The 2020 MWP Award – Full motivation

Citation

The 2020 Marcus Wallenberg Prize is awarded to Richard Waring, Joseph Landsberg, and Nicholas Coops for their groundbreaking work in developing forest growth models based on tree ecophysiology, and further development of these models to widespread geospatial forest analysis using remote sensing techniques. In the 20th century, forest growth was largely predicted based on inventories of historical stand growth, with limited ability to predict responses to innovations in silviculture and changing environments. Prof. Waring and Prof. Landsberg focused on understanding forest growth as a result of ecophysiology at the level of trees and stands. Prof. Coops further developed this approach to explore environmental and biotic influences on forest growth across large landscapes using remote sensing techniques, with applications expanded beyond forest growth into areas of future responses to changing climates and invasive pests. Together these scientists fundamentally changed our understanding of forest growth, providing new, spatially explicit tools that are routinely used by forest managers, scientists and policy makers. Understanding of the forest biomass and subsequently the carbon sink scenarios across large areas is currently of utmost importance when developing tools for climate change mitigation globally.

Background and Prize Motivation

For two centuries, the growth of forests was examined primarily with statistical approaches. Extensive sampling of existing forests allowed the development of yield tables that sought to describe the expected accumulation of wood in relation to stand age. Some stands grew wood more rapidly than others, so the yield tables included notions about site productivity (or site index) that might account for the unknown factors behind differences in forest growth (Assmann 1970, Puettmann et al. 2008, Pretzsch 2010; see Figure 1). Statistical patterns were explained using circular logic: high growth rates occurred on better sites, and such sites were known to be better because growth was higher.

In contrast, Waring and Landsberg pioneered the examination of forest growth as a response to the amount of light absorbed by forest canopies, and the efficiency with which light was used to produce carbohydrates that were apportioned to grow leaves, roots, and stems (Waring 1983). This functional, ecophysiological approach also encompassed the availability of water and soil nutrients, explaining growth in response to quantifiable environmental factors. Representation of forest growth as the product of quantifiable factors led to the development of models in which outcomes were constrained by mass balance. This path-breaking, functional approach to the growth of forest stands by Prof. Waring and Dr. Landsberg led to development of a powerful, practical model that explained why forest growth differed across landscapes: the 3PG model (Physiological Principles Predicting Growth, Landsberg and Waring 1997). Professor Coops expanded this modeling approach beyond the stand level, using spatial and remote sensing approaches to gain insights across large landscapes. He also tackled issues beyond growth predictions, expanding the applications of the model to issues of climate and insect outbreaks. The 3PG model is one of the most widely used process-based growth models in the world, providing predictions for species as varied as plantation eucalypts and pines, including clonal variations in South America and South Africa, to landscape and continental predications for species distributions and stress under changing climates in countries ranging from Australia to North America (reviewed by Gupta and Sharma 2019).

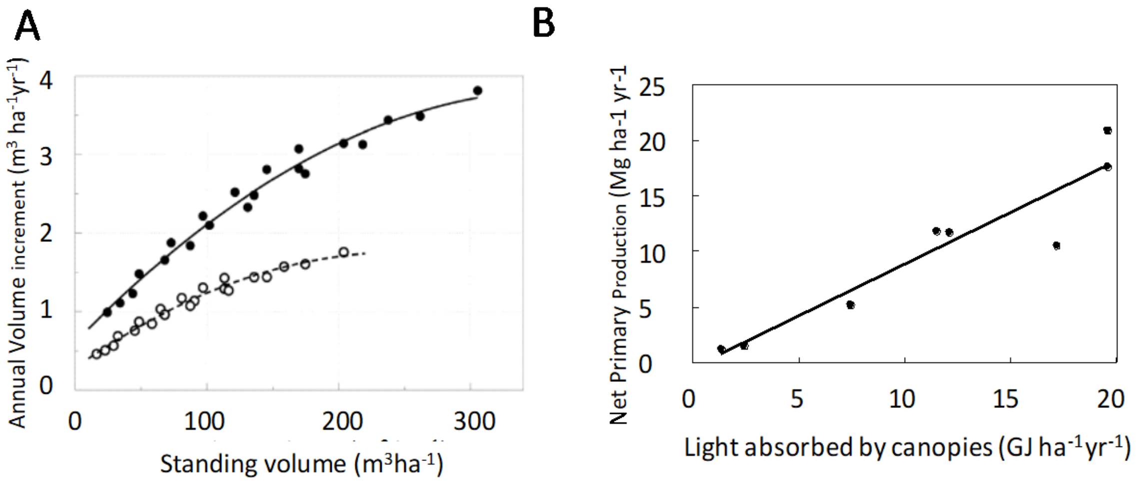

Figure 1. For more than a century, forest growth was predicted based on inventory statistics, with wood growth explained as a function of forest age or standing volume (A, historical example taken from Lundqvist 2017). Differences in growth between sites with the same age or same volume were explained as “site” effects that could only be identified with circular logic (site was known to be poor or good based on growth, and growth was high or low based on site). Late in the 20th century, Waring, Landsberg, and Coops (and colleagues) began to explain growth as a result of the interception of light by canopies, and canopy properties and light interception could be measured, avoiding the circular logic of statistically based descriptions (B, from Runyon et al. 1994).

At a time when process model development was in its infancy and most models were highly complex and/or proprietary, the 3PG modelling approach provided a deliberate and highly innovative simplification of complexity, resulting in effective landscape-level forest growth assessment. Landsberg, Waring and Coops ensured free and open access to the model to the forest community, in a variety of formats, effectively ensuring its broad uptake. Landsberg’s and Waring’s initial paper on the 3PG model (Landsberg and Waring 1997) has received over 1000 citations to date.

As the 3PG model requires data on the characteristics of forest canopies, advances in computing and modelling technology allowed this information to be obtained via remote sensing across large plantations and landscapes (for example, Australia and New Zealand, Coops et al. 1998). The further development of the model by Coops and Waring subsequently demonstrated its utility to predict species distributions and stress in species under a changing climate, as well as linking growth reductions to insect infestations. Its practical outputs such as volume, diameter and biomass have also made the model popular with forest managers wishing to understand growth in short rotation stands. It is also used to assess the potential of afforesting agricultural fields and pastures, and evaluating land suitability (for example, Almeida et al. 2004, 2010). By integrating remote sensing and functional modeling the 3PG model has been used to address a wide range of forest issues on every continent. Over 180 studies have demonstrated its application and its ease of use and open and free availability has resulted in ongoing, extensive model “tailoring” by users worldwide. This includes managers and researchers looking at factors as diverse as forest growth in plantations and mixed-species stands, sensitivity of tree species distributions to a changing climate (Figure 2), regional patterns of biodiversity, changing risks of severe wildfires, and spatial patterns of risks of severe insect outbreaks.

Prof. Waring, Dr. Landsberg, and Prof. Coops have provided a basis for understanding how environmental factors influence forests and their contributions provide a foundation that will support advances far into the future. Thanks to their innovative, cooperative work on developing process-based models, the possibilities to predict future developments in forests caused by environmental changes, such as silviculture and climate change are now considerably more accurate. The combination of process-based models to remote sensing provide tools for accurate and rapid inventory of forest biomass and subsequent understanding of their carbon sink behavior in the future.

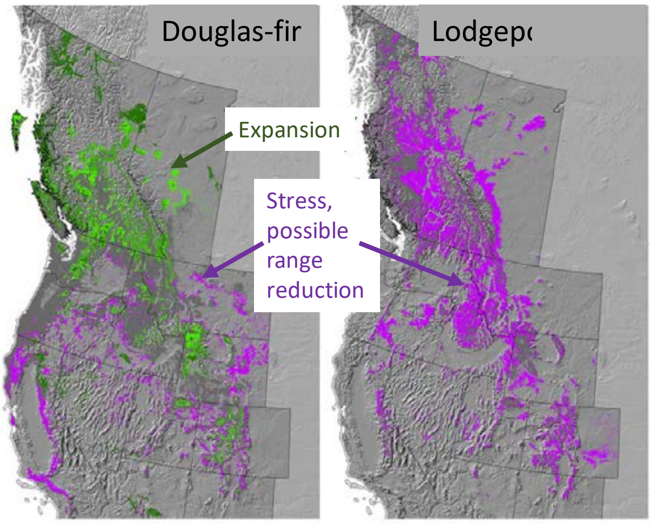

Figure 2. Coops and colleagues expanded the functional approach to explaining forest growth to predict future stress and range expansion of tree species across western North America. Douglas-fir (with contraction to the south) and general contraction for lodgepole pine (from Mathys et al., 2016).

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Nicholas C Coops

Prof. Nicholas Coops' was born in Melbourne, Australia, in 1968 and received his PhD at the Royal Melbourne Institute of Technology in Australia in 1995. Until 2003 he was employed at the Commonwealth Scientific and Industrial Research Organisation, CSIRO, Australia, where he initially worked on the 3PG model with Joseph J Landsberg and Richard H Waring. Today he is a Professor at the University of British Columbia, Vancouver, Canada, where he holds a Canada Research Chair in remote sensing. His research has focused on the use of remote sensing techniques to gain an in-depth knowledge of forest structure, health, biological function and diversity as well as further development and application of the 3PG model globally. He has published more than 460 scientific articles in joint authorship in scientific journals.

Joseph J (Joe) Landsberg

Prof. Joseph Landsberg was born in Harare, Zimbabwe, in 1938. He graduated from the University of Natal and spent a number of years in agricultural research before moving to Scotland, then England. He obtained his PhD from the University of Bristol, UK. His research has focused on the interactions between climate, weather and forests around the world. He was Chief of the Division of Forest Research in the Commonwealth Scientific and Industrial Research Organisation, CSIRO, from 1981 to 1988 and has been Adjunct Professor at Charles Sturt University, Bathurst, and at the University of Queensland, Brisbane – all in Australia. He was a visiting professor at NASA between 1993 and 1994, and at the University of Helsinki, Finland, in 1998. He is an External Member of the Finnish Academy of Science and Letters and was the holder of a Visiting Erskine Fellowship at the University of Canterbury, Christchurch, New Zealand in 2002. He has published four books concerned with the physiological ecology of forests as well as more than a hundred articles, reports and chapters in books.

Richard H (Dick) Waring

Prof. Richard H. Waring was born in 1935 in Chicago, Illinois, USA, and received degrees in Forest Management and Botany from the University of Minnesota. After receiving his PhD at the University of California, he was a professor at Oregon State University. He has been a visiting researcher at many universities and research institutions around the world – The Ecosystems Centre in Woods Hole, Massachusetts, and NASA headquarters in Washington DC, both in the USA; the University of Western Australia in Perth, Australia; the Swedish University of Agricultural Sciences in Uppsala, Sweden; the University of Innsbruck, Austria; the University of Edinburgh, UK; the Commonwealth Scientific and Industrial Research Organisation, CSIRO, in Canberra, Australia; and the University of Waikato, New Zealand. He is now Distinguished Professor Emeritus of Forest Science at Oregon State University, USA, and has published more than 130 articles in scientific journals, along with three editions of a textbook on Forest Ecosystems and numerous book chapters.