Resilience and Feedbacks within a Deep Sand Savannah Ecological Site

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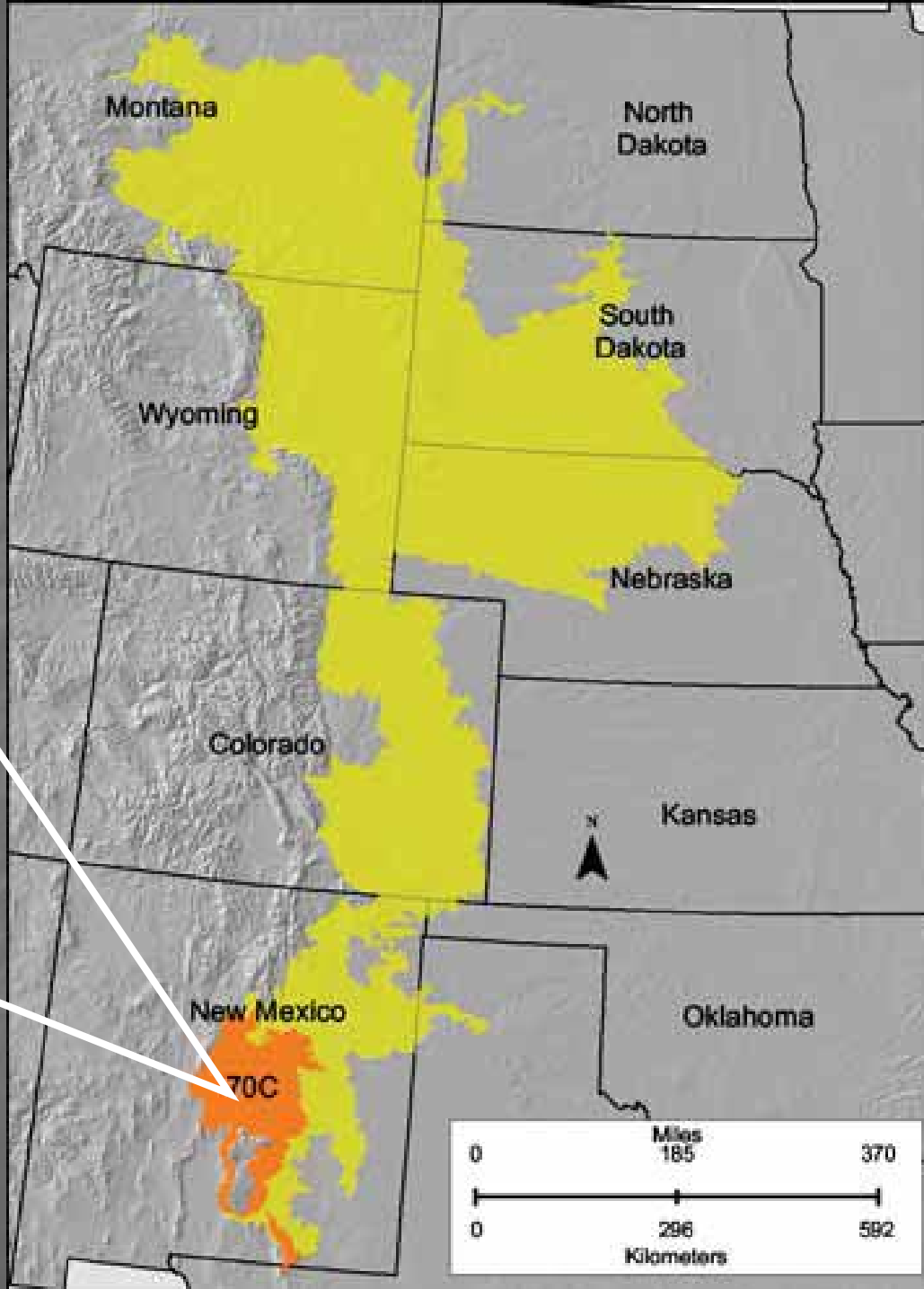
Land Resource Region:G

Western Great Plains and Irrigated Region – 554,395 sq. km.

Major Land Resource Area: 70C

Central New Mexico Highlands – 32,375 sq. km.

Ecological Site: Deep Sand Savannah - 12,950 ha.



Deep Sand Savannah Ecological Site

- 1750 – 2000 m elevation
- Flat to rolling dune topography
- Aeolian sand deposits
- 33 – 40 cm average annual precipitation
- 75 % of precipitation comes during growing season
- 130 – 160 day growing season (early May to early Oct)

Historical Accounts

- Golden-grassed plains
  - Spanish mission early 1600's– (Hogan, 1954)
    - Abandoned 1677
- Good grass cover, scattered piñon and juniper (McLeullough, 1882)
- Treeless but very grassy with sabinos (junipers) dotting it (Bandelier, 1884)

Natural Range of Variability

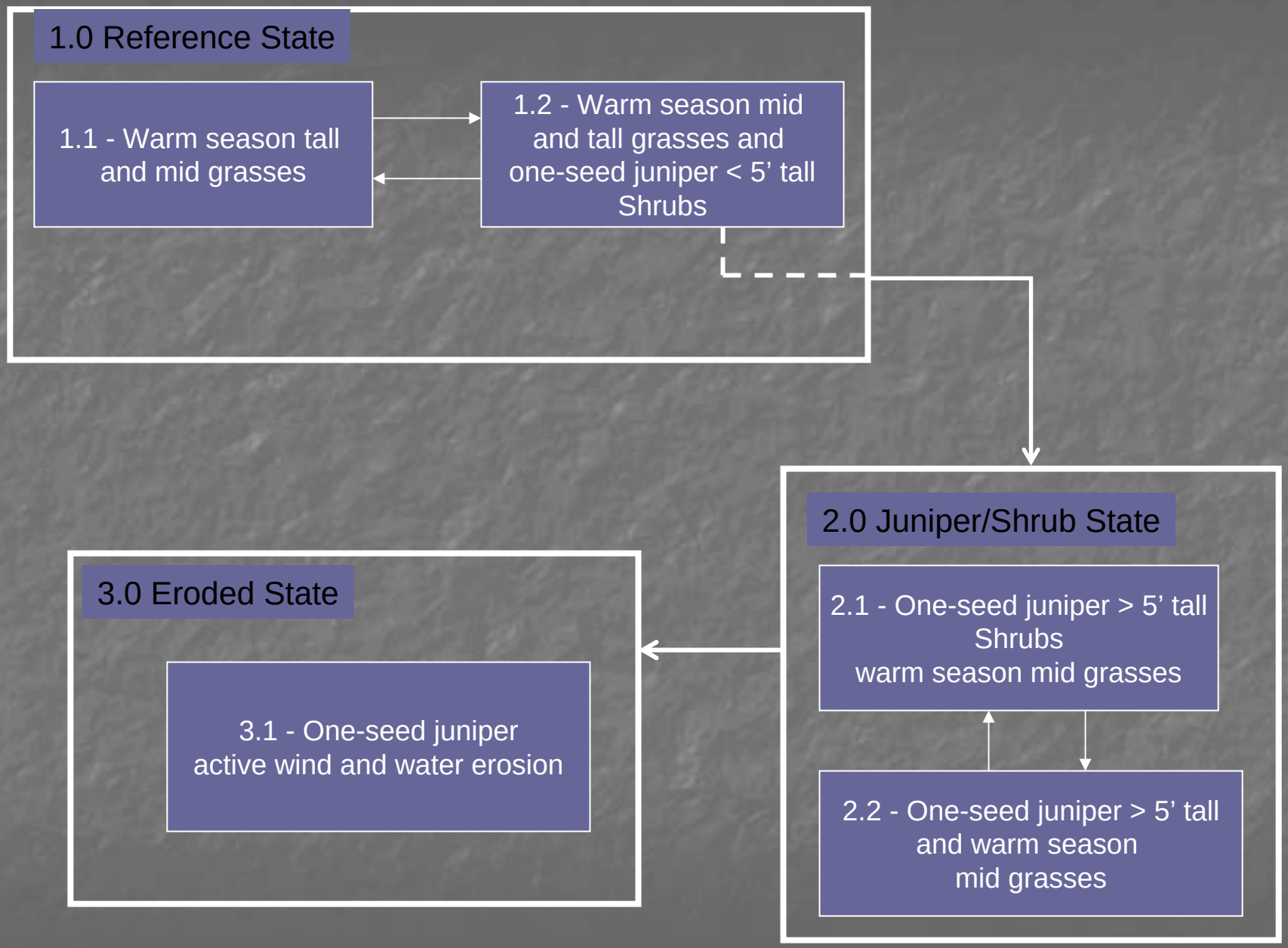
- Fire maintained grassland or savannah aspect (Natural and human ignition)
  - 4 – 6 years (Frost, 1998)
  - 6 – 11 years (Baisan & Swetnam, 1997)
  - 16 – 20 years (Allen, 1989)
- Drought/Wet Years
- Herbivory

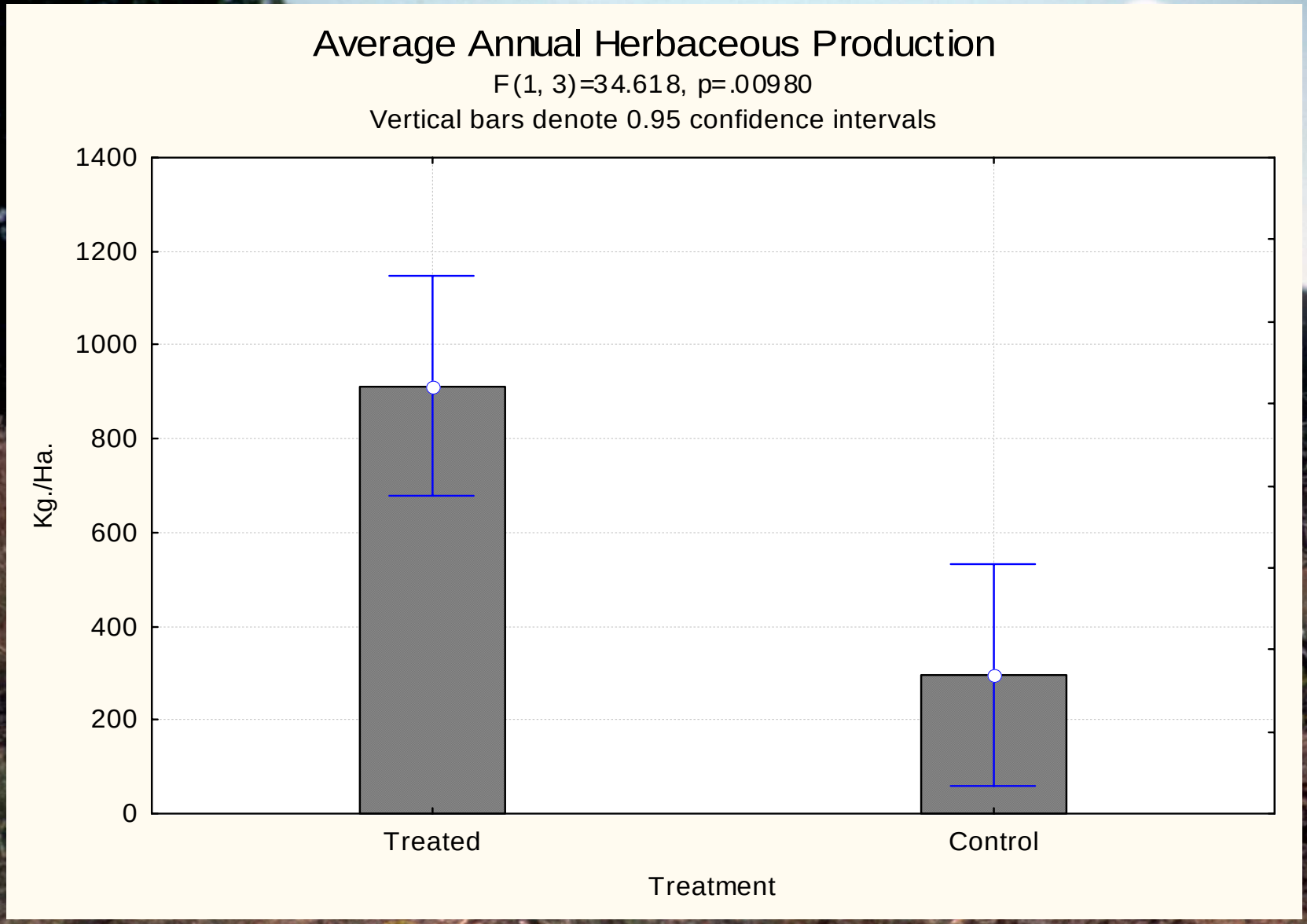
Present

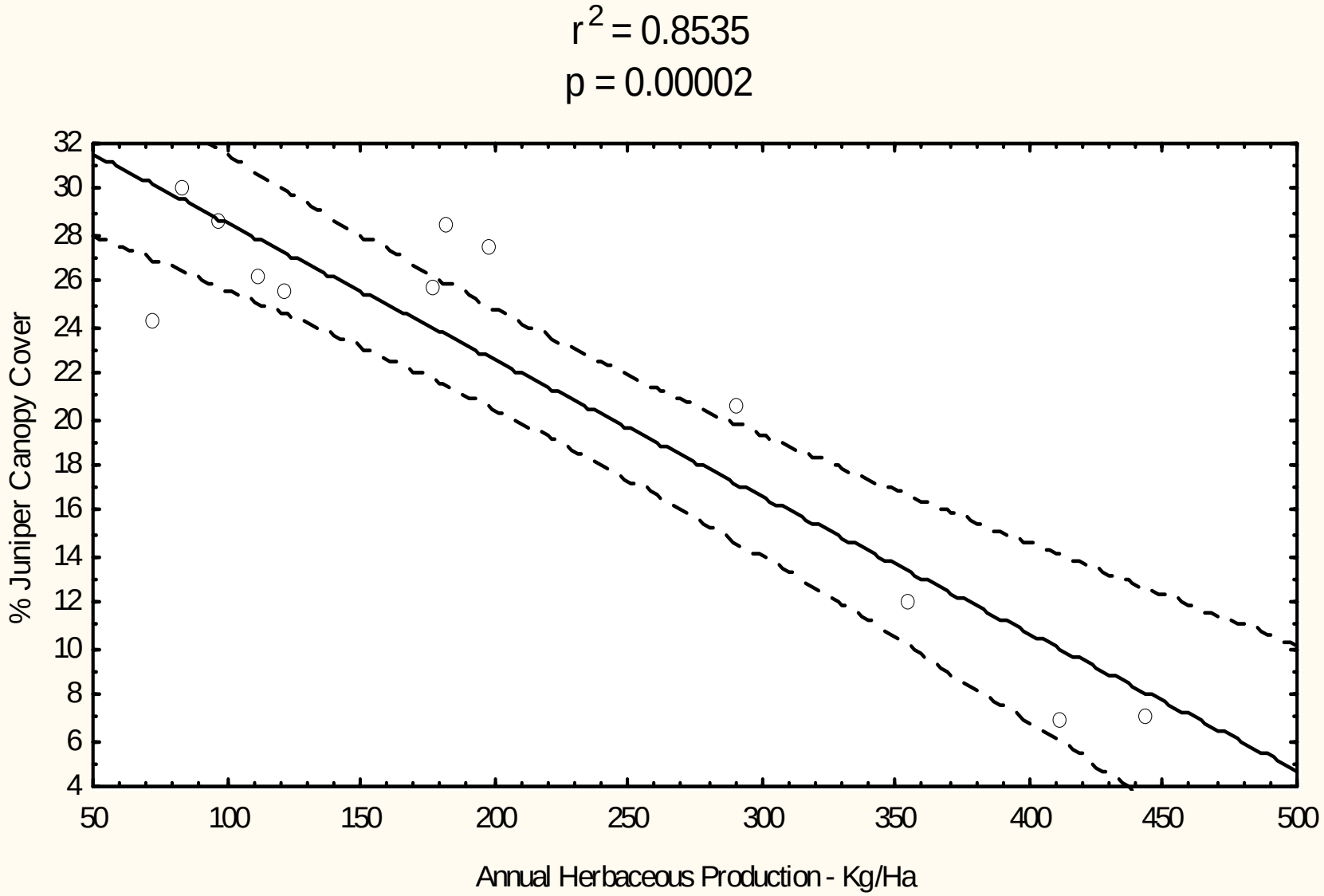
- One-seed juniper > 4 m tall
- Juniper canopy cover 15 - 25%
- Annual herbaceous production 100 – 200 kg/ha

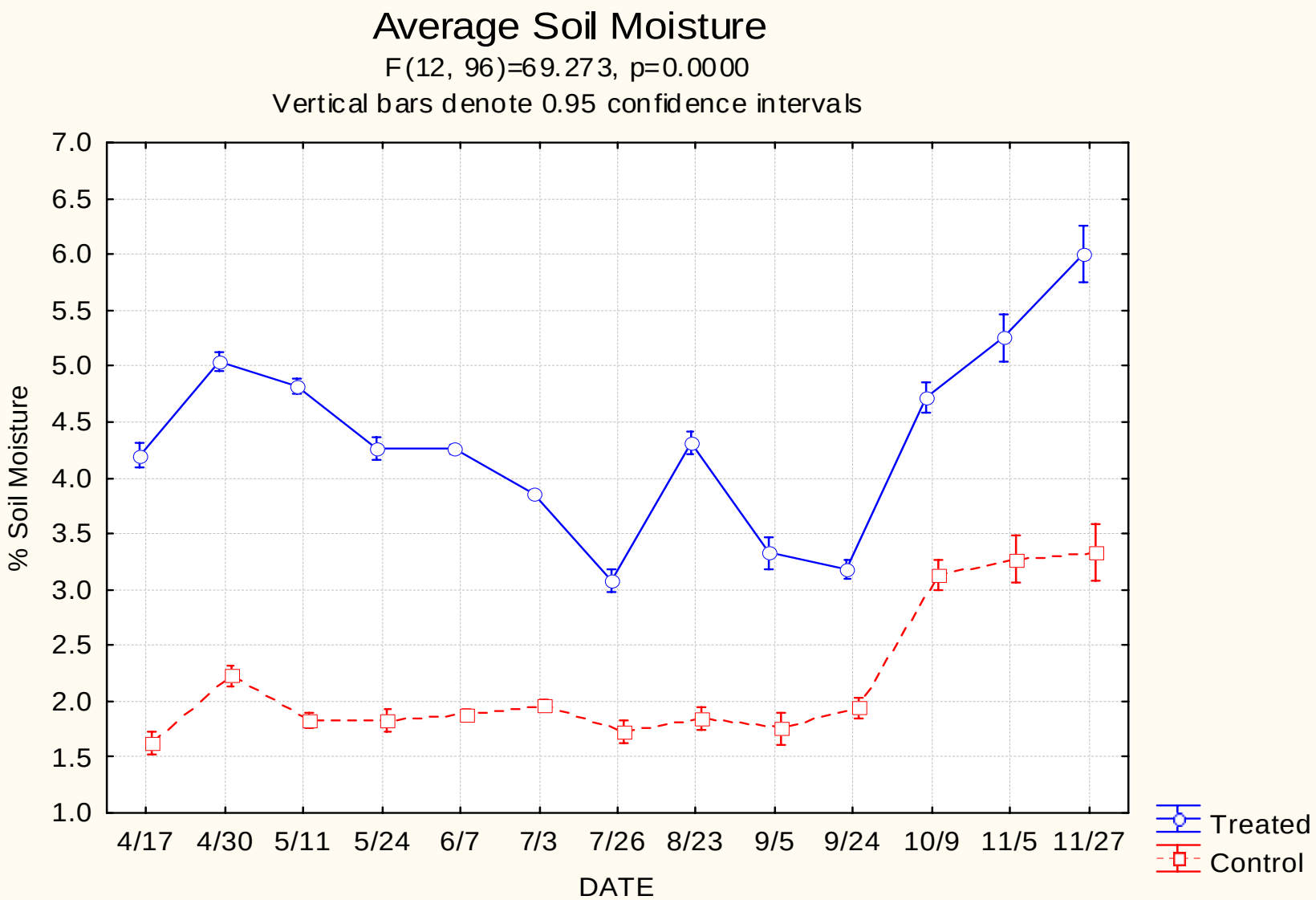
Post Settlement Dynamics

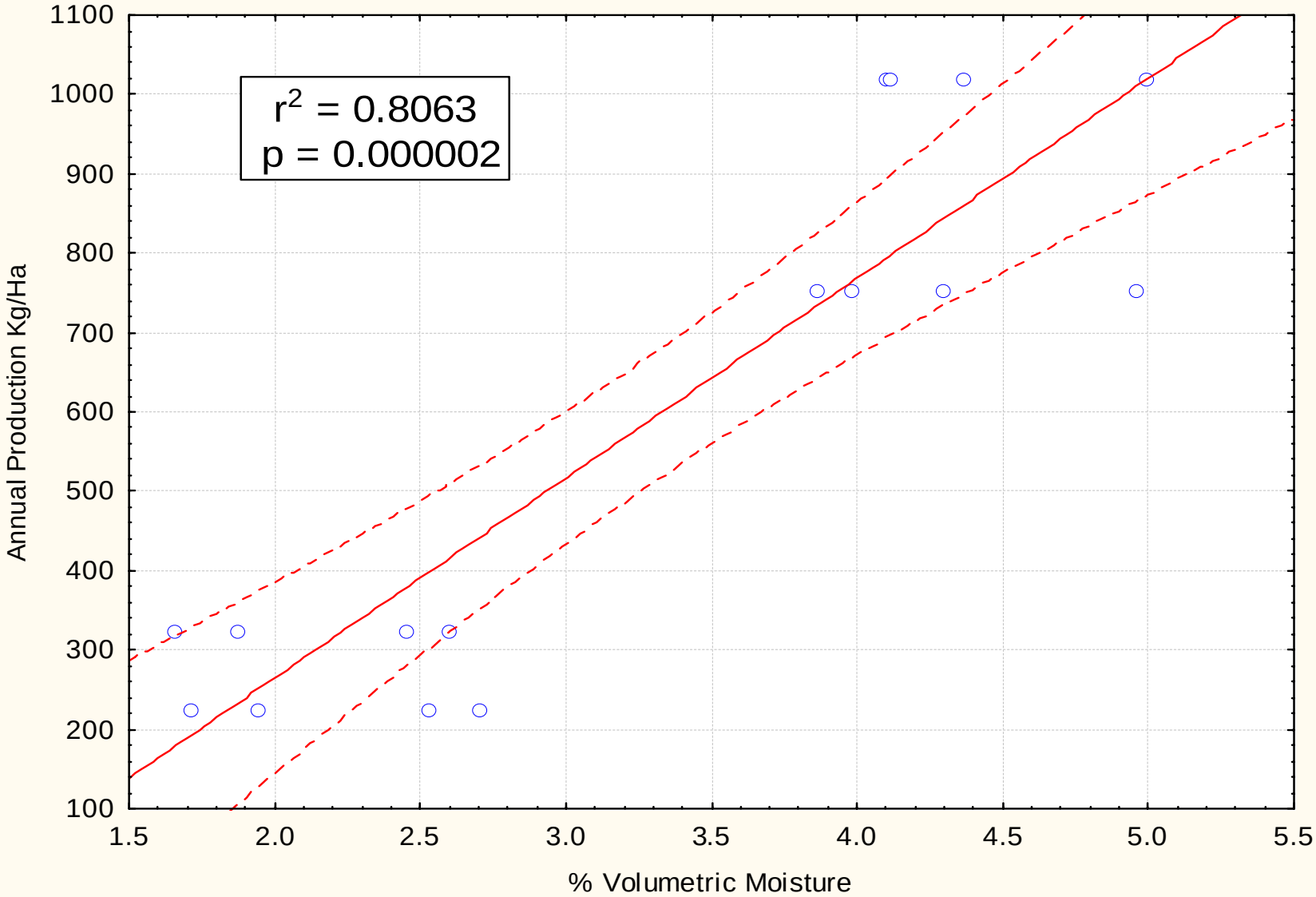
- Large herds of livestock (sheep then cows)
- Fire suppression
  - Lack of fine fuel
  - Active suppression

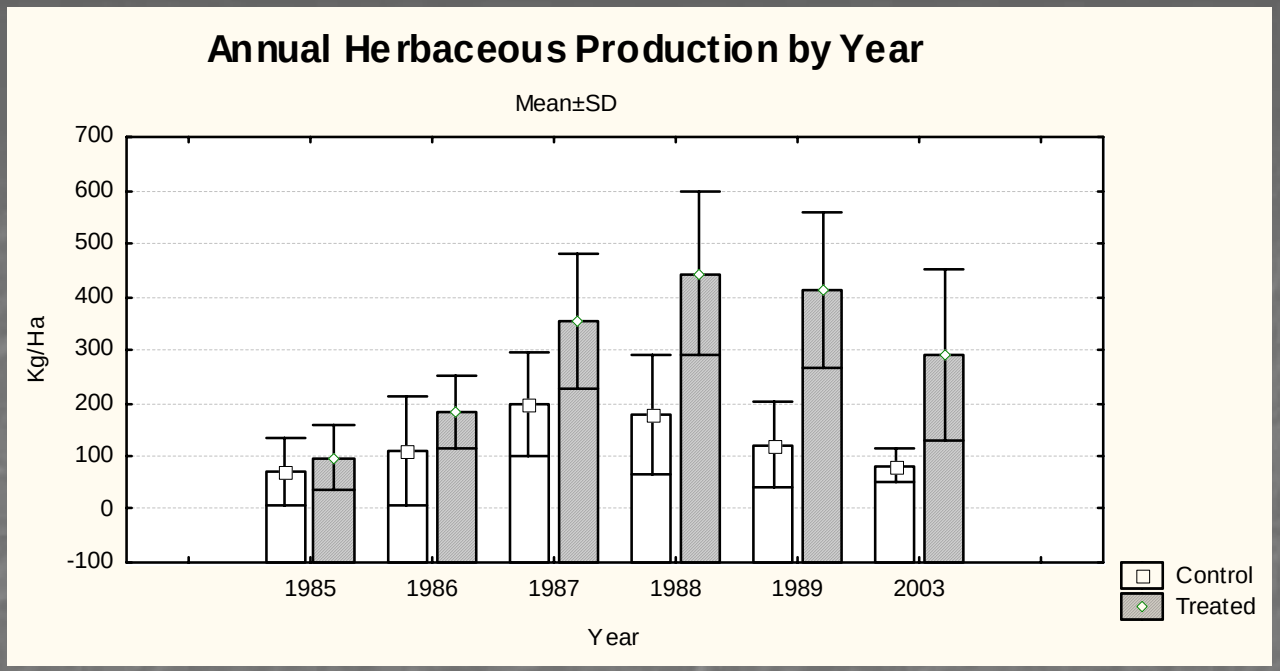

1.0 Reference State
1.1 - Warm season tall and mid grasses
1.2 - Warm season mid and tall grasses and one-seed juniper < 5' tall Shrubs
2.0 Juniper/Shrub State
2.1 - One-seed juniper > 5' tall Shrubs warm season mid grasses
2.2 - One-seed juniper > 5' tall and warm season mid grasses
3.0 Eroded State
3.1 - One-seed juniper active wind and water erosion

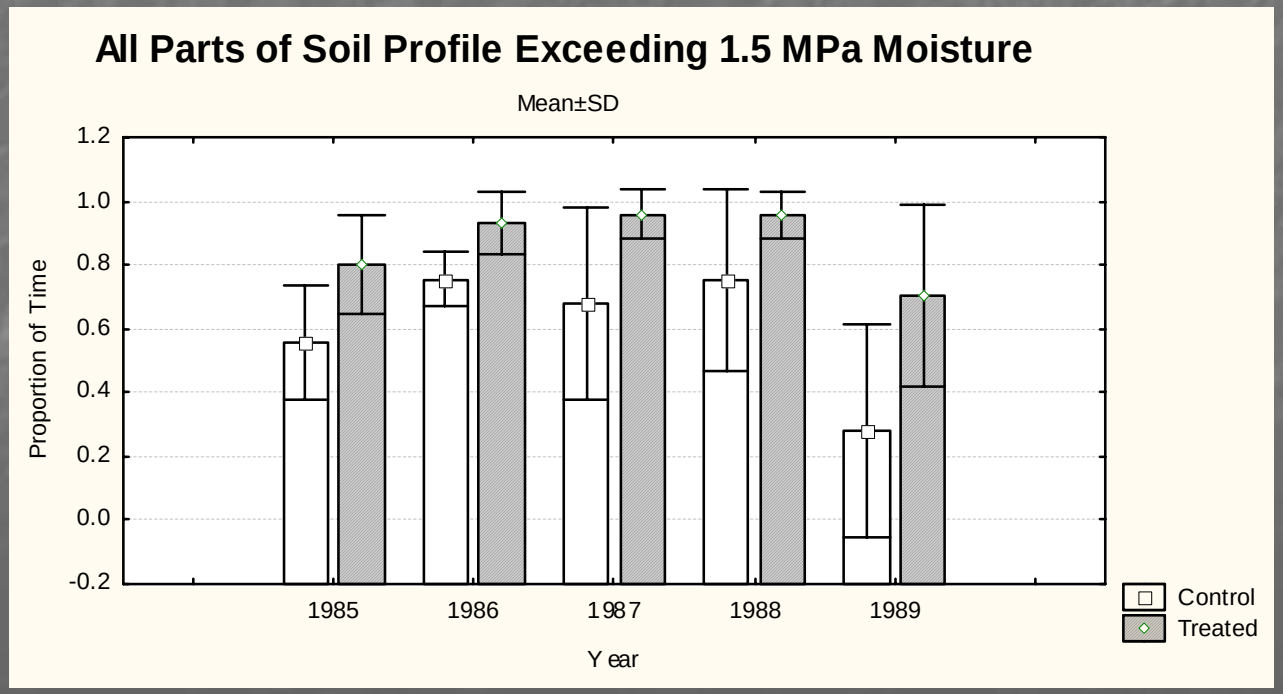

Average Annual Herbaceous Production
F(1, 3)=34.618, p=.00980
Vertical bars denote 0.95 confidence intervals
1400
1200
1000
800
600
400
200
0
Kg./Ha.
Treated
Control
Treatment

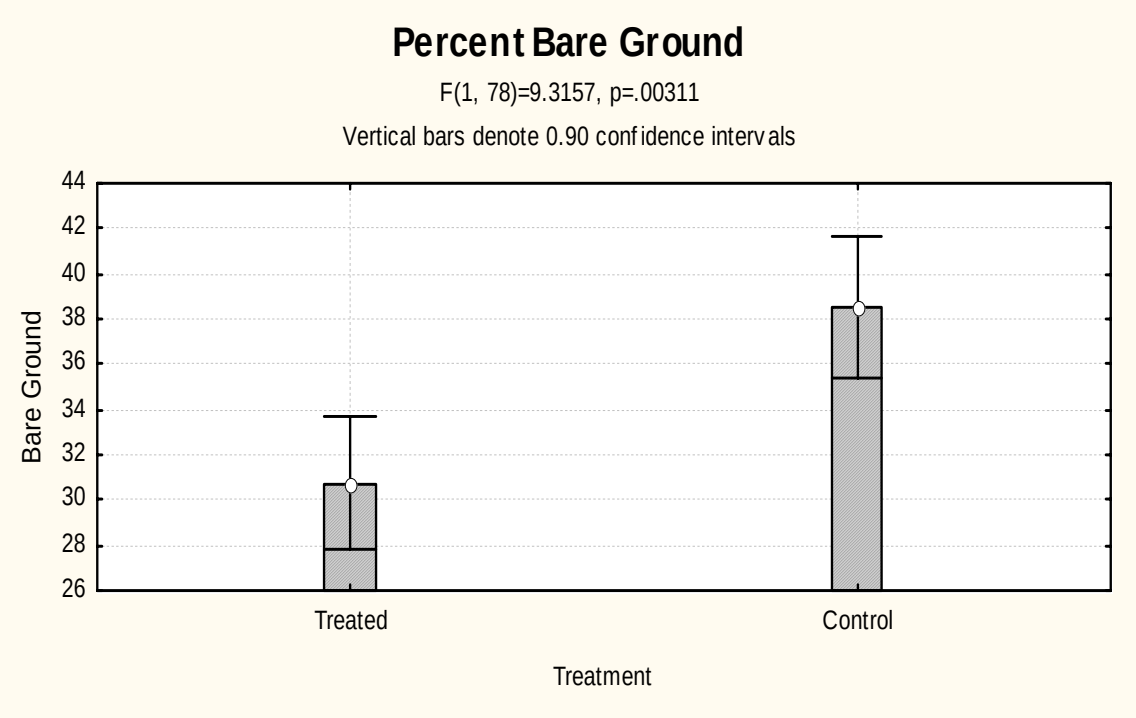

r2 = 0.8535
p = 0.00002
% Juniper Canopy Cover
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
50
100
150
200
250
300
350
400
450
500
Annual Herbaceous Production - Kg/Ha

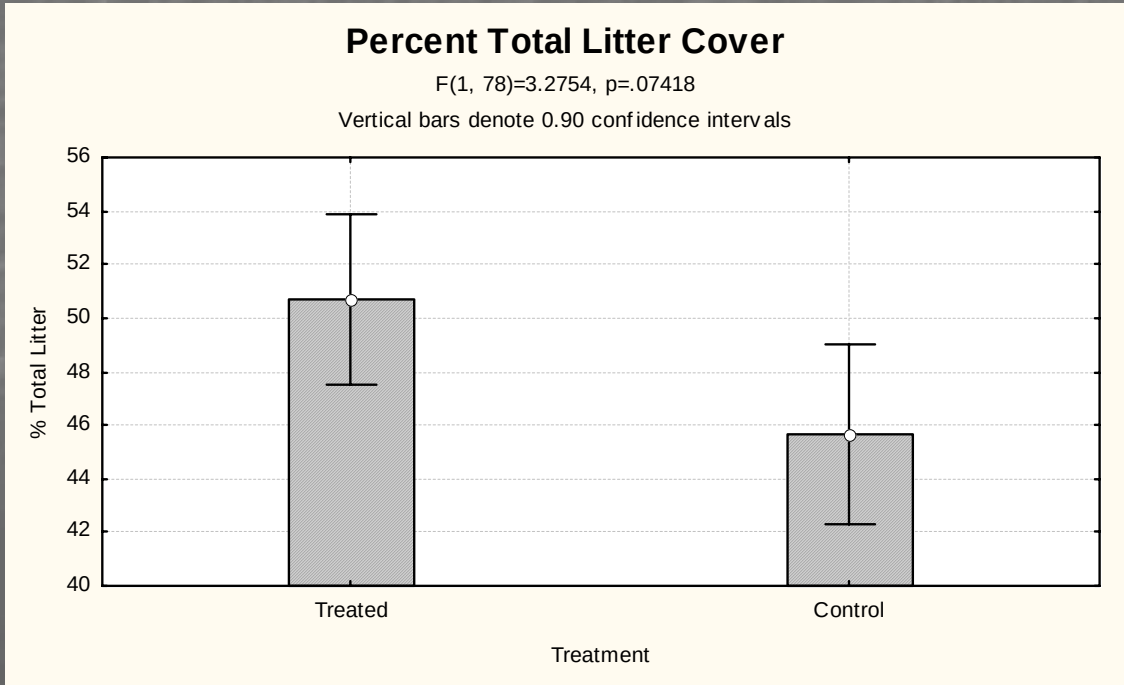

Average Soil Moisture
F(12, 96)=69.273, p=0.0000
Vertical bars denote 0.95 confidence intervals
% Soil Moisture
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
4/17
4/30
5/11
5/24
6/7
7/3
7/26
8/23
9/5
9/24
10/9
11/5
11/27
DATE
Treated
Control

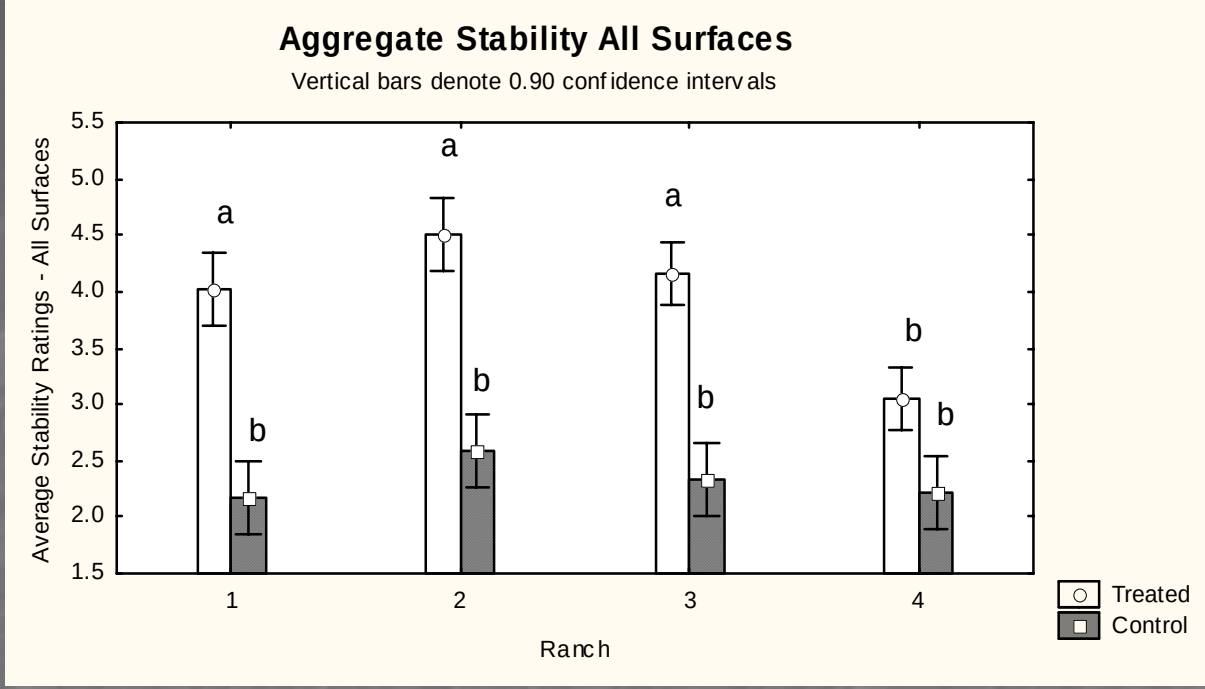

r2 = 0.8063
p = 0.000002
Annual Production Kg/Ha
1100
1000
900
800
700
600
500
400
300
200
100
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
% Volumetric Moisture

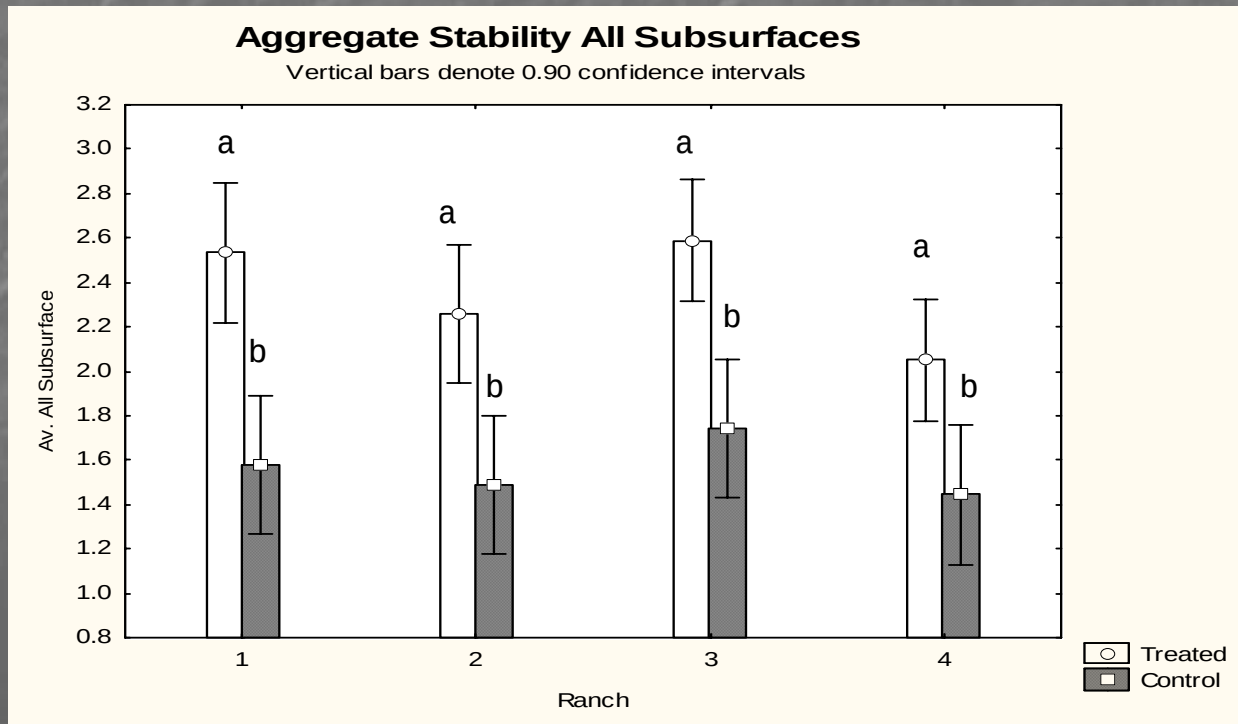

Annual Herbaceous Production by Year
Mean±SD
Kg/Ha
700
600
500
400
300
200
100
0
-100
1985
1986
1987
1988
1989
2003
Year
Control
Treated

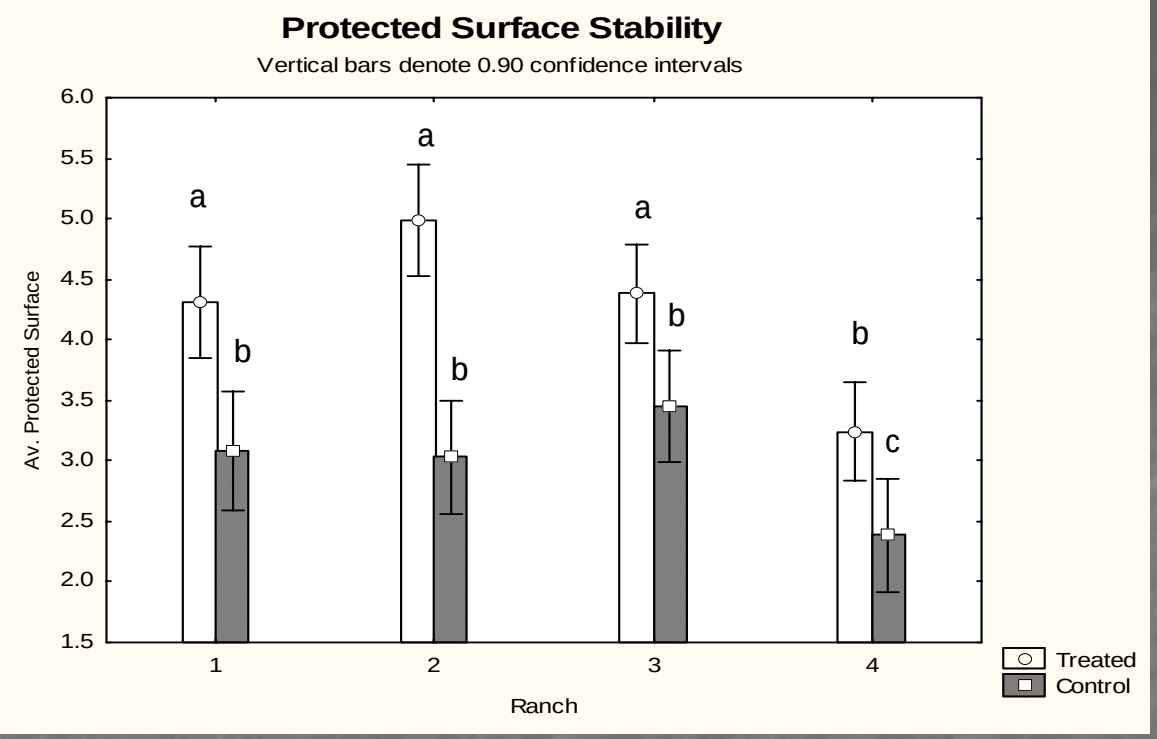

All Parts of Soil Profile Exceeding 1.5 MPa Moisture
Mean±SD
Proportion of Time
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
1985
1986
1987
1988
1989
Year
Control
Treated

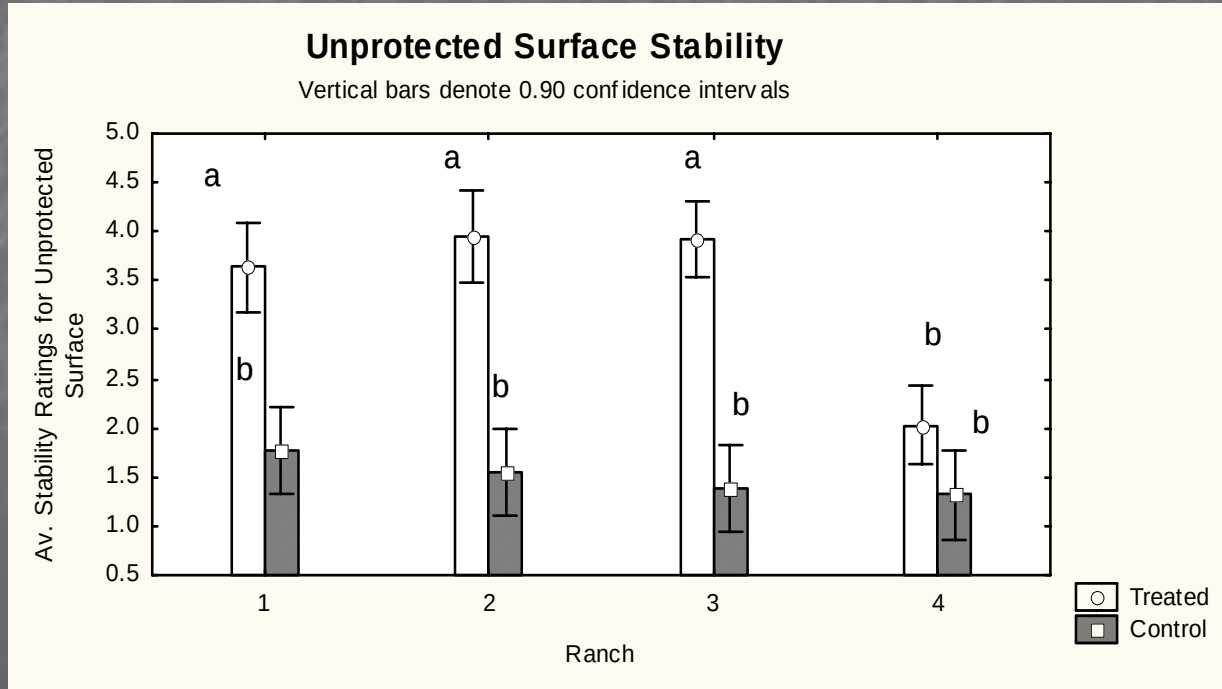

Percent Bare Ground
F(1, 78)=9.3157, p=.00311
Vertical bars denote 0.90 confidence intervals
Bare Ground
44
42
40
38
36
34
32
30
28
26
Treated
Control
Treatment

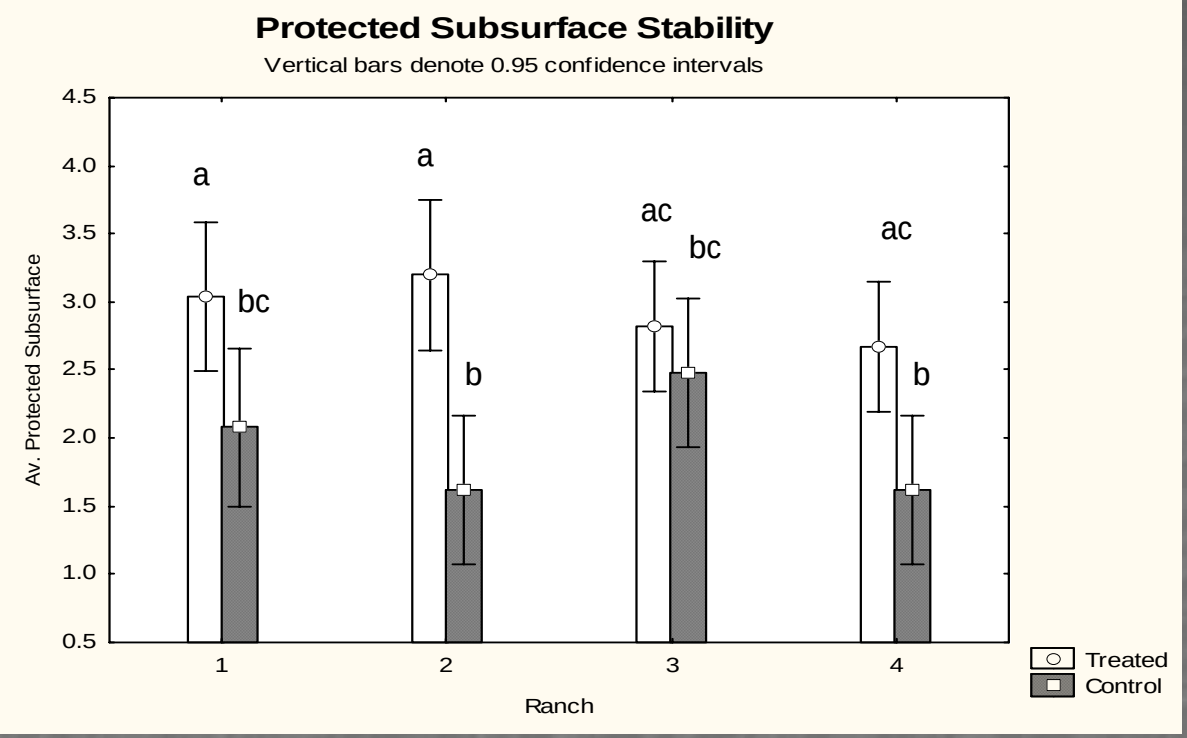

Percent Total Litter Cover
F(1, 78)=3.2754, p=.07418
Vertical bars denote 0.90 confidence intervals
% Total Litter
56
54
52
50
48
46
44
42
40
Treated
Control
Treatment

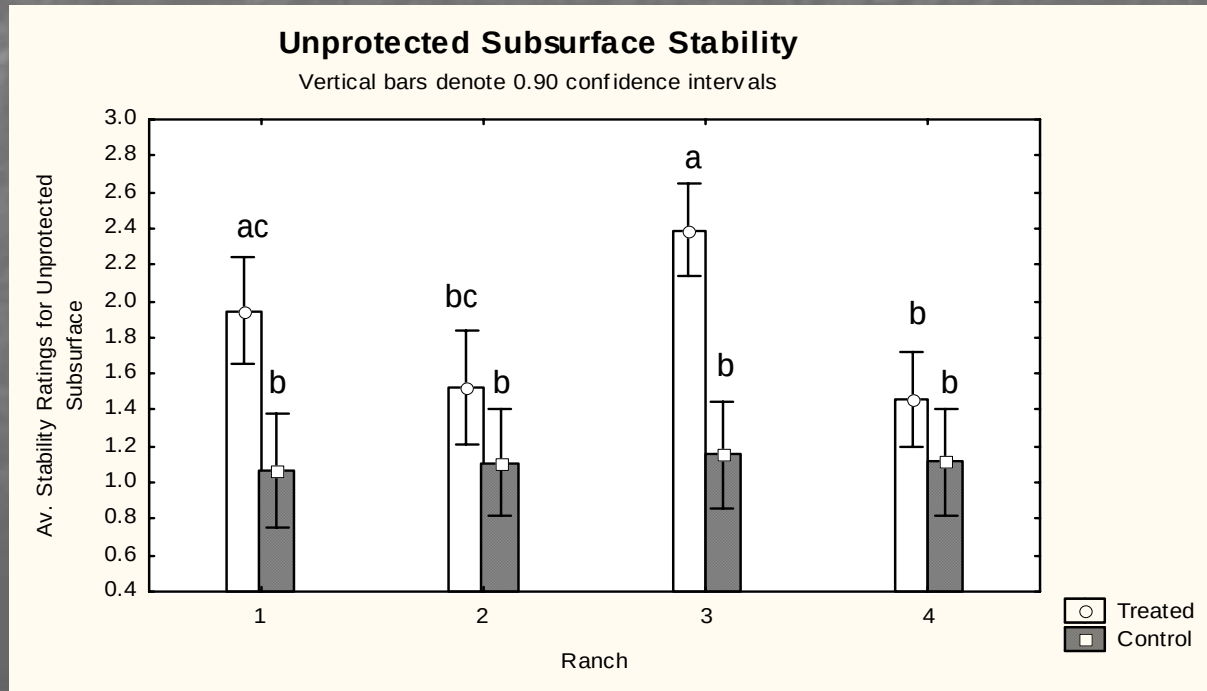

Aggregate Stability All Surfaces
Vertical bars denote 0.90 confidence intervals
Average Stability Ratings - All Surfaces
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
a
b
a
b
a
b
b
b
1
2
3
4
Ranch
Treated
Control


Aggregate Stability All Subsurfaces
Vertical bars denote 0.90 confidence intervals
Av. All Subsurface
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
a
b
a
b
a
b
a
b
1
2
3
4
Ranch
Treated
Control


Protected Surface Stability
Vertical bars denote 0.90 confidence intervals
Av. Protected Surface
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
a
b
a
b
a
b
b
c
1
2
3
4
Ranch
Treated
Control


Unprotected Surface Stability
Vertical bars denote 0.90 confidence intervals
Av. Stability Ratings for Unprotected Surface
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
a
b
a
b
a
b
b
b
1
2
3
4
Ranch
Treated
Control


Protected Subsurface Stability
Vertical bars denote 0.95 confidence intervals
Av. Protected Subsurface
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
a
bc
a
b
ac
bc
ac
b
1
2
3
4
Ranch
Treated
Control


Unprotected Subsurface Stability
Vertical bars denote 0.90 confidence intervals
Av. Stability Ratings for Unprotected Subsurface
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
ac
b
bc
b
a
b
b
b
1
2
3
4
Ranch
Treated
Control

Soil Aggregate Stability

- Soil organic matter incorporated into aggregates at the soil surface
- Biological Crust
- Decomposing organic matter adhering to the soil particles forming aggregates

Feedbacks

Juniper Encroachment

Juniper captures moisture

Decrease in understory vegetation

Decrease in litter & SOM

Increase in bare ground

Deterioration in soil structure

Decreased soil stability

Feedbacks

Decrease in juniper canopy

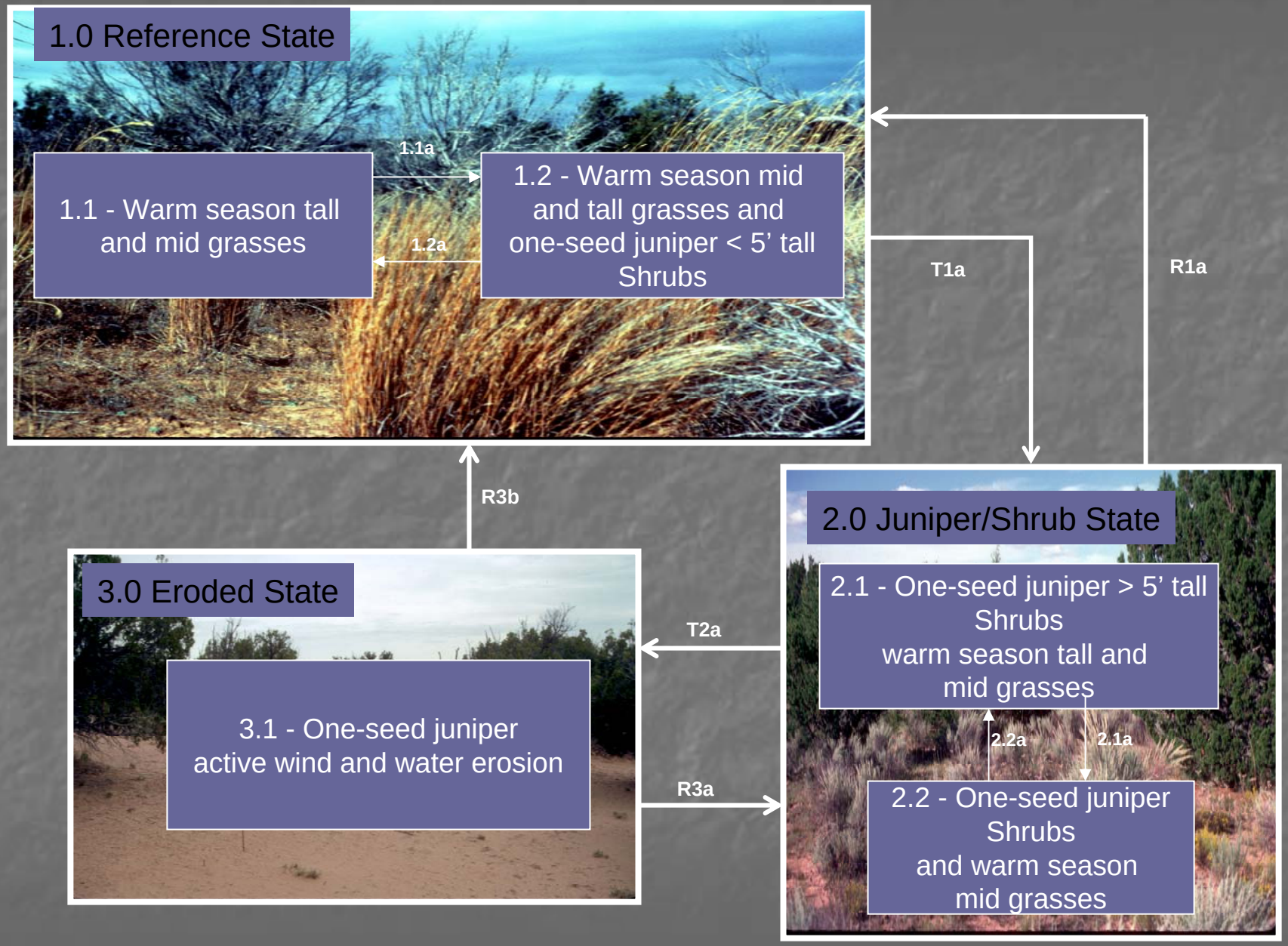
Increase in herbaceous production

Decrease in bare ground

Increased organic matter inputs

Increased soil surface stability

Increased annual production


1.0 Reference State
1.1 - Warm season tall and mid grasses
1.1a
1.2a
1.2 - Warm season mid and tall grasses and one-seed juniper < 5' tall Shrubs
T1a
R1a
R3b
2.0 Juniper/Shrub State
2.1 - One-seed juniper > 5' tall Shrubs warm season tall and mid grasses
2.2a
2.1a
2.2 - One-seed juniper Shrubs and warm season mid grasses
T2a
R3a
3.0 Eroded State
3.1 - One-seed juniper active wind and water erosion

Thank You!