

Permafrost-Affected Soils in Alaska: Distribution, Comparative Morphology, and Taxonomic Change

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UMN Mathematics of Climate Seminar
05NOV2019

Photo: Noatak River Valley, Brooks Range, AK - N. Jelinski

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Roadmap

- (1) What is soil, what is permafrost?
- (2) Distribution of Near-Surface Permafrost (NSP) in Alaska
- (3) Permafrost-Affected Soil Taxonomy and Taxonomic Change
- (4) Comparative Mechanisms and Morphology of Cryoturbation

Photo: Noatak River Valley, Brooks Range, AK - N. Jelinski

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Roadmap

- (1) **What is soil, what is permafrost?**

Photo: Noatak River Valley, Brooks Range, AK - N. Jelinski

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Soil is:

The unconsolidated mineral or organic material on the surface of the earth that has been subjected to and shows the effects of alteration by:

Photo: Bethel, AK - N. Jelinski

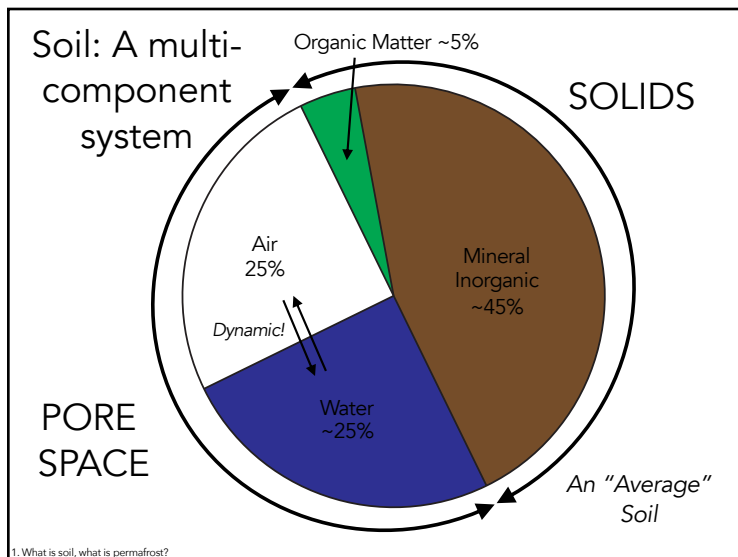
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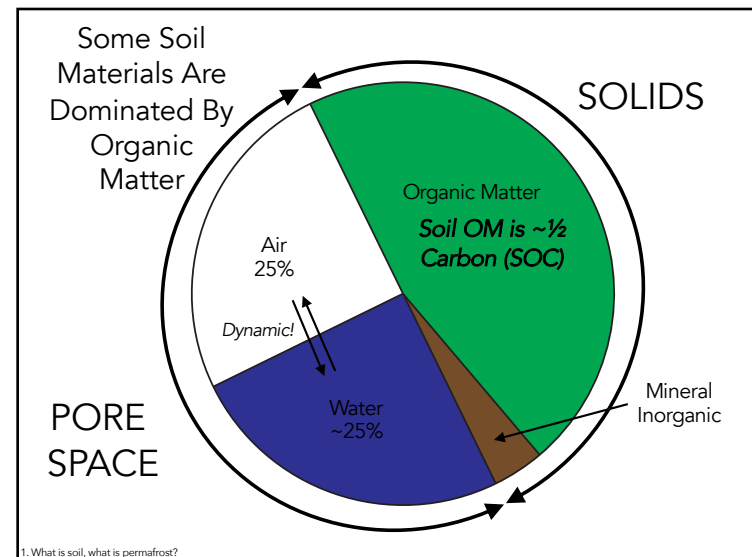
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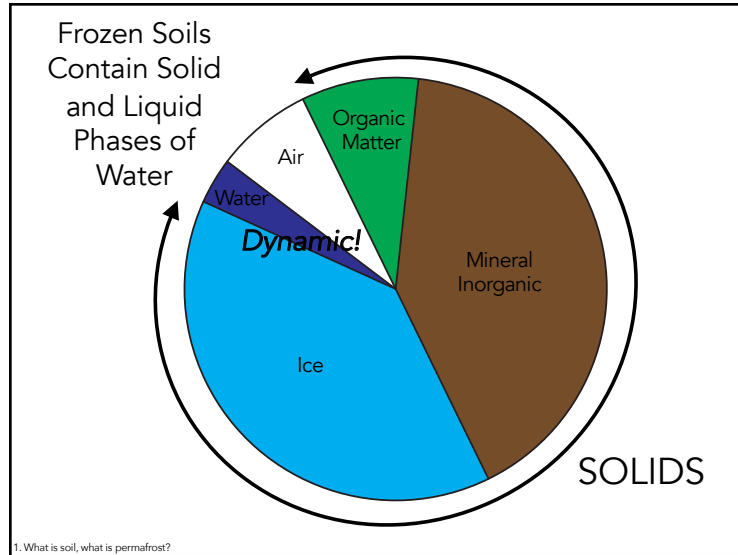
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What is Permafrost?

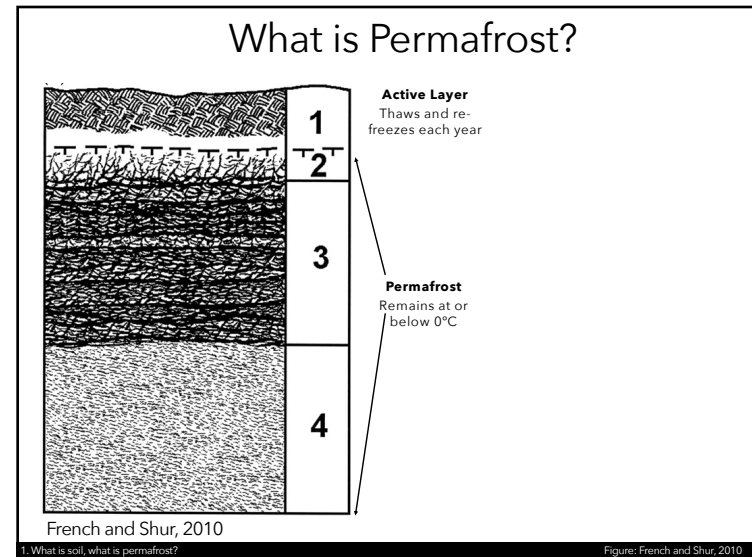
- Permafrost is any material that remains at or below 0 °C for at least 2 consecutive years.
- Permafrost is a **thermal state**, not a material type.
- Many types of materials: rock, soil, ice.
- Permafrost does not need to have ice. There is dry permafrost in Antarctica (Bockheim and Tarnocai, 1998) and on the Tibetan Plateau (Luo et al., 2018)

Most permafrost is ice-cemented, however, esp. in the northern circumpolar region.

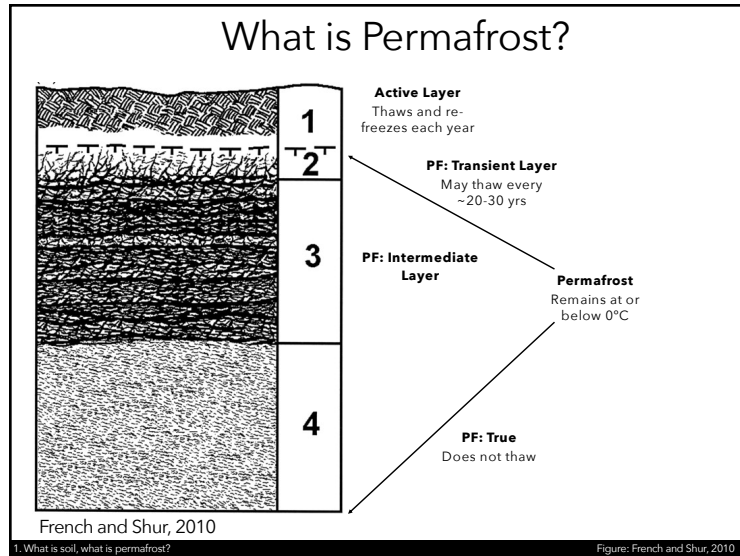
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Image: N. Jelinski, Sagwon Hills AK

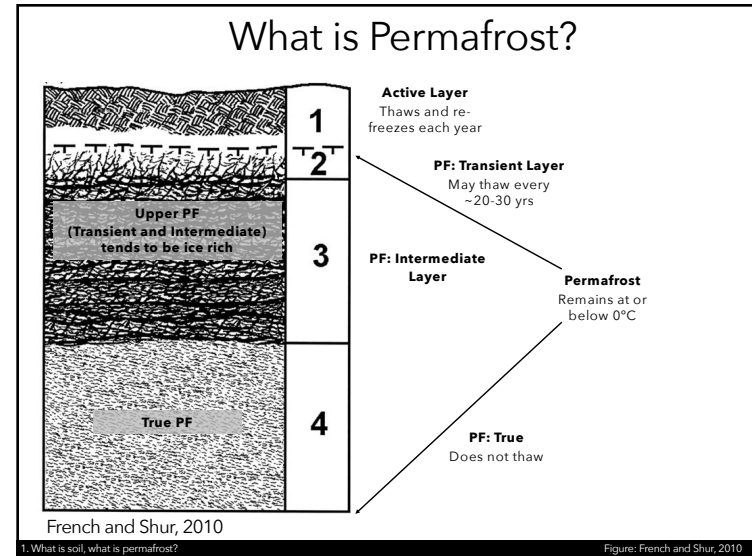
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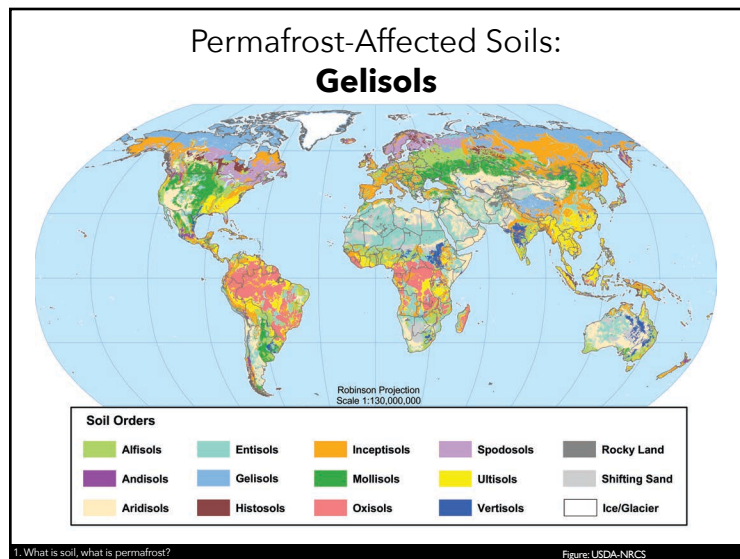
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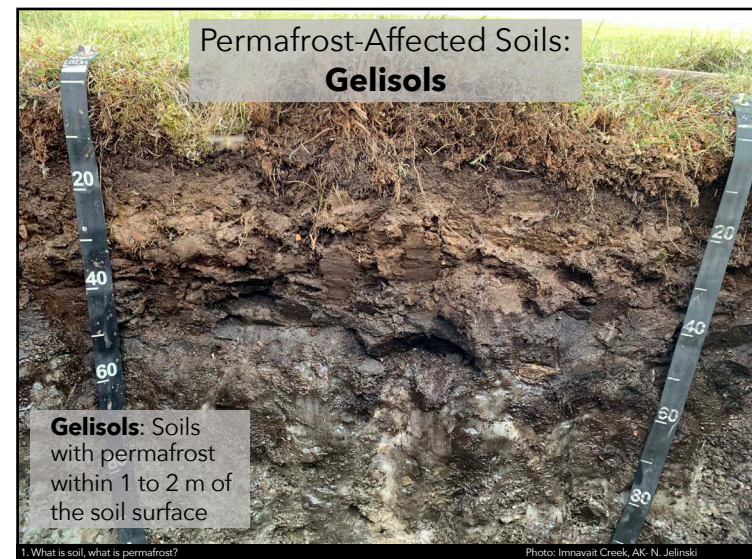
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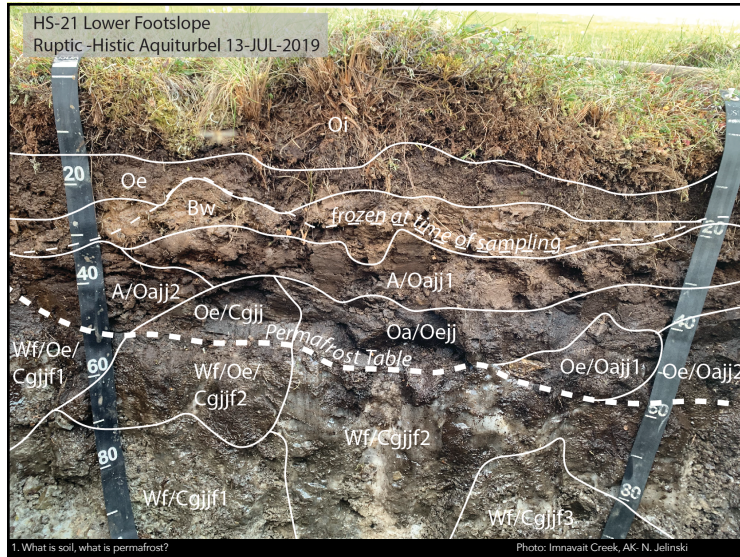
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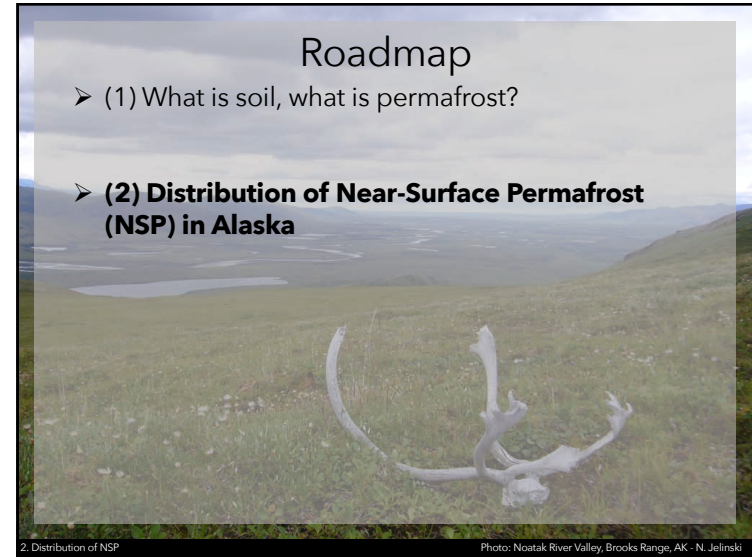
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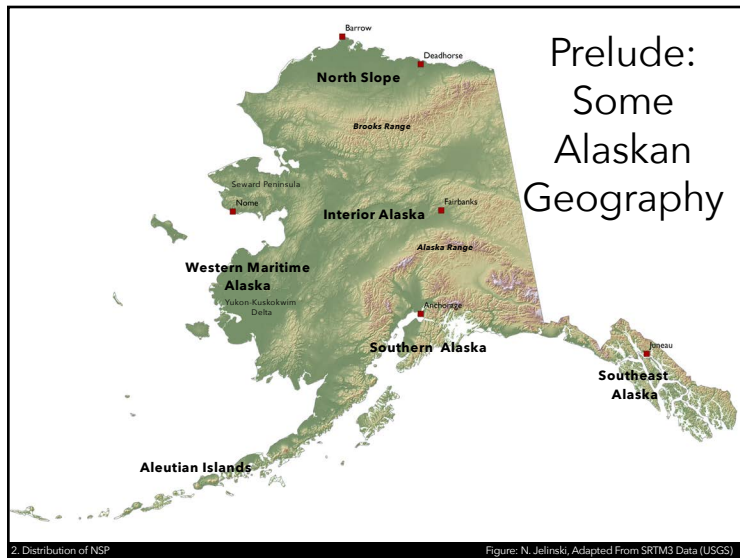
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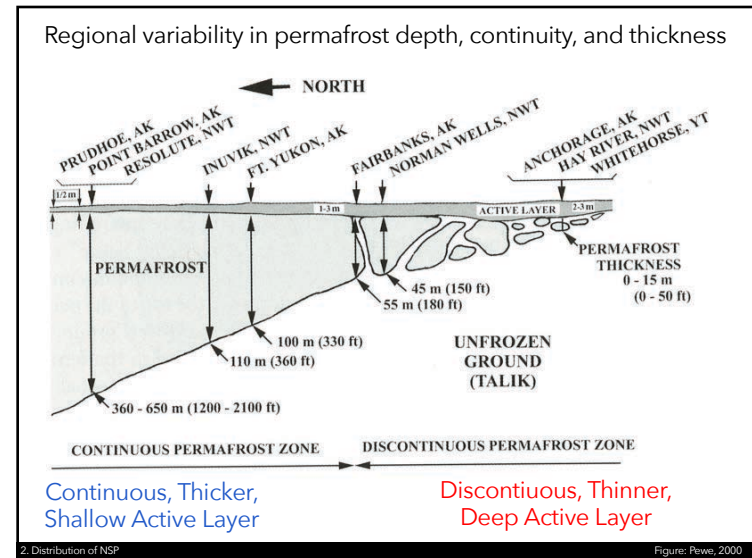
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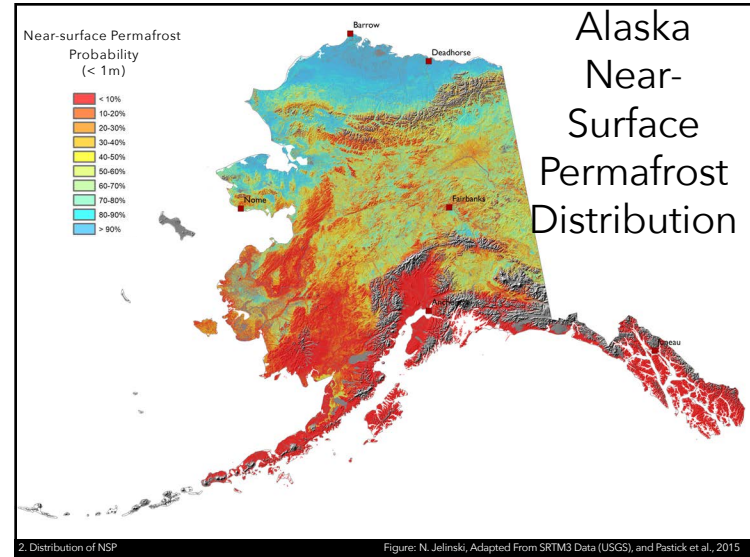
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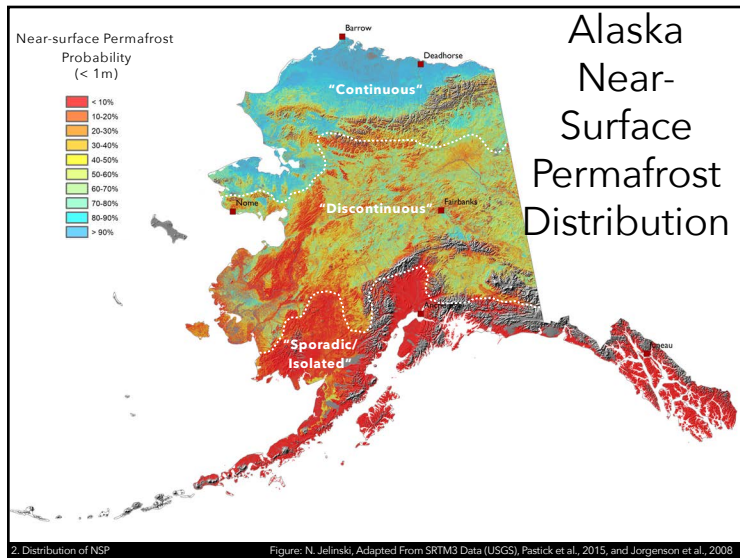
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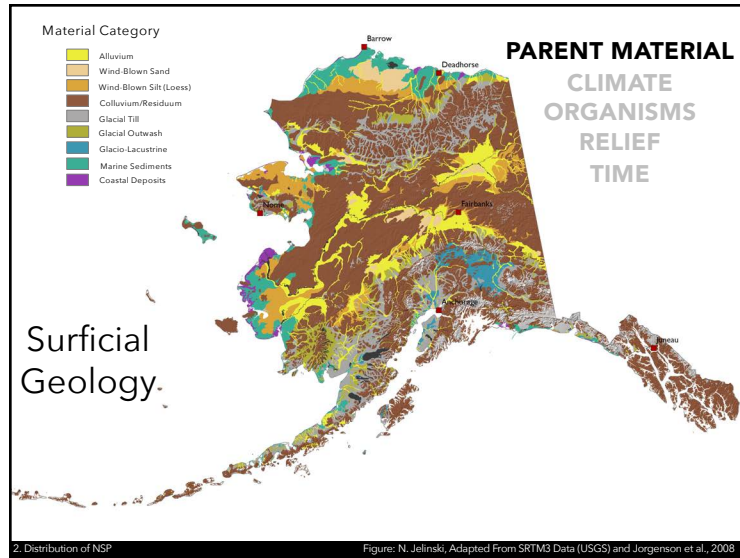
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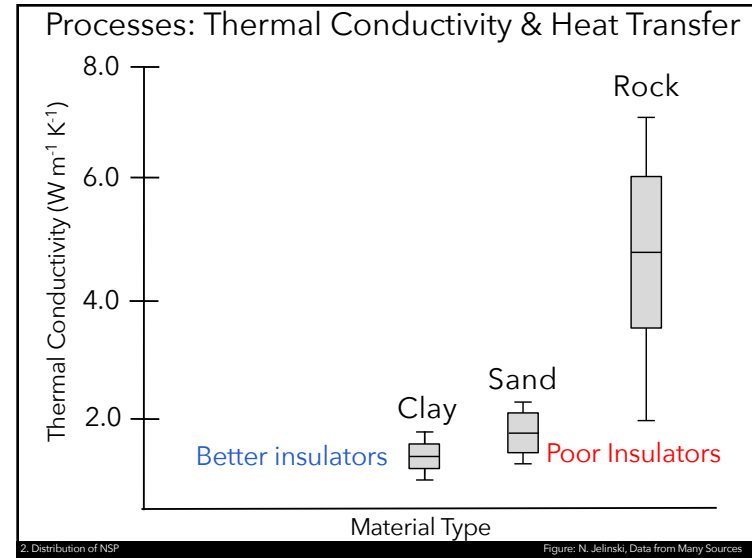
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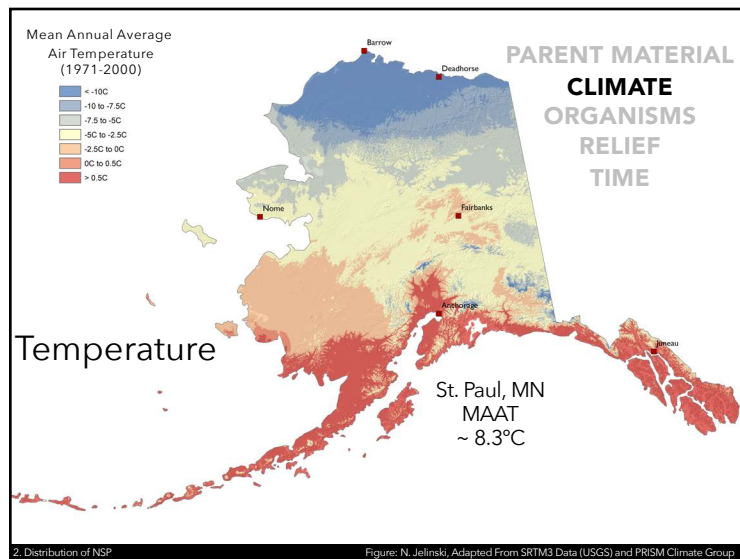
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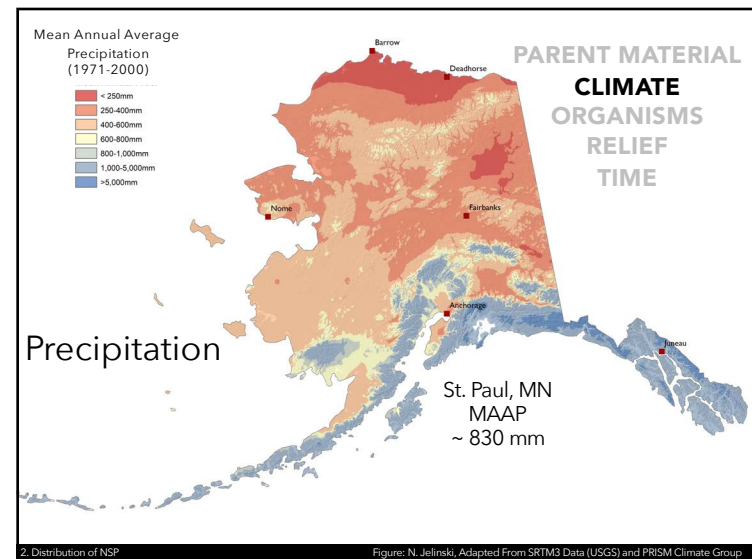
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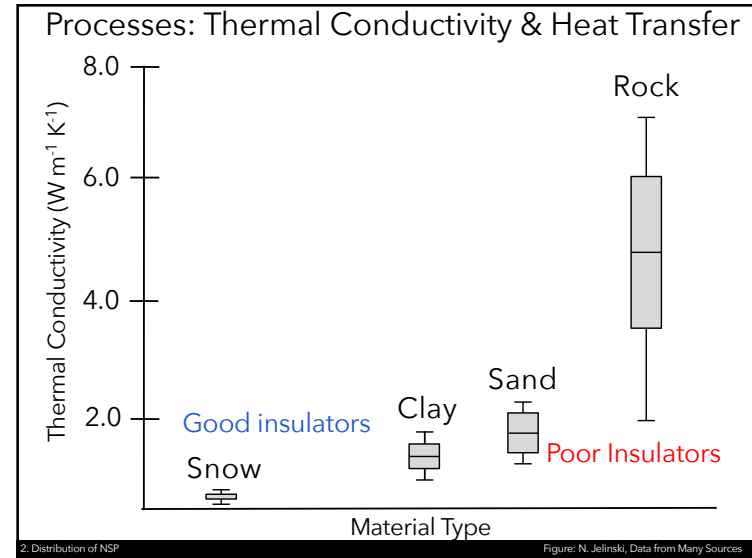
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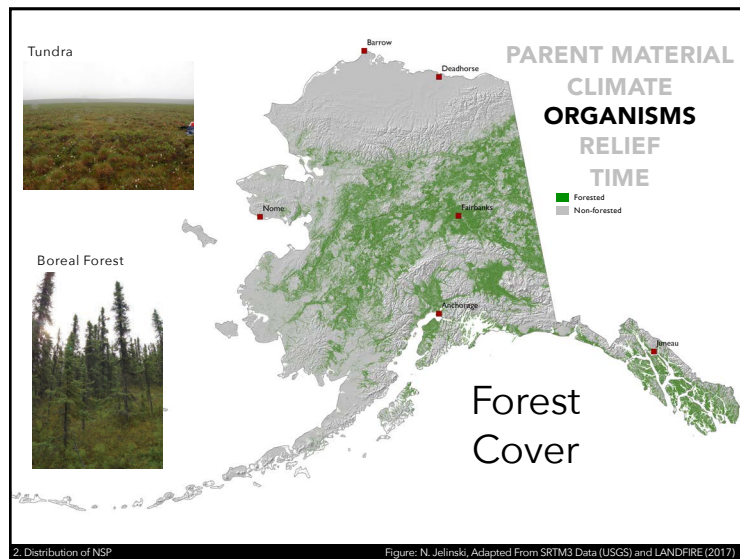
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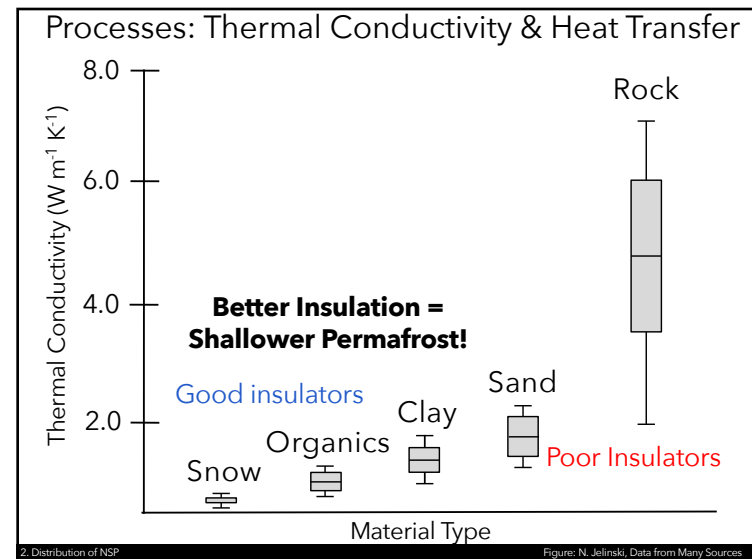
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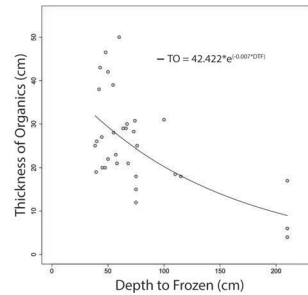
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Organic layer thickness as an important control on permafrost depth

- Organic materials are excellent insulators (poor thermal conductivity) and their thickness exerts a primary control on depth to permafrost.

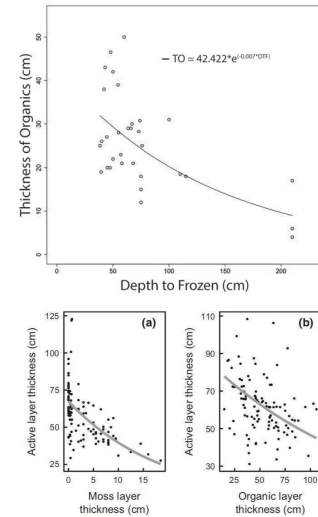


1. What is soil, what is permafrost? Figure: (T) Jelinski et al. (In Press) - Copper River Basin Soils; (B) Fisher et al., 2016 Global Change Biology

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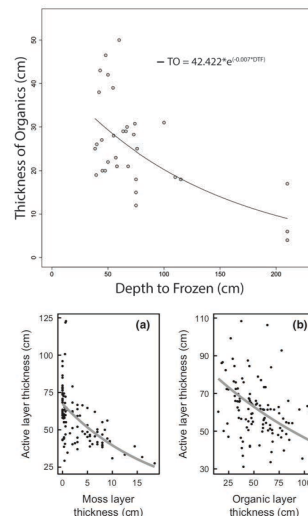


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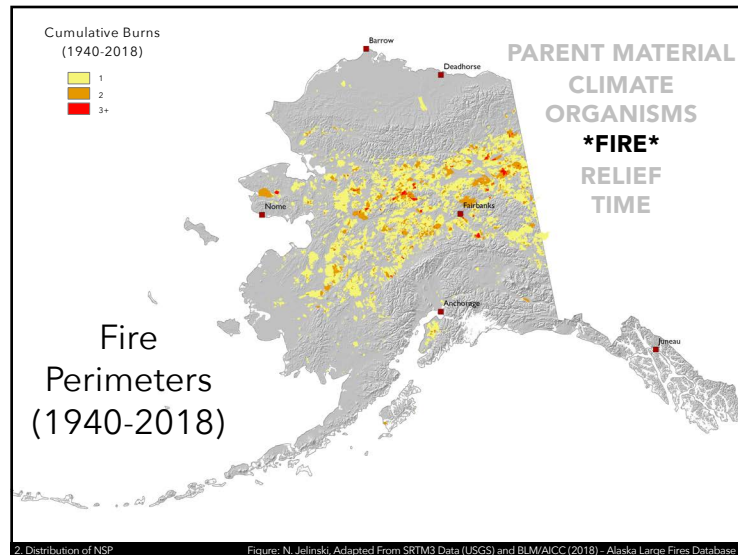
Organic layer thickness as an important control on permafrost depth

- Organic materials are excellent insulators (poor thermal conductivity) and their thickness exerts a primary control on depth to permafrost.
- Thermal conductivity increases with increasing decomposition of organics and increasing water content.
- Dry, undecomposed organic materials provide the best insulation



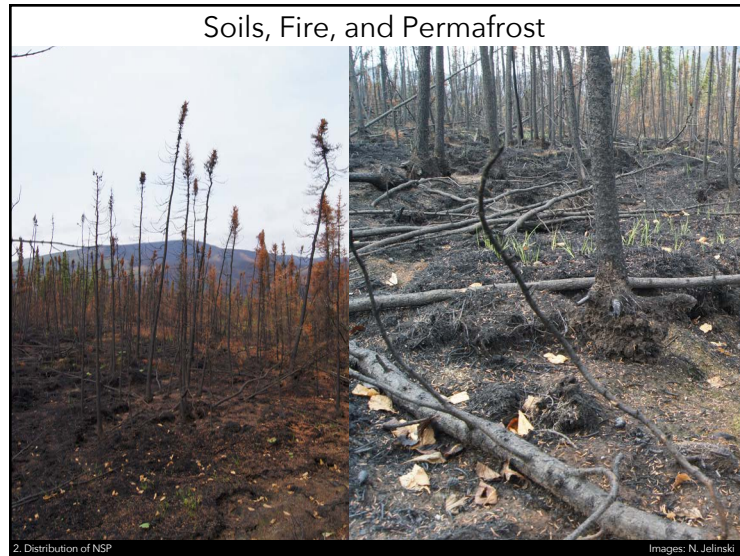
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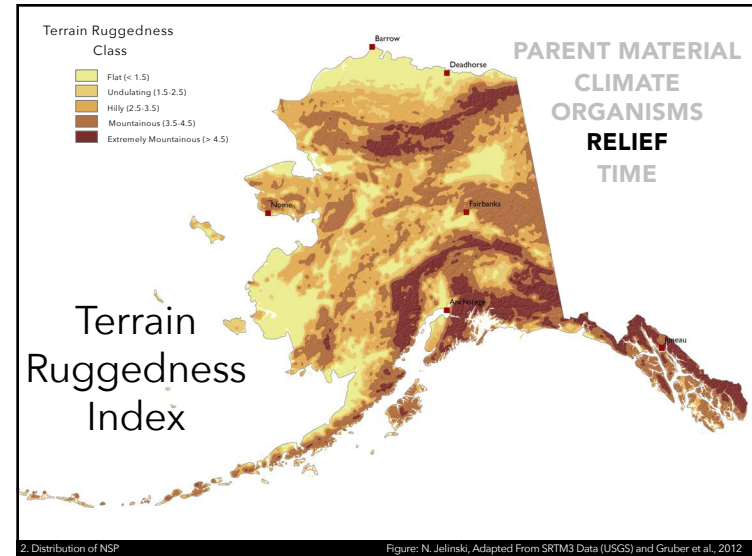


2. Distribution of NSP Figure: N. Jelinski, Adapted From SRTM3 Data (USGS) and BLM/AICC (2018) - Alaska Large Fires Database

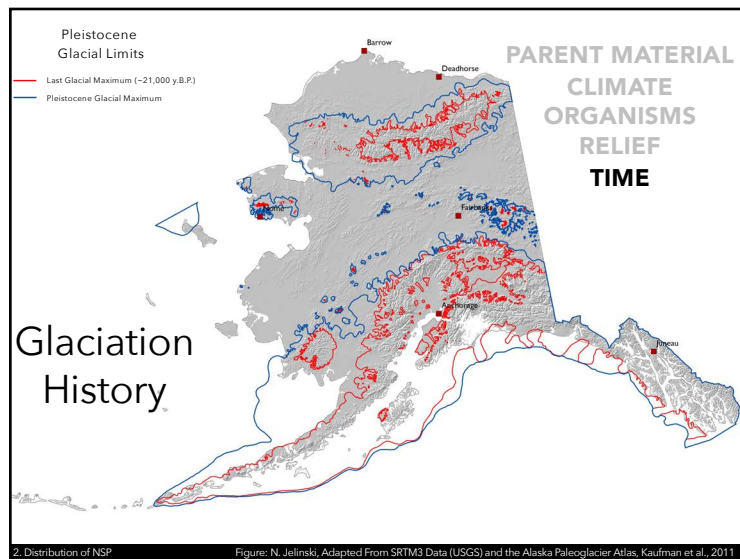
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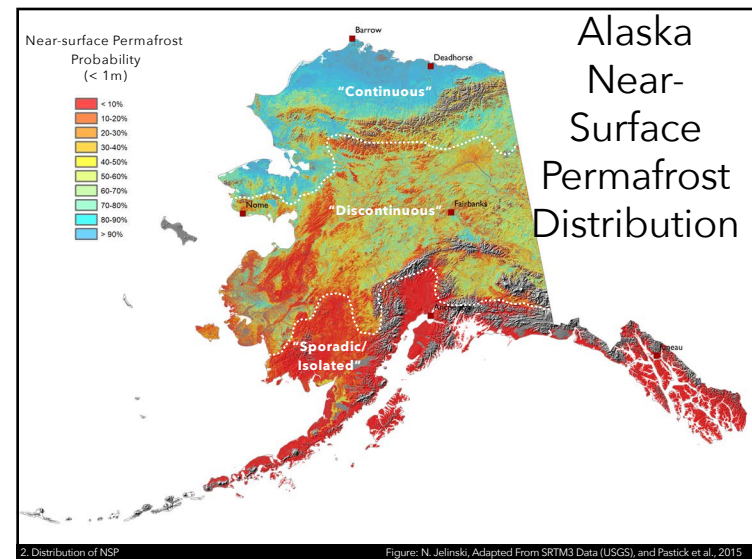
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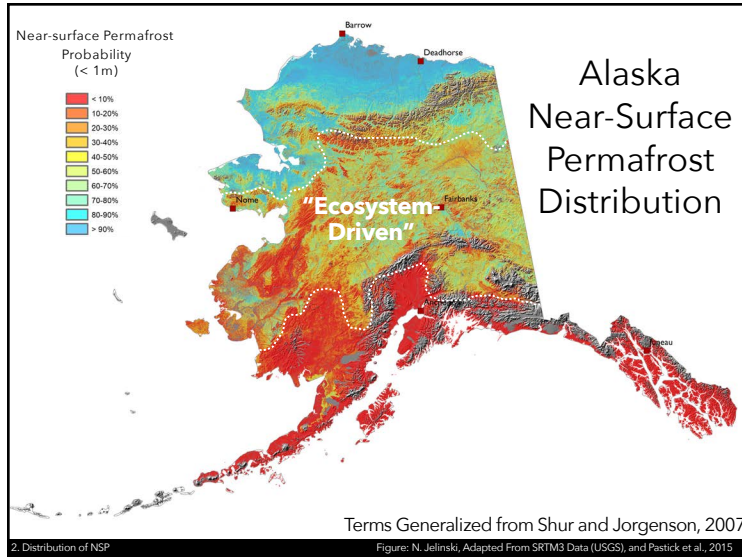
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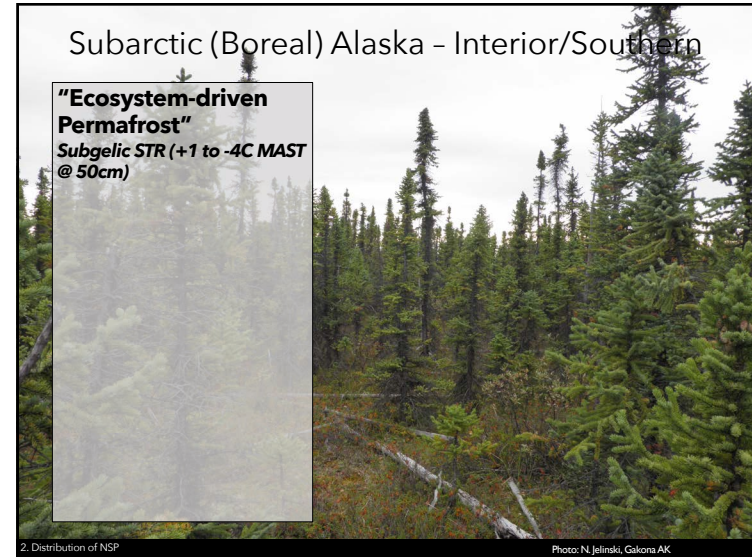
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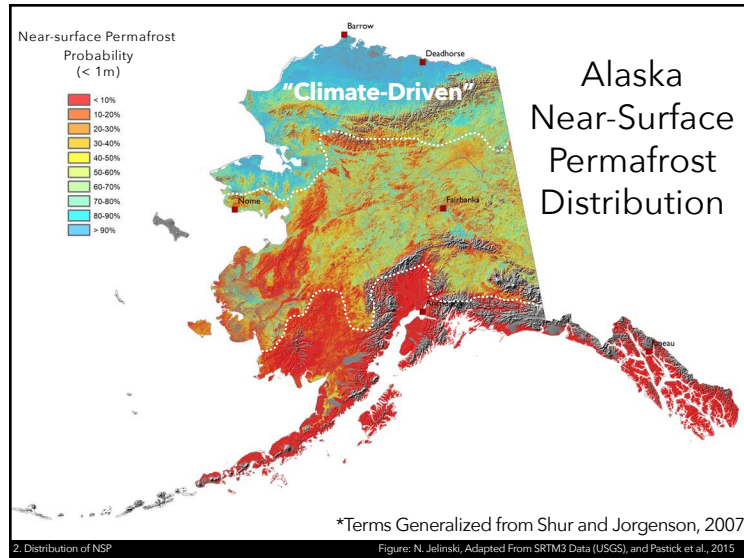
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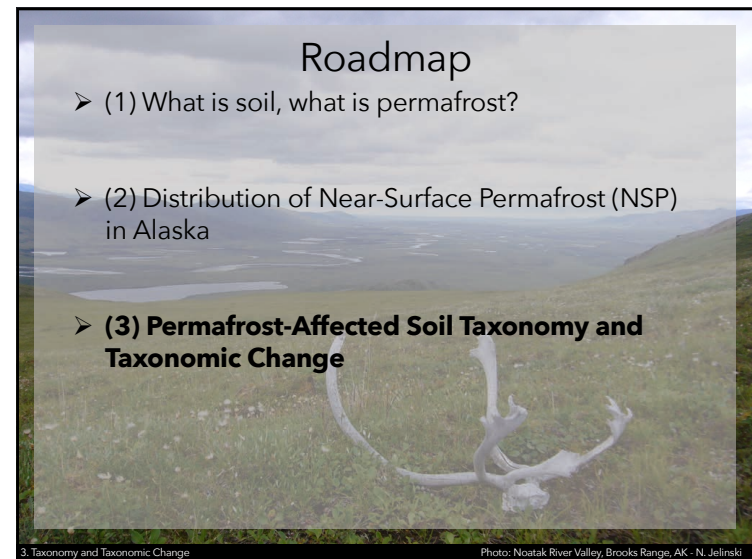
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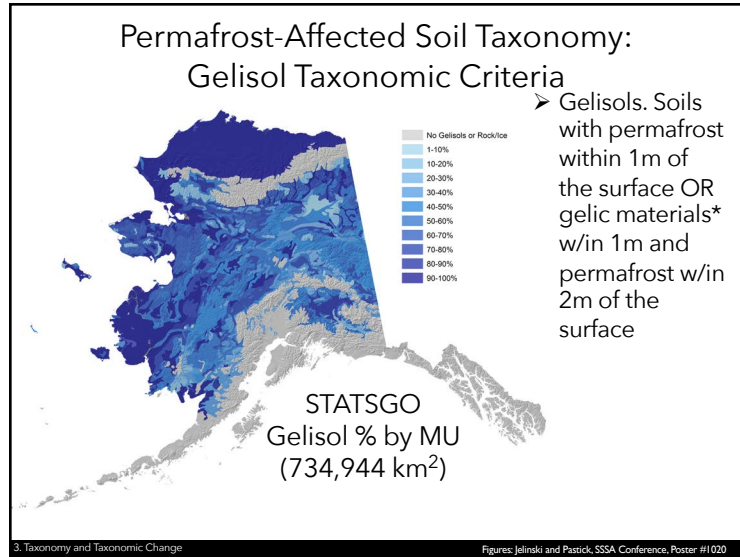
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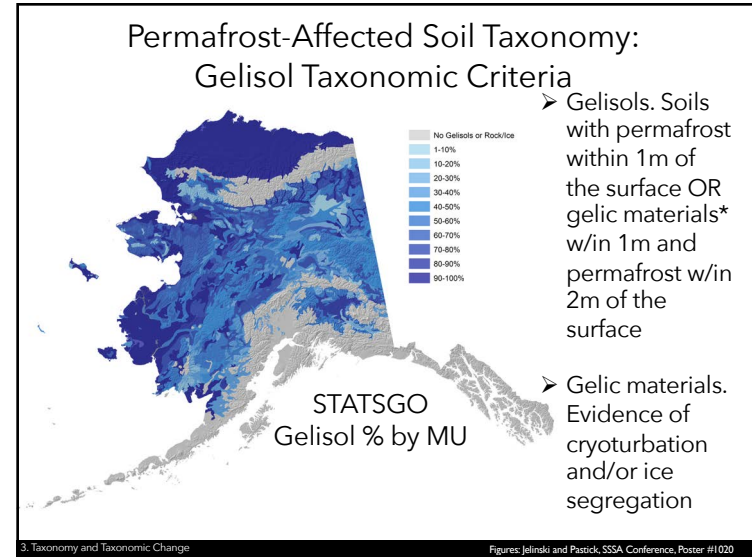
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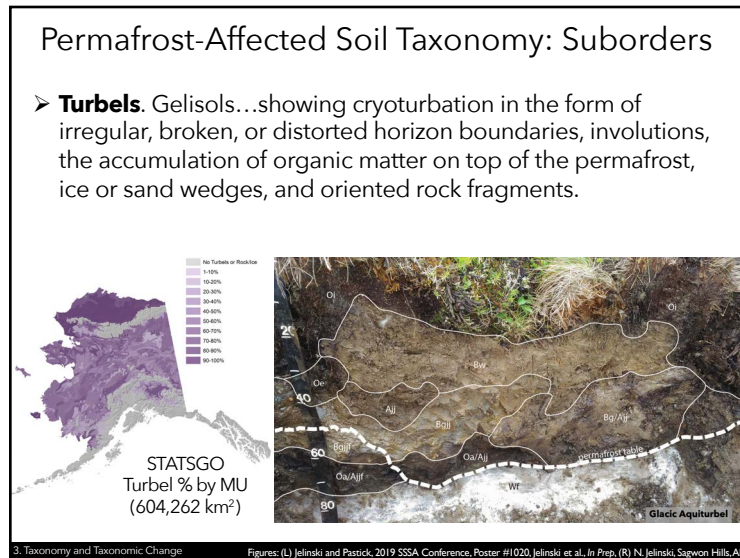
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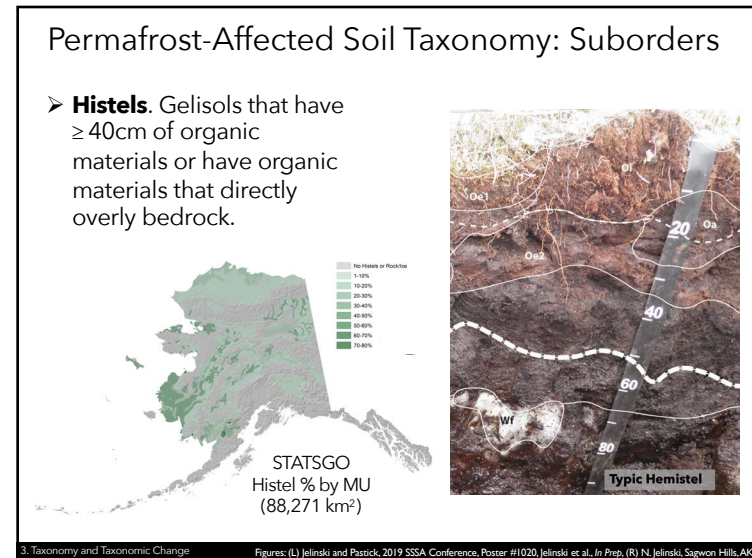
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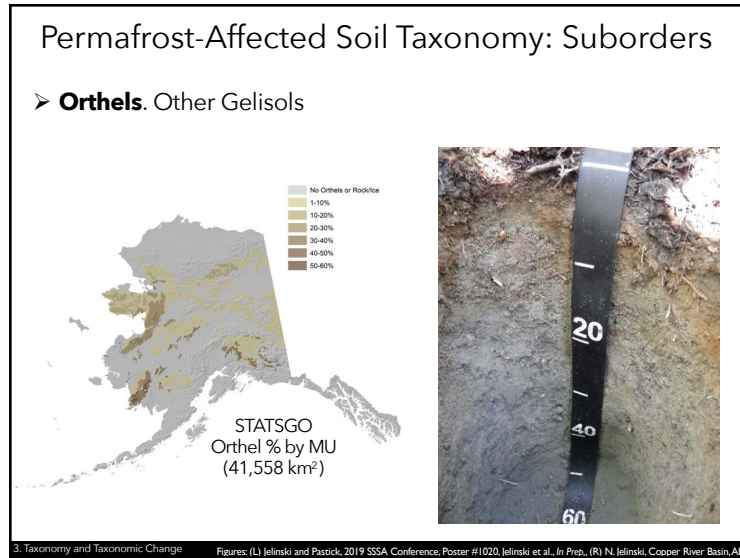
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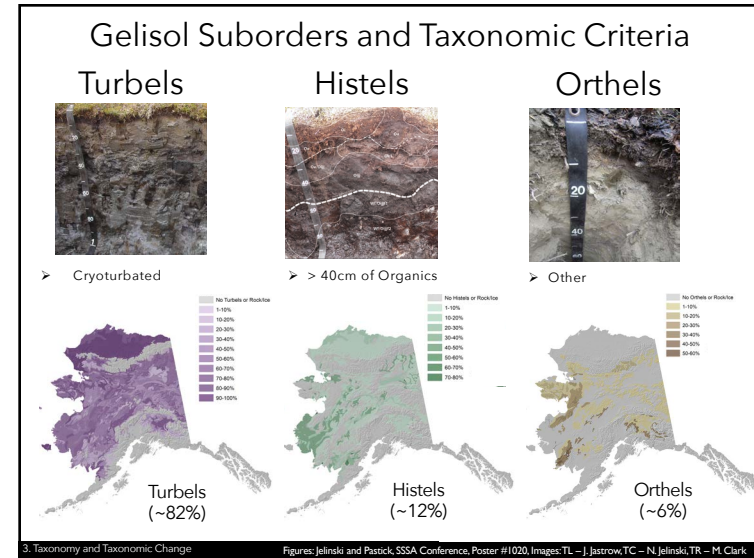
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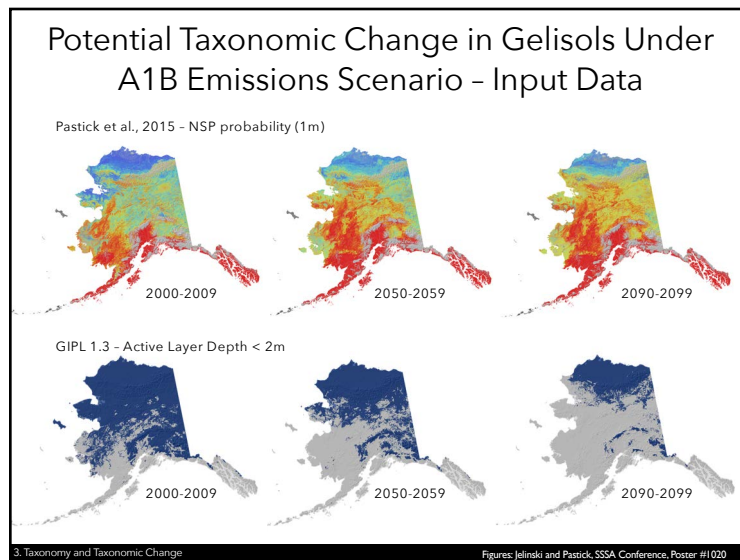
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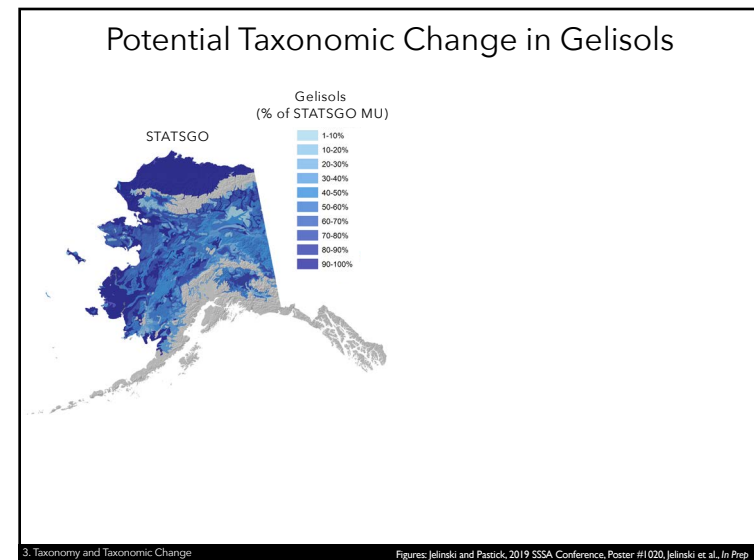
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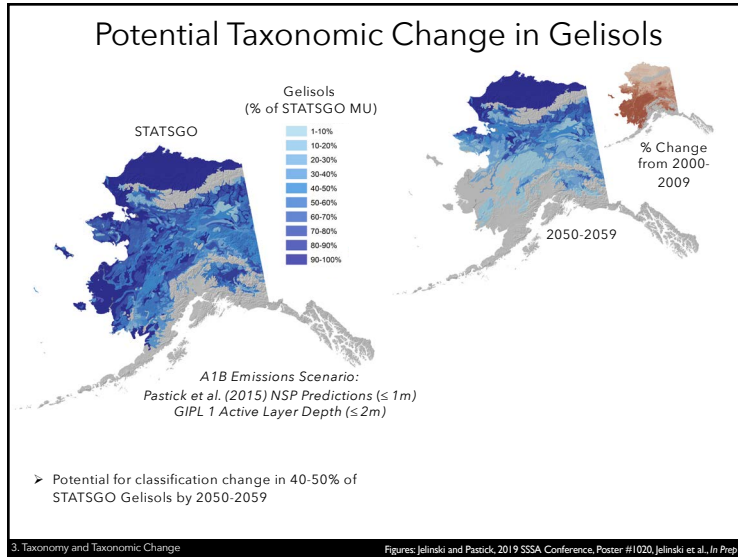
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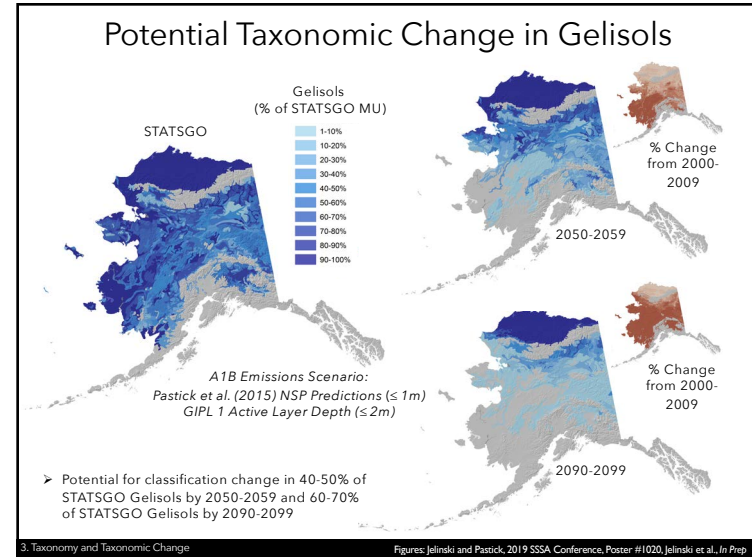
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4. Cryoturbation Mechanisms and Morphology Photo: Noatak River Valley, Brooks Range, AK - N. Jelinski

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Cryoturbation: Ubiquitous and Important

4. Cryoturbation Mechanisms and Morphology Images: (TL) N. Jelinski, (BL) C.L. Ping, (TR) N. Jelinski, (BR) J. Jastrow

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Cryoturbation: Ubiquitous and Important

- Cryoturbation is critical for modeling the genesis and fate of high-latitude SOC stocks (Koven et al., 2009)

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- Cryoturbated mineral soils account for > 40% of northern circumpolar carbon stocks to 3m and > 60% of Gelisol SOC stocks (Hugelius et al., 2014).

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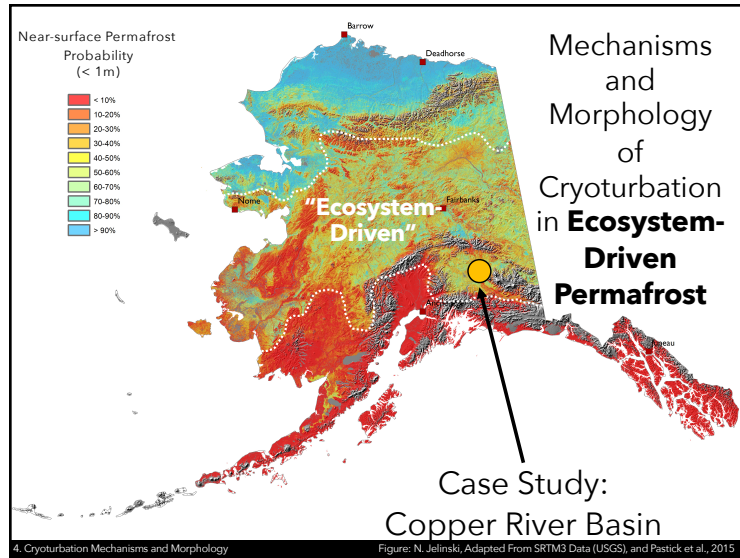
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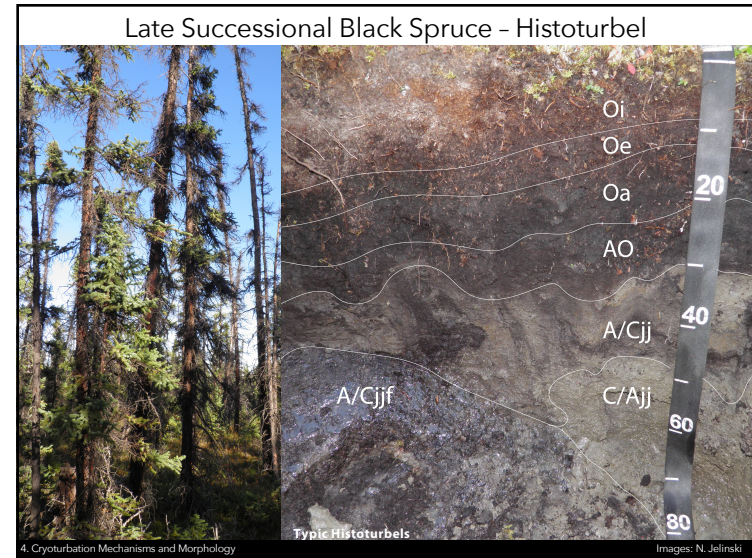
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- Understanding mechanisms of cryoturbation and their response to climate is critical for predicting soil response to environmental change (Bockheim, 2007).

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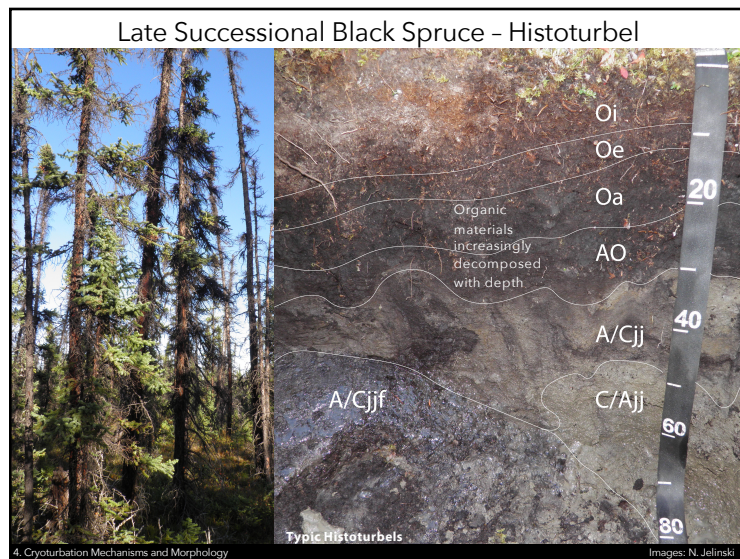
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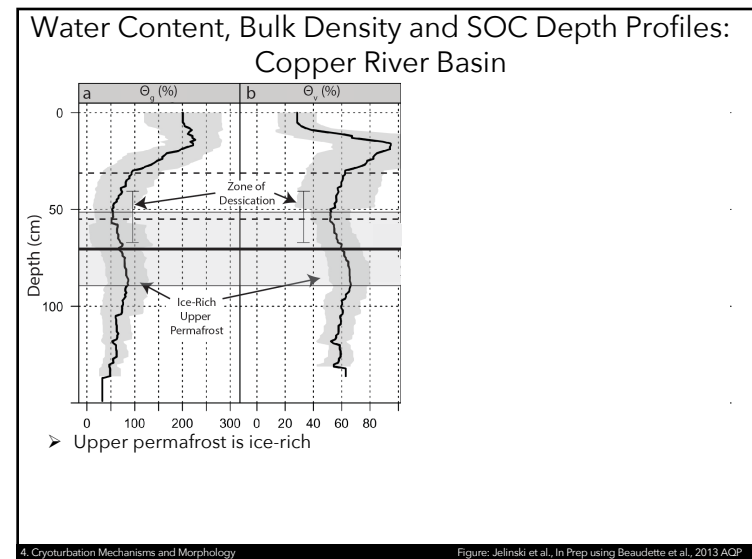
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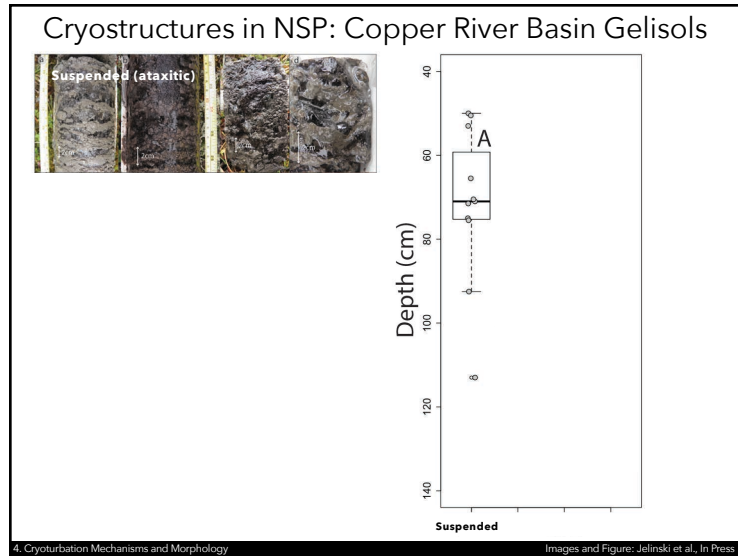
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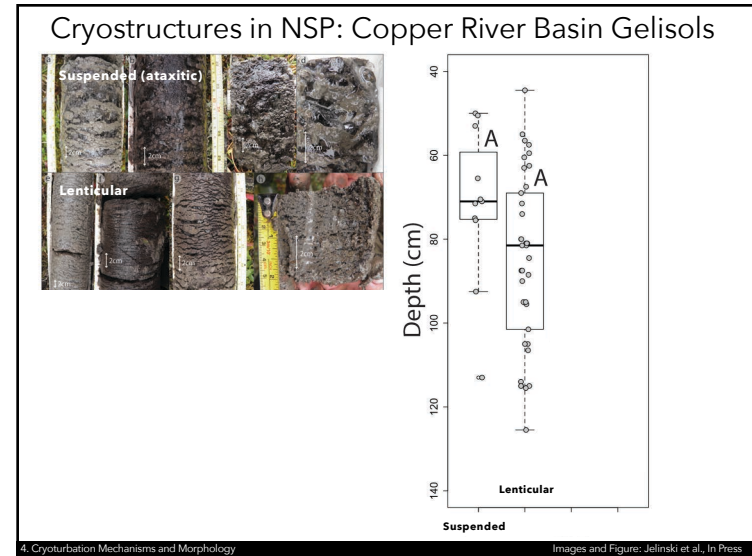
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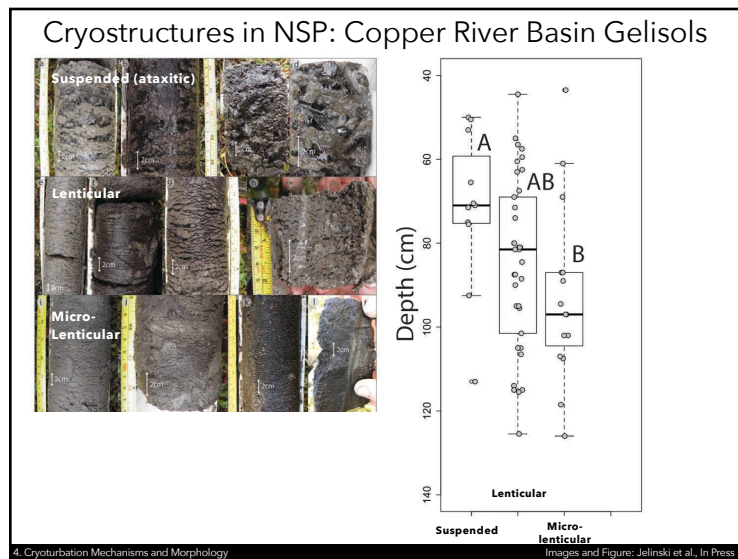
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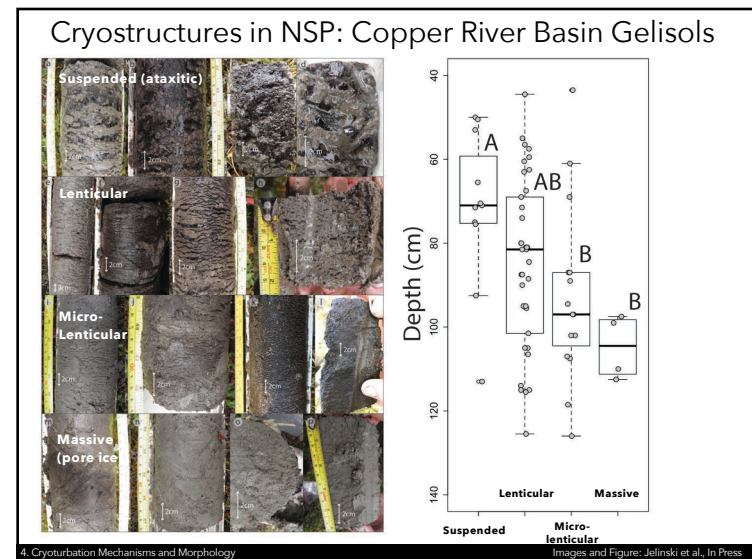
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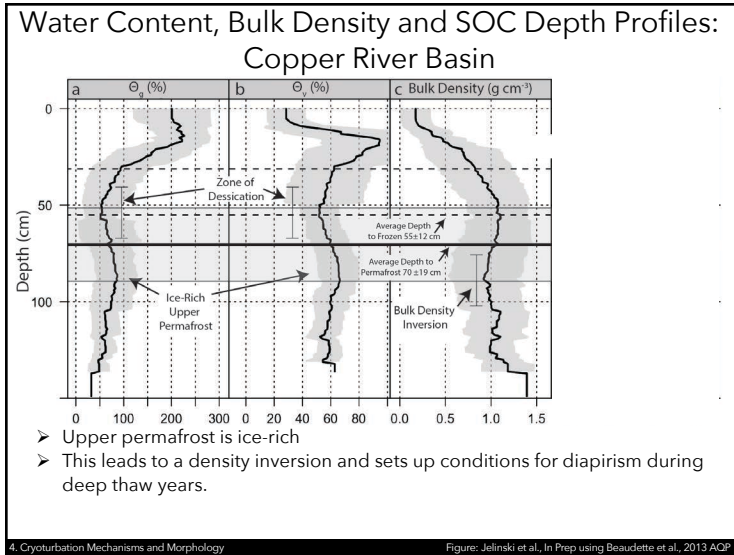
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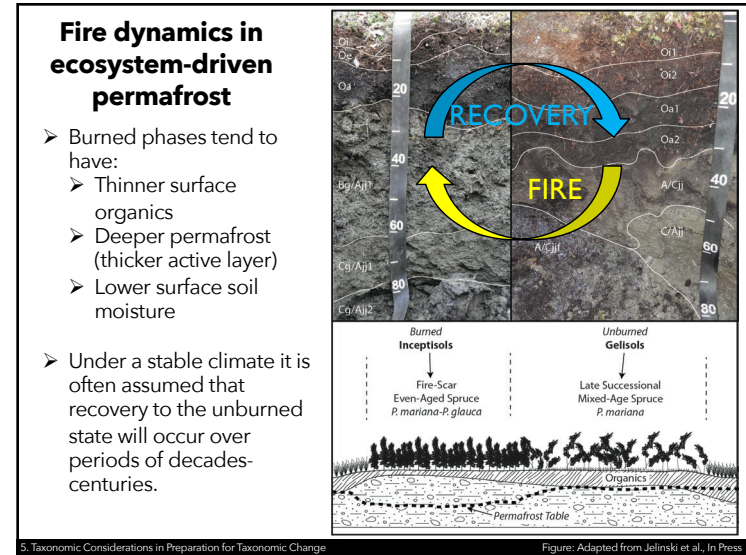
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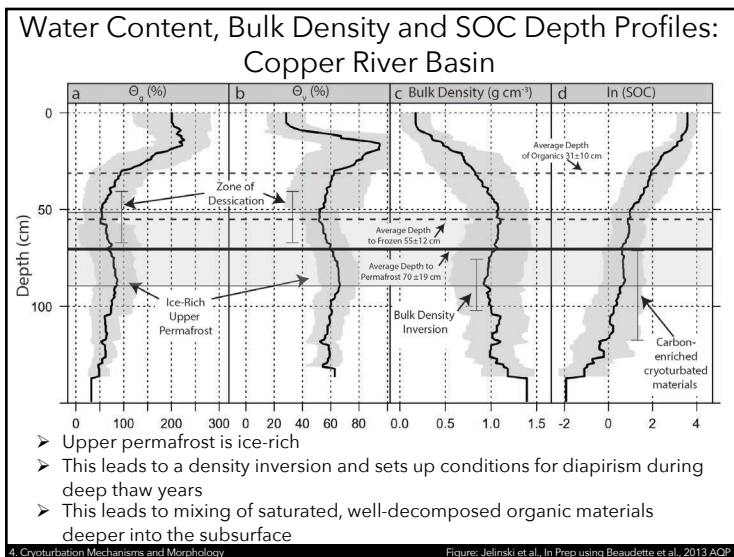
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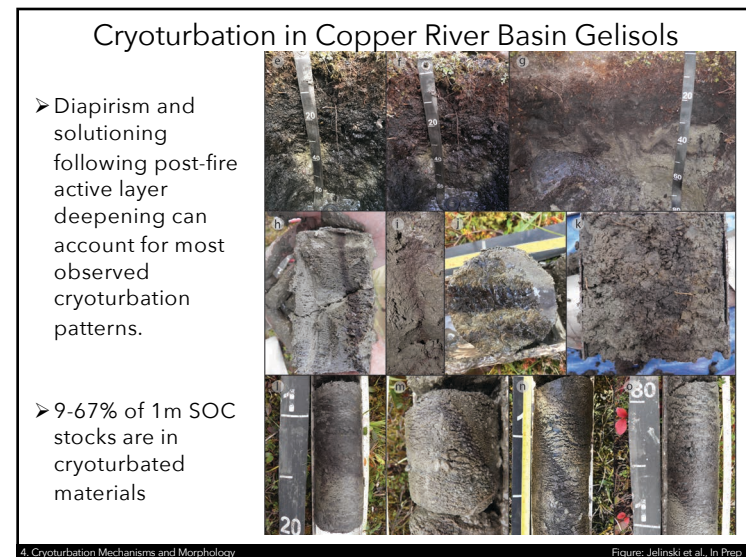
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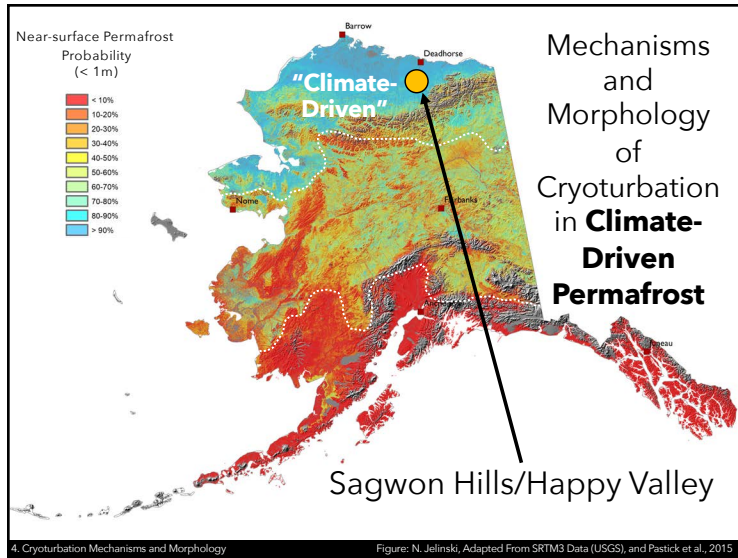
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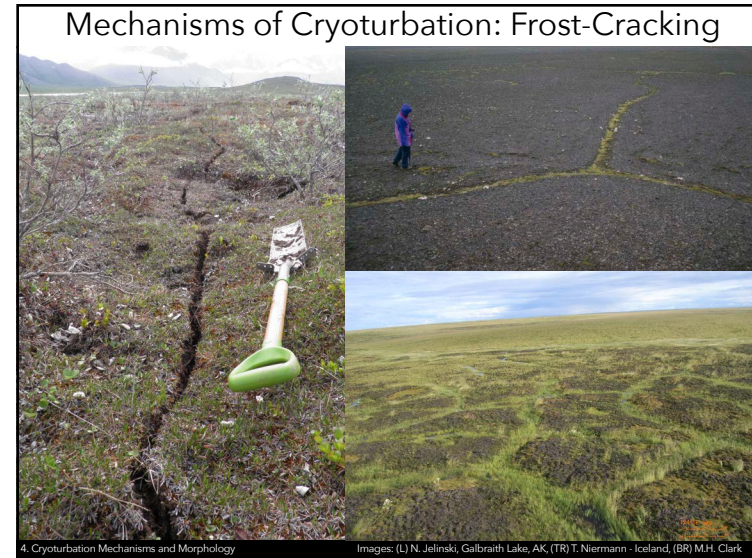
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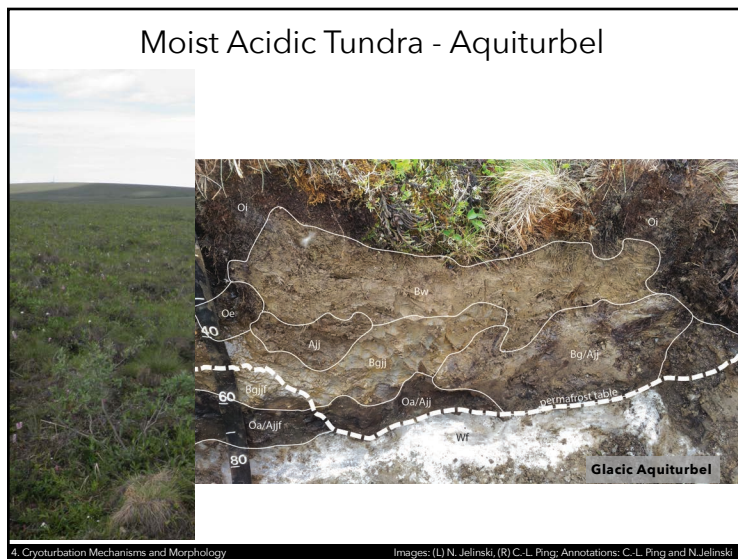
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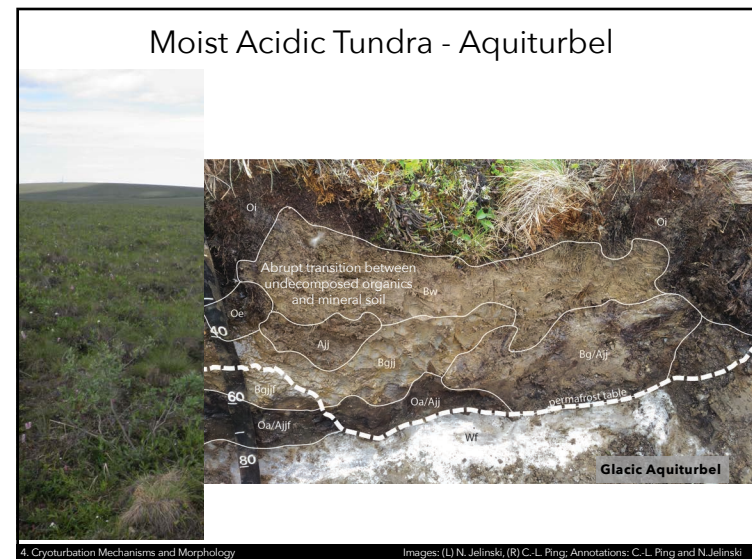
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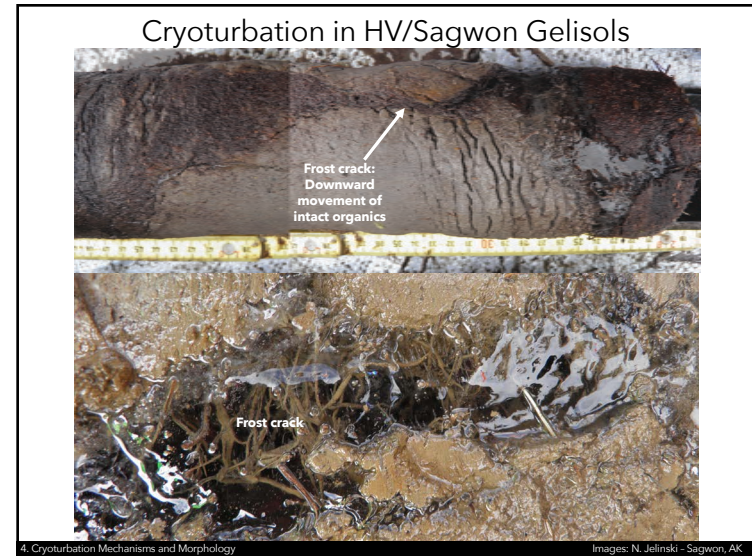
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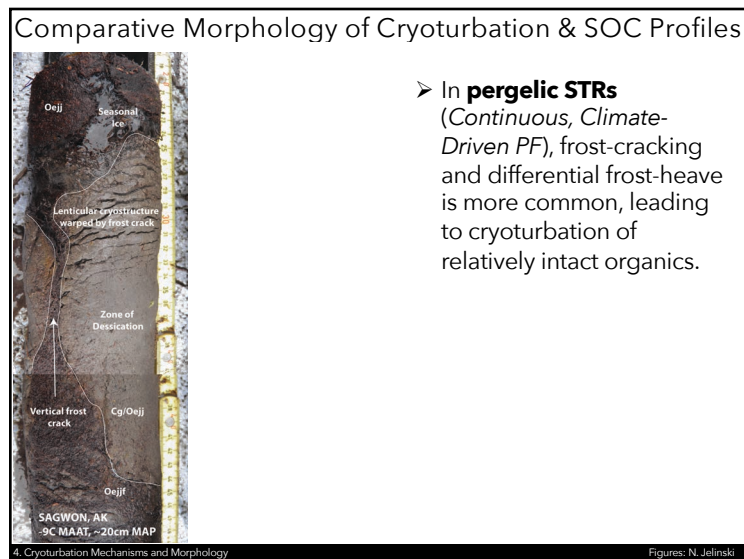
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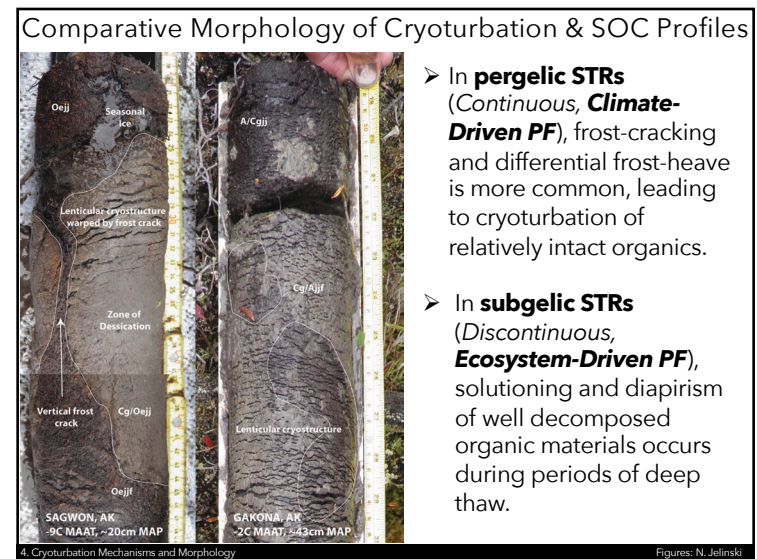


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➤ In **pergelic STRs** (*Continuous, Climate-Driven PF*), frost-cracking and differential frost-heave is more common, leading to cryoturbation of relatively intact organics.

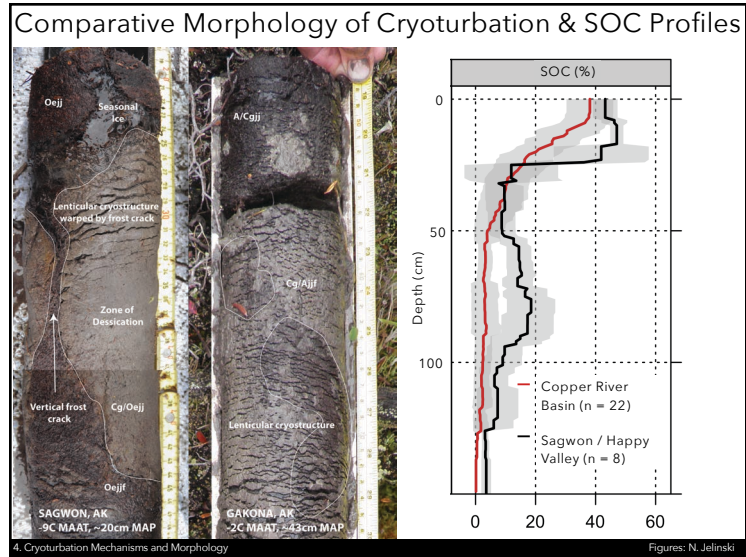
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➤ In **subgelic STRs** (*Discontinuous, **Ecosystem-Driven PF***), solutoning and diapirism of well decomposed organic materials occurs during periods of deep thaw.

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Conclusions

- Near-surface permafrost and soil properties/soil genesis are intimately linked.
- Loss of near-surface permafrost may lead to extensive taxonomic change by mid- to late-century.
- Turbels span large climatic gradients and are likely to undergo significant change over this century. These changes will affect cryoturbation mechanisms.
- Cryoturbation mechanisms vary significantly across climatic and vegetation gradients and affect SOC type, quantity, and distribution.

5. Conclusions Photo: Noatak River Valley, Brooks Range, AK - N. Jelinski

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Acknowledgements

➤ **Mentors:**

- Dr. Chien-Lu Ping (UAF)
- Dr. David Swanson (NPS)

➤ **Collaborators:**

- DOE (ANL): Dr. Julie Jastrow, Dr. Roser Matamala, T. Vugteveen, J. Lederhouse
- USGS (KBR): Dr. Neal Pastick
- USDA-NRCS: Mark Clark, Jessica Lene, Cory Cole, Dennis Mulligan, Drea Williams
- Ahtna, Inc.: Karen Linnell, Edward GreyBear, Katie Finnesand

➤ **Students:**

- Mike Sousa
- Vanessa Zachman
- Ashley Hansen
- Spencer Shaver
- Sara Bauer
- Katie Ring

Acknowledgements Image: D. Swanson - National Park Service; Inset: J. Jastrow

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