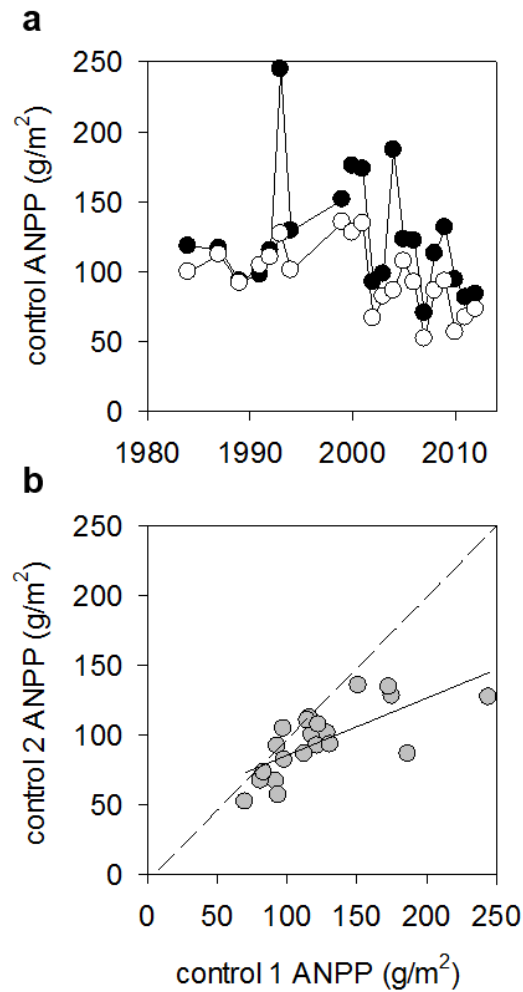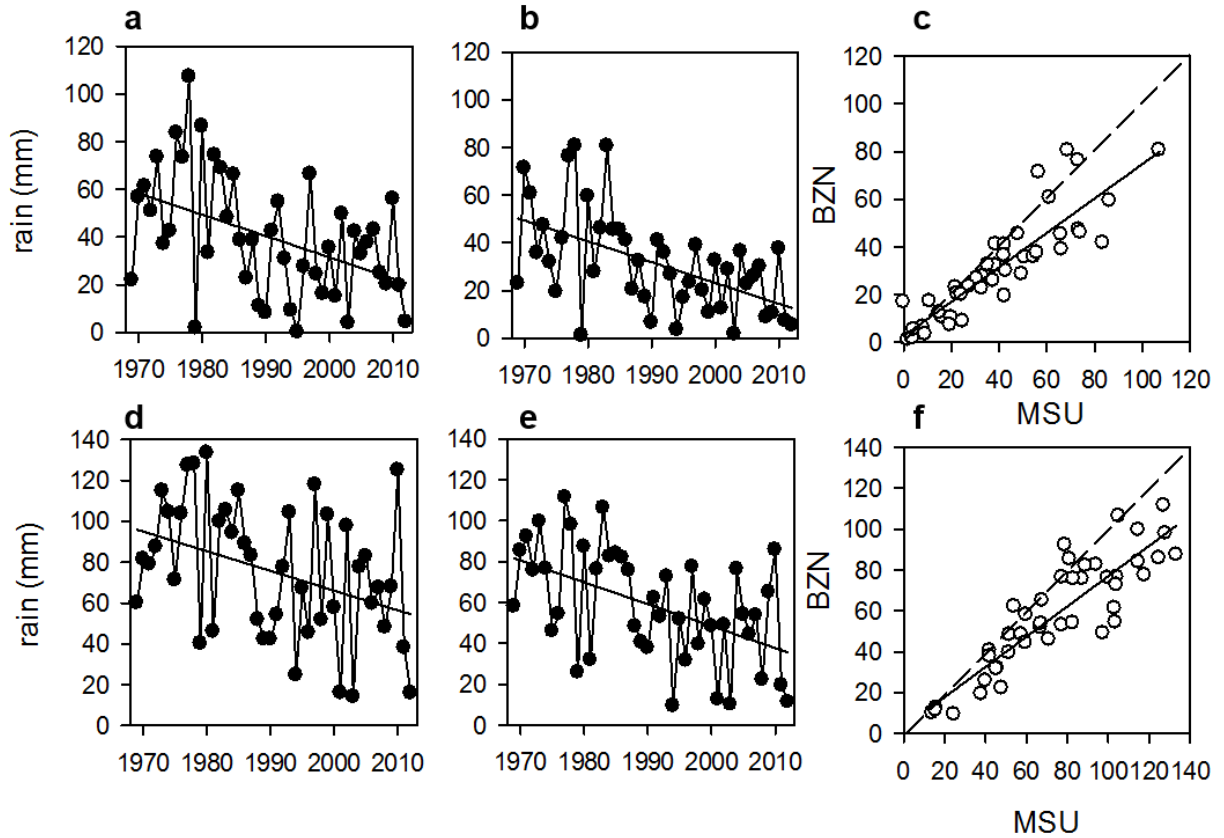**Supplementary Figure 1**

**Supplementary Fig. 1 | Similarity of long-term patterns in ANPP between control plots 1 (black symbols) and 2 (open symbols).** (a) Both control areas show significant decline ($p < 0.02$, linear regression, $n=21$) over time. (b) Simple regression between these two plots shows significant ($p < 0.001$, $n =21$) positive temporal correspondence but overall slightly lower ANPP in control plot 2 (dashed line is 1:1) and a shallower slope driven by two high-productivity years in control 1.
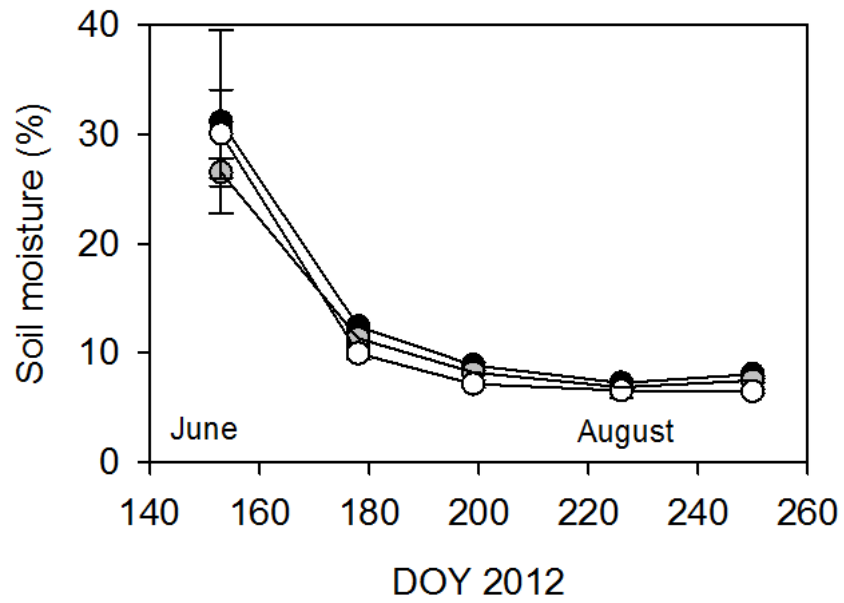
Supplementary Figure 2

Supplementary Fig. 2 | Long term decline in September (a and b) and combined August and September rainfall (d and e) recorded at Montana State University (MSU; a and d) and Bozeman Yellowstone International Airport (BZN; b and e). Rainfall recorded at these stations is highly correlated ($p < 0.001$, $n = 44$) but is generally higher at MSU (c, e).
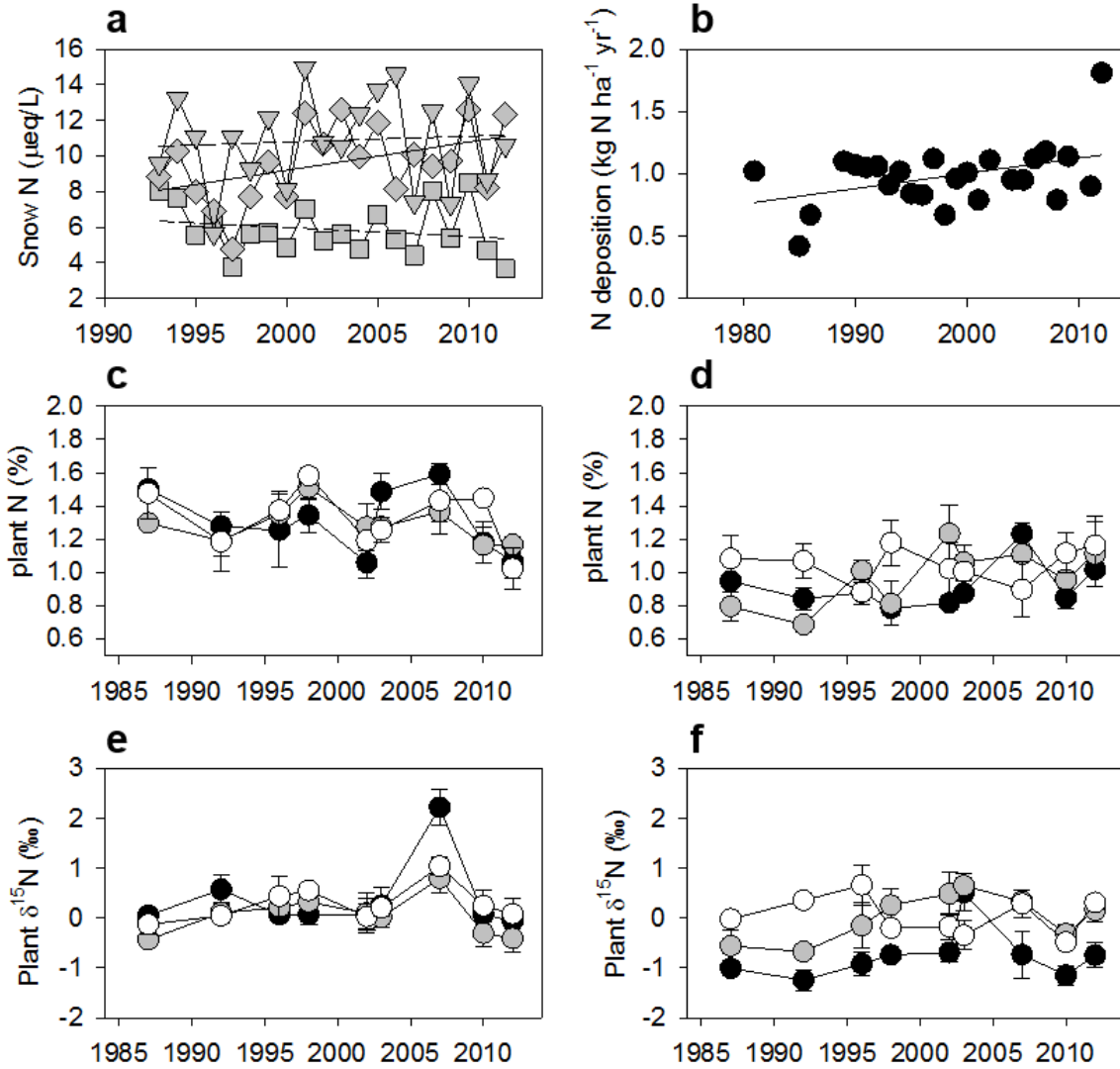
Supplementary Figure 3
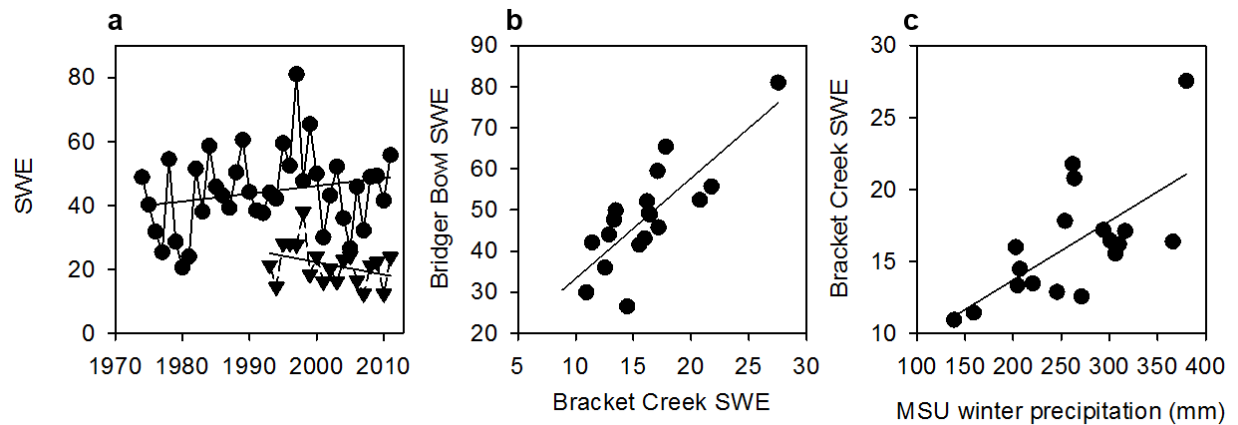
Supplementary Fig. 3 | Time series of maximum snow water equivalent (SWE) and winter precipitation. (a) SWE (cm) measured at Bridger Bowl (circles) and Bracket Creek SNOTEL (triangles) stations. (b) These stations show significant (p <0.001, linear regression, n =18) temporal correspondence with each other and (c) snowfall recorded at MSU, indicating strong regional coherence in winter precipitation.

Supplementary Figure 4

Supplementary Fig. 4 | Gravimetric soil moisture measured in shallow soils (0 -15 cm) as a function of day of the year (DOY) in the control (black symbols) and experimental x2-snow (grey) and x4-snow (open) plots in summer 2012. Error bars are 1SE around the mean (n = 5).

Supplementary Figure 5

Supplementary Fig. 5 | Time series of N inputs in precipitation and snowpack and N contents and isotopic signatures in plant biomass. (a) N in regional snowpack and (b) atmospheric N deposition and (c and d) N contents and (e and f) ^{15}N composition in aboveground biomass of forbs (c and e) and grasses (d and f) across control (black symbols), x2-snow (grey symbols) and x4-snow (open symbols) plots. In (a) data from Daisy Pass (diamond symbols) showed a

significant (P = 0.048) but small positive trend. Regressions for Big Sky (squares) and Red

Mountain (triangles) were not significant (P > 0.3). Atmospheric N deposition is low but

increased significantly (p = 0.037, linear regression, n = 22) at the Yellowstone NADP site.

However, this relationship is rendered insignificant (p = 0.2) after omitting the 2012 value.

There were no significant temporal trends in N contents or ^{15}N across functional groups and

experimental treatments. Error bars are ± 1 SE.