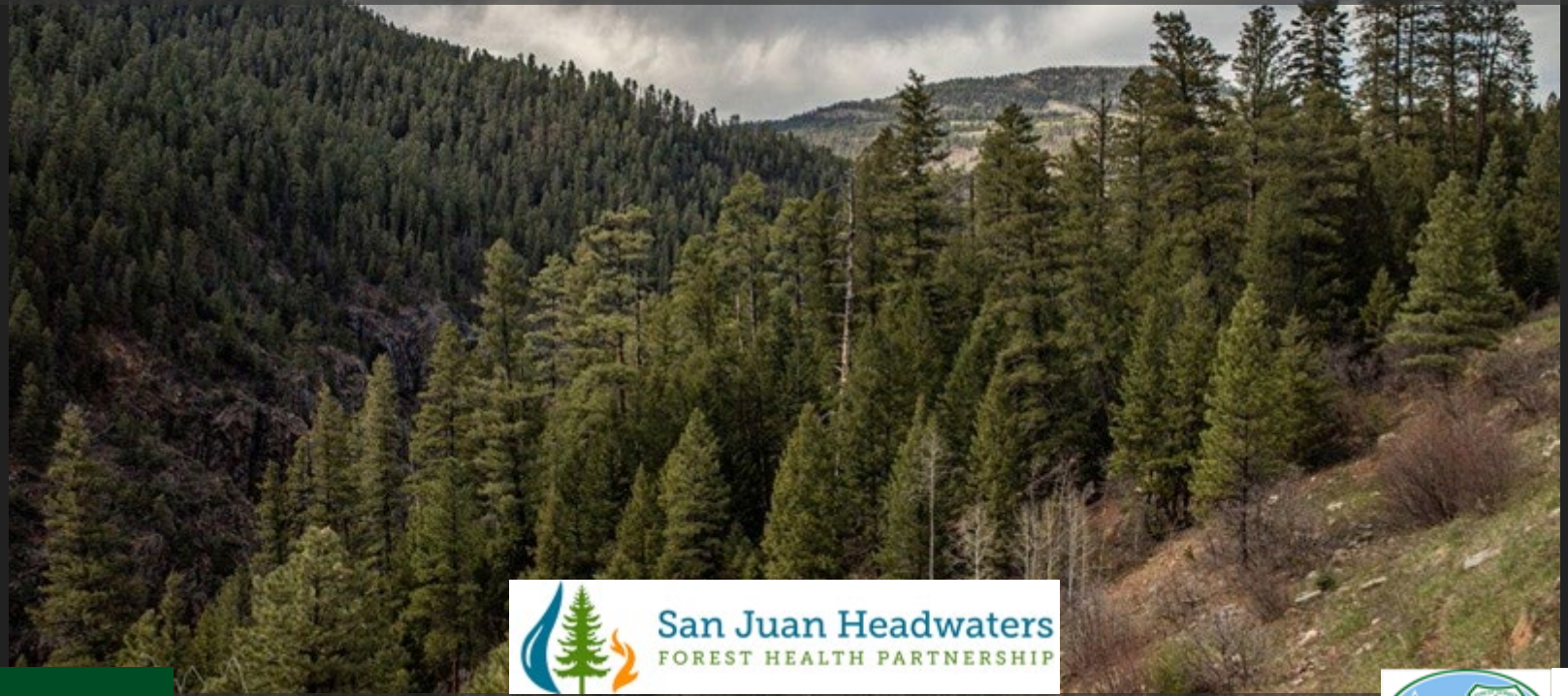
Mixed Conifer in the San Juan Mountain Region of Colorado, USA:
The Status of our Knowledge and Management Implications



San Juan Headwaters
FOREST HEALTH PARTNERSHIP

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Fort Lewis College

Mountain Studies Institute

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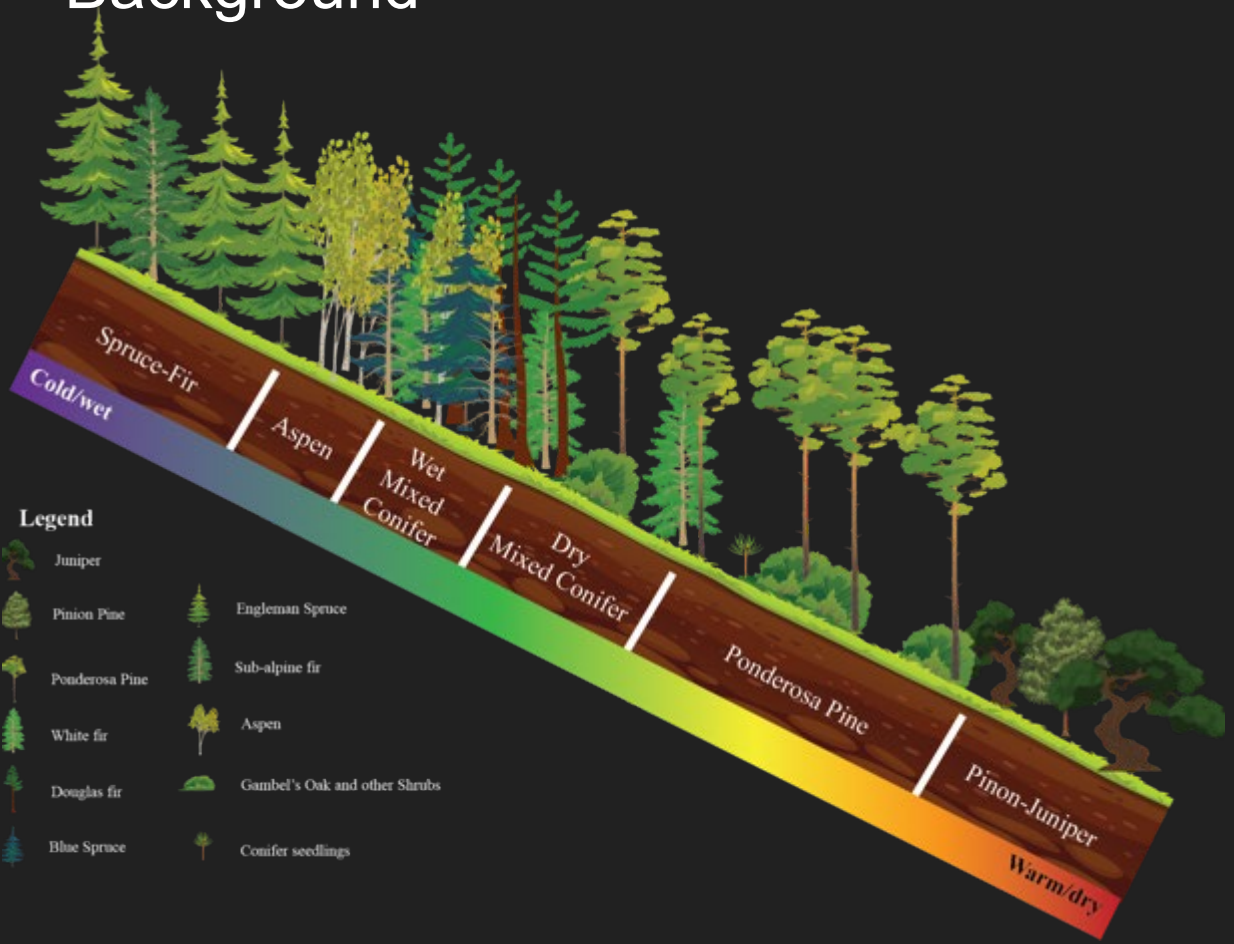
Background

- Mixed conifer - complex!
- Poorly defined
  - “Dry mixed conifer”
  - “Wet mixed conifer”
- Mixed conifer definitions not clear in literature
- Lots of implications for understanding ecology and management of these complex forests

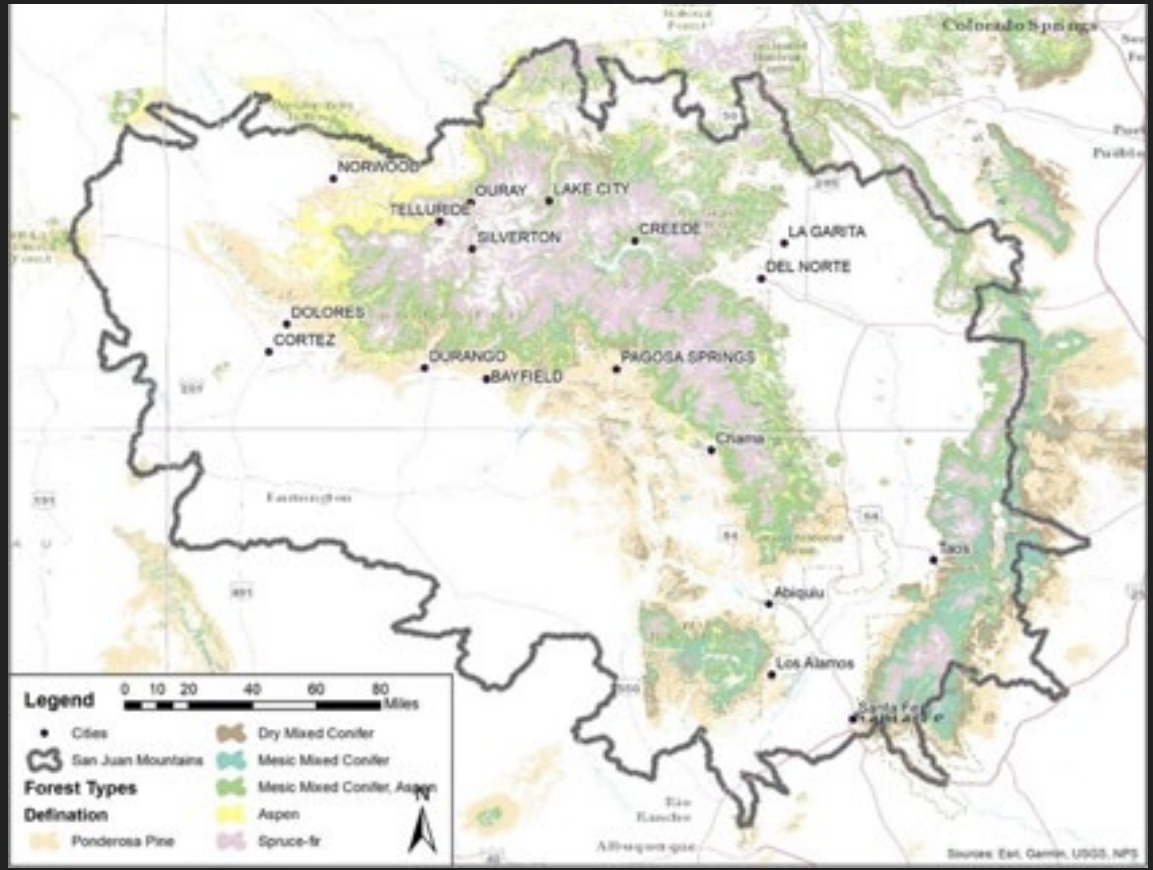
Background



- Mixed conifer forest type rarely existing in stable or isolated form
- Exist in a continuous spectrum of stand structure and composition rather than in discrete stands
- Highly influenced by stand disturbance history, soils, topography, aspect, etc.

Mixed Conifer in the San Juan Mountains

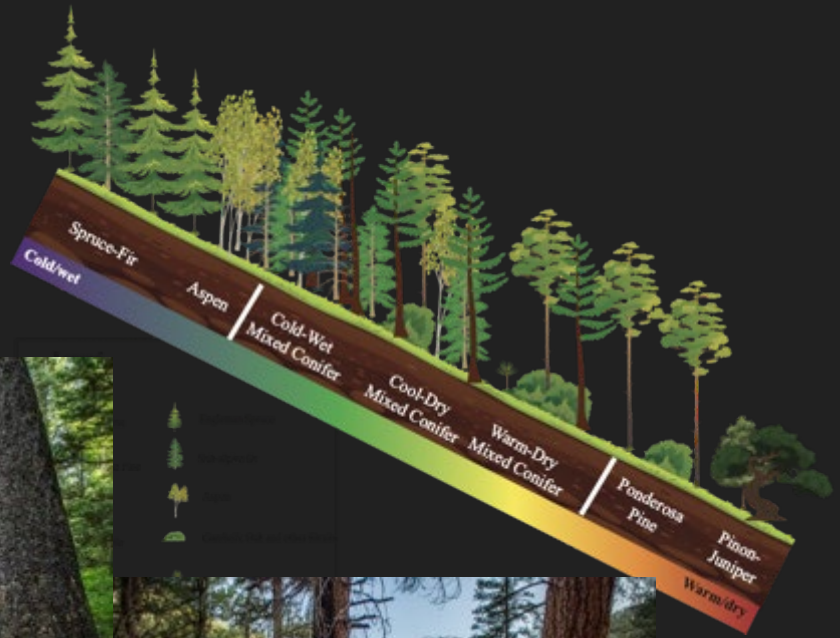
- ~880,000 aces in the San Juan Mountain Region
- Comprises 36% of forests in this region
- Watershed based definitions of the San Juan Mountains include Jemez Mountains and Sangre de Cristo regions (Rio Grande Tributaries)



Cold/Wet

Cool/Dry

Warm/Dry



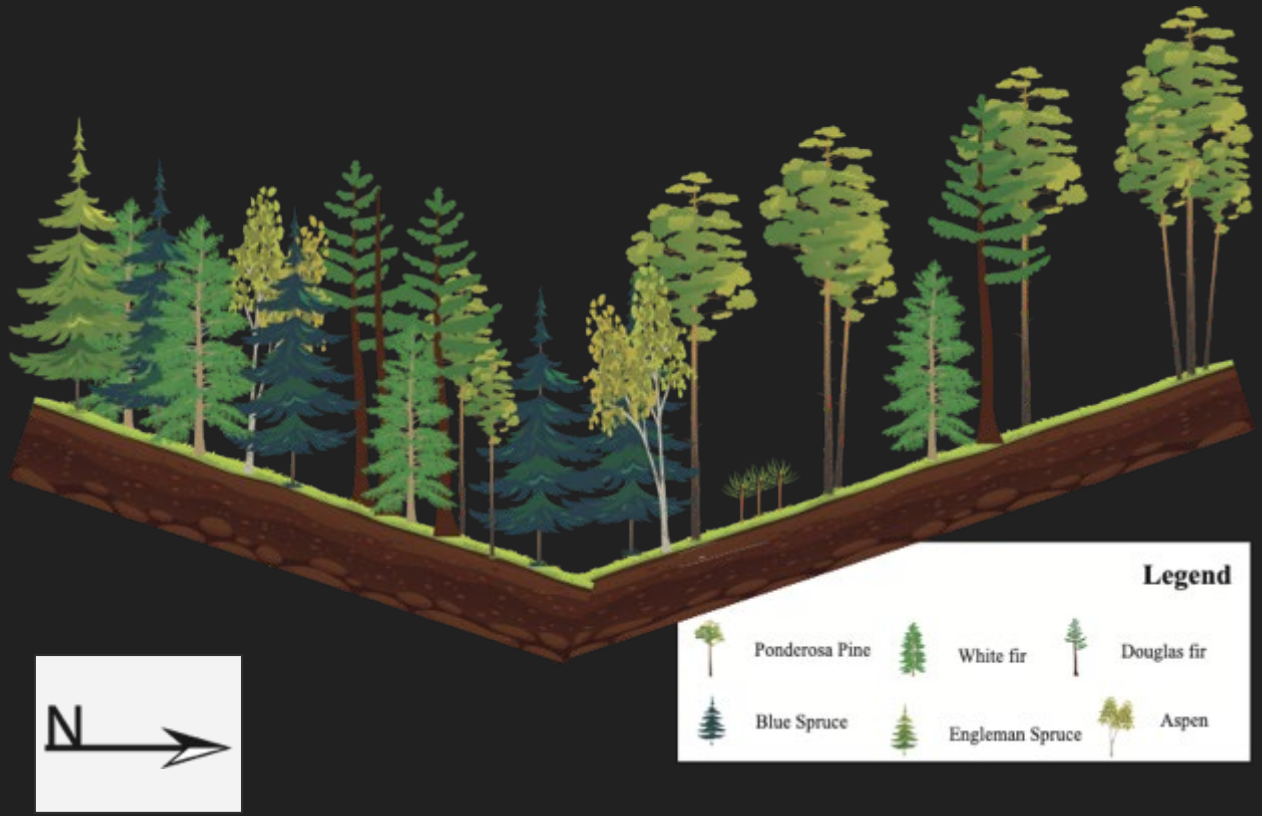
Mixed Conifer forests and environment

Climate:

- Precipitation and temperature
- Generally co-vary with elevation
- Geography (i.e., rainshadow)

Mixed Conifer Forest Types

Topographic variation can result in small scale variation in forest conditions in mixed conifer forests



Mixed Conifer forests and environment

Soils

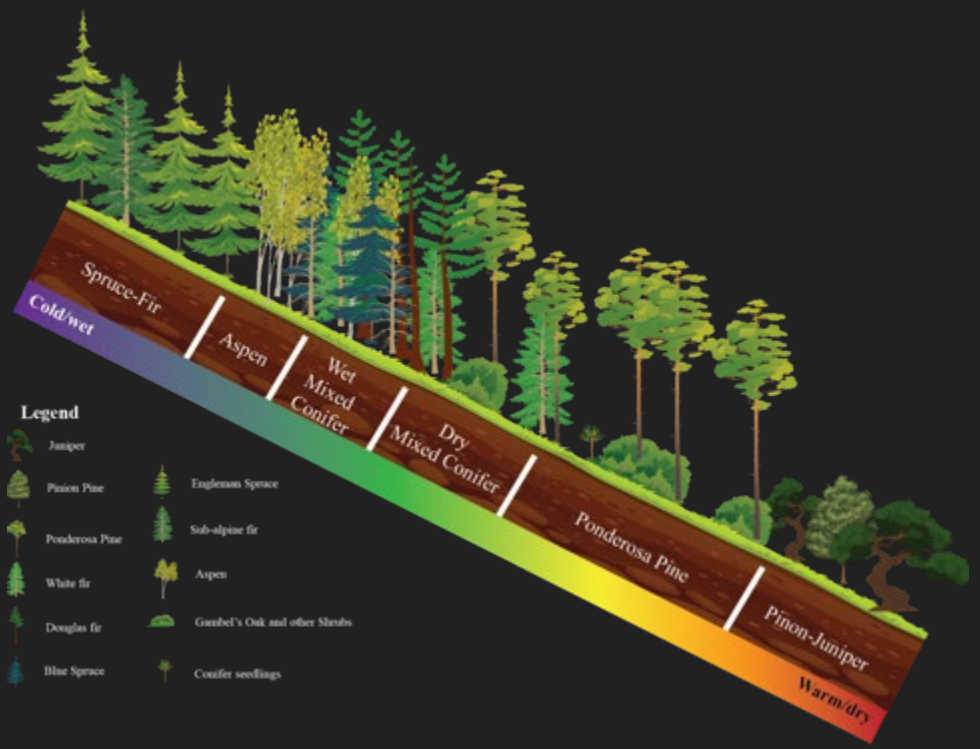
- Can exacerbate or mitigate climate effects

- INCREASING CLAY CONTENT
- INCREASING WATER HOLDING CAPACITY
- INCREASING GRAIN SIZE
- DECREASING WATER HOLDING CAPACITY

Mixed Conifer forests types

- Defining forest types is to enhance ability to understand and communicate stand characteristics,

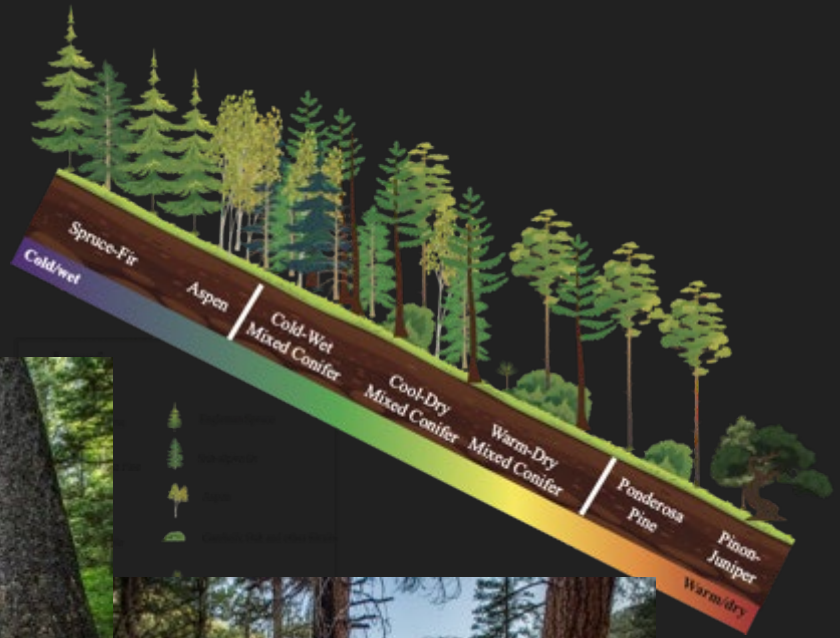
- but these exist in a continuum rather than discrete categories



Cold/Wet

Cool/Dry

Warm/Dry



Warm/Dry Mixed Conifer

Warm/Dry Mixed Conifer

- Tends to occupy drier sites
  - Lower elevations
  - South facing
  - Rocky outcrops
    - SW White Pine tends to be present here

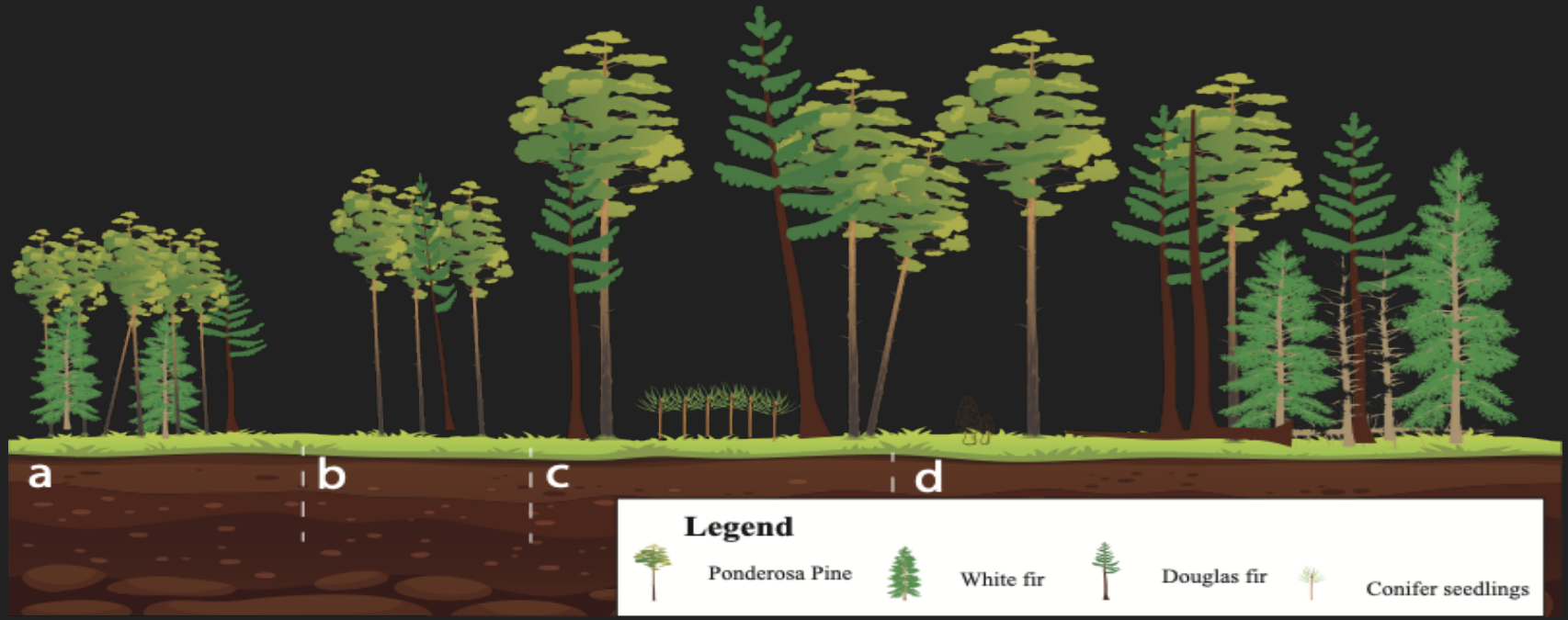
Warm/Dry Mixed Conifer

Disturbance

- Fire historically occurred every 5-30 years
  - Low - moderate severity with of some element of high severity
- Fire free periods controlled by wet climates that favored regeneration

Warm/Dry Mixed Conifer

- Varying stand structures maintained by different process



Warm/Dry Mixed Conifer

Insects and Disease

- Bark beetles
  - Mountain Pine Beetle
  - Roundheaded Pine Beetle
  - Douglas fir beetle
- Douglas fir tussock moth
- Western spruce budworm
- Annous root rot

- Particularly impactful when trees are stressed by drought

- Rarely results in >80% mortality in a stand

Warm/Dry Mixed Conifer

Climate Change

- Increased burn area and possible increases in burn severity
- Reduced post-disturbance regeneration
- Reduced tree growth

Warm/Dry Mixed Conifer

Protect climate and fire refugia

- Areas that are slightly wetter than surrounding areas with reliable moisture
- Provide important seed sources/biological legacy
- Managed to preserve refugia

Warm/Dry Mixed Conifer

Management Implications

- Restoring historic variability can increase resilience
  - Especially if re-entry and economic considerations are made
- Protect fire and climate refugia
- Concerns for regeneration
- Social and economic values

Warm/Dry mixed conifer knowledge & degree of confidence

	High confidence	Moderate confidence	Low confidence
Successional trajectories	Spatial variability maintains diverse age groups across larger areas to provide resilience	Periodic recruitment of ponderosa pine	Sprouting shrubs may periodically establish as an intermediate successional trajectory
Fire	Frequent low-moderate severity surface fire historically	Occasional high severity burning in smaller patches historically; some recent fires reflect large (e.g., >1000 ac) high severity burn patches	
Insects/ disease	Endemic populations of several beetle species result in periodic mortality	Mortality of trees is higher in drought stressed trees and trees with reduced growth rates 10 years prior to outbreak	Infrequent outbreaks of mountain pine beetle and round headed bark beetle can result in severe mortality events. Mortality events are episodic and rarely exceed 80% mortality
Climate change		• Climate change is likely to increase burned area and burn severity from wildfire • Reduced regeneration in disturbed areas • Reduced plant growth, particularly in over-dense forest	• Increased risk of type conversions • Increased drought resistance in less dense stands for overstory trees • Increased susceptibility to drought for regeneration in less dense stands
Compound disturbances	Low-moderate severity disturbances favor desirable spatial variability	Repeated disturbances can favor type conversions, particularly following high severity wildfire and drought conditions	
Management implications	Restoring historical variability can enhance resilience to a variety of disturbances	Fire and climate refugia should be identified and protected from possible extreme events	Facilitating regeneration following artificial and natural disturbance can be difficult

Cool/Dry Mixed Conifer

Cool/Dry Mixed Conifer

- Dominated by Douglas Fir and White Fir with occasional aspen and ponderosa pine
  - Douglas fir selectively logged in many cases
- Shrubby understory of snowberry, serviceberry, rocky mountain maple, and chokecherry

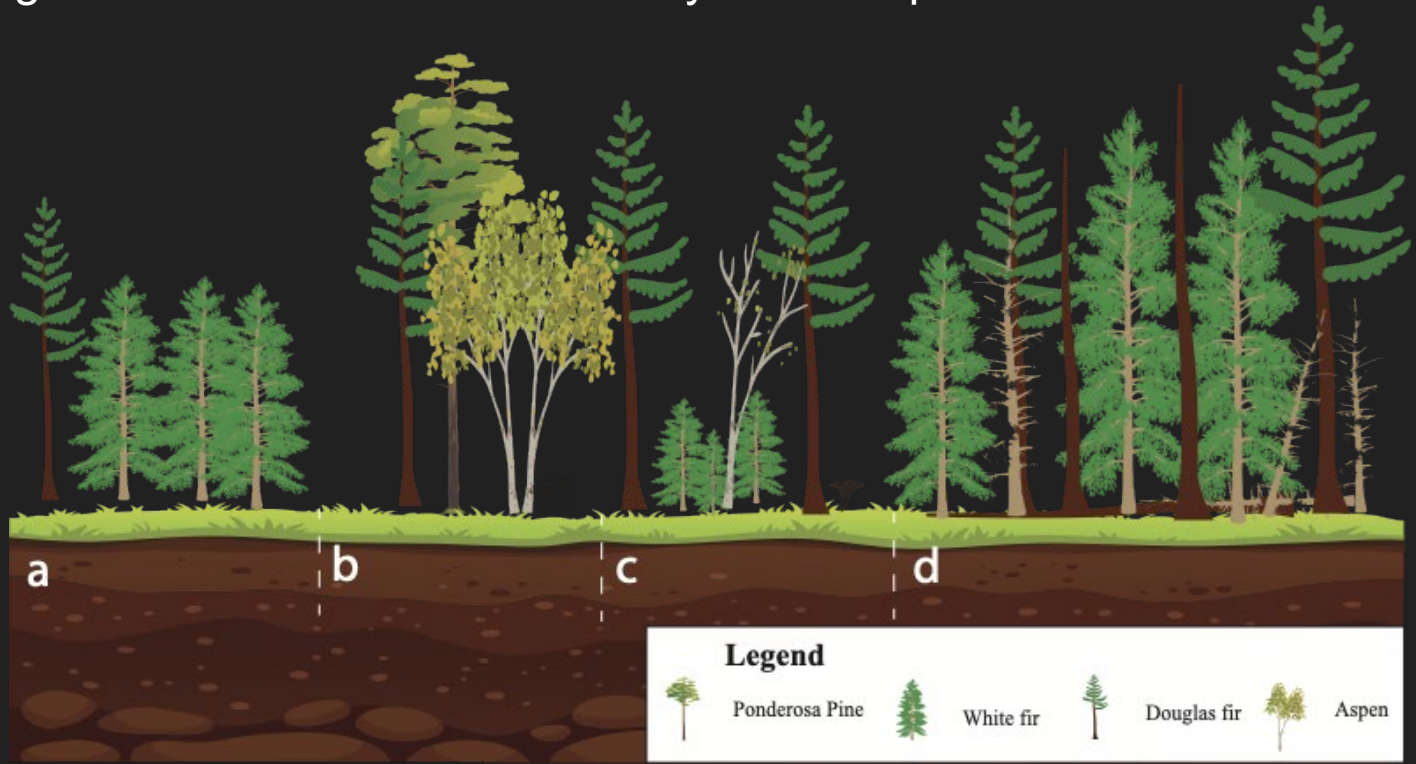
Cool/Dry Mixed Conifer

Disturbance

- Fire less common, 30-100 years
  - White fir recruitment occurred heavily during fire free periods
  - Mixed severity with high severity patches up to 75ha in size
- Openings and areas with aspen

Cool/Dry Mixed Conifer

- Varying stand structures maintained by different process



Cool/Dry Mixed Conifer

Management Implications:

Considerations similar to warm/dry mixed conifer forests can also be applied here as climate adaptation strategies.

Cool/Dry mixed conifer knowledge & degree of confidence

	High confidence	Moderate confidence	Low confidence
Successional trajectories	Shade-tolerant species infill understory overtime	Post-disturbance communities consist of sprouting species or shade-intolerant species	
Fire		Infrequent (30-100 years) mixed severity fire driven by drought and abundance of fuels	High severity patches were historically small, with some larger patches
Insects/ disease	Because of high species diversity, numerous native insects and diseases exist	Periodic Western Spruce Budworm outbreaks driven by warm/wet conditions	Annosus root disease is an important regulator in shade-tolerant species and infections worsen as susceptible species densities increase
Climate change		Drought and warmer conditions are likely to increase risk to extreme fire events	Drought is likely to alter regeneration dynamics and successional trajectories, perhaps resulting in type conversion and/or loss of forested areas
Compound disturbances	Low-moderate severity disturbances favor desirable spatial variability		Where present, sprouting species (e.g., aspen or Gambel oak) may become a dominant species following repeat disturbances
Management implications	Restoring historical variability can enhance resilience to a variety of disturbances	Embracing complexity is a critical component of managing these forests	Future desired conditions should consider current conditions and potential future conditions based on climate change and potential for disturbance

Cold/Wet Mixed Conifer

Cold/Wet Mixed Conifer

- Dominated by blue spruce, Engelmann spruce, white fir and occasional Douglas-fir and Aspen
  - Less legacy of previous logging
- Shrubby understory of elderberry, gooseberry and common juniper

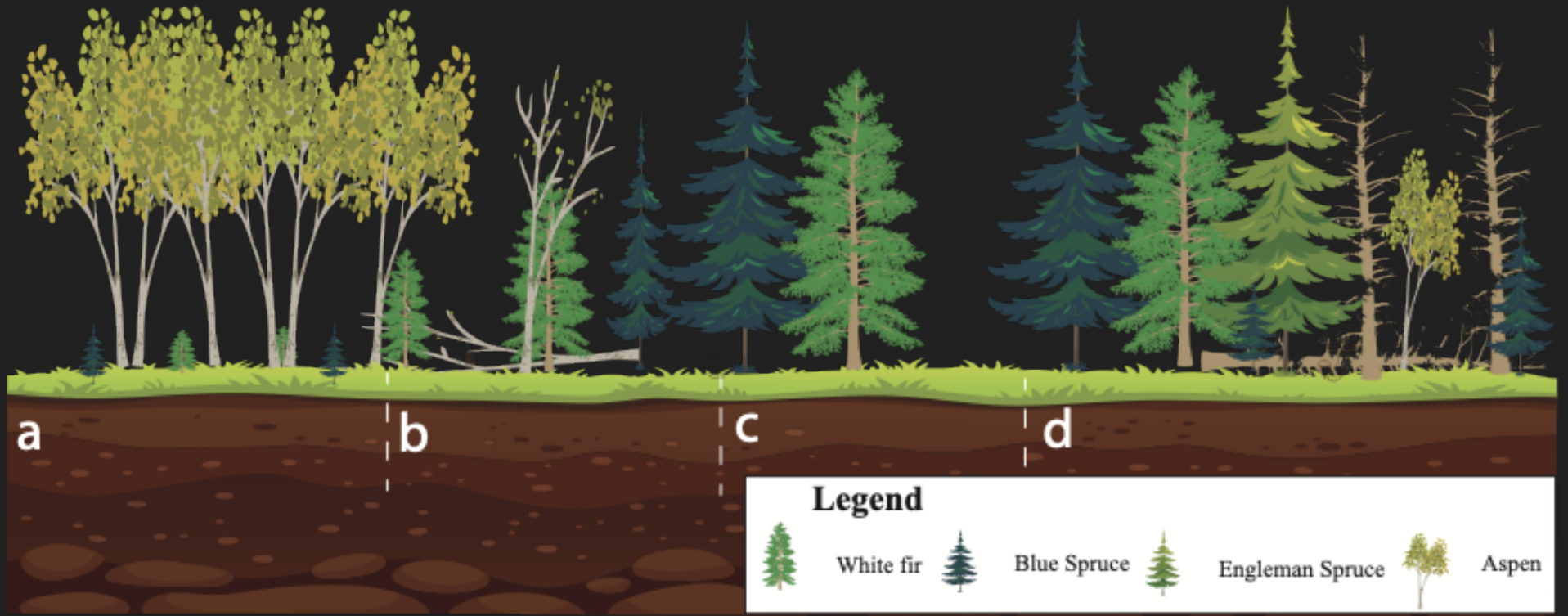
Cold/Wet Mixed Conifer

Disturbance

- Infrequent fire, every 100-300 years
  - All species except aspen tend to establish and grow during fire free periods
- Wet, short growing seasons with heavy winter snow

Cold/Wet Mixed Conifer

- Varying stand structures maintained by different process



Cold/Wet Mixed Conifer

Management Implications

- Limited operable ground due to roadless, steep slopes and wilderness

Cold/Wet Mixed Conifer

Management Implications

- Salvage logging may be appropriate if advanced regeneration is already present
    - Must protect regeneration and microsites for regeneration

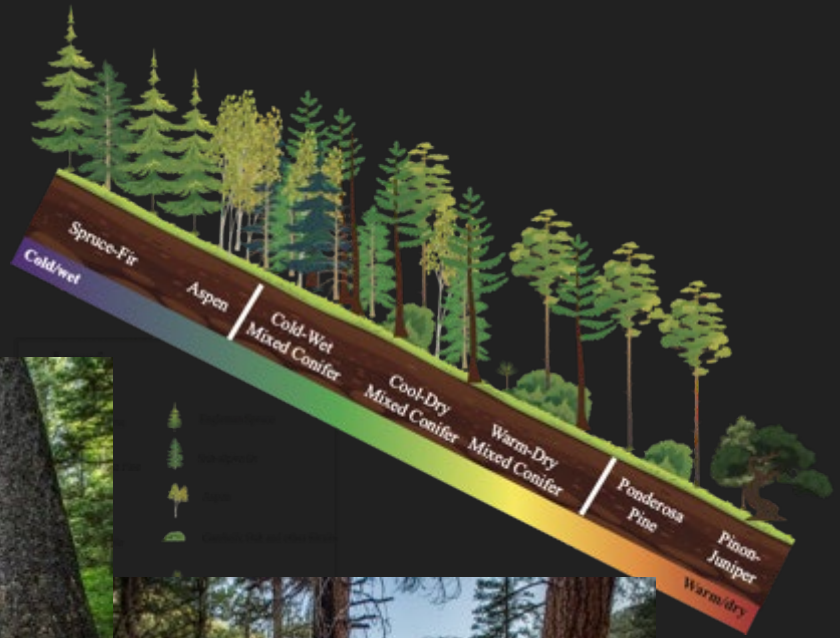
Cold/Wet mixed conifer knowledge & degree of confidence

	High confidence	Moderate confidence	Low confidence
Successional trajectories		Pre-disturbance conditions influence successional trajectories If aspen is present, aspen dominance followed by a transition to conifer	Tree regeneration may vary based on climatic conditions at the time of regeneration, sometimes favoring dry adapted species
Fire		Infrequent, stand-replacing fire every 300+ years	Mixed severity fire can occur based on variability in fuels, topography, or fire weather
Insects/ disease		Episodic bark beetle outbreaks can occur during time periods of drought	Temperature may also be a factor influencing bark beetle outbreak, thus making recent outbreaks unprecedent compared to historical outbreaks
Climate change			Drier conditions could favor more extreme and frequent fire behavior; warmer conditions could facilitate regeneration of lower elevation species
Compound disturbances			Insect outbreaks alter and redistribute fuels that sometimes can alter fire behavior, but not burn severity
Management implications			Group selections that retain overstory trees can increase resilience to insect outbreaks; thinning to favor advanced regeneration can accelerate stand development

Cold/Wet

Cool/Dry

Warm/Dry



Summary

- Mixed conifer forests in the San Juan Mountain Region are complex and diverse

- Site conditions, disturbance history, land use all influence forests on small to large spatial scales to result in diverse forest conditions.

The Perfect Forest

Borrowing from the geomorphology perfect landscape….

Mt Hood and Mt Rainer share similar geologic defining characteristics, but yet are distinguishable

The Perfect Forest

Borrowing from the geomorphology perfect landscape….

Two warm dry mixed conifer forests may be the same general type, yet very different

The Perfect Forest

The elevation gradient and forest ‘types’ are met to serve as gradients of a continuous possible range of forest conditions.

There are infinite possible stand conditions and characteristics

Management Implications

- Management of these forests must embrace complexity across space and time

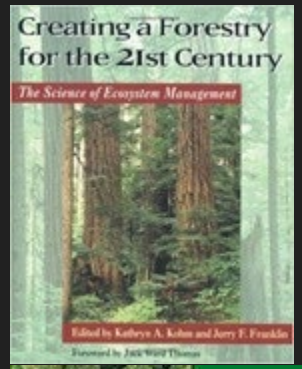
Management Considerations

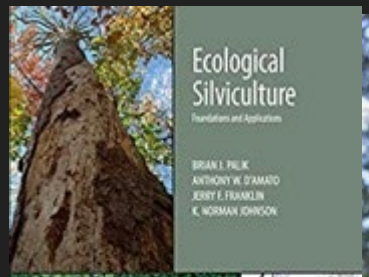
- Many areas of these forest types are within roadless or wilderness areas

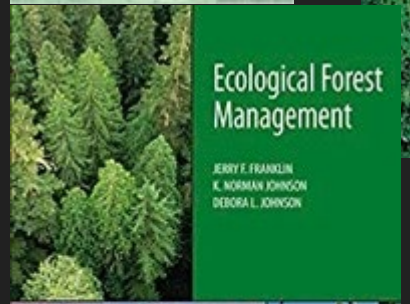
- Areas of non-management are opportunities

Ode to Ecological Forestry/Jerry Franklin

- **Ecological Forestry**
  - Jerry Franklin’s “new forestry”
  - Manage for complexity, consider the economics, social and ecological values
  - Each stand treated differently







Broader geographies = even more diversity

Ponderosa Pine / Lodgepole Pine / Douglas Fir

Cool/Dry Mixed Conifer

Conifer, Colorado

Ponderosa Pine / Western Larch / Douglas Fir/ Lodgepole Pine

Cool/Dry Mixed Conifer

McCall, Idaho

High **species diversity** and similar **functional diversity**

Acknowledgements & thank you!

SJHFHP participants

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USDA-Rocky Mountain Research Station: Mike Battaglia

Fort Lewis College: Julie Korb

Bill Baker (retired ecologist)

Many more!

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