The Temporal Effects of *Ulex europaeus* on Soil Properties, Modeling Impact of Invasive Species with Respect to Time, and Possible Consequences of Soil Property Changes

Bronwyn Scott
&
Sarah E. Reichard
University of Washington

Meeting the Challenge:
Invasive Plants in PNW Ecosystems
Seattle, Washington
Sept. 2006

Invasives Weeds or Plants

- A crisis in important economic areas such as forestry and agriculture
- US GAO 2005 report states:
  - US federal agencies spend $40 million on control activities for non-agricultural lands
  - 47 million acres of federal lands infested with invasive weeds
  - 133 million acres are infested across the whole US

Impact

- Impact describes the consequences of invasion
- Usually split into economics and ecological impacts
- Need to be able to better quantify ecological invasion effects in order to better prioritize:
  - Research
  - Management
  - Legislation

Current Research on Invasives

- Emphasis has been on effects at multiple levels (spatial scales):
  - Population
  - Community
  - Ecosystem
- At a single point in time…
- But what about temporal effects?
- Some invasive plants can continue to have ecosystem effects

General Purpose of Study

- Examine an invasive plant's ability to alter soil properties
- Assess current status of impact modeling in invasive plant ecology

So, why gorse?

Ulex europaeus = gorse, furze & whin

- Native to Western Europe
- Invasive in Australia, New Zealand, Chile, Hawaii, and the Western and Eastern coasts of North America
- Perennial in Fabaceae (legume)
- Dense, spiny, grows to 4 meters
- Closely related to *Cytisus scoparius* (Scot's broom)

Picturesque Gorse

Pictures courtesy of the USDA

Impacts of Gorse

- Invades disturbed and open areas
  - Cleared timber land
  - Overgrazed pastures (and other disturbed areas)
  - Sand dunes
- Grows in thick impenetrable stands
- Intense rapid growth
- Large and long lived seed bank (30-100 years)
- Nitrogen-fixer with extensive litter-fall.
- Volatile Organic Compounds (VOC)

Oregon Coast, picture courtesy of the USDA

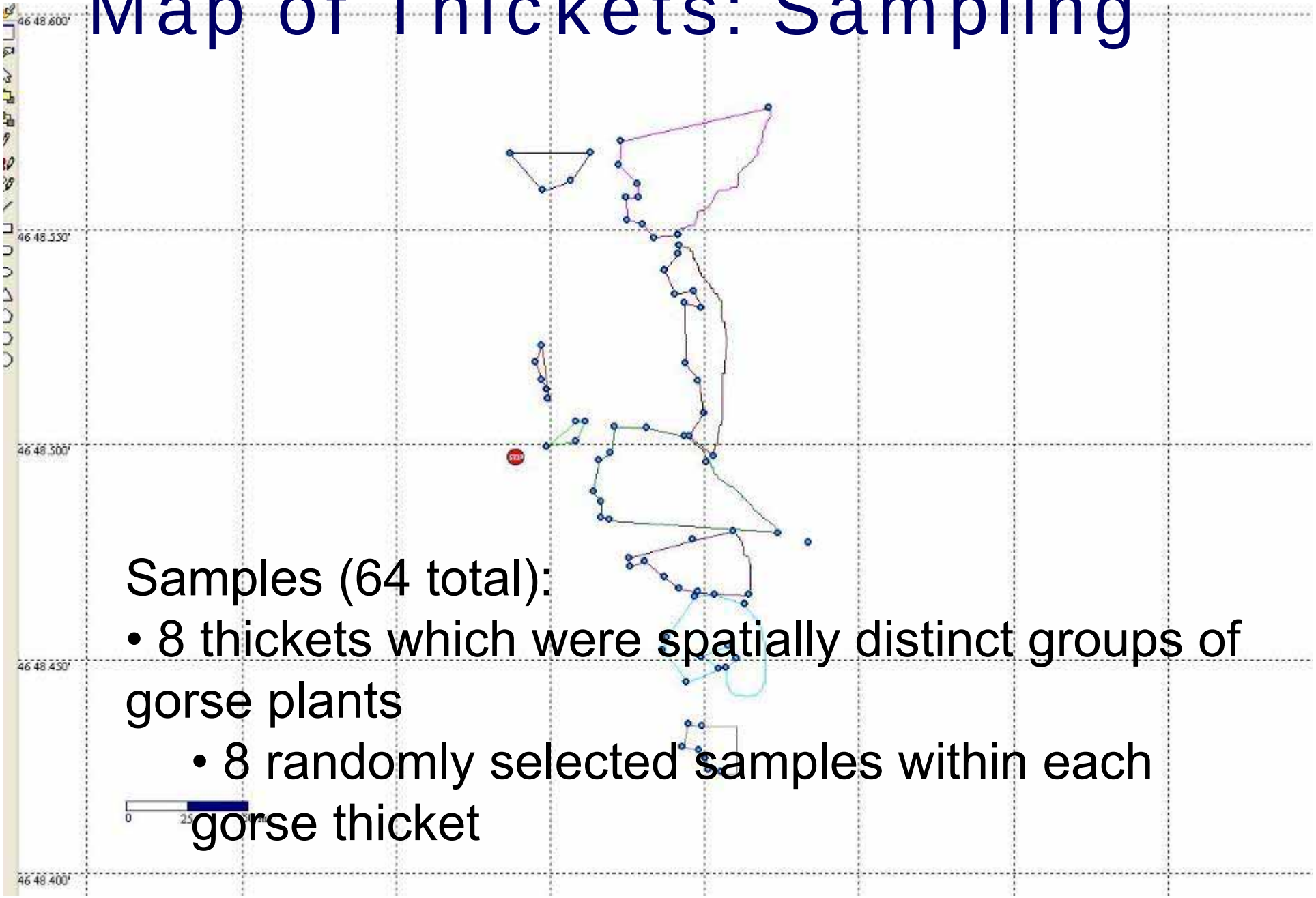
Site Selection

- Grayland Beach, Westport, Washington, Western Coast of U.S.
- Gorse invading sand dunes

Field Research, Questions

- What soil properties are being affected by gorse?
- How much and how fast are the effects of gorse on soil properties?

Map of Thickets: Sampling



Samples (64 total):

- 8 thickets which were spatially distinct groups of gorse plants
  - 8 randomly selected samples within each gorse thicket

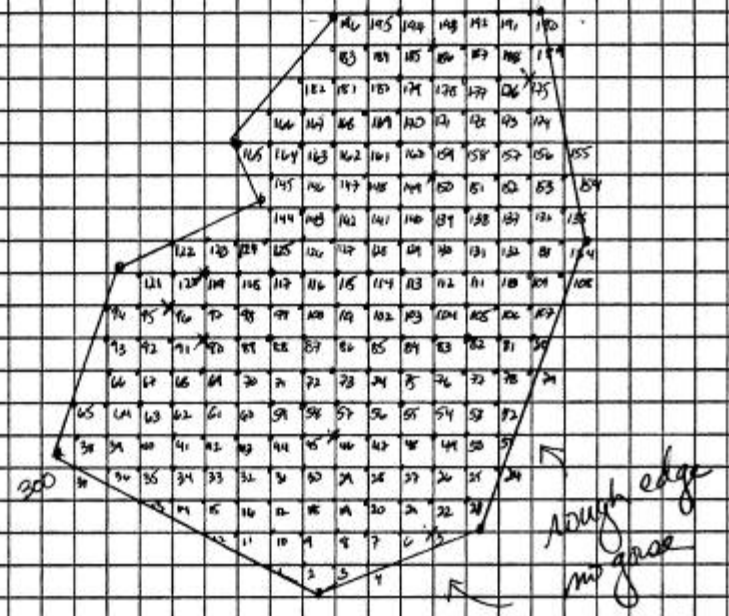
Population C (BSD) Written area.

N

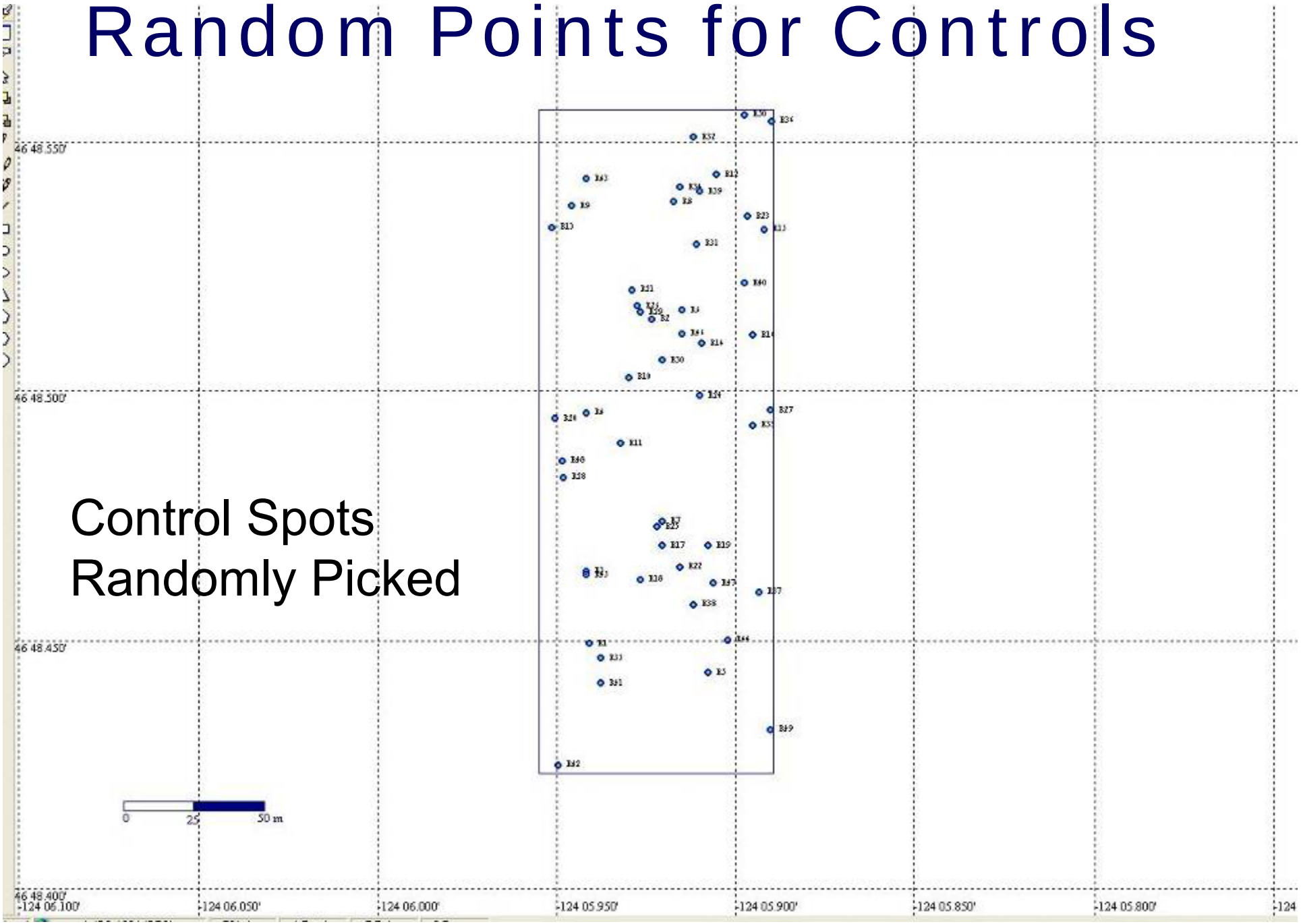
Random 1-196

186
46
119
96
175
150
90
5
} initial pts.

161
88
121
155
} extra



Random Points for Controls

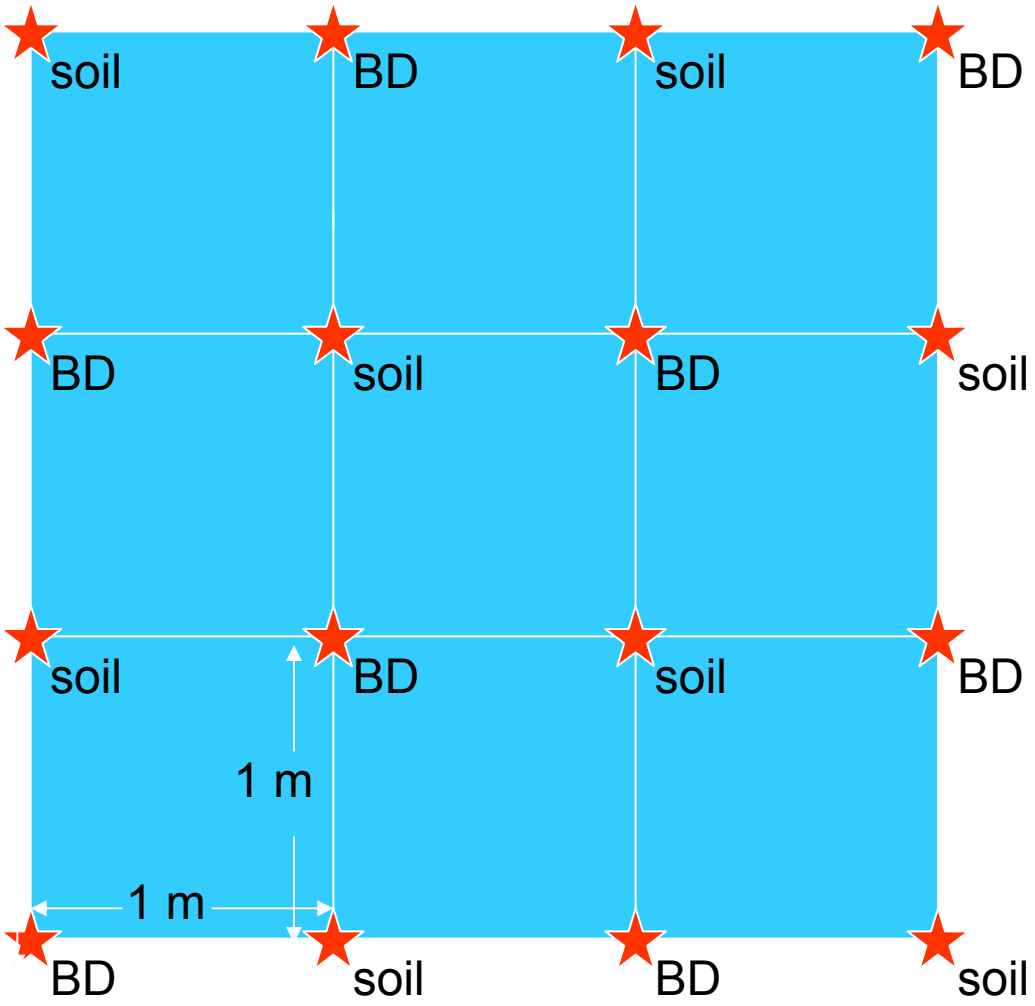


Control Spots
Randomly Picked

Measurements for Controls

Sampling at each spot was systematic

(due to high homogeneity of control areas)



BD = bulk density

Soil Properties:

- pH
- N, P, K, Ca, Mg, NH_4 & NO_3
- % OM (organic matter)
- CEC and PBS for K, Mg & Ca
- Soluble salts
- B, Mn, Zn, Cu, Fe, Pb, Cd, Ni, Cr & Al
- BD (bulk density)

Time:

- Annual rings on stems counted and used to represent time

Results: Comparing gorse and non-gorse soil properties

Significant Results ($\alpha = 0.05$):

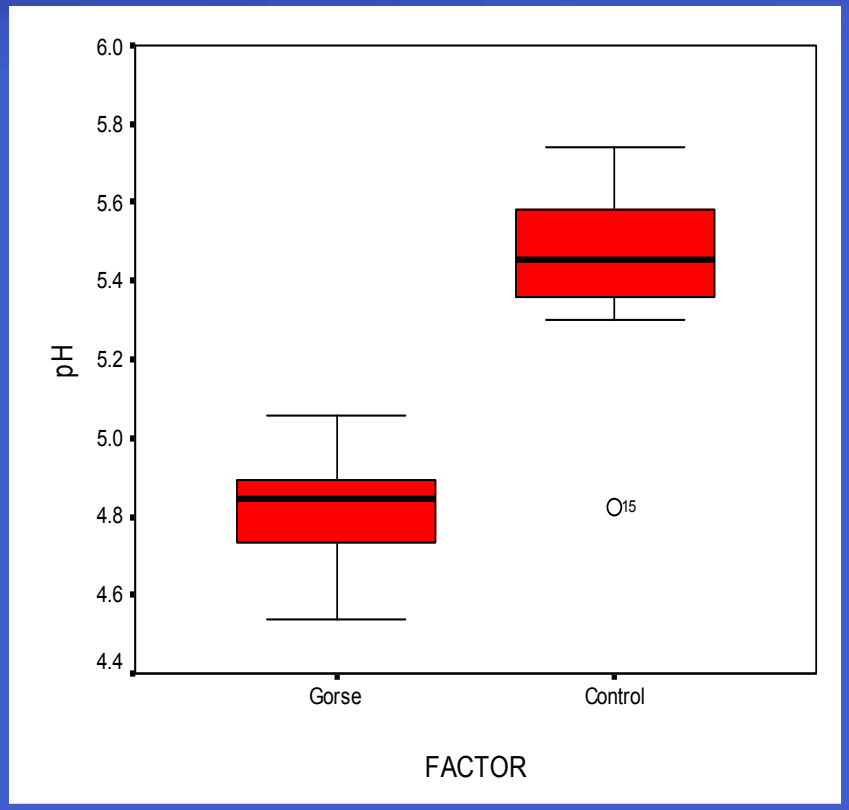
Statistical test: *Two sided t-test*

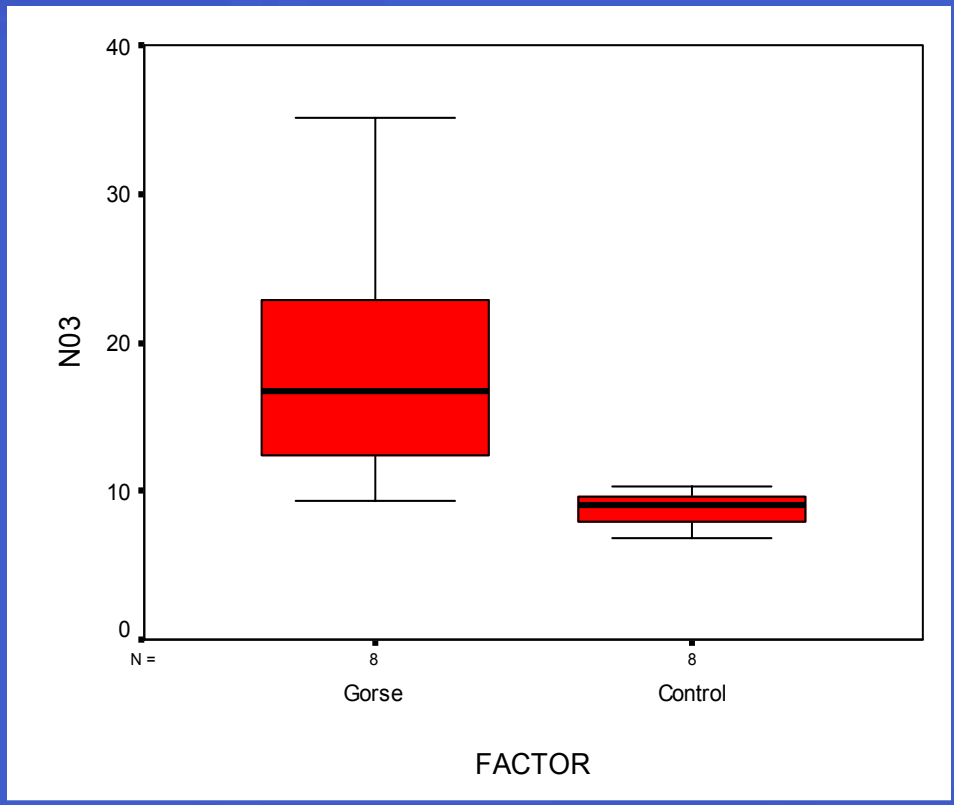
- pH, NH_4, NO_3, OM, Soluble Salts, Mn, Pb, Ni & Cr

Statistical test: *One sided t-test*

- Total N (assuming an increase in N)

Boxplots for pH & Nitrate





pH

NO_3

In boxplots, gorse is on the left

Results:
Soil Properties over Time

Significant Results ($\alpha = 0.05$):

Statistical test: Linear Regression

- BD, Total N, pH, OM, CEC & Pb

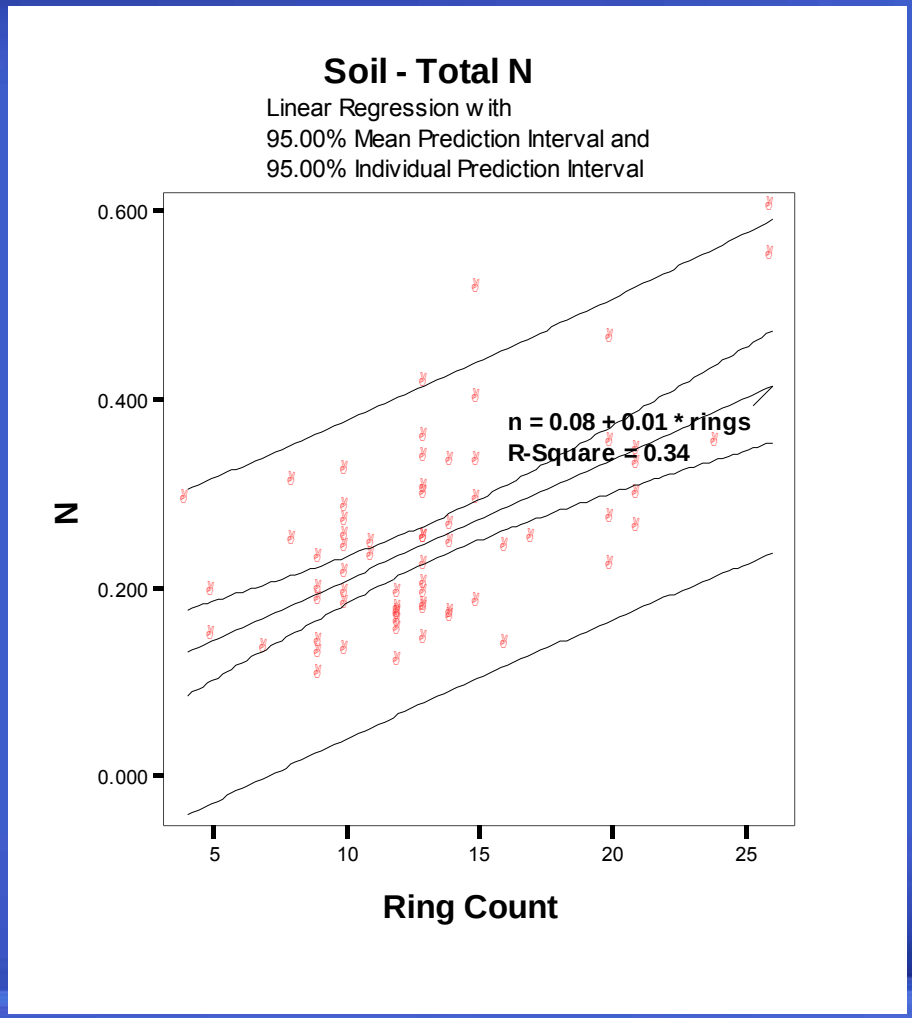
Trends (what direction):

- Increasing: Total N, OM, CEC & Pb
- Decreasing: BD, pH

Linear Regression for N

P=0.000

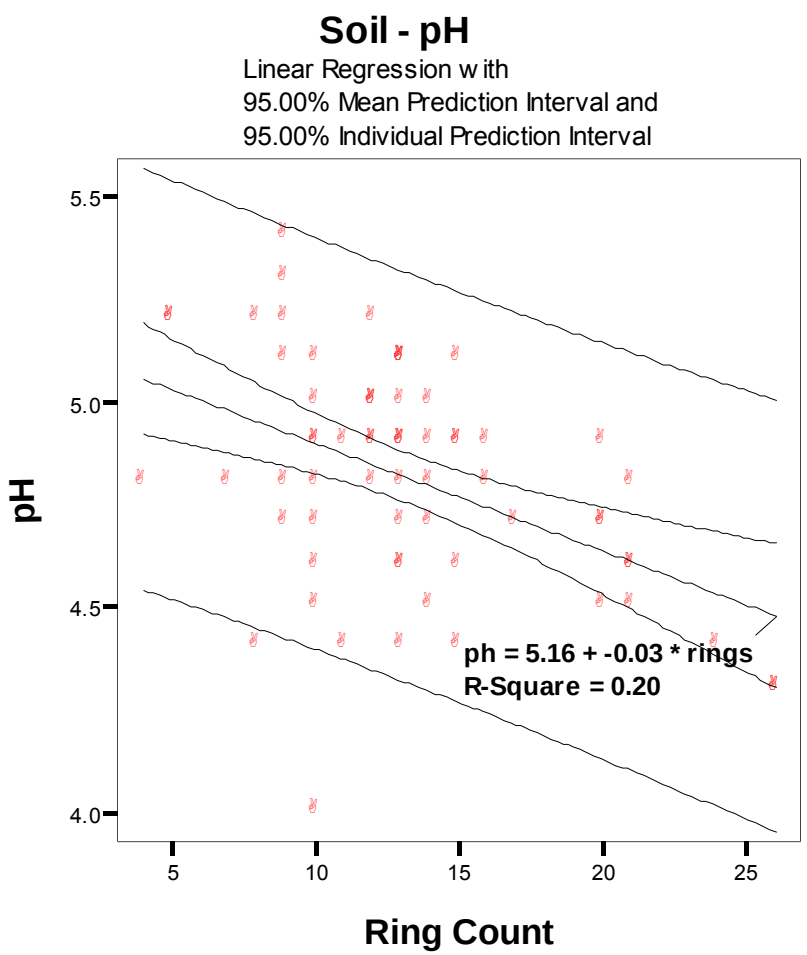
R^2=.34



Linear Regression for pH

P=0.000

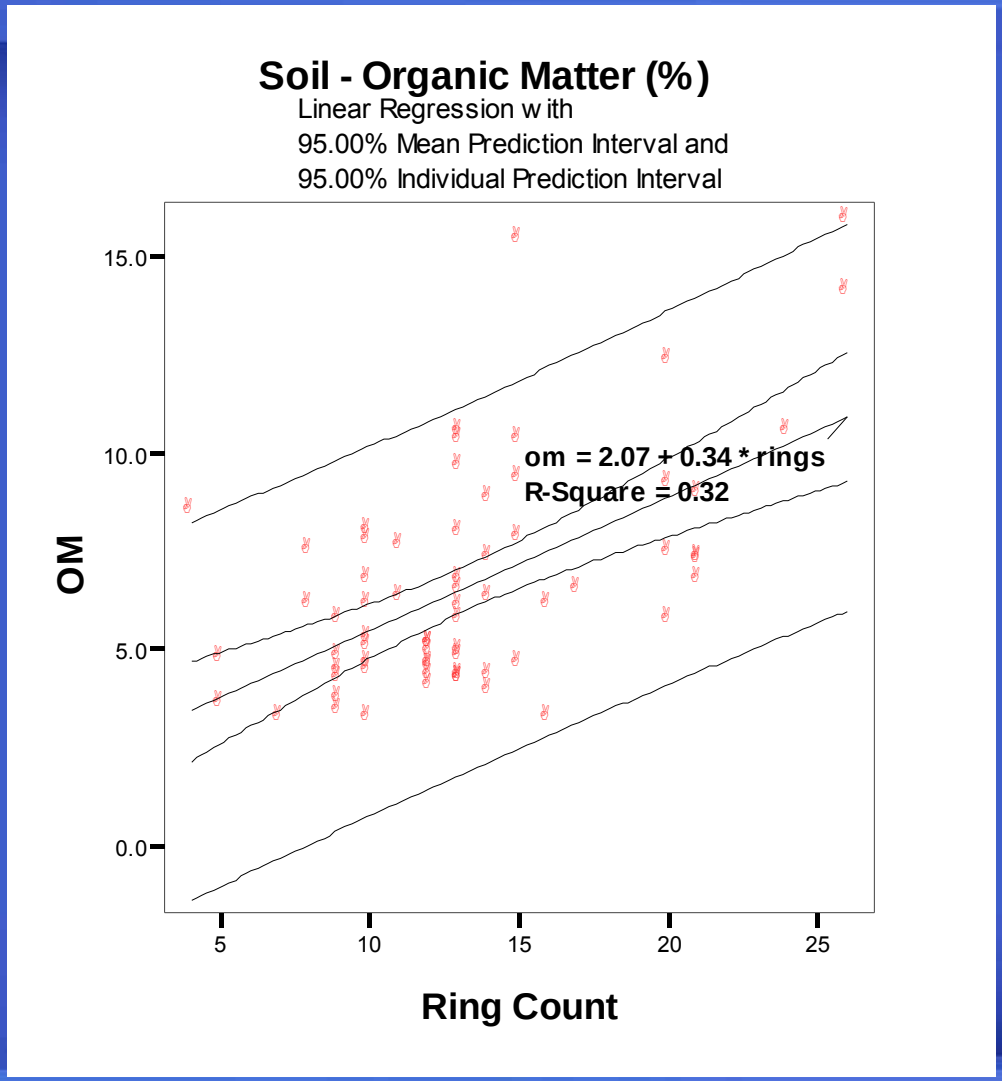
R^2=.20



Linear Regression for OM

P=0.000

R^2=.32



Discussion: Soil Properties

- Most important changes in the soil:
  - Increase in organic matter
  - Decrease in pH
  - Increase in nitrogen
- Organic matter build up is helping to drive the pH down, and the N up
- All of these are very important to plants, particularly plants using the top 10 cm, such as seedlings

Modeling Impact: Ecology

Parker et al. (1999) suggested:

$I = R \times A \times E$

I is overall impact on geographic scale

R is range area

A is average abundance across range

E is effect per individual

Modeling Impact: Agriculture

Vilá et al. (2004) suggested:

The impact of a weed cannot be considered independently of the crop.

The duration of the weed's presence, and the life history of the crop are also important.

Modeling Impact: My addition

Scott, B. (2005, Masters' thesis) suggest:

Plant invasions cannot be considered independent of the invaded community.

The duration of the invasive plant's presence is also important.

Consider plant characteristics which increase impact for specific systems:

Examples:

1. Increase fire risk a problem in dry areas, but not wet areas
2. Change in fertility a problem in low fertility systems, but maybe not roadsides

Implications of Soil Property Changes

After a plant invader is successfully removed…

- Increasing N may facilitate other invasive species
- Soil property changes may persist (see Dougherty & Reichard, Plant Protection Quarterly)
- Soil properties can be difficult to correct

Conclusions:

- This research showed that an invasive plant can continue to have effects as it stays resident.
- These effects need to be identified, and possibly corrected for before restoration.
- Need to have clearer understanding of how ecosystems are changed, and at what rate.
- Need to understand what constitutes impact in specific communities

Acknowledgements:

The soil and foliage tests done in this research were paid for by a seed grant from the Center for Invasive Plant Management, Montana State University.

Many thanks to my committee, Kern Ewing, Jennifer Ruesink and Darlene Zabowski.