Soil Nutrient Status Following Prescribed Burns and Wildfire

Nitrogen

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Why?

Nitrogen

- N is critical nutrient in forests and streams

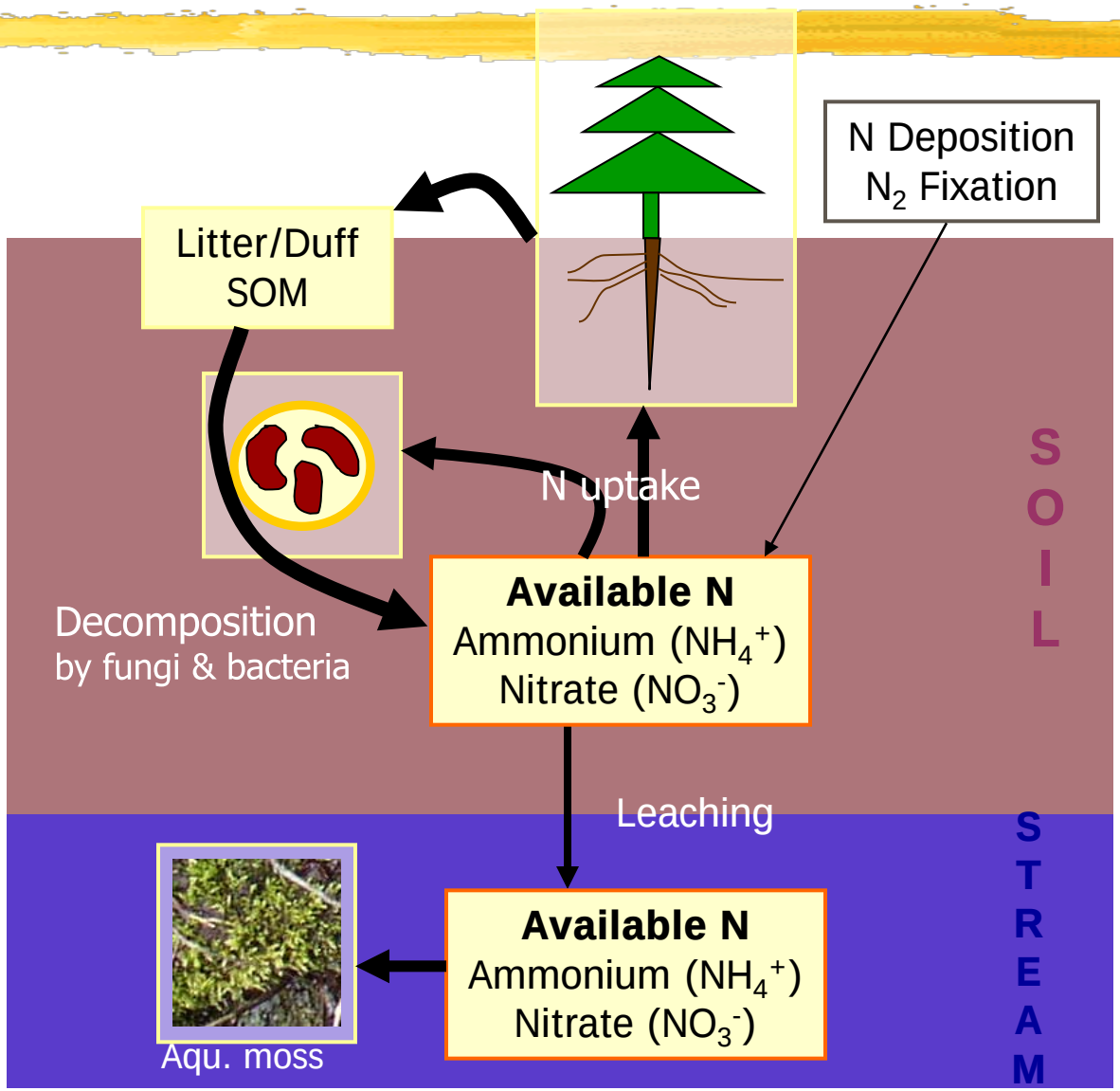
Wildfire and spring prescribed burn effects

- Fire can have profound effects on N dynamics
- ➢ No direct comparisons of wildfire and spring prescribed burn in same geographic area at same time

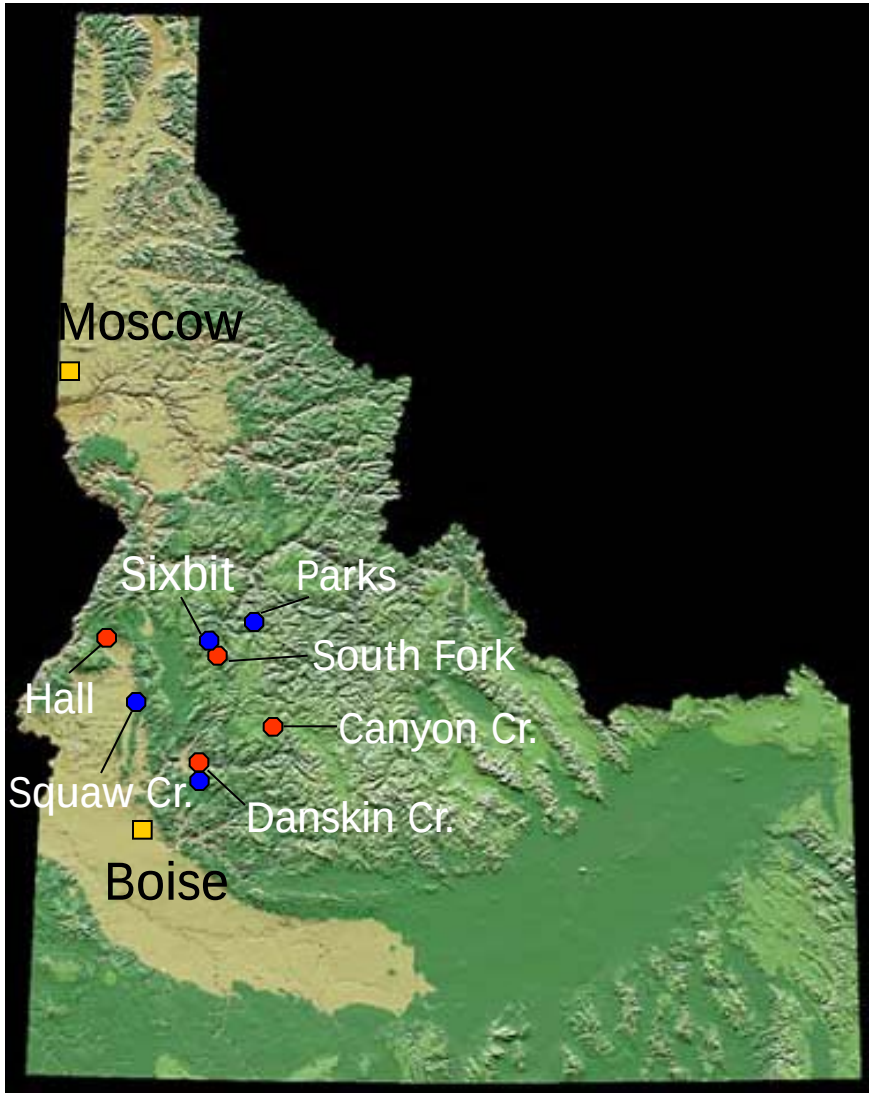
Headwater watersheds

- Terrestrial and aquatic component are inseparable functional unit = watershed ecosystem

N cycle


N Deposition
N_2 Fixation
Litter/Duff
SOM
N uptake
Decomposition
by fungi & bacteria
Available N
Ammonium (NH_4^+)
Nitrate (NO_3^-)
SOIL
Leaching
Available N
Ammonium (NH_4^+)
Nitrate (NO_3^-)
STREAM
Aqu. moss

Study sites



Wildfires: August 2003
(Danskin Cr.: 2002)

Spring Rx: April/May 2004

Watershed Elevation: 1400- 2200 m
(4500 ft – 7200 ft)

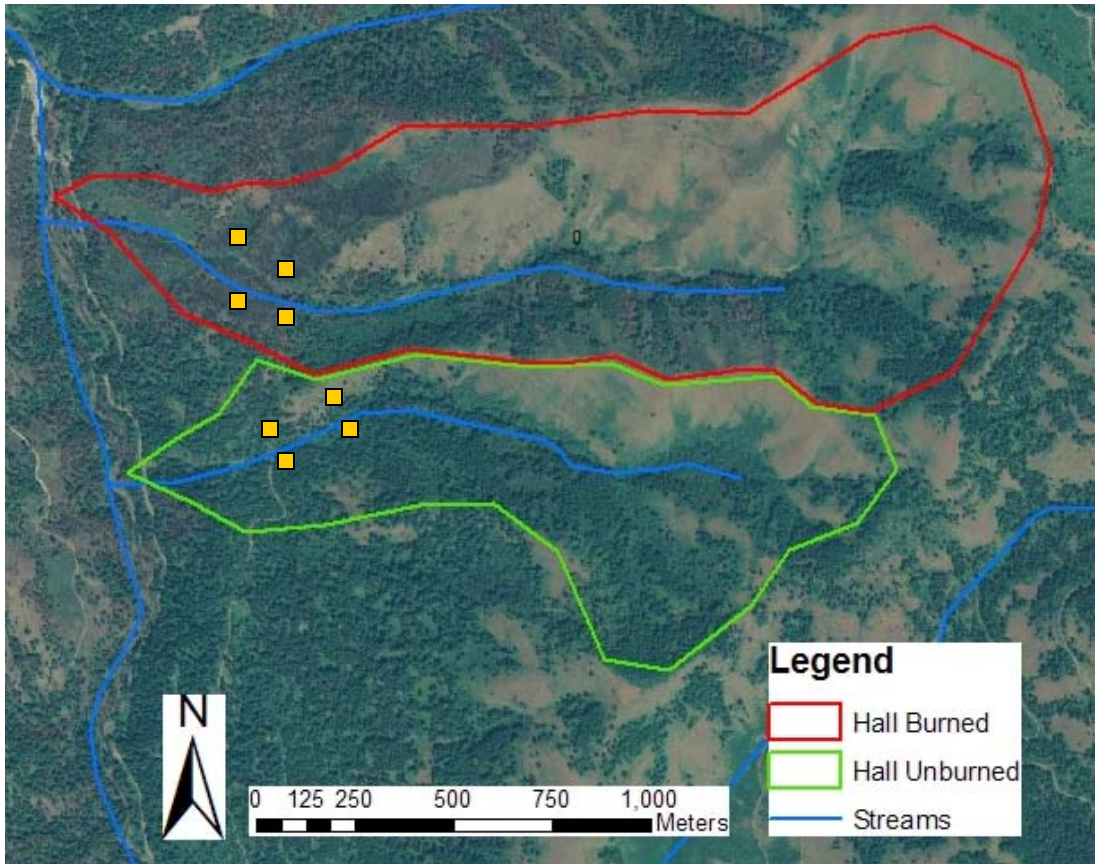
Watershed size: 78 ha (range 8 – 512 ha)

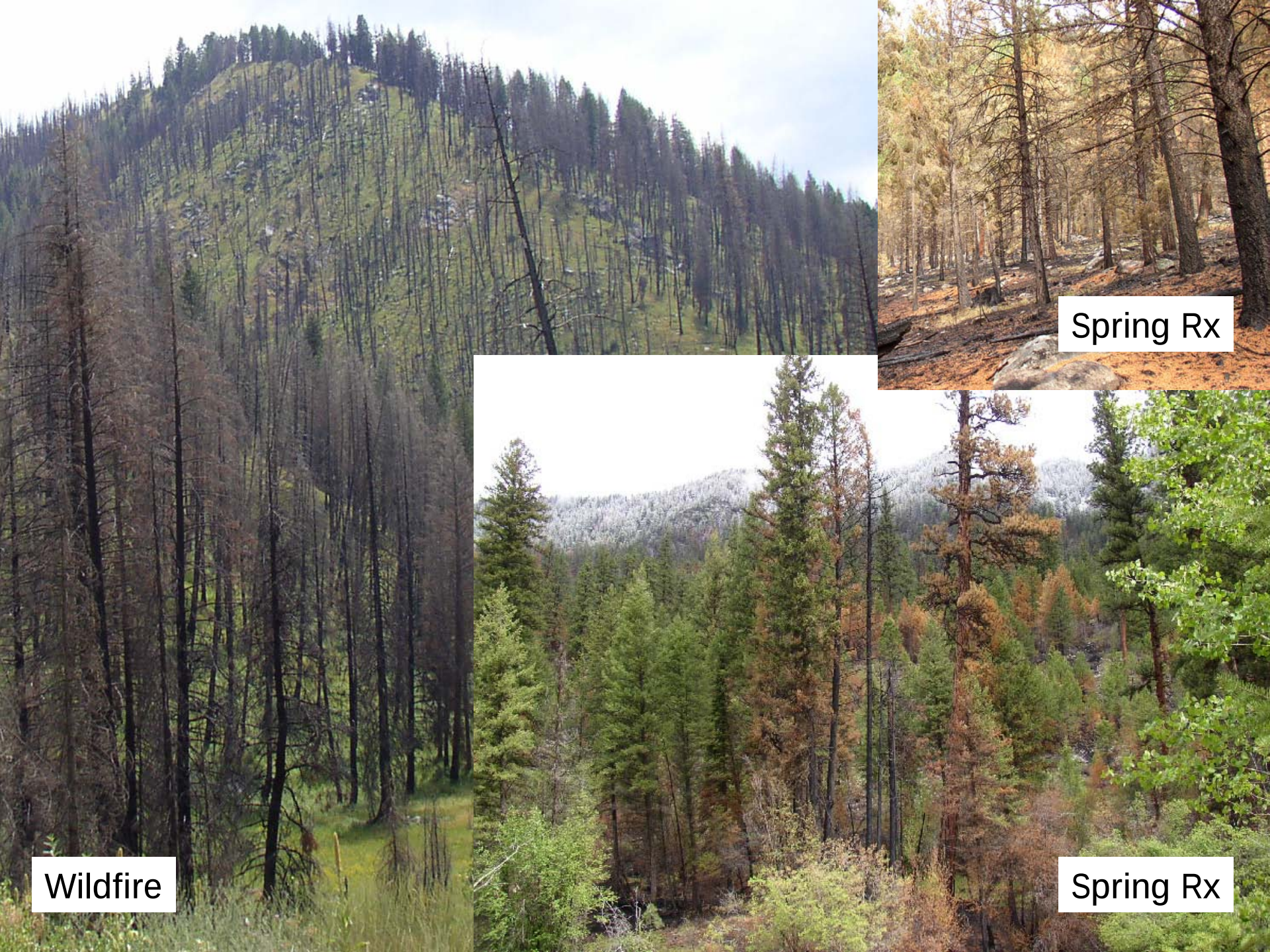
Streams: intermittent or
small (1st order) perennial

Overstory: *Pseudotsuga menziesii*
Pinus ponderosa

Design

- 4 W + 4 Rx Sites (Replications)
  - 2 Watersheds
    - -Burned
    - -Unburned
    - 4 Plots (Subsamples)
      - Min. Soil (0-10 cm)
      - Foliage




Spring Rx
Wildfire
Spring Rx

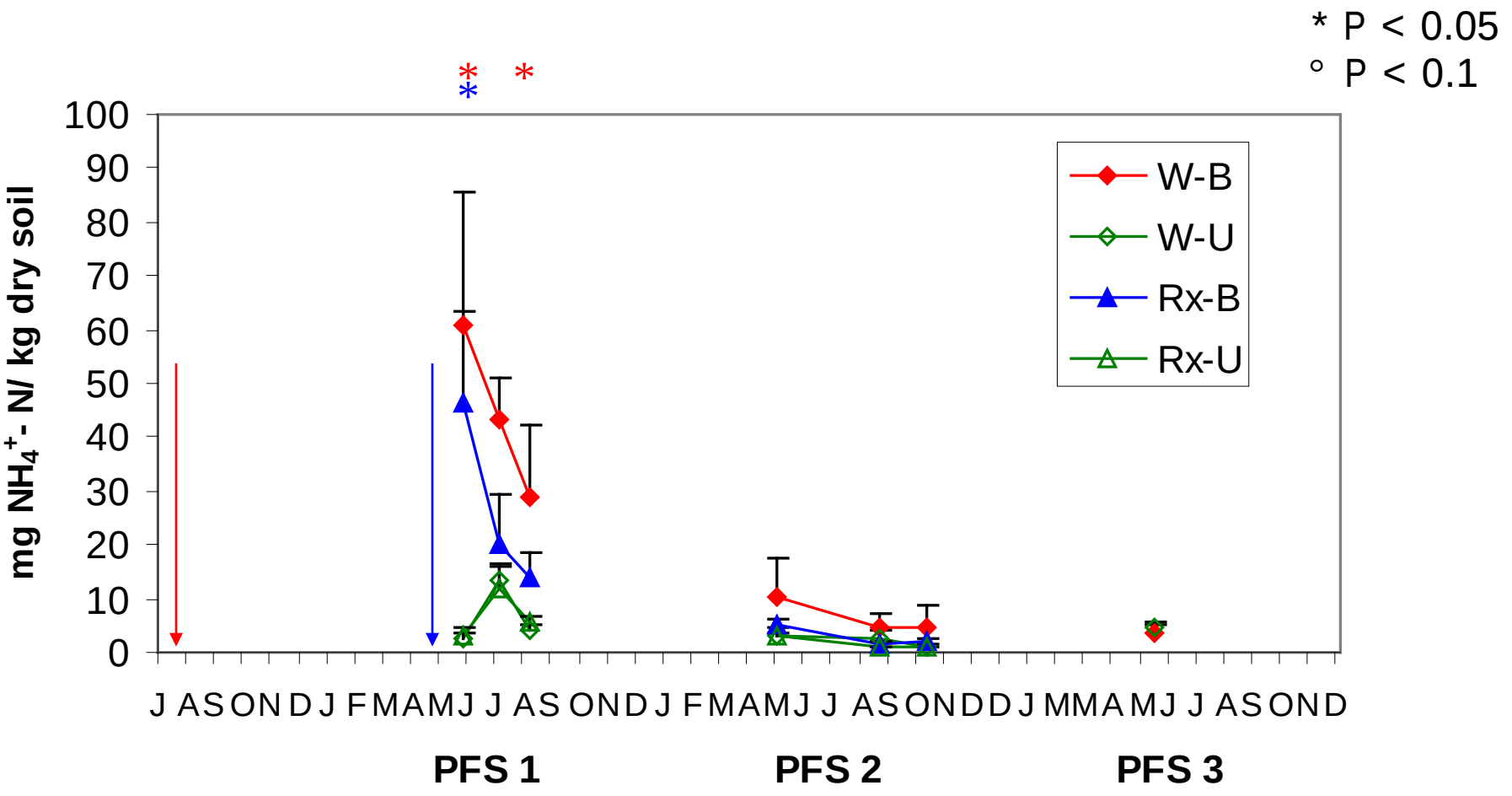

Wildfire
Spring Rx

Fire Effects on N Pools

- N loss due to organic matter combustion (oxidation to N_2)
  - N loss proportional to fuel consumption
    - ca. 5 kg N lost per 1000 kg fuel consumed (Fisher & Binkley 2000)
    - N loss: 10-1000 kg N/ ha (Raison et al 1985)
    - 50 cm (20") DBH Douglas-fir contains 2.3 kg N (above ground)
  - N loss from mineral soil is rare
    - 0-10 cm mineral soil contain ca 1400 kg N/ha

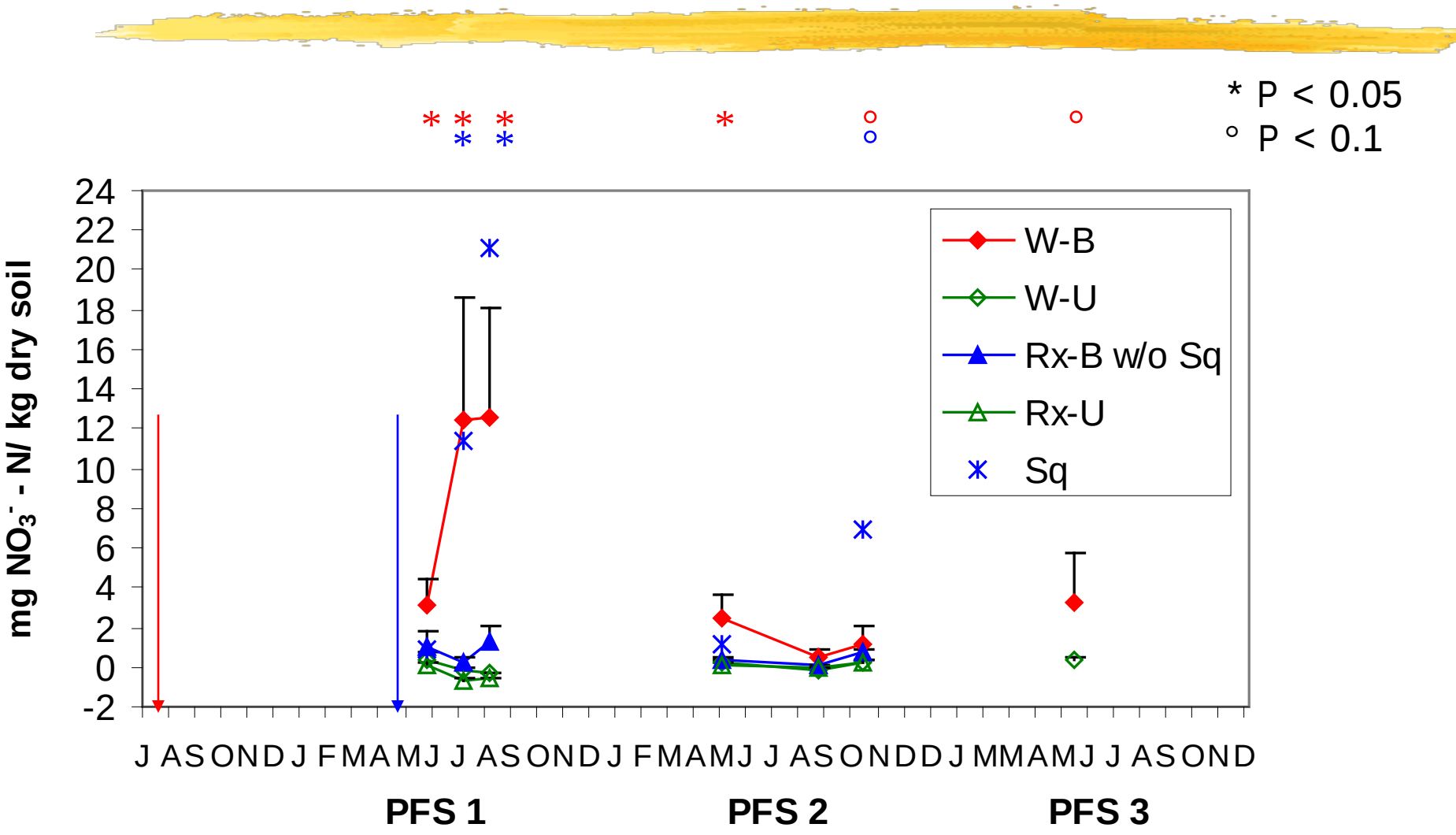
Soil ammonium concentrations

mg N/ kg dry soil



Soil nitrate concentrations

mg N/ kg dry soil



Mechanisms of post-fire soil inorganic N increase

- Reduced uptake by plants
  - due to reduced plant cover
- Increased decomposition
  - Higher soil moisture, temperature, (pH)
- Removal of allelochemical inhibitors
  - E.g. terpenes in pine needles, phenols in ericaceous shrubs
- Reduced microbial uptake
  - C-limitation of heterotrophic microorganisms

Foliar N concentrations of understory plants

Spiraea betulifolia
(Rosaceae)

Physocarpus malvaceus
(Rosaceae)

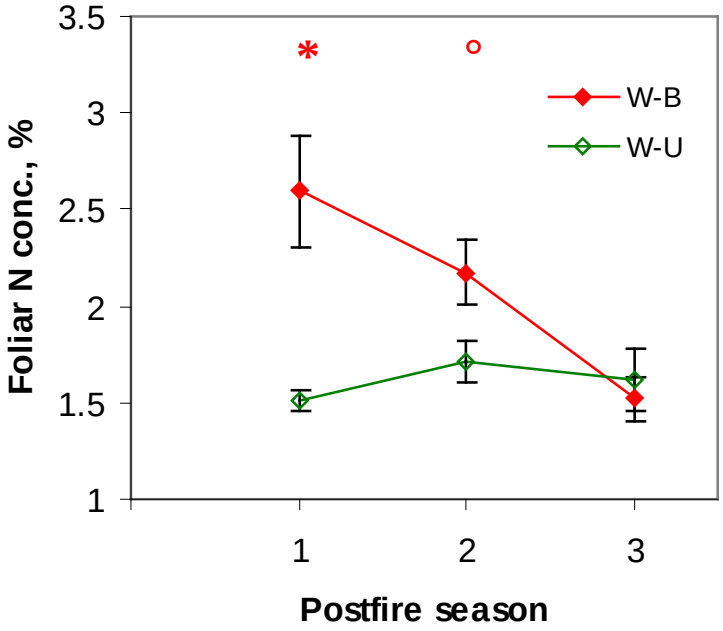
Symphoricarpos albus
(Caprifoliaceae)

Carex geyeri
(Cyperaceae)

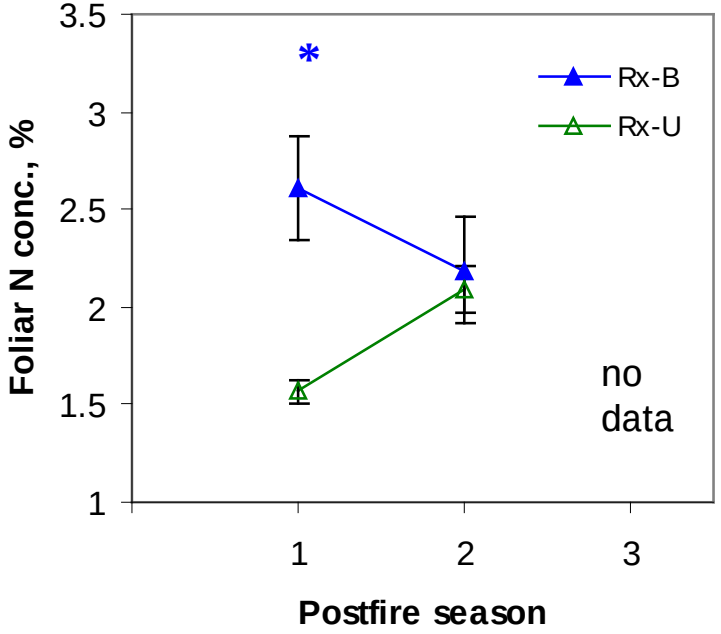
Foliar N concentration

%

Wildfire



Rx



* P < 0.05

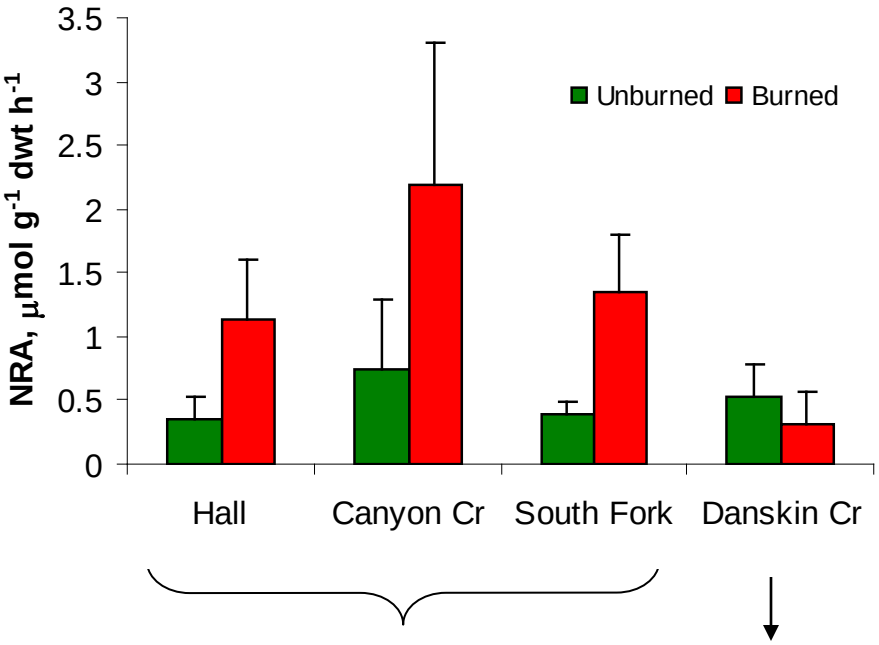
° P < 0.1

Plant N assimilation-
Nitrate Reductase Activity

Second Post-Fire Season

Error bars 1 SD

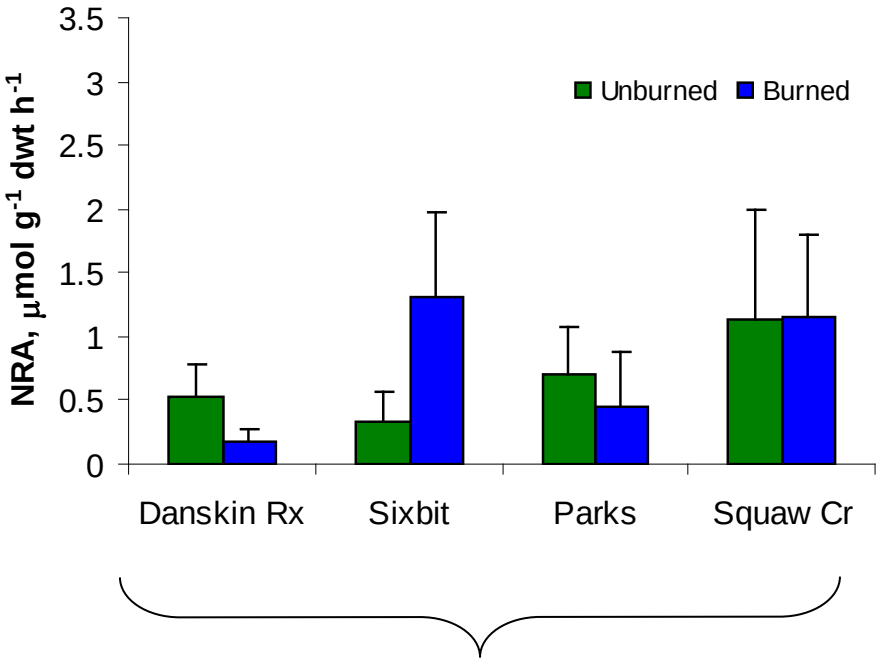
Wildfire



P = 0.035

Year 3

Rx

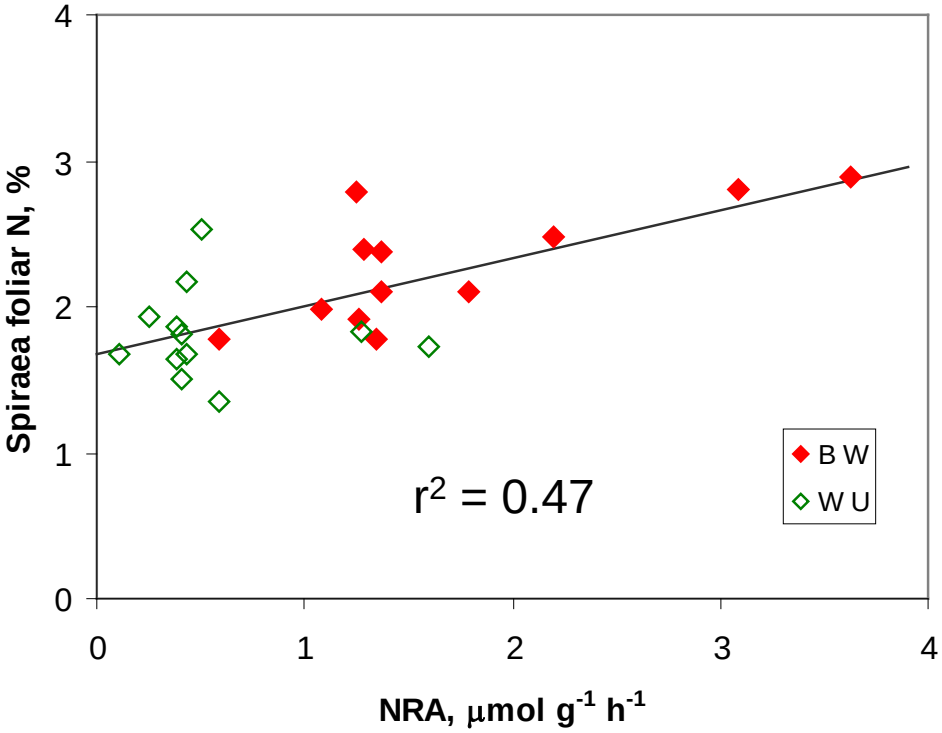


n.s.

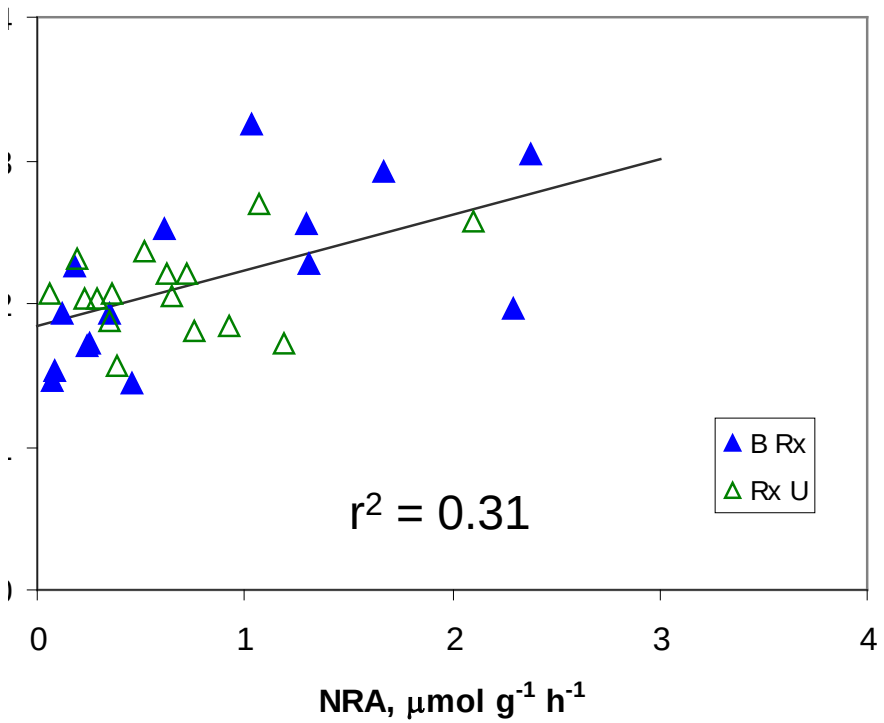
Plant N assimilation-
Nitrate Reductase Activity

Second Post-Fire Season

Wildfire



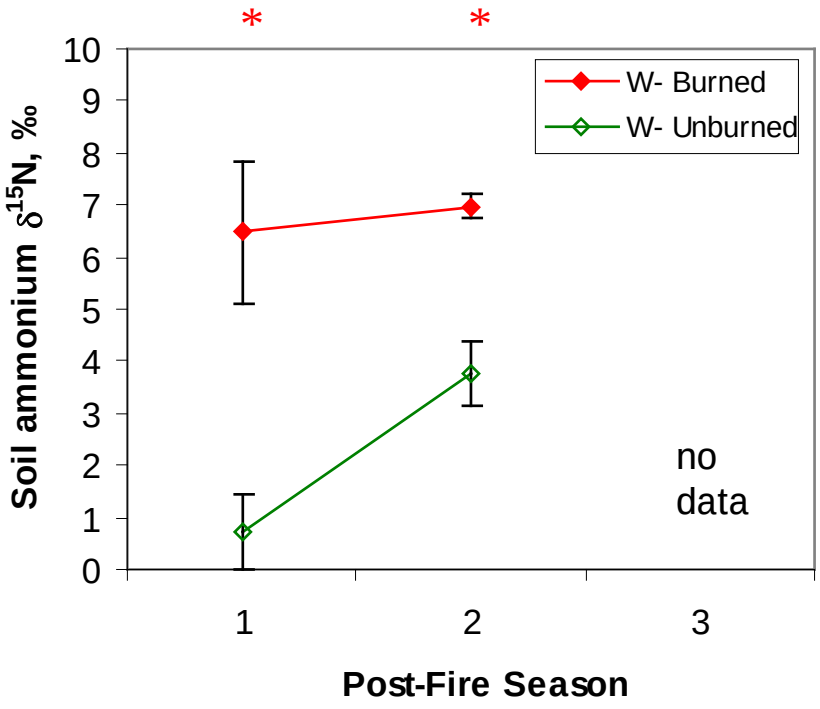
Rx



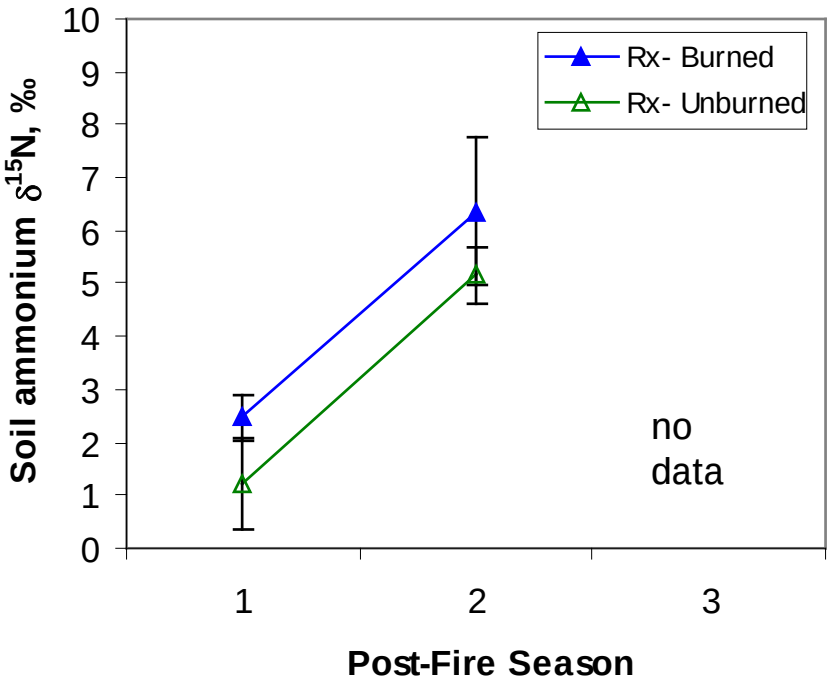
Plant N sources- clues from stable isotopes ^{14}N:^{15}N

* P < 0.05

Wildfire



Rx

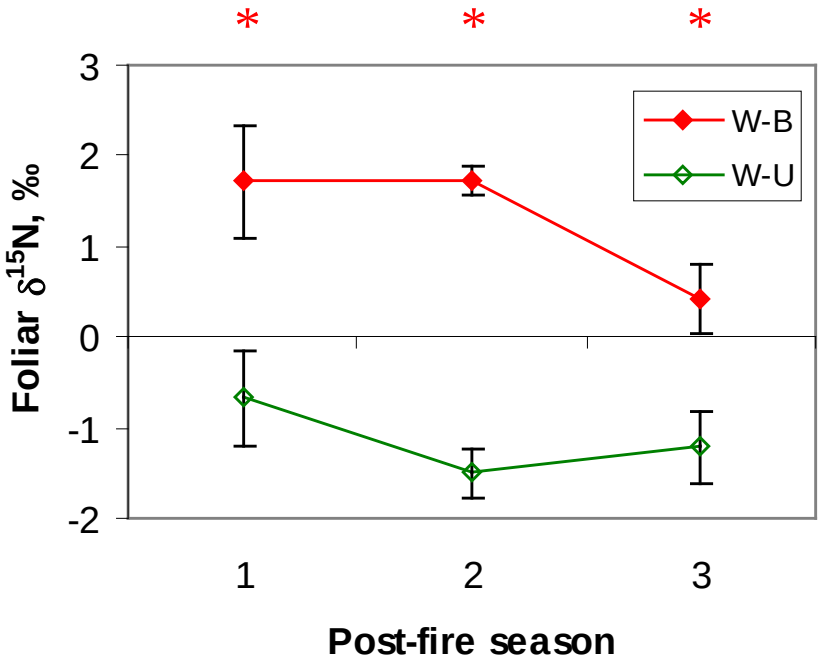


Soil ammonium is isotopically heavier after wildfire.

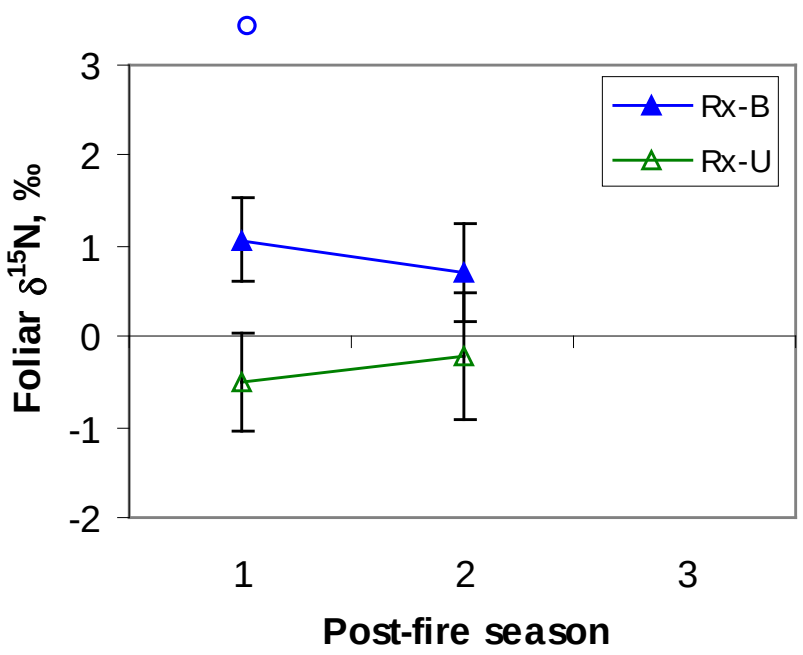
Plant N sources- Foliar N isotope values

* P < 0.05
° P < 0.1

Wildfire



Rx

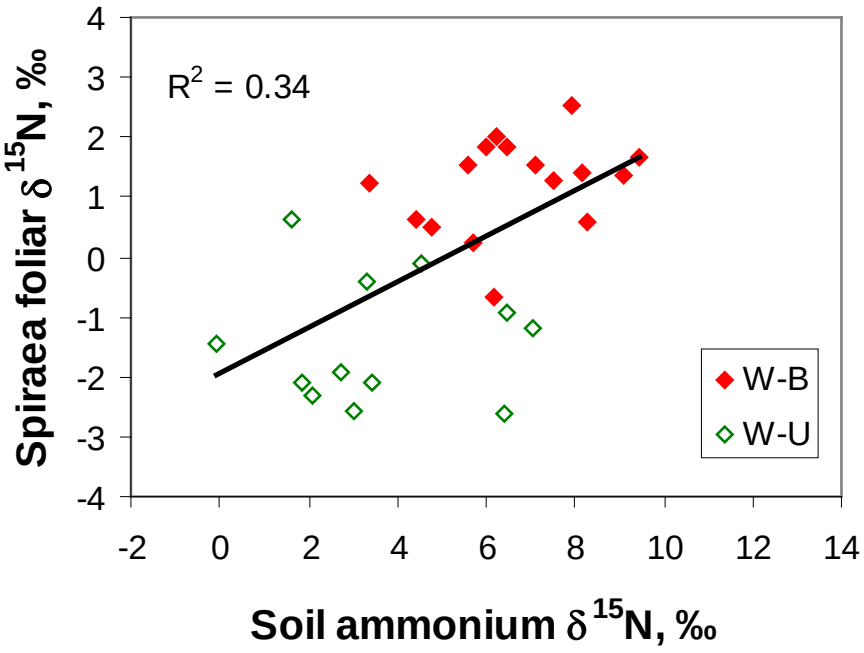


Spiraea foliage is isotopically heavier after wildfire.

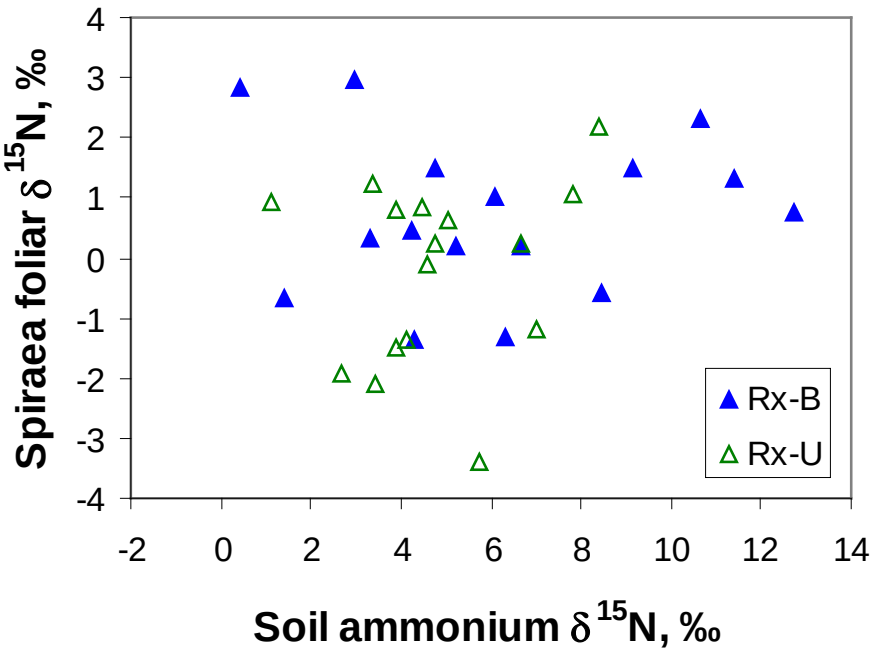
Plant N sources- Foliar N isotope values

Second Post-Fire Season

Wildfire



Rx



Foliage has isotopic signal of fire.

Source N not isotopically altered.

Ash

Contains between 0.15-1.88 % N (mostly organic N)

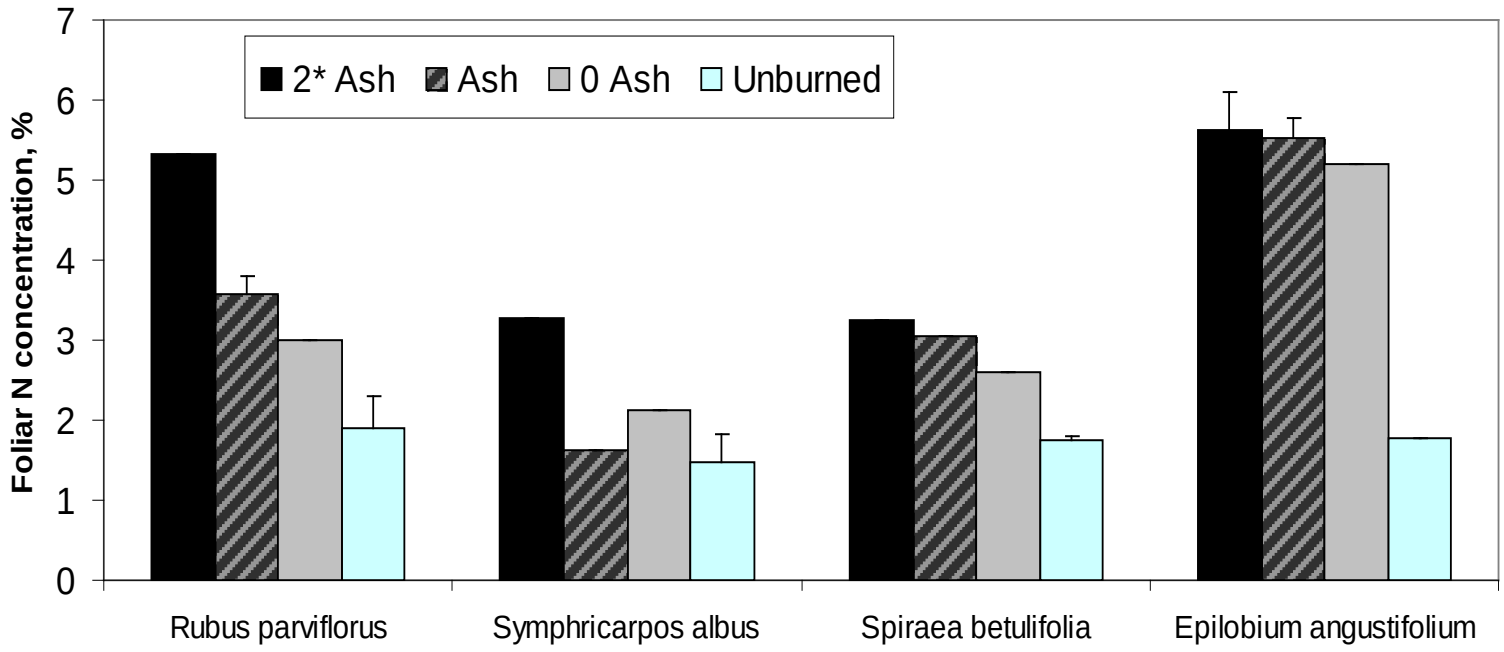
Danskin Cr., Boise NF
Photo A. Koyama

E.g.
grey wood ash:
0.15 % N
3.5 % P
1.2 % K
24% Ca
2.5 % Mg
(Raison et al. 1985)

N input via ash:
89 kg N/ ha
(Grogan et al. 2000)
23 kg N/ ha
(Grier 1975)

Ash

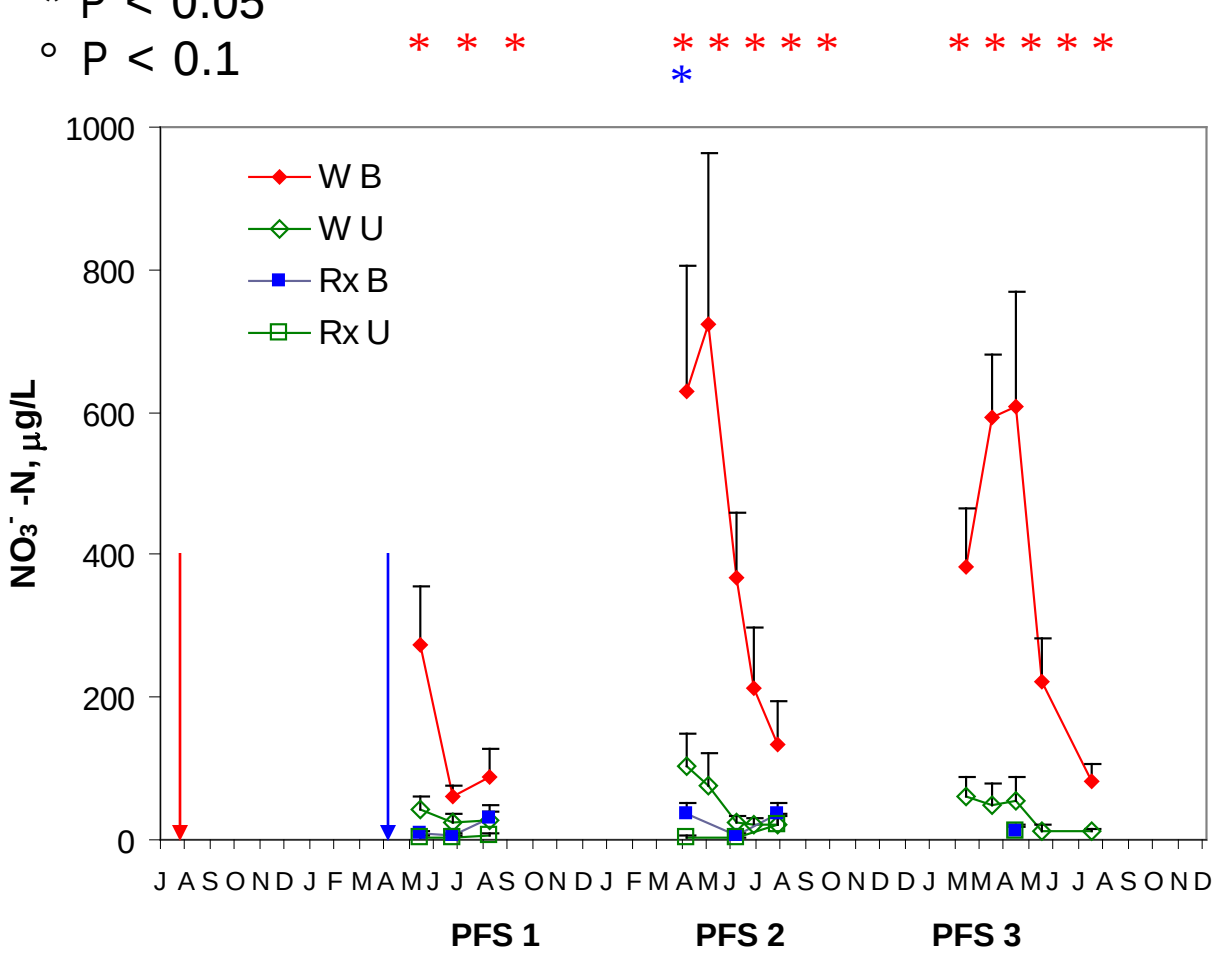
Grogan et al. 2000:
Aboveground biomass in ash-removal plots 1/3 of biomass in control plots
Resprouting plants favored by presence of ash



Koyama et al. unpubl. manuscript

Streamwater nitrate concentrations, μg/L

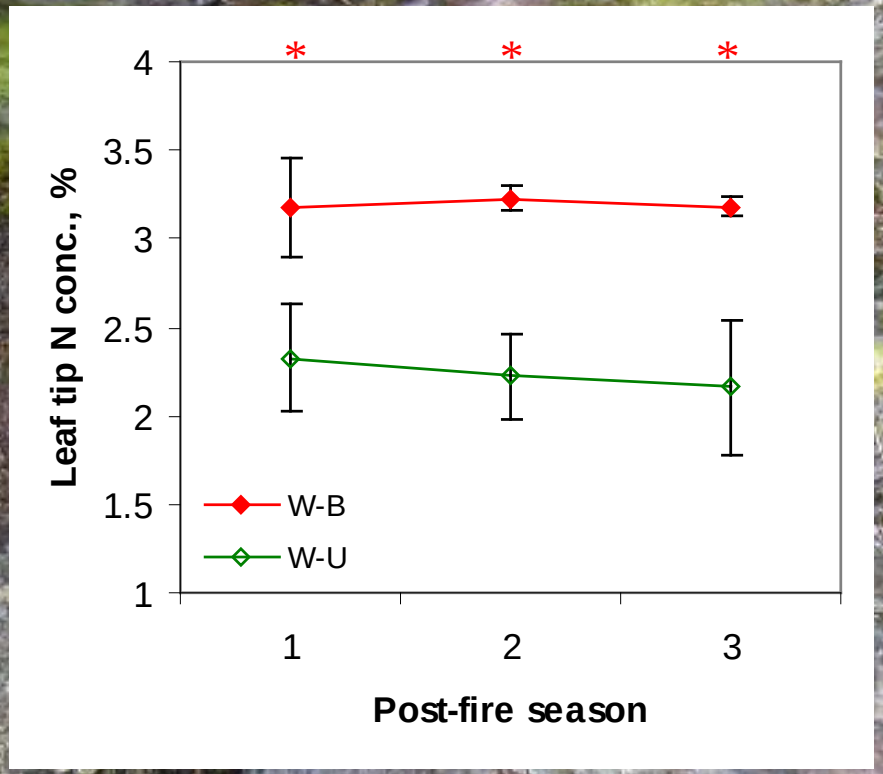
* P < 0.05
° P < 0.1

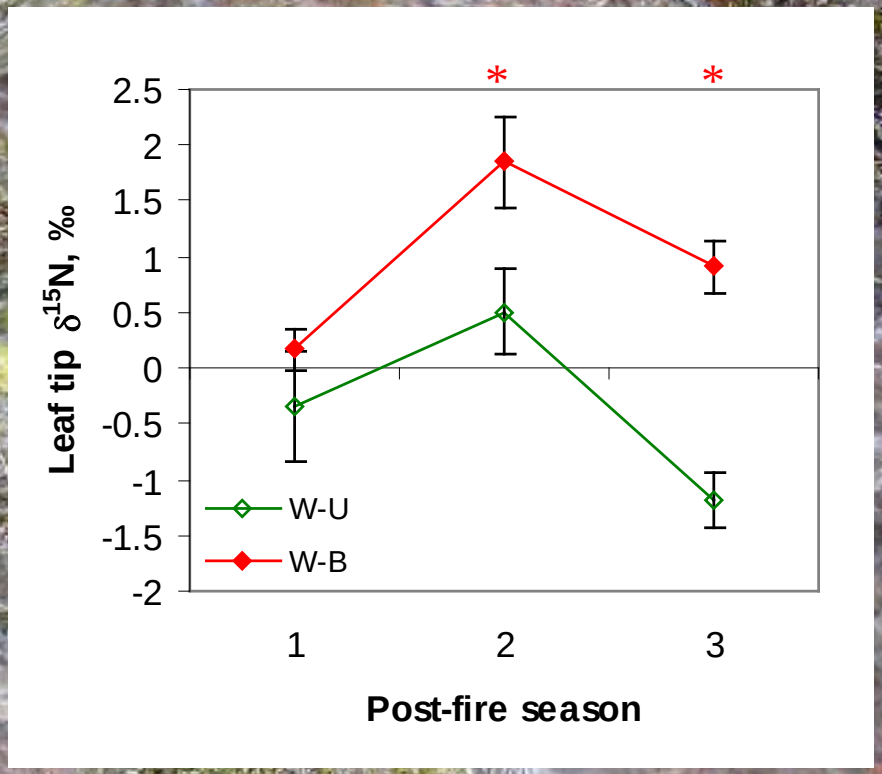


Moss N concentration & N isotopes

Wildfire

* P < 0.05
° P < 0.1





Summary Wildfire vs. Spring Rx

	Wildfire		Spring Rx
Overstory killed	Yes		No
Soil:			
Increased NH_4^+	**Yes** 1 PFS	=	**Yes** 1 month
Isotopic signal	**Yes** 2(+?) PFS		**No**
Increased NO_3^-	**Yes** 2+ PFS	>	**Yes** 1 PFS
Vegetation:			
N retention in foliage	**Yes** 1-2 PFS	=	**Yes** 1PFS
Isotopic signal	**Yes** 3(+?) PFS	>	**Yes** 2(+?) PFS
Streamwater:			
NO_3^- conc. increase	**Yes** 3(+?) PFS		**No**
Stream-biota:			
N retention	**Yes** 3(+?) PFS		**No** (no source)
Isotopic signal	**Yes** 3(+?) PFS		**No**

Conclusions- fire effects on N cycling

Wildfire		**Spring Rx**
Watershed wide	Scale	Localized
Short, intermediate (& long) term	Duration	Short term

Acknowledgements

Joint Fire Sciences Program, US Forest Service: Lowman and Emmett Ranger Districts, Idaho Stable Isotopes Lab, Doug Bradley, Ed Fochtman, Ann Abbott, Anita Falen, Jen Szarkowski, Pete Gag, Matt Thompson, Chad Opatz, Mark Noyes, Brent Keith, Bob Paffile