Can a multistage approach improve individual tree mortality predictions in eastern North America?*

Cen Chen[1], John Kershaw Jr[2], Aaron Weiskittel[1], and Elizabeth McGarrigle[3]

[1] Center for Research on Sustainable Forests, University of Maine, Orono, ME 04469, USA

[2] Faculty of forestry & Environmental Management, University of New Brunswick, Fredericton, NB E3B 5A3, Canada

[3] Nova Scotia Department of Natural Resources, Halifax, NS B3J 3M8, Canada

* Chen, C., Kershaw Jr., J., Weiskittel, A., and McGarrigle, E. 2023. Can a multistage approach improve individual tree mortality predictions across the complex mixed-species and managed forests of eastern North America? Forest Ecosystems 10: 100086.

Background

- Tree mortality plays a fundamental role in the dynamics of forest ecosystems but is difficult to accurately predict.
- The lack of accuracy is related to tree mortality being rare and stochastic as well as poorly understood processes underlining tree mortality.
- A variety of modeling strategies have been developed to improve tree mortality predictions, of which a multistage approach has mostly been applied in stand mortality models.

A new multistage approach

The stages

Stage 1: predict annual probability *p* that a stand experiences mortality.

Stage 2: predict stand basal area mortality *m* ($m^2\ ha^{-1}\ yr^{-1}$).

Stage 3: predict annual tree survival probability *s*.

A new multistage approach

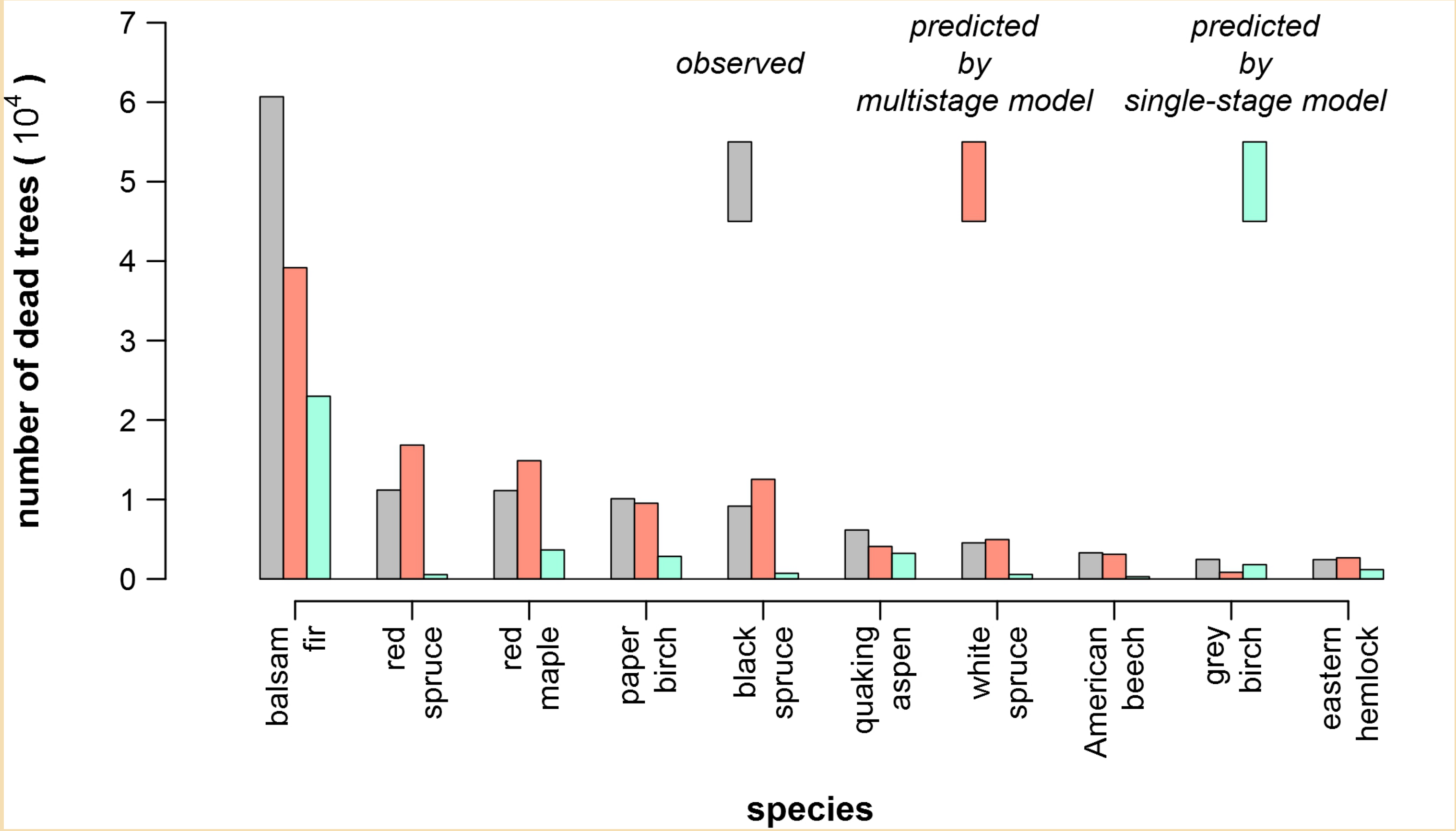
The procedure

1. Multiply stand mortality probability p by an indicator variable I such that $I = 0$ if $p < v$ and $I = 1$ otherwise, where v is an optimized threshold value.
2. Multiply stand basal area mortality m by $p \cdot I$
3. trees are ranked by predicted survival probabilities s in each plot, and trees with the lowest s are sequentially killed until basal area mortality predicted in the first two stages ($m \cdot p \cdot I$) is achieved.

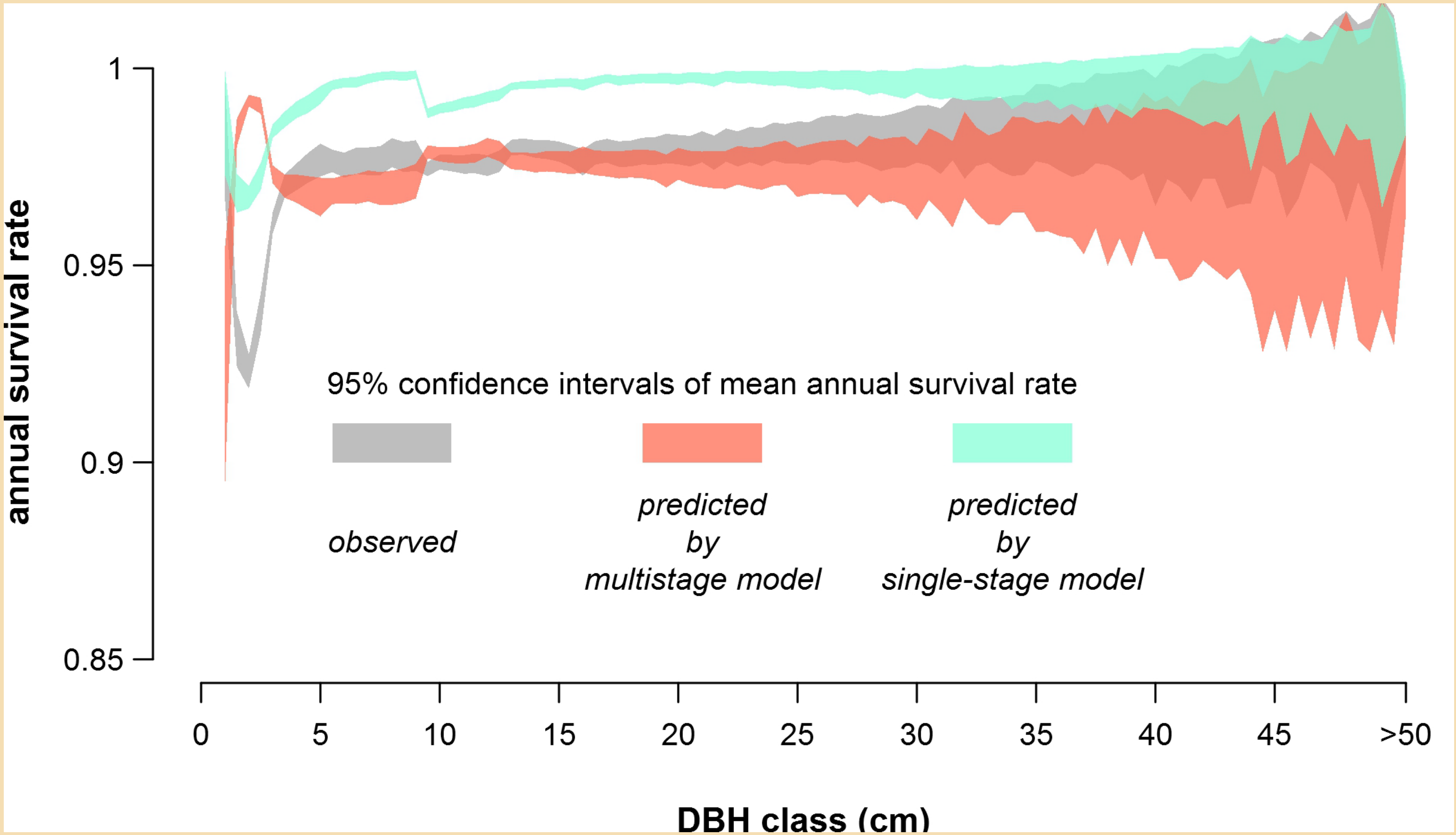
Comparisons with a conventional tree mortality model

- 9,442 permanent plots across Maine, New Brunswick, Nova Scotia, and Quebec.
- Observed mortality was between 0.14 m^2 ha^{-1} yr^{-1} in Maine and 0.32 m^2 ha^{-1} yr^{-1} in New Brunswick.
- Balsam fir, red spruce, red maple, paper birch, and black spruce had the highest observed mortality of 60,679, 11,183, 11,115, 10,097, and 9,160 trees, respectively.

Comparisons with a conventional tree mortality model

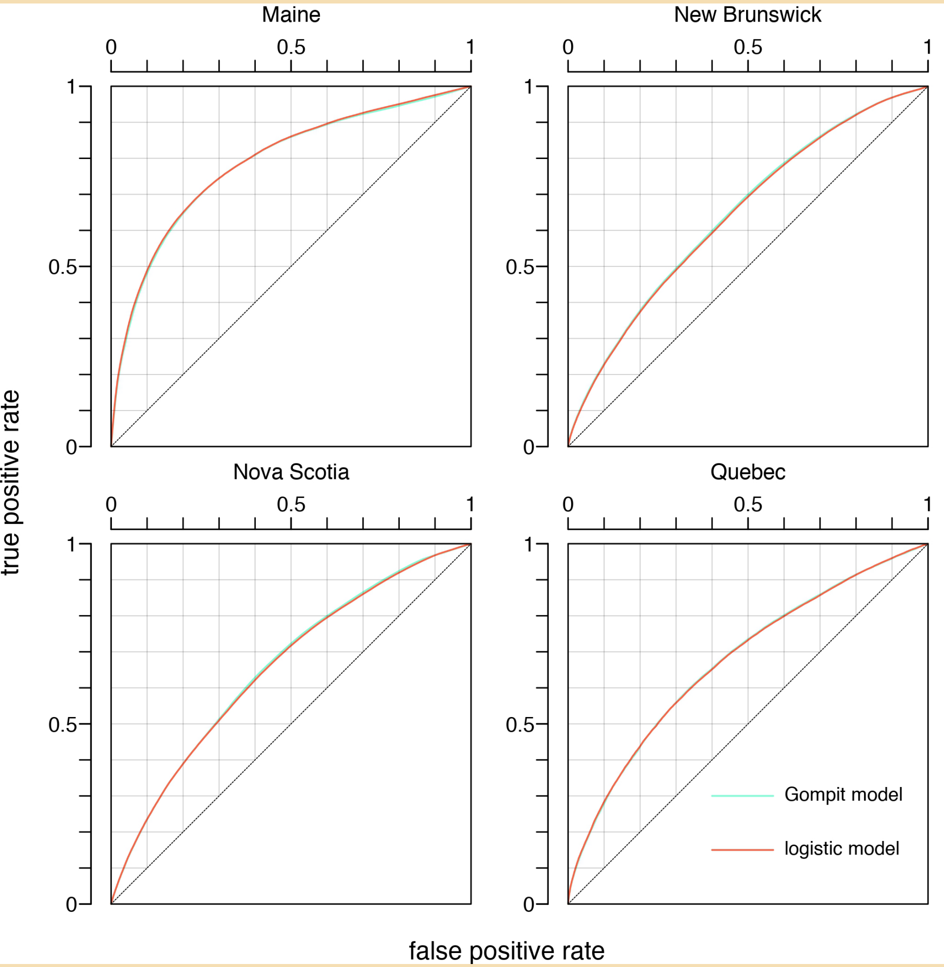


Comparisons with a conventional tree mortality model

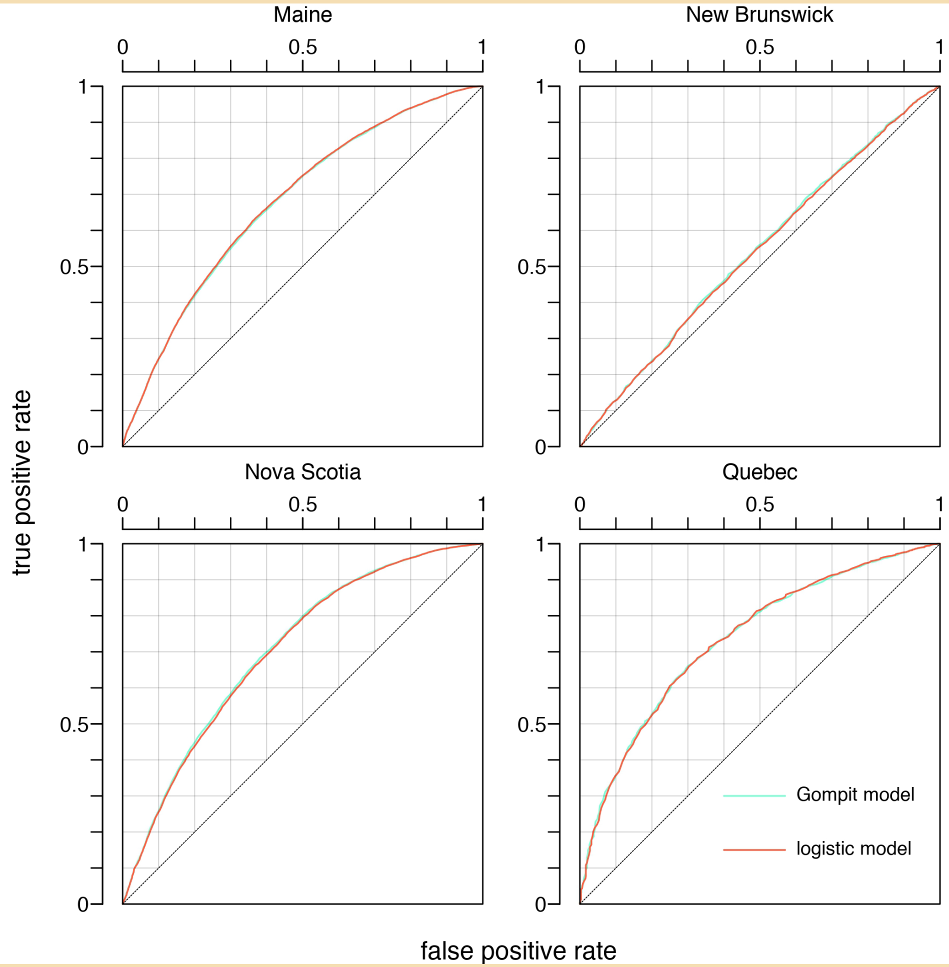


Logistic vs. Gompit

Individual-tree mortality probability



Stand-level mortality probability



Takeaways

- The two modeling approaches have similar fit statistics but distinctive model behaviors.
- Both stand basal area mortality and mortality probability models always have nonzero predictions, but the introduction of an indicator variable extends the range of multistage predictions to zero.
- Previous mortality disaggregation techniques always “kill” a portion of a tree by modifying the tree's mortality probability or expansion factor, and errors in the nonzero tree mortality probability predictions are ignored. A ranking system uses ranks in predicted survival probabilities and is more tolerant to errors in predictions.

Thank you