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Future Vulnerabilities to Alaskan Ecosystems and Tools for Permafrost

June 29, 2017

SERDP DOD • EPA • DOE | ESTCP

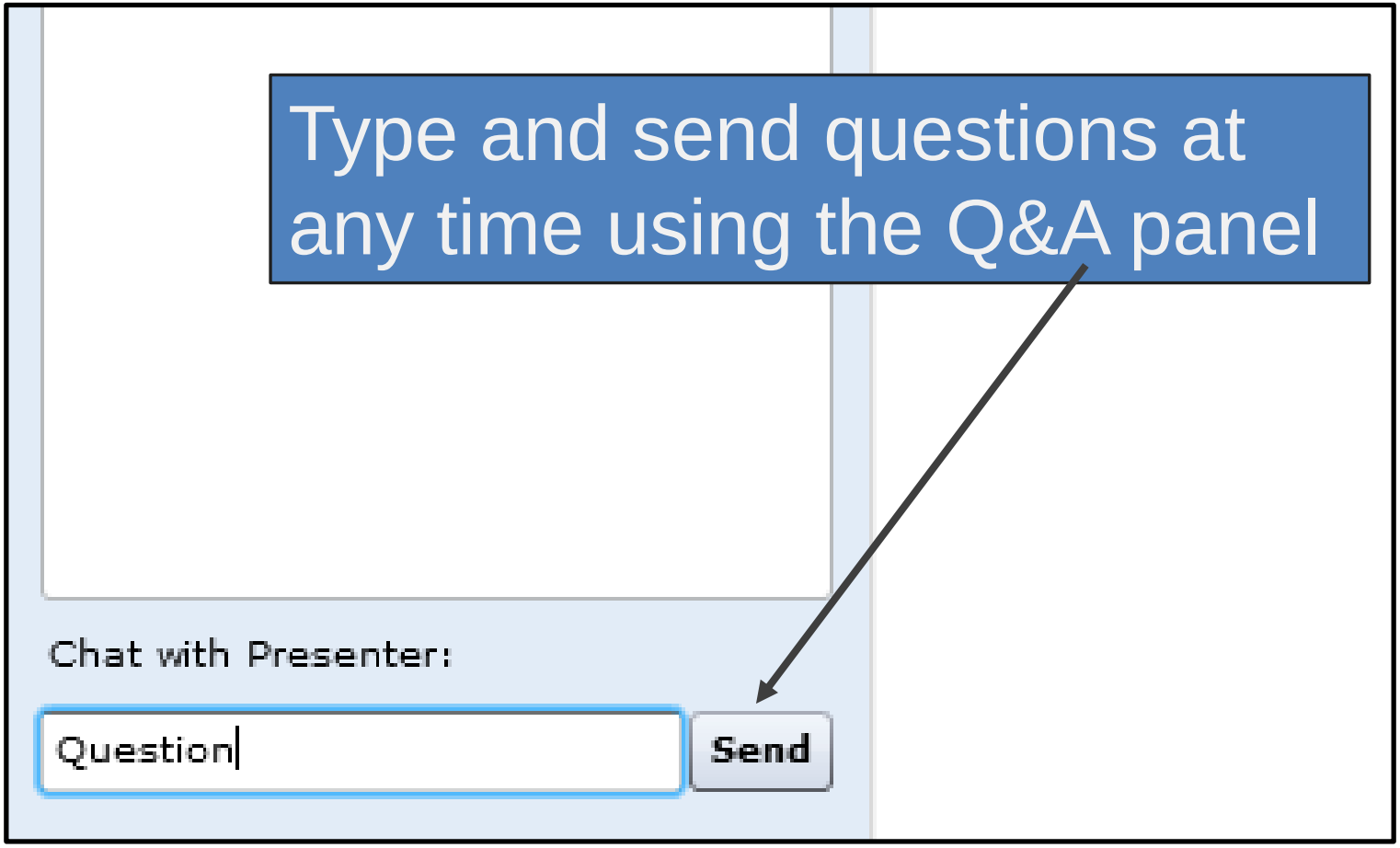
Welcome and Introductions

Jennifer Nyman, Ph.D., P.E.
Webinar Facilitator

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Jennifer Nyman, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Identifying Indicators of State Change and Forecasting Future Vulnerability in Alaskan Boreal Forest** (25 minutes + Q&A)
  Dr. Michelle Mack, Northern Arizona University
- **Subsurface Geophysical Mapping of Permafrost for Infrastructure Projects** (25 minutes + Q&A)
  Mr. Kevin Bjella, Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers
- **Final Q&A session**

How to Ask Questions



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  - If delays continue, call into the conference line
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SERDP and ESTCP Overview

Kurt Preston, Ph.D.
Resource Conservation and Resiliency Program Manager

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SERDP

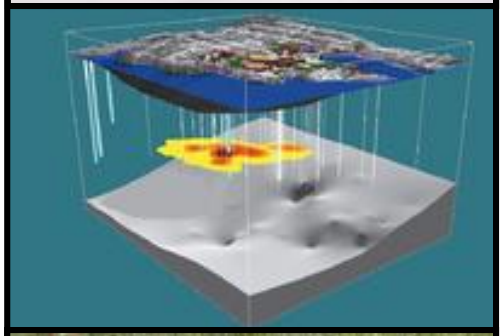
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

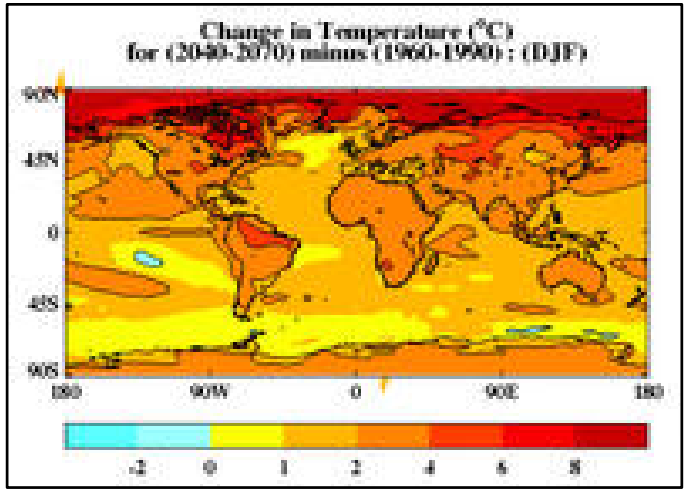
Program Areas

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



Resource Conservation and Resiliency

- Natural resources
  - Ecological forestry
  - Arid lands ecology and management
  - Cold regions ecology and management
  - Pacific island ecology and management
  - Coastal and estuarine ecology and management
  - Living marine resources ecology and management
  - Species ecology and management
  - Watershed processes and management
- Climate change
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- Air quality
  - Fugitive dust
  - Fire emissions



SERDP and ESTCP Webinar Series

Date	Topic
July 27, 2017	Management of Energetic and Propellant Material Releases on Testing and Training Ranges
August 17, 2017	Zinc Nickel Dip and Brush Plating
September 7, 2017	Research and Development Needs for Management of DoD's PFAS Contaminated Sites
September 21, 2017	Building Envelop Technologies
October 5, 2017	New Resource Conservation Insights to Desert Environments

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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SERDP • ESTCP SYMPOSIUM

2017 | Enhancing DoD's Mission Effectiveness

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

- November 28 - November 30, 2017
- Washington Hilton Hotel
  1919 Connecticut Avenue, NW
  Washington, DC 20009
- ***Registration is open***

Identifying Indicators of State Change and Forecasting Future Vulnerability in Alaskan Boreal Forest

Michelle C. Mack, Ph.D.
Northern Arizona University

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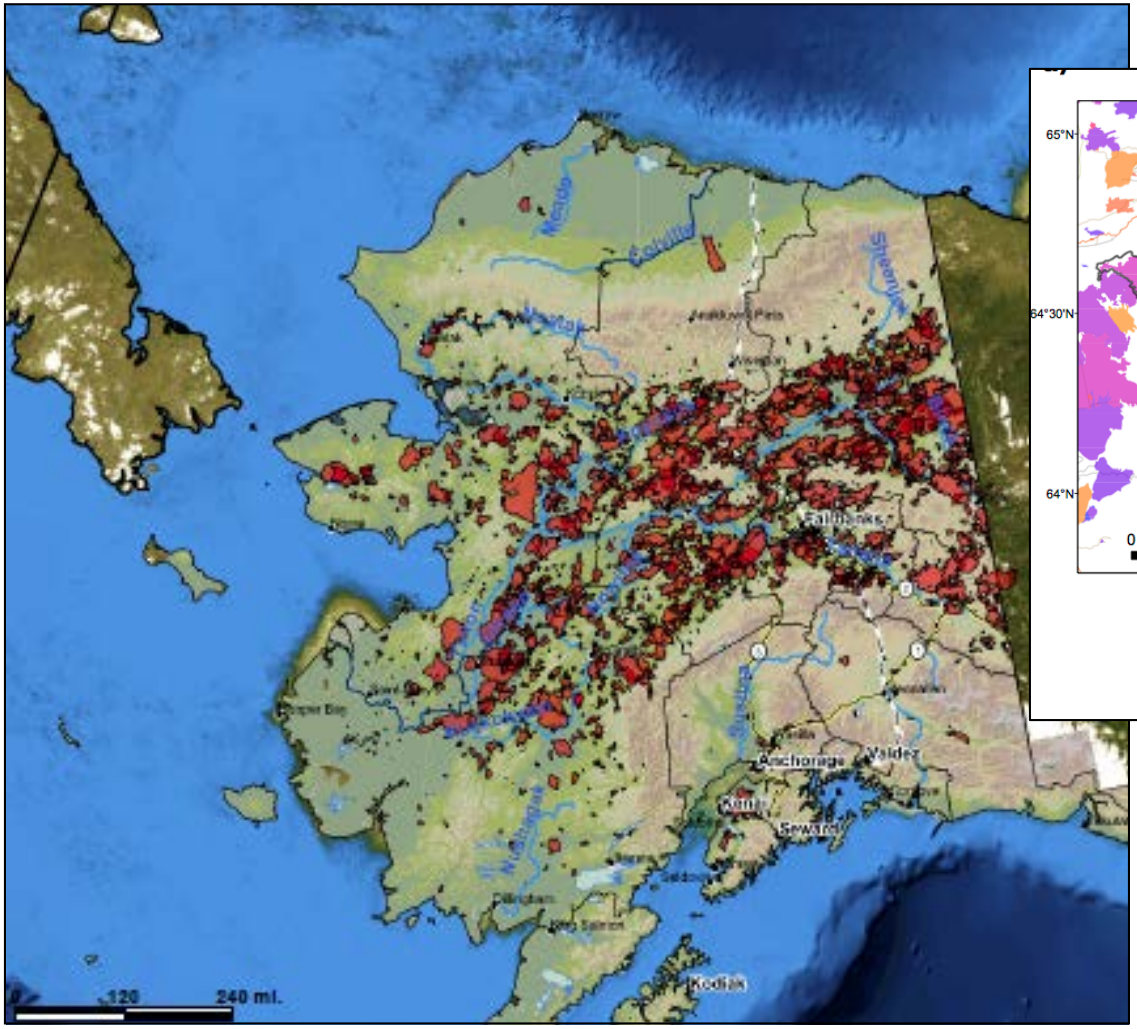
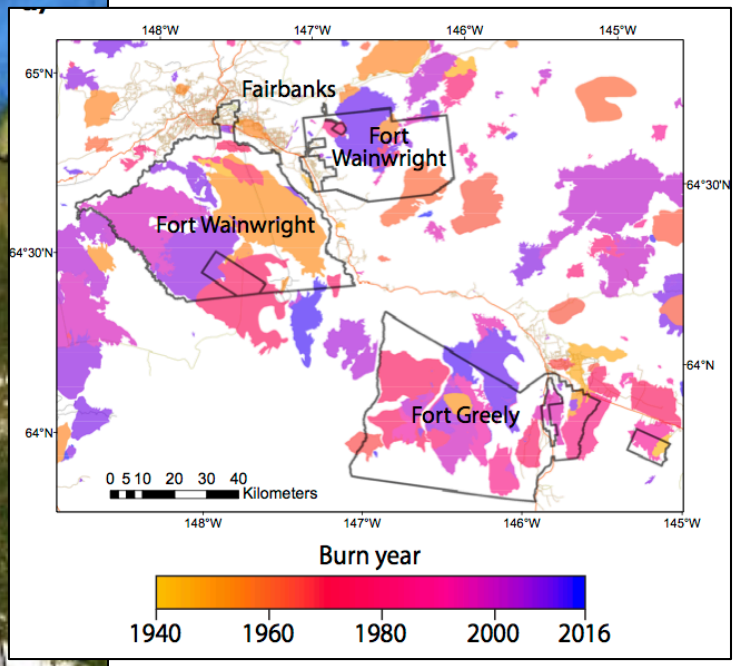
Agenda

- Alaska's changing boreal forests
- Wildfire response to warming climate
- Forest recovery and permafrost thaw
  - Keys to managing military land use
- Co-benefits of ecosystem state change
- Forecasting fire management impacts on future landscapes

Alaska's Changing Boreal Forests

Burned Area in Interior Alaska





DoD manages 7,000 km^2 (1,730,000 acres) in Interior Alaska

= Burned after 1950

Figure from Brendan Rogers, 2017

Past and Predicted Future Area Burned in Interior Alaska

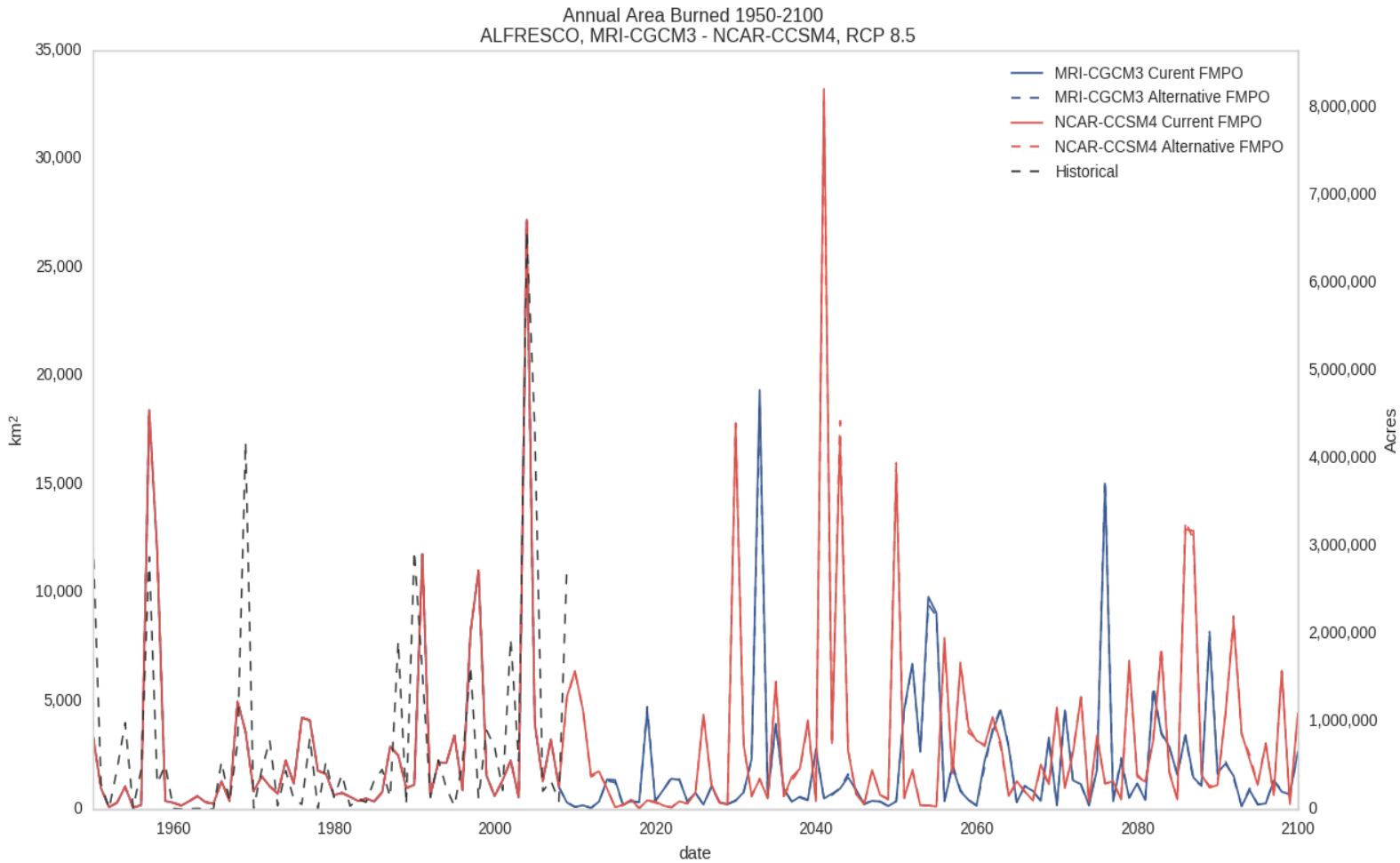


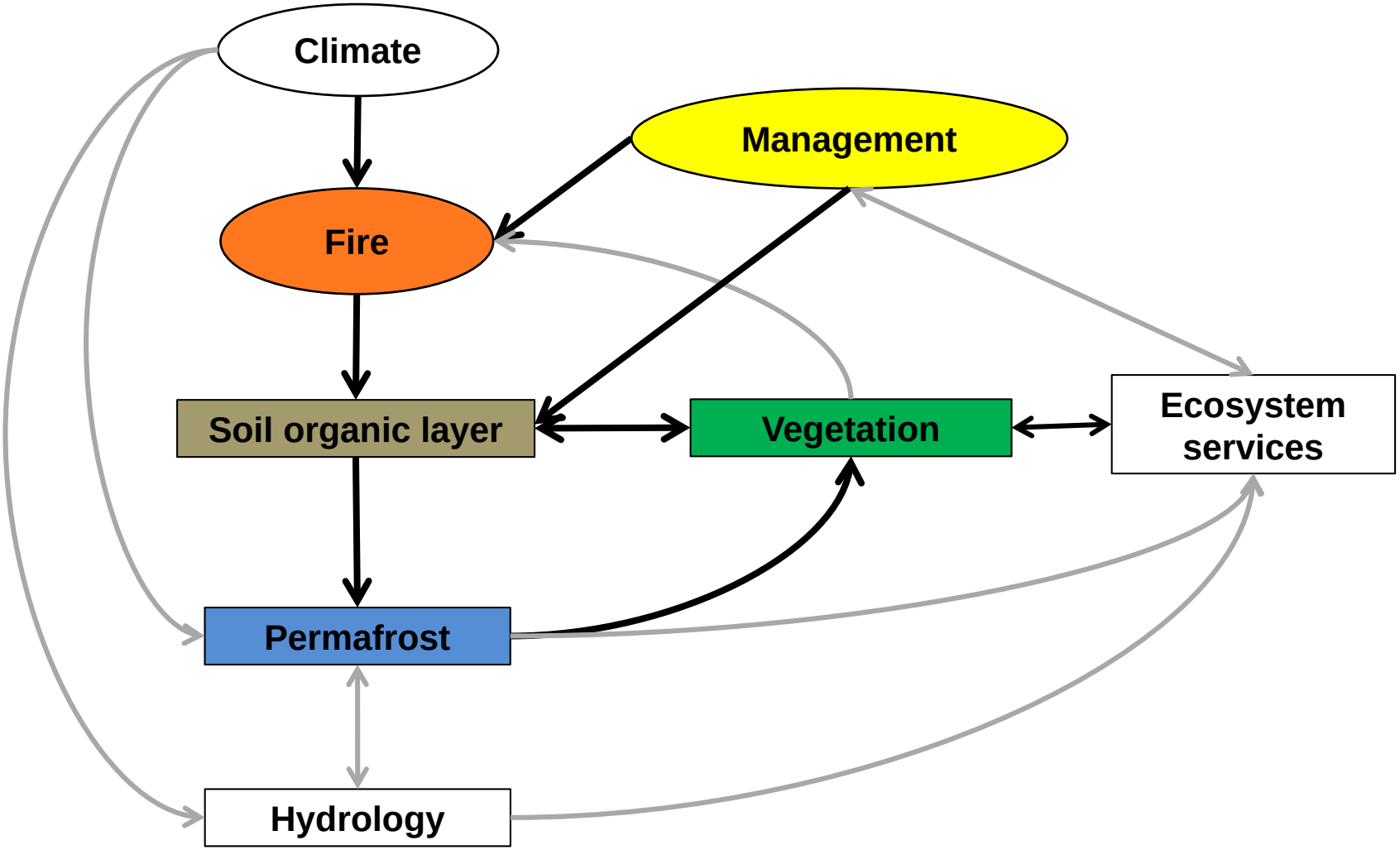
Figure from Breen et al., 2016

Burning of the Soil Organic Layer Makes Boreal Fires Unique

Consequences of Deep Burning

- Burning of the ground layer dominates combustion
  - Low severity fires - surface burning of mosses and litter
  - High severity fires - deep burning of soil organic matter
- The soil organic layer modulates important ecosystem functions
  - Insulates permafrost
  - Controls infiltration
  - Harbors plant propagules
  - Provides habitat
  - Cycles carbon and nutrients
- Hypothesis
  - Severity of burning drives ecosystem state change because of its effects on permafrost, vegetation and carbon cycling

Effects of Climate Change on Ecosystem State via Wildfire Disturbance

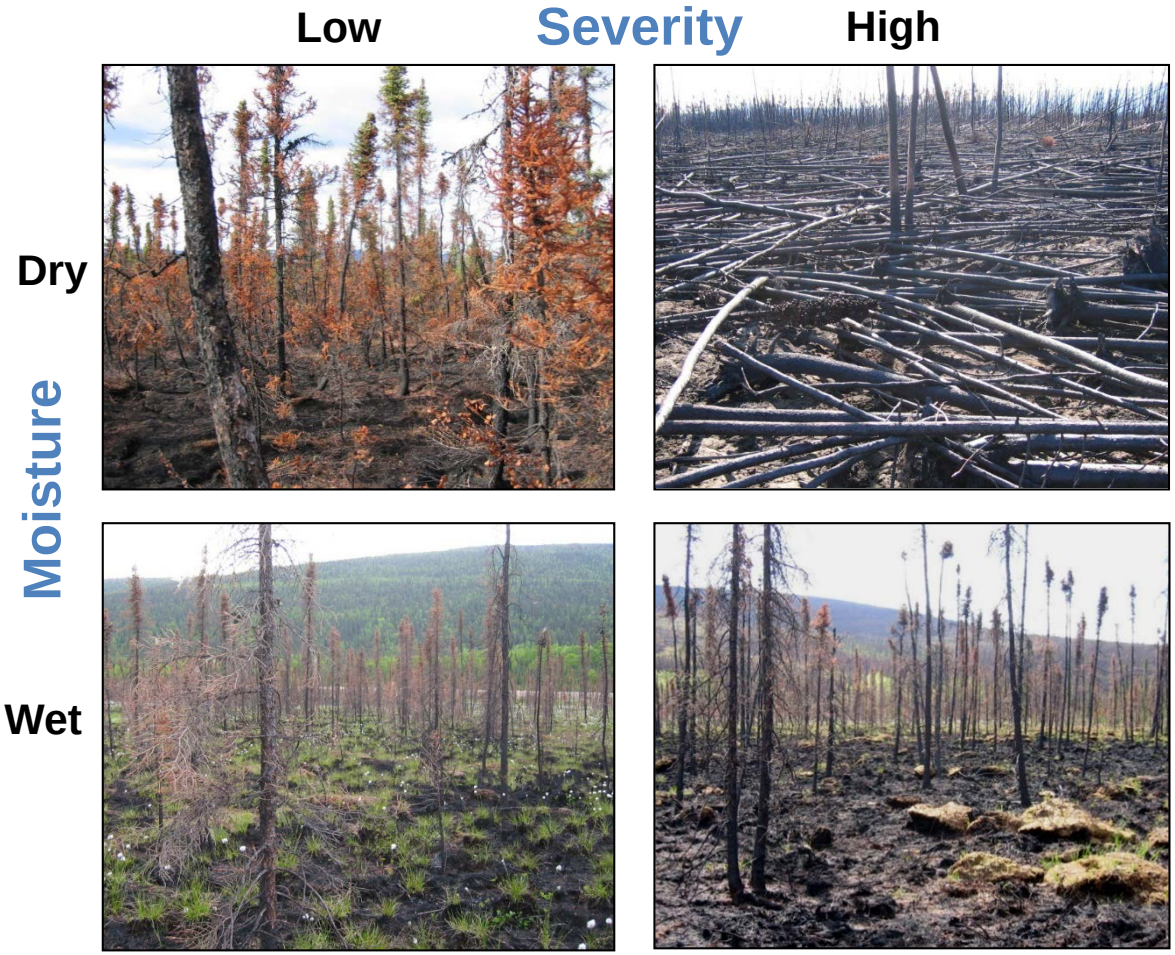


Low Severity Historic Fire Regime in Black Spruce Forests

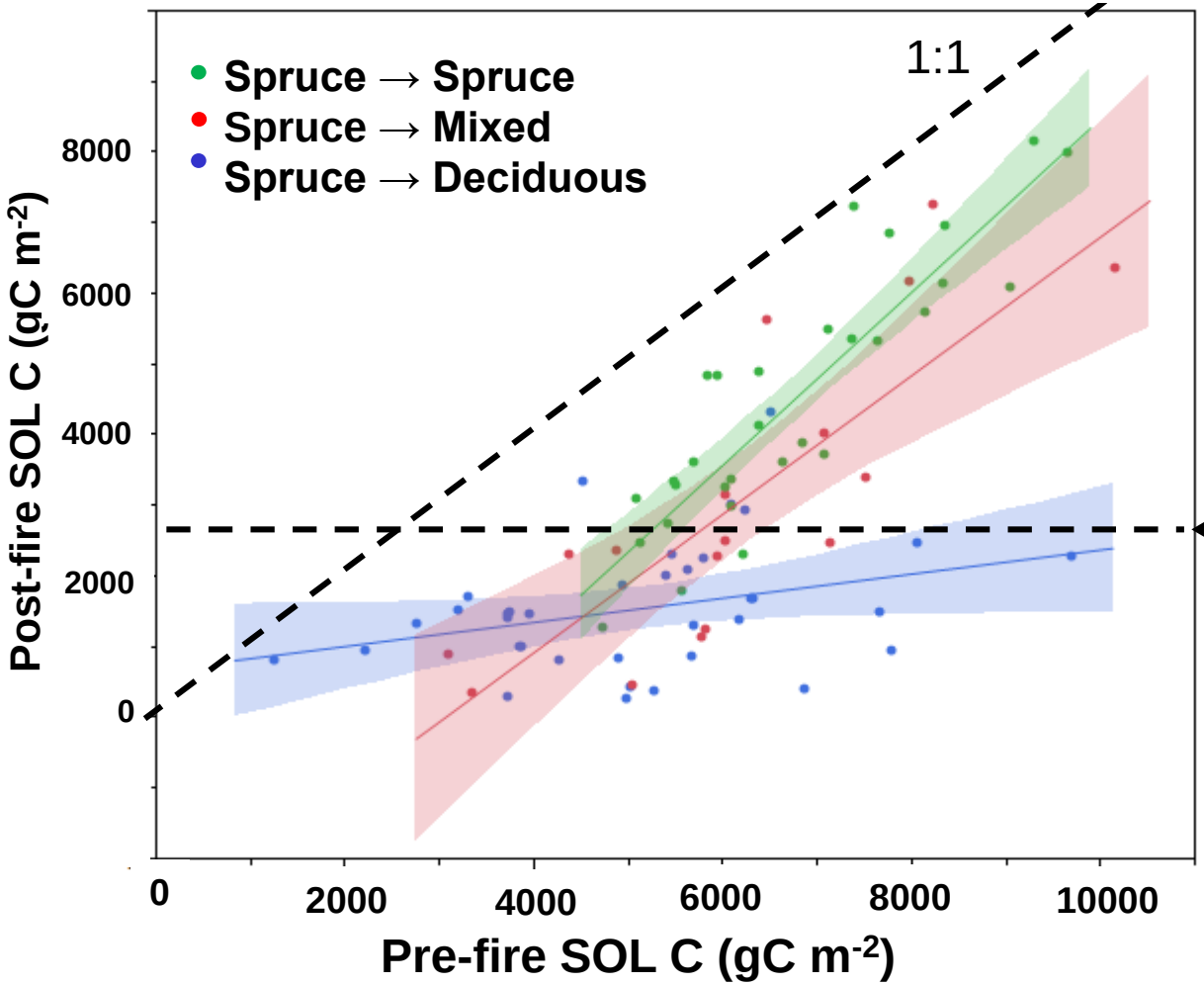
- Self-replacement successional trajectory
- Soil and seed legacies of past ecosystem are carried forward

Determining Indicators of State Change in Black Spruce Forests

- In 2004, 27,000 km^2 of forests burned in interior Alaska
- Record fire year: 7 x greater than long-term average area burned
- Historic monitoring plots burned
- Assessed combustion and recovery in 100 black spruce stands throughout interior Alaska



Deep Burning Shifts Forests from Spruce to Deciduous Tree Dominance



Mean residual soil depth ~ 9cm

SOL C = Soil Organic Layer Carbon

High Severity Fire Regime

- Severe burning erases soil and seed legacies of past ecosystem

Functional Differences in Forest Types

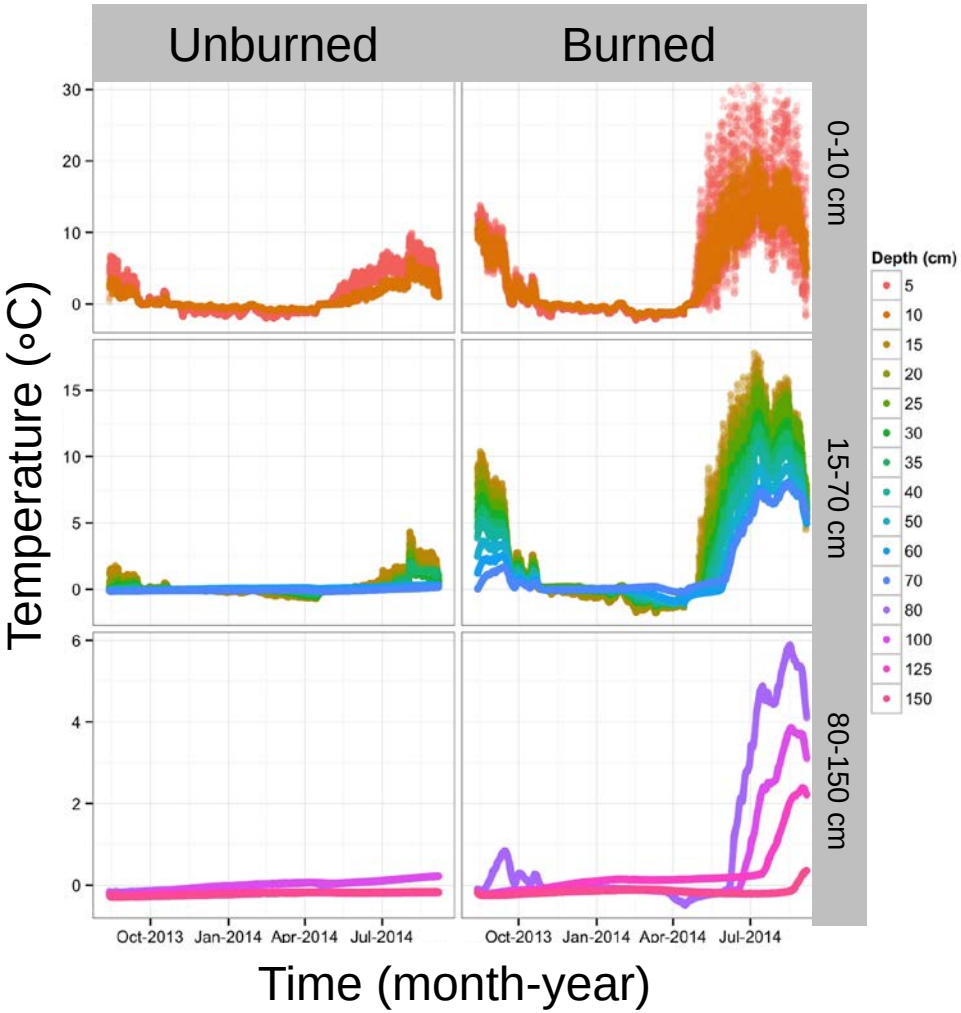
Black Spruce

- High flammability fuels
- Semi-serotinous
- Slow growth
- Accumulates carbon in soil
- Low quality wildlife habitat
- Permafrost recovers
- Sensitive to disturbance

Deciduous

- Low flammability fuels
- Seeds in from outside
- Fast growth
- Accumulates carbon in trees
- High quality wildlife habitat
- Permafrost degrades
- Robust to disturbance

After Fire, Soil Temperature Range Increases, Permafrost Warms



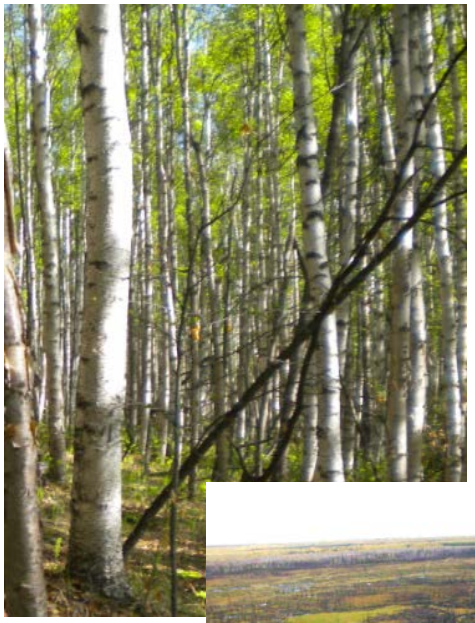


Figure from E. Schuur, unpublished

Deep Burning Leads to Loss of Permafrost in Upland but not Lowland Sites

Thaw Depth (m)

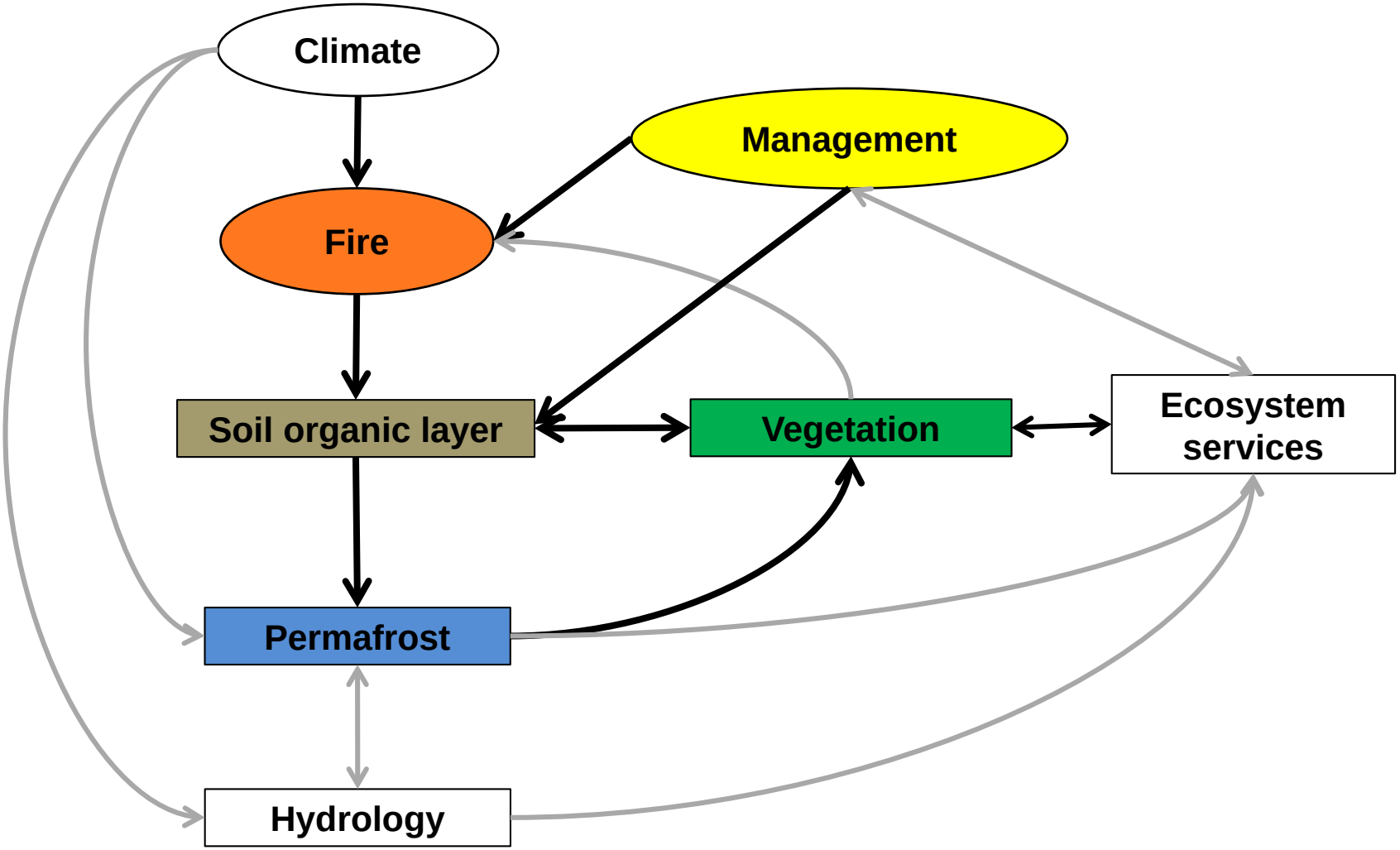
Upland

Thaw Depth (m)

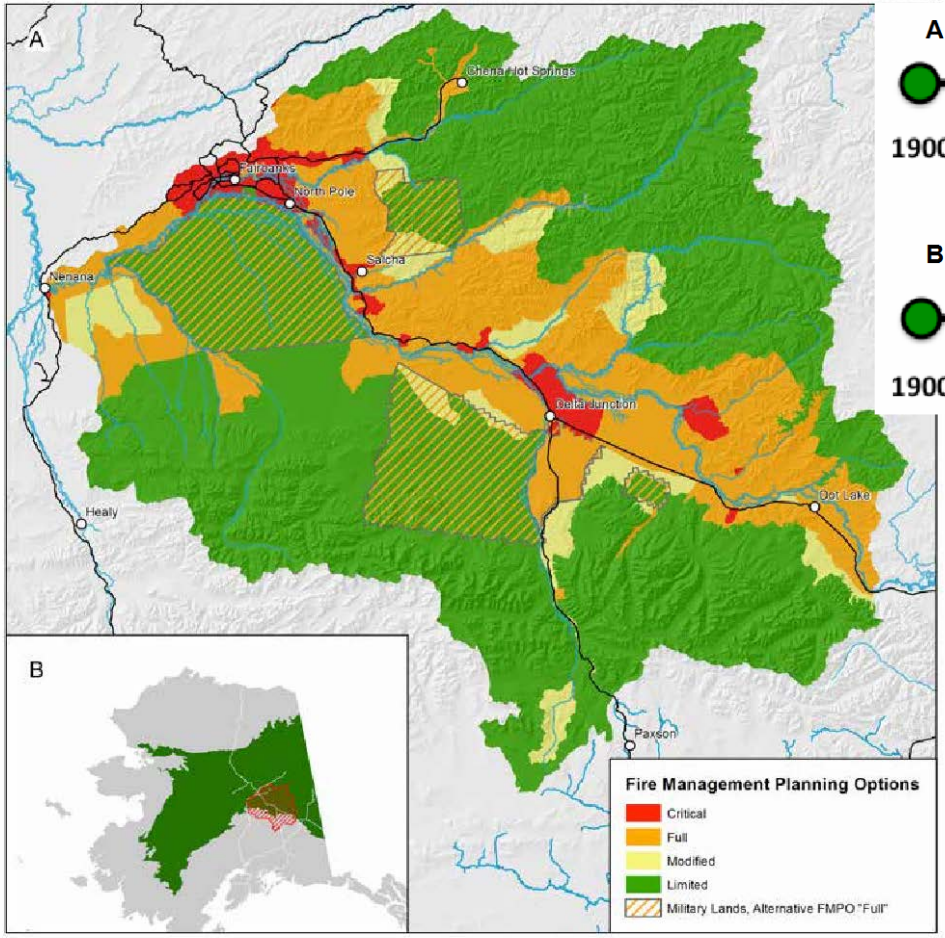
Lowland

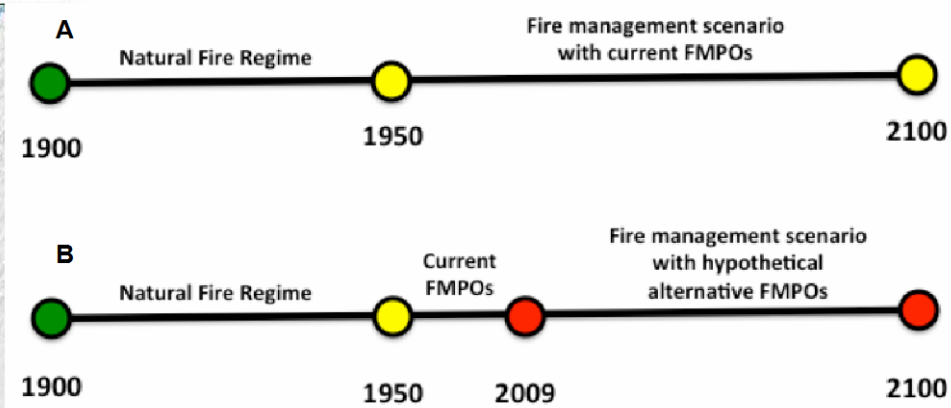
Figure from Jafarov et al., 2013

Effects of Climate Change on Ecosystem State via Wildfire Disturbance



Modeling the Impacts of Fire Management Planning Options (FMPO) on DoD Land





- Military lands have unique ignition sources
- What would happen if they were designated "full" protection?

Figure from Breen et al., 2016

Changing DoD Lands to Full Protection Slightly Decreases Area Burned

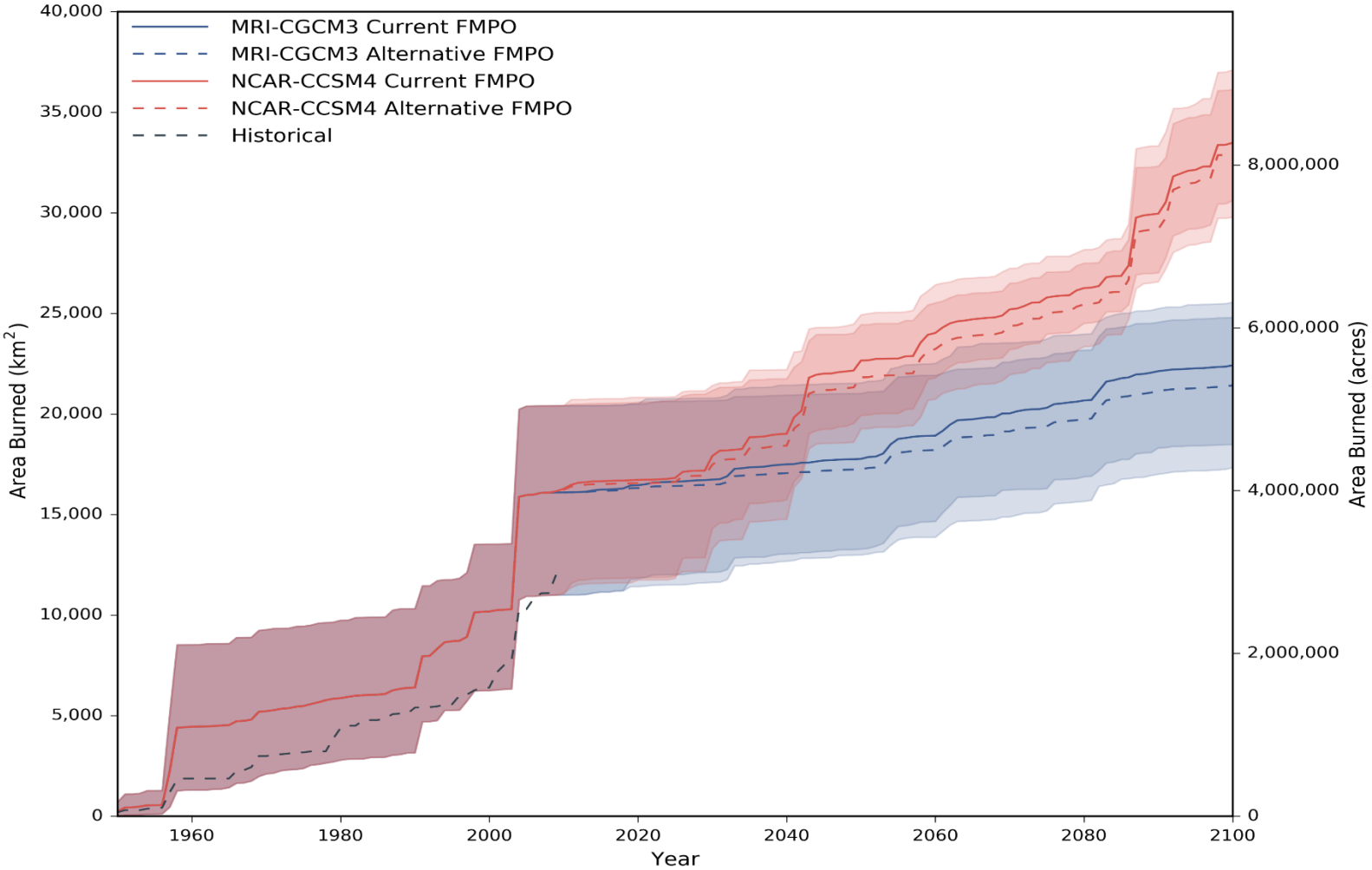


Figure from Breen et al., 2016

Changing DoD Lands to Full Protection Slightly Increases the Ratio of Conifer:Deciduous Stands

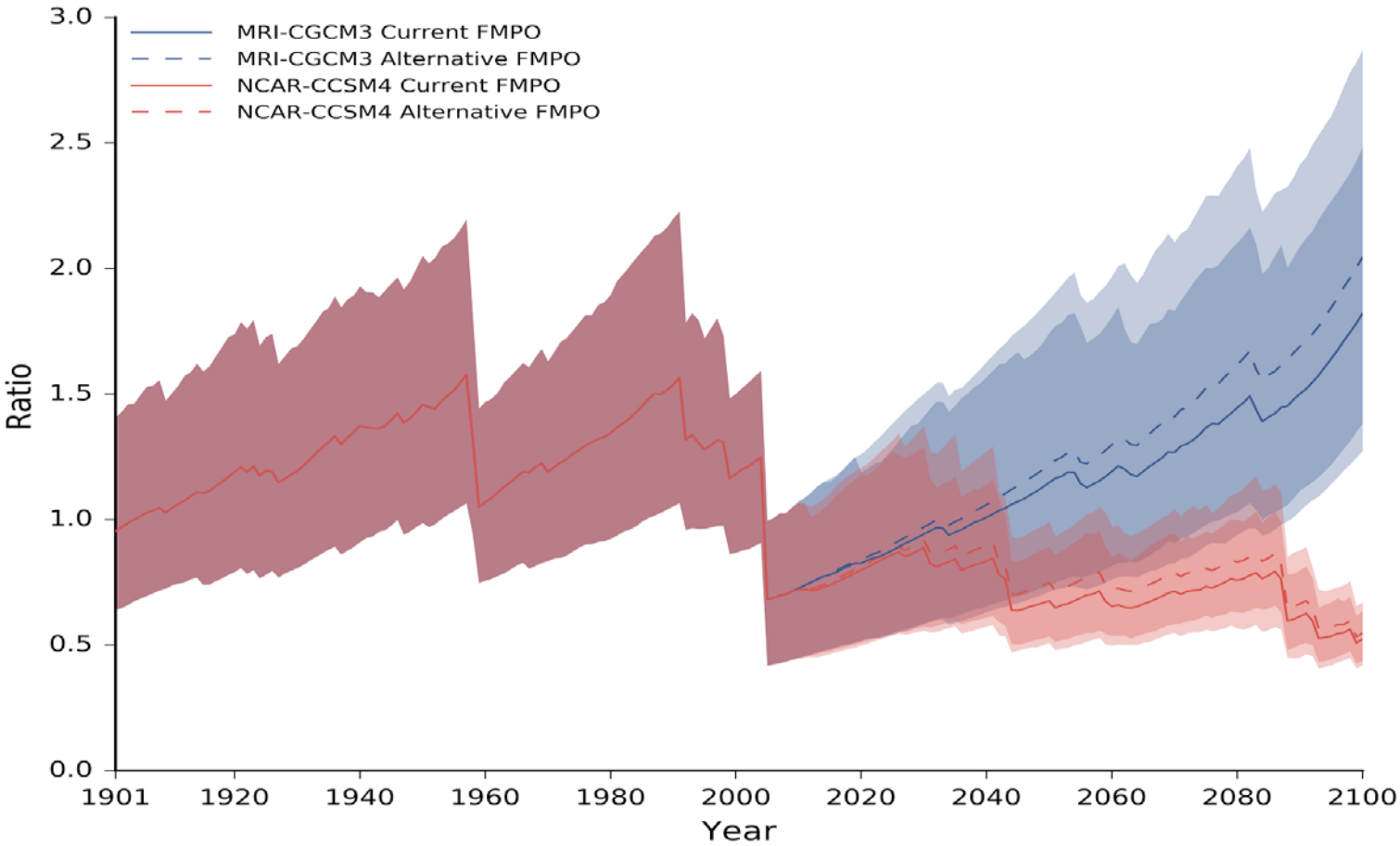


Figure from Breen et al., 2016

Fuel Management Treatments

Thinned

Shearbladed

Shearblading Increases the Dominance of Deciduous Tree Seedlings

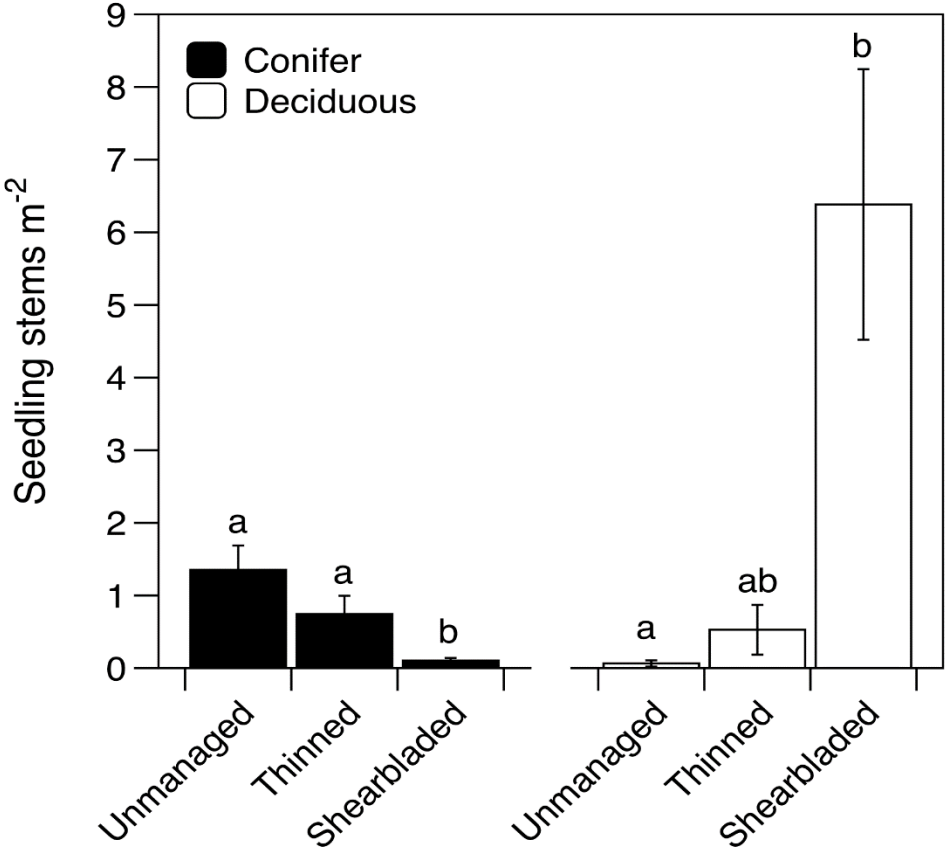


Figure from Melvin et al., in review

Shearblading Increases Permafrost Thaw

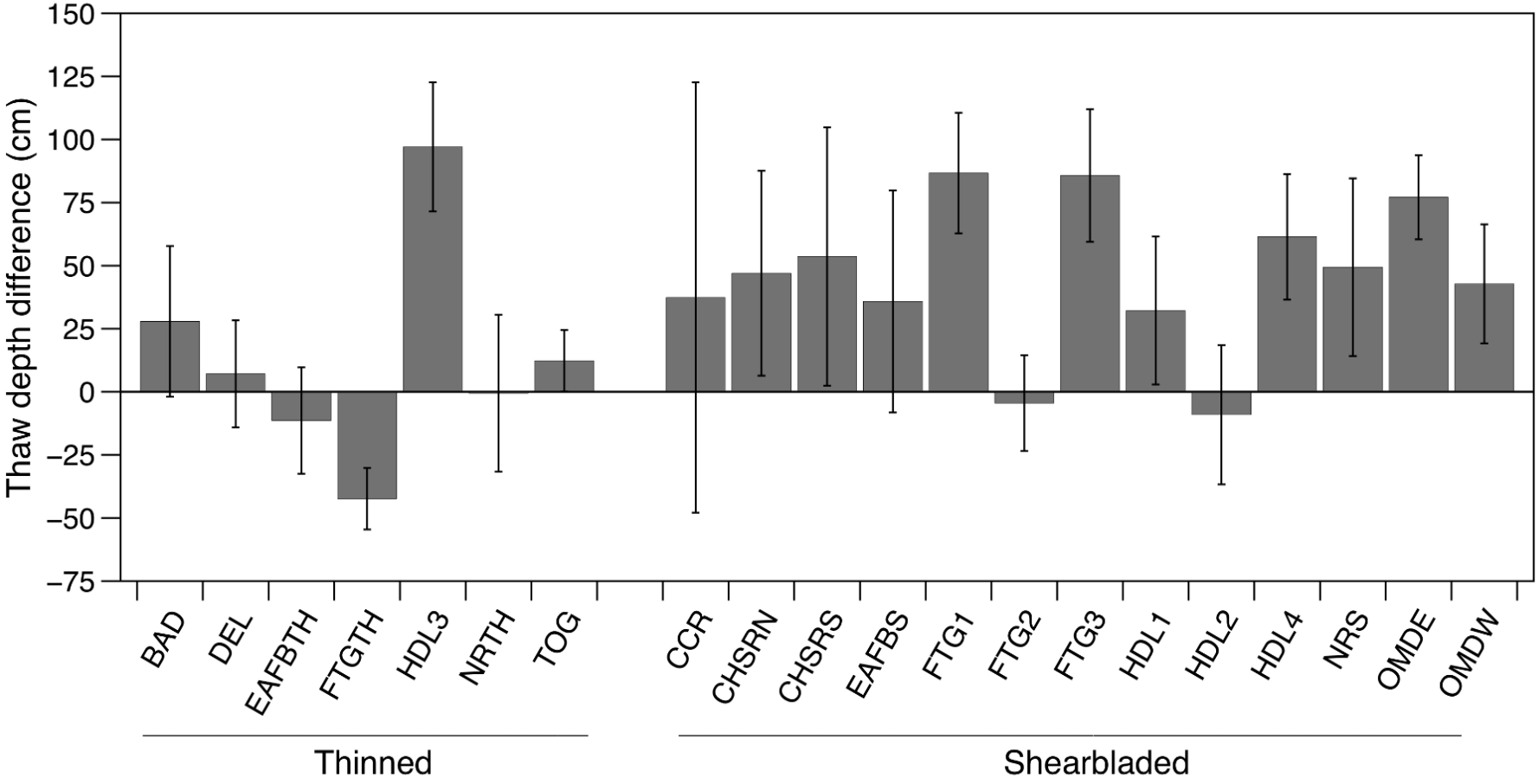


Figure from Melvin et al., in review

Conclusions

- Wildfire is expected to continue to increase as climate warms
- Effects of deeper burning of soil
  - Shift ecosystems to dominance by deciduous trees
  - Thaws permafrost soils
- Alternative fire management - changing DoD lands to full protection - could slightly reduce area burned but increase conifer tree dominance
- Fuels management techniques can promote desired ecosystem attributes such as deciduous tree dominance

DoD Benefits

- Climate warming is causing state changes in boreal forests through affects on wildfire
- Full suppression on DoD lands will have limited effects
- Fire-driven change to a deciduous tree dominated landscape has co-benefits
  - Reduced flammability
  - Resilience to training activities
  - Wildlife habitat and fuelwood harvest
- Fuels management treatments can attain long-term co-benefits through shifts to deciduous tree dominance
- Burning or shearblading also leads to degradation of permafrost soils
  - Better outcomes for rocky uplands than silty lowlands

Acknowledgments

- Project PIs
  - Ted Schuur, Northern Arizona University
  - Jill Johnstone, University of Alaska Fairbanks
  - David McGuire, University of Alaska Fairbanks
  - Scott Rupp, University of Alaska Fairbanks
- Staff
  - Amy Breen, University of Alaska Fairbanks
  - Helene Genet, University of Alaska Fairbanks
  - Randi Jandt, Alaska Fire Science Consortium
  - Alison York, Alaska Fire Science Consortium
  - April Melvin, University of Florida
- Collaborators
  - Dan Rees, U.S. Army Alaska
  - Alaska Division of Natural Resources Division of Forestry

For additional information, please visit

https://serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Cold-Regions-Ecology-and-Management/RC-2109

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Q&A Session 1

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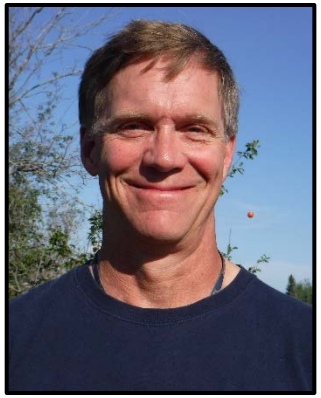
Subsurface Geophysical Mapping of Permafrost for Infrastructure Projects

Kevin Bjella

Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers



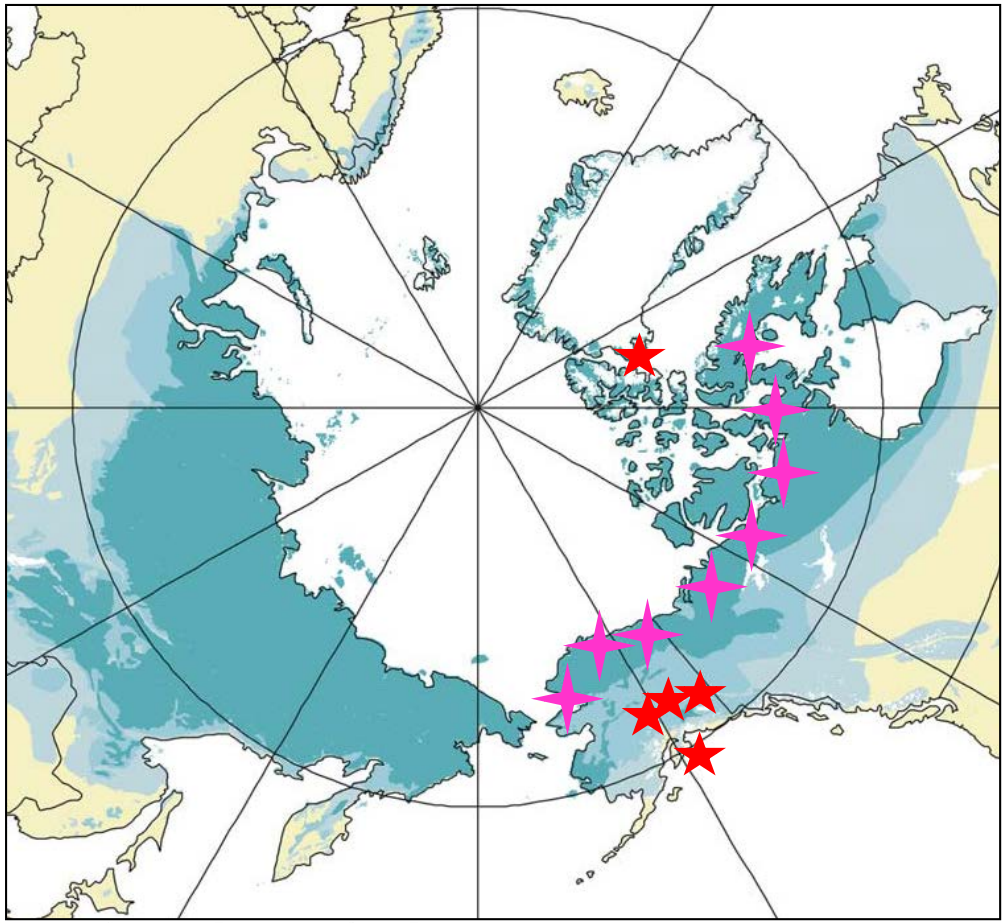
Agenda

- DoD and the Arctic
- Permafrost and thawing issues
- Geotechnical characterization
- Geophysics investigations
- Benefits of higher ground resolution
- Refined designs and climate warming

Background

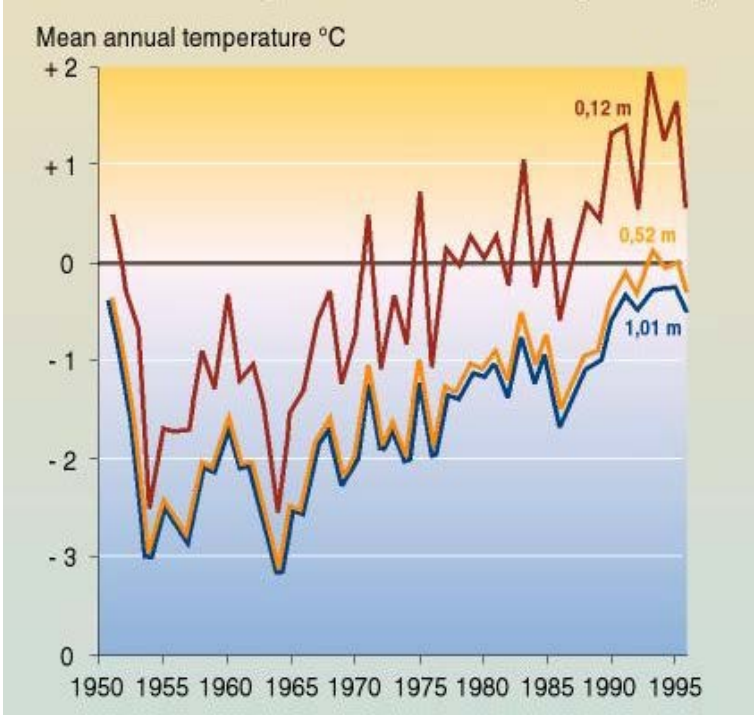
- U.S. DoD operates installations in polar/sub-polar regions
- These regions consist of frozen/icy terrains
- Point sampling (drilling) traditionally defines the permafrost character
- However, geophysics better delineates the amount and extent of ground ice
- Ground ice detail reduces over-engineering, costs and logistics
- Refined designs can offset climate impacts

Arctic and Subarctic Installations



Continuous Discontinuous Sporadic

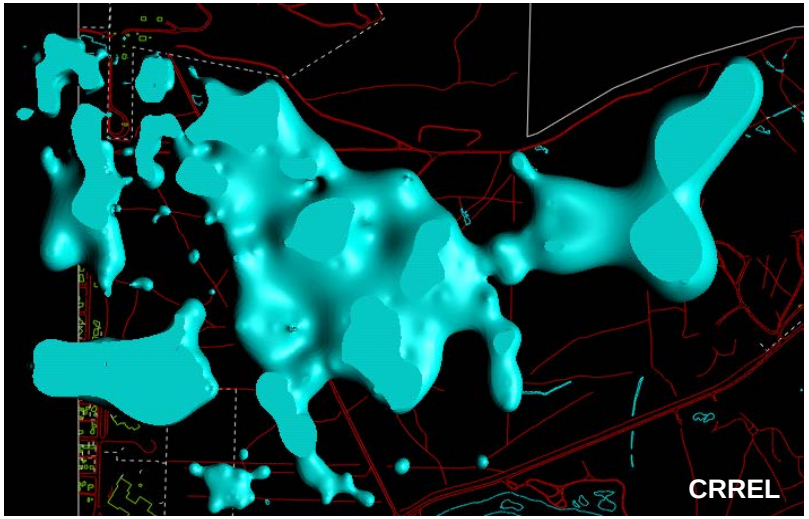
Vast, austere and rapidly changing environment



Modified from Brown and others, 1998 by the U.S. Arctic Research Commission Permafrost Task Force Report (2003)

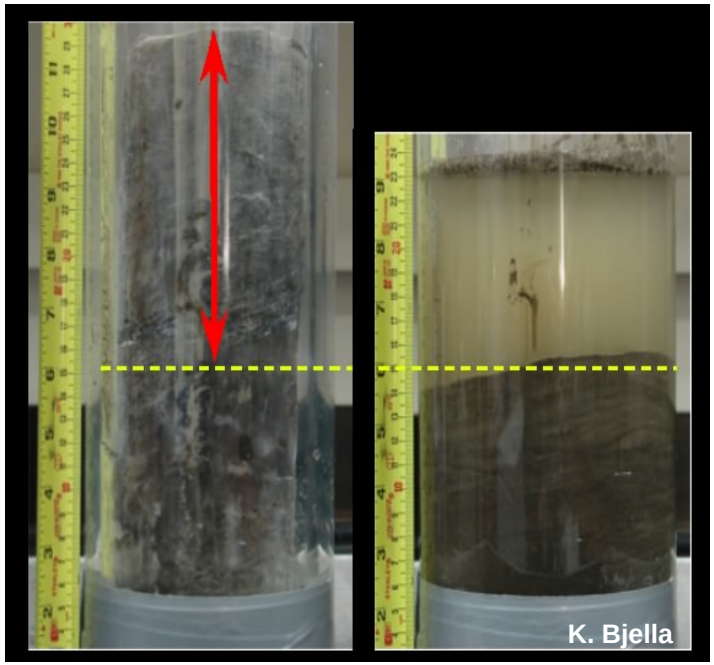
Permafrost

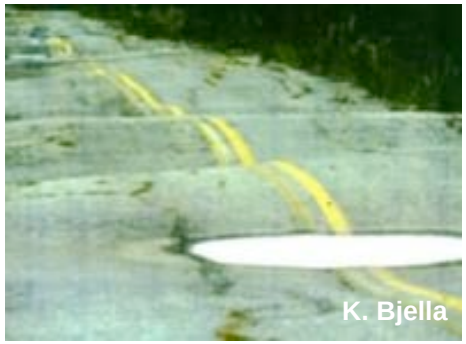
Ice is a Major and Formidable Component



Degrading Ground Ice

Severe Displacements





Degrading Ground Ice and DoD

Maintenance and Serviceability

Refrigeration

High Initial and Long Term Costs

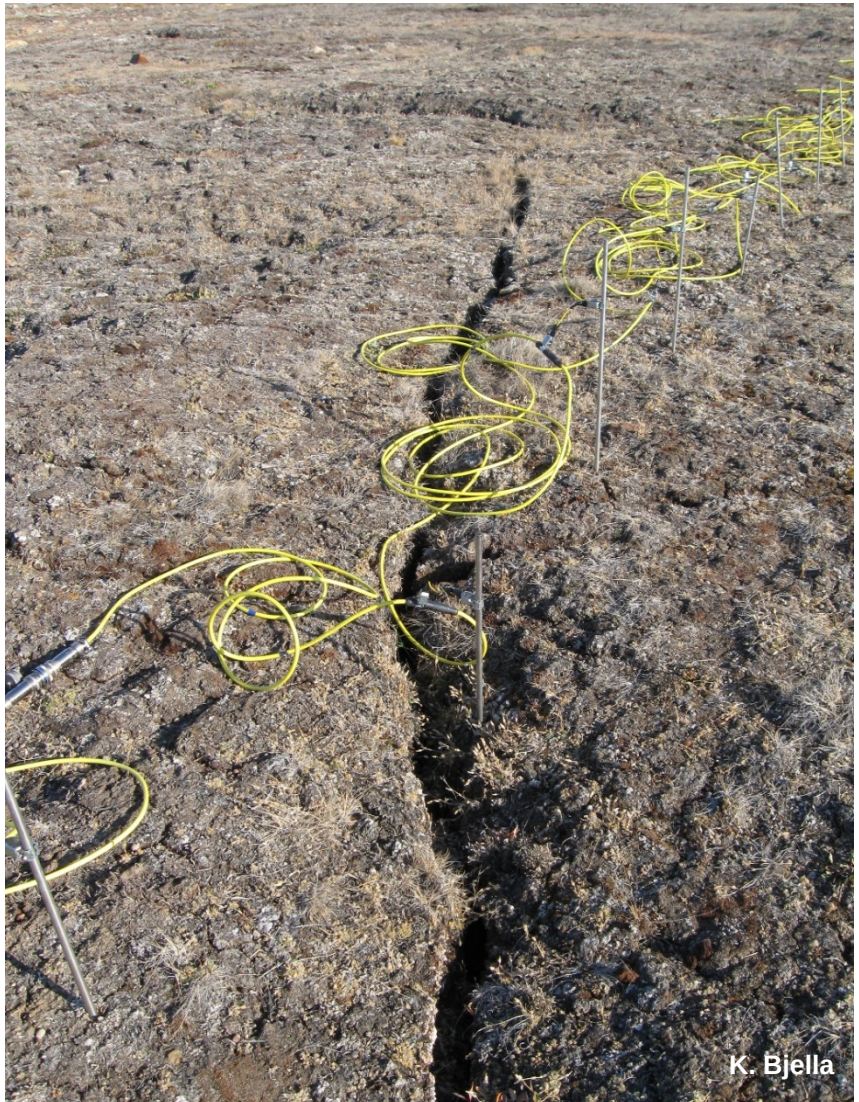
Traditional Geotechnical Investigations

Borehole Drilling

Electrical Resistivity

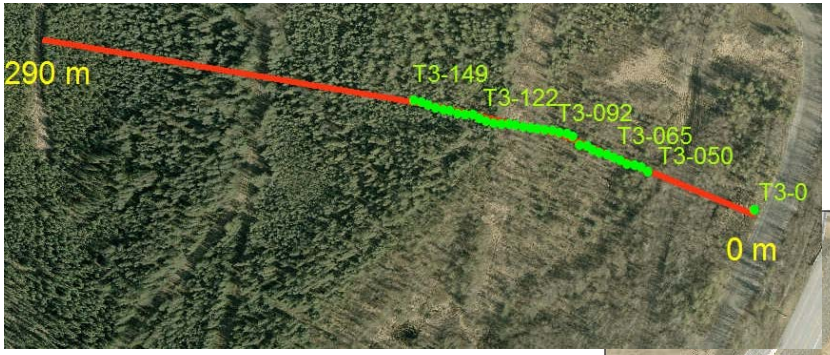
CCR and ERT

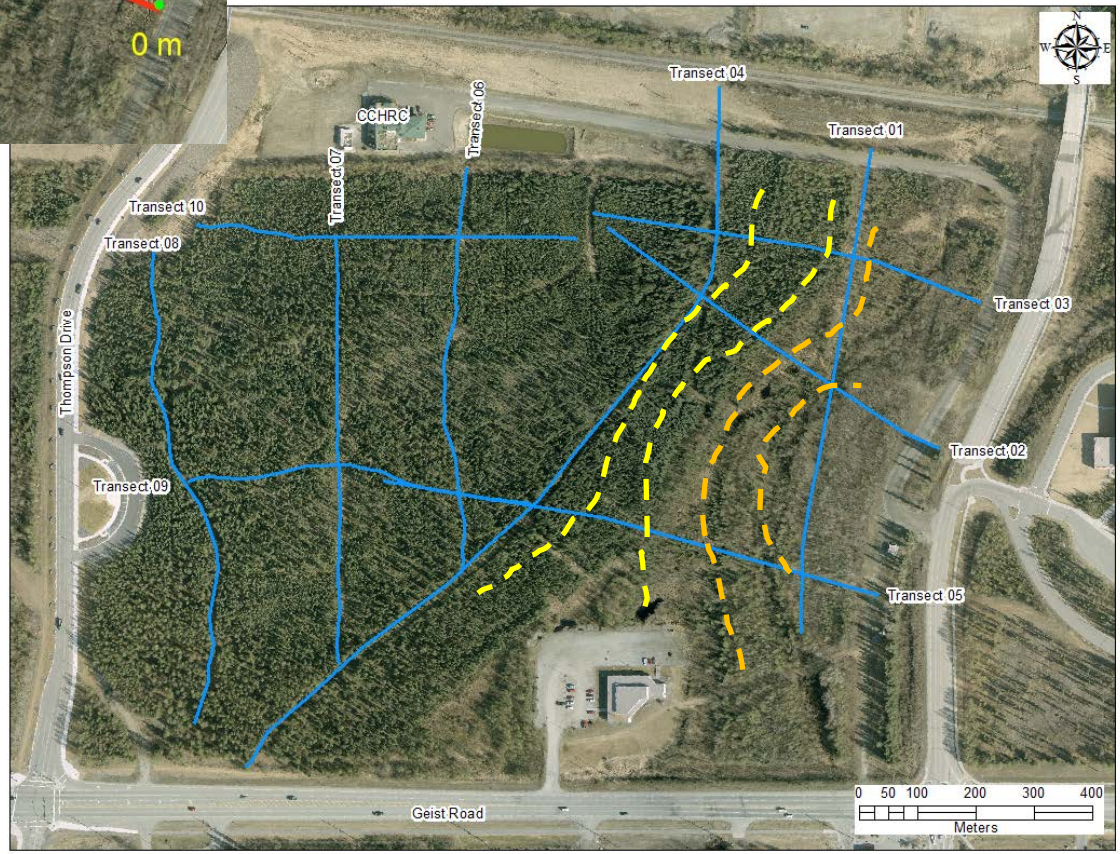
CCR: Capacitively-Coupled Resistance
ERT: Electrical Resistivity Tomography



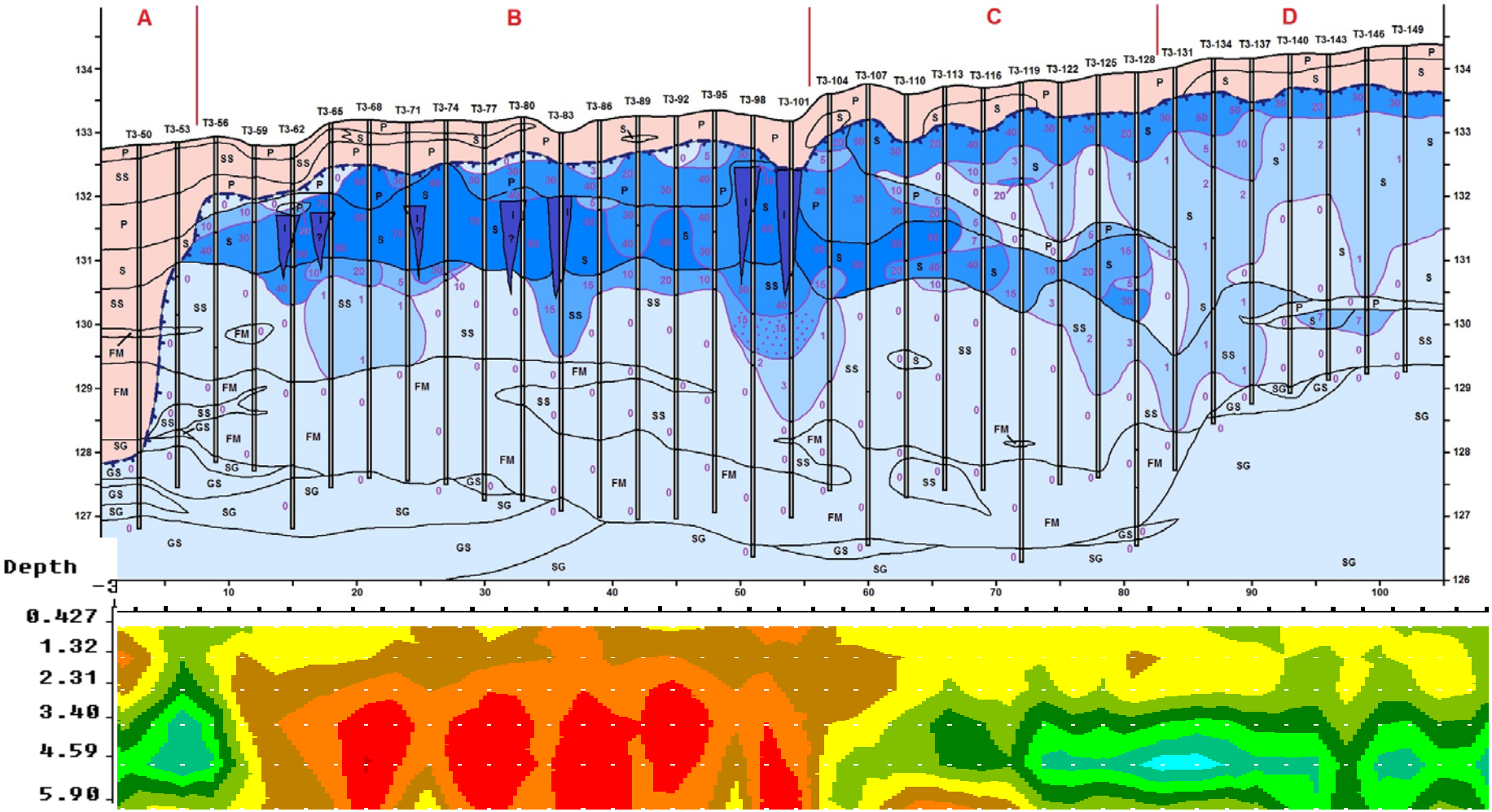
Testing

High Density Drilling and Resistivity Surveys





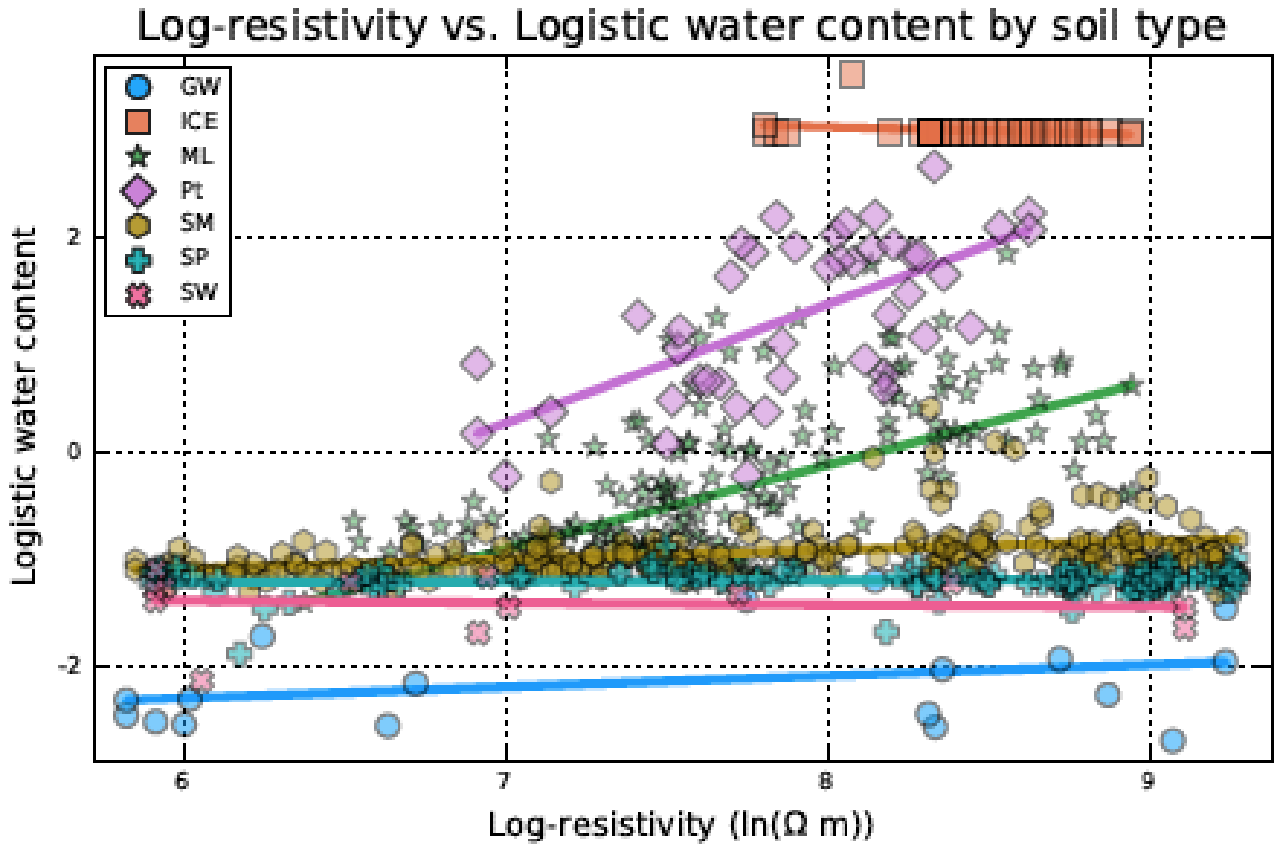
Drilling versus CCR



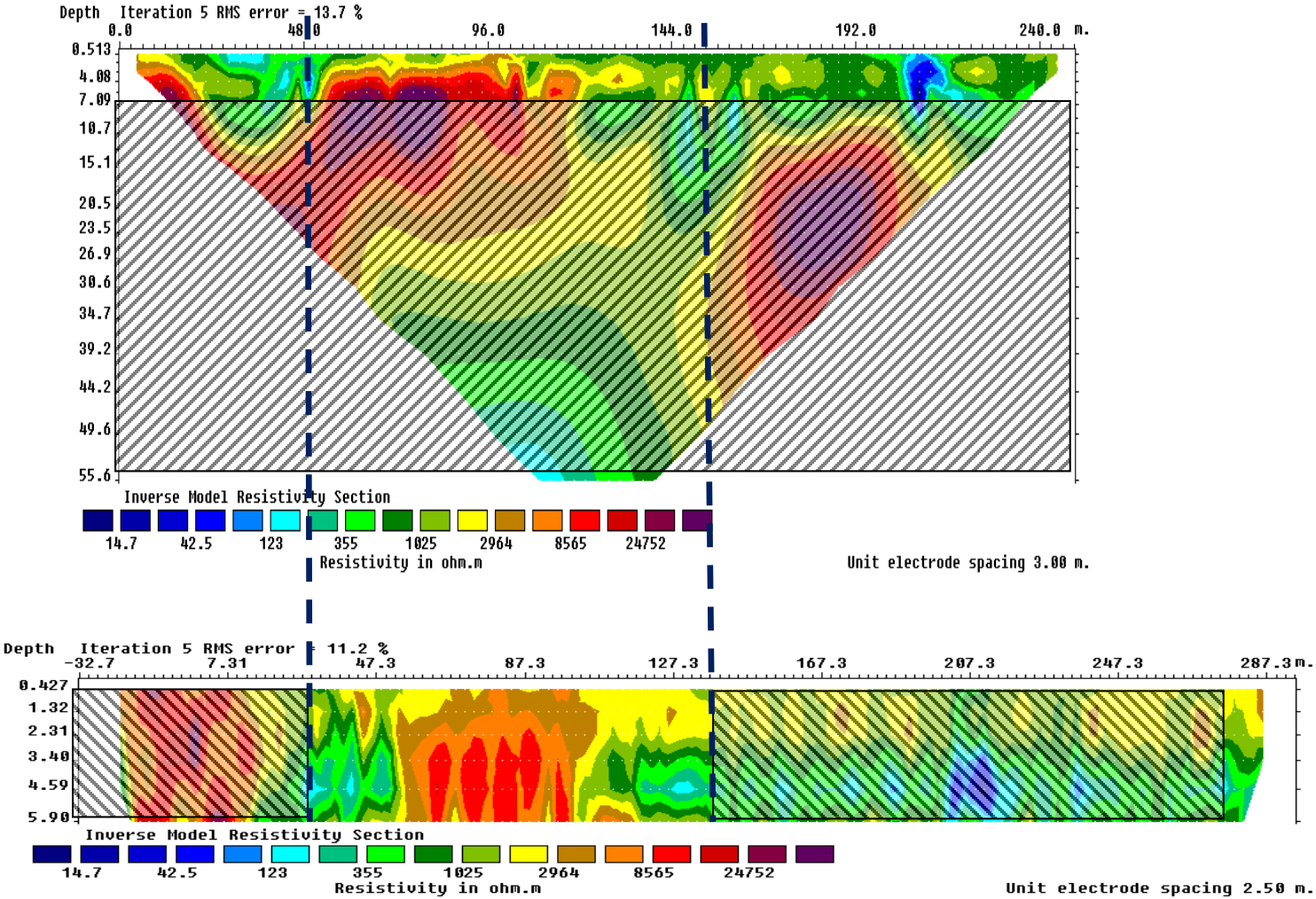
Drilling versus CCR

Soil types used and their abbreviations. Based on simplified USCS

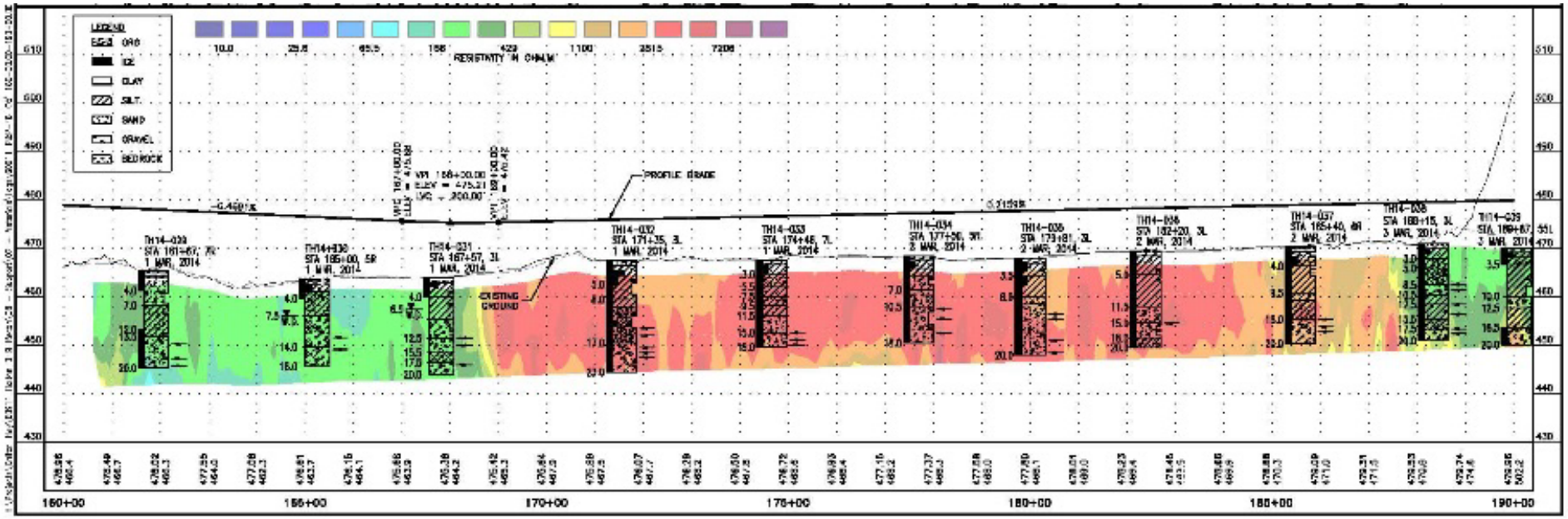
USCS code	Description
Pt	Organic soil (peat)
OL	Organic-mineral soil (organic silt, silty peat, silty with peat layers)
ML	Silt
SM	Sandy silt or silty sand, very fine to fine
SP	Fine to medium sand
SW	Gravelly sand, fine to very coarse
GW	Sandy gravel
(ICE)	Massive ice



ERT versus CCR

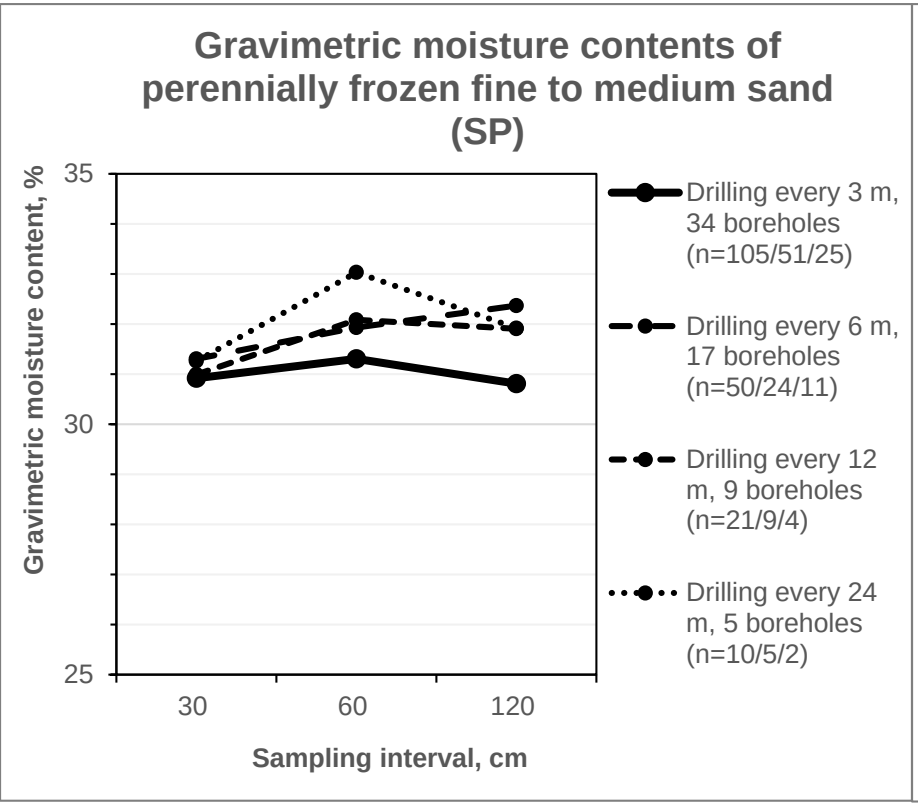


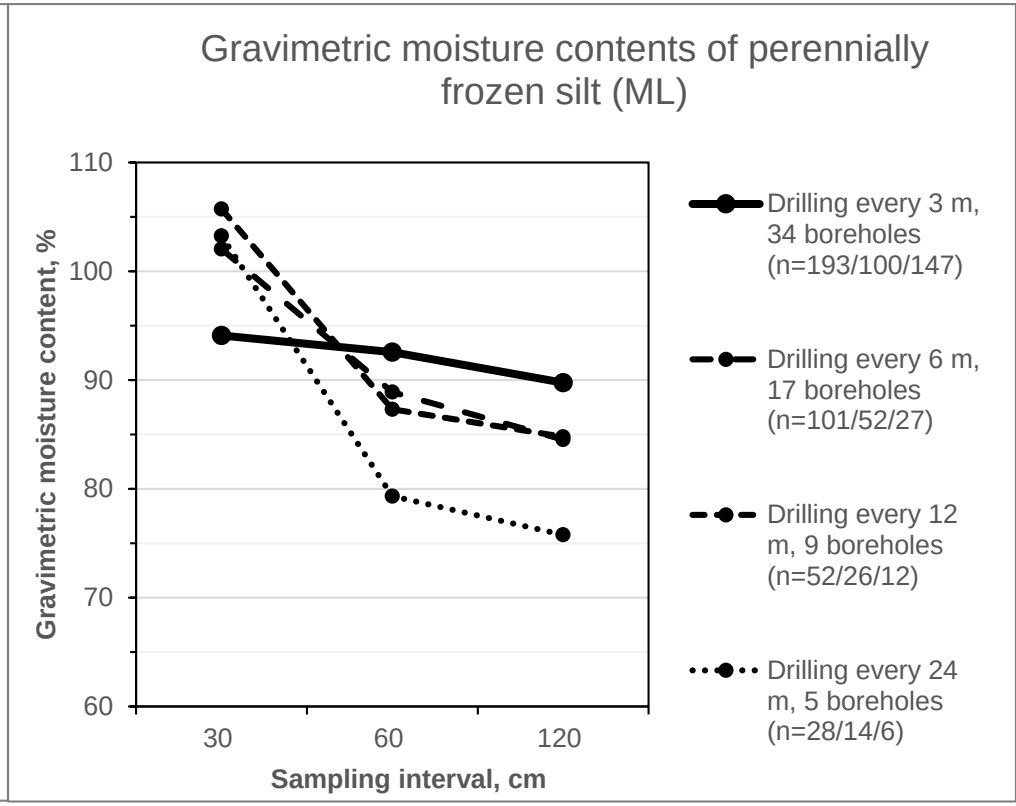
Immediate Rate-of-Return



~35% Borehole Reduction

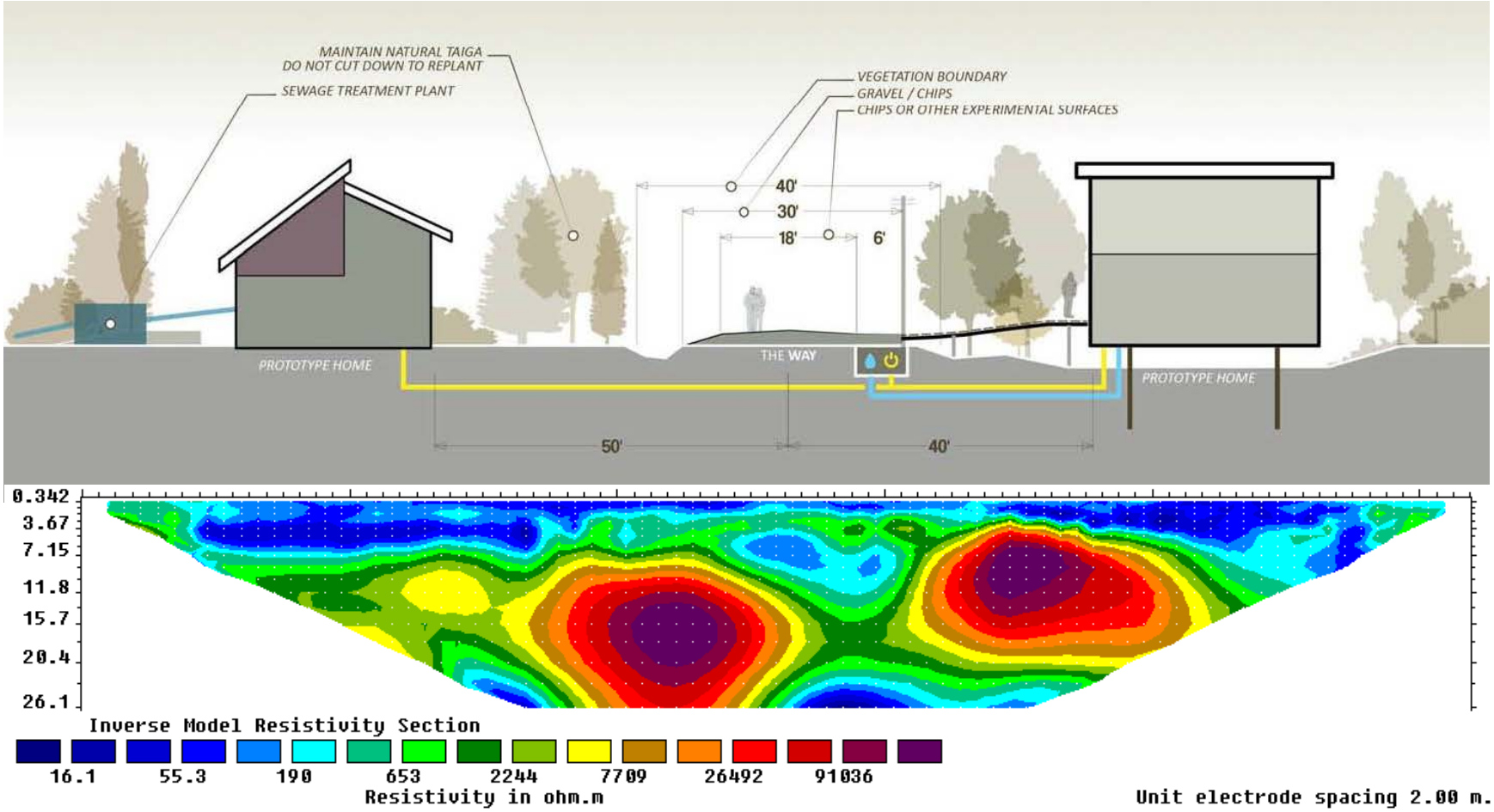
Drilling Guidance



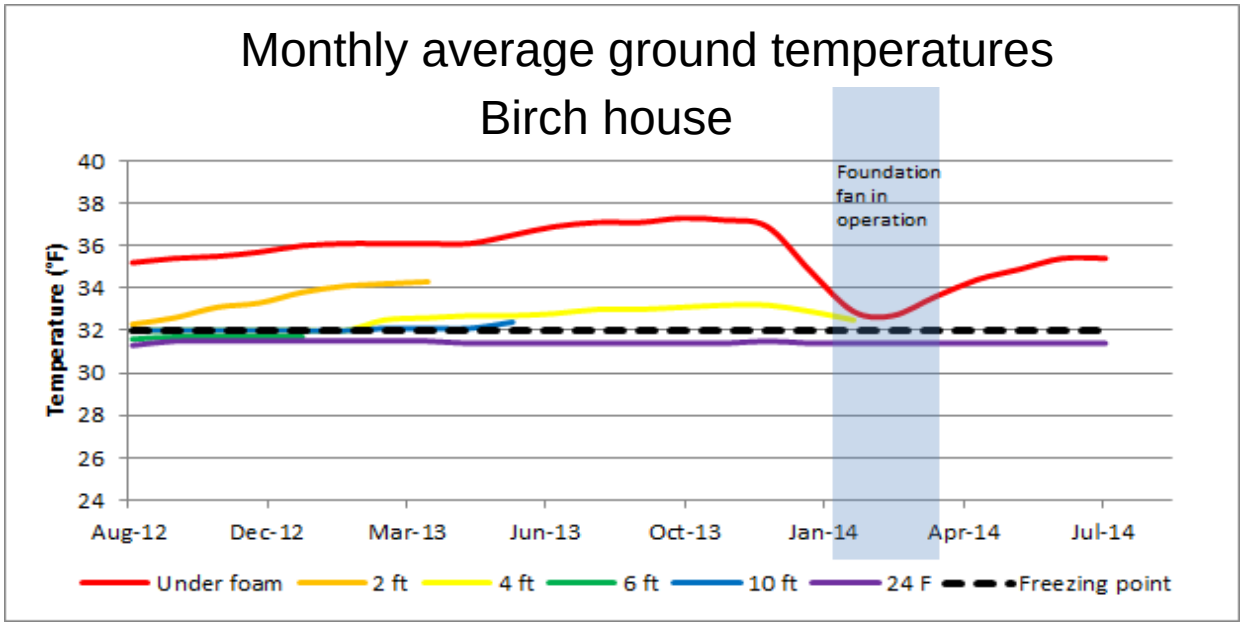


Sediment type dictates the sampling plan

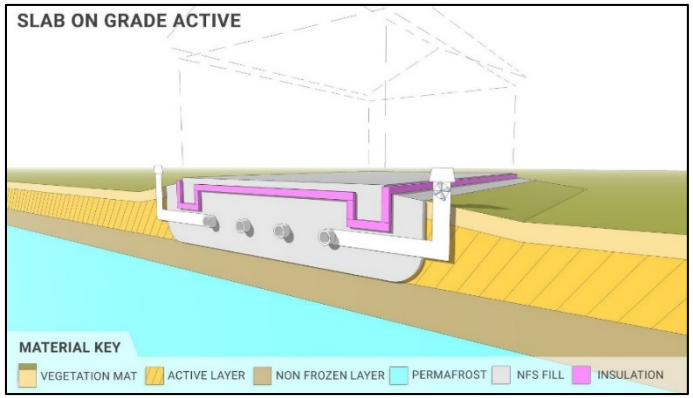
Proper Utilization of Refined Site Characterization



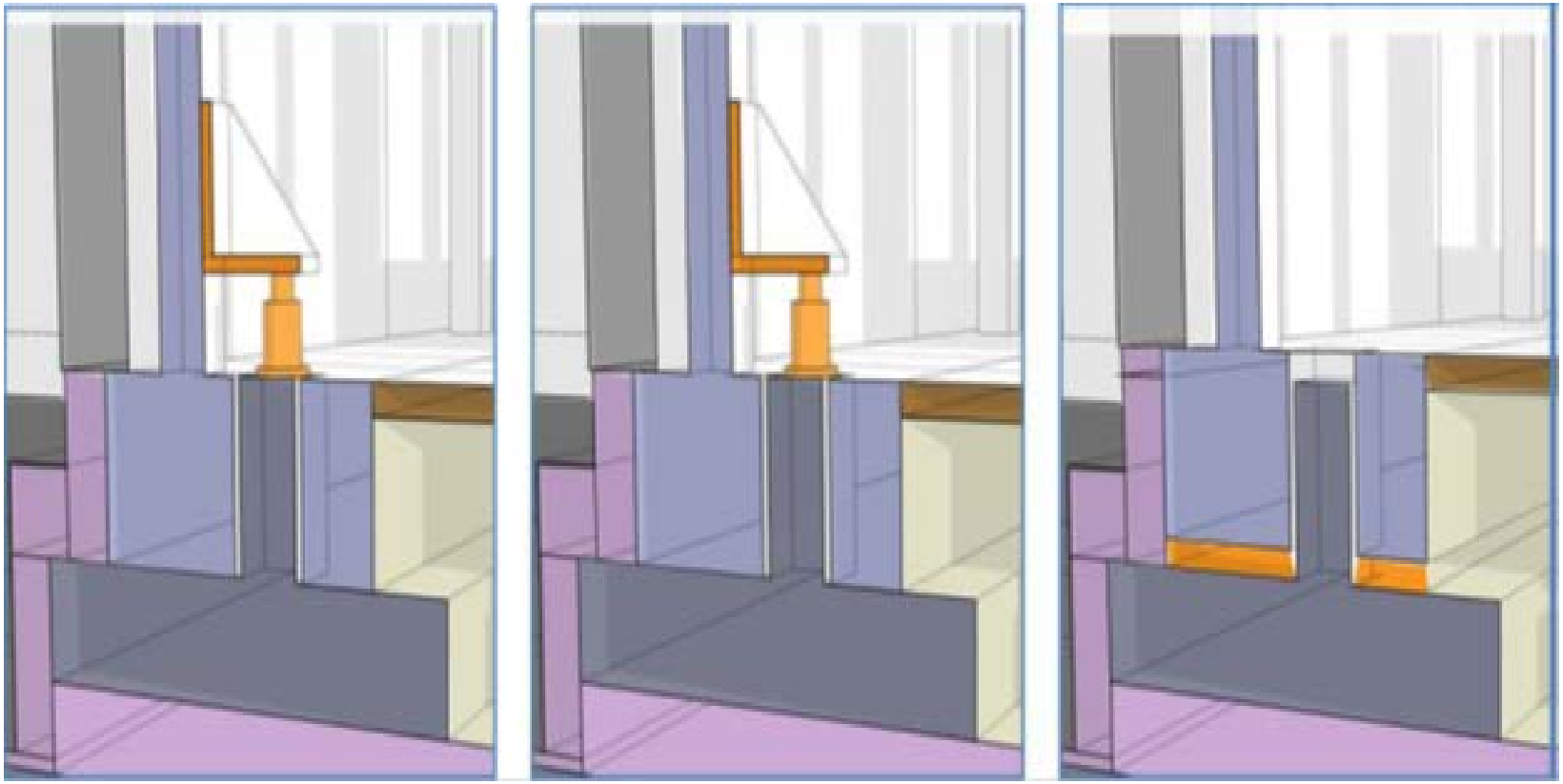
Direct Ground Coupling



K. Bjella



Facilitating Novel Foundation Designs



Realized DoD Benefit

Conclusions

- Geotechnical drilling provides low ground ice resolution in most permafrost terrains
- Electrical resistivity methods provide an efficient method to greatly increase ground ice resolution
- Electrical resistivity is well correlated to moisture (ice) content of permafrost terrains
- Increased ground ice resolution allows for novel engineering with unconventional solutions

Conclusions

- This work allows engineers to think outside of normal constraints and create more efficient designs, where current engineering is over-constructing for projected climate warming
- Further DoD presence in Arctic and sub-Arctic regions will require efficiencies related to construction, remote logistics and long term operation. This work provides tools to create these important efficiencies

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Cold-Regions-Ecology-and-Management/RC-2436

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Q&A Session 2

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The next webinar is on July 27, 2017

Management of Energetic and Propellant Material Releases on Testing and Training Ranges

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends

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