Modeling variation in individual tree defoliation caused by spruce budworm in Maine, USA and New Brunswick, Canada

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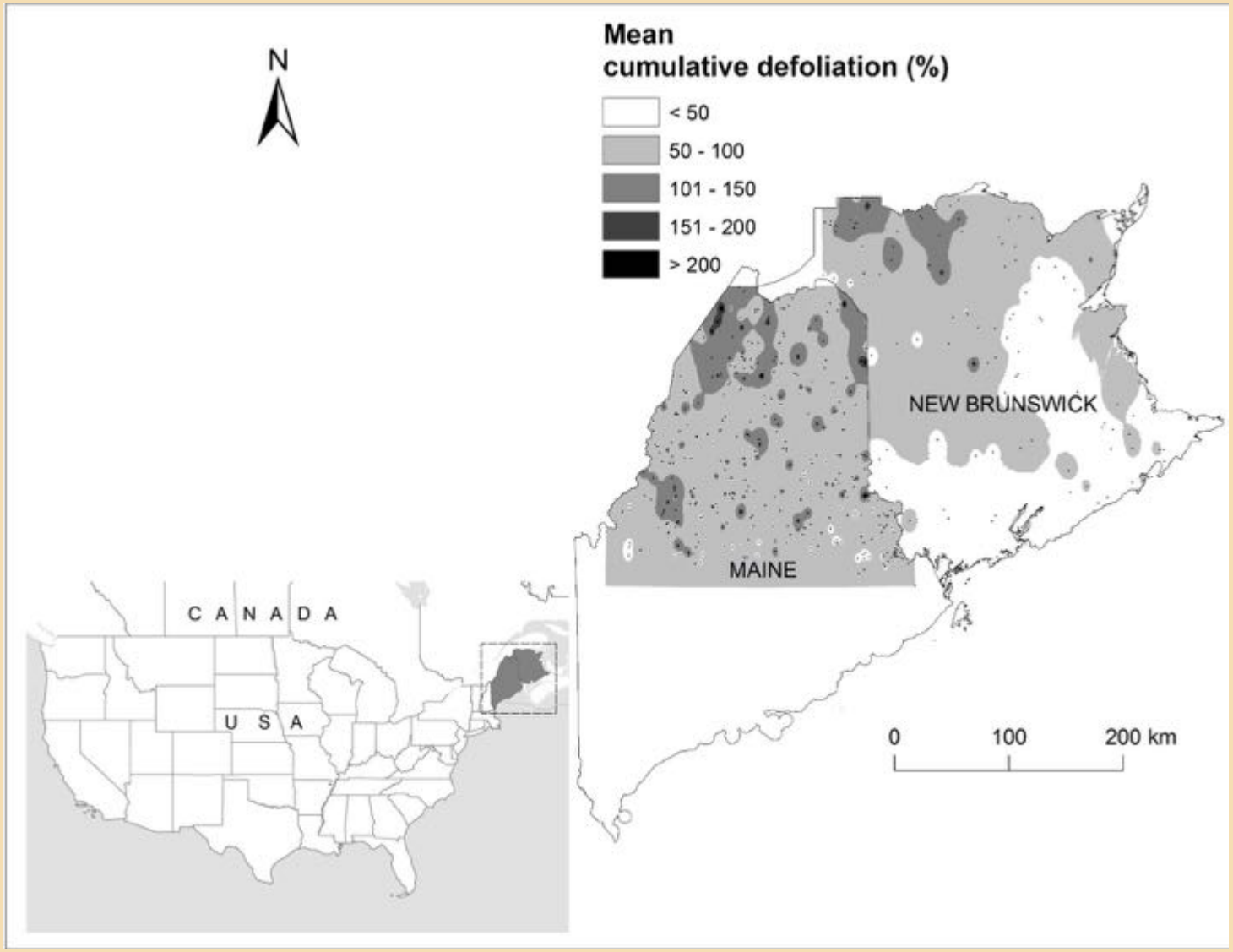
Introduction

- *Spruce budworm (SBW) is the most influential forest pest in the softwood forest of northeastern North America, has a larger spatio-temporal scale, shorter return interval, and greater influence on forest productivity than other disturbances such as fire and wind;*
- *Our previous studies evaluated the influences of SBW defoliation on some key stand and individual tree growth components, and found all of these influences are significant and species dependent, and relied on accurately quantifying individual tree defoliation;*

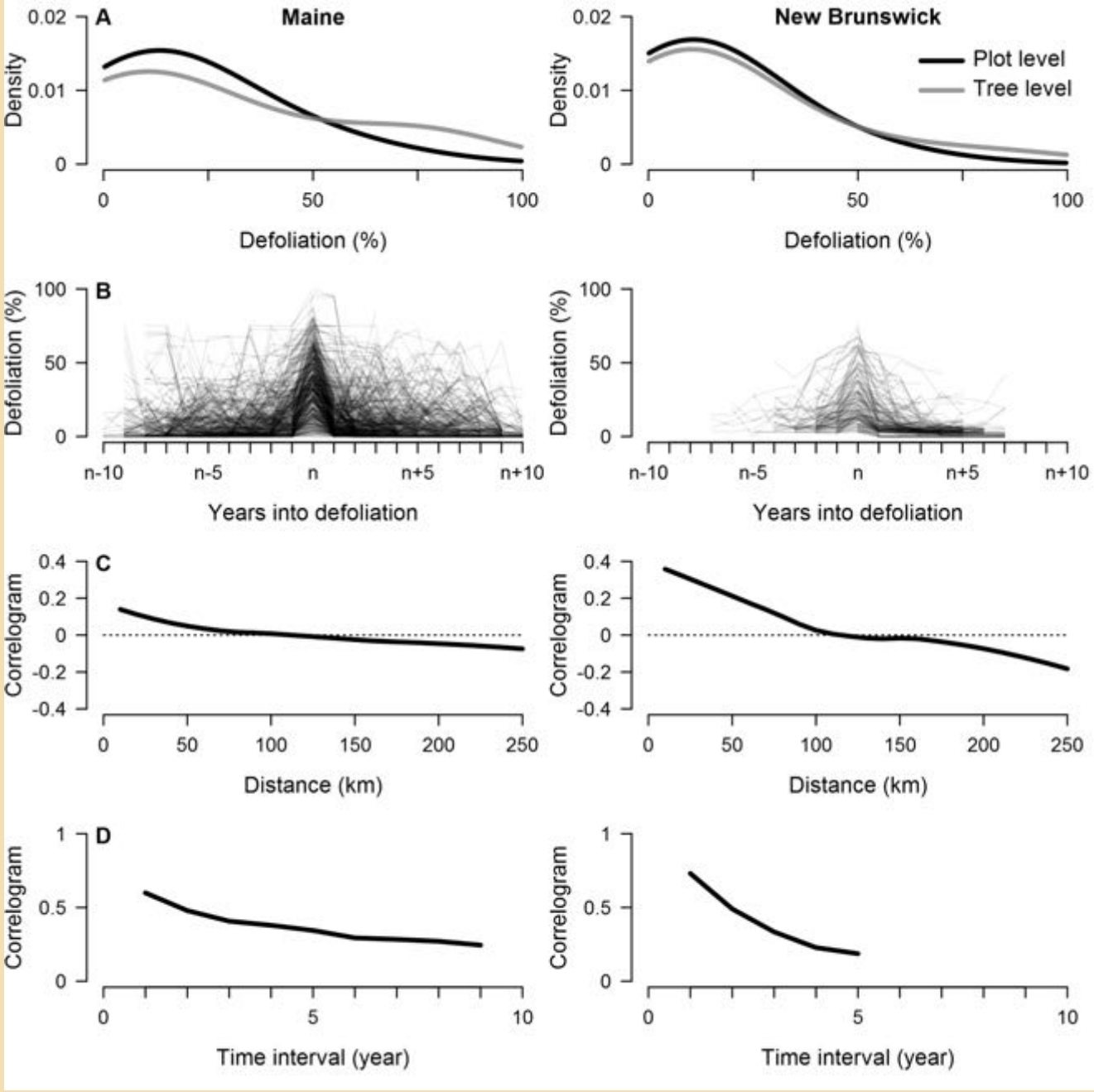
Introduction

- *Defoliation is highly variable spatially, temporally, and among trees especially of different species, possibly in interaction with other tree, site, and stand characteristics;*
- *it is much more convenient to obtain large-scale observations of defoliation. It is therefore our goal to construct quantitative relationships between highly variable individual tree defoliation and plot-level (potentially other large-scale) observations in defoliation, and identify influential factors in these relationships;*
- *The results potentially provide efficient monitoring of SBW outbreaks, help understand defoliation dynamics, and support forest management planning.*

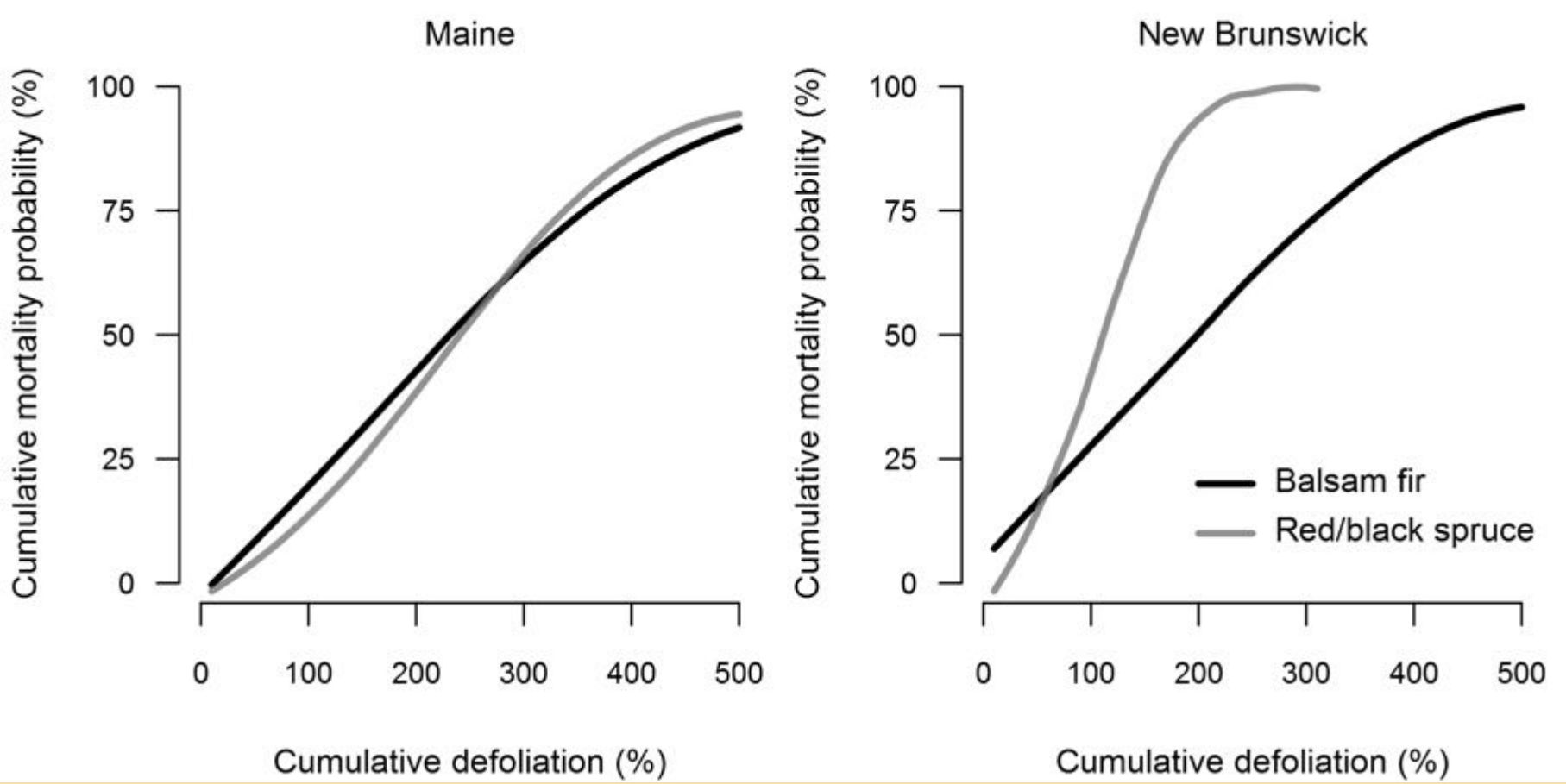
Study area, sample plots, and defoliation



General patterns Of defoliation



Relationship between defoliation and mortality -- an example



Methods

Bayesian regression based on a random walk Metropolis-Hastings algorithm

(n = 42,349 in Maine, n = 16,599 in New Brunswick)

$$(\boldsymbol{\beta},\phi)^{t+1} = \begin{cases} (\boldsymbol{\beta},\phi)^{t} + Uniform(-1,1)\cdot \boldsymbol{s} \;\; with\; probability \min\left\{1, \dfrac{p\left((\boldsymbol{\beta},\phi)^{t} + Uniform(-1,1)\cdot \boldsymbol{s}|\boldsymbol{y}\right)}{p\left((\boldsymbol{\beta},\phi)^{t}|\boldsymbol{y}\right)}\right\} \\ (\boldsymbol{\beta},\phi)^{t} \;\; otherwise \end{cases}$$

$$p(\boldsymbol{\beta},\phi|\boldsymbol{y}) \propto Beta\,(a,b)\cdot N(\boldsymbol{\mu 2},\boldsymbol{\Sigma}),\; where\, a = \mu 1\cdot\phi,\; and\; b = (1-\mu 1)\phi$$

$$\ln\left(\frac{\mu 1}{1-\mu 1}\right) = \beta 1 + \beta 2\cdot DEF_P + \beta 3\cdot SPP + \beta 4\cdot\frac{BA_{HW}}{BA} + \beta 5\cdot DBH + \beta 6\cdot\frac{HT}{MHT_{SW}} + \beta 7\cdot BAL_{SW} + \beta 8\cdot CR$$

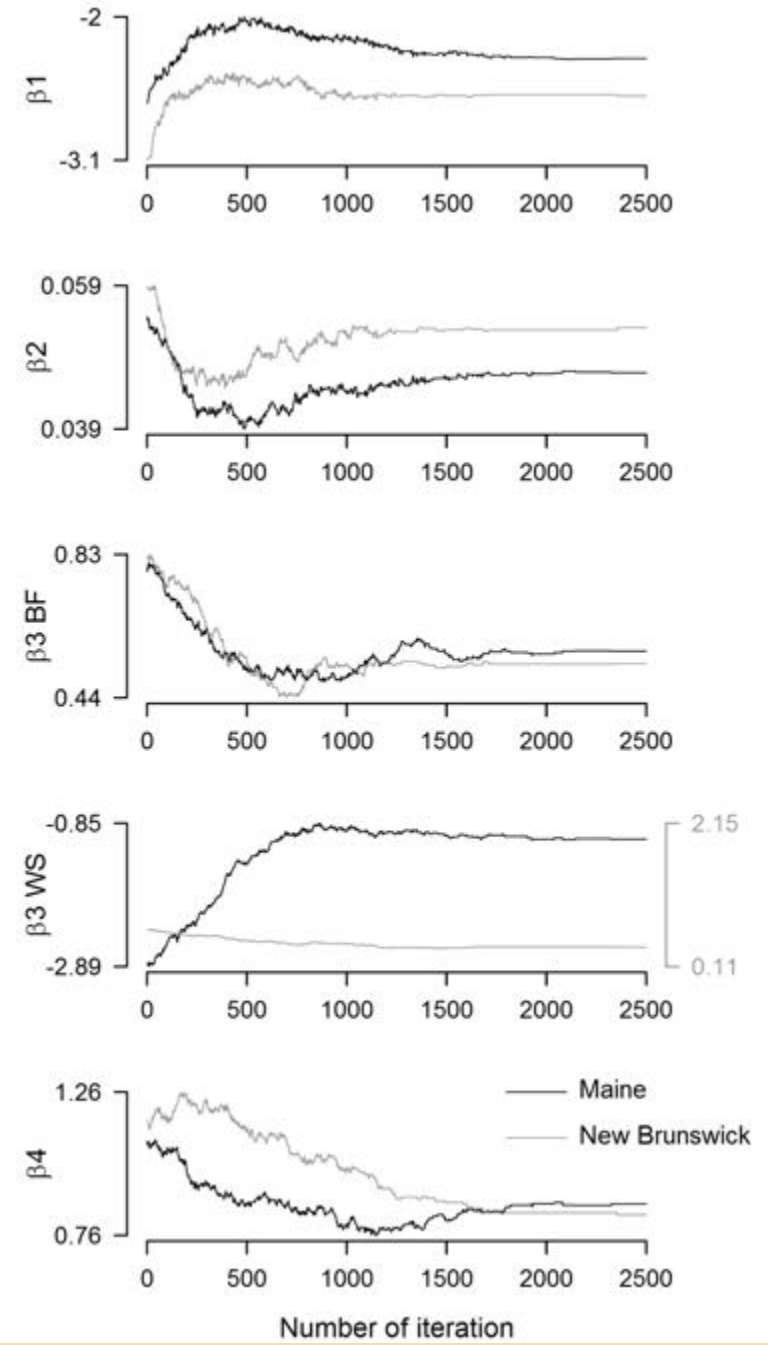
Results

Important factors

	Maine		New Brunswick	
Model	**AIC**	**ΔAIC**	**AIC**	**ΔAIC**
Null	14904	--	241	--
DEF_P	-10614	-25518	-4151	-4392
DEF_P + SPP	-18711	-8097	-4868	-717
DEF_P + SPP + BA_HW/BA	-20191	-1480	-5086	-218
DEF_P + SPP + BA_HW/BA + DBH + HT/MHT_SW + BAL_SW + CR*	-20844	-653	-5097	-11

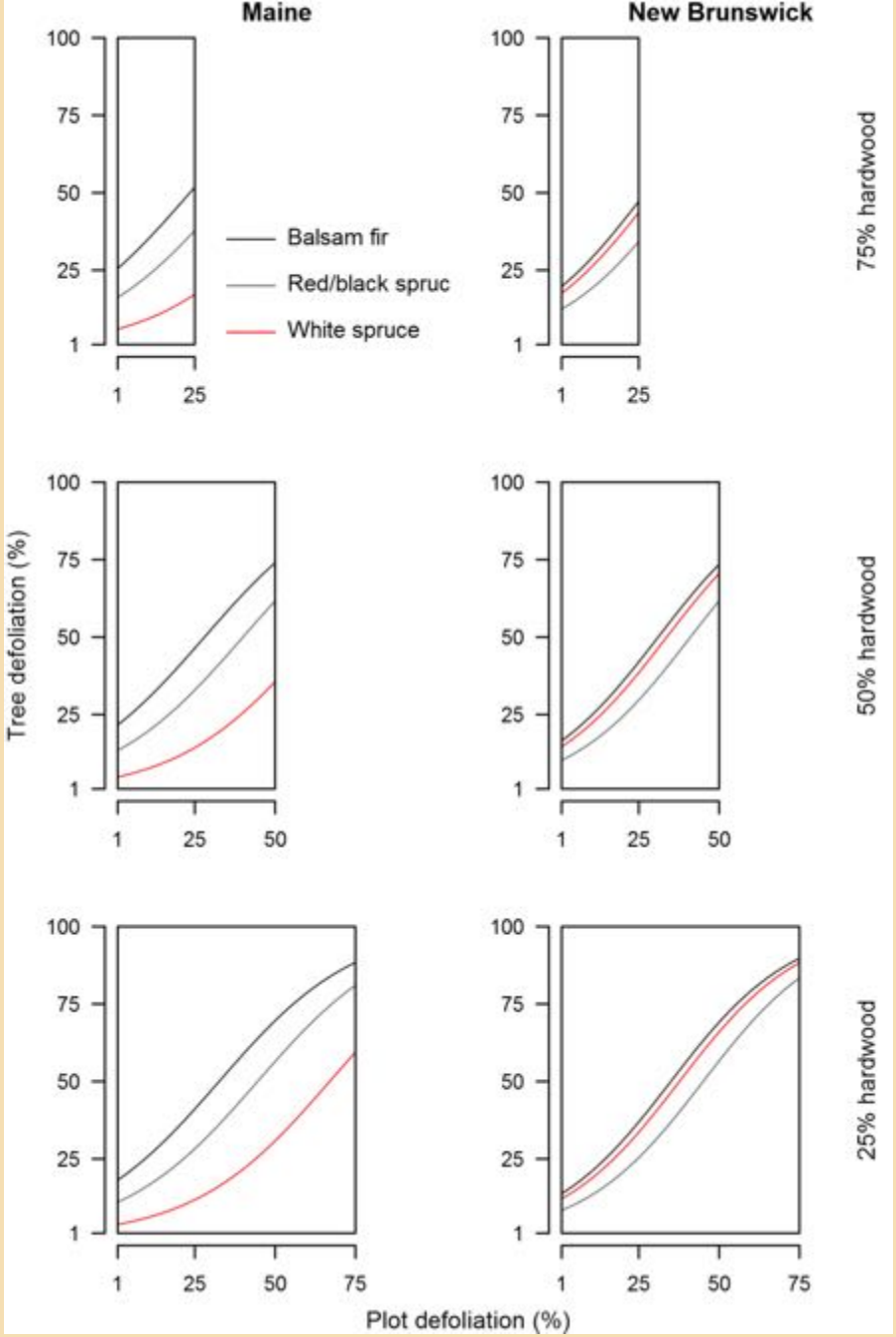
Results

Parameter estimates



Results

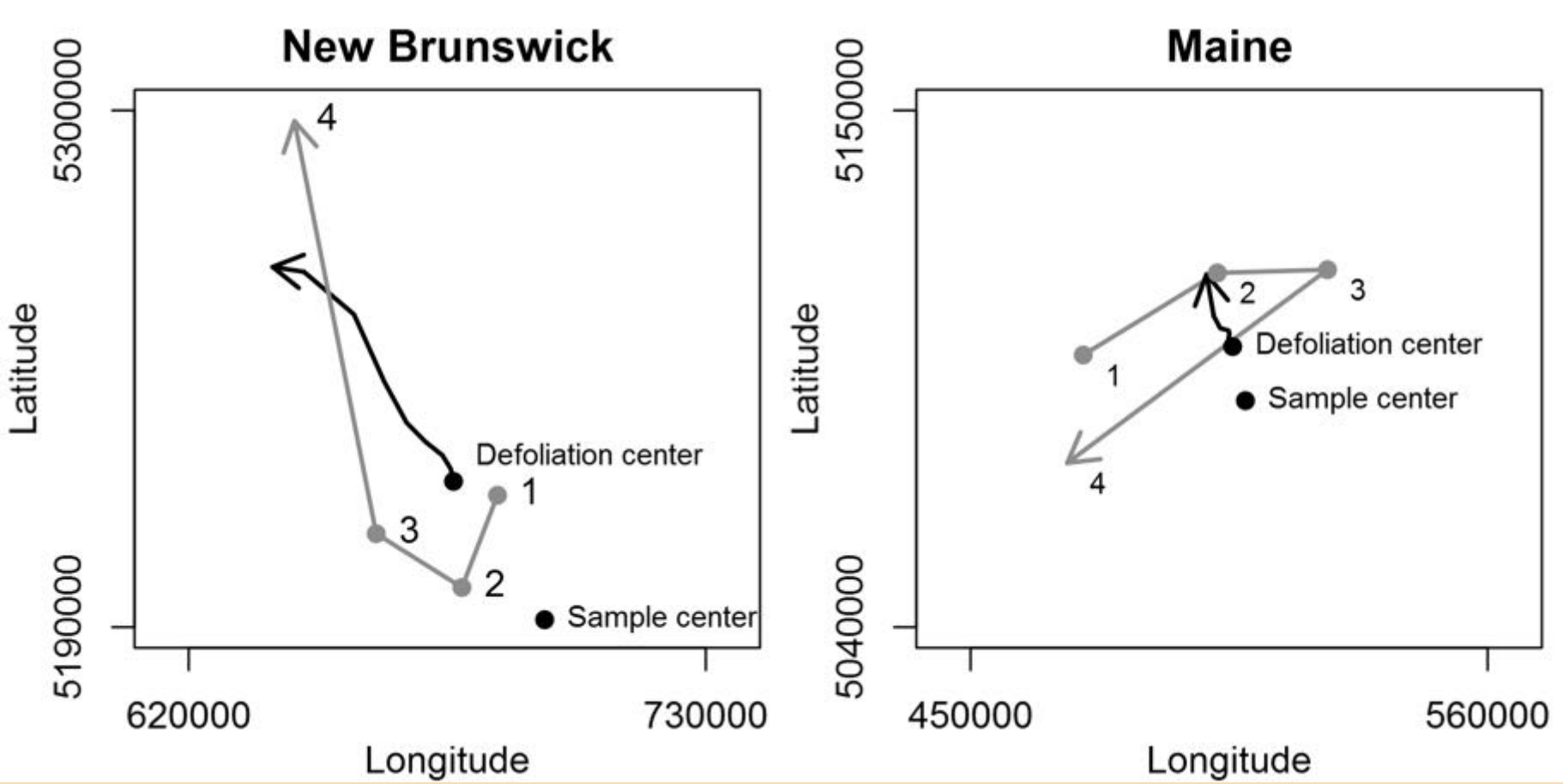
Predictions



Discussion

Black lines are the increasing defoliation; grey lines are the abundance of white spruce, where 4 indicates 4 trees/plot.
The graphs show that white spruce has different natural gradient of distribution in the two regions, and more in the northwest of NB, i.e. heavily defoliated areas, which likely leads to the overestimation of its susceptibility, as shown in the previous graph and as the result of Henniger's publication.

Influence of sampling design on the results



Discussion

- *Different species' susceptibility to defoliation is significantly different;*
- *Species was the single most important predictor (followed by the proportion of hardwood) relating observations of defoliation at different scales, while other site and stand factors play a much lesser role in this relationship;*
- *Large-scale observation of defoliation through remote sensing can potentially be related to individual tree defoliation, hence growth response.*

Questions?

Source: http://en.wikipedia.org/wiki/Choristoneura_fumiferana