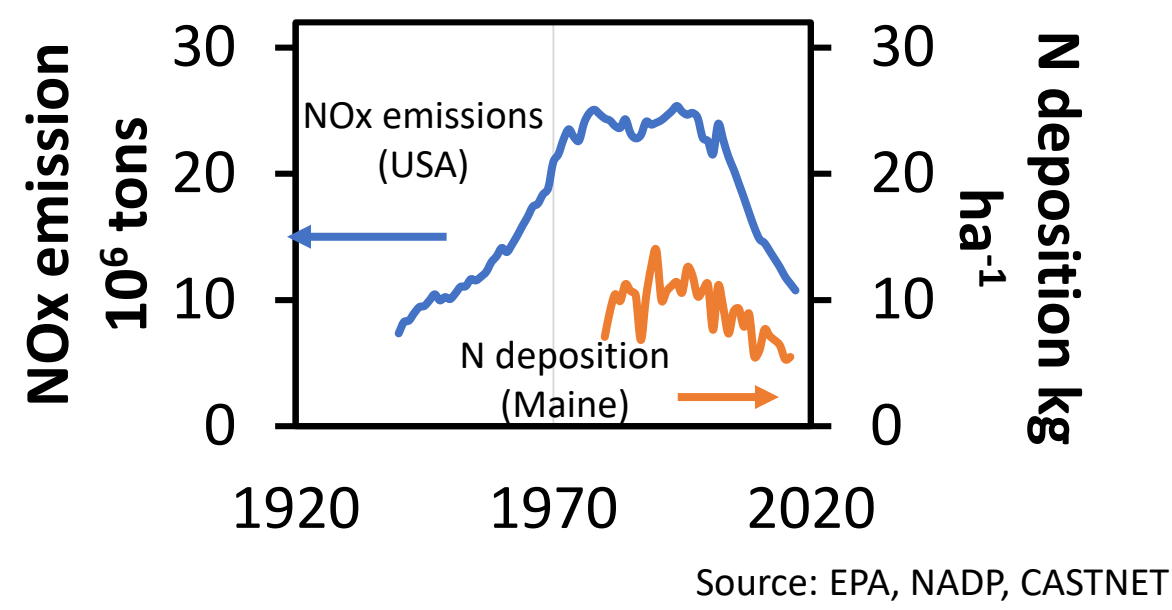


Multi-Decadal Evolution of Nitrogen Dynamics at the Bear Brook Watershed in Maine

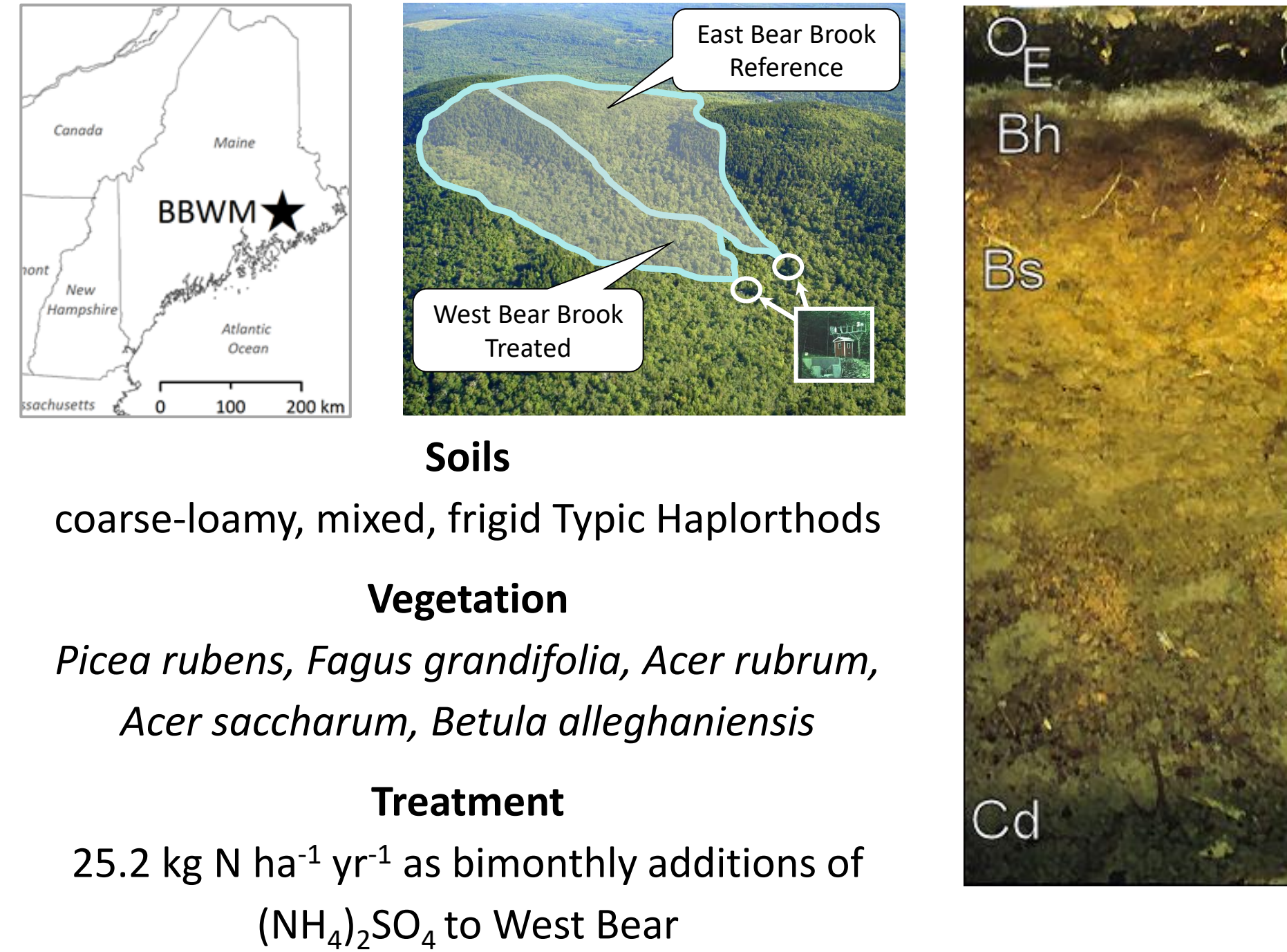
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ELEVATED N DEPOSITION

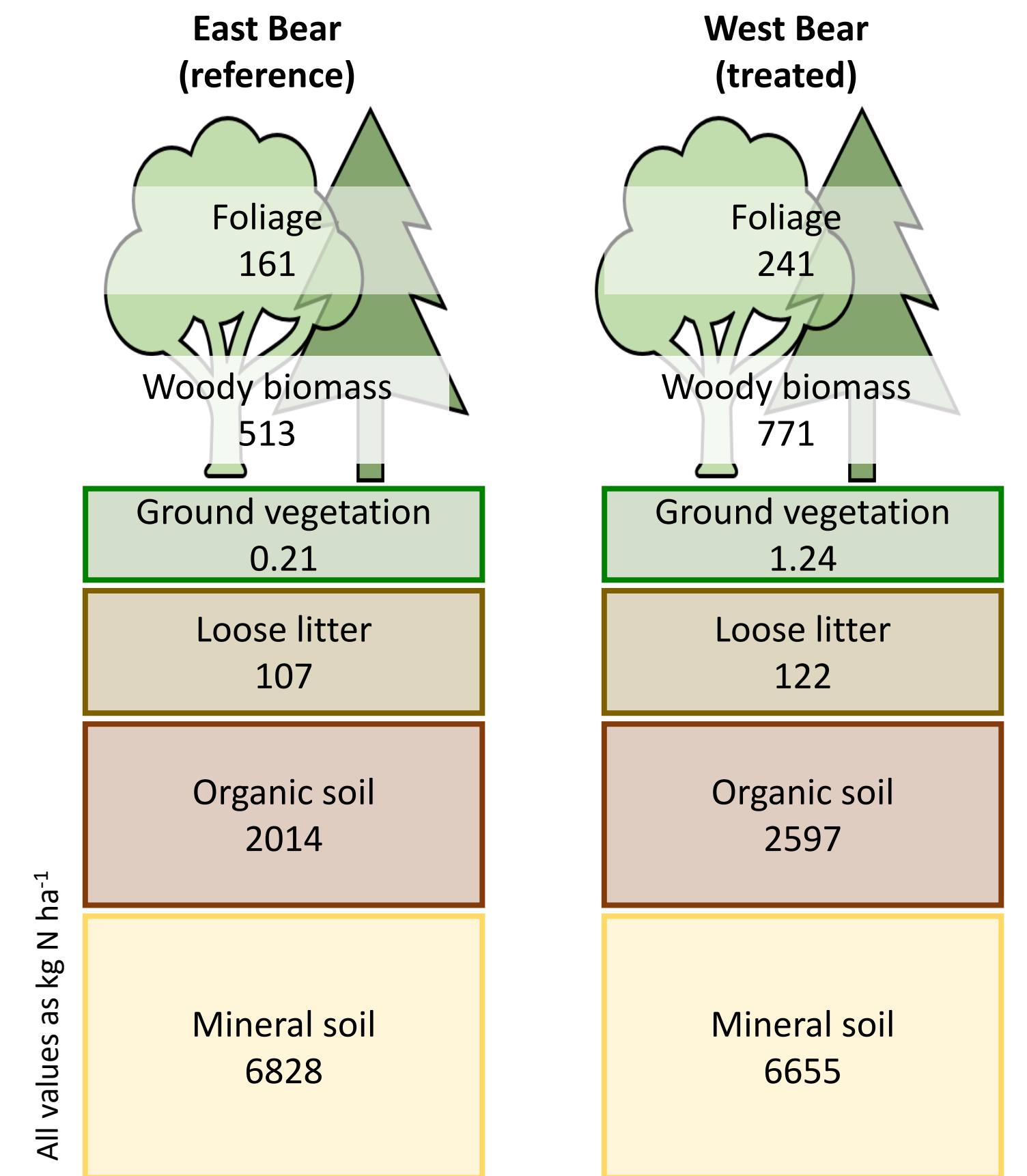


Anthropogenically derived deposition of reactive nitrogen (N) in the 20th and 21st centuries has altered N cycling in temperate forests, with significant implications for forest ecosystem function. Here, we examine ecological effects of 25 years of experimental N enrichment at a forested ecosystem in Maine.

THE BEAR BROOK WATERSHED IN MAINE¹



ECOSYSTEM N POOLS



Vegetation (trees, loose litter, and ground vegetation) accounted for ~10% of total ecosystem N.

Vegetation N pool was ~1.3X greater in WB than in EB, because of **increased biomass growth** and **higher N concentrations**.

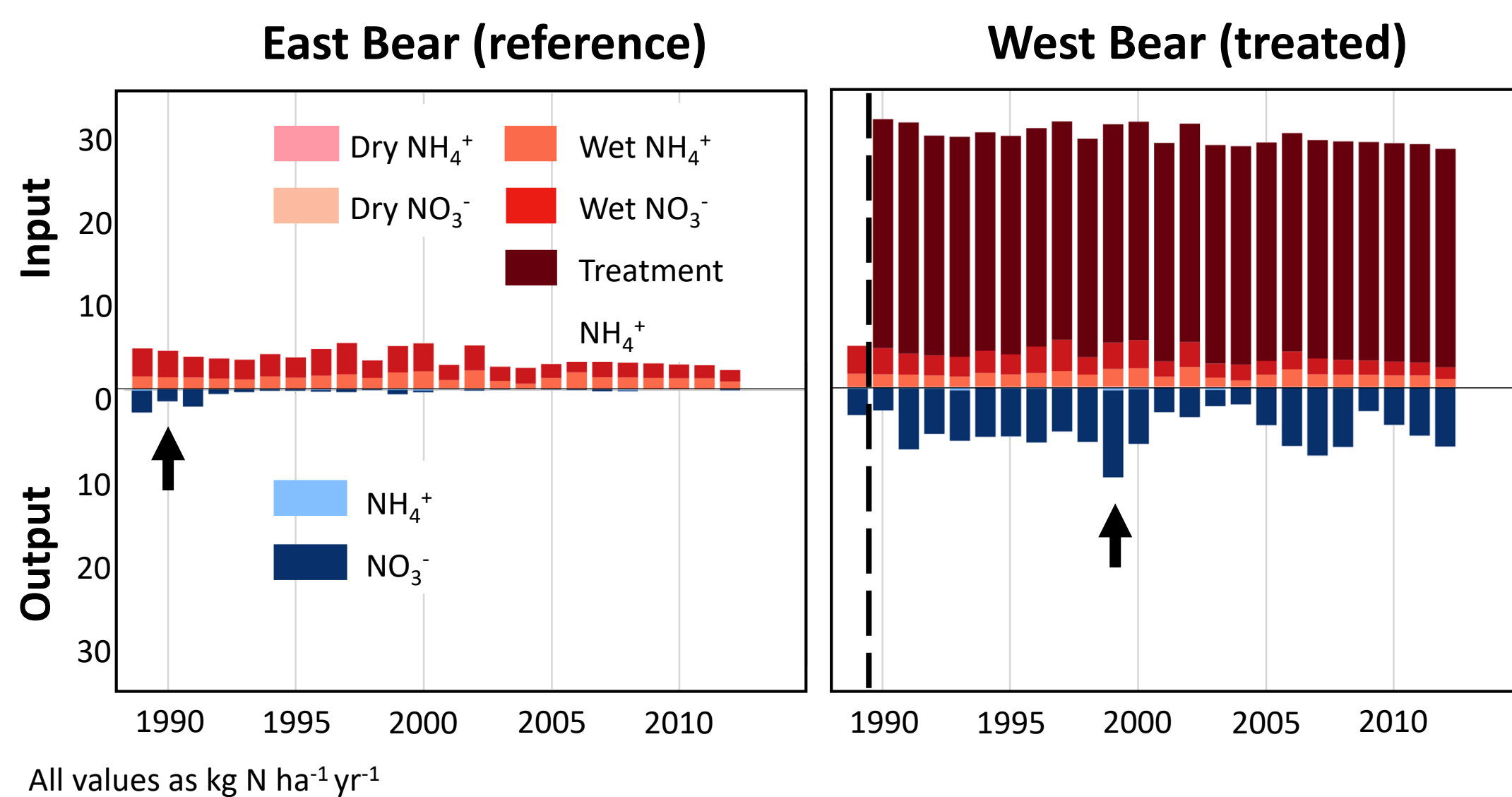
O horizon soil N pool was greater in WB than in EB, because of **thicker soils** in WB.

Total pedon N pool did not differ significantly between watersheds.

Tree uptake exceeded N inputs in both watersheds, suggesting that trees are **mining N from the soil** despite chronic N additions.

N fluxes, kg N ha ⁻¹ yr ⁻¹	East Bear	West Bear
Input	2.0	27.0
Output	0.2	7.0
Retention (input minus output)	1.8	20.0
Tree biomass N accumulation	18.8	23.2

INPUTS AND OUTPUTS



Ambient N inputs declined ~50% 1989–2012.

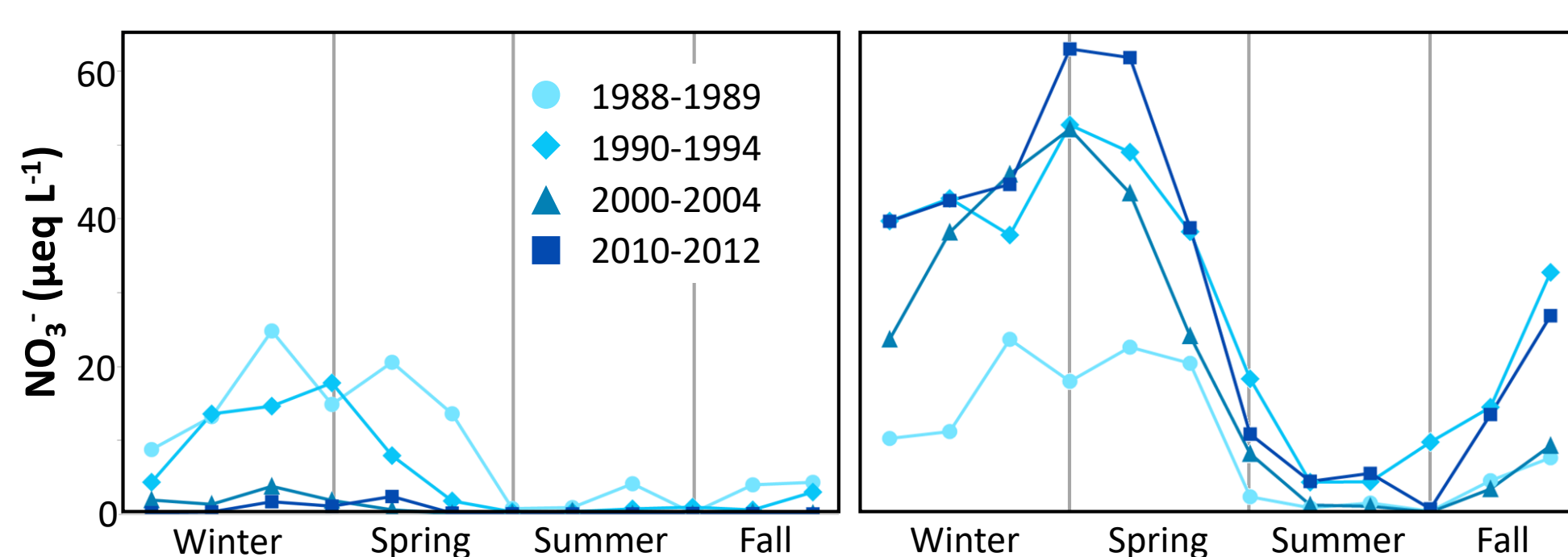
Treatment stimulated nitrification: N additions (as NH₄⁺) increased N losses (as NO₃⁻).

Cumulative ecosystem N retention was 90% in EB and 80% in WB. **WB is still retaining most of the N added.**

Long-term trends show influence of severe winters in 1989–1991 (EB) and the ice storm of 1998 on N export (WB) (see arrows).

STREAMS

SEASONAL NITRATE CONCENTRATIONS



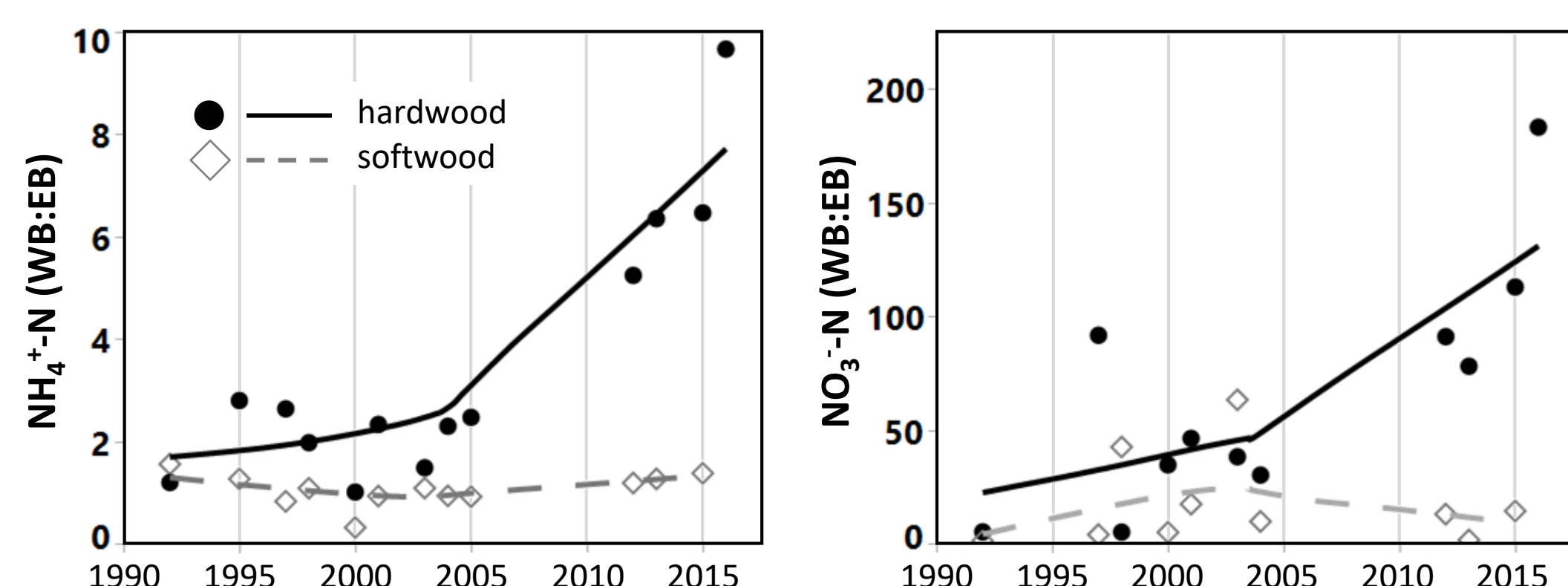
EB NO₃⁻ concentrations were highest in the early years because of severe winters, and showed a distinct seasonal pattern.

WB NO₃⁻ concentrations increased after N additions, and were highest in winter-spring, because of accelerating soil N mineralization during a period of limited tree uptake. Base flow concentrations of NO₃⁻ were low in summer because of increased tree uptake.

The seasonality of stream NO₃⁻ concentrations suggests that **inputs have not exceeded tree demand** (Stage 2 of the Stoddard N saturation model).²

SOILS

EXTRACTABLE INORGANIC N



Results reported as extractable N concentrations in WB relative to EB (WB:EB ratio)

Significant multi-decadal pattern for hardwoods, but not for softwoods.

EB and WB soils did not differ in 1992, four years into the treatment. Treatment effects were seen only after 1995, and were greater in the third decade.

WB:EB NH₄⁺ ratio increased because EB NH₄⁺ concentrations declined through time, likely because of declining N inputs.

A QUARTER CENTURY OF MANIPULATION: KEY FINDINGS ON N

WB is currently at intermediate N saturation, and may have achieved **transient dynamic equilibrium**.

There is evidence of an **ecosystem shift** around 1994–1995, after which soil N availability increased in WB.

Stochastic weather events and disturbances increased N exports.

The effects seen in WB are consistent with our current understanding of N saturation models and critical loads exceedances.^{3–5}

In EB, declining N deposition appears consistent with emergent oligotrophy of these forests.⁶

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