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Forward to the second special seedling root development

Issue of *New Forests*

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The papers included in this special edition of *New Forests* were presented during a virtual symposium "Forest Seedling Root Development and Function for Reforestation and Restoration" held October 19–21, 2021. The symposium was organized by the U.S. Department of Agriculture (USDA) Forest Service, the Western Forest and Conservation Association, and Purdue University. Additionally, the event was support by the USDA National Institute of Food and Agriculture and the International Union of Forest Research Organizations (IUFRO) divisions 1.01.03 (Temperate Forest Regeneration), 1.06.00 (Restoration of Degraded Sites), and 3.02.00 (Stand Establishment and Treatment). IUFRO is a non-profit, non-governmental network of more than 150,000 forest scientists in more than 125 countries to promote global cooperation in research and to enhance the understanding of the ecological, economic, and social aspects of forests and trees.

A similar conference also focusing on seedling root development was held in 2004 in Eugene, Oregon (Haase 2005). The proceedings of that event were also published in a special issue of *New Forests* in 2005 (Volume 30, issue 2–3). That issue has been quite popular and garnered many citations. In 2019, we decided it was time to host another event focused on root development. Little did we know there would be a pandemic that would make conference planning very challenging. After rescheduling the event twice, we shifted to the online venue. While an in-person event offers many advantages, the virtual platform helped facilitate wide international participation. The symposium was intended to provide a forum for exchange of ideas related to principles of root development in nursery seedlings and juvenile forest trees. Emphasis was placed on the development of effective and environmentally sound technologies to optimize seedling quality and promote reforestation and forest restoration operations. The range of scientific topics included were expected to provide new, useful information that can be readily and widely applied to nursery and forest practices. All presentations were recorded and are available to view online at: https://rngr.net/resources/webinars.

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As recognized in the 2004 event, seedling research is disproportionately skewed toward aboveground parameters. Plant parts above the soil line are relatively easy to measure and do not require labor-intensive and destructive approaches compared with belowground plant parts. Thus, the body of literature on morphological and physiological development of seedlings planted for reforestation and restoration has a plethora of research that quantified shoot responses, such as height, stem diameter, and gas exchange, in response to a variety of treatment applications or environmental conditions, while data on root responses to the same variables are often lacking. Nonetheless, seedling root development is critical for water and nutrient uptake, structural integrity, and plant vigor after outplanting (Grossnickle 2005, 2012; Grossnickle and MacDonald 2018). In fact, growers can consider seedlings as a "root crop" due to the crucial role of good-quality root systems (Landis 2008). Root quality can be quantified with various measures including mass, shoot-to-root ratio, form, length, fibrosity, root growth potential, and nutrient/carbohydrate content (Davis and Jacobs 2005; Haase 2011).

Of the 13 speakers at the 2021 event, 7 submitted articles for this special issue. One speaker submitted two articles for a total of 8 in this issue. Grossnickle and Ivetić (2022) reviewed the influence of seasonal growth patterns and nursery culturing practices on subsequent seedling quality and field establishment. Gonzalez-Beneckea et al. (2022) described a study to evaluate the use of a vacuum chamber for measurement of whole-plant root system hydraulic conductance. Aubrey (2022) examined treatments to expedite emergence of longleaf pine from the grass stage and their implications on belowground carbon allocation and subsequent ecosystem resilience. Montagnoli and co-authors contributed two papers to the special issue. In the first article, Dumroese et al. (2022) excavated and quantified architectural development of 32-year-old ponderosa pine that were grown in their first year in copper-treated containers to modify their root systems. In the second article, Montagnoli et al. (2022) described research to produce seedlings with asymmetrical root systems and demonstrated that such seedlings have potential for reforestation on challenging sites. Zhang et al. (2022) studied subtropical tree species' root responses to application of varying nitrogen forms. Moler et al. (2022) investigated both genetics and culturing as tools to improve seedling root systems and enhance field performance. Toca et al. (2022) reviewed the influence of nursery environmental conditions on root system growth dynamics.

Many goals have been developed around the world to increase reforestation and restoration to mitigate climate change and address multiple environmental issues such as soil erosion, water quality, food security, etc. (Fargione et al. 2021; Griscom et al. 2017; Verdone and Seidl 2017; Löf et al. 2019). Thus, production of quality seedlings that can survive and thrive is more important than ever if these global goals are to be met (Haase and Davis 2017). The papers included in this special issue are notable contributions to the literature and pave the way for further investigation to deepen our understanding of root development and refine our approaches to successful reforestation and restoration.

We thank the many reviewers who provided thoughtful commentary on the papers included in this special issue. Their constructive comments were instrumental in ensuring each paper was clear, complete, and scientifically sound.

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