# Investigating an Emerging Threat (Sickleweed)

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RMRS
ROCKY MOUNTAIN RESEARCH STATION

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

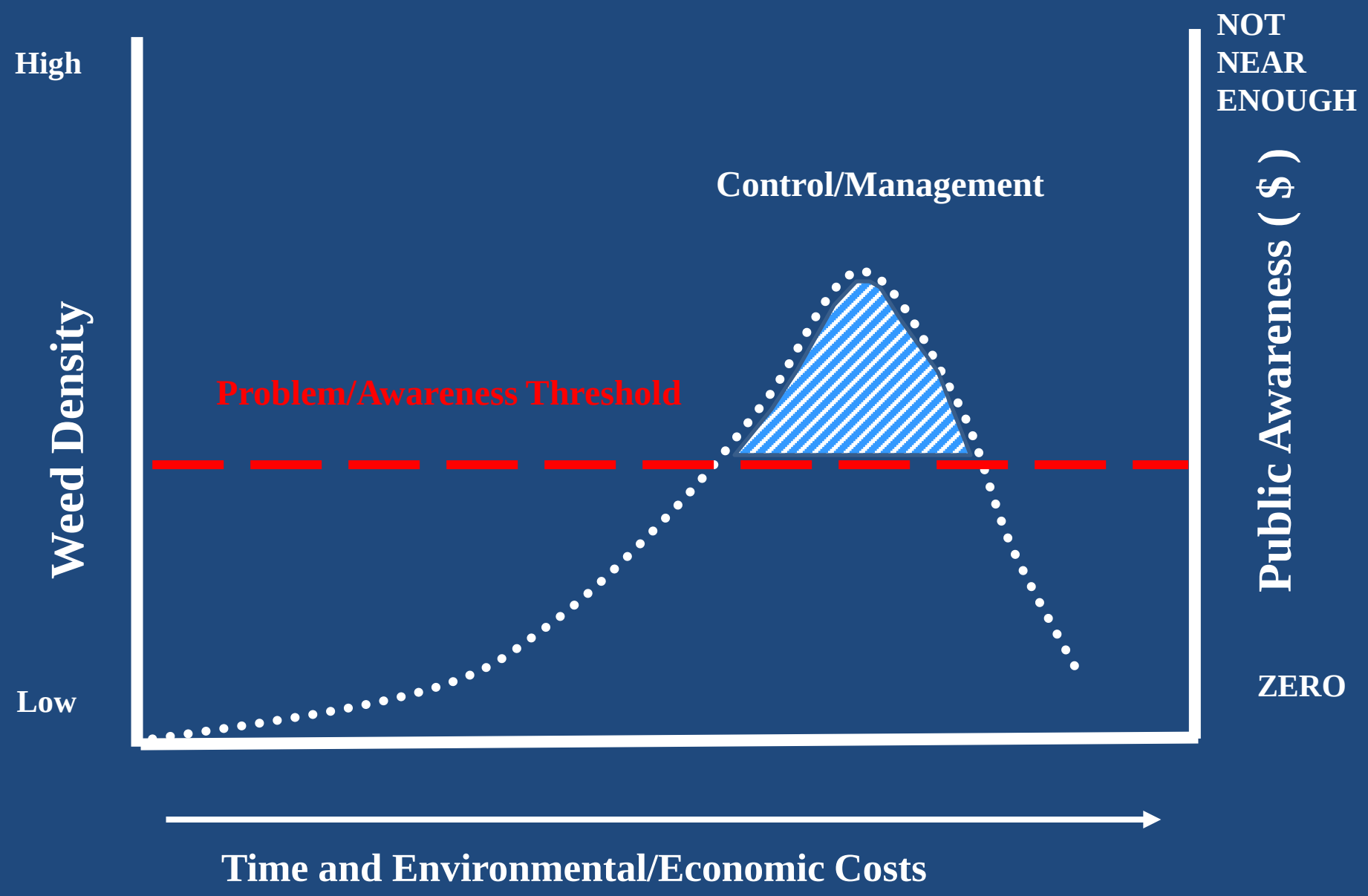
# Sickleweed (Apiacacea, *Falcaria vulgaris* L.)

PLANTS
Database
You are Here
SPM
DC
HI
PR
VI
FAVU

# Sickleweed on the Fort Pierre National Grasslands

**7 ft. 6 in. Professional Basketball Player for Scale**

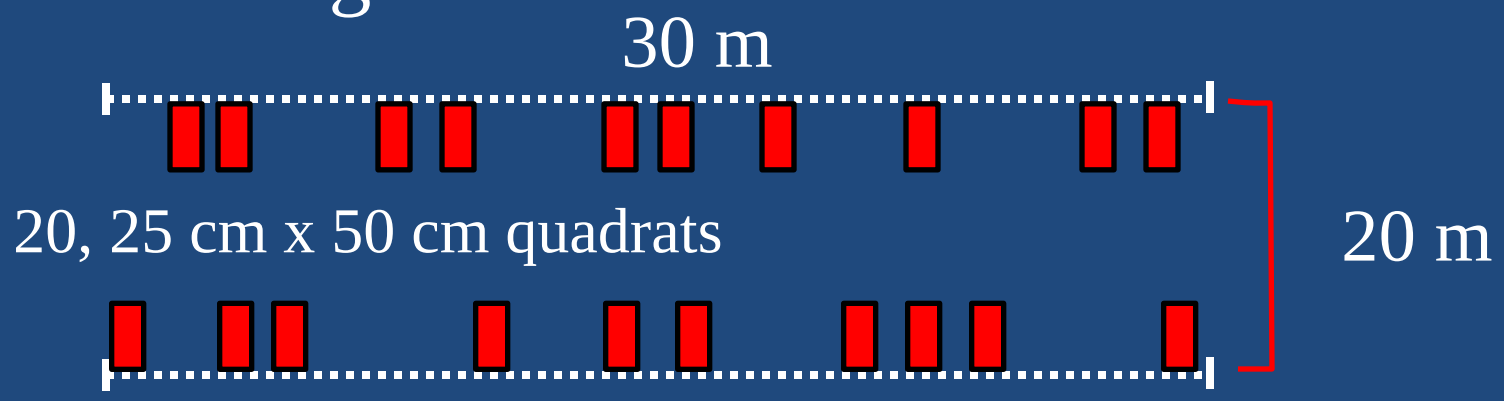
# How Did This Happen?

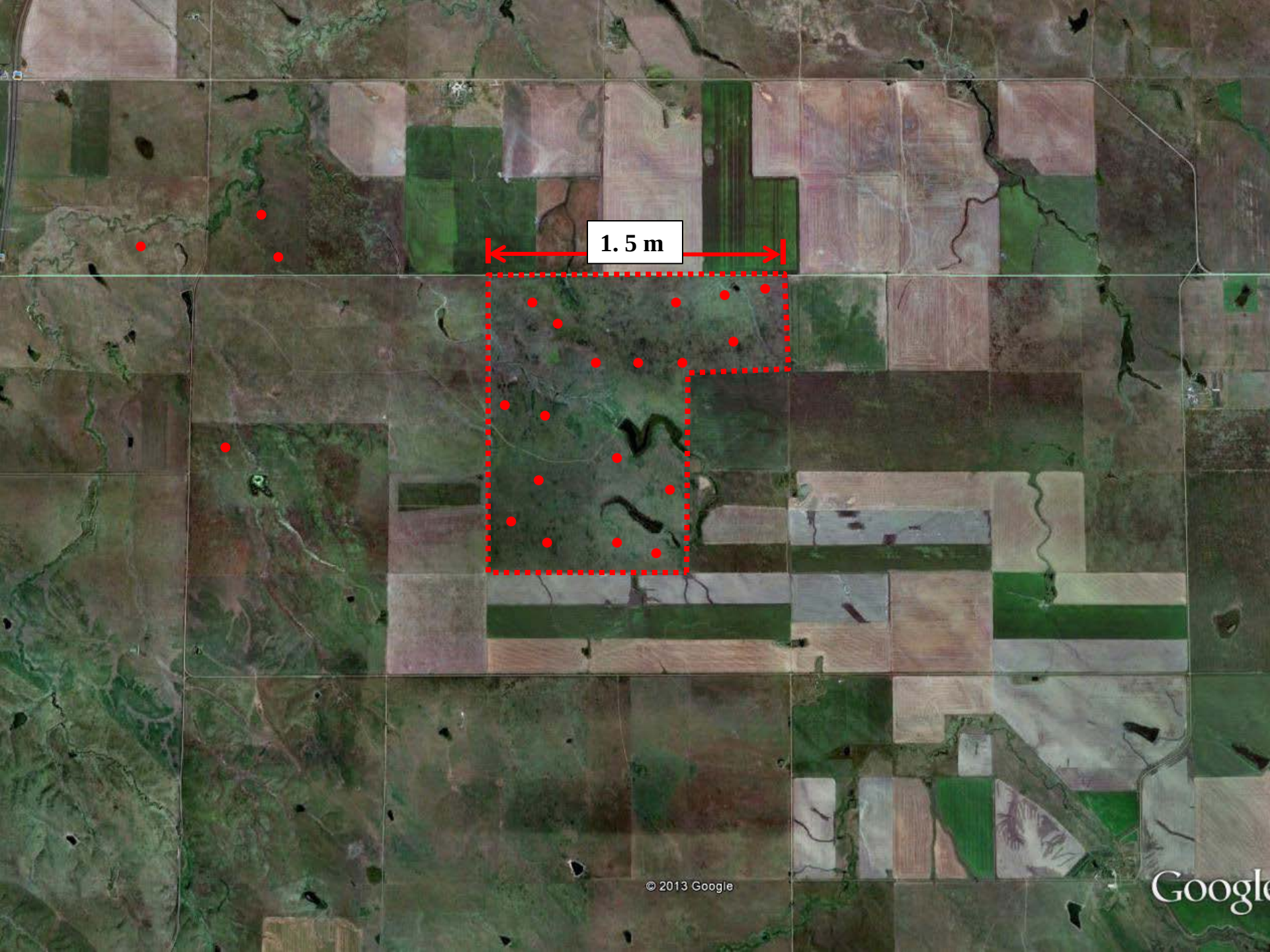

High
Low
Weed Density
Problem/Awareness Threshold
Control/Management
NOT
NEAR
ENOUGH
Public Awareness ( $ )
ZERO
Time and Environmental/Economic Costs

# Fort Pierre National Grasslands

# Vegetation Sampling

- 36 Randomly Placed Plots
  - 18 Burned / 18 Unburned
- Foliar Cover by Species Sampled in 2006 & 2007
- Plot Design




1. 5 m
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Google

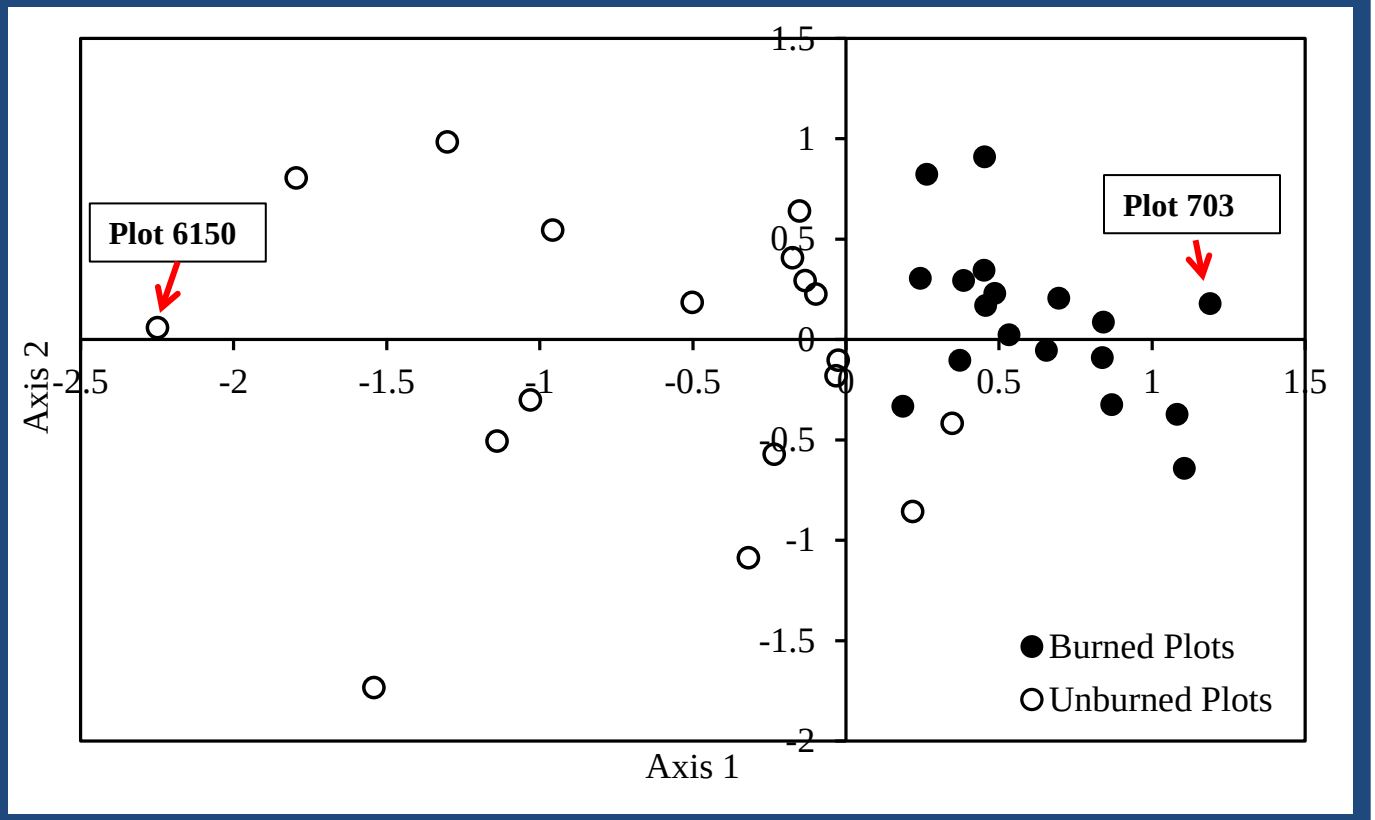
| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | Plots | | | | | | | | | | | | | |
| 63 | Species | | | | | | | | | | | | | |
| | Q | Q | Q | Q | Q | Q | Q | Q | Q | Q | Q | Q | Q | Q |
| Plots | **FALVUL** | ACHMIL | AGRCRI | ALLTEX | ANDGER | ARIPUR | ASCPUM | ASTADS | ASTFAL | BOUCUR | BOUGRA | BROINE | BROJAP | BUCDAC |
| 6324 | **50** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.625 | 0 |
| 63 | **46** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0 | 0 | 0 | 0 | 0 |
| 6160 | **45** | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.125 | 0 | 0.5 | 0 |
| 701 | **34** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 702 | **32** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 711 | **27** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.15 | 0 |
| 705 | **27** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.525 | 0 |
| 64 | **26** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8.125 | 5.25 | 0 | 0 | 0 |
| 712 | **25** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.275 | 0 |
| 719 | **24** | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.25 | 0 | 11.05 | 0 |
| 710 | **22** | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.025 | 0 |
| 717 | **20** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.125 | 0 | 0 | 1.125 | 0 |
| 6325 | **19** | 0 | 0 | 0 | 0 | 0 | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 707 | **19** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.875 | 0 |
| 720 | **18** | 0 | 19.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 | 2.25 | 4.9 | 0 |
| 713 | **17** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 716 | **17** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31.625 | 0.125 |
| 706 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.375 | 0 |
| 708 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 718 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.75 | 0 | 27.875 | 0 |
| 714 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.525 | 0 |
| 723 | **15** | 0 | 3.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 | 4.8 | 0.125 |
| 709 | **15** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.45 | 0 |
| 715 | **13** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.175 | 0 |
| 722 | **13** | 0 | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.125 | 6.275 | 0 |
| 703 | **10** | 0 | 0 | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 | 0 | 0 |
| 721 | **10** | 0 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 4.625 | 5 | 0 | 0.875 | 0 |
| 6125 | **7** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0 | 17 | 0.125 |
| 704 | **6** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6236 | **3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5.25 | 0 | 13.25 | 12.625 |
| 6139 | **1** | 0.125 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 2.5 | 0 |
| 2551 | **0** | 2.625 | 0 | 0 | 0 | 0 | 0 | 0 | 4.5 | 6.125 | 2.125 | 0 | 4 | 4.125 |
| 2552 | **0** | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.25 | 1.125 | 0 | 2.75 | 0 |
| 6150 | **0** | 1.25 | 1.625 | 0 | 0 | 0.375 | 0 | 0.125 | 2.625 | 0 | 0.25 | 0 | 9.875 | 8.5 |
| 6198 | **0** | 0 | 0 | 0 | 0.125 | 0.375 | 0 | 0 | 0 | 13.5 | 0 | 0 | 0 | 0 |
| 6256 | **0** | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0.5 | 0 | 0 | 1.5 | 0 |

# Indirect Gradient Analysis

## Ordination: NMDS (PC-ORD)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Plots | | | | | | | | |
| 63 | Species | | | | | | | | |
| | Q | Q | Q | Q | Q | Q | Q | Q | Q |
| Plots | **FALVUL** | ACHMIL | AGRCRI | ALLTEX | ANDGER | ARIPUR | ASCPUM | ASTADS | ASTFAL |
| 701 | **34** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 702 | **32** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 703 | **10** | 0 | 0 | 0.25 | 0 | 0 | 0 | 0 | 0 |
| 704 | **6** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 705 | **27** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 706 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 707 | **19** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 708 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 709 | **15** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 710 | **22** | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 711 | **27** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 712 | **25** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 713 | **17** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 714 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 715 | **13** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6160 | **45** | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6236 | **3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6256 | **0** | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 |
| 63 | **46** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.75 |
| 64 | **26** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 716 | **17** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 717 | **20** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 718 | **16** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 719 | **24** | 0.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 720 | **18** | 0 | 19.125 | 0 | 0 | 0 | 0 | 0 | 0 |
| 721 | **10** | 0 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 722 | **13** | 0 | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 |
| 723 | **15** | 0 | 3.125 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2551 | **0** | 2.625 | 0 | 0 | 0 | 0 | 0 | 0 | 4.5 |
| 2552 | **0** | 0.125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6125 | **7** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6139 | **1** | 0.125 | 17 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6150 | **0** | 1.25 | 1.625 | 0 | 0 | 0.375 | 0 | 0.125 | 2.625 |
| 6198 | **0** | 0 | 0 | 0 | 0.125 | 0.375 | 0 | 0 | 0 |
| 6324 | **50** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6325 | **19** | 0 | 0 | 0 | 0 | 0 | 0.125 | 0 | 0 |

| Plot | | X-Axis | Y-Axis |
|---|---|---|---|
| 701 | Burn | 0.70 | 0.20 |
| 702 | Burn | 0.46 | 0.17 |
| 703 | Burn | 1.19 | 0.18 |
| 704 | Burn | 0.45 | 0.34 |
| 705 | Burn | 0.37 | -0.10 |
| 706 | Burn | 0.45 | 0.91 |
| 707 | Burn | 1.08 | -0.37 |
| 708 | Burn | 0.39 | 0.29 |
| 709 | Burn | 0.84 | 0.09 |
| 710 | Burn | 0.87 | -0.33 |
| 711 | Burn | 0.84 | -0.09 |
| 712 | Burn | 0.66 | -0.06 |
| 713 | Burn | 0.53 | 0.02 |
| 714 | Burn | 0.24 | 0.30 |
| 715 | Burn | 0.49 | 0.23 |
| 6160 | Burn | 0.19 | -0.33 |
| 6324 | Burn | 0.27 | 0.82 |
| 6325 | Burn | 1.11 | -0.64 |
| 63 | Unburned | 0.22 | -0.86 |
| 64 | Unburned | -0.32 | -1.09 |
| 716 | Unburned | -0.10 | 0.23 |
| 717 | Unburned | 0.35 | -0.42 |
| 718 | Unburned | -0.13 | 0.29 |
| 719 | Unburned | -0.17 | 0.41 |
| 720 | Unburned | -0.15 | 0.64 |
| 721 | Unburned | -0.23 | -0.57 |
| 722 | Unburned | -0.03 | -0.18 |
| 723 | Unburned | -0.03 | -0.10 |
| 2551 | Unburned | -1.80 | 0.80 |
| 2552 | Unburned | -0.96 | 0.54 |
| 6125 | Unburned | -0.50 | 0.18 |
| 6139 | Unburned | -1.03 | -0.30 |
| 6150 | Unburned | -2.25 | 0.06 |
| 6198 | Unburned | -1.54 | -1.73 |
| 6236 | Unburned | -1.14 | -0.51 |
| 6256 | Unburned | -1.30 | 0.98 |




| Plot | | X-Axis | Y-Axis |
|---|---|---|---|
| 701 | Burn | 0.70 | 0.20 |
| 702 | Burn | 0.46 | 0.17 |
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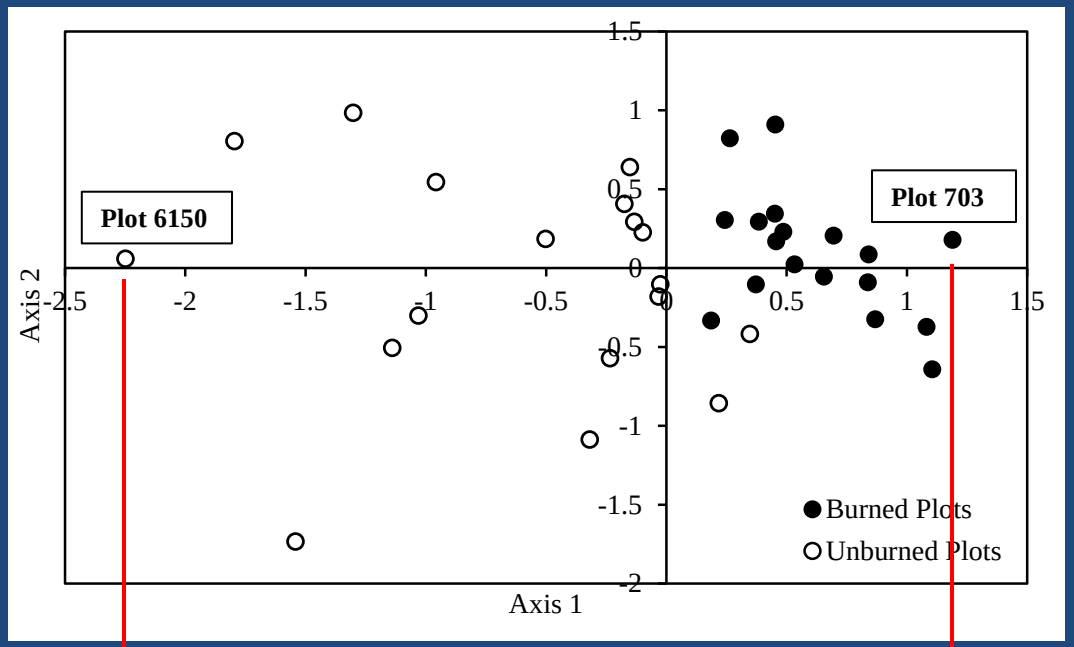
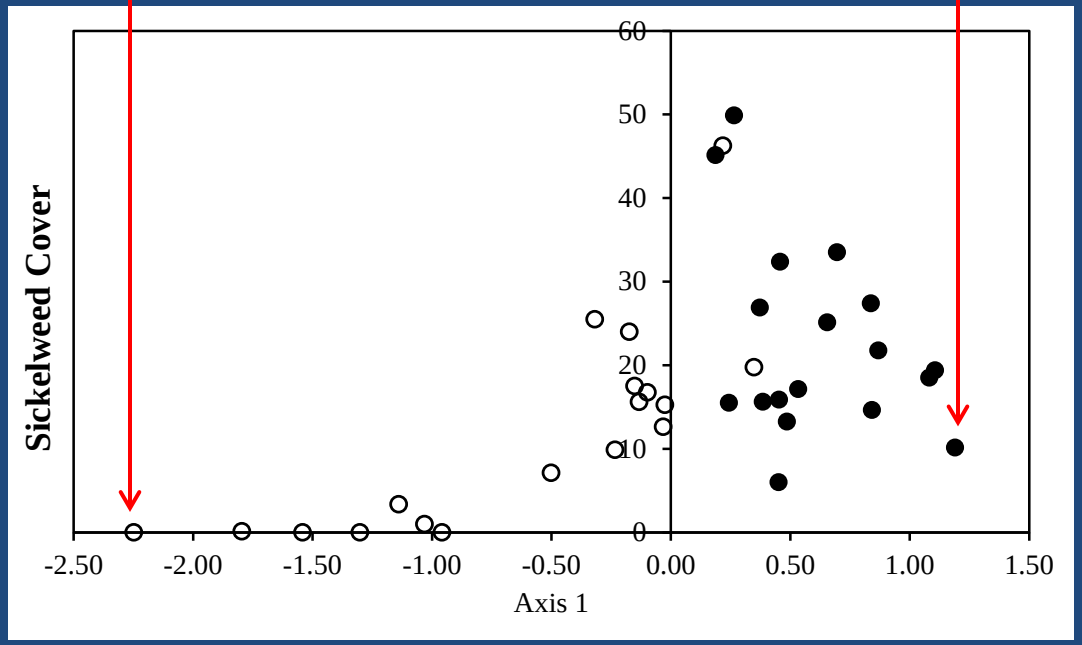
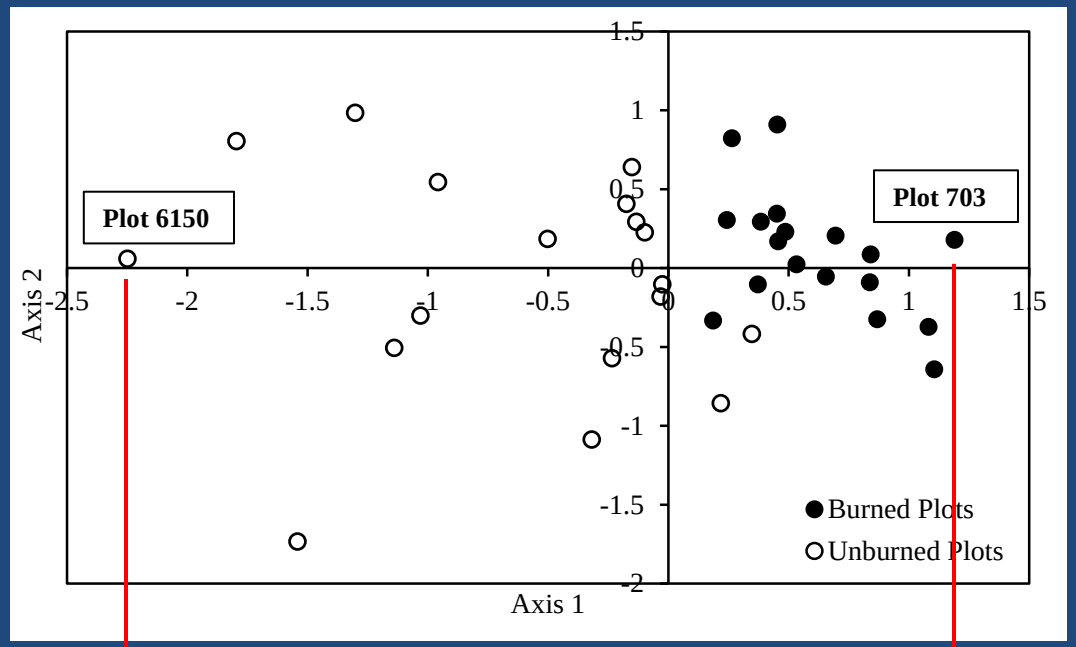
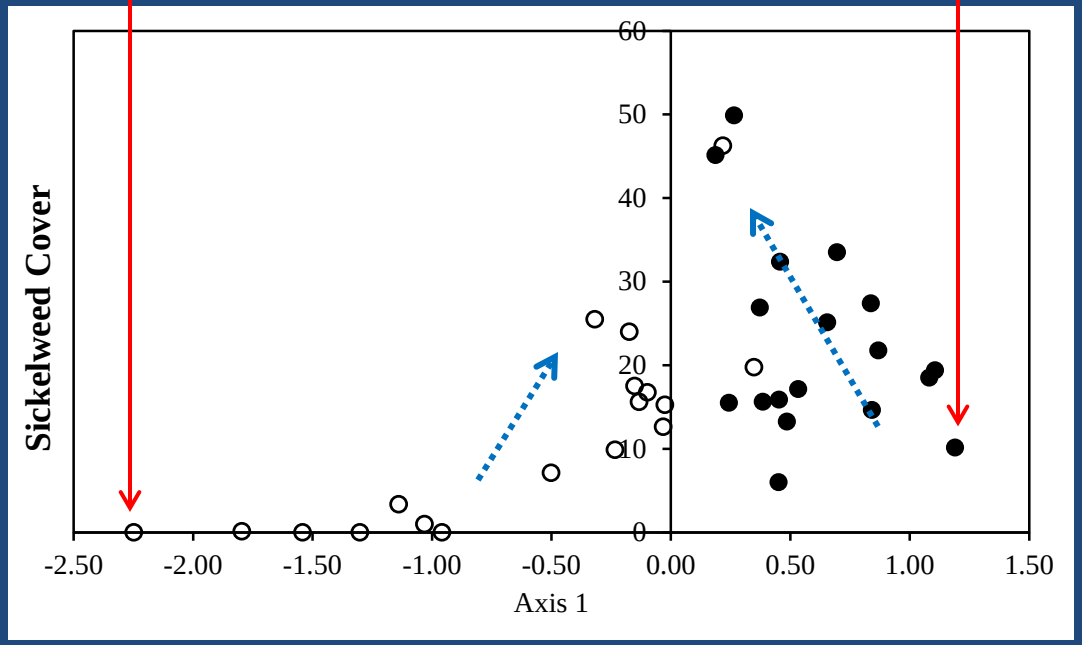
| 707 | Burn | 1.08 | -0.37 |
| 708 | Burn | 0.39 | 0.29 |
| 709 | Burn | 0.84 | 0.09 |
| 710 | Burn | 0.87 | -0.33 |
| 711 | Burn | 0.84 | -0.09 |
| 712 | Burn | 0.66 | -0.06 |
| 713 | Burn | 0.53 | 0.02 |
| 714 | Burn | 0.24 | 0.30 |
| 715 | Burn | 0.49 | 0.23 |
| 6160 | Burn | 0.19 | -0.33 |
| 6324 | Burn | 0.27 | 0.82 |
| 6325 | Burn | 1.11 | -0.64 |
| 6150 | Unburned | -2.25 | 0.06 |
| 2551 | Unburned | -1.80 | 0.80 |
| 6256 | Unburned | -1.30 | 0.98 |
| 6198 | Unburned | -1.54 | -1.73 |
| 2552 | Unburned | -0.96 | 0.54 |
| 6139 | Unburned | -1.03 | -0.30 |
| 6236 | Unburned | -1.14 | -0.51 |
| 720 | Unburned | -0.15 | 0.64 |
| 718 | Unburned | -0.13 | 0.29 |
| 716 | Unburned | -0.10 | 0.23 |
| 723 | Unburned | -0.03 | -0.10 |
| 721 | Unburned | -0.23 | -0.57 |
| 6125 | Unburned | -0.50 | 0.18 |
| 722 | Unburned | -0.03 | -0.18 |
| 719 | Unburned | -0.17 | 0.41 |
| 64 | Unburned | -0.32 | -1.09 |
| 717 | Unburned | 0.35 | -0.42 |
| 63 | Unburned | 0.22 | -0.86 |



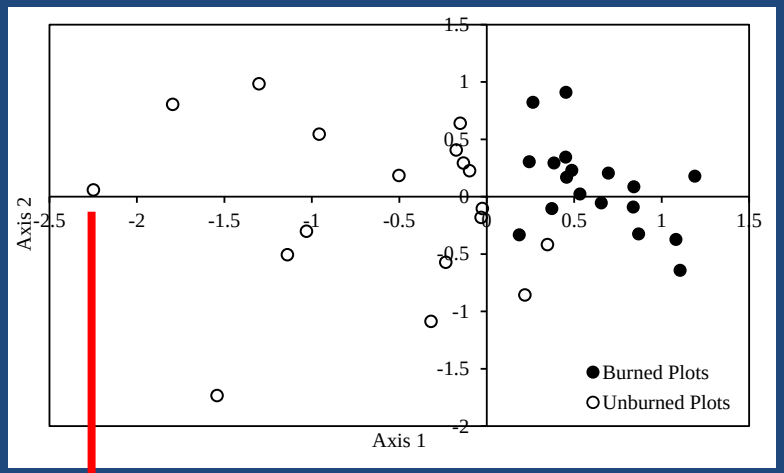

| Plot | Burn | Axis 1 | FALVUL |
|---|---|---|---|
| 701 | B | 0.696 | 34 |
| 702 | B | 0.457 | 32 |
| 703 | B | 1.190 | 10 |
| 704 | B | 0.452 | 6 |
| 705 | B | 0.373 | 27 |
| 706 | B | 0.453 | 16 |
| 707 | B | 1.082 | 19 |
| 708 | B | 0.385 | 16 |
| 709 | B | 0.842 | 15 |
| 710 | B | 0.869 | 22 |
| 711 | B | 0.838 | 27 |
| 712 | B | 0.655 | 25 |
| 713 | B | 0.534 | 17 |
| 714 | B | 0.244 | 16 |
| 715 | B | 0.487 | 13 |
| 6160 | B | 0.187 | 45 |
| 6324 | B | 0.265 | 50 |
| 6325 | B | 1.106 | 19 |
| 6150 | UB | -2.249 | 0 |
| 2551 | UB | -1.796 | 0 |
| 6256 | UB | -1.302 | 0 |
| 6198 | UB | -1.541 | 0 |
| 2552 | UB | -0.958 | 0 |
| 6139 | UB | -1.031 | 1 |
| 6236 | UB | -1.140 | 3 |
| 720 | UB | -0.152 | 18 |
| 718 | UB | -0.133 | 16 |
| 716 | UB | -0.098 | 17 |
| 723 | UB | -0.025 | 15 |
| 721 | UB | -0.234 | 10 |
| 6125 | UB | -0.501 | 7 |
| 722 | UB | -0.032 | 13 |
| 719 | UB | -0.174 | 24 |
| 64 | UB | -0.318 | 26 |
| 717 | UB | 0.348 | 20 |
| 63 | UB | 0.218 | 46 |



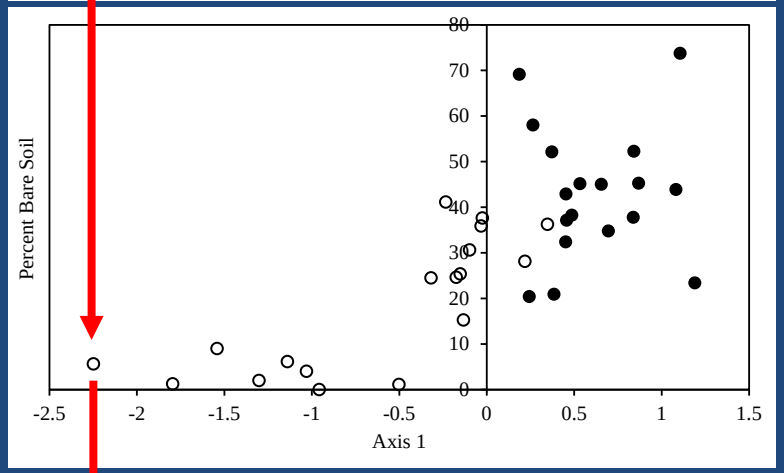




| Plot | Burn | Axis 1 | FALVUL |
|---|---|---|---|
| 701 | B | 0.696 | 34 |
| 702 | B | 0.457 | 32 |
| 703 | B | 1.190 | 10 |
| 704 | B | 0.452 | 6 |
| 705 | B | 0.373 | 27 |
| 706 | B | 0.453 | 16 |
| 707 | B | 1.082 | 19 |
| 708 | B | 0.385 | 16 |
| 709 | B | 0.842 | 15 |
| 710 | B | 0.869 | 22 |
| 711 | B | 0.838 | 27 |
| 712 | B | 0.655 | 25 |
| 713 | B | 0.534 | 17 |
| 714 | B | 0.244 | 16 |
| 715 | B | 0.487 | 13 |
| 6160 | B | 0.187 | 45 |
| 6324 | B | 0.265 | 50 |
| 6325 | B | 1.106 | 19 |
| 6150 | UB | -2.249 | 0 |
| 2551 | UB | -1.796 | 0 |
| 6256 | UB | -1.302 | 0 |
| 6198 | UB | -1.541 | 0 |
| 2552 | UB | -0.958 | 0 |
| 6139 | UB | -1.031 | 1 |
| 6236 | UB | -1.140 | 3 |
| 720 | UB | -0.152 | 18 |
| 718 | UB | -0.133 | 16 |
| 716 | UB | -0.098 | 17 |
| 723 | UB | -0.025 | 15 |
| 721 | UB | -0.234 | 10 |
| 6125 | UB | -0.501 | 7 |
| 722 | UB | -0.032 | 13 |
| 719 | UB | -0.174 | 24 |
| 64 | UB | -0.318 | 26 |
| 717 | UB | 0.348 | 20 |
| 63 | UB | 0.218 | 46 |

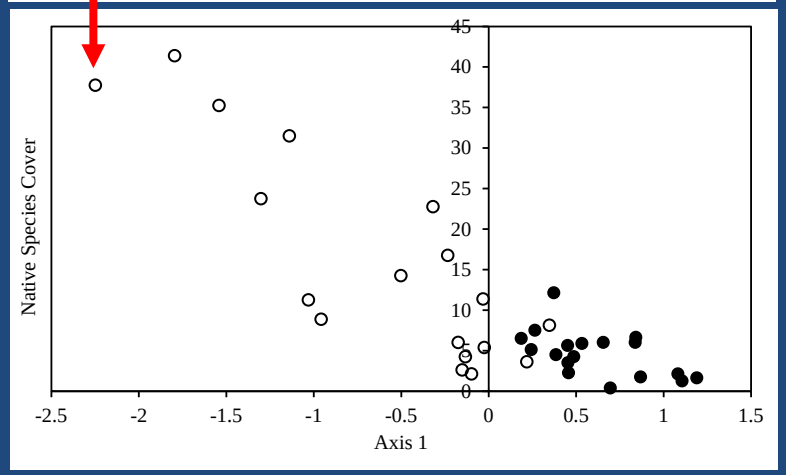
**Ordination Plot Axis 1 * Axis 2**



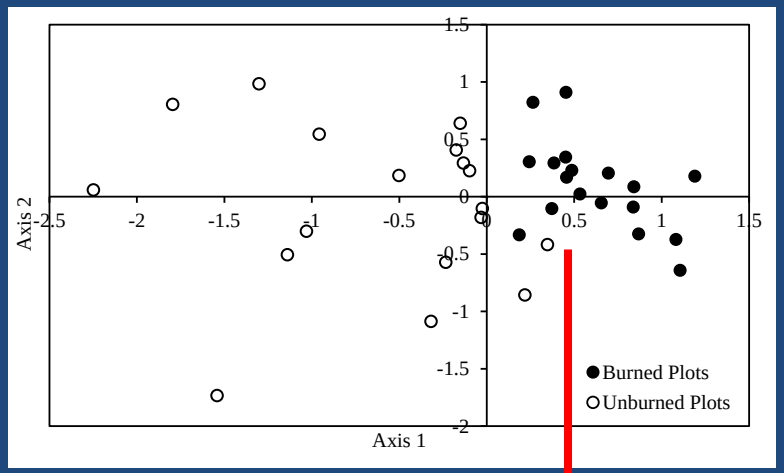

**Plot of Bare Soil * Axis 1**



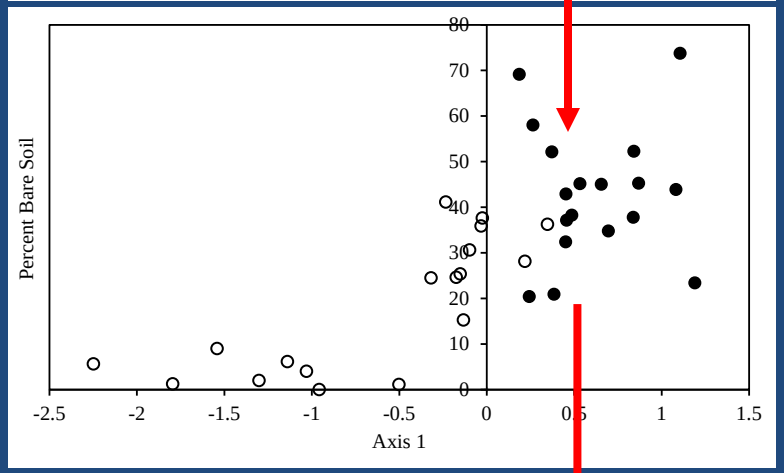

**Plot of Native Species Cover * Axis 1**



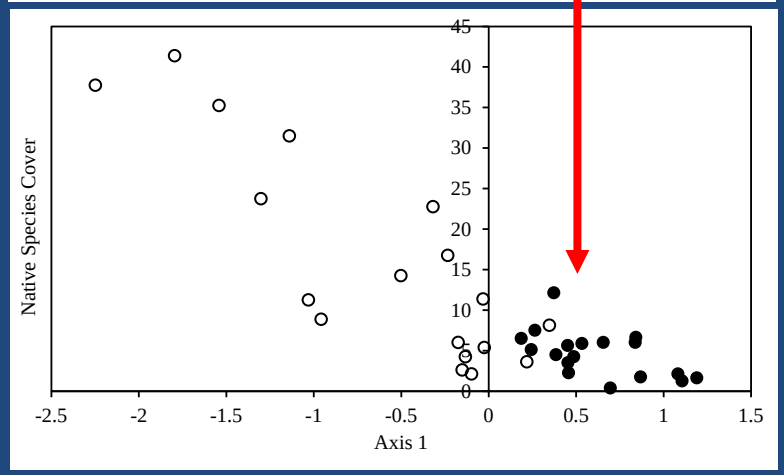
**Ordination Plot Axis 1 * Axis 2**

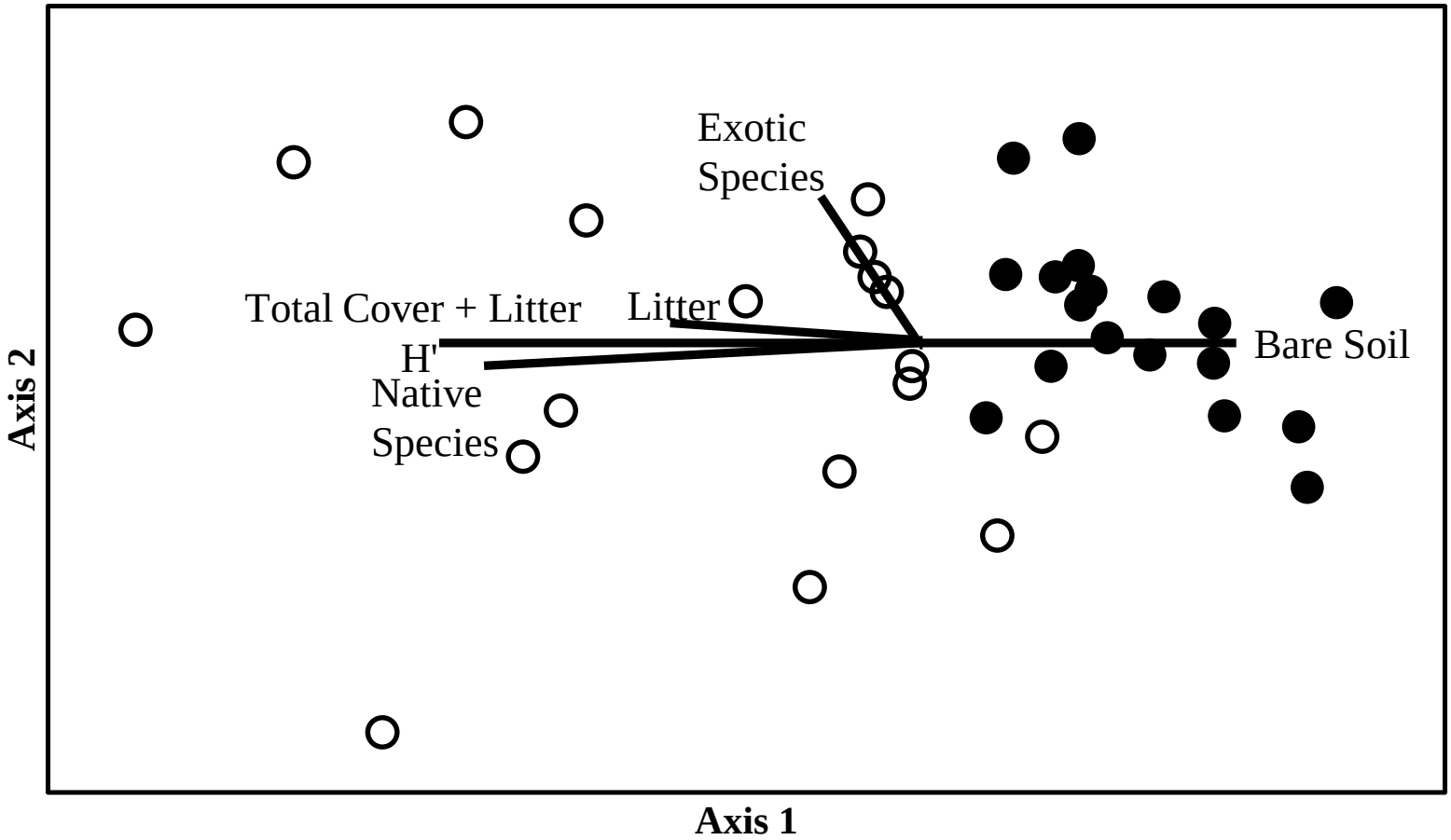



**Plot of Bare Soil * Axis 1**



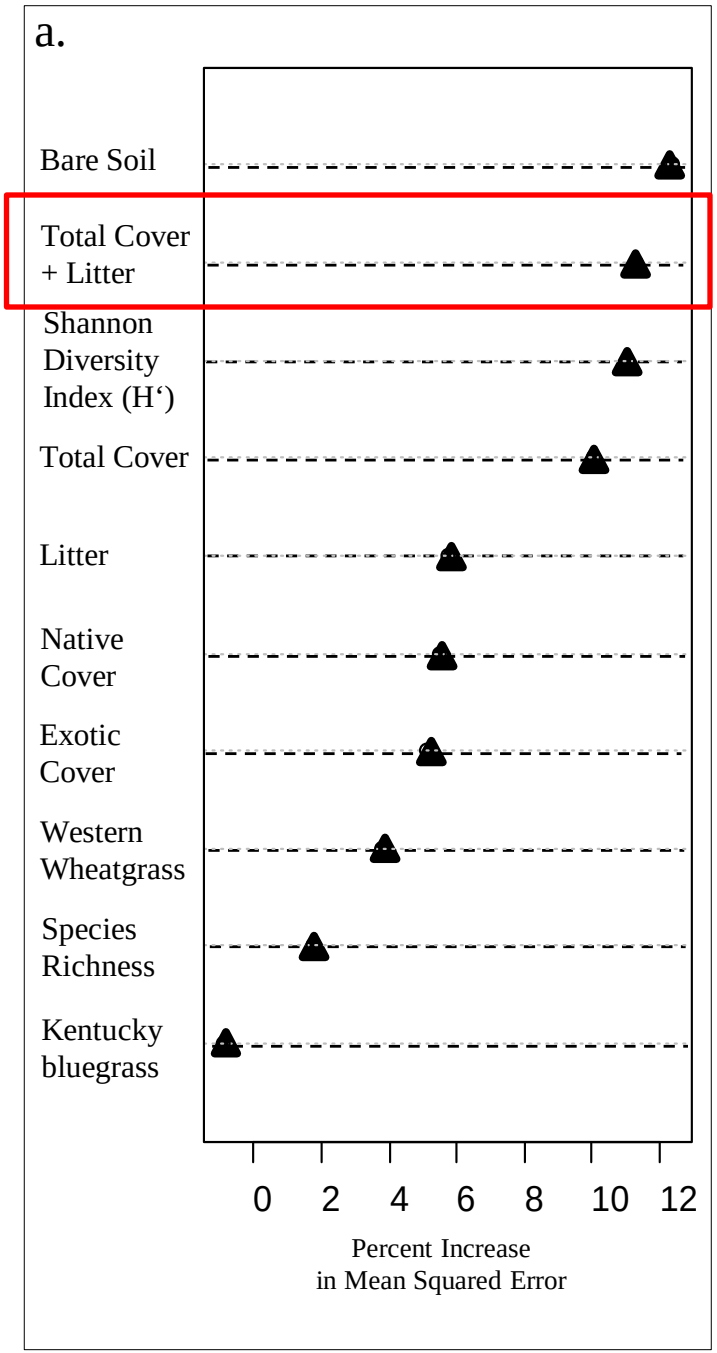

**Plot of Native Species Cover * Axis 1**



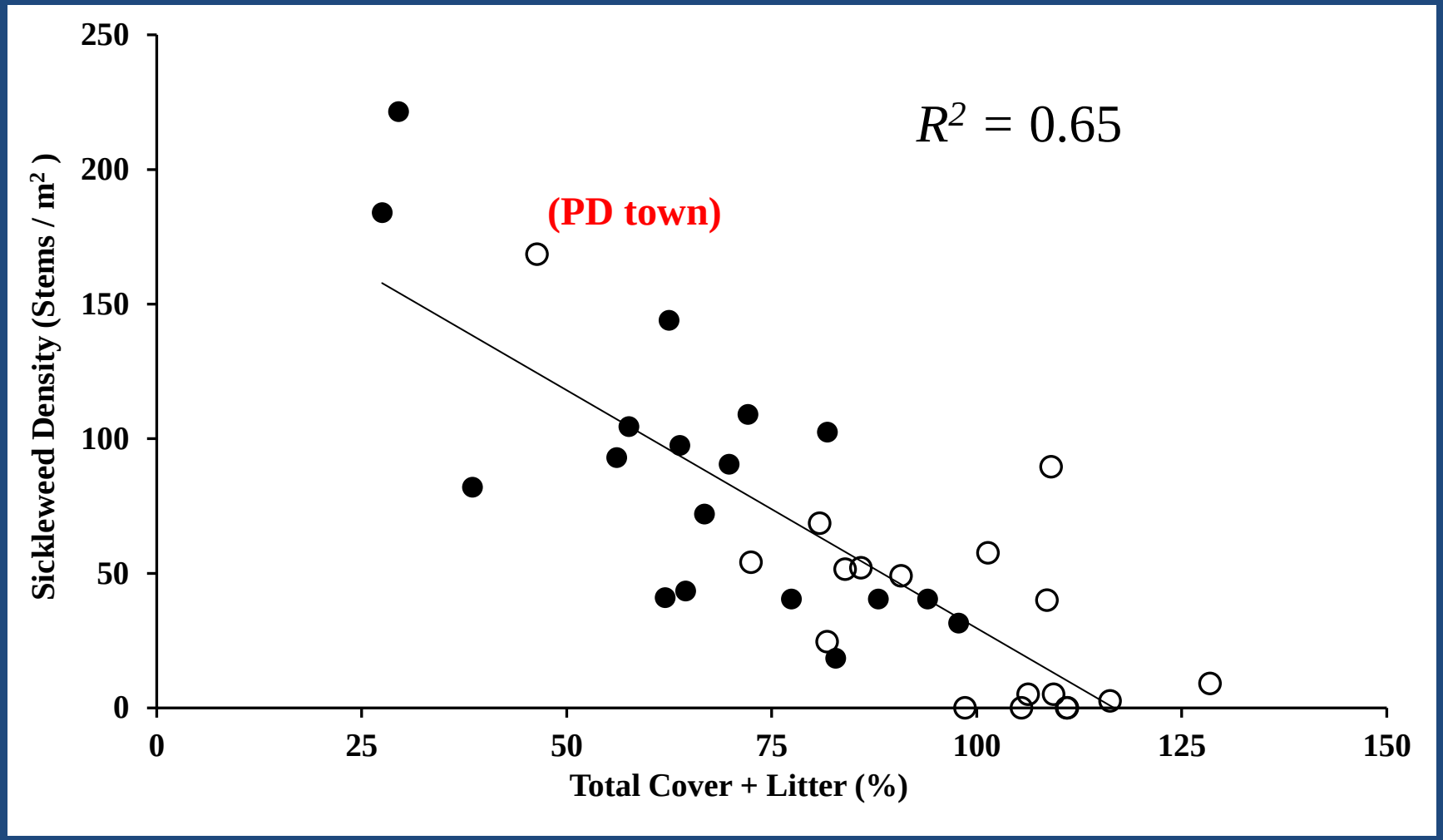

Exotic
Species
Total Cover + Litter
Litter
H'
Native
Species
Bare Soil
Axis 2
Axis 1

# Variable Importance Plot (R software)

**Ranks importance of variables to Sickleweed Density**

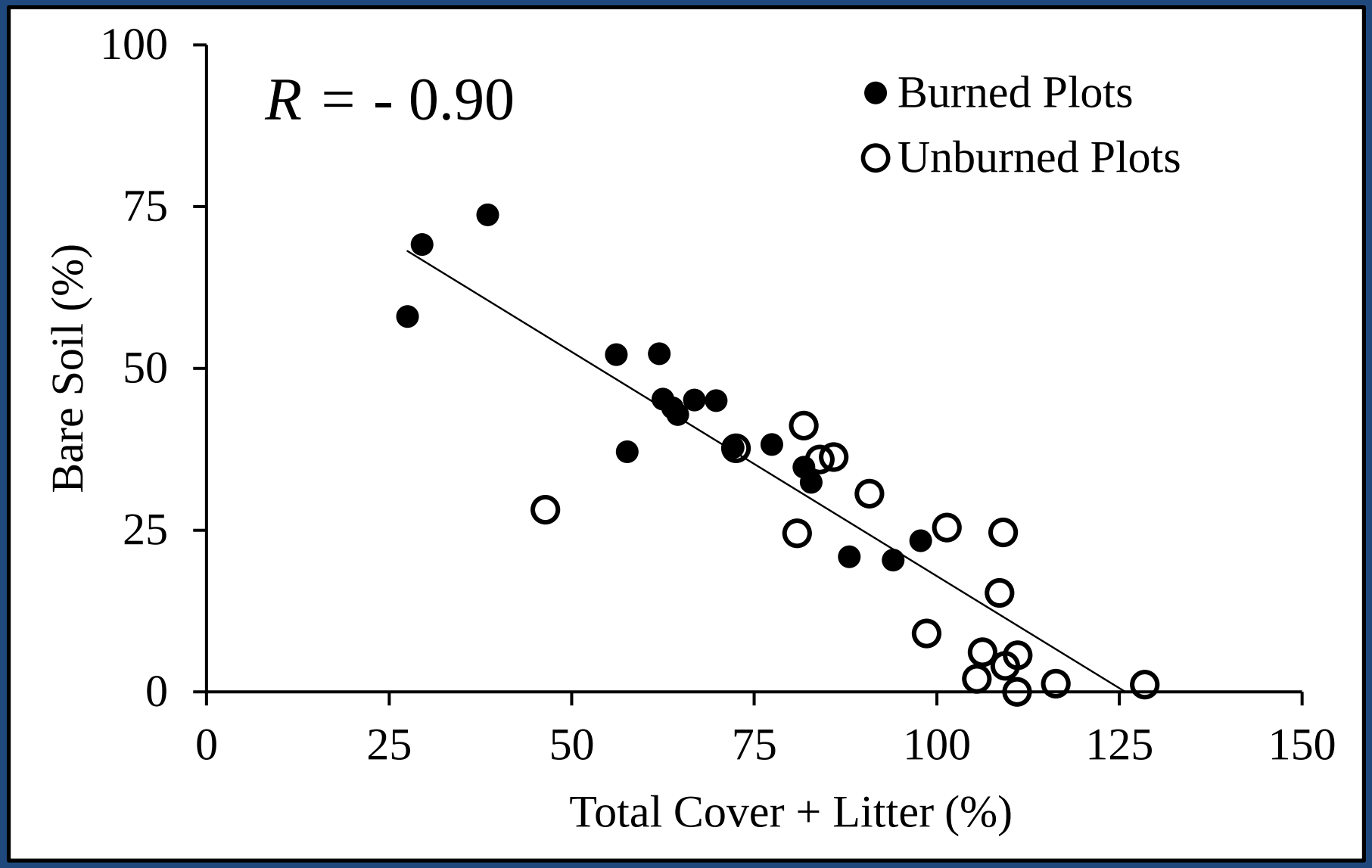


# Sickleweed Density * Total Cover + Litter

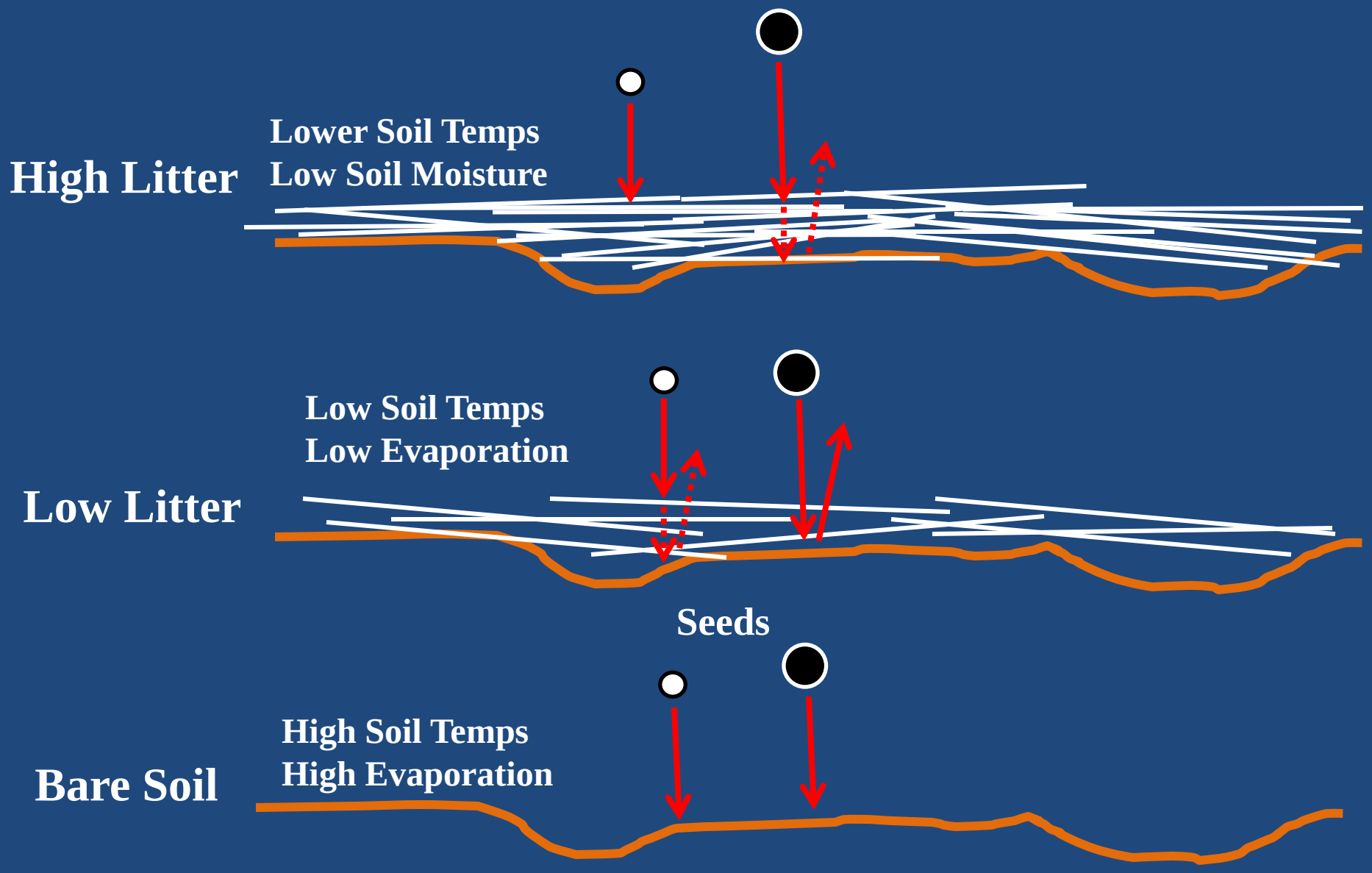



**Total Cover (minus FALVUL) ≈ Competition Intensity**
**Litter: Lowers Soil Temperature + Mechanical Barrier**

# Strong Correlation: Bare Soil * Total Cover + Litter

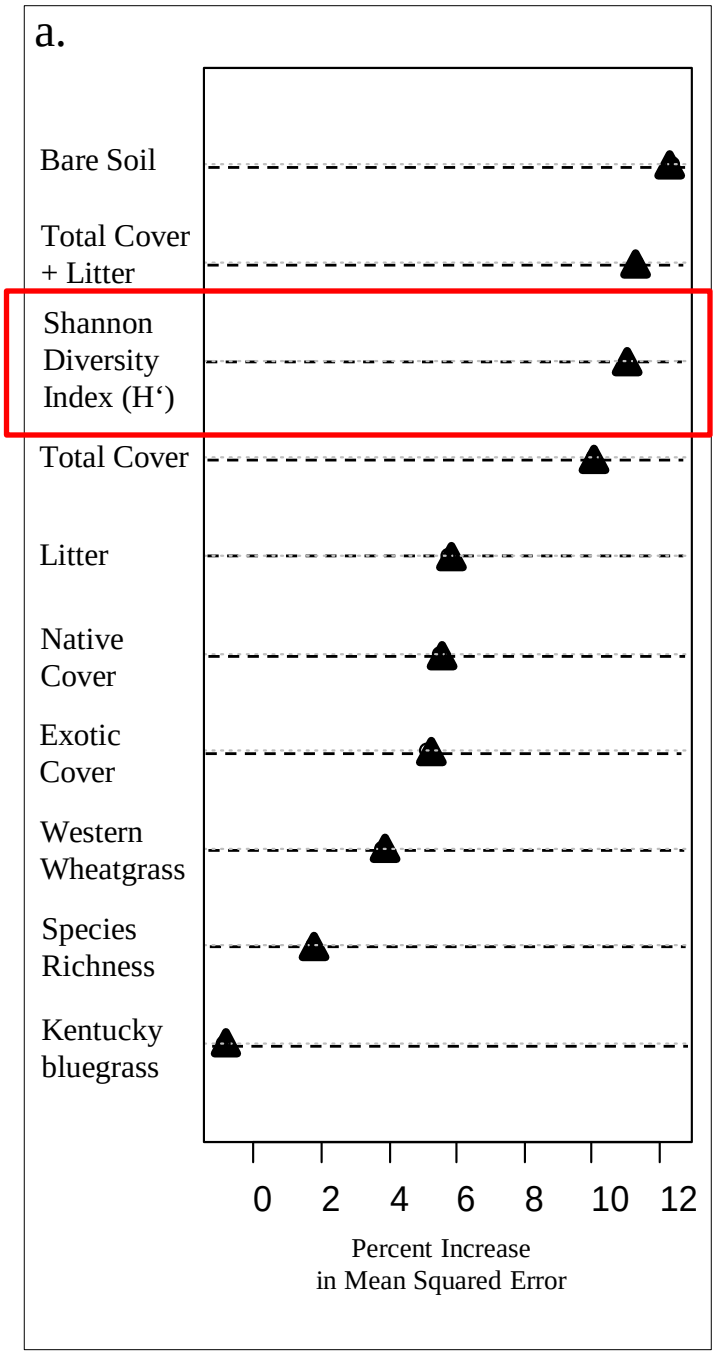


# Effects of Litter on Seed Germination & Emergence



# Variable Importance Plot

**Ranks importance of variables to Sickleweed Density**

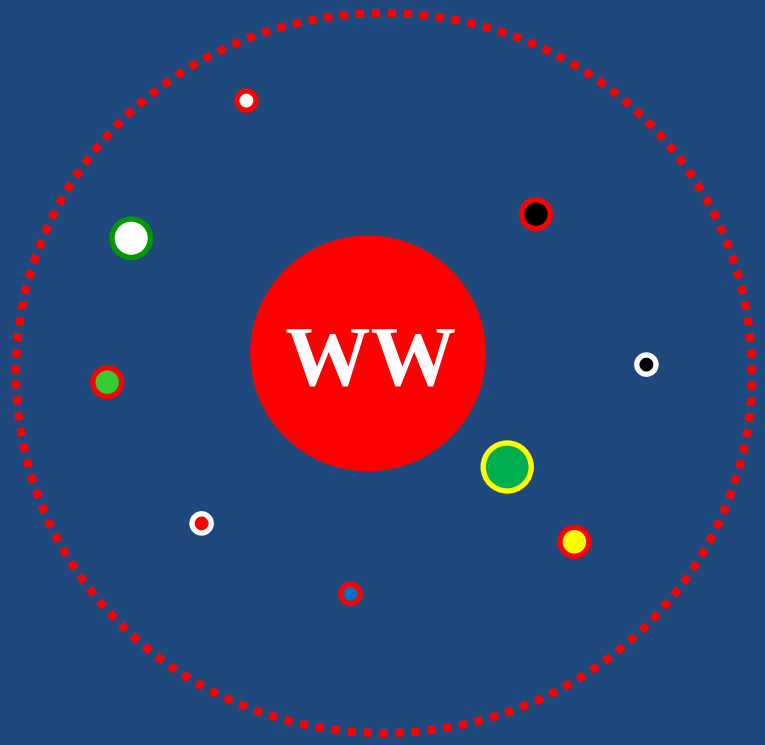


# Shannon Diversity Index (H′)

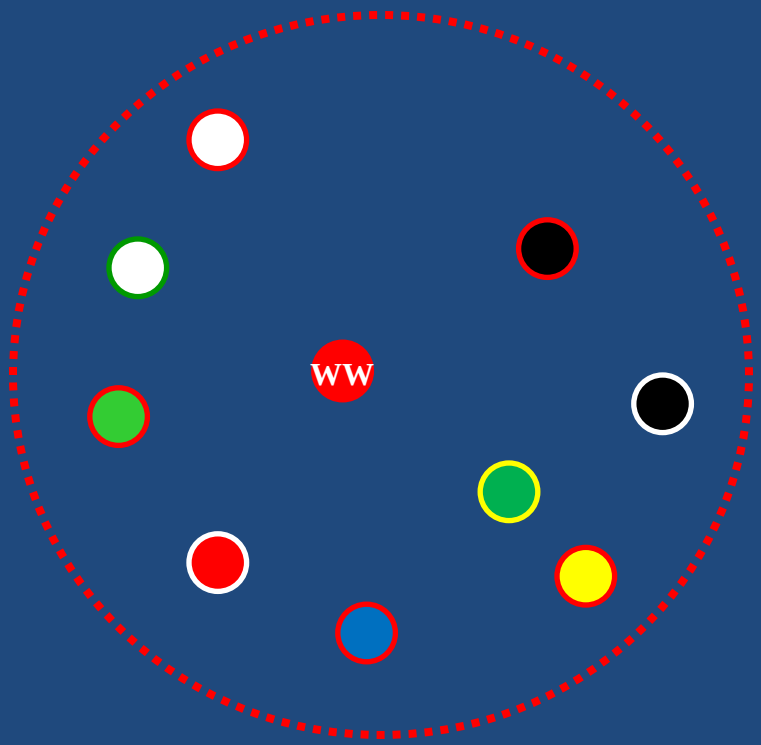
- Proportional Abundance
- Number of Species (Richness)

Our Study H′ values ranged from 0.824 to 2.578

**Low Diversity**




**High Diversity**



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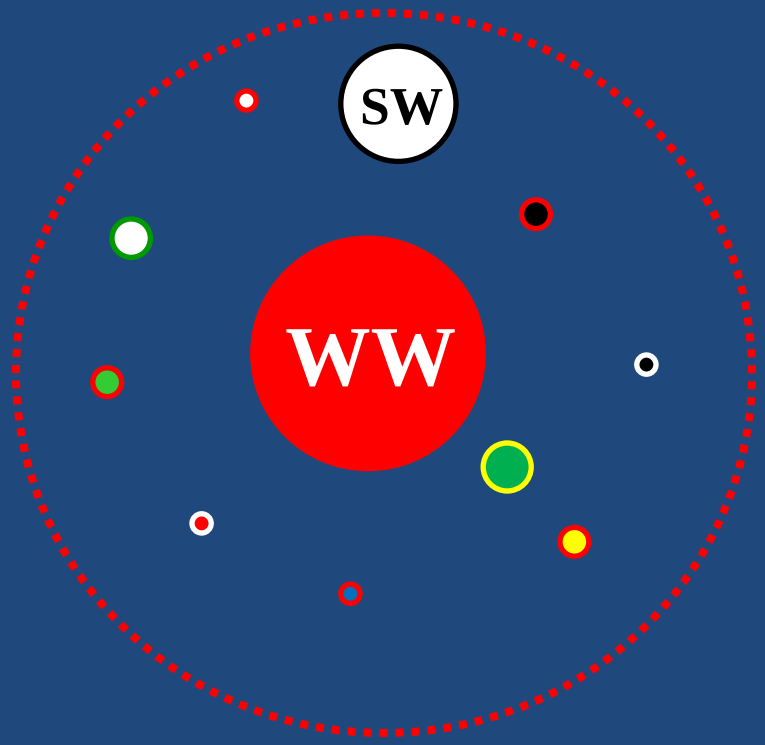
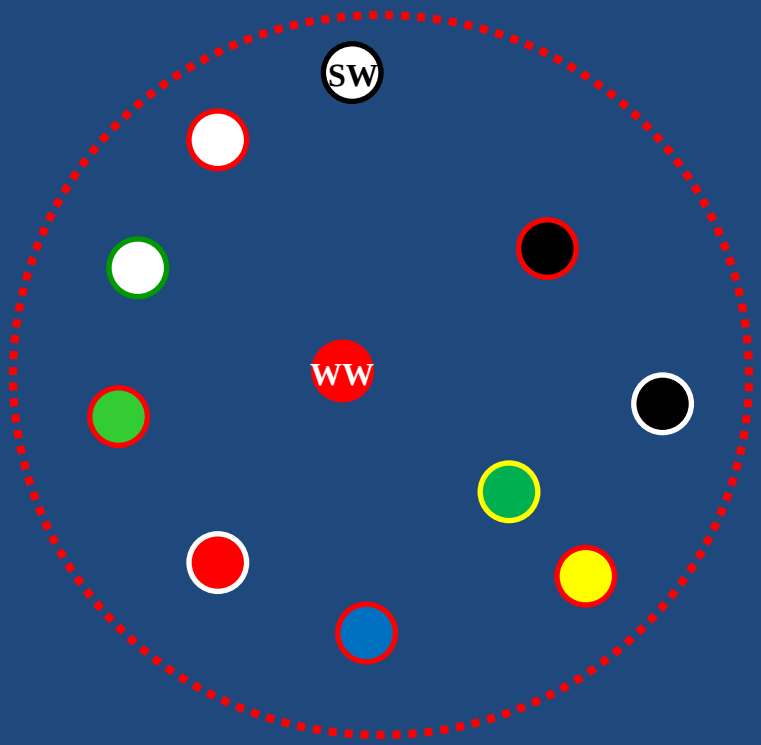



**High Diversity**

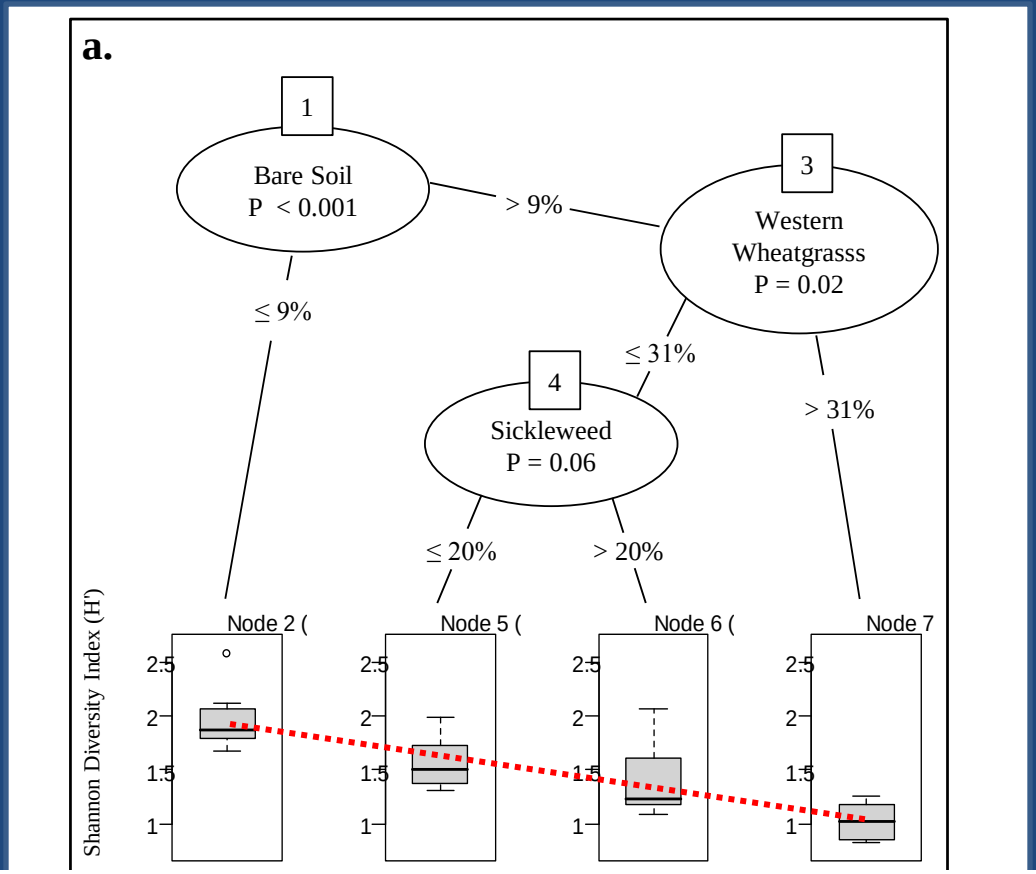


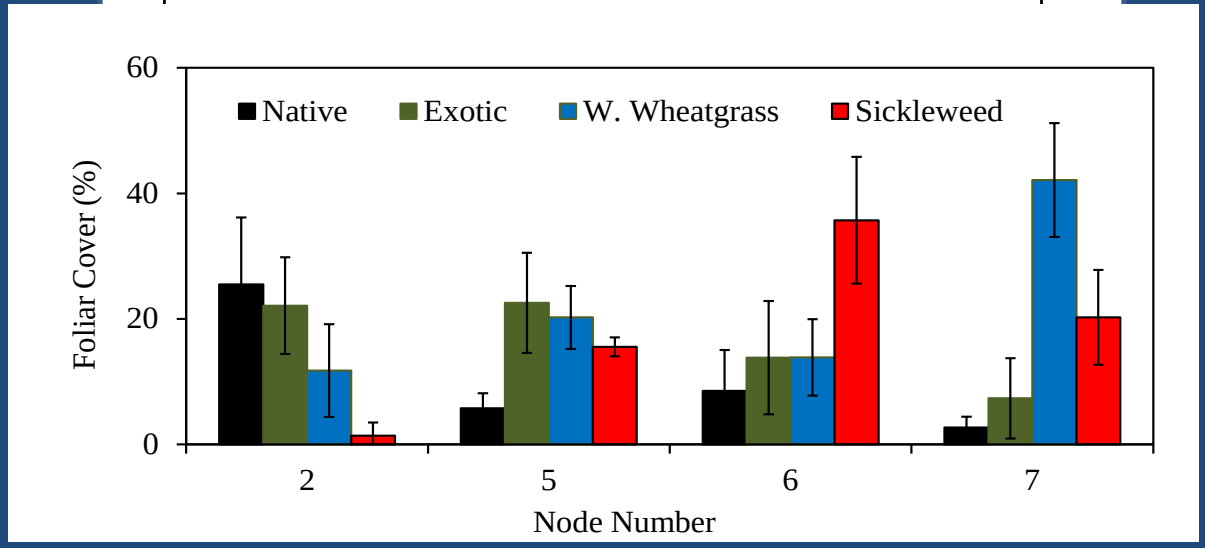
# Classification and Regression Tree (ctree)

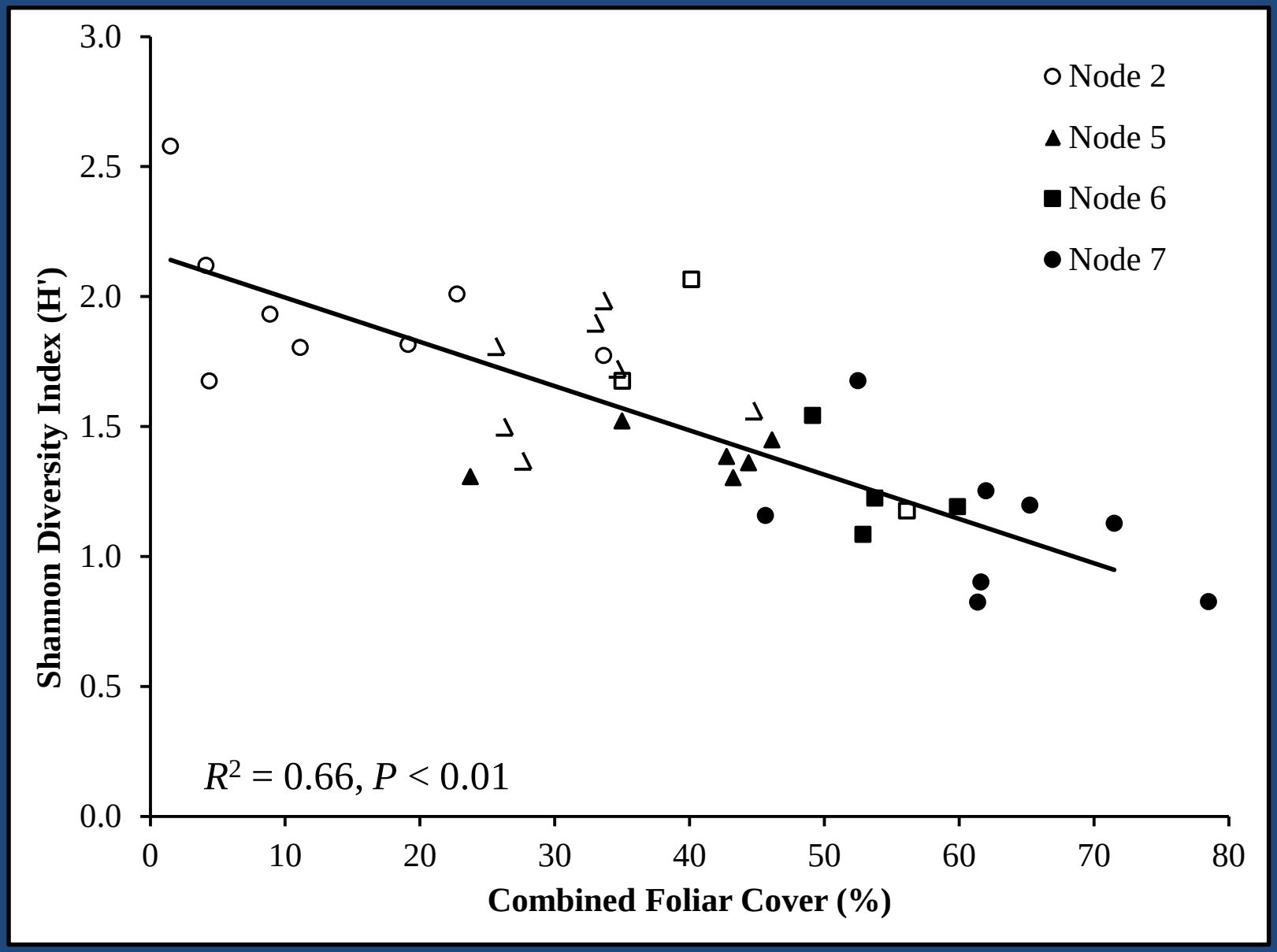
## Model Used

Shannon Diversity Index = Amount of Bare Soil, Western Wheatgrass, and Sickleweed

Classifies the 36 plots into 4 nodes





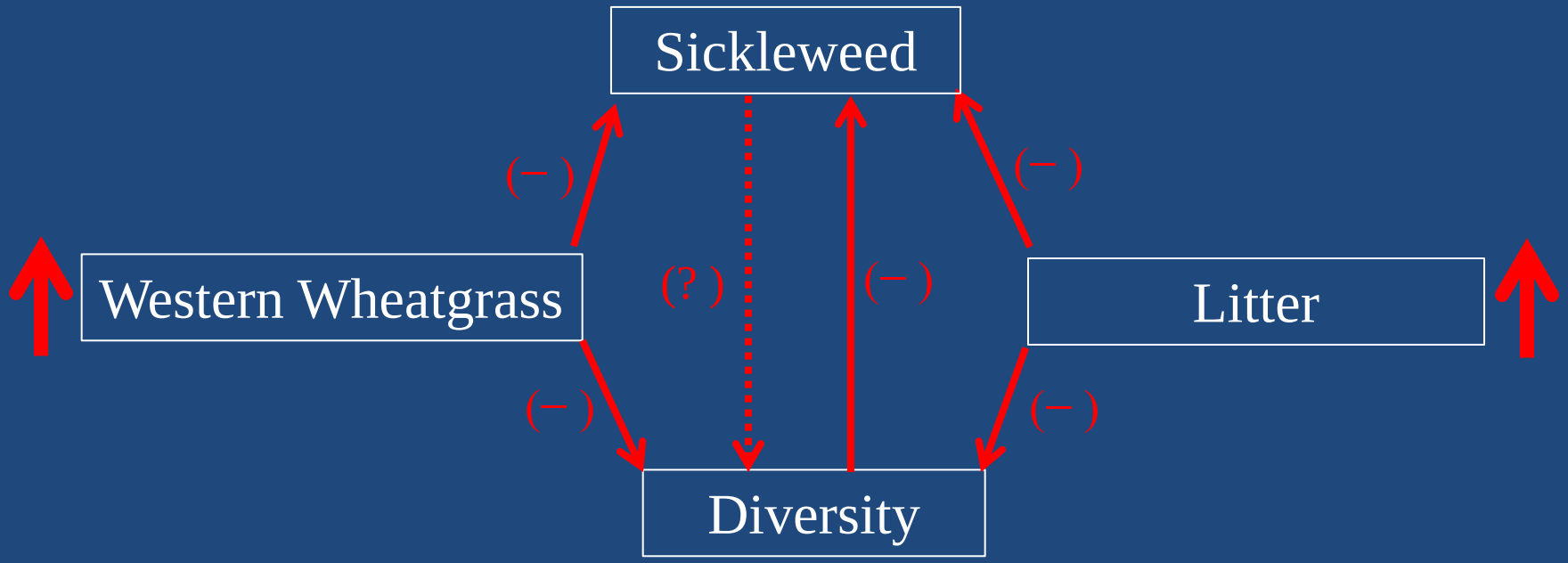

**Combined Foliar Cover of Western Wheatgrass and Sickleweed**

# Reducing Susceptibility to Sickleweed

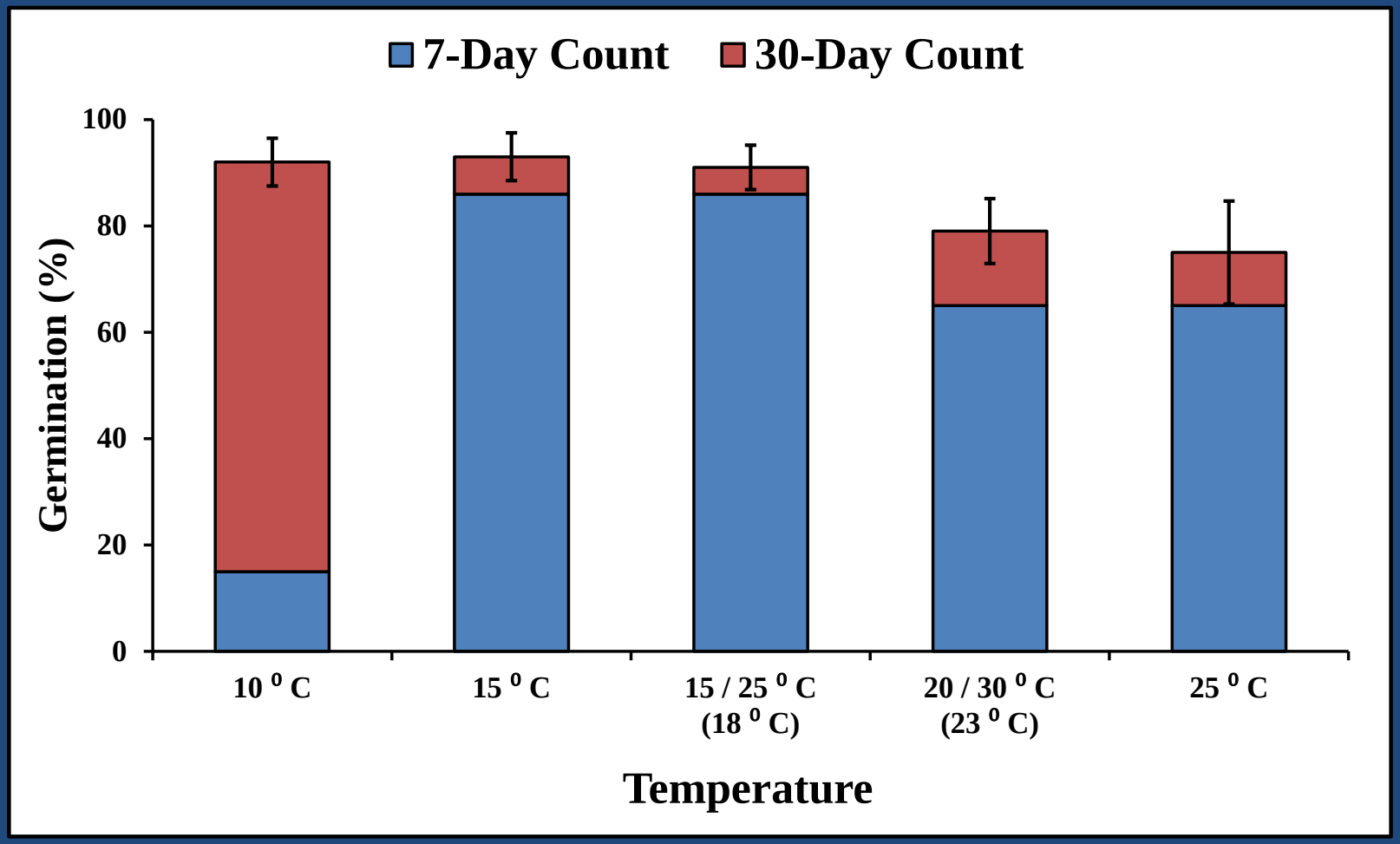
Abundant, Diverse Vegetation + Unknown Amount of Litter

**OR**

Abundant Western Wheatgrass + Unknown Amount of Litter



# Germination Trials

- Treatments
  - 5 temperature treatments
    - 3 constant
    - 2 alternating
  - 50 seeds per germination box
    - 8 germination boxes

# Effects of Temperature on Germination