The influence of rock type on conifer species' nutrition and biomass partitioning

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Mark Kimsey, Director of the Intermountain Forestry Cooperative, explains the influence of rock type on conifer species' nutrition and biomass partitioning

The growth and health of conifer species are heavily influenced by soil characteristics, which are, in turn, shaped by the underlying rock type. Parent material plays a fundamental role in soil formation, determining nutrient availability, soil texture, drainage, and overall fertility. These soil factors directly impact conifer nutrition, affecting biomass partitioning, root development, and above-ground growth.

Here, we explore the relationship between rock type, conifer nutrition, and biomass allocation, drawing on research findings (1,2,3,4,5,6) from coniferous forests in northwestern North America.

Nutrient availability and conifer growth

The nutrient content of forest soils is a crucial determinant of conifer growth. Essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients like boron (B) and sulfur (S), all play significant roles in tree development.

1. Nitrogen (N) deficiency – Nitrogen is often the most limiting nutrient for conifer growth, particularly in soils derived from highly weathered sedimentary or metamorphic rocks. Research has shown that conifer species like Douglas fir (Pseudotsuga menziesii) and grand fir (Abies grandis) experience significant growth boosts following nitrogen fertilization, particularly in nutrient-deficient soils.
2. Potassium (K) deficiency and nutrient imbalances – While potassium is essential for water regulation and resistance to environmental stresses, its availability varies widely based on soil parent material. Basalt-derived soils tend to be rich in potassium, whereas granitic and highly weathered sedimentary soils often exhibit potassium deficiencies. Studies have highlighted the risks of nitrogen fertilization without balancing potassium inputs, which can lead to nutrient imbalances and increased mortality due to root diseases like Armillaria root rot.

3. Sulfur (S) and Boron (B) limitations – Sulfur deficiencies are common in coniferous forests growing on soils derived from highly weathered or acidic parent materials. Sulfur plays a critical role in nitrogen metabolism, and research indicates that its deficiency often limits tree growth despite nitrogen fertilization. Boron, another crucial micronutrient, affects cell wall formation and shoot development. It is frequently deficient in soils derived from acid igneous and sedimentary rocks, leading to poor tree form and reduced productivity.

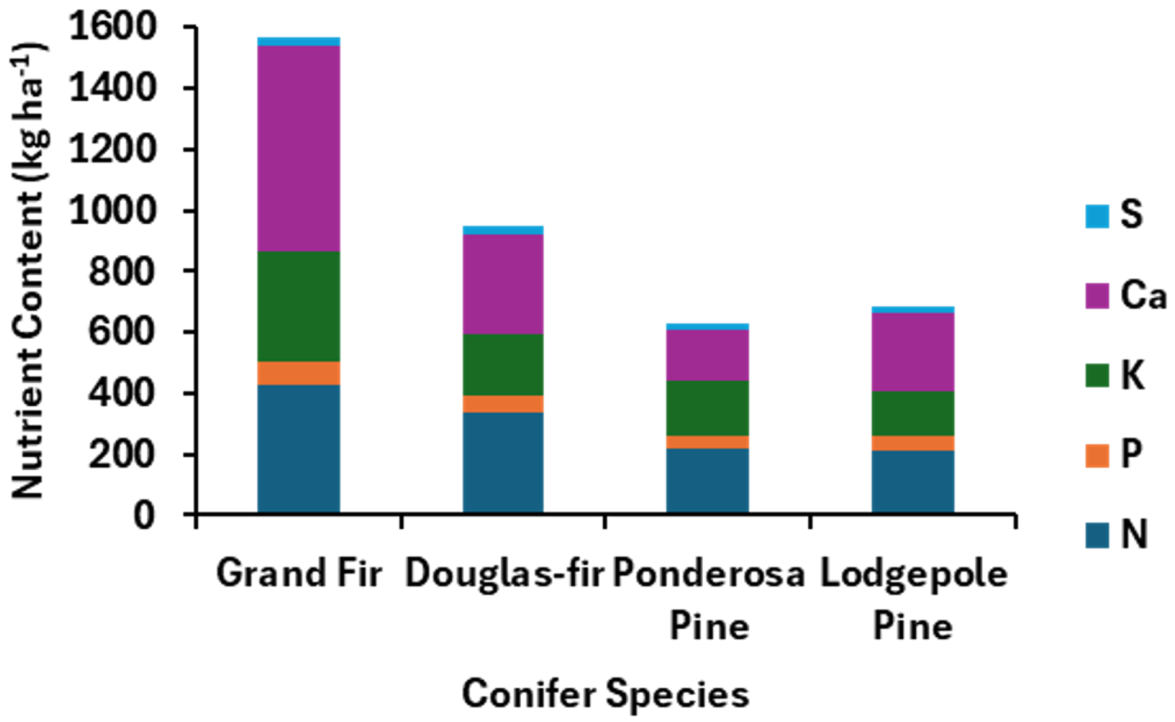

Figure 1. Total nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and sulfur (S) content in the tree canopy (foliage, branches) of four northwestern North American conifer species: grand fir, Douglas-fir, ponderosa pine, and lodgepole pine.

Nutrient partitioning in conifers

Nutrient allocation in conifer species follows distinct patterns, with most essential elements concentrated in foliage, fine roots, and younger tissues:

- Foliage:
  Typically holds the highest concentration of nitrogen (N), phosphorus (P), and potassium (K), essential for photosynthesis and metabolic functions.
- Branches and twigs:
  Store moderate levels of nutrients, acting as a secondary reservoir for potassium and calcium.
- Stemwood and bark:
  Contain lower nutrient concentrations but serve as long-term storage for structural elements like calcium (Ca) and magnesium (Mg).
- Roots:
  Show increased biomass allocation in nutrient-poor soils, with fine roots playing a critical role in nutrient and water uptake.

Implications for forest management

Understanding the relationship between rock type, conifer nutrition, and biomass partitioning has significant implications for sustainable forest management.

1. Targeted fertilization strategies –
   Forest managers should conduct site-specific foliar and soil nutrient analyses before applying fertilizers to avoid nutrient imbalances and ensure effective amendments. Sites with potassium-deficient soil should receive balanced N-K applications to mitigate risks associated with nutrient dilution and susceptibility to diseases such as Armillaria root rot.
2. Species selection –
   Nutrient-demanding species like grand fir and Douglas-fir may struggle on nutrient-poor sites, whereas resilient species like western larch (Larix occidentalis) and ponderosa pine (Pinus ponderosa) may perform better.
3. Sustainable harvesting practices –
   Retaining organic matter, particularly foliage and small branches, helps maintain soil nutrient levels and supports long-term forest productivity. This is particularly critical in forests where nutrient-rich foliage biomass proportions are high (e.g., grand fir ecosystems). Tree crown removal during harvesting can remove large pools of plant essential nutrients (Fig. 1).

Conclusion

In conclusion, rock type plays a fundamental role in shaping nutrient partitioning and biomass allocation in conifer forests. Understanding these relationships can guide effective forest management strategies for sustainable timber production and ecosystem health.

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