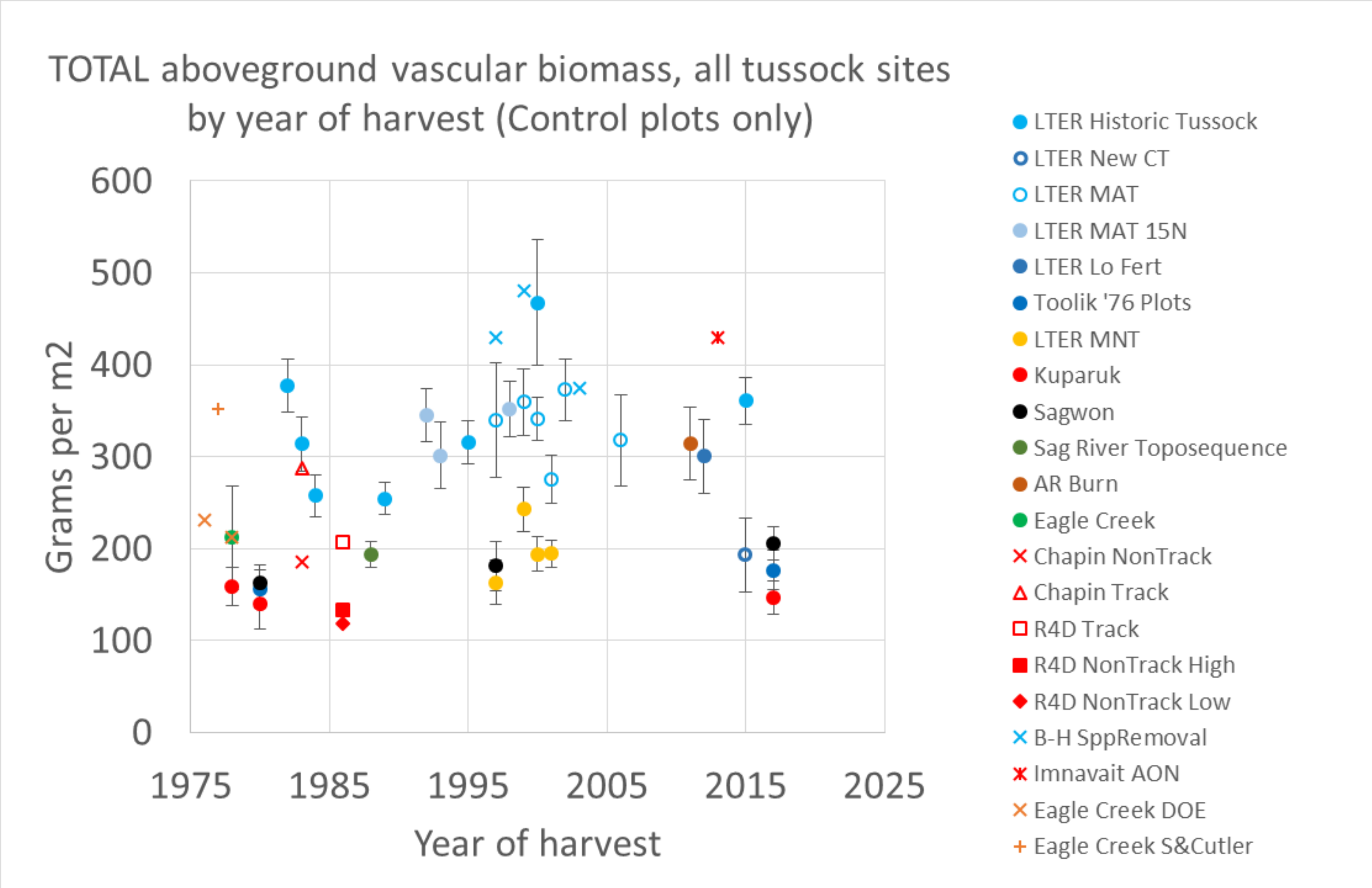
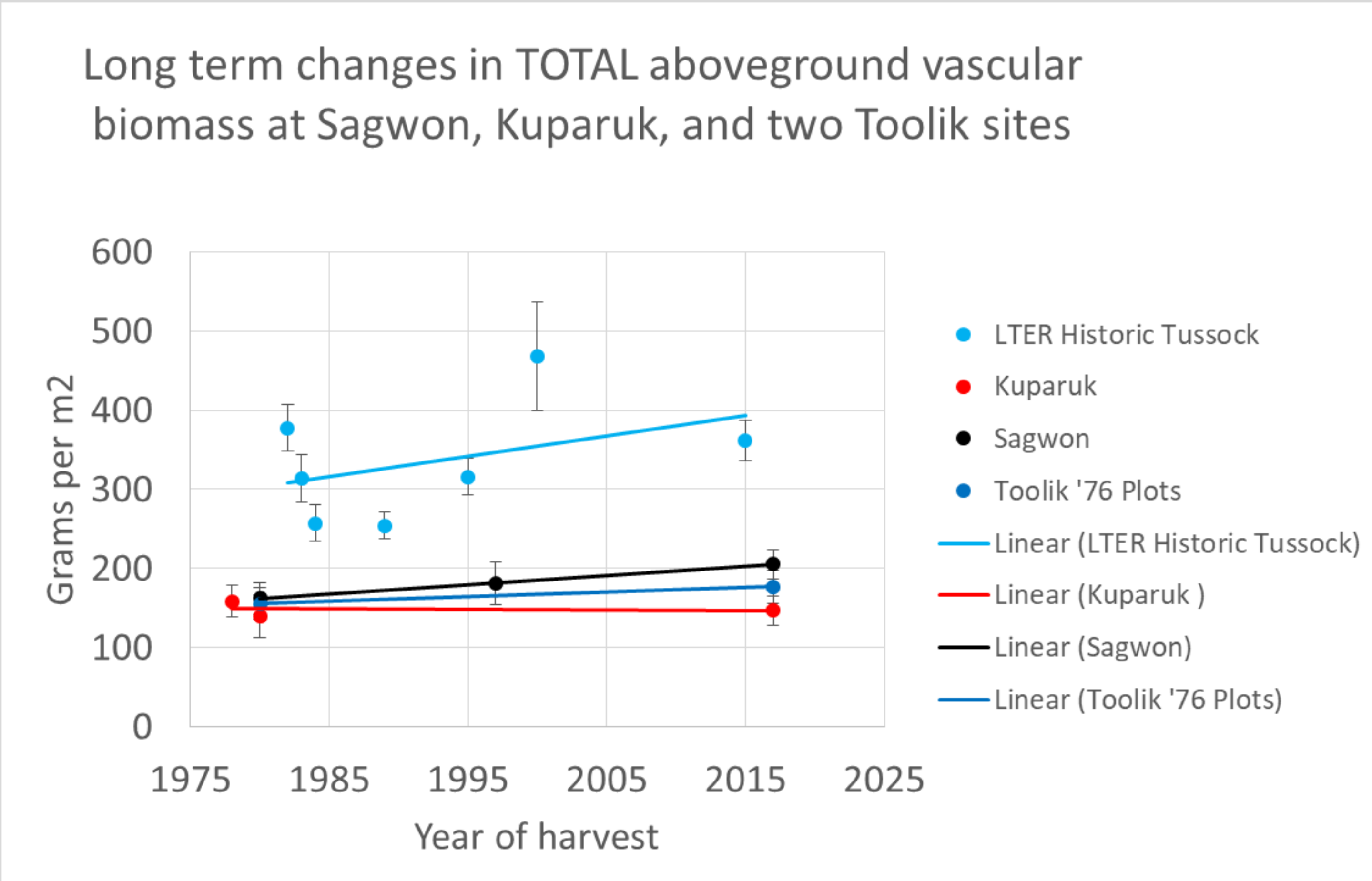
Forty years of change (or not) in composition, structure, and function of monitored and manipulated Alaskan tundra ecosystems

By: G. Shaver and MANY others



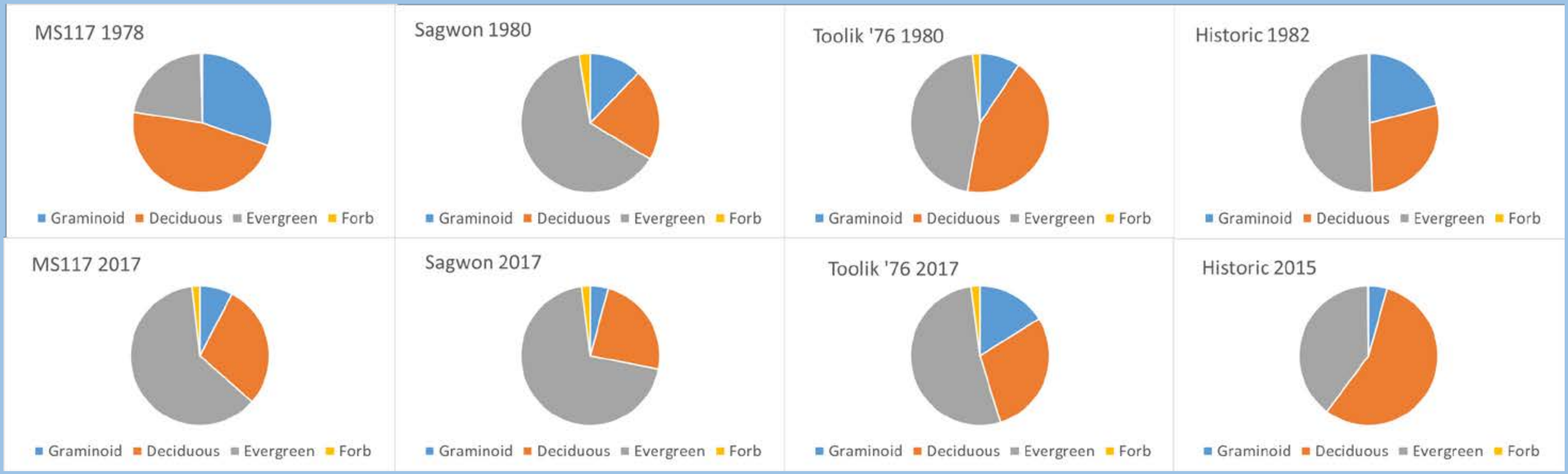
Tussock tundra: 21 sites, 45 plucks over 41 years

What can we conclude about long term trends, annual variation, and controls over time and space?



Four sites with long term records and multiple harvests over >30 years
No significant long term trends in aboveground biomass
Highly significant annual variation at Historic site
2-fold difference between two sites only ~100 m apart

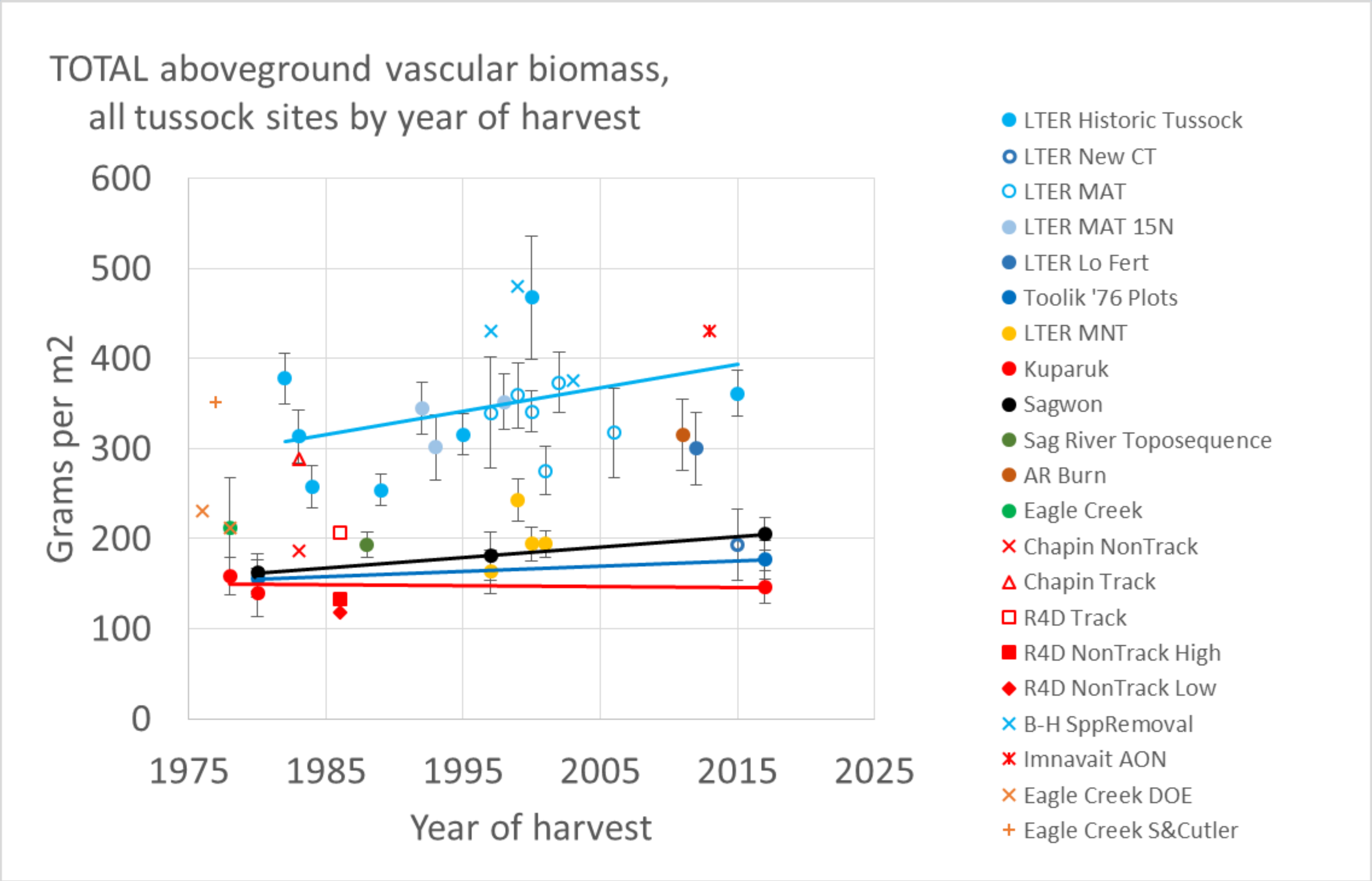
What about species/functional type composition?



In undisturbed tussock tundra the same 6 species always comprise 85-95% of aboveground vascular biomass

At 4 sites with long term records, large changes in relative abundance over time but no consistency among sites in species/functional types that are changing

No clear pattern overall; evidence for deciduous shrub increase only at Historic site

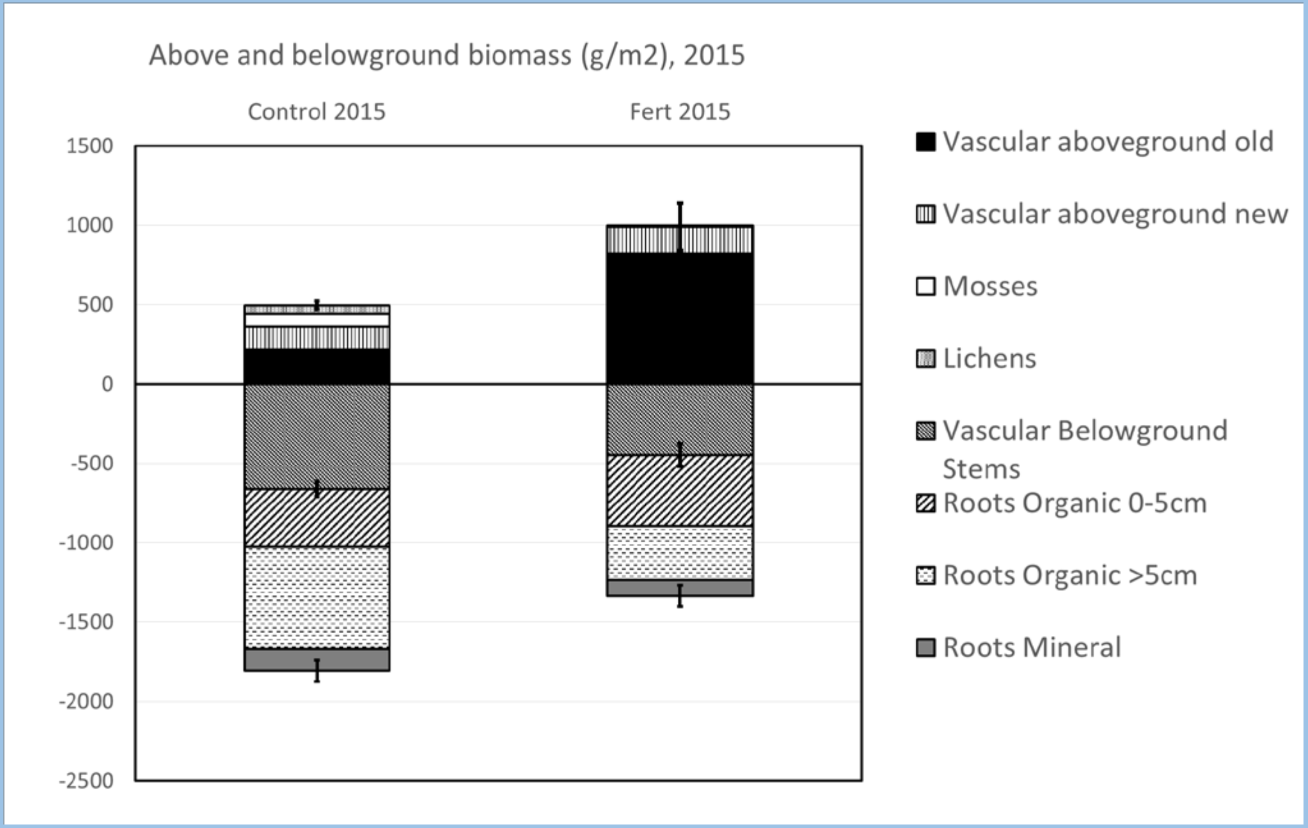


LTER Sites with longest records encompass the full range of spatial and temporal variation in aboveground biomass in moist tussock tundra on the North Slope

Major controls include topographic position, surface age, annual weather variation

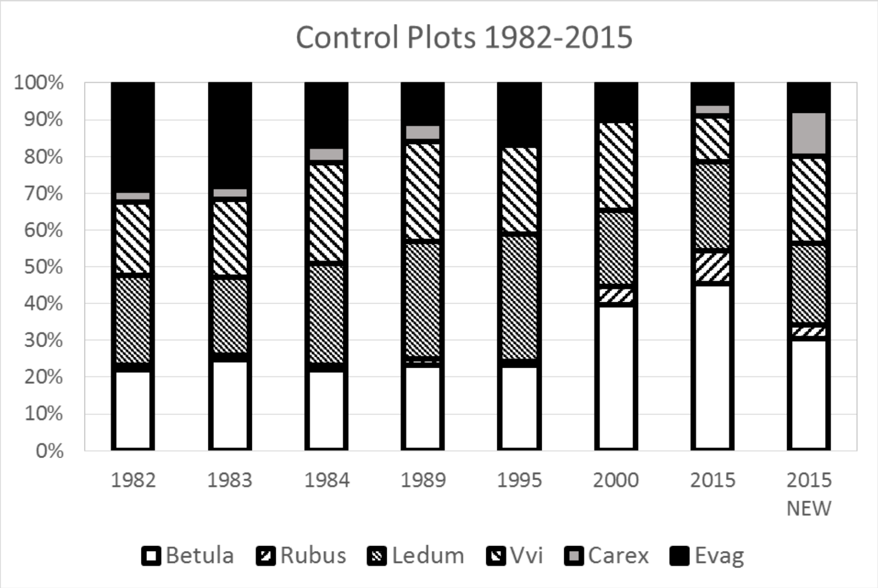
No clear long term trends

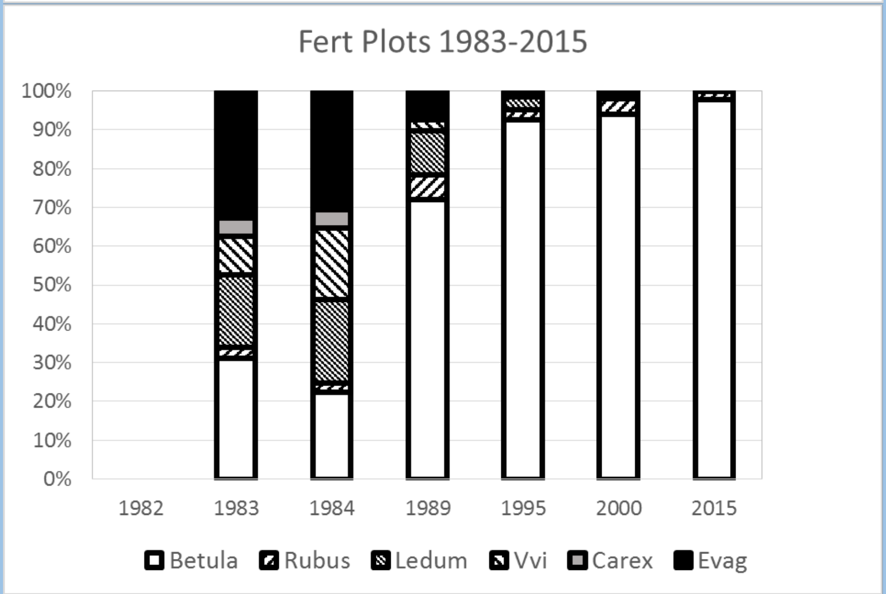
Are large changes in manipulated ecosystems regulated in the same way as small, long term changes in undisturbed systems?



Total biomass does not change after 35 years of fertilization but biomass allocation changes dramatically both within and among species.

Aboveground NPP (not shown) in fert plots is about twice that of controls





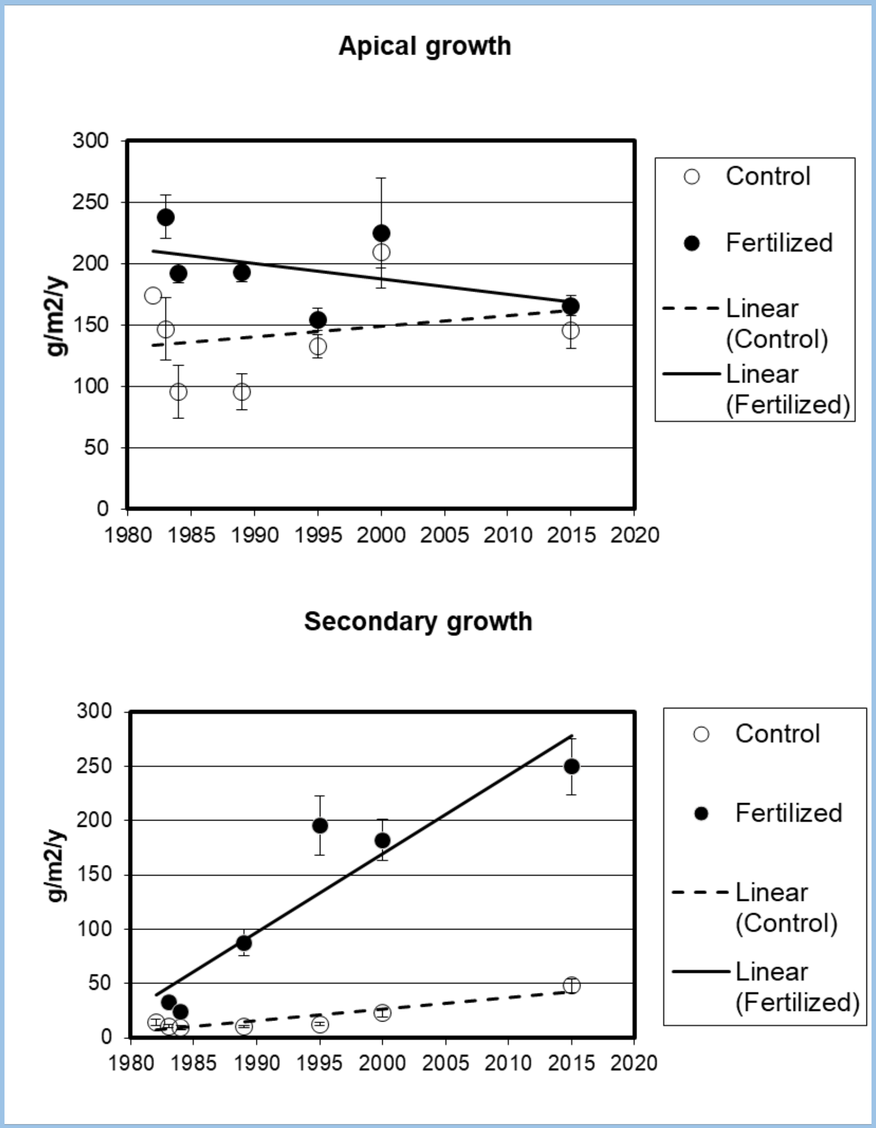
Species composition shifts in CT and Fert plots, shown as change in the relative abundance of the 6 vascular species that consistently account for >90% of total aboveground biomass in CT plots.

In CT plots, the relative abundance of Eriophorum generally declined over 35 years, while the relative abundance of Betula and Rubus increased in 2000 and 20015. In the “middle years” (1984-1995), Ledum and Vvi seemed to be in greatest relative abundance.

In Fert plots, Betula started taking over in the late 1980s and became increasingly dominant with each succeeding harvest. Although the relative abundance of Rubus increased with fertilization (its greatest relative abundance was in 1989 and 2000), Rubus was never more than ~8% of aboveground biomass in fert plots (in 1989).

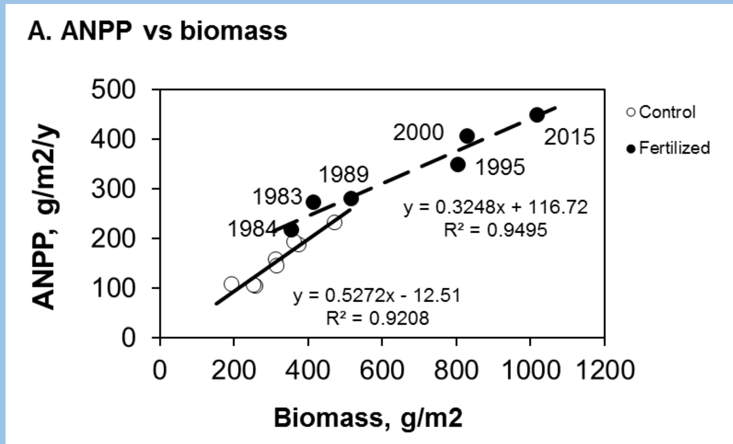
ANPP has two main components:

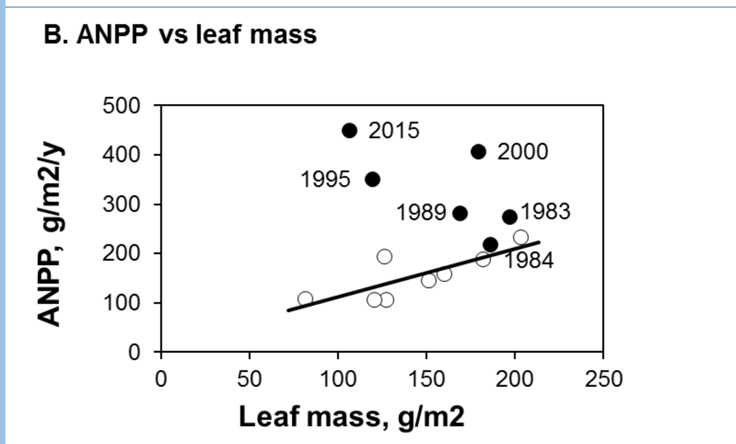
(1) Apical (including Intercalary) growth and
(2) Secondary growth

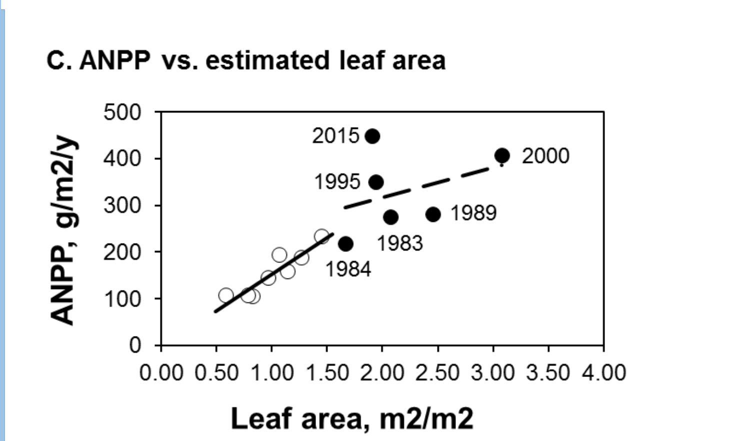


Fertilizer initially increases apical growth but after 35 years there is no difference from controls

As fertilized plots become more shrubby, secondary growth becomes the dominant component of ANPP in fertilized plots



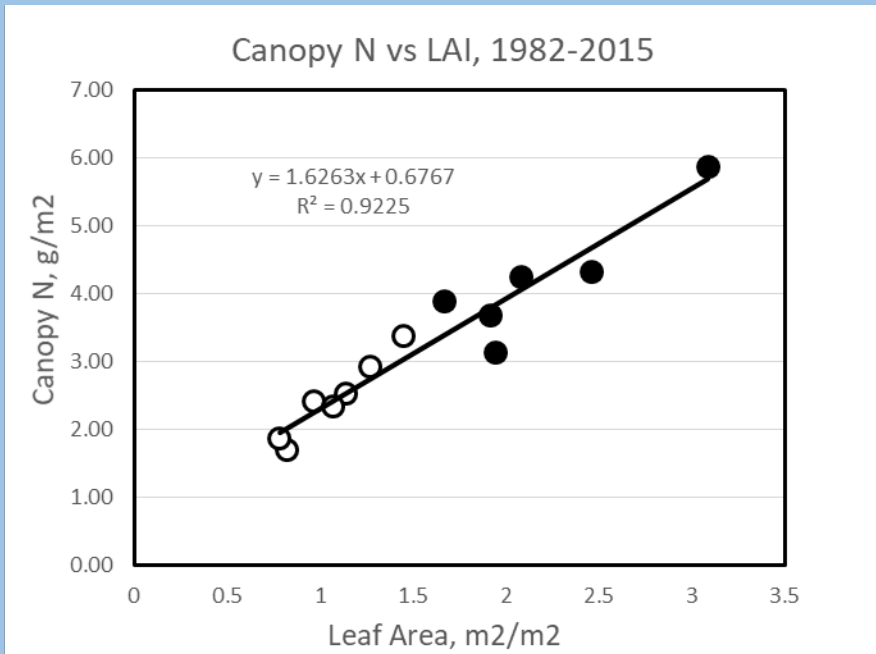


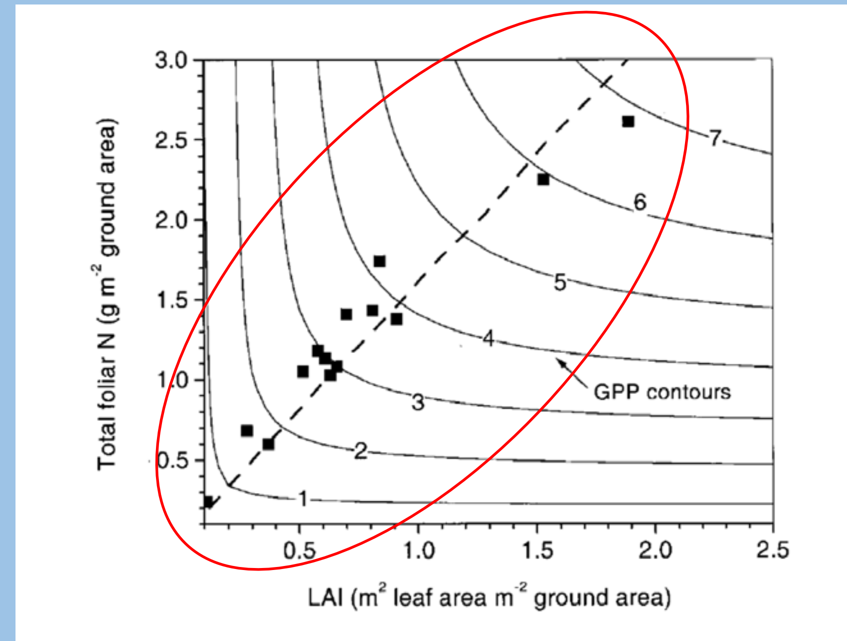


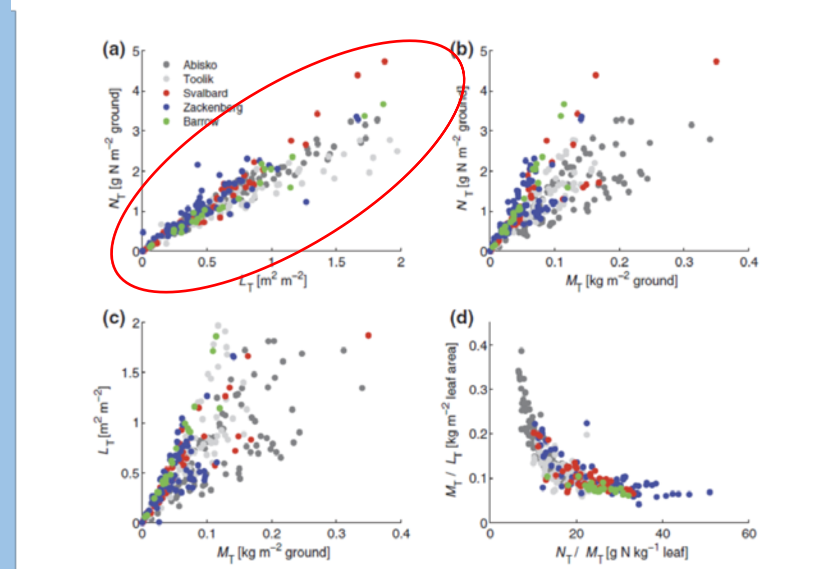
Production: biomass relationships are remarkably constant over time in both CT and Fert despite variation in species composition in both CT and Fert. It may also be possible that both CT and Fert represent a single continuous relationship

ANPP vs leaf mass is a tight relationship in CT but not so in Fert, probably because species composition changes so dramatically

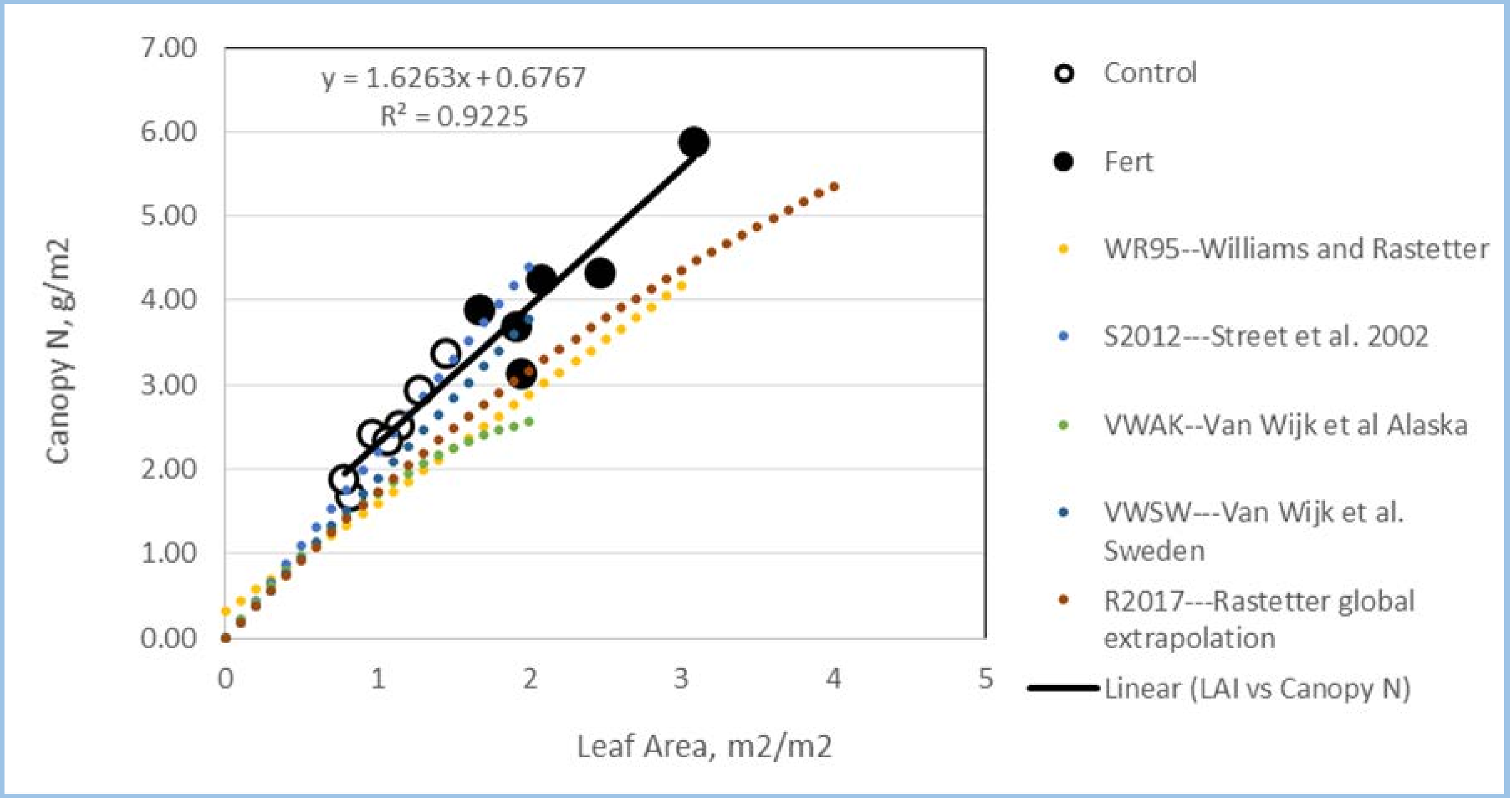
ANPP vs leaf area is again very tight esp in CT, and again may be a single continuous relationship.







Comparison of Leaf area/canopy N relationships in Historic Plots versus Williams and Rastetter 1995 and Street et al. 2012



Rapidly changing manipulated tussock tundra systems follow the same canopy allometry and production:biomass relationships (and are equally efficient in N use) as all tundra systems examined, of widely varying biomass, production, and composition throughout the Arctic

So What?

- Local and regional variation in tussock tundra production and biomass appears linked to climate, topographic position and glacial history
- Response to climate change is slow and small; rapid and large changes require disturbance such as fire, thermokarst, or fertilizer addition
- Large annual variation in growth is not reflected in long term trends in biomass accumulation
- Expected increase in deciduous shrubs not found in undisturbed tussock tundra
- All arctic vegetation whether stable or changing follows the same canopy allometry and production: biomass relationships, independent of species/functional type composition. This suggests that rather that driving whole-canopy functions by linear scaling-up of mean leaf properties, plant species of a variety of leaf functional types all build near-identical canopies, mainly by variation in leaf display.