Forest Regeneration in Changing Environments

July 11-13th, 2017 || LaSells Stewart Center || Corvallis, OR

IUFRO

Oregon State University

Purdue University

University of Idaho

Welcome!

Welcome to this international conference on **Forest Regeneration in Changing Environments**! Successfully regenerating and managing young forests is the first principle of sustainable forest management. Being able to continuously adapt forest regeneration practices to changing climate, natural, and anthropogenic disturbances, policies, markets, and technologies presents continuous challenges and opportunities in successfully managing forests around the globe.

This is the 9th time that this conference has been held since 1992. Previously called the International Forest Vegetation Management Conference under IUFRO Unit 1.01.04, this meeting has been held about every three years. Previous conferences were held in Halmstad, Sweden (August 2014), Valdivia, Chile (November 2011), Rotorua, New Zealand (March 2009), Corvallis, Oregon (June 2005), Nancy, France (June 2002), Sault Ste. Marie, Ontario, Canada (August 1998), Rotorua, New Zealand (March 1995), and Auburn, Alabama (April 1992).

At the Halmstad, Sweden conference in 2014, conference leaders agreed to expand the scope of the conference beyond managing forest vegetation to include all topics related to forest establishment and early growth dynamics. The name of IUFRO Unit 1.01.04 was changed at that meeting to Forest Establishment & Early Growth Dynamics. This conference is the first to be held under this new title and broader theme.

The goal of this conference is to bring together leading forest researchers and practitioners to share the latest research findings on managing forest regeneration and early stand dynamics in changing environments around the globe. Of particular interest are those new discoveries and practices related to managing forest regeneration that will allow quicker and/or better adaptation to changing environmental, economic, and policy conditions. Proceedings containing selected publications from the conference will be published as a special issue in the international journal, *New Forests*.

Thank you for your contributions to this meeting and we look forward to an exciting three days of keynote presentations, submitted oral and poster presentations, and field tours of the latest forest regeneration research in the US Pacific Northwest.

We hope you benefit from the information presented, the networking opportunities throughout the event, and enjoy the conference overall. Thanks for being here!

Sincerely,

Robert Wagner
Conference Chair

SCHEDULE AT A GLANCE

MONDAY, JULY 10th	
4:00pm	**Conference Registration available in the Gallery**
5:00pm	**Welcome Reception** *LaSells Stewart Center Gallery*
TUESDAY, JULY 11th	
7:30am	**Conference Registration in the Gallery** *Continental Breakfast available*
8:30am	**Opening Plenary** *Construction & Engineering Hall* **Welcome** with Bob Wagner, Conference Chair and Anthony Davis, Oregon State University
8:45am	**Keynote Speaker**: Glenn Howe, Oregon State University **Genetic Considerations in Reforestation in the Face of Climate Change**
9:30am	**Keynote Speaker**: Christian Messier, University of Quebec, Montreal **The Unassisted Migration: Managing Invasive Plants Using a Complexity Approach**
10:15am	**BREAK**
11:00am	**Concurrent Sessions (see page 6)**
12:00pm	**LUNCH**
1:00pm	**Poster Session**: Authors stationed at posters
1:30pm	**Concurrent Sessions continued (see page 6)**
3:00pm	**BREAK**
3:30pm	**Concurrent Sessions continued (see page 6)**
4:30pm	**Concurrent Sessions END**
4:45pm	**Business Meeting** *Ag Production Room*
5:45pm	**Banquet attendees (ticket required) meet in front of conference venue to board bus to Eola Hills Winery (Rickreall, OR) 6-9pm**
WEDNESDAY, JULY 12th	
7:30am	**Conference Registration in the Gallery** *Continental Breakfast available*
8:30am	**Opening Plenary** *Construction & Engineering Hall* **Keynote Speaker**: Peter Reich, University of Minnesota **Forest Regeneration Under Global Environmental Change: The Good, the Bad, and the Ugly**
9:15am	**Keynote Speaker**: Lee Allen, North Carolina State University (retired) **Precision Silviculture is a Possibility, But What is Required for it to Become a Reality?**
10:00am	**BREAK**
11:00am	**Concurrent Sessions (see page 7)**
12:00pm	**LUNCH**
1:00pm	**Concurrent Sessions continued (see page 7)**
2:30pm	**BREAK**
3:00pm	**Concurrent Sessions continued (see page 7)**
4:30pm	**Wrap-up** *Construction & Engineering Hall*
5:00pm	**Social Hour in the Gallery-** Refreshments provided!
6:00pm	**Conference Sessions END**
THURSDAY, JULY 13th	
Field Tours (pre-registration required)	
FRIDAY, JULY 14th to SUNDAY, JULY 16th	
Post-Conference Field Tour (pre-registration required)	

Forest Regeneration Planning Committee

Scientific Program Committee

This conference was organized as a joint meeting of IUFRO 1.01.04 – Forest Establishment & Early Growth Dynamics (Coordinator: Robert G. Wagner, United States and Deputy: Nicholas Mc Carthy, Ireland) and IUFRO 2.01.15 – Whole Plant Physiology (Coordinator: Douglass Jacobs, United States Deputies: Barbara J. Hawkins, Canada and Pedro Villar-Salvador, Spain) This scientific content of the conference also was led by an international program committee:

M. Paulina Fernández
Pontifical Catholic University of Chile

Karin Hjelm
The Forestry Research Institute of Sweden

Keith Little
Nelson Mandela Metropolitan University, South Africa

Euan Mason
University of Canterbury, New Zealand

Nick Mc Carthy
Waterford Institute of Technology, Ireland

Carol Rolando
Scion, New Zealand

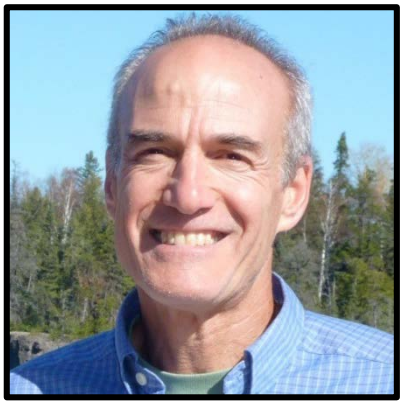
Nelson Thiffault
Ministry of Forests, Wildlife, and Parks, Canada

Keynote Speakers

Lee Allen
North Carolina State University (retired)
Lee is owner of ProFOR Consulting and C.A. Schenck Distinguished Professor Emeritus at the Department of Forestry and Environmental Resources at North Carolina State University (NCSU). During the first 30 years of his career, Lee provided the leadership of the Forest Nutrition Cooperative (FNC). Under his leadership, the FNC grew from a regional fertilizer cooperative into an internationally recognized silviculture research and education partnership. For the last nine years, Lee has provided technical support and recommendations for all aspects of silviculture for clients throughout the Americas who are interested in enhancing the value of their forests. Lee received his BS and MS in Forestry from the University of Maine and his Ph.D. in Forestry from NCSU.

Glenn Howe
Oregon State University
Glenn is an Associate Professor of forest genetics and Director of the Pacific Northwest Tree Improvement Research Cooperative at Oregon State University (OSU). He received his B.S. degree in forestry from Pennsylvania State University, M.S. degree in forest genetics from Michigan State University, and a Ph.D. in genetics from Oregon State University. Glenn held positions at the University of Minnesota and Ohio State University before returning to OSU in 2001. Glenn's research interests include the physiological and ecological genetics of forest trees, forest tree genomics, tree breeding, and adapting forests to climate change.

Christian Messier
University of Quebec, Montreal
Christian is professor of Forest Ecology and Urban Forestry and scientific director at ISFORT at the University of Quebec, in Canada (UQO and UQAM). His research interests are wide, ranging from the basic understanding of tree growth and death, forest community and ecosystem functioning to decision-making tools to better manage and conserve natural and urban forests. His research has brought him to study various biomes across the world. He has published more than 220 referee journal papers and recently co-edited a book for the general public on basic ecological concept that can be observed in the city titled "Nature all around us". He is also co-author of a recent book titled "A critique of silviculture: managing for complexity" and a more recent one titled "Managing forests as complex adaptive systems". He holds a research Chair on tree growth.



Peter Reich
University of Minnesota
Peter is a professor of forest ecology in the Department of Forest Resources at the University of Minnesota. His teaching and research both focus on ecology, global change, and the sustainability of managed and unmanaged terrestrial ecosystems. His work focuses regionally on the forests and grasslands of North America and globally on terrestrial ecosystems in aggregate. This work includes long-term experimental field studies of climate change effects on grasslands and forests, long-term observational studies using field and inventory data, and the development of complex global carbon cycling models.

Attendee Resources

Parking…

This is a reminder that **parking on campus requires a permit**. Please see someone at the Registration Table if you have questions about parking.

Get connected…

All conference participants can connect to OSU's wi-fi! Access the wi-fi setting on your device and choose "Visitor". Password not required. (Reconnection required every 4 hours.)

Recharge…

Look for a charging station in the Myrtle Creek Alcove.

Network…

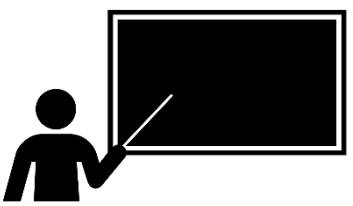
Need a place to have a cup of coffee or conversation with a professional contact, colleague, or friend? Help yourself to a table in the Gallery during the concurrent sessions.

Abstracts…

Abstracts can be accessed at http://blogs.oregonstate.edu/forestregen2017/abstracts-2017/.

Oral Presenters…

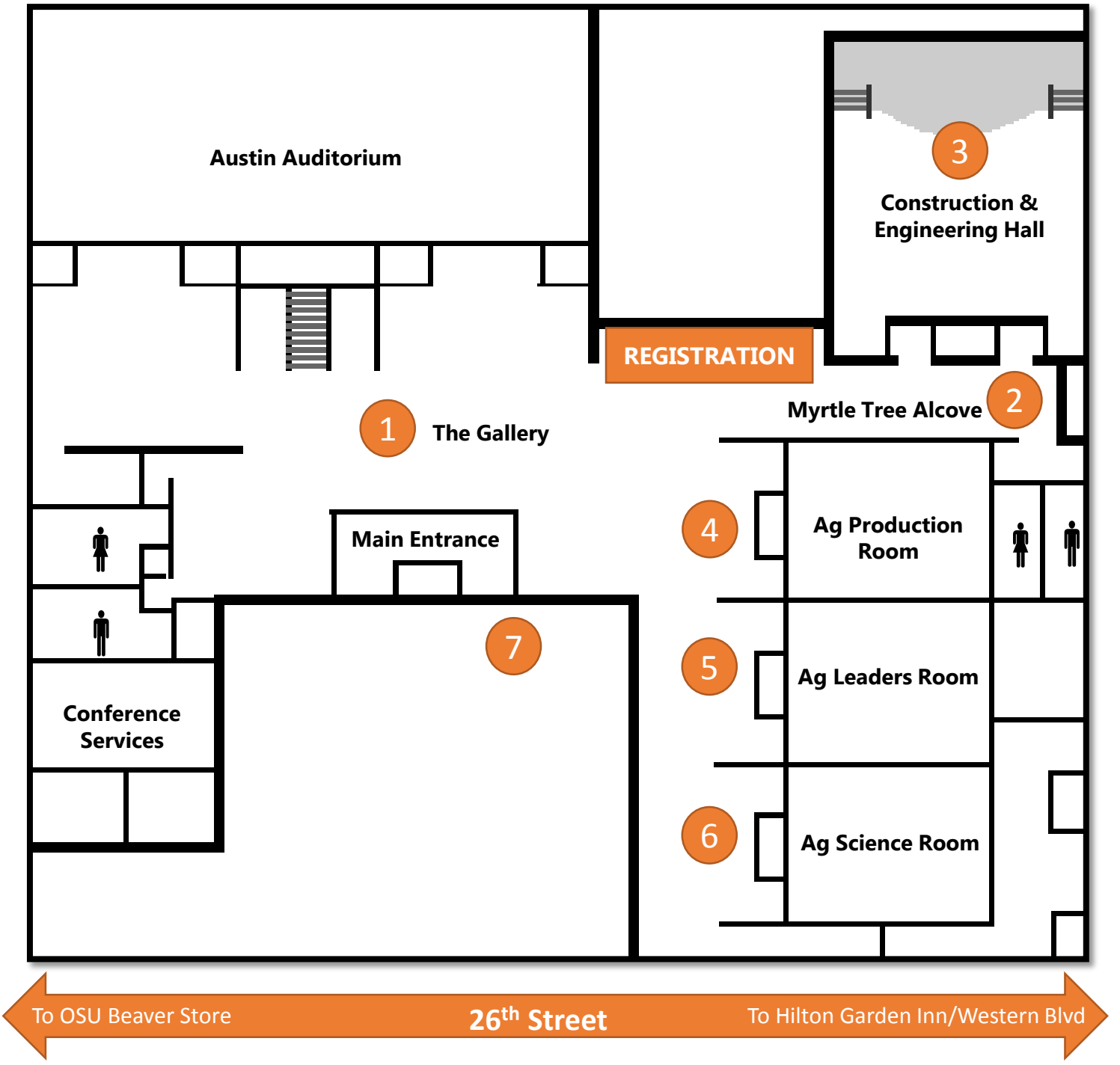
Bring your USB to the Registration Table (due east of the main entrance) to upload your presentation for the conference.



Poster Presenters…

See the Poster Map located on the poster boards or at the Registration Table. Please hang your poster **before** the poster session on Tuesday afternoon. Posters can remain on the boards until the close of the conference on Wednesday.

LaSells Stewart Center Map



1. The Gallery - Exhibitors, Registration, Coffee Stations, Breaks, Lunch, Poster Session
2. Myrtle Tree Alcove - Charging Station
3. Construction & Engineering Hall – Plenary Sessions, Concurrent Sessions
4. Ag Production Room – Concurrent Sessions
5. Ag Leaders Room – Concurrent Sessions
6. Ag Science Room - Concurrent Sessions
7. Loading Area – Meet for Banquet or Field Tours

TUESDAY, JULY 11th

TUESDAY CONCURRENT SESSIONS

	Session	**Modeling Forest Regeneration & Young Stand Dynamics**	**Seedling Health (Insect & Disease)**	**Reforestation Silviculture**	**Precision Silviculture & Intensive Forest Management**
	Location	Construction & Engineering Hall	Ag Production Room	Ag Leaders Room	Ag Science Room
	Moderator	Douglas Maguire, Oregon State University	Mary Anne Sayer, USDA Forest Service	Karin Hjelm, The Forestry Research Institute of Sweden	Kristina Wallertz, Southern Swedish Forest Research Center
11:00am		**John-Pascal Berrill** *Humboldt State University* Kriging understory light to predict stump sprout growth in mixed multiaged stands in North Coastal California	**Cecilia Malmqvist** *Linnaeus University* Survival, early growth and impact of damage by late spring frost and winter desiccation of Douglas-fir in southern Sweden	**Dorota Dobrowolska** *Forest Research Institute* Natural regeneration after fire in Scots pine forests in central Poland	**Matthew Aghai** *University of Washington* Early survival and growth response of native Washington tree species to light and moisture gradients: Informing artificial regeneration
11:30am		**Olalla Diaz-Yanez** *University of Eastern Finland* What variables make a young forest stand more vulnerable to ungulate browsing occurrence?	**Nick Mc Carthy** *Waterford Institute of Technology Ireland* Pests and Pathogens: Potential to radically change Irish forest regeneration!	**Felix Oboite** *University of Alberta Edmonton* Release response of black spruce and white spruce following overstory lodgepole pine mortality due to mountain pine beetle attack	**Douglass Jacobs** *Purdue University* Conversion of introduced conifer plantations: Influences of light and nutrients on understory hardwood regeneration
12:00pm		**LUNCH & Poster Session**			
	Session	**Modeling Forest Regeneration & Young Stand Dynamics**	**Seedling Health (Insect & Disease)**	**Reforestation Silviculture**	**Precision Silviculture & Intensive Forest Management**
	Location	Construction & Engineering Hall	Ag Production Room	Ag Leaders Room	Ag Science Room
	Moderator	Douglas Maguire, Oregon State University	Mary Anne Sayer, USDA Forest Service	Karin Hjelm, The Forestry Research Institute of Sweden	Kristina Wallertz, Southern Swedish Forest Research Center
1:30pm		**Emma Holmström** *Swedish University of Agricultural Science* Modeling birch seed supply and seedling establishment during forest regeneration	**Brianna McTeague** *USDA Forest Service* Considerations for managing regeneration of Foxtail pine (*Pinus balfouriana*) in the face of a non-native pathogen and a changing	**Karin Hjelm** *The Forestry Research Institute of Sweden* Regeneration of *Populus spp* in Sweden: a challenge?	**Urban Nilsson** *Swedish University of Agricultural Science* Pre-commercial thinning to create fodder for browsing animals
2:00pm		**John Lhotka** *University of Kentucky* Comparing individual-tree approaches for predicting height growth of underplanted seedlings	**Mary Anne Sayer** *USDA Forest Service* Effect of season of prescribed fire on the foliage reestablishment and starch dynamics of *Pinus palustris* Mill. saplings	**Olivia Moskowitz** *University of Washington* The effects of varying light and moisture levels on early survival and development of twelve Pacific Northwest tree species	**Cathrine Steffy Pater** *University of Copenhagen* Effects of planting date and container volume in relation to site and year on survival and height of planted conifers and broadleaves
2:30pm		**Douglas Maguire** *Oregon State University* Models for projecting competing vegetation dynamics by life form in young Douglas-fir plantations	**Bora Imal** *Cankiri Karatekin University* Comparing P-V curve and polyethylene glycol tests in Anatolian Black Pine (*Pinus nigra* Arnold. subsp. pallasiana) in different provenance of Turkey	**Valeriu-Norocel Nicolescu** *University Transylvania of Brasov Romania* Regeneration and early tending of black locust (*Robinia pseudoacacia L.*) in the north-west of Romania	**Joshua Sloan** *New Mexico State University* Use of stable isotopes to trace the fate of applied nitrogen in an intensively managed black walnut plantation
3:00pm		**BREAK**			
	Session	**Modeling Forest Regeneration & Young Stand Dynamics**	**Seedling Production, Quality, & Physiology**	**Reforestation Silviculture**	**Precision Silviculture & Intensive Forest Management**
	Location	Construction & Engineering Hall	Ag Production Room	Ag Leaders Room	Ag Science Room
	Moderator	Douglas Maguire, Oregon State University	Anthony Davis, Oregon State University	Karin Hjelm, The Forestry Research Institute of Sweden	Kristina Wallertz, Southern Swedish Forest Research Center
3:30pm		**Doug Mainwaring** *Oregon State University* Modifiers for predicting the negative effect of competing vegetation on growth of Douglas-fir trees in young plantations	**Matthew Aghai** *University of Washington* Evaluating microbial endophytes as a nursery and field amendment for improving reforestation success	**Oscar Nilsson** *Southern Swedish Forest Research Center* Establishment and initial growth of planted Scots pine and Norway spruce on low and high fertility sites in northern and southern Sweden	**Richard Sniezko** *USDA Forest Service* The role of genetics in successful regeneration of forests
4:00pm		**Euan Mason** *University of Canterbury* Precision forestry: What does hybrid physiological/mensurational modelling offer?	**NO SCHEDULED TALK**	**Brian Richardson** *New Zealand Forest Research Institute* Why is New Zealand not planting more trees?	**Kristina Wallertz** *Southern Swedish Forest Research Center* Site preparation techniques: Effects on planting conditions, seedling growth and pine weevil damage
4:30pm		**END OF CONCURRENT SESSIONS**			

WEDNESDAY, JULY 12th

WEDNESDAY CONCURRENT SESSIONS

	Session	**Modeling Forest Regeneration & Young Stand Dynamics**	**Seedling Production, Quality, & Physiology**	**Reforestation Silviculture**
	Location	Ag Production Room	Ag Leaders Room	Ag Science Room
	Moderator	Douglas Maguire, Oregon State University	Inger Fløistad, Norwegian Insitute of Bioeconomy Research	Andrew Nelson, University of Idaho
11:00am		**Serajis Salekin** *University of Canterbury* Modeling juvenile height yield of *Eucalyptus globoidea* and *Eucalyptus bosistoana* in response to micro-site effects	**Owen Burney** *New Mexico State University* Drought-conditioning during nursery production influences physiology and resource allocation of *Populus tremuloides* and *Pinus ponderosa* seedlings	**Ulf Sikström** *The Forestry Research Institute of Sweden* Regeneration success of *Picea abies* after whole-tree harvesting and ash addition
11:30am		**Chenchen Shen** *University of Idaho* The response and adaptation of tree seedling regeneration to potential competition in the Inland Northwest Forests, USA	**Anthony Davis** *Oregon State University* Enhancing nursery practices in politically and environmentally challenging regions	**Florent Noulèkoun** *Center for Development Research* Above and belowground responses of fast- and slow-growing afforestation species to silvicultural management on degraded cropland in semi-arid zone of Benin
12:00pm		**LUNCH**		
	Session	**Vegetation Management & Invasive Plants**	**Seedling Production, Quality, & Physiology**	**Forest Reclamation**
	Location	Ag Production Room	Ag Leaders Room	Ag Science Room
	Moderator	Elizabeth Cole, Oregon State University	Inger Fløistad, Norwegian Insitute of Bioeconomy Research	Andrew Nelson, University of Idaho
1:00pm		**Elizabeth Cole** *Oregon State University* Douglas-fir and western larch response to vegetation management treatments in Northeastern Oregon	**Nicklos Dudley** *Hawaii Agriculture Research Center* Expanding the Koa Network: An eco-regional approach to deploying disease resistant *Acacia koa* in Hawaii	**Horacio Bown** *University of Chile* Compensating copper mining impacts with forest plantations of native species under strong water limitations in Northern Chile
1:30pm		**Carlos Gonzalez-Benecke** *Oregon State University* Use of Water Stress Integral as a tool to analyze competing vegetation effects on Plant Water Stress and Seedling Productivity	**Douglass Jacobs** *Purdue University* Nursery cultural techniques to promote restoration of *Acacia koa* competing with exotic grass in a dry tropical forest	**John Lhotka** *University of Kentucky* Forestry Reclamation Approach in the Appalachian Coal Fields: Nineteen-year results from a multi-species reforestation experiment
2:00pm		**Ed Fredrickson** *Thunder Road Resources* Conifer tolerance, herbaceous and woody brush control with Cleantraxx: A New Forestry Herbicide	**Inger Fløistad** *Norwegian Institute of Bioeconomy Research* Effect of photoperiod and fertilization on growth and establishment in *Picea abies* seedlings	**Katie McMahen** *University of British Columbia* Forest legacy-based mine reclamation methods for facilitating recolonization of soil biological communities: Preliminary field and greenhouse trial results
2:30pm		**BREAK**		
	Session	**Vegetation Management & Invasive Plants**	**Seedling Production, Quality, & Physiology**	
	Location	Ag Production Room	Ag Leaders Room	
	Moderator	Elizabeth Cole, Oregon State University	Inger Fløistad, Norwegian Insitute of Bioeconomy Research	
3:00pm		**Robert Wagner** *Purdue University* Influence of browsing and overstory retention on American beech and sugar maple regeneration nine years following understory herbicide release in central Maine	**Rebecca Sheridan** *Oregon State University* Impacts of initial root volume on Douglas-fir seedling growth and physiological function after planting	**NO SCHEDULED TALK**
3:30pm		**Maxwell Wightman** *Oregon State University* Integrated analysis on the effects of chemical vegetation management treatments on understory vegetation community dynamics in the Pacific Northwest, USA	**Jessica Sarauer** *University of Idaho* Biochar and Douglas-fir seedling growth and quality	**NO SCHEDULED TALK**
4:00pm		**Willoughby, Ian** *Forestry Commission* *Gaultheria shallon* can be effectively controlled by the herbicides picloram, triclopyr or glyphosate if they are applied at the correct time of year	**Jacob Reely** *University of Idaho* Biomass allocation patterns of three Northwest conifer species: The effects of seedling quality, site quality, and moisture stress	**NO SCHEDULED TALK**
4:30pm		**END OF CONCURRENT SESSIONS**		

Modeling Forest Regeneration & Young Stand Dynamics

Modeling Forest Regeneration & Young Stand Dynamics

Tuesday, July 11th

Construction & Engineering Hall

11:00am	**John-Pascal Berrill** Kriging understory light to predict stump sprout growth in mixed multiaged stands in North Coastal California
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3:30pm	**Doug Mainwaring** Modifiers for predicting the negative effect of competing vegetation on growth of Douglas-fir trees in young plantations
4:00pm	**Euan Mason** Precision forestry: What does hybrid physiological/mensurational modelling offer?

Wednesday, July 12th

Ag Production Room

11:00am	**Serajis Salekin** Modeling juvenile height yield of *Eucalyptus globoidea* and *Eucalyptus bosistoana* in response to micro-site effects
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Vegetation Management & Invasive Plants

Vegetation Management & Invasive Plants

Wednesday, July 12th

Ag Production Room

1:00pm	**Elizabeth Cole** Douglas-fir and western larch response to vegetation management treatments in Northeastern Oregon
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2:00pm	**Ed Fredrickson** Conifer tolerance, herbaceous and woody brush control with Cleantraxx: A New Forestry Herbicide
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4:00pm	**Ian Willoughby** Gaultheria shallon can be effectively controlled by the herbicides picloram, triclopyr or glyphosate if they are applied at the correct time of year

Seedling Health (Insects & Disease)

Tuesday, July 11th

Ag Production Room

11:00am	**Cecilia Malmqvist** Survival, early growth, and impact of damage by late spring frost and winter desiccation of Douglas-fir in southern Sweden
11:30am	**Nick Mc Carthy** Pests and Pathogens: Potential to radically change Irish forest regeneration!
1:30pm	**Brianna McTeague** Considerations for managing regeneration of Foxtail Pine (*Pinus balfouriana*) in the face of a non-native pathogen and a changing climate
2:00pm	**Mary Anne Sayer** Effect of season of prescribed fire on the foliage reestablishment and starch dynamics of *Pinus palustris* Mill. saplings
2:30pm	**Bora Imal** Comparing P-V curve and polyethylene glycol tests in Anatolian Black Pine (*Pinus nigra* Arnold. subsp. pallasiana) in different provenance of Turkey

Seedling Production, Quality, & Physiology

Tuesday, July 11th

Ag Production Room

3:30pm	**Matthew Aghai** Evaluating microbial endophytes as a nursery and field amendment for improving reforestation success

Wednesday, July 12th

Ag Leaders Room

11:00am	**Owen Burney** Drought-conditioning during nursery production influences physiology and resource allocation of *Populus tremuloides* and *Pinus ponderosa* seedlings
11:30am	**Anthony Davis** Enhancing nursery practices in politically and environmentally challenging regions
1:00pm	**Nicklos Dudley** Expanding the Koa Network: An eco-regional approach to deploying disease resistant *Acacia koa* in Hawaii
1:30pm	**Douglass Jacobs** Nursery cultural techniques to promote restoration of *Acacia koa* competing with exotic grass in a dry tropical forest
2:00pm	**Inger Fløistad** Effect of photoperiod and fertilization on growth and establishment in *Picea abies* seedlings
3:00pm	**Rebecca Sheridan** Impacts of initial root volume on Douglas-fir seedling growth and physiological function after planting
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Reforestation Silviculture

Reforestation Silviculture

Tuesday, July 11th

Ag Leaders Room

11:00am	**Dorota Dobrowolska** Natural regeneration after fire in Scots pine forests in central Poland
11:30am	**Felix Oboite** Release response of black spruce and white spruce following overstory lodgepole pine mortality due to mountain pine beetle attack
1:30pm	**Karin Hjelm** Regeneration of *Populus* spp in Sweden: a challenge?
2:00pm	**Olivia Moskowitz** The effects of varying light and moisture levels on early survival and development of twelve Pacific Northwest tree species
2:30pm	**Valeriu-Norocel Nicolescu** Regeneration and early tending of black locust (*Robinia pseudoacacia L.*) in the north-west of Romania
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Wednesday, July 12th

Ag Science Room

11:00am	**Ulf Sikström** Regeneration success of *Picea abies* after whole-tree harvesting and ash addition
11:30am	**Florent Noulèkoun** Above and belowground responses of fast- and slow-growing afforestation species to silvicultural management on degraded cropland in semi-arid zone of Benin

Forest Reclamation

Forest Reclamation

Wednesday, July 12th

Ag Science Room

1:00pm	**Horacio Bown** Compensating copper mining impacts with forest plantations of native species under strong water limitations in Northern Chile
1:30pm	**John Lhotka** Forestry Reclamation Approach in the Appalachian Coal Fields: Nineteen-year results from a multi-species reforestation experiment
2:00pm	**Katie McMahen** Forest legacy-based mine reclamation methods for facilitating recolonization of soil biological communities: Preliminary field and greenhouse trial results

Precision Silviculture & Intensive Forest Management

Precision Silviculture & Intensive Forest Management

Tuesday, July 11th

Ag Science Room

11:00am	**Matthew Aghai** Early survival and growth response of native Washington tree species to light and moisture gradients: Informing artificial regeneration
11:30am	**Douglass Jacobs** Conversion of introduced conifer plantations: Influences of light and nutrients on understory hardwood regeneration
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3:30pm	**Richard Sniezko** The role of genetics in successful regeneration of forests
4:00pm	**Kristina Wallertz** Site preparation techniques: Effects on planting conditions, seedling growth and pine weevil damage

Posters

Attend the Poster Session at 1:00pm in the Gallery on Tuesday. Abstracts available online.

IRIS ALLEN || WEST VIRGINIA UNIVERSITY || ICA0002@MIX.WVU.EDU
SOPHAN CHHIN AND JIANWEI ZHANG
EVALUATING POST-FIRE RESTORATION IN THE MIXED CONIFER FOREST OF THE SIERRA NEVADA USING PLANTATIONS

JOHN BUTNOR || USDA FOREST SERVICE || JBUTNOR@FS.FED.US
KURT JOHNSON, BRITTANY VERRICO, STEPHEN KELLER, CHRIS MAIER, AND VICTOR VANKUS
RED SPRUCE IN THE SOUTHERN APPALACHIANS: GENE CONSERVATION, SEED PROPERTIES AND ADAPTIVE TRAITS FOR FUTURE CLIMATES

ERDA CELER || OREGON STATE UNIVERSITY || ERDA.CELER@OREGONSTATE.EDU
GLENN HOWE
DOUGLAS-FIR SEEDLINGS IN THE PACIFIC NORTHWEST: THE GENETICS OF DROUGHT ADAPTATION

JONATHAN CHERICO || UNIVERSITY OF IDAHO || CHER1952@VANDALS.UIDAHO.EDU
ANDREW NELSON AND THERESA JAIN
LONG TERM EFFECTS OF SITE PREPARATION ON GROWTH AND PRODUCTIVITY OF INTERIOR DOUGLAS-FIR AND WESTERN WHITE PINE IN NORTHERN IDAHO

HERMAN FLAMENCO || OREGON STATE UNIVERSITY || HERMAN.FLAMENCO@OREGONSTATE.EDU
MAXWELL WIGHTMAN AND CARLOS GONZALEZ-BENECKE
LONG TERM EFFECTS OF VEGETATION MANAGEMENT IN THE PNW: ASSESSMENT OF BIOMASS STOCK AND NET PRIMARY PRODUCTIVITY RESPONSES OF FOUR CONIFEROUS SPECIES

INGER FLØISTAD || NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH || INGER.FLOISTAD@NIBIO.NO
ESPEN KRISTOFFER JENSEN
CONTROL OF *SAMBUCUS RACEMOSA* ON FOREST REGENERATION SITES

KAITLIN GERBER || OREGON STATE UNIVERSITY || KAITLIN.GERBER@OREGONSTATE.EDU
ANTHONY DAVIS AND ANDREW NELSON
PHOTOPERIOD REDUCTION INFLUENCES WESTERN LARCH (*LARIX OCCIDENTALIS* NUTT.) SEEDLING DEVELOPMENT

CARLOS GONZALEZ-BENECKE || OREGON STATE UNIVERSITY || CARLOS.GONZALEZ@OREGONSTATE.EDU
MAXWELL WIGHTMAN
USING AGE-SHIFT METHOD TO ESTIMATE LONG-TERM GAINS OF VEGETATION MANAGEMENT

AMY RAMSEY || WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES || AMY.RAMSEY@DNR.WA.GOV
RICHARD SNIEZKO, DAN OMDAL, ROBERT DANCHOK, DOUGLAS SAVIN AND ANGELIA KEGLEY
ESTABLISHING AND MONITORING BLISTER RUST RESISTANCE, PATHOGEN VIRULENCE, AND GENETIC ADAPTABILITY OF WESTERN WHITE PINE IN WASHINGTON

ASHIK RUBAIYAT || UNIVERSITY OF GOETTINGEN || ASHIK108@GMAIL.COM
LOKMAN HOSSAIN, SARAH JABEEN KRISTY AND KAWSER UDDIN
SHIP BREAKING YARD SOIL: SAFE OR HARM FOR SEEDLINGS GROWTH

ANDREW SELF || MISSISSIPPI STATE UNIVERSITY || BRADY.SELF@MSSTATE.EDU
JOHN WILLIS
ACHIEVING ADEQUATE OAK REGENERATION THROUGH SHELTERWOOD CUTTINGS IN MISSISSIPPI

KRISTEN WARING || NORTHERN ARIZONA UNIVERSITY || KRISTEN.WARING@NAU.EDU
ANTONIO CASTILLA, SAM CUSHMAN, ANDREW ECKERT, LLUVIA FLORES, RICHARD SNIEZKO, CHRISTOPHER STILL, CHRISTIAN WEHENKEL, AMY WHIPPLE AND MICHAEL WING
COLLABORATIVE RESEARCH FOR SUSTAINABLE MANAGEMENT OF SOUTHWESTERN WHITE PINE

Conference Extras

Banquet- Ticket Required

The banquet will take place from 6:30-9pm on Tuesday, July 11th at **Eola Hills Winery in Rickreall, Oregon**. The banquet includes appetizers, dinner, and one glass of wine or beer. It tends to cool off in the evenings in the valley, so please bring a sweater or light jacket for warmth. Transportation will be provided. Bus boarding will begin at **5:45pm** in front of LaSells Stewart Center (26th Street) and we will leave promptly at 6pm to arrive at the winery on time for dinner. The bus will return to OSU around 9pm.

Please note: *if you did not purchase a banquet ticket during registration, you will not be able to attend the banquet. On-site tickets will not be available. To verify that you purchased a ticket, please consult your registration confirmation or check with someone at the Registration Table.*

Field Tours- Pre-registration Required

Thursday, July 13th

There are 3 field tours that will take place on Thursday, July 13th. Pre-registration is required and was available during conference registration. No on-site field tour registration is available. If you are not sure whether you signed up for a field tour, please consult your registration confirmation, or check with someone at the Registration Table.

It will be important to have accurate counts for both the transportation and the catered lunches, so it's important that you **attend the field tour that you are registered for**. Meet your group by 7:30am in front of the LaSells Stewart Center to load into the vans for departure. Transportation, lunch, refreshments, and detailed itineraries will be provided during the tours. Field tours will return to Corvallis by approximately 6pm.

What to wear/bring:

- Comfortable shoes for walking on uneven ground
- Layered clothing
- Hats and/or sunglasses
- Sunscreen
- Water bottles
- Something to take notes with/on

Post-Conference Field Tour - Pre-registration Required

Friday July 14th - Sunday, July 16th

The post-conference field tour will depart from Corvallis at 7am on Friday, July 14th. Meet the tour group (led by Andrew Nelson, University of Idaho) in front of LaSells Stewart Center by 6:45am to load your bags into the vehicles. Remember that you will not return to Corvallis, so please bring everything with you. You will receive a detailed itinerary at the beginning of the tour. Refer to the list above (for the one-day field tours) for some items that you should keep handy during the tour. **Reminder**: Transportation, double occupancy lodging, and meals are included in the tour, but there will be opportunities for purchasing souvenirs at several of the stops. The tour will end at the Portland International Airport on the morning of Sunday, July 16th.

Participant List

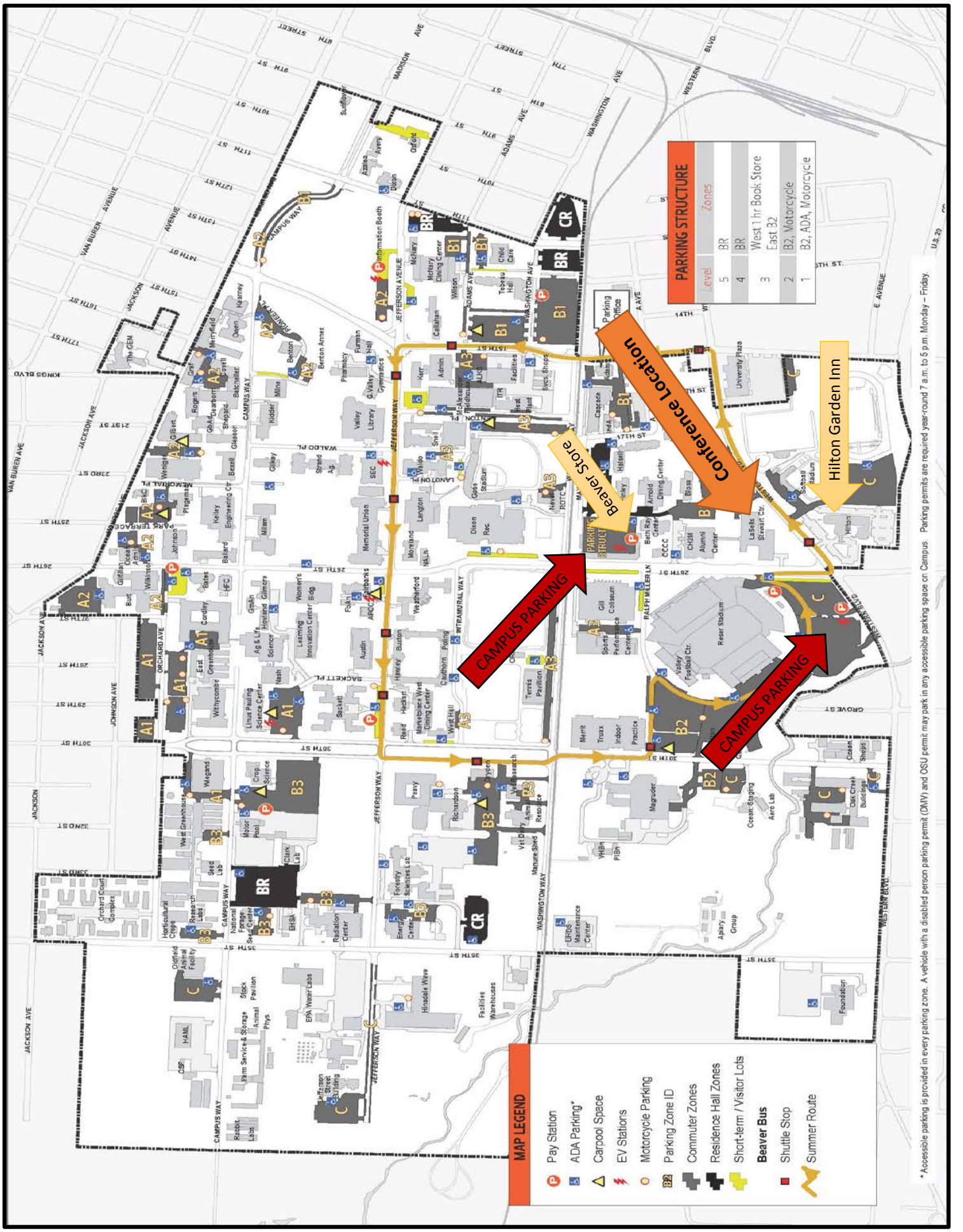
First Name	Last Name	Email Address	Organization
Abbie	Acuff	abbie.acuff@potlatchcorp.com	Potlatch Corporation
Matthew	Aghai	aghai@uw.edu	University of Washington
Arnulfo	Aldrete	aaldrete@colpos.mx	
Lee	Allen	allen.profor@gmail.com	North Carolina State University
Rick	Allen	rick@starkerforests.com	Starker Forests, Inc.
Iris	Allen	ica0002@mix.wvu.edu	West Virginia University
Pascal	Berrill	pberrill@humboldt.edu	Humboldt State University
Horacio	Bown	hbown@uchile.cl	University of Chile
Taisa	Brown	tlbrown@westernforest.com	Western Forest Products
Owen	Burney	oburney@nmsu.edu	New Mexico State University
Charles	Bush	charlie.bush@prt.com	PRT Growing Services Ltd.
John	Butnor	jbutnor@fs.fed.us	USDA Forest Service
Erda	Celer	erda.celer@oregonstate.edu	Oregon State University
Jonathan	Cherico	cher1952@vandals.uidaho.edu	University of Idaho
Elizabeth	Cole	liz.cole@oregonstate.edu	Oregon State University
Linsey	Courtney	lcourtney@hnrg.com	Hancock Forest Management
Anthony	Davis	anthony.davis@oregonstate.edu	Oregon State University
Dorota	Dobrowolska	i.gogolinska@ibles.waw.pl	Forest Research Institute
Nicklos	Dudley	nicklosdudley@gmail.com	Hawaii Agriculture Research Center
Olalla	Diaz-Yanez	olalla.diaz@gmail.com	University of Eastern Finland
Herman	Flamenco	herman.flamenco@oregonstate.edu	Oregon State University
Inger	Floistad	inger.floistad@nibio.no	Norwegian Institute of Bioeconomy Research
Rudy	Frazzini	rfrazzini@hnrg.com	Hancock Forest Management
Ed	Fredrickson	thunderroad3@frontier.com	Thunder Road
Kaitlin	Gerber	kaitlin.gerber@oregonstate.edu	Oregon State University
Carlos	Gonzalez-Benecke	carlos.gonzalez@oregonstate.edu	Oregon State University
Karin	Hjelm	karin.hjelm@skogforsk.se	The Forestry Research Institute of Sweden
Emma	Holmstrom	emma.holmstrom@slu.se	Swedish University of Agricultural Science
Harvey	Holt	holth@purdue.edu	Green Systems Analytics, LLC
Glenn	Howe	glenn.howe@oregonstate.edu	Oregon State University
Christopher	Hubbard	christopher.hubbard@oregonstate.edu	Oregon State University
Michael	Irvine	michael.t.irvine@gmail.com	Ontario Ministry of Natural Resources and Forestry
Douglass	Jacobs	djacobs@purdue.edu	Purdue University
Nabil	Khadduri	nabil.khadduri@dnr.wa.gov	Washington State DNR
Alan	Kycek	alankycek@hamptonlumber.com	Hampton Family Forests
Robbie	Lefebvre	robert.f.lefebvre@oregon.gov	Oregon Department of Forestry
John	Lhotka	john.lhotka@uky.edu	University of Kentucky Department of Forestry
Keith	Little	keith.little@nmmu.ac.za	Nelson Mandela Metropolitan University
Jason	Mack	jason.mack@gwrglobal.com	GreenWood Resources
Douglas	Maguire	doug.maguire@oregonstate.edu	Oregon State University

Participant List

First Name	Last Name	Email Address	Organization
Doug	Mainwaring	doug.mainwaring@oregonstate.edu	Oregon State University
Cecilia	Malmqvist	cecilia.malmqvist@lnu.se	Linnaeus University
Bill	Marshall	bmarshall@cascadetimber.com	Cascade Timber Consulting
Euan	Mason	euan.mason@canterbury.ac.nz	University of Canterbury
Nick	Mc Carthy	nmccarthy@wit.ie	Waterford Institute of Technology Ireland
Katie	McMahen	katiemcmahen@gmail.com	University of Britich Columbia
Brianna	McTeague	bmcteague@fs.fed.us	USDA Forest Service
Christian	Messier	ch.messier@gmail.com	University of Quebec
Carli	Morgan	carli.j.morgan@oregon.gov	Oregon Department of Forestry
Olivia	Moskowitz	oliviam1@uw.edu	University of Washington
Andrew	Nelson	asnelson@uidaho.edu	University of Idaho
Valeriu-Norocel	Nicolescu	nvnicolescu@unitbv.ro	University Transylvania of Brasov Romania
Oscar	Nilsson	oscar.nilsson@slu.se	Swedish University of Agricultural Science
Urban	Nilsson	urban.nilsson@slu.se	Swedish University of Agricultural Science
Florent	Noulekoun	s7flnoul@uni-bonn.de	Center for Development Research (ZEF)
Stephanie	O'Dell	stephanieodell@fs.fed.us	USDA Forest Service
Felix	Oboite	oboite@ualberta.ca	University of Alberta
Cathrine Steffy	Pater	csp@ign.ku.dk	University of Copenhagen
Mike	Premer	michael.premer@rayonier.com	Rayonier
Jacob	Reely	reel3043@vandals.uidaho.edu	University of Idaho
Peter	Reich	preich@umn.edu	University of Minnesota
Brian	Richardson	brian.richardson@scionresearch.com	Scion, NZ Forest Research Institute
Randy	Roeh	rroeh@hnrg.com	Hancock Forest Management
Serajis	Salekin	serajis.salekin@pg.canterbury.ac.nz	University of Canterbury
Jessica	Sarauer	sara8172@vandals.uidaho.edu	University of Idaho
Mary Anne	Sayer	msword@fs.fed.us	USDA Forest Service
Justin	Schmal	justin.schmal@dnr.wa.gov	Washington State DNR
Andrew	Self	brady.self@msstate.edu	Mississippi State University
Chenchen	Shen	cshen@uidaho.edu	University of Idaho
Rebecca	Sheridan	rebecca.sheridan@oregonstate.edu	Oregon State University
Ulf	Sikstrom	ulf.sikstrom@skogforsk.se	The Forestry Research Institute of Sweden
Joshua	Sloan	joshua.l.sloan@gmail.com	New Mexico State University
Richard	Sniezko	rsniezko@fs.fed.us	USDA Forest Service
Meghan	Thornton		Hancock Forest Management
John	Trobaugh	john.trobaugh@dnr.wa.gov	Washington State DNR
Robert	Wagner	rgwagner@purdue.edu	Purdue University
Kristina	Wallertz	kristina.wallertz@slu.se	Southern Swedish Forest Reasearch Centre
Maxwell	Wightman	maxwell.wightman@oregonstate.edu	Oregon State University
Ian	Willoughby	ian.willoughby@forestry.gsi.gov.uk	Forestry Commission

Notes

Oregon State University Map



Thank You!

This conference is jointly sponsored and organized by Oregon State University's College of Forestry, Purdue University's Department of Forestry and Natural Resources, and the University of Idaho's Department of Forest, Rangeland and Fire Sciences. Additional financial contributions were made by Rayonier and Stuewe & Sons.

Oregon State University
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University of Idaho
uidaho.edu

Kirk McEachern
Rayonier
kirk.mceachern@rayonier.com || 904.548.9008

Eric Stuewe
Stuewe & Sons, Inc.
eric@stuewe.com || 541.757.7798

MATTHEW AGHAI || UNIVERSITY OF WASHINGTON || AGHAI@UW.EDU
GREG ETTL

EARLY SURVIVAL AND GROWTH RESPONSE OF NATIVE WASHINGTON TREE SPECIES TO LIGHT AND MOISTURE GRADIENTS: INFORMING ARTIFICIAL REGENERATION

There is an increasing demand for structural and compositional diversification of largely mono-specific Douglas-fir dominated forestlands in the Pacific Northwest. A better understanding of how spatial harvest patterns alter the understory light environment and influence artificial regeneration can facilitate more precise silvicultural prescriptions designed to meet a growing diversity of management objectives. Achieving greater stand and landscape level diversity within relatively short time spans will require an improved ecophysiological knowledgebase for a larger suite of native tree species. The proposed oral presentation features two studies; each having evaluated the effect of available light, rhizosphere moisture, and the synergy between these two key factors on the survival and development of nine native timber species during the two critical years following transplant. Seedlings were planted into five characteristic stands across western Washington, each containing three geographically distinct but proximal plots replicating "open," "partially shaded," and "fully shaded" light regimes, respectively. Each light regime was a function of overstory retention level and was selected for providing ~35% incremental differences in available light. A factorial outplanting simulation was established at a 'control' site using the same planting stock as the field sites and featured fixed light (ambient, 35% shade, 70% shade) and moisture levels (wet, moderate, dry). Within species, stocktype was sourced from the same seed provenance and nursery to ensure uniform culturing methods and a similar phenological and nutritional status. The in- and ex-situ trials were established – in parallel – to validate general findings and to reduce experimental confounding typically associated with stock quality and experimentation with random biotic and abiotic field conditions. The trials were completed in 2016 and have yielded nuanced results for each species and corresponding environmental scenario. The presentation will highlight select outcomes by contrasting species-specific morphophysiological response from both the control trial and field sites.

MATTHEW AGHAI || UNIVERSITY OF WASHINGTON || AGHAI@UW.EDU
GREG ETTL, ZAREEN KHAN, AND SHARON DOTY

EVALUATING MICROBIAL ENDOPHYTES AS A NURSERY AND FIELD AMENDMENT FOR IMPROVING REFORESTATION SUCCESS

Myriad reductionist analyses have demonstrated that the response of plants to shared resources from co-evolved microbiomes can result in adaptive phenotypic changes, stress mitigation, as well as improved plant immunity through direct and indirect mechanisms. This presentation will showcase research that provided an assessment of select microbial endophyte consortia for use in improving native conifer seedling growth and development. We evaluated *Pseudotsuga menziesii* and *Thuja plicata* seedlings, established and grown under greenhouse conditions, and through simulated field testing, to determine if colonized plants have improved establishment potential when subject to common stressors including drought and nutrient deficiency. Our experimentation determined that following approximately 1-year post-inoculation, seedlings of both species demonstrate the maintenance of significantly ($p<0.05$) higher physiological performance potential versus the control (mock-inoculated) seedlings. If inoculation took place prior to sowing, seedling morphology was significantly different ($p<0.05$) from control plants, with greater lateral root growth among *P. menziesii* seedlings, and increased branching among *T. plicata* seedlings. Improved drought tolerance was demonstrated for both species. Further, evidence from the trials suggests that a healthy seedling nutritional status may be the catalyst for improved plant growth and development when select microbial endophytes are present in *P. menziesii.* Thus, successful inoculation of widely used conifer species with endophytes holds promise for increasing forest productivity and reforestation efficiency; particularly through a decrease in tending costs during early stand management. The results of this trial will inform nurseries, restoration ecologists, and the forest industry on the potential benefits of acquiring and deploying endophytes for improving reforestation success in coniferous systems. More research is necessary to acquire and evaluate microbial endophyte consortia for a greater variety of species, and for use in stress mitigation for a greater diversity of difficult planting site conditions.

IRIS ALLEN || WEST VIRGINIA UNIVERSITY || ICA0002@MIX.WVU.EDU
SOPHAN CHHIN AND JIANWEI ZHANG

EVALUATING POST-FIRE RESTORATION IN THE MIXED CONIFER FOREST OF THE SIERRA NEVADA USING PLANTATIONS

The fire regime in the mixed conifer forests of the Sierra Nevada has changed in the past century due to fire suppression and logging practices. Historic fires were frequent and low to mixed severity, keeping the forest horizontally heterogeneous and low density. Fire suppression has increased tree density and fuel continuity. This has resulted in much larger, more severe fires that leave large, continuous areas intensely burned. Mixed conifer tree regeneration is often limited after large, high severity fires due to loss of seed source and shrub encroachment. For these reasons plantations are established to aid in restoring the forest. This is what happened after the high severity, 2004 Power Fire in the Eldorado National Forest. Over 2000 hectares of plantations, in several different planting arrangements were planted, including a cluster arrangement consisting of 2-4 trees spaced out 1m from each other with 6.4m between clusters, and evenly spaced trees 3-4.5m from each other. Current sampling efforts are looking at planting arrangement effect on growth, shrub coverage, stomatal conductance, natural recruitment, and soil characteristics. We are comparing thinned and untinned cluster and even plantations as well as natural regenerating stands. Growth rates and fire will be modeled through each stand. Through this research, we hope to inform the management of post fire plantations in their efforts to restore forest structure and function.

LEE ALLEN || NORTH CAROLINA STATE UNIVERSITY || ALLEN.PROFOR@GMAIL.COM
FRANCISCO FLORES

PRECISION SILVICULTURE IS A POSSIBILITY BUT WHAT IS REQUIRED FOR IT TO BECOME A REALITY?

Precision silviculture – imposing the right treatment, at the right time, at the right place, and for the right reasons, requires an understanding of factors affecting productivity, the logistics of forest operations, and financial considerations. Precision silviculture is becoming more of a possibility in part due to an explosion in the quantity and availability of spatial explicit data. Using these data effectively to implement precision silviculture is a real challenge. This includes determining what data are relevant and then processing and preparing these data into useable information that can be easily accessed and understood by forest managers. We will highlight the importance of understanding the ecophysiology of forest productivity, the plant, soil, and climatic factors that affect resource acquisition and use, and information that can be used to assist foresters in making precision silviculture decisions. We will review several examples from temperate to tropical forest plantations where spatial and temporally explicit data are being used to guide decisions regarding genetic material selection, planting density and spacing, vegetation management, and nutrient additions. We are strong advocates of a high tech, high touch approach.

JOHN-PASCAL BERRILL || HUMBOLDT STATE UNIVERSITY || PBERRILL@HUMBOLDT.EDU
KURT SCHNEIDER, CHRISTA DAGLEY, AND LYNN WEBB

KRIGING UNDERSTORY LIGHT TO PREDICT STUMP SPROUT GROWTH IN MIXED MULTIAGED STANDS IN NORTH COASTAL CALIFORNIA

We studied conifer and hardwood stump sprout response to group selection and variable retention. Our experimental harvest treatments were conducted in ~100 year old second growth. We examined relationships between understory light, varying overstory tree retention, and growth of coast redwood (*Sequoia sempervirens*) and tanoak (*Notholithocarpus densiflorus*) stump sprouts arising after harvest. First, we quantified understory light throughout this 30 ha experiment comparing four different retention treatments repeated at four sites. Then we related understory light to post-treatment stand density and treatment type (i.e., complete harvest in 1-ha group selection opening, low-density dispersed retention, and either aggregated or dispersed high-density retention). Finally, we quantified growth of stump sprouts in response to understory light, retention treatment, and other variables influencing growth of stump sprout regeneration after partial harvesting. Mean understory light did not differ significantly between treatments with the same density but where residual trees were retained in aggregated vs. dispersed spatial patterns. However, the dispersed retention had the lowest minimum light levels when compared to the aggregated retention treatment. The dominant sprout within clumps of redwood sprouts generally grew faster than dominant tanoak sprouts within tanoak clumps. Differences in sprout height growth between aggregated and dispersed treatments were minimal. In the low density dispersed treatment, redwood sprouts (commercial species) outperformed tanoak sprouts (non-commercial species) by the greatest margin. Regeneration of redwood and tanoak was most rapid in high light within group selection openings.

HORACIO BOWN || UNIVERSITY OF CHILE || HBOWN@UCHILE.CL
JUAN-PABLO FUENTES

COMPENSATING COPPER MINING IMPACTS WITH FOREST PLANTATIONS OF NATIVE SPECIES UNDER STRONG WATER LIMITATIONS IN NORTHERN CHILE

Copper mining is the main economic activity in Chile, producing over one third of the global copper output while accounting for more than 50% of the GDP. Environmental impacts of the industry are extensive but increasingly controlled by the Environmental Policy Law (1994) enforcing mitigation and compensation actions. Antofagasta Minerals is a company operating mainly in the semi-arid Coquimbo Region of Chile. As part of their compensation for industrial operations (copper mines, tailings, roads, etc), Antofagasta Minerals establishes and maintains forest plantations with sclerophyll native species with mixed results in terms of survival and development. This study reports the monitoring of growth & development, phenology, soil volumetric water content, water use efficiency and water consumption of six tree species during two years (2014-2016). A water balance model was fitted to prescribe best irrigation practices. Changing soil textural class, preferential water flow and mulching in the planting hole are seen as main practices that would allow to substantially reduce irrigation in an area where water is strongly restricted.

OWEN BURNEY || NEW MEXICO STATE UNIVERSITY || OBURNEY@NMSU.EDU
JOSHUA SLOAN AND JEREMY PINTO

DROUGHT-CONDITIONING DURING NURSERY PRODUCTION INFLUENCES PHYSIOLOGY AND RESOURCE ALLOCATION OF POPULUS TREMULOIDES AND PINUS PONDEROSA SEEDLINGS

Current and historical nursery practices employ optimal growing conditions from germination until lifting for outplanting or storage. However, these optimal conditions may produce physiological and morphological seedling characteristics that do not match those required for post-transplant survival on harsh sites, resulting in restoration failures. To address these issues, this study was developed to test the effects of drought stress induced during the nursery growth phase on seedling morphology and physiology, with the hypothesis that drought-conditioned seedlings would develop characteristics predisposing them to be more resilient after outplanting into water-limited environments. Containerized aspen (*Populus tremuloides*) and ponderosa pine (*Pinus ponderosa*) seedlings were grown under greenhouse conditions, with each species represented by three seed sources collected from latitudinal gradients within their native ranges. Seedlings were exposed to one of three levels of moisture availability (well-watered control, moderate drought, and severe drought) from shortly after germination until the end of their first growing season. Physiological (e.g., photosynthesis and xylem flow velocity) and morphological (e.g., biomass and root volume) parameters were assessed after the first growing season. For both species, drought-conditioning increased net photosynthesis, reduced soluble sugar concentrations in stems, increased soluble sugar contents in leaves, and reduced biomass allocation to roots. Drought-conditioned aspen seedlings also showed increased xylem flow velocity. Seed source significantly influenced most measured parameters for both species. Findings suggest that drought-

conditioned seedlings of both species altered biomass allocation and leaf physiology so as to emphasize leaf development over root development, presumably prioritizing increased water-use efficiency over root system expansion. Empirical examinations of the post-transplant drought tolerance of these stocktypes are underway. The absence of interactions between drought-conditioning treatments and seed sources within each species suggests that the morphological and physiological changes resulting from drought-conditioning may be inducible via nursery cultural practices for a variety of species and seed sources.

JOHN BUTNOR || USDA FOREST SERVICE || JBUTNOR@FS.FED.US
KURT JOHNSON, BRITTANY VERRICO, STEPHEN KELLER, CHRIS MAIER, AND VICTOR VANKUS

RED SPRUCE IN THE SOUTHERN APPALACHIANS: GENE CONSERVATION, SEED PROPERTIES AND ADAPTIVE TRAITS FOR FUTURE CLIMATES

Red spruce (*Picea rubens*) populations in the southern Appalachians (Tennessee, North Carolina, Virginia) are disjunct from larger northern populations in New York, Vermont, New Hampshire, Maine and Canadian Maritime provinces. Heavy logging followed by severe fires in the early 20th century resulted in a > 90% reduction in spruce-fir forests in the southern Appalachians. The remaining red spruce populations are highly fragmented and restricted to high elevations. Considering their adaptation to cool, humid environs, they have the potential to become maladapted with predicted climate change. To assess existing populations for adaptive traits (phenology, physiology) we collected seed from several populations in North Carolina, Tennessee, and Virginia (half-sib) with the goal of propagating seedlings and identifying phenotypic differences in common garden plantings. Seed was collected from 15 trees in 2015 and 115 trees in 2016 from elevations ranging from 1036 to 1988 m. Red spruce produces seed in large quantities every 3-8 years making seed collection difficult and subject to finds of opportunity. The cones were dried, seeds removed and de-winged manually, heavier seed were removed from debris and cleaned via aspiration. A subset was weighed and counted to yield mean seed mass and 200 seeds were exposed to radiographic imaging to estimate the percent of filled and potentially viable seed. Across all 130 families seed mass ranged from 1.0 to 4.4 mg and averaged 2.6 mg per seed. Seed mass and germination rate increased with elevation across all families and the relationship was strongest in trees in close geographic proximity from different elevations. Percent filled seed generally increased with elevation, but declined at the highest elevations. Surprisingly, estimated percent filled seed did not relate to germination rate. Germination experiments are ongoing to assess whether all families have optimal germination at standard conditions for the genus *Picea* (30C/8hr/light and 20C/16hr/dark). Seedlings are currently being propagated for phenotypic and physiological comparisons (growth, photosynthetic capacity, WUE, bud break, bud set) and will be out planted for continued study. Key findings are that red spruce in the southern Appalachians are producing the largest, most viable seeds the very tops of the mountains and have essentially run out of elevation to migrate towards. We hope to identify and deploy families that are suited to survive and regenerate at lower elevations and warmer conditions to resist losing species range for as long as possible in a warmer future.

ERDA CELER || OREGON STATE UNIVERSITY || ERDA.CELER@OREGONSTATE.EDU
GLENN HOWE

DOUGLAS-FIR SEEDLINGS IN THE PACIFIC NORTHWEST: THE GENETICS OF DROUGHT ADAPTATION

Douglas-fir (*Pseudotsuga menziesii*) is a widely distributed, ecologically important, and commercially valuable tree species in North America. However, climate change is expected to adversely impact Douglas-fir trees, and assisted migration may become necessary to lessen the effects of climate change. Because drought stress is one of the projected effects of climate change in the western U.S., it is increasingly important to include drought adaptation traits in breeding programs and in reforestation decisions. In this study, I addressed the following objectives: (1) obtain baseline measurements and climate data to help in the analysis and interpretation of future measurements in the Drought Hardiness Study; (2) characterize the quantitative genetics of drought adaptation traits; and (3) determine whether drought adaptation traits are associated with the climatic origin of Douglas-fir seedlings. To achieve these objectives, data were collected from about 10,000 Douglas-fir seedlings from 429 families from western Oregon and Washington that were planted at two sites (Sprague and Lost Creek) in southern Oregon. Measured variables, which I refer to as drought adaptation traits, included height, second flushing, spring bud flush, damage (foliage, stems, and leaders), and survival. I will discuss the design and results of a study that help increase the understanding about the importance of climatic-driven genetic differences for drought adaptation traits in Douglas-fir. The results of this study will provide useful information for understanding drought, enhancing breeding programs, and potentially adjusting forest management to climate change impacts.

JONATHAN CHERICO || UNIVERSITY OF IDAHO || CHER1952@VANDALS.UIDAHO.EDU
ANDREW NELSON AND THERESA JAIN

LONG TERM EFFECTS OF SITE PREPARATION ON GROWTH AND PRODUCTIVITY OF INTERIOR DOUGLAS-FIR AND WESTERN WHITE PINE IN NORTHERN IDAHO

Silvicultural treatments applied prior to regeneration or during early stages of stand development can affect tree and stand productivity throughout the rotation. Most studies rarely extend measurements beyond the first decade after treatment, limiting our ability to properly assess long-term treatment efficacy. This is especially true in forests of the Inland Northwest. In 1982, a study was initiated on the Priest River Experimental Forest in northern Idaho to test the effects of different mechanical and chemical site preparation treatments on regeneration performance of interior Douglas-ir (*Pseudotsuga menziesii* var. glauca) and western white pine (*Pinus monticola* Dougl. ex. D. Don) seedlings. The study was replicated at two sites: a high elevation site and a low elevation site. Within each site four treatments were replicated 3 or 4 times per tree species, including (1) organic horizon removal and mineral exposure (scalping), (2) organic soil bedding without competition removal, (3) organic soil bedding with chemical competition control, and (4) an untreated control. The objective of the study is to examine temporal trends in tree growth and growth efficiency to determine if tree productivity was substantially altered by the type of site preparation. Measurements will occur in summer 2017, 35 years after treatment, and 27 years since previous measurements. Trees will be destructively sampled to reconstruct patterns of stem diameter

and height growth, and growth efficiency (volume growth increment per unit leaf area). The results of this study will be useful in understanding if site preparation treatments affect site conditions enough to alter changes in tree growth and potential productivity.

ELIZABETH COLE || OREGON STATE UNIVERSITY || LIZ.COLE@OREGONSTATE.EDU
AMANDA LINDSAY, MIKE NEWTON, AND JOHN BAILEY

DOUGLAS-FIR AND WESTERN LARCH RESPONSE TO VEGETATION MANAGEMENT TREATMENTS IN NORTHEASTERN OREGON

The intermountain region of the USA, including northeastern Oregon, is characterized by a warm, dry summer climate that can make plantation establishment difficult. Reducing competition can extend the net growing season length as well as increasing the proportion of site resources that are available to establishing seedlings. Three recently cutover sites in northeastern Oregon near Elgin scheduled for reforestation were selected for study. We included 20 herbicide treatments applied during 3 times: spring 2007, summer 2007, and spring 2008. Plots sprayed in spring 2007 were planted shortly after spraying in March. All other herbicide treatments were planted in May 2008. Later snow melt resulted in a delay in planting in 2008. Bareroot Douglas-fir and bareroot and plug western larch were planted in all plots. We measured gravimetric soil moisture and vegetation cover during the summers of 2007 and 2008. Some herbicide treatments decreased vegetation cover enough to have a significant impact on soil moisture, but the response was highly variable within and among sites. Herbicide applications altered survival 7 and 8 years after planting depending on year, treatment, site and stock type. In general, spring 2007 plantings had greater survival and growth than spring 2008 plantings. Most herbicide treatments did not result in major increases in volume growth, but did result in increases in survival, which would impact growth at the stand level over time. There were greater numbers of taller and larger seedlings in some of the treated versus untreated plots. Douglas-fir tended to have greater survival and less growth than larch across the treatments. Volume index within each plot illustrated relationships with soil moisture and cover of competing vegetation, although the relationships were highly variable. Moisture limitations in such dry climatic and micro-climatic conditions can be lessened with appropriate vegetation management to improve reforestation success.

ANTHONY DAVIS || OREGON STATE UNIVERSITY || ANTHONY.DAVIS@OREGONSTATE.EDU

ENHANCING NURSERY PRACTICES IN POLITICALLY AND ENVIRONMENTALLY CHALLENGING REGIONS

Effective reforestation projects often depend on access to high quality seedlings. Procurement of such seedlings can be difficult due to biological, financial, administrative, and technical issues. The Target Plant Concept (TPC) presents a framework for improving success of tree planting projects by quantifying seedling attributes that are linked to field performance. By determining which parameters are most influential on seedling performance after planting, one is able to monitor these attributes and refine propagation practices as needed to enhance the growth of the crop species in the nursery. Despite recognition of this approach in scientific circles, its application has been less pronounced on the global scale. This presentation highlights a body of research from wide-ranging projects that identifies barriers and opportunities for improvements to seedling production systems that would allow for the TPC model to be properly engaged. Challenges faced in procuring appropriate genetic material, rearing quality seedlings, and applying optimal post-planting practices are similar around the globe. Examples of large-scale projects in Lebanon and Jordan will characterize the potential for seedling production to shift from a focus on quantity to quality. In Haiti, Armenia, and Togo, all countries with unique and well-documented deforestation issues, small-scale, community oriented nurseries have been established. These nurseries face similar challenges in access to materials and staff trained in contemporary propagation methods. Sharing modern research-based practices established in developed countries with developing countries provides a means to enhance seedling production practices at a global scale.

OLALLA DIAZ-YANEZ || UNIVERSITY OF EASTERN FINLAND || OLALLA.DIAZ@GMAIL.COM
BLAS MOLA-YUDEGO AND JOSÉ RAMÓN GONZÁLEZ-OLABARRIA

WHAT VARIABLES MAKE A YOUNG FOREST STAND MORE VULNERABLE TO UNGULATE BROWSING OCCURRENCE?

Ungulate browsing is an important factor affecting establishment of young stands having a considerable economic and ecosystem consequences. Ungulates browsing damage occurrence is difficult to study due to the lack of knowledge on ungulates' behavior, but there are patterns related to forest variables that can be identified. We have analyzed the browsing damage occurrence in forest stands of Norway. The data is based in a 20 years' National Forest Inventory dataset. We used the machine learning based method classification trees. Classification trees provided information on which variables make forests more susceptible to browsing damage, but also about the interactions among them. Our models were developed using variables that describe the state of the forest before it was damaged. The models show the relation between stand, site and treatment variables and the probability of browsing damage occurrence. Our results showed that most vulnerable stands are young with densities bellow 1400 trees ha-1 and dominated by birch, pine or mixed species. Consistent with other studies, stand diversity and previous treatments like thinnings also increase the probability of browsing damage occurrence, making more diverse stands more vulnerable to browsing. But also, that less studied variables like stand size could play a role on forest susceptibility to browsing occurrence. These results emphasize the need and possibility of creating management alternatives that account and mitigate the negative impact that ungulate browsing have on young stands.

DOROTA DOBROWOLSKA || FOREST RESEARCH INSTITUTE || D.DOBROWOLSKA@IBLES.WAW.PL
BOGDAN PAWLAK

NATURAL REGENERATION AFTER FIRE IN SCOTS PINE FORESTS IN CENTRAL POLAND

Fire is one of natural disturbances that influence the regeneration of forest stands. In managed forests in Poland usually the disturbed area is clear-cut and new trees are planted. In Myszyniec Forest District (central Poland) Minister of Environment decided to leave the disturbed area without any intervention to observe natural processes following forest fire. The aim of the study was to know the rate of forest regeneration after forest fire. The study was conducted in Scots pine (*Pinus sylvestris* L.) stands damaged by fire in 2015. We

established sample plots in disturbed area but also in zone without any symptoms of fire in Myszyniec Forest District. Data were collected on 34 concentric circular plots established in a grid of 50x150 m in two habitat types: very poor and poor conifer forest type. (1) Trees (diameter at breast height (at 1.3 m, DBH) ≥ 7) were measured in the largest circular plot (250 m2). (2) Seedlings (H ≤ 0.5 m) and saplings (H > 0.5 m and DBH < 7 cm) were measured in the medium circular plots (100 m2). We also measured the height and assessed the vitality of seedlings and saplings. We described the cover of ground by shrubs, grass, herbs and regeneration. The primary results showed that regeneration started one year after the disturbance. We observed not only the regeneration of trees but also shrubs, especially invasive *Prunus serotina*. The most abundant was Scots pine. We found regeneration of pedunculated oak and silver birch. Quantity of regeneration was higher in non-disturbed area. We observed the establishment of grasses and herbs after the fire. The next measurement will be done this year. The results will show the process of regeneration of the ground floor and the changes in stands following forest fire.

NICKLOS DUDLEY || HAWAII AGRICULTURE RESEARCH CENTER || NICKLOSDUDLEY@GMAIL.COM
TYLER JONES, AILEEN YEH, RICHARD SNIEZKO, AND PHIL CANNON

EXPANDING THE KOA NETWORK: AN ECO-REGIONAL APPROACH TO DEPLOYING DISEASE RESISTANT *ACACIA KOA* IN HAWAII

Koa (*Acacia koa*) is a valuable tree species economically, ecologically, and culturally in Hawaii. A vascular wilt disease of *Acacia koa* (koa) due to infection by the fungal pathogen *Fusarium oxysorum* f. sp. koae (FOXY) causes high rates of mortality in field planting and threatens native koa forests in Hawaii. Producing seeds with genetic resistance to FOXY is vital to successful koa reforestation and restoration. The Hawaii Agriculture Research Center (HARC) with its partners, operates a tree improvement program to develop koa wilt resistant populations in Hawaii. HARC has estimated seed zones based on biogeographic variables and has selected wilt resistant populations for six ecological (eco-regions) in Hawaii. Disease resistant progeny trials have been established in three regions, an additional three trials sites will be established in the Spring of 2017. Growth performance and early survival data will be summarized by location.

HERMAN FLAMENCO || OREGON STATE UNIVERSITY || HERMAN.FLAMENCO@OREGONSTATE.EDU
MAXWELL WIGHTMAN AND CARLOS GONZALEZ-BENECKE

LONG TERM EFFECTS OF VEGETATION MANAGEMENT IN THE PNW: ASSESSMENT OF BIOMASS STOCK AND NET PRIMARY PRODUCTIVITY RESPONSES OF FOUR CONIFEROUS SPECIES

Currently the Vegetation Management Research Cooperative (VMRC) at Oregon State University has two CTP (Critical Period Threshold) studies with 15-16 years of monitoring data on different conifer species (Douglas-fir, western redcedar, western hemlock, and grand fir), in sites located in Coastal range and Piedmont of Cascade Mountains. These studies provide a unique opportunity to evaluate long-term responses to intensive vegetation management treatments, assessing differences across species as well as differences across sites. Even though responses in basal area and volume per acre are well documented for these studies, we do not know the long-term impact of these treatments on total ecosystem productivity and stand sustainability. An effective way to estimate that response is by evaluating aboveground net primary productivity (ANPP, Mg ha-1 year-1) or total biomass stock (including soil, forest floor and competing vegetation biomass). On both sites we measured litterfall, tree biomass, understory biomass, forest floor and soil organic matter in two contrasting VM treatments.

INGER FLØISTAD || NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH || INGER.FLOISTAD@NIBIO.NO
ESPEN KRISTOFFER JENSEN

CONTROL OF *SAMBUCUS RACEMOSA* ON FOREST REGENERATION SITES

The widespread of red elderberry (*Sambucus racemosa*) has increased considerably in recent years and the species are troublesome especially on forest regeneration sites. Sufficient seedling establishment of new forest are important both for the forest owner and to achieve the role of forest related to climate change (IPCC 2014). Dense stands with red elderberry are one of the main reasons for use of glyphosate on forest regeneration sites in Norway. The measure is controversial, and there is therefore a need for documentation on the effect of the measure compared with alternative control methods. Natural spread of the species occurs mainly by birds who willingly eat the juicy fruits. In the risk assessment to "Norwegian Black 2012» red elderberry was categorized as "high risk" because species with its rich fruit setting and juicy fruits can affect the spread of our domestic shrubs with juicy fruits. Experimental plots were established on three sites in Eastern Norway in 2013 to provide a better knowledge on control methods. The experiment consists of the following treatments 1) cutting in June or (2) October; 3) cutting in June and stump treatment with glyphosate; 4) leaf spraying with glyphosate June or 5) August; 6) cutting in June and spraying with glyphosate on regrowth in August; 7) control. There was a high level of regrowth following cutting, and this methods had only limited effect on the height of the shrub. There was a significant correlation between stem diameter before cutting and height and number of re-sprouting stem and branches two growing seasons after cutting. Spraying in August showed markedly reduced plant height in all three fields. Spraying in June was effective in two of three sites. Stump treatment was not as effective as leaf spraying, probably because it is too small stumps and therefore less uptake of glyphosate.

INGER FLØISTAD || NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH || INGER.FLOISTAD@NIBIO.NO
TORIL DRABLØS ELDHUSET

EFFECT OF PHOTOPERIOD AND FERTILIZATION ON GROWTH AND ESTABLISHMENT IN *PICEA ABIES* SEEDLINGS

Sturdy seedlings with a high root growth capacity and a balanced shoot:root ratio are needed for successful regeneration of *Picea abies* seedlings. The aim of our study was 1) to identify above- and belowground growth responses in one year old seedlings to different combinations of photoperiod and fertilization, and 2) to study whether these responses would influence regeneration ability

after planting. The growing phase was conducted in greenhouse and treatments were control and short day (SD) (10 h) combined with each of three levels of K:N ratios in the nutrient solution. The SD treatment resulted in significantly reduced shoot height irrespective of fertilization treatment (Fløistad & Eldhuset 2017). No combination of photoperiod and fertilization treatment affected the root collar diameter. Lengths of current year's fine roots, in predefined diameter classes, were determined using WinRhizo V2013a with an Epson Expression scanner. SD treatment increased root length significantly for some of the root diameter classes and fertilization treatments. We expected the small increase in root length to improve establishment and a field trial was therefore established with the plant material. SD plants had higher shoot growth, higher frequency of lammas shoots and less damage compared to control seedlings. The fertilization treatments provided in the greenhouse did not significantly influence growth or vitality after planting in the field. Root collar diameter and fine root dry weight and length were not different between treatments. Our conclusion is that that SD treatment with traditional fertilization is a good and sufficient measure to control height growth and improve vitality after outplanting of *P. abies* seedlings.

ED FREDRICKSON || THUNDER ROAD RESOURCES || THUNDERROAD3@FRONTIER.COM
VANELLE PETERSON

CONIFER TOLERANCE, HERBACEOUS AND WOODY BRUSH CONTROL WITH CLEANTRAXX®: A NEW FORESTRY HERBICIDE

This paper will summarize six years of data collected from replicated field experiments evaluating Cleantraxx as a potential forestry herbicide. The paper will summarize results for efficacy regarding both pre and post emergent applications on herbaceous vegetation as well as the ability of Cleantraxx to control woody brush germination as a pre-emergent application. Data includes both fall and spring application results. Results of trials focusing on western conifer tolerance will also be summarized for pre and post plant applications of Cleantraxx. Conifer species tested included ponderosa pine, Douglas-fir, white fir, sugar pine, Incense cedar, redwood and western larch.

KAITLIN GERBER || OREGON STATE UNIVERSITY || KAITLIN.GERBER@OREGONSTATE.EDU
ANTHONY DAVIS AND ANDREW NELSON

PHOTOPERIOD REDUCTION INFLUENCES WESTERN LARCH (*LARIX OCCIDENTALIS* NUTT.) SEEDLING DEVELOPMENT

Western larch seedlings grown in a greenhouse were subject to short day treatments that resulted in differences in seedling morphology and physiological status. Once seedlings reached 10 cm in height growth, treatments were induced that resulted in reduction of photoperiod from ambient to 8 hours for durations of 7, 14, 21, or 28 days (a 0-day control was also maintained). A 5mm blackout polyfilm cloth was positioned above the containers to eliminate photosynthetically active radiation from reaching the seedlings. Height, root collar diameter, bud formation, outplanting survival rates, and seedling net photosynthetic assimilation were assessed. The objectives of this study were to (1) determine the morphological and physiological effects of mid-summer photoperiod reduction of differing durations on western larch seedlings and (2) compare growth and survival between fall- and spring-planted seedlings subjected to these short-day treatments. It is hypothesized that short-day treatments, particularly those of a longer duration, will induce dormancy (as measured by cessation of height growth, initiation of bud-set, and decreased rates of photosynthesis) and will result in greater fall outplanting success, as measured by seedling survival. If the duration of short day treatments can be minimized while still producing the desired dormancy induction, effort towards applying blackout cloth can be minimized within nursery operations.

CARLOS GONZALEZ-BENECKE || OREGON STATE UNIVERSITY || CARLOS.GONZALEZ@OREGONSTATE.EDU
ERIC DINGER

USE OF WATER STRESS INTEGRAL AS A TOOL TO ANALYZE COMPETING VEGETATION EFFECTS ON PLANT WATER STRESS AND SEEDLING PRODUCTIVITY

Water Stress Integral (WSI) is the cumulative integral of pre-dawn water potential over any chosen period of time. Using bi-weekly measurements of xylem water potential and soil moisture during first two growing seasons, we analyzed the impact of competing vegetation treatments on plant water relations and productivity. There was a large gradient in plant water stress due to competing vegetation effects on soil water availability. We observed a strong relationship between WSI and volume growth on each growing seasons. We determined that pre-dawn xylem water potential measured on early August is highly correlated to seasonal WSI and therefore to volume production. We demonstrated that soil moisture can be used as a surrogate for pre-dawn water potential and seasonal WSI allowing for operational monitoring on seasonal WSI.

CARLOS GONZALEZ-BENECKE || OREGON STATE UNIVERSITY || CARLOS.GONZALEZ@OREGONSTATE.EDU
MAXWELL WIGHTMAN

USING AGE-SHIFT METHOD TO ESTIMATE LONG-TERM GAINS OF VEGETATION MANAGEMENT

Age shift (or time gain) is an alternative method for analyzing long-term responses to silvicultural treatments that focuses on determining the number of years of advancement in growth realized at a given age. We analyzed 4 studies with long-term responses of planted conifer stands to vegetation management treatments using the age-shift approach. For the 4 conifer species tested (Douglas-fir, western hemlock, western redcedar and grand fir), the age-shift response ranged between 0 to 8 years, depending on site and vegetation management treatment applied. When compared at the same site, western red cedar was more responsive to treatments and had age-shifts that were 2-6 years larger than Douglas-fir. One year of spring release showedno effect on Douglas-fir and western hemlock. Age-shift analysis can be used to support decision making about thinning and rotation length making it a useful tool in economic analysis.

KARIN HJELM || THE FORESTRY RESEARCH INSTITUTE OF SWEDEN || KARIN.HJELM@SKOGFORSK.SE
LARS RYTTER

REGENERATION OF *POPULUS* SPP IN SWEDEN – A CHALLENGE?

The interest in renewable energy sources is increasing. Biomass is one of the largest components of Sweden's renewable resources, and there are potentially large areas, both agricultural and forest land, that could be used for biomass cultivation of fast growing tree species. Poplars and hybrid aspen are currently the highest producing tree species available and are therefore natural choices for biomass-oriented cultivation. In comparison with Norway spruce, which has a rotation period of about 60 years in southern Sweden, the rotation period could be reduced to around 20-25 years with these species. Growing poplars and hybrid aspen has been of most interest on agricultural land, but the knowledge and experience about their cultivation is still limited. In relation to the proportion of agricultural land suitable for cultivation, the proportion of forest land is significantly higher. So far, the establishment on forest soils has been disappointing. One explanation could be low pH-levels. Results show that soil acidity can hamper the establishment of poplars, while hybrid aspen seems to be less sensitive to low pH. Other factors that have a large impact on the regeneration results are competing vegetation, browsing and damage caused by voles or climatic factors. If we can reduce some of the establishment stress, poplar species seem to have a high growth potential. On both agricultural land and forest land, site preparation methods that reduce the amount of competing vegetation and fencing to reduce herbivore browsing are necessary measures to secure plant establishment. Vole damage and damage caused by climatic events are other important factors that should be controlled if possible. Cultivation of these tree species requires more knowledge and they need to be more intensively managed than for example Norway spruce. Specific site conditions including restricting factors should be carefully considered and managed during the first years after planting. However, with increased knowledge, poplar species can provide short rotations and a larger annual removal of biomass.

EMMA HOLMSTRÖM || SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCE || EMMA.HOLMSTROM@SLU.EDU
MATTS KARLSSON AND URBAN NILSSON

MODELING BIRCH SEED SUPPLY AND SEEDLING ESTABLISHMENT DURING FOREST REGENERATION

The seed ecology and regeneration management of birch species in Fennoscandia has been quite thoroughly investigated through decades of forestry research. Nonetheless, there are few methods for precise predictions of spontaneous natural regeneration of silver birch (*Betula pendula* Roth.) and downy birch (*Betula pubescens* Ehrh.). In this study a first framework of a model is presented that combines possible seed supply with seed emergence and seedling survival based on GIS data and the results of past experiments. The birch seed supply was calculated by combining spatial data on standing birch volume with birch seed dispersal distributions. Two different ways to estimate dispersal was compared, one based on the knowledge of wind turbulence and seed dispersal out on a clearcut, a micrometeorological method, and the other was based on an experiment with seed traps on a transect of distances from seed source. Further on, the seed germination and seedling survival was modeled with probabilities based on results from field experiments with measured soil moisture conditions and soil scarification treatments. The model was validated for two independent data sets, one from field experiments and one from random clearcuts. There were statistically small differences between the methods of calculating seed dispersal and seed supply in the landscape. The model output responded linearly to the validation data up to seedling densities of 30 000 seedlings ha-1) with a mean residual value 0.078. The increasing germination success and seedling survival with more intense soil disturbance also corresponded well to the experimental results. This model shows a reduced variance compared to general means of seed supply and partly explains the variation between sites with the same soil scarification treatments. Even though additional management and ecological variables should be incorporated to increase the model's predictive ability, it could already be of use in practical forestry.

GLENN HOWE || OREGON STATE UNIVERSITY || GLENN.HOWE@OREGONSTATE.EDU

GENETIC CONSIDERATIONS FOR REFORESTATION IN THE FACE OF GLOBAL CLIMATE CHANGE

Climate change complicates forest regeneration. Ultimately, wise reforestation decisions rely on matching the species, seed sources, and reforestation methods to the target site. Yet, the local site conditions that drive these decisions are uncertain and changing. Although the broad implications of climate change are clear, forest managers require site specific projections of climate change and recommended actions. Of course, these are not available with certainty. Thus, forest managers must increasingly learn to manage risk, experiment, and work with the public to accept the 'failures' that lead to new knowledge. Broadly, my talk will focus on the difficult decisions involved in managing forests given climate change. These include decisions about relying on natural versus artificial regeneration; how to choose appropriate species, populations, and genotypes for future climates; and how to communicate about climate change, uncertainty, and risk with the public. More specifically, I will discuss the need for land management organizations to engage in 'organizational science,' and then discuss tools we are developing to provide managers 'actionable' information that can be used to help forests adapt to climate change.

BORA IMAL || CANKIRI KARATEKIN UNIVERSITY || BIMAL@KARATEKIN.EDU.TR
AKKIN SEMERCI AND CARLOS GONZALEZ-BENECKE

COMPARING P-V CURVE AND POLYETHYLENE GLYCOL TESTS IN ANATOLIAN BLACK PINE (*PINUS NIGRA* ARNOLD. SUBSP. PALLASIANA) IN DIFFERENT PROVENANCE OF TURKEY

Turkey is sites at the intersection of three phyto-geographic regions and is one of the richest flora centers of the world. However, the natural resources of the country have been damaged extensively for thousands of years of human activity. Today, large areas located in semi-arid ecosystems need to be afforested. *Pinus nigra* Arnold., which is known to be a drought resistant pine species, it is of great interest for afforestation in those disturbed areas of Turkey. Drought tolerance testing in initial stages of plant development, including seed germination, is of vital importance, because the seed with more rapid germination under water deficit conditions may be expected to achieve a rapid seedling establishment, resulting in greater survival and growth. We used the early drought test (polyethylene glycol), to investigate the effects of water stress on germination of *P. nigra* seeds collected from 10 provenances which represent different bioclimatical regions in Turkey. Seeds were subjected to -0.2, -0.4, -0.6 and -0.8 MPa osmotic potential using polyethylene

glycol 6000 solutions. Seeds of each water stress treatment, including a control treatment, were kept for 20 days at 20 ± 0.5°C and germination percentage, germination value and seedling dimensions were determined. In addition, results from the same seed lots were compared with pressure-volume tests on two years old *P. nigra* seedling.

DOUGLASS JACOBS || PURDUE UNIVERSITY || DJACOBS@PURDUE.EDU
ANTHONY DAVIS, R. KASTEN DUMROESE, AND OWEN BURNEY

NURSERY CULTURAL TECHNIQUES TO PROMOTE RESTORATION OF *ACACIA KOA* COMPETING WITH EXOTIC GRASS IN A DRY TROPICAL FOREST

Cattle grazing and introduced grasses have caused prominent losses of forest cover in the seasonally dry tropical forests of Hawaii, USA. Naturally regenerating seedlings under heavy grazing often fail due to consumption by cattle and competition from introduced exotic grasses. A major challenge to artificial reforestation of koa (Acacia koa) in Hawaii is the introduced exotic kikuyu grass (*Pennisetum clandtstinum),* a rapidly growing, rhizomatous plant. We examined use of varying nursery cultural techniques to facilitate establishment of koa seedlings amidst dense kikuyu grass on a cinder cone at 1200 m. Seedlings were grown in three container sizes (49, 164, 656 cm3) and with four rates (0, 10, 15, 20 kg m-3) of 15-9-12 (NPK) controlled-release fertilizer incorporated into media prior to sowing. After 16 months in the field, seedling survival was greater than 80% for all treatments with the exception of the non-fertilized 49 cm3 and 164 cm3 containers (78% and 24% survival, respectively). At 10 years, only these two treatments had significantly lower survival (35% and 10%, respectively) than the other treatments. At 1 year following planting, none of the unfertilized seedlings exhibited phyllodes (vs. the early true leaves) regardless of container size. For the fertilized 656 cm3 container, 78-85% of seedlings had phyllodes, with mean values increasing by fertilizer rate. In koa, phyllodes are known to confer greater drought resistance, which may help to explain improved survival noted for fertilized trees. Overall, the use of fertilizer was significantly more influential on seedling height and diameter response than container size. However, the greatest container size (656 cm3) with addition of fertilizer produced significantly larger trees than all other stocktype treatments during the early regeneration phase; growth differences tended to disappear at 10 years due to inter-tree canopy competition. This data confirms the importance of nursery fertilization in promoting outplanting success of koa, despite the capacity of the species to fix atmospheric nitrogen through rhizobium associations. Nursery cultural techniques may play an important role in restoration of tropical sites invaded by invasive vegetation.

DOUGLASS JACOBS || PURDUE UNIVERSITY || DJACOBS@PURDUE.EDU
ANTHONY DAVIS, R. KASTEN DUMROESE, AND OWEN BURNEY

CONVERSION OF INTRODUCED CONIFER PLANTATIONS: INFLUENCES OF LIGHT AND NUTRIENTS ON UNDERSTORY HARDWOOD REGENERATION

Conversion of introduced conifer plantations that are mature and/or in decline to valuable threatened hardwood species represents a viable restoration opportunity in the US Midwest. In this experiment, we examined regeneration responses of two threatened hardwood species, northern red oak (*Quercus rubra* L.) and American chestnut (*Castanea dentata* (Marsh.) Borkh), planted into eastern white pine (*Pinus strobus* L.) plantations. We sought to determine the effects and interactions of light intensity and fertilization treatments on underplanted seedling growth, and understand differences in soil chemical and physical characteristics between conifer-influenced and non-conifer-influenced soils and their effect on seedling growth. We manipulated pine canopies to create the same three silvicultural treatments, then underplanted hybrid American chestnut and northern red oak. Additionally, a fourth 'open field' treatment was added. For 2 growing seasons, 2 levels of controlled release fertilizer (CRF) were applied directly to seedling root systems along with an unfertilized control. Weeding was done each growing season in all plots. Chestnut and oak seedlings both had significantly greater height and RCD in the clear cut and shelterwood than uncut control and open field after the 2 growing seasons. Chestnut height and RCD were triple that of oak, likely due to contrasting growth strategies of the two species in addition to disparate initial planting stock size. Fertilization increased seedling growth more in the clear cut and open field than uncut shelterwood and uncut control. This response was probably due to the absence or presence of canopy effect on light and water availability. Open field seedling survival and leaf nutrient concentration were less than the other treatments, likely associated with occurrence of flooding and incidence of ambrosia beetle, rather than soil effects. Soils were not very different between open field and pine-forested treatments, except open field had significantly higher levels of pH, potassium, and sulfur, likely due to high buffering capacity of soils. Though the soils of current or former conifer plantation sites in this study have low pH andbase saturation, oaks and chestnuts are adapted to these conditions. Due to observed high rates of survival and growth, we concluded that pine plantations are ideal locations for American chestnut and northern red oak restoration. Shelterwoods and clearcuts are each viable silvicultural conversion options for underplanting oak and chestnut seedlings, and CRF addition further augments growth increase, especially in open environments.

JOHN LHOTKA || UNIVERSITY OF KENTUCKY || JOHN.LHOTKA@UKY.EDU
EDWARD LOWENSTEIN

COMPARING INDIVIDUAL-TREE APPROACHES FOR PREDICTING HEIGHT GROWTH OF UNDERPLANTED SEEDLINGS

Quantitative approaches describing the relationship between canopy structure and seedling growth can inform silvicultural decision making regarding the development of tree reproduction beneath a dominant forest canopy. Individual-tree seedling growth models with canopy structure predictors derived from tree inventory data have not been well-explored. This study compared a model framework fit using point-based measures of canopy structure observed at the seedling level to one fit using area-wide canopy structure variables derived from standard inventory plot data. Species-specific models predicting five-year height growth were fit for cherrybark oak (*Quercus pagoda* Raf.), water oak (*Quercus nigra* L.), and yellow-poplar (*Liriodendron tulipfera* L.) underplanted within a canopy structure gradient created by silvicultural manipulation of a closed-canopy forest in Georgia, USA. Though the species varied in shade tolerance and growth rates, the general relationship between the predictor variables and height growth was similar among species and model type. Models highlight the importance of including predictor variables that describe seedling size along with openness and vertical structure of the forest canopy. While the two model frameworks had comparable fit statistics, the one with

predictors derived from tree inventory data may have enhanced utility as it can be directly integrated into existing individual-tree forest growth simulators.

JOHN LHOTKA || UNIVERSITY OF KENTUCKY || JOHN.LHOTKA@UKY.EDU
WESLEY DEMENT, CHRISTOPHER BARTON, AND JEFFREY STRINGER

FORESTRY RECLAMATION APPROACH IN THE APPALACHIAN COAL FIELDS: NINETEEN-YEAR RESULTS FROM A MULTI-SPECIES REFORESTATION EXPERIMENT

Surface coal mining has disturbed more than one million acres of Appalachian forest. Reclamation employed in compliance with federal regulations often compacts substitute soil material (spoil) and inhibits tree growth. In 1996, University of Kentucky researchers established an experiment on the since renamed Starfire Mine in eastern Kentucky, USA. The study established nine reclamation areas to investigate the effects of spoil compaction on tree growth and survival and develop guidelines regarding site preparation and tree species compatible with mine reforestation. The study evaluated three spoil grading treatments: 1) no grading (loose-dump); 2) graded with one equipment pass (strike-off); and 3) multi-pass grading resulting in uniform surface appearance (compacted). Treatments were planted with six native tree species. Nineteen growing seasons following planting, differences in survival and growth were compared among species and treatment. Survival ranged from 3.8% for black walnut in compacted spoil to 87 % for white ash in the loose-dump treatment. Analysis of overstory tree height data revealed significantly larger mean overstory heights for all species in the loose-dump and strike-off treatments versus the compacted treatment with the exception of black walnut. Mean overstory heights were not significantly different between loose-dump and strike-off treatments. Long-term data indicate the benefit of low compaction grading for reforestation of Appalachian surface mines. Data further suggest that strike-off sites may support tree survival and growth as well as sites where end-dumping practices leave spoil uncompacted. The strike-off reforestation treatments exhibit generally uniform topography that may facilitate efficient application of silvicultural treatments and timber harvesting, making this a promising approach for reclamation of Appalachia's surface mines.

DOUGLAS MAGUIRE || OREGON STATE UNIVERSITY || DOUG.MAGUIRE@OREGONSTATE.EDU
TIMOTHY HARRINGTON, ROBERT WAGNER, AND DOUG MAINWARING

MODELS FOR PROJECTING COMPETING VEGETATION DYNAMICS BY LIFE FORM IN YOUNG DOUGLAS-FIR PLANTATIONS

Successful establishment and rapid early growth of Douglas-fir plantations can benefit from control of competing vegetation on many site types and in a wide variety of vegetation communities. Forest growth models that cover the full rotation must therefore include early stages of plantation development from bare ground to crown closure to understand the effect of alternative treatments of competing vegetation on tree growth. These models must also have the capacity to predict the change in cover of competing vegetation in addition to tree growth. In the early 1980s an experiment was established at six installations in coastal Oregon and Washington to test Douglas-fir growth responses to six contrasting competing vegetation treatments. Within each of the 36 experimental units, plant cover was recorded by species on 20 40.5-m2 circular plots. These data were analyzed to build models capable of predicting annual change in cover of the following life forms: herbs, shrubs, deciduous broadleaves, and conifers other than Douglas-fir. The final models contained two general components, the first predicting the probability of a positive (and negative) 1-yr change in cover, and the second predicting the conditional positive change in cover and the conditional negative change. Predictor variables included initial cover of the subject life form, initial cover of various other life forms, Douglas-fir basal area, and years since plantation establishment or since last release treatment. Simulations were validated against datasets from other studies.

DOUG MAINWARING || OREGON STATE UNIVERSITY || DOUG.MAINWARING@OREGONSTATE.EDU
DOUGLAS MAGUIRE, ROBIN ROSE, ERIC DINGER, AND TIMOTHY HARRINGTON

MODIFIERS FOR PREDICTING THE NEGATIVE EFFECT OF COMPETING VEGETATION ON GROWTH OF DOUGLAS-FIR TREES IN YOUNG PLANTATIONS

Accurate prediction of plantation growth responses to competing vegetation is an important tool for gauging the efficacy of alternative treatments for reducing competition effects. Data from plots on numerous field trials in young Douglas-fir plantations throughout western Oregon and Washington were analyzed to model annual growth and mortality of individual trees. Modifier functions taking on values from zero to one represented the negative effects of competing vegetation, and these effects increased with increasing cover at a marginally decreasing rate. The negative effect of competing vegetation was found to decrease with increasing height of planted crop trees, with differential effects for height and diameter growth. The effect of competing vegetation was also found to vary by lifeform when separate modifiers were included for herbs, shrubs, broadleaved trees, and non-crop conifers. When coupled with rotation-length projections of treated plantations, yield estimates provide a means of estimating potential financial gains that can be achieved from early competing vegetation control.

CECILIA MALMQVIST || LINNAEUS UNIVERSITY || CECILIA.MALMQVIST@LNU.SE
KRISTINA WALLERTZ AND ULF JOHANSSON

SURVIVAL, EARLY GROWTH AND IMPACT OF DAMAGE BY LATE SPRING FROST AND WINTER DESICCATION OF DOUGLAS-FIR IN SOUTHERN SWEDEN

The need for species that will grow well through ongoing climate change has increased interest in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in Sweden. One of the most common problems seen in plantations of Douglas fir seedlings is damage caused by late spring frost. Also winter desiccation is thought to be among the most serious damage to seedlings, although more infrequent. The aim of this study was to investigate early growth, survival and damage from late spring frost and winter desiccation among Douglas fir provenances. The field study was performed at Tönnersjöheden Experimental Forest, Southwest Sweden (56°43'N, 13°08'E) in a provenance trial comprising four coastal and three interior provenances of Douglas fir originating from British Columbia, Canada. Seedling height, length of the leading shoot and occurrence of damage was measured after one, three and six growing seasons. The

interior provenances were more frequently damaged by late spring frost compared to the coastal provenances. The injuries proved not to be fatal though, the interior Douglas fir provenances had a higher survival rate after six growing seasons than the coastal provenances. The coastal Douglas fir seedlings was damaged by winter desiccation to a much higher extent and more severely than the interior Douglas fir seedlings. Choice of provenance may reduce the risk for either late spring frost or winter desiccation.

EUAN MASON || UNIVERSITY OF CANTERBURY || EUAN.MASON@CANTERBURY.AC.NZ
JUSTIN MORGENROTH AND HORACIO BOWN

PRECISION FORESTRY: WHAT DOES HYBRID PHYSIOLOGICAL/MENSURATIONAL MODELLING OFFER?

Hybrid mensurational/physiological modelling was used to estimate site productivity at 15 m resolution across four very large plantation estates. Model code was written in R and included impacts of mean daytime temperature, vapour pressure deficit and soil water balance on radiation-use efficiency monthly for a span of 10 years of real-time data. Routines used to localise weather data were tested using a set of independent meterological stations. The model was run at millions of points and so a supercomputer was employed to enable such a large amount of computation. Estimates of site index generally had standard errors of ~1.9 m when compared to estimates from permanent sample plots, and independent variables included potential radiation-use efficiency between 2005 and 2015, slope, aspect, soils and other features related to micro-topography. Raster layers were created for forest managers with estimates of productivity and also layers showing factors limiting productivity. These estimates offer features that other sources of productivity estimation, such as harvester head measurements or remote sensing, do not, and these extra features are discussed in the context of how all sources of information complement each other. This kind of estimation represents a new, Popperian approach to mensuration, and the implications of the new approach are discussed.

NICK Mc CARTHY || WATERFORD INSTITUTE OF TECHNOLOGY IRELAND || NMCCARTHY@WIT.IE

PESTS AND PATHOGENS - POTENTIAL TO RADICALLY CHANGE IRISH FOREST REGENERATION!

Both indigenous and invasive pests and pathogens will pose one of the most significant but least addressed threats to the future of Irish forestry. Forest pests and pathogens are having significant impacts on forests worldwide and while the devastating impacts of some indigenous forest pests are already recognized, those of introduced species are increasingly being discovered as well. Rapid transport, ease of travel, and free trade, have facilitated the spread of these forest pests, as evidenced by the number of transboundary species recorded in recent FAO surveys. Most countries do not have reliable information on the area of forest affected by forest pests and pathogens because they do not systematically monitor them. Data are often collected only after significant damage has been caused by an individual species and studies have shown that significantly more information is available on pests in commercially valuable planted forests than in naturally regenerated forests. However awareness of the need to collect, collate and share information on forest pests and pathogens at national, regional and global levels is increasing. This paper firstly presents a snapshot of the Invasive pest species that are known to be already affecting Ireland's forest regeneration and secondly attempts to project and analyses the potential threats these and some emerging pest and pathogen species will have on the regeneration of Irish forest estate over the next 50 years. Using studies, and data, on potential pests and pathogens, carried out in other countries together with the most recent National forest inventory the author will extrapolate and map the potential damage and influence that some of these emerging species could potentially have on the Irish forest industry into the future.

KATIE McMAHEN || UNIVERSITY OF BRITISH COLUMBIA || KATIEMCMAHEN@GMAIL.COM
SUZANNE SIMARD

FOREST LEGACY-BASED MINE RECLAMATION METHODS FOR FACILITATING RECOLONIZATION OF SOIL BIOLOGICAL COMMUNITIES: PRELIMINARY FIELD AND GREENHOUSE TRIAL RESULTS

In mine reclamation, substrates available for use as growing mediums (e.g., tailings, subsoil) often lack the desired physical, chemical and biological properties. This presents a challenge for attaining mine closure land capability objectives. Facilitating recolonization of soil biological communities in these substrates can promote soil development, nutrient cycling, and establishment of native vegetation. This study tests the potential for forest ecosystem legacies to enhance recolonization of soil microbial communities and improve vegetation establishment following mining disturbance. To test this, a full factorial randomized block design field trial using *Picea engelmannii* x glauca (hybrid white spruce) forestry stock seedlings was established at the Mount Polley Mine, BC, encompassing areas of tailings deposition and scoured zones of exposed till that resulted from the 2014 tailings dam embankment breach. Factors included were site preparation, native forest soil transplants (active forest legacies), and spatial connectivity with the adjacent undisturbed forest (passive forest legacies associated with soil biota ingress and mycorrhizal network connectivity). Preliminary analysis of first growing season data suggests that soil transplants improved seedling survival and vigour, and site preparation increased vigour, although neither factor affected aboveground growth. Initial results of a supporting greenhouse trial using field site substrates indicate that the soil transplant effects can be partially attributed to the biological component (tested through sterilized versus unsterilized soil), which increased seedling vigour and chlorophyll fluorescence (a measure of stress), providing a benefit beyond the native soil physiochemical characteristics. First growing season treatment effects may have been masked by the nursery seedlings' high vigour and prior fertilization. Ongoing monitoring will track soil biota establishment and provide refined results for treatment effects on the soil food web, root microbial communities, and seedling above- and belowground traits. These results are anticipated to inform best practices for mine reclamation and rehabilitation of severely disturbed terrestrial ecosystems.

BRIANNA McTEAGUE || USDA FOREST SERVICE || BMCTEAGUE@FS.FED.US
ROBERT DANCHOK, ANGELIA KEGLEY, AND RICHARD SNIEZKO

CONSIDERATIONS FOR MANAGING REGENERATION OF FOXTAIL PINE (*PINUS BALFOURIANA*) IN THE FACE OF A NON-NATIVE PATHOGEN AND A CHANGING CLIMATE

High elevation species as well as species with limited and/or fragmented ranges may be particularly vulnerable to the effects of climate change and the associated spread of pathogens and competitors. Foxtail pine (*Pinus balfouriana*) is a long-lived, high elevation species endemic to California with a narrow and disjunct distribution, and has been classified as "Near Threatened" by the IUCN's Red List. Like all white pines, foxtail pine is highly susceptible to the introduced fungal pathogen *Cronartium ribicola,* the cause of white pine blister rust (WPBR). Future reforestation or restoration efforts with foxtail pine will be most successful if managers know the level of WPBR resistance, as well as the current and projected rust hazard of the sites being planted. Here we report early findings from our first WPBR resistance screening trials of foxtail pine, involving seedling progeny of 20 seed trees. Early results indicate that foxtail pine is extremely susceptible; all seedlings were cankered within 14 months of inoculation, and mortality reached nearly 80% by 18 months. These initial results suggest that seedlings from natural regeneration or planting will not likely survive unless on low hazard sites. Resistance screening of additional seedling families, and establishment of field rust trials to confirm the screening results is warranted to determine whether useable levels of resistance exist in this species. Rating sites for rust hazard under anticipated future climates, as well as incorporating recent information on patterns of adaptive genetic diversity in foxtail pine, would help guide management efforts. Seed collections have been started to preserve the range of genetic diversity of the species and for future research and restoration efforts. Insights from proactive management of foxtail pine can also be applied to other threatened non-commercial or high elevation tree species.

CHRISTIAN MESSIER || UNIVERSITY OF QUEBEC || MESSIER.CHRISTIAN@UQAM.CA

THE UNASSISTED MIGRATION: MANAGING NONNATIVE INVASIVE PLANTS USING A COMPLEXITY APPROACH

Few places on earth have not been invaded by a nonnative species, being of plants or animals. I call this the unassisted migration. This often means that the ecosystem we are currently managing is different from the one that we are used to or hope for, what many now called novel ecosystems. Furthermore, many of these successful nonnative species are extremely competitive and in most cases, but not always, they affect negatively the normal functioning of our ecosystem. Recognizing that we are managing novel ecosystems that are experiencing novel plant assemblages and environmental conditions is an important first step in managing for nonnative invasive plants. The traditional approach of "command and control" may not be the best approach and one needs to have a better understanding of the basic functional characteristics of our uninvited vegetative "guests" to design the appropriate intervention. The first question to ask is: what are these nonnative plant species doing or contributing to the ecosystem? Are they interfering with the growth of our desirable plant species (trees or other plants)? Are they providing some functional traits that could be beneficial in the current or future climate? Remembering that the ecosystem is changing and a famous sentence that Yogi Berra supposedly said, "the future is not like it used to be" are important. Then, if controlling these nonnative species is still required, one needs to understand their autecology or, in other words, what are the environmental conditions that favor their growth so that we could design silvicultural treatments that create unfavorable conditions for growth? In my talk, I will argue that an approach based on complexity theory is needed to minimize the possible negative impacts of these uninvited new species at low cost. The general approach should not be to try to eradicate the species, which is what a "command and control" approach would do, but instead viewing the problem as part of a complex adaptive system where we want to create conditions that favor the adaptive capacity of the forest. To achieve this, we need to follow a set of broad principles: (1) put the problem of the nonnative invasive species in the broader context where we evaluate how it is likely to affect many ecosystem services, not only the yield of one or a few species; (2) Focus on building the overall adaptive capacity of the forest and not only in producing one type of timber or one type of ecosystem service; (3) Look at the problem at both the stand and landscape scales and see what approach(es) can be implemented that could reduce the potential problem. Connectivity is often promoted in natural systems to preserve biodiversity, but modularity, i.e. the extent to which a system can be divided into independent units, could also be important to consider here to control some undesirable "guests"; and (4) Plan and develop long-term scenarios that acknowledge the prevalence of highly uncertain social, economic and environmental conditions. The problem of nonnative invasive plant species might be perceived differently if such a long-term approach incorporating uncertainty is considered.

OLIVIA MOSKOWITZ || UNIVERSITY OF WASHINGTON || OLIVIAM1@UW.EDU
MATTHEW AGHAI AND GREG ETTL

THE EFFECTS OF VARYING LIGHT AND MOISTURE LEVELS ON EARLY SURVIVAL AND DEVELOPMENT OF TWELVE PACIFIC NORTHWEST TREE SPECIES

Partial-cutting techniques are increasingly being used to improve structural diversity in even-aged plantations across the Pacific Northwest. Corresponding silvicultural or restoration prescriptions must account for openings of varying size and shape, which create differences in the amount of light and moisture available in the understory environment. A better understanding of how different species respond to varying levels of light and rhizosphere moisture is critical for species selection and successful regeneration efforts. This study examined the early growth dynamics and tolerances of seven tree species native to the west side and five species or varieties of species native to the east side of the Cascade Mountains. Seed provenance and stocktype were controlled within species in order to reduce confounding associated with sourcing and nursery culture. The experiment followed a factorial design in which seedlings were grown in large pots with three light levels created by precision-rated shade cloth and three distinct tapered irrigation regimes. This component study paralleled an in situ experiment conducted at field sites in the Puget Trough and Eastern Cascade Foothills Ecoregions of Washington State. Seedling response was assessed through repeated measurements of survival and aboveground morphology. After one year, seedlings were destructively sampled for measurements of leaf area and dry shoot and root weight. The majority of morphological responses for each species were significantly ($p<0.05$) affected by light availability. Light was the significant ($p<0.05$) driver of above- and belowground growth of *Abies grandis, Larix occidentalis, Pinus monticola, Pseudotsuga menziesii, Tsuga*

heterophylla, and the eastside varieties of *Pinus ponderosa* and *Thuja plicata*. The interaction between light and water treatments had a significant ($p<0.05$) impact on above- and belowground growth of *Alnus rubra* and the westside varieties of *P. ponderosa* and *T. plicata*. The highest mortality rates were observed for Acer macrophyllum and the westside variety of P. ponderosa, suggesting poor stock quality influenced early field potential.

VALERIU-NOROCEL NICOLESCU || UNIVERSITY TRANSYLVANIA OF BRASOV ROMANIA || NVNICOLESCU@UNITBV.RO
CORNELIA HERNEA

REGENERATION AND EARLY TENDING OF BLACK LOCUST (*ROBINIA PSEUDOACACIA* L.) IN THE NORTH-WEST OF ROMANIA

Black locust (*Robinia pseudoacacia* L.), the first North-American hardwood species imported to Europe (1601), was introduced in Romania in ca. 1750 and is cultivated as a forest tree since 1852. Currently, the species covers about 250,000 ha (ca. 4% of Romanian forest land). In the north-west of the country (Valea lui Mihai - Carei Plain, about 27,000 ha of land, of which ca. 5,000 ha of mobile and semi-mobile continental sand dunes), the black locust has been used since 1892 to prevent wind erosion and sand dune movement as well as produce firewood. The sand dunes are covered by sandy soils, of light texture, moderately acid to neutral, and poor (with low fertility and nutrient content). In this plain, black locust is nowadays the dominant species (covers about 90% of the forest area), being established either in pure or mixed stands, mostly with black cherry *Prunus serotina* Ehrh, but also on a much lower scale, with hybrid poplars. Since its introduction in the area, the species has been regenerated by planting, using 4,000 - 5,000 seedlings ha-1 produced in local nurseries. Young black locust plantations do not require any release cutting; two cleaning-respacing are carried out in thicket stage, in order to eliminate the low-quality trees (e.g., forked, with cankers, wounds, etc.) and re-space the remaining individuals until the beginning of pole stage. Black locust is chiefly established from root suckers as all black locust crops in the region are treated as low coppices (rotations: 20-30 years), followed by removal of stumps and soil preparation to allow for the vegetative establishment of a new cohort. Such young stands include tens of thousands of suckers per ha and no release cuttings are performed. Two cleaning-respacing are carried out until the pole stage, with the same aims as in the plantations.

OSCAR NILSSON || SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCE || OSCAR.NILSSON@SLU.SE
KARIN HJELM AND EMMA HOLMSTRÖM

ESTABLISHMENT AND INITIAL GROWTH OF PLANTED SCOTS PINE AND NORWAY SPRUCE ON LOW AND HIGH FERTILITY SITES IN NORTHERN AND SOUTHERN SWEDEN

Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea Abies* L. Karst.) are the dominant tree species in Sweden. Even though the species have very different requirements, silvicultural measures applied at regeneration, such as site preparation methods, are often the same. To be able to choose proper regeneration methods and species at different sites, a study was established with these species where growth and survival was studied at four sites, one poor and one fertile site in northern respectively southern Sweden. The trials were established on forest land 2011 and 2012, just after harvest of the previous crop. In order to create environments with different nitrogen availability, three different soil treatments were applied, being: i) control, ii) bare mineral soil and iii) turned over soil. The soil treatment plots were then split in half, where a fungicide was applied once in one of the two sub-plots. The fungicide decreased growth in an approximately similar way for all soil treatments, species and sites, and the negative effect of fungicide was still present after 5 and 6 years. For Norway spruce, growth was significantly higher in the turned over soil treatment compared to the bare mineral soil treatment at all sites. Whereas, for Scots pine, the highest growth was found on the turned over soil treatment and the lowest growth on the control treatment. This indicates that Norway spruce is more negatively affected when all organic material, and hence part of the nitrogen pool is removed, in comparison with Scots pine, that seems to get a hold of nitrogen even on the bare mineral soil treatment. At the most fertile site in southern Sweden, no effects of either soil- or fungicide treatments could be found for Scots pine, indicating a high availability of nitrogen at that site. This study shows a more rapid initial growth of Scots pine overall, a time-lag of the positive effect of the turned over soil treatment on poor sites, and that growth of Norway spruce is more negatively affected in environments with less availability of nitrogen.

URBAN NILSSON || SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCE || URBAN.NILSSON@SLU.SE
ANNIKA FELTON, EMMA HOLMSTRÖM, AND MATTS KARLSSON

PRE-COMMERCIAL THINNING TO CREATE FODDER FOR BROWSING ANIMALS

Various pre-commercial thinning (PCT) treatments with the aim to combine a positive growth response for crop-trees of planted Norway spruce and high availability of fodder for browsing animals were tested on four sites in southern Sweden. The PCTs tested were spot cleaning around selected crop trees, PCT to a mixed birch-Norway spruce dense spacing and total PCT leaving only crop-trees of Norway spruce, in comparison with an unthinned control. PCT was done when the mean height of crop-trees was about 1 m, which is somewhat earlier than normal. The two PCT-treatments spot cleaning and PCT to dense spacing reduced total availability of fodder compared to the unthinned control. However, because browsing on individual trees in the two thinned treatments were higher than in the control, total browsing on birch was not reduced by PCT. Total PCT reduced browsing compared to the control because of reduced availability of fodder and because the fodder was made up of stump-sprouts which was less attractive for the browsing animals than retained birches originating from seeds. Other broadleaved trees than birch may have been important for the browsing animals and it is important to quantify this in future studies. Growth during the first three years after PCT was positively affected by all three PCT-treatments but the most significant increase was found in the total PCT and thereafter in PCT to dense spacing. This study indicated that both spot-cleaning and PCT to dense spacing combined a positive growth response of crop-trees with high availability of fodder. It is possible that a second PCT may further improve growth of crop-trees.

FLORENT NOULÈKOUN || CENTER FOR DEVELOPMENT RESEARCH || S7FLNOUL@UNI-BONN.DE
JOHN LAMERS, JESSE NAAB, AND ASIA KHAMZINA

ABOVE- AND BELOWGROUND RESPONSES OF FAST- AND SLOW-GROWING AFFORESTATION SPECIES TO SILVICULTURAL MANAGEMENT ON DEGRADED CROPLAND IN SEMI-ARID ZONE OF BENIN

In drylands of West Africa, where deforestation and cropland soil degradation occur at alarming rates, the (re-)introduction of trees on degraded lands can improve and sustain farming systems and landscapes. The effect of silvicultural management on above- and belowground growth was assessed in five afforestation species on degraded cropland in the semi-arid zone of Northern Benin. The performance of fast-growing *Leucaena leucocephala* Lam., *Moringa oleifera* Lam. and Jatropha curcas L., and slow-growing *Anacardium occidentale* L. and Parkia biglobosa Jacq. subjected to fertilization (1 kg of manure per plant), supplemental irrigation (0.5 liter of water per sapling per day), or both, was monitored over two rainy and one dry season. Highest survival rates (94-100%) were observed in *J. curcas*, *L. leucocephala* and *M. oleifera*. The mortality rate of the most drought-sensitive species *P. biglobosa* was reduced ten-fold through supplemental irrigation during the dry season. Fertilization and irrigation enhanced the shoot growth of both the fast and slow growers during the dry and rainy seasons. In contrast, the root growth was either increased or reduced by fertilization and irrigation during the rainy and dry seasons. Biomass accumulation was positively affected by manuring and irrigation in the three fast growers during both rainy seasons, while the slow growers positively responded to the treatments during the dry and second rainy season. The fast growers accumulated most biomass (7.6-14.4 Mg/ha) under manuring 15 months after planting, but the slow growers demonstrated a more plastic response to the treatments than did the fast growers. Overall, a mix of fast and slow growers may promote the long-term productivity of tree plantations on degraded cropland while the early growth and establishment of saplings could be boosted by supplementary irrigation and a supply of manure.

FELIX OBOITE || UNIVERSITY OF ALBERTA EDMONTON || OBOITE@UALBERTA.CA
PHIL COMEAU

RELEASE RESPONSE OF BLACK SPRUCE AND WHITE SPRUCE FOLLOWING OVERSTORY LODGEPOLE PINE MORTALITY DUE TO MOUNTAIN PINE BEETLE ATTACK

Advance regeneration is present in many lodgeople pine stands in Alberta. When the overstory pine canopy is killed by Mountain Pine Beetle (MPB) the growth of this advance is likely to increase. Understanding the growth response of these understory tree species is needed to improve mid-term timber supply projections and management decisions. To quantify the growth (diameter, height, height/diameter ratio) responses of black spruce and white spruce to lodgepole pine mortality,sample trees of black and white spruce advance regeneration were selected from 7 lodgepole pine dominated stands (5 attacked; 2 control) in the Foothills Region of western Alberta. Measurements were collected 7-8 years after MPB attack across a wide range of spruce height and stand densities. Analysis was done using mixed model linear regression. Result indicates that there was an increase in both diameter and height growth after MPBattack; however, this increase in growth was delayed for about four years. Both spruce species had similar height response and their height/diameter ratio decreased after release, partly as a result of increased understory light associated with loss of needles in the pine canopy. In addition, the diameter and height growth responses of both spruce species were strongly related to density, prerelease growth and initial size.

CATHRINE STEFFY PATER || UNIVERSITY OF COPENHAGEN || CSP@IGN.KU.DK
PELLE MADSEN, NICLAS BENTSEN, ESBEN MØLLER MADSEN, AND TORBEN LYNGE MADSEN

EFFECTS OF PLANTING DATE AND CONTAINER VOLUME IN RELATION TO SITE AND YEAR ON SURVIVAL AND HEIGHT OF PLANTED CONIFERS AND BROADLEAVES

Forest regeneration and afforestation tree plantings usually involve stock densities in the range of 1,000-6,000 seedlings per hectare depending on a number of management issues as well as local or national forestry tradition, legislation or subsidy schemes. This study is part of an overall effort to develop more cost-effective regeneration systems for planting focusing on the use of young (3-14 month old) container stock types. Small and young planting stock types may be a promising alternative for temperate forestry to the commonly used, larger and older bareroot stock types. The objective of the study is to contribute to the development of planting systems using small container stock and to quantify the effects of planting date and container volume. The field experiments were established from July 2006 until March 2009 at eight sites in total; each site comprising one to three planted tree species generally considered adapted for the site. The tree species included are ash (*Fraxinus excelsior*), beech (*Fagus sylvatica*), Douglas-fir (*Pseudotsuga menziesii*), Japanese larch (*Larix kaempferi*), pedunculate oak (*Quercus robur*), sessile oak (*Quercus petrea*), Sitka spruce (*Picea sitchensis*) and sycamore maple (*Acer pseudoplatanus*). Ash was eliminated by the disease ash dieback (*Hymenoscyphus pseudoalbidus*) shortly after planting. In total the experiments comprises 980 individual plots each typically including 30-50 planted seedlings. The main inventory was conducted in 2013. Both planting date and container type and volume had significant but inconsistent effects on survival and height of the trees. The different intolerance of tree species to open site conditions in the regeneration phase was clearly demonstrated; the small stock types provided successful regeneration under shelter (shelterwood or nurse crop), whereas the regeneration success was much more unpredictable at open sites like clear cuts. This is particularly true for species like beech, Douglas fir, Sitka spruce and sycamore maple.

AMY RAMSEY || WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES || AMY.RAMSEY@DNR.WA.GOV
RICHARD SNIEZKO, DAN OMDAL, ROBERT DANCHOK, DOUGLAS SAVIN AND ANGELIA KEGLEY

ESTABLISHING AND MONITORING BLISTER RUST RESISTANCE, PATHOGEN VIRULENCE, AND GENETIC ADAPTABILITY OF WESTERN WHITE PINE IN WASHINGTON

Western white pine (WWP, *Pinus monticola* Dougl.) is a wide-ranging forest tree species of high economic and ecological value. However, due to several factors, including the inadvertent introduction of the non-native fungal pathogen *Cronartium ribicola* Fisch. (cause of white pine blister rust (WPBR) disease) around 1910, there has been extreme levels of mortality in many natural populations

of WWP, and a greater reluctance to use this species in reforestation. The Washington Department of Natural Resources and the USDA Forest Service's Dorena Genetic Resource Center have partnered to undertake a series of field trials to evaluate disease resistant WWP. Trials recently planted in western Oregon and eastern Washington, complementing another test series planted in 2006/2007 in western Washington, will provide key information on the efficacy of rust resistance over time, as well as the adaptability of different seed sources of WWP in a changing climate. These trials include both the most advanced seed orchard lots currently available, as well as seedlings from parents spanning the full range of resistance types currently known for WWP. The parent trees for this trial originate from Oregon, Washington, Idaho and British Columbia. A This series of trials will provide information on genetic resistance to white pine blister rust, on adaptability of seedlots from different geographic sources in these locations, and serve as sentinel plantings to monitor impacts of pathogens and insects or impacts from abiotic events associated with a changing climate. Nine years after planting the western Washington trials, the level of blister rust infection varies dramatically among the six sites assessed in 2015, from 6.9 % to 61.9%. Sites in western Washington vary dramatically in their apparent rust hazard, according to our data, and different management strategies (level of resistance, pruning, spacing, etc.) may be utilized across the region.

JACOB REELY || UNIVERSITY OF IDAHO || REEL3043@VANDALS.UIDAHO.EDU
ANDREW NELSON

BIOMASS ALLOCATION PATTERNS OF 3 NORTHWEST CONIFER SPECIES: THE EFFECTS OF SEEDLING QUALITY, SITE QUALITY, AND MOISTURE STRESS

Reforestation in the Inland Northwestern US is dominated by containerized seedlings. High mortality and poor growth following establishment is common, which can be partially attributed to seedling quality. Seedling quality can be assessed with root growth potential (RGP) testing that examines the performance of seedlings under optimal laboratory conditions. RGP is often correlated with field performance since the test assesses a seedlings' ability to initiate new roots and acclimate to site conditions. The objective of this study is to examine morphological changes of common Inland Northwest conifer species during the first growing season after planting on three sites with contrasting soil moisture and temperature regimes and use this information to better understand seedling growth and survival. Interior Douglas-fir, western larch, and grand fir seedlings were planted in spring 2016 following RGP testing that evaluated the number of new roots produced in aeroponic chambers. Above- and belowground portions of the trees were destructively sampled monthly throughout the growing season (June-August) and again in October and November. Concurrently, pre-dawn plant moisture stress was measured. Soil moisture and temperature loggers were installed at each site. Results on the seasonal changes in root volume, leaf area, above- and belowground biomass, and plant moisture stress by species, in relation to soil moisture and temperature and new root production during RGP testing will be presented. Additional results exploring how these factors influence seedling height, diameter, and survival will also be discussed. The results will help managers better understand how RGP results relate to field performance and provide a mechanistic understanding of periodic changes in seedling morphology and how they relate to first year growth and survival on common planting sites in the region.

PETER REICH || UNIVERSITY OF MINNESOTA || PREICH@UMN.EDU

FOREST REGENERATION UNDER GLOBAL ENVIRONMENTAL CHANGE: THE GOOD, THE BAD, AND THE UGLY

Rising CO_2, and associated changes in the levels and timing of temperature and precipitation, are having, and will have, myriad impacts on forest function, including tree regeneration. Those effects occur via direct physiological impacts as well as through indirect mechanisms involving changes in soil moisture, competitive hierarchies, biotic interactions, management priorities, species pools, and rates and kinds of natural disturbances, to name just a few. Thus, global change has the potential to alter not only the relative success of forest regeneration, but the composition and diversity of new communities. In my talk, I will provide a brief overview of what forest regeneration looks like today and in the near future around the globe and then focus in on the boreal-temperate ecotone in Minnesota, USA where my views are informed by work in natural experiments, spatial gradients, inventory observations, and long-term open-air climate change experiments in the field.

BRIAN RICHARDSON || NEW ZEALAND FOREST RESEARCH INSTITUTE || BRIAN.RICHARDSON@SCIONRESEARCH.COM
RUSSELL DALE, JUAN MONGE AND CAROL ROLANDO

WHY IS NEW ZEALAND NOT PLANTING MORE TREES?

The forest industry, based primarily on a planted forest estate of exotic (non-native) species, is New Zealand's third largest primary industry export revenue earner at NZ$4.8 b in 2015 and this amount is forecast to grow in the coming years. It is also an important contributor to regional economies and is a key component of many Regional Development Action Plans. A high proportion of the planted forest estate is Forest Stewardship Council certified and there are ongoing efforts to ensure sustainability of forestry practices. There is also increasing recognition of the net positive contribution of planted forests to a variety of ecosystem services, especially when compared with many other primary production sectors. Despite these positive environmental and economic indicators, the planted forest estate in New Zealand has significantly declined from its peak of 1.83 million ha in 2003 to the current level of 1.72 million ha, a net loss of about 110,000 ha or about 9%. It is argued that sub-optimal economic and environmental outcomes are being delivered at a national and regional level, driven by factors that include a lack of overarching policies for land use and for forestry, and lack of formal recognition of externalities from different production systems. At the same time there are clear opportunities for sector complementarity where, if different primary production sectors worked together in a manner underpinned by sound policy, net economic and environmental outcomes would be enhanced and the planted forest area would increase.

SERAJIS SALEKIN || UNIVERSITY OF CANTERBURY || SERAJIS.SALEKIN@PG.CANTERBURY.AC.NZ
EUAN MASON, JUSTIN MORGENROTH, MARK BLOOMBERG AND DEAN MEASON

MODELING JUVENILE HEIGHT YIELD OF *EUCALYPTUS GLOBOIDEA* AND *EUCALYPTUS BOSISTOANA* IN RESPONSE TO MICRO-SITE EFFECTS

Traditionally local variation in plantation forests has been treated homogenously. Large scale variations are commonly included in growth and yield models, but variation due to micro-site factors plays a vital role, particularly in juvenile crops. In this study, we explored micro-site factors and accommodated them in height yield modeling of two durable eucalypt species (*Eucalyptus globoidea* and *Eucalyptus bosistoana*). We collected within-stand tree, soil, topographic and climatic data. Permanent sample plot (PSPs) data were provided by the New Zealand dry land forest initiative (NZDFI). We analyzed the data by fitting height yield models with several micro-scale variables describing topographic, climatic and soil factors as independent variables augmenting the models. Models such as these will allow foresters to understand factors influencing variation in stem dimensions within stands and to more precisely allocate silvicultural spending.

JESSICA SARAUER || UNIVERSITY OF IDAHO || SARA8172@VANDALS.UIDAHO.EDU
MARK COLEMAN

BIOCHAR AND DOUGLAS-FIR SEEDLING GROWTH AND QUALITY

Artificial forest regeneration with greenhouse-grown Douglas-fir (*Pseudotsuga menziesii* var. glauca) seedlings is common in Idaho. Growing Douglas-fir seedlings in a greenhouse requires the use of water and fertilizer to get an optimal tree for out planting. The cost of fertilizer can be high and excessive fertilizer use can lead to downstream pollution. Biochar is an amendment that could reduce the amount of water and fertilizer necessary for growing seedlings because of its high water and nutrient holding capacity. The objective of this study was to determine if using biochar as a growing media amendment will reduce the amount of fertilizer necessary for adequate seedling growth and quality. Treatments included 18 growing media combinations of biochar (0, 25, and 50% by volume) and fertilizer (0.79, 0.40, and 0.20 g N L-1). Douglas-fir seeds were sown in March 2016 and seedlings were grown under standard light and temperature conditions at an operational forest nursery for 9 months. Every 13 weeks seedlings were measured for photosynthetic activity, destructively harvested, and analyzed for C and N content. After 39 weeks, seedlings grown with biochar where significantly smaller (height, diameter, and biomass) than those grown without biochar (variable by fertilizer rate). Seedlings grown in the highest rate of fertilizer were 2.6 times larger in total biomass than those in the lowest rate, while biochar amendments decreased growth by 66% relative to those without biochar. The same trend, increase with fertilizer rate, but decrease with added biochar, was observed for height and diameter. P-values for testing amendments were <0.001 for all main effects and their interaction. Poor growth is attributed to growing media pH. Adjusting the pH of biochar might be necessary to use it for growing Douglas-fir seedlings for forest regeneration.

MARY ANNE SAYER || USDA FOREST SERVICE || MSWORD@FS.FED.US
MICHAEL TYREE AND DYLAN DILLAWAY

EFFECT OF SEASON OF PRESCRIBED FIRE ON THE FOLIAGE REESTABLISHMENT AND STARCH DYNAMICS OF *PINUS PALUSTRIS* MILL. SAPLINGS

Repeated prescribed fire reduces understory fuel, changes understory composition to benefit wildlife, and perpetuates the plants and animals of pine ecosystems in the southeastern United States. Consequently, prescribed fire every two to five years is common across this region. While there are many benefits of prescribed fire, this tool may decrease forest production if the loss of foliage by scorch substantially reduces whole-crown carbon fixation. Two studies conducted on the Kisatchie National Forest in central Louisiana, USA evaluated relationships between season of fire, regrowth of scorched foliage, the seasonal availability of stored carbohydrate, and the stemwood growth of sapling longleaf pine. Rapid flush and fascicle expansion led to normal crown leaf areas by one year after burning regardless of the season of fire application. After crown scorch in spring, the rate of root starch mobilization suggested that these energy reserves which peaked in late winter, were an important means of leaf area recovery. In contrast, fall prescribed fire coincided with the normal period when starch is nearly depleted in southern pines. It is likely, therefore, that foliage recovery after fall burning relied on current photosynthate produced by residual, non-scorched foliage rather than stored starch. In February and March after fall prescribed fire, average starch levels in woody root, stem, and terminal branch tissues were reduced by 68, 47, and 77 percent, respectively, compared to similar levels in non-burned plots. One apparent result of redirecting current photosynthate, therefore, may have been low levels of starch accumulation in the year after fall prescribed fire. Prolonged drought which occurs frequently across the southeastern United States, has the potential to reduce photosynthesis and therefore, the availability of carbohydrate for metabolism, growth, and starch accumulation. The consequences of low starch accumulation at the time of severe drought will be discussed.

ANDREW SELF || MISSISSIPPI STATE UNIVERSITY || BRADY.SELF@MSSTATE.EDU
JOHN WILLIS

ACHIEVING ADEQUATE OAK REGENERATION THROUGH SHELTERWOOD CUTTINGS IN MISSISSIPPI

Bottomland hardwood sites have some of the most productive forest soils, and correspondingly high species richness ratings found in North America. However, inherently fertile soils often lead to increased vegetative competition and difficulty establishing oak species in total harvest operations across the southeastern U.S. Shelterwood harvesting is often prescribed as a viable regeneration option in these systems with a basal area target of 11.48m2/ha. Six, 8.1 hectare study areas representing typical bottomland hardwood sites were selected in Mississippi. Stands selected averaged 83 years, possessed overstory canopies comprised of 67.5 percent oak, and initial basal area ranging between 21.12m2/ha and 28.01m2/ha. Six overstory removal treatments (16.07m2/ha, 13.77m2/ha, 11.48m2/ha, 9.14m2/ha, 6.89m2/ha, and untreated) and midstory removal were tested to determine which residual basal area created appropriate light and competition conditions to maximize regeneration density. Six year results are presented with a wider range of

treatments than typically prescribed in regeneration efforts of this forest type. While, the 11.48m2/ha basal area treatment yielded the greatest seedling densities, seedling density in other treatments was excellent as well. It is entirely possible that land managers may target a wider, more flexible basal area range than typically prescribed in these systems.

CHENCHEN SHEN || UNIVERSITY OF IDAHO || CSHEN@UIDAHO.EDU
ANDREW NELSON

THE RESPONSE AND ADAPTATION OF TREE SEEDLING REGENERATION TO POTENTIAL COMPETITION IN THE INLAND NORTHWEST FORESTS, USA

Growth and survival of forest regeneration are crucial to a variety of ecosystem processes, including changes in forest structure, succession and population dynamics. Regeneration is also necessary for future wood production, the maintenance of biodiversity and forest sustainability. Seedling regeneration tends to respond and adapt to various biotic and abiotic factors including concurrent competition from overstory trees and understory vegetation. The objective of this study is to investigate the change in seedling populations in response to canopy tree density and understory non-tree vegetation abundance for common species across the Inland Northwest using FIA data. Overstory density in each subplot is classified into 6 groups based on relative basal area (RBA). Generalized additive model and two-level generalized nonlinear mixed models are used due to complex correlations between seedling population and independent variables (total tree species; stand basal area; total vegetation species; maximum vegetation layer and total vegetation cover percent) for each species. Modeling results indicate species-specific seedling demographics vary by RBA of the overstory. For instance, ponderosa pine seedlings were affected by competition from both overstory trees and understory vegetation at a median RBA. Douglas-fir seedling populations showed no consistent response to competition, while western larch was positively influenced by understory vegetation when RBA was low. Variation analysis based on re-measured data demonstrates the seedling regeneration responses vary by species and across a gradient of geographic attributes. Our findings can be effectively implemented in adaptive forest management practices at both regional and local scales. These models will allow forest managers to assess the effects of overstory and understory competition on seedling survival and recruitment, and enable them to identify situations that may warrant competition control.

REBECCA SHERIDAN || OREGON STATE UNIVERSITY || REBECCA.SHERIDAN@OREGONSTATE.EDU
ANTHONY DAVIS

IMPACTS OF INITIAL ROOT VOLUME ON DOUGLAS-FIR SEEDLING GROWTH AND PHYSIOLOGICAL FUNCTION AFTER PLANTING

Seedlings face many challenges when planted in reforestation projects, particularly in dry locations. The Target Plant Concept can be used to define the characteristics that seedlings need to establish on an outplanting site. Defining targets for high-quality seedlings requires understanding how seedling morphology and physiology integrate to produce successful seedlings. The objective of this study was to determine the impact of seedlings' initial root volume on the water relations and growth of inland Douglas-fir seedlings. We excised portions of the root system to achieve starting root volumes that represented 100%, 66%, or 33% of the original container-grown volume. The seedlings grew in growth chambers for a six-week establishment period, then were subjected to drought or well-watered conditions for two months. Seedlings with root volumes reduced to one-third of the original volume maintained photosynthesis and growth throughout the experiment. Seedling hydraulic physiology measurements, including hydraulic conductivity per root volume and pressure-volume curve parameters, were comparable across the treatments. The morphological quantification of root growth (number of new root tips, new root area, and new root dry mass) showed that seedlings with lower initial root volumes grew as much new root tissue as the seedlings that started with full root systems. The drought-stressed seedlings had a trend of greater root growth than the well-watered seedlings. We observed that seedlings can adjust root growth to compensate for lower initial volumes while maintaining hydraulic function. Within the drought-stressed seedlings, the seedlings with smaller root volumes used less water per leaf area, which suggests that water use efficiency may change with initial root volume and subsequent root growth. These results will help refine the target root volumes for container seedlings and can inform planting decisions made for dry sites.

ULF SIKSTRÖM || THE FORESTRY RESEARCH INSTITUTE OF SWEDEN || ULF.SIKSTROM@SKOGFORSK.SE

REGENERATION SUCCESS OF *PICEA ABIES* AFTER WHOLE-TREE HARVESTING AND ASH ADDITION

In Sweden, the use of biofuels as an energy source has increased substantially during the last decades. Whole-tree harvesting (WTH) is, and ash recycling might become, large scale practices in operational forestry. WTH includes extraction of stems, tops and branches at harvest. There are few available field experiments with ash addition, especially when added in clear-cuts. In order to increase requested knowledge on how WTH and ash recycling affect growth of Norway spruce (*Picea abies* L. Karst.), the following hypotheses are tested in an experimental series including three sites located in Sweden: (i) the growth is reduced after WTH by c. 10%, (ii) at fertile sites the growth is enhanced by ash addition, unaffected at medium-productive sites, and reduced at low-productive sites, (iii) the reduced growth by WTH is compensated for by ash addition at fertile sites only. The method includes monitoring of survival and tree growth measurements in the three field experiments located on sites of different fertility. The experimental design is treatments randomized within blocks (n = 5). At all sites the following treatments are included: (i) harvest of stems only (SOH), (ii) whole-tree harvest (WTH), (iii) SOH + 3 tonnes (d.m.) of self-hardened crushed biofuel ash (SOH + ASH), and (iv) WTH + ASH. The experiments were established between 2011 and 2015. Results on survival and growth over 2-6 growing seasons will be presented.

JOSHUA SLOAN || NEW MEXICO STATE UNIVERSITY || JOSHUA.L.SLOAN@GMAIL.COM
OWEN BURNEY AND DOUGLASS JACOBS

USE OF STABLE ISOTOPES TO TRACE THE FATE OF APPLIED NITROGEN IN AN INTENSIVELY MANAGED BLACK WALNUT PLANTATION

Intensively managed forest plantations often require fertilization to maintain site fertility over successive rotations, as well as to improve growth and yield. Although little is known about the fate of fertilizers applied to such plantations, studies have demonstrated low fertilizer use efficiency (FUE), and various "enhanced-efficiency fertilizers" (EEFs) have been developed in an effort to improve FUE. To examine the fate of applied N in a mid-rotation black walnut (*Juglans nigra* L.) plantation, we applied 15N-enriched urea-based fertilizers to crop trees and tracked the fate of applied 15N within crop trees, soils, competing vegetation, and litter during the twelve months after application. Fertilizer treatments consisted of an unfertilized control, Agrotain Ultra (urea coated with a urease inhibitor), Arborite EC (urea coated with water-soluble boron and phosphate), Agrium ESN (polymer-coated urea), and uncoated urea. Fertilizers were applied at a rate of 224 kg N ha-1. Agrotain Ultra and Arborite EC increased δ15N values of crop tree leaves above those of controls at one and two months after application, respectively, whereas Agrium ESN and uncoated urea did not increase crop tree leaf δ15N until three months after application. Similarly, Agrotain Ultra and Arborite EC increased N concentrations of competing vegetation within one month after application, whereas neither Agrium ESN nor uncoated urea significantly increased N concentrations of competing vegetation during the experiment. Competing vegetation δ15N values show that fertilizer-derived N from all treatments had been incorporated by one month after application, although to a lesser extent for Agrium ESN, with similar patterns observed in litter δ15N. Applied N was not found to measurably impact soil N pools and was rapidly incorporated into biological components of the ecosystem. Agrium ESN was the only EEF which exhibited controlled-release activity in this study, with other fertilizers behaving similarly to uncoated urea.

RICHARD SNIEZKO || USDA FOREST SERVICE || RSNIEZKO@FS.FED.US

THE ROLE OF GENETICS IN SUCCESSFUL REGENERATION OF FORESTS

Most newly regenerated forests are expected to grow and stay healthy for several decades or longer. The choice of which species or combination of species to utilize, as well as which seed sources to use to assist in the successful regeneration of forests are key factors in starting on the road to success. These factors are even more important with an increasingly dynamic world where climatic change and non-native pathogens and insects continue to impact species. Understanding the adaptive genetic variation within a species and how it can best be utilized to ensure long-term development of regenerated forests is important component of adaptive management. Applied programs in the Pacific Northwest U.S. with four species, western white pine (*Pinus monticola*) , whitebark pine (*P. albicaulis*), sugar pine (*P. lambertiana*) and Port-Orford-cedar (*Chamaecyparis lawsoniana*) will be used to illustrate genetic considerations and information gathering that are used to maintain these species in forest ecosystems in the face of challenges. The designation of breeding zones, disease resistance breeding (to non-native diseases), having a reliable source of high quality seed, maintenance of genetic diversity, and establishment of sentinel plantings provide land managers with vital information and tools. To optimize the successful regeneration of forests, the information on genetics should be complemented by proper silvicultural tools and information on current and projected site conditions.

ROBERT WAGNER || PURDUE UNIVERSITY || RGWAGNER@PURDUE.EDU
ARUN BOSE, BRIAN ROTH AND AARON WEISKITTEL

INFLUENCE OF BROWSING AND OVERSTORY RETENTION ON AMERICAN BEECH AND SUGAR MAPLE REGENERATION NINE YEARS FOLLOWING UNDERSTORY HERBICIDE RELEASE IN CENTRAL MAINE

Increasing dominance of American beech (*Fagus grandifolia*) in the understory and midstory of Northern Hardwood forests present a major challenge for managing natural regeneration across the northeastern US and eastern Canada. Development of effective and low-cost methods to favor more desirable hardwood species, especially sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*), is a top priority. We examined hardwood regeneration characteristics nine years after application of a 3 x 4 factorial combination of glyphosate herbicide (0.56, 1.12, and 1.68 kg/ha) and surfactant concentrations (0.0, 0.25, 0.5, and 1.0%) to release sugar maple regeneration from beech-dominated understories in three shelterwood-harvested stands in central Maine. Successful sugar maple release, as documented three years after herbicide treatment, was sustained through year nine. Glyphosate rate increased both absolute (AD) and relative density (RD) of sugar maple regeneration, but not height (HT). In contrast, beech AD, RD, and HT were all significantly reduced with increasing glyphosate rate. However, post-release browsing and an increased overstory basal area reduced the sugar maple HT. Our results indicated that glyphosate herbicide can significantly increase the abundance of sugar maple regeneration, however, subsequent browsing combined with the negative influence of the residual overstory in shelterwood-harvested stands can reduce the overall benefit of these treatments. Therefore, in addition to herbicide treatment, intermediate harvesting and browsing-control measures may be needed to promote sugar maple regeneration over beech in northern hardwood stands.

KRISTINA WALLERTZ || SOUTHERN SWEDISH FOREST RESEARCH CENTER || KRISTINA.WALLERTZ@SLU.SE
KARIN HJELM, MAGNUS PETERSSON SÖDRA, NIKLAS BJÖRKLUND AND LARS-GÖRAN SUNDBLAD

SITE PREPARATION TECHNIQUES & EFFECTS ON PLANTING CONDITIONS, SEEDLING GROWTH AND PINE WEEVIL DAMAGE

Site preparation techniques - effects on planting conditions, seedling growth and pine weevil damage in northern Europe the risk for newly planted conifer seedlings to get severe damage by pine weevil (*Hylobius abietis*) is high. Site preparation is one of the most important measures that could decrease the risk of damage and is also well known to improve growth and establishment. The reduction of pine weevil damage is highly dependent on the amount of pure mineral soil around the seedling. We investigated how four different site preparation techniques; 1) no site preparation, disc trenching with either 2) Bracke T26 or 3) MidiFlex, and soil inversion with 4) Karl-Oskar, affected the soil conditions of the planting spots and growth and survival of planted Norway spruce (*Picea abies*) seedlings, particularly regarding pine weevil damage. Without soil preparation, most planting spots consisted of undisturbed humus. MidiFlex

had the lowest proportion of spots with pure mineral soil. The proportion was somewhat higher after Bracke T26 and Karl-Oskar created most spots with pure mineral soil. On very stony soils, Bracke T26 created more mineral soil spots than Karl-Oskar. All site preparation techniques reduced pine weevil damage in comparison with no site preparation. Fewer seedlings were attacked and severely damaged by pine weevil after Karl-Oskar than after MidiFlex. Seedling growth was positively affected by site preparation, but no significant differences were found between the three different techniques, although there was a tendency that seedlings planted after Karl-Oskar achieved the greatest mean height. The results indicate that the quality of the planting spots depends on the technique used. In this study pine weevil damage was assumed to be the major cause of damage, and therefore planting spots with pure mineral soil was the key factor. During these circumstances, Karl-Oskar was the most sufficient method.

KRISTEN WARING || NORTHERN ARIZONA UNIVERSITY || KRISTEN.WARING@NAU.EDU
ANTONIO CASTILLA, SAM CUSHMAN, ANDREW ECKERT, LLUVIA FLORES, RICHARD SNIEZKO, CHRISTOPHER STILL, CHRISTIAN WEHENKEL, AMY WHIPPLE AND MICHAEL WING

COLLABORATIVE RESEARCH FOR SUSTAINABLE MANAGEMENT OF SOUTHWESTERN WHITE PINE

A collaborative team of researchers from the United States (U.S.) and Mexico have begun an exciting new research project funded by The National Science Foundation's Macrosystems Biology program. The project is to study ecological and evolutionary processes affecting the distribution of southwestern white pine, an important tree species of mixed conifer forests in the southwest U.S. and Mexico. Southwestern white pine (*Pinus strobiformis*) sustainability is threatened by changing climate, and a non-native tree disease, white pine blister rust. White pine blister rust causes extensive tree decline and mortality where it occurs in North America, including where it overlaps with southwestern white pine, an ever-expanding area. Climate may change too rapidly for southwestern white pine to adapt. The dual threats of climate change and an invasive species make forecasting future tree distributions across continental scales an urgent challenge. The goal is to determine how gene movement among populations, adaptation to disease and drought, heritable changes beyond DNA mutations, and a changing environment interact to govern the success of southwestern white pine. This project will develop tools to help forecast and manage the future of the species, including genomics, common gardens, disease resistance testing, engineering, and technology innovation to measure drought tolerance, and computer modeling in landscape ecology and genomics. The research team is using the Southwest Experimental Garden Array, set of common gardens, that allows scientists to quantify the ecological and evolutionary responses of species to changing climate conditions. We will present an overview of the project, an update on status and preliminary results, and potential management applications focused on regeneration of southwestern white pine.

MAXWELL WIGHTMAN || OREGON STATE UNIVERSITY || MAXWELL.WIGHTMAN@OREGONSTATE.EDU
CARLOS GONZALEZ-BENECKE

INTEGRATED ANALYSIS ON THE EFFECTS OF CHEMICAL VEGETATION MANAGEMENT TREATMENTS ON UNDERSTORY VEGETATION COMMUNITY DYNAMICS IN THE PACIFIC NORTHWEST, USA

Numerous studies have demonstrated a positive effect of chemical vegetation control on conifer plantation establishment and growth. As a result, chemical vegetation control treatments have become widespread in the management of industrial forest lands throughout the Pacific Northwest. As the use of chemical vegetation control treatments has become more widespread there has also been increased concern regarding the impact of these treatments on the biological diversity and abundance of understory plant species. The Vegetation Management Research Cooperative (VMRC) at Oregon State University has established numerous study sites throughout Oregon and Washington states to investigate a variety of different research questions. In this study we used data from a subset of seven ongoing VMRC study sites that received similar chemical vegetation control treatments. The data was pooled in order to conduct a region-wide analysis on the influence of fall site preparation and spring release vegetation control treatments on understory community dynamics over the first four growing seasons after planting. The specific goal was to develop a region-wide analysis of the number of years required for understory biodiversity and abundance to recover following the application of chemical vegetation control treatments.

IAN WILLOUGHBY || FORESTRY COMMISSION || IAN.WILLOUGHBY@FORESTRY.GSI.GOV.UK
JACK FORSTER AND VICTORIA STOKES

***GAULTHERIA SHALLON* CAN BE EFFECTIVELY CONTROLLED BY THE HERBICIDES PICLORAM, TRICLOPYR OR GLYPHOSATE IF THEY ARE APPLIED AT THE CORRECT TIME OF YEAR**

Salal (*Gaultheria shallon*) is a vigorous evergreen perennial shrub that is native to the west coast of North America. Since its introduction into the UK almost a century ago it has become an increasing problem in many forests, where it completely shades out other understory vegetation including young trees, effectively preventing regeneration and making future sustainable forest management impossible. Non chemical management is only practical on a small scale, and to date efforts to control this invasive weed with herbicides have been largely ineffective. In our work we found that a single application of 2.69 kg active ingredient (a.i.) ha-1 picloram (as 11.2 litres ha-1 Tordon 22K (240 g l-1 picloram)) diluted in water plus the adjuvant Mixture B NF at 2% of final spray volume, applied between spring and mid-summer, killed all treated plants within two growing seasons. Treatment with 3.84 kg a.i. ha-1 triclopyr (as 8 litres ha-1 Timbrel (480 g l-1 triclopyr)) diluted in water plus Mixture B NF at 2% of final spray volume, sprayed initially when flower buds are swelling or flushed but vegetative buds are largely dormant (late April in southern Britain), with a repeat application made 4-8 weeks later, was also very effective. Glyphosate also provided some control, but follow up treatment was required.