Nicolas Tarasewicz

Simplifying models to help sustainable Swedish forestry

Expressing ecosystem model output and Swedish forestry goals with composite indicators

Forests provide many ecosystem services (ES) essential to human survival. They range widely from timber and food to providing a sense of place or an area of recreation. A holistic balance of many services is required to ensure a sustainable future. More than half of Sweden is covered by forests, most privately-owned monocultures with only one tree species. Seedlings are planted and clear-cut harvested regularly every 60 to 120 years, known as even-aged forestry (EAF). Changing climate conditions across Sweden raises average annual temperatures and increases the amount of damage from high-wind storms, droughts, floods, and pest outbreaks, threatening forest ecosystems' stability. Ecosystem models can simulate the regional patterns of how different climate change scenarios affect forests.

Models help predict potential change but often produce complex and challenging-to-understand output. A tool to simplify these datasets while preserving their integrity is known as composite indicators (CIs), which are widely applied in creating and maintaining sustainability policy. This study developed a CI to convert already-existing model output to aid decision-makers in selecting the best management practices for different regions in Sweden. A CI structure was designed around a central framework capturing the policy aims of Sweden's Environmental Objectives and the UN's Sustainable Development Goals. ES values were averaged into three different regions and grouped based on which goals they most directly addressed. The CI balanced these theoretical groups by considering the underlying relationships and mathematical dynamics at play between each of the ES. The CI mirrored the Swedish Forestry Agency's emphasis on placing equal priority on environmental conservation and production efforts. Another perspective explored prioritizing ES contributing to biodiversity and climate change mitigation over economic production.

Findings suggest the ideal forest management practices combine continuous cover and EAF mixed broadleaf stands for all simulated regions and climate scenarios. Trees adapted to warmer conditions have an advantage over less tolerant coniferous species prevalent in today's monocultures. Continuous cover stands are not clear-cut, and instead, trees are only removed once they are fully grown. EAF strategies showed a preference for longer growing times and less thinning of branches and non-planted trees. The CI prioritized strategies that retained the most carbon in the ecosystem related to climate and biodiversity goals, even with a trade-off of decreasing production output and heightening storm sensitivity. The best strategy focusing only on protection and mitigation aims is unmanaged forests, which severely reduces the amount of useable timber but are extremely beneficial for ecosystem health. The diverse range of benefits gained when transitioning to these managements is substantial. The CI also highlighted ways to improve the model. Any arbitrary decisions during development show that every choice must be justified; otherwise, CIs may distort findings. Current and future sustainability goals will only be met by preserving the full range of services forests provide. A combination of model simulations conveyed with CIs can help inform policymaker and forest owner decisions.

Keywords: Physical geography, ecosystem analysis, forest management, multifunctionality, LPJ-GUESS, composite indicator, climate change adaptation, biodiversity, SDGs, Sweden

Advisor: **Anna Maria Jönsson**
Master degree project 30 credits in Physical Geography and Ecosystem Science, 2021
Department of Physical Geography and Ecosystem Science, Lund University. Student thesis series INES nr 540