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Editorial: Using Landscape Simulation Models to Help Balance Conflicting Goals in Changing Forests

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Editorial on the Research Topic

Using Landscape Simulation Models to Help Balance Conflicting Goals in Changing Forests

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Forest ecosystems have long been affected by forestry practices and climate change will have additional affects (Soja et al., 2007; Boulanger et al., 2017; Montoro Girona et al., 2018) on the distribution of tree species (Iverson and Prasad, 1998) and on natural disturbance regimes (Boulanger et al., 2014; Seidl et al., 2017; Navarro et al., 2018). As these effects will have strong economic and ecological implications, there are strong incentives to adapt forestry practices to mitigate anticipated negative effects of climate change, through for instance increasing uptake of carbon by vegetation (Lal, 2004), tree species diversification (Hof et al., 2017), and minimizing tree damage by natural disturbances (Noss, 2001; Montoro Girona et al., 2019; Lavoie et al., 2021). Such adaptations may have uncertain effects on other ecosystem services provided by forests (Noss, 2001; Hof and Hjältén, 2018). Thus, a good understanding of how forestry practices and climate change may affect forest dynamics is required if we want to safeguard the ecosystem services that forests provide and the biodiversity they host.

Landscape simulation models are useful tools to assess the effects of anthropogenic and natural disturbances as well as that of climate change on forests. They are primarily used in forestry management, but can also be valuable for other purposes (Xi et al., 2009). They provide valuable information on possibilities for increased carbon sequestration (Scheller et al., 2011), effects of bioenergy extraction (Hof et al., 2018), effectiveness of forest restoration practices (Hof and Hjältén, 2018), and biodiversity (Cadieux et al., 2019, 2020). The 13 articles collected in this research topic on "Using Landscape Simulation Models to Help Balance Conflicting Goals in Changing Forests" give an overview of current work on the use of simulation and modeling techniques to better understand the current and potential future effects of forestry practices and natural disturbances on ecosystem services provided by forests, and how to balance conflicting goals. In this spirit, Sturtevant and Fortin reviewed the recent progress in simulation and modeling techniques used to integrate the effects of disturbances across scales. Gustafson et al. enhanced the PnET-Succession of the forest landscape model LANDIS-II to allow simulation of waterlogged soils and their effects on tree growth and competition. They tested how these modifications to the model alter the water balance and its effect on tree growth and competition, while simulating species range expansion and contraction under climate change across a latitudinal gradient in Siberia.

Several articles addressed the balance between biodiversity conservation and resource extraction in forest landscapes. Biber et al. simulated forest biodiversity, carbon sequestration, and wood production for three combined climate and socio-economic scenarios in ten European forest landscapes. The projections revealed that there was generally no reduction in outcomes for biodiversity indicators with an increase in wood production and that net carbon uptake was not strongly correlated with biodiversity. Furthermore, levels of sustainable wood production varied widely across the landscapes. This demonstrates the complexity of simulating impacts of disturbances on forest ecosystem services across wide scales and stresses the need for individual studies because results cannot necessarily be transferred across time and space. Haga et al. simulated scenarios of potential conflicts between renewable energy and biodiversity conservation in a watershed in north-eastern Japan in the face of climate change. They showed that impacts of renewable energy extraction on biodiversity can be large and that careful planning is needed to balance decarbonization and biodiversity conservation. Pearman-Gillman et al. used a combination of species distribution models and landscape change models to assess how landscape change scenarios built around natural resource planning and socio-economic drivers affect wildlife distributions in the forests of New England, USA. They found that occurrence of most species declined under all scenarios, which emphasizes the importance of integrating such landscape change drivers to assess future suitability of an area for species. Mikusinski et al. assessed habitat suitability for low and high demanding forest specialist species in the network of high conservation value forests in boreal Sweden strengthened by older forests that have not been clear-felled in a long time. They showed that by adding the older forests to the existing conservation value forest network, substantial suitable area can be gained for low demanding species whilst additional habitat restoration is needed for high demanding species. Norris et al. examined the cumulative effects of multiple disturbances on future habitat for a near threatened songbird in Canada's western boreal forest by developing habitat suitability models and using simulation models to project future change in habitat availability under different management and fire regime scenarios. Their results indicate that forest management needs to adapt if we are to conserve specific birds. Micheletti et al. used a novel toolkit built in R to forecast the combined direct and indirect effects of climate pathways, including their interactions and feedbacks, on birds in Canada. They found that, especially due to direct climate effects, the amount of suitable habitat would increase in future for 73% of species assessed. They suggest that hybrid approaches using statistical models and landscape simulation tools could improve forecasts of wildlife presence. Leston et al. projected how boreal birds will respond to cumulative effects of harvest plans, natural disturbances, conservation strategies, and energy-sector development in Alberta, Canada. They evidenced that harvest plans increased habitat for most species associated with forests older than 50 years, but that fire generally reduced the relative amount of habitat for these species. They conclude that multiple anthropogenic impacts should be considered in conservation and land use planning.

Other articles in the collection were focused on the balance between the management of several natural resources. De Jager et al. simulated the impacts of climate change and moose (*Alces alces*) browsing rates on the forests of Isle Royale National Park, USA. Their results suggest that the effects of current moose population management may not be effective in future, because moose may not be able to persist on the island any longer due to decreasing productivity of the vegetation. Robinne et al. used a conservation planning approach to compare nine scenarios of retention harvesting in a boreal mixed wood forest, Canada. Their findings allow assessments of trade-offs between timber production and conservation goals. Lundholm et al. incorporated ecosystem service indicators in a Forest Management Decision Support System (Remsoft Woodstock) that can deal with climate change and dynamic timber markets and analyzed the impact that intensified forest management will have on such indicators in the face of climate change in Ireland. The system they developed can be applied to other forest landscapes across Europe, and by stakeholders that use Remsoft Woodstock. Suárez-Muñoz et al. give a step-by-step workflow to initialize and calibrate a frequently used forest landscape model in a forest landscape in the Mediterranean mountains in Europe and thoroughly test model behavior. As such, this article may greatly benefit and guide new users of such models.

This series of papers stresses the importance of combining models and approaches to address current forest management issues under climate change to maintain ecosystem services provided by forests as well as conserve biodiversity. Despite these developments, we can conclude that we still need to (1) increase our understanding of how successional pathways will be influenced by the sequence of disturbances and drivers, (2) improve the accuracy and availability of parameters needed for models, especially regarding natural disturbances at regional scales, (3) develop new or enhance existing modeling tools to be able to simulate e.g., the impact of other natural disturbances, invasive species propagation, terrestrial and aquatic interactions, understorey vegetation, (4) integrate or augment interactions and feedback loops among ecological processes (for example, annual vegetation changes to affect annual wildfire forecasts, which in turn affect subsequent vegetation). More multidisciplinary scientific collaboration is needed at an international level to create a powerful and useful network of ecological modelers able to include these methodological challenges. Furthermore, collaboration between policymakers and the scientific community is essential to transfer and apply findings in climate change policies.

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AH, MMG, JT, and M-JF: conceptualization, writing original draft, and writing—review and editing. All authors contributed to the article and approved the submitted version.

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REFERENCES

Boulanger, Y., Gauthier, S., and Burton, P. J. (2014). A refinement of models projecting future Canadian fire regimes using homogeneous fire regime zones. *Can. J. For. Res.* 44, 365–376. doi: 10.1139/cjfr-2013-0372

Boulanger, Y., Taylor, A. R., Price, D. T., Cyr, D., McGarrigle, E., Rammer, W., et al. (2017). Climate change impacts on forest landscapes along the Canadian southern boreal forest transition zone. *Landsc. Ecol.* 32, 1415–1431. doi: 10.1007/s10980-016-0421-7

Cadieux, P., Boulanger, Y., Cyr, D., Taylor, A. R., Price, D. T., Sólymos, P., et al. (2020). Projected effects of climate change on boreal bird community accentuated by anthropogenic disturbances in western boreal forest, Canada. *Divers. Distrib.* 26, 668–682. doi: 10.1111/ddi.13057. 719

Cadieux, P., Boulanger, Y., Cyr, D., Taylor, A. R., Price, D. T., and Tremblay, J. A. (2019). Spatially explicit climate change projections for the recovery planning of threatened species: the Bicknell's Thrush (*Catharus Bicknelli*) as a case study. *Glob. Ecol. Conserv*. 17:e00530. doi: 10.1016/j.gecco.2019.e00530

Hof, A. R., Dymond, C. C., and Mladenoff, D. J. (2017). Climate change mitigation through adaptation: the effectiveness of forest diversification by novel tree planting regimes. *Ecosphere* 8:e01981. doi: 10.1002/ecs2.1981

Hof, A. R., and Hjältén, J. (2018). Are we restoring enough? Simulating impacts of restoration efforts on the suitability of forest landscapes for a locally critically endangered umbrella species. *Restor. Ecol.* 26, 740–750. doi: 10.1111/rec.12628

Hof, A. R., Löfroth, T., Rudolphi, J., Work, T., and Hjältén, J. (2018). Simulating long-term effects of bioenergy extraction on dead wood availability at a landscape scale in Sweden. *Forests* 9, 457. doi: 10.3390/f9080457

Iverson, L. R., and Prasad, A. M. (1998). Predicting abundance of 80 tree species following climate change in the eastern United States. *Ecol. Mono.* 68, 465–485. doi: 10.1890/0012-9615(1998)068[0465:PAOTSF]2.0.CO;2

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma* 123, 1–22. doi: 10.1016/j.geoderma.2004.01.032

Lavoie, J., Montoro Girona, M., Grosbois, G., and Morin, H. (2021). Does the type of silvicultural practice influence spruce budworm defoliation of seedlings? *Ecosphere* 12:e03506. doi: 10.1002/ecs2.3506

Montoro Girona, M., Morin, H., Lussier, J. M., and Ruel, J. C. (2019). Post-cutting mortality following experimental silvicultural treatments in unmanaged boreal forest stands. *Front. For. Glob. Change* 2:4. doi: 10.3389/ffgc.2019.00004

Montoro Girona, M., Navarro, L., and Morin, H. (2018). A secret hidden in the sediments: Lepidoptera scales. *Front. Ecol. Evol.* 6:2. doi: 10.3389/fevo.2018.00002

Navarro, L., Morin, H., Bergeron, Y., and Girona, M. M. (2018). Changes in spatiotemporal patterns of 20th century spruce budworm outbreaks in eastern Canadian boreal forests. *Front. Plant Sci.* 9:1905. doi: 10.3389/fpls.2018.01905

Noss, R. F. (2001). Beyond Kyoto: forest management in a time of rapid climate change. *Conserv. Biol.* 15, 578–590. doi: 10.1046/j.1523-1739.2001.015003578.x

Scheller, R. M., Van Tuyl, S., Clark, K. L., Hom, J., and La Puma, I. (2011). Carbon sequestration in the New Jersey pine barrens under different scenarios of fire management. *Ecosystems* 14, 987–1004. doi: 10.1007/s10021-011-9462-6

Seidl, R., Thom, D., Kautz, M., Martin-Benito, D., Peltoniemi, M., Vacchiano, G., et al. (2017). Forest disturbances under climate change. *Nat. Clim. Change* 7, 395–402. doi: 10.1038/nclimate3303

Soja, A. J., Tchebakova, N. M., French, N. H., Flannigan, M. D., and Shugart, H. H., et al. (2007). Climate-induced boreal forest change: predictions versus current observations. *Glob. Planet. Change* 56, 274–296. doi: 10.1016/j.gloplacha.2006.07.028

Xi, W., Coulson, R. N., Birt, A. G., Shang, Z.-B., Waldron, J. D., et al. (2009). Review of forest landscape models: types, methods, development and applications. *Acta Ecol. Sin*. 29, 69–78. doi: 10.1016/j.chnaes.2009.01.001

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