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Tree defense in a changing world: allocation, functioning and modeling

Henrik Hartmann (1), Rupert Seidl (2), Henry D. Adams (3), Kenneth F. Raffa (4), Almuth Hammerbacher (5,6), Amy M. Trowbridge (7), Dineshkumar Kandasamy (6), Devin W. Goodsman (8), Chonggang Xu (9), Jonathan Gershenzon (6), Markus Kautz (10), and Jianbei Huang (1)

(1) Max-Planck Institute for Biogeochemistry, Biogeochemical Processes, Jena, Germany (hhart@bgc-jena.mpg.de), (2) Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, Austria, (3) Department of Plant Biology, Ecology, and Evolution, Oklahoma State University, Stillwater, USA, (4) Department of Entomology, University of Wisconsin, Madison, WI 53706, USA, (5) Forestry and Agricultural Biotechnology Institute, Department of Zoology and Entomology, University of Pretoria, Private Bag X20, 0028 Pretoria, South Africa , (6) Max Planck Institute for Chemical Ecology, Jena, Germany, (7) Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, USA, (8) Natural Resources Canada, Canadian Forest Service, Victoria, BC, V8Z1M5, Canada, (9) Los Alamos National Laboratory, Los Alamos, NM 87545, USA, (10) Institute of Meteorology and Climate Research – Atmospheric Environmental Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen 82467, Germany

Rapidly changing climate promotes epidemic insect outbreaks and has caused large-scale herbivory-induced forest mortality with major consequences for ecosystem functions, atmospheric processes and global biogeochemical cycles. However, the physiological linkages between climate change, tree defense and biotic attack are still not well understood, hindering our ability to realistically predict biotic attack-driven tree mortality under ongoing climate change.

Here we propose an interdisciplinary research agenda for developing a mechanistic framework of conifer tree defense, aiming to close a crucial knowledge gap in predicting biotic disturbance dynamics under climate change. Our agenda spans field manipulations, laboratory experiments and vegetation modelling, and focuses on a major forest pest, bark beetles, as a model system. Our approach builds upon existing theory and assumptions: 1) there is a trade-off in tree carbon allocation between primary (e.g. growth, storage and osmoregulation via non-structural carbohydrates), and secondary metabolism (e.g., protection and defence via secondary metabolites); 2) secondary metabolites are a main chemical component of tree defence against bark beetles and associated fungi and affects colonization success; and 3) implementing conifer tree-bark beetle interactions in current vegetation simulation models improves predictions of forest disturbance in a changing climate. Our framework provides guidance for addressing a major shortcoming in current implementations of large-scale vegetation models, i.e. herbivory induced tree mortality.