact on SPB infestation.

•Mean summer temperature two years ago has a positive impact on SPB infestation in current year.

•Precipitation in spring and fall one year ago has a negative impact on SPB infestation in current year.

•Removal of SPB infested trees via timber salvage helps reduce SPB infestation, although forest stock density does not show a statistically significant effect on SPB infestation.

Projected regional SPB risk under future climate change

Fig. 2a. Projected SPB risk (%) under the climate change projected by HADCM3

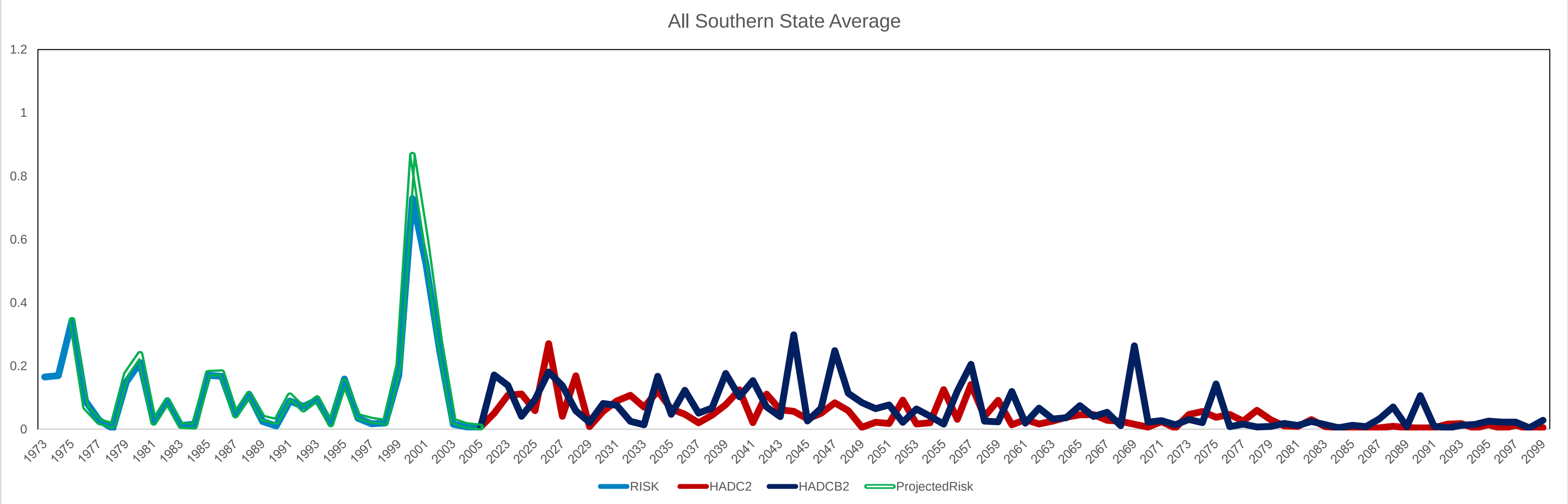
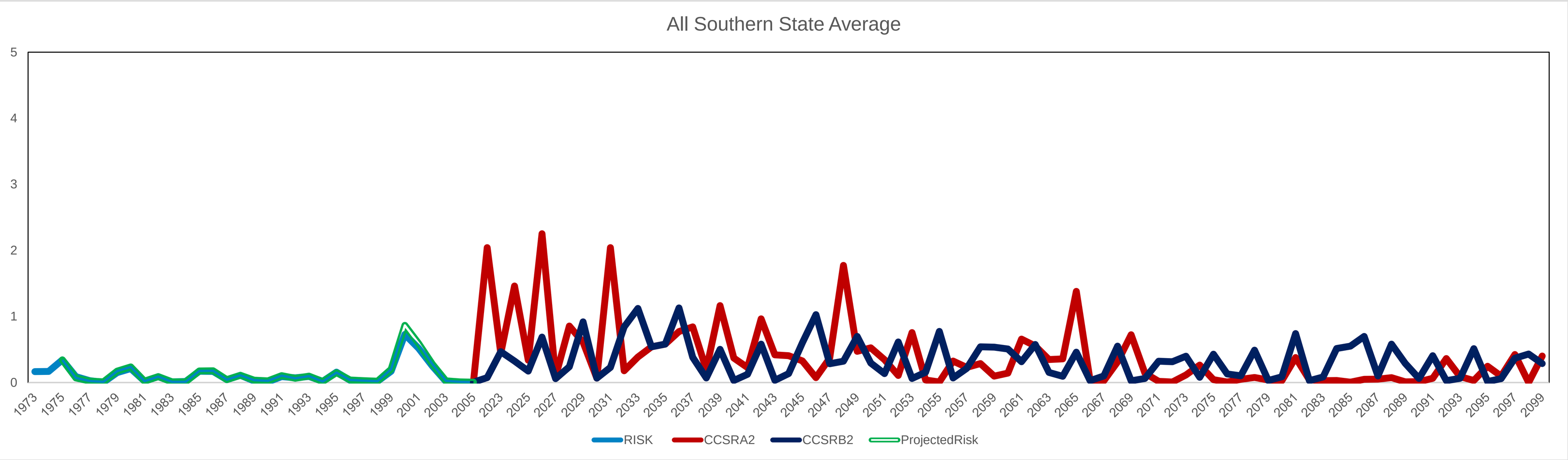


Fig. 2b. Projected SPB risk (%) the climate change projected by CCSR



STUDY AREA

Fig. 1. Target Area: 11 southern states including Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, South and North Carolinas, Tennessee, Texas, and Virginia.

CONCLUSION

- In general, higher temperature and lower precipitation tend to increase SPB risk.
- Minimum winter temperature has a smaller impact on SPB risk than mean spring and summer temperatures, although they are all positively correlated with SPB infestation.
- The impact of climate change on SPB risk would vary spatially and temporally.
- Uncertainty exists in projected SPB risk under climate change largely because of the uncertainty in projected future climate.
- Salvage harvesting could be used to alleviate the spreading of SPB infestation.

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