Environmental Control of Shrub Density Development at the Seneca II Mine - 1987 to 2014

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June 2016

Regulatory Programs and Shrub Density

- Surface Mining Control and Reclamation Act of 1977 (SMCRA PL 95-87)
  - Restore mined land to a condition capable of supporting premining land uses
  - Wildlife habitat and woody density
- Colorado permanent regulatory program (SMCRA primacy)
  - Fish and wildlife habitat land use requires establishment of woody density
  - Negotiated standard in consultation with CPW (formerly CDOW)
- Seneca II Mine permit
  - Concentration area standard 2000 stems/ac on minimum of 5 % of area
  - Background standard 200 stems/ac
- Ecological Conflict in regulatory requirements
  - Effective cover provided by herbaceous species
  - Productivity for grazing land use
  - Shrubs struggle in strong herbaceous community

Shrub Establishment Methods

- Shrub seed in seed mixes
  - Shrub seed added to general seed mix starting in mid 1980's
  - Separate shrub seed mix in low competition reclaimed sites begin early 1990's
- Planted seedlings
  - Primarily site sourced seed and tall shrub species
- Plant Protection

  Later – elk proof fencing and measures to reduce herbaceous competition

Shrub Establishment Methods (continued)

- Direct haul topsoil plant propagules
- Seed immigration from adjacent native stands
- Increasing number of seed producing parent shrubs in reclaimed areas
  - Successional proceses

Addition of Grazing – Implement Land Use and Enhance Shrub Establishment

- Grazing introduced in 1987 on Seneca II Mine
- 356 acre Wadge Pasture included in reclaimed land grazing program
- Late summer grazing
- Moderate grazing pressure

Initial Shrub Establishment on Early SMCRA Reclaimed Lands

Shrub Establishment in Early Topsoiled Areas at the Seneca II Mine - 1982

	Direct Haul Topsoil		Stockpile Topsoil	
	% Rel. Density	Stems/ac	% Rel. Density	Stems/ac
Amelanchier alnifolia	1.4	10	4.7	40
Artemisia tridentata ssp vaseyana	55.2	389	31.2	472
Symphoricarpos rotundifolius	35.6	251	54.6	270
Padus virginiana ssp. melanocarpa	4.8	34	6.3	54
Rosa woodsii	2.1	15	1.6	14
Chrysothamnus viscidiflorus	0.7	5	0	0
Quercus gambelii	0.2	2	1.6	14
Total	100	706	100	864

- Direct haul topsoil 1977 -1982, stockpile topsoil 1972 – 1981
  - Less than 18 months in stockpile, possibly some direct haul topsoil
- Initial results for tall shrub species encouraging but in several years mostly dropped out of stand
  - Dry soils and heavy herbaceous competition with slow root regeneration
  - Observed best to least root sprouting – snowberry>chokecherry>serviceberry>rose>Gambel oak

Naturally Developing Shrub Concentration Areas

- Shrub concentration areas required in permit
- Develop in dispersed locations in reclamation with proper site conditions
  - Availability of seed producing mature shrubs
  - Environmental and site conditions favor establishment and competitive opportunities

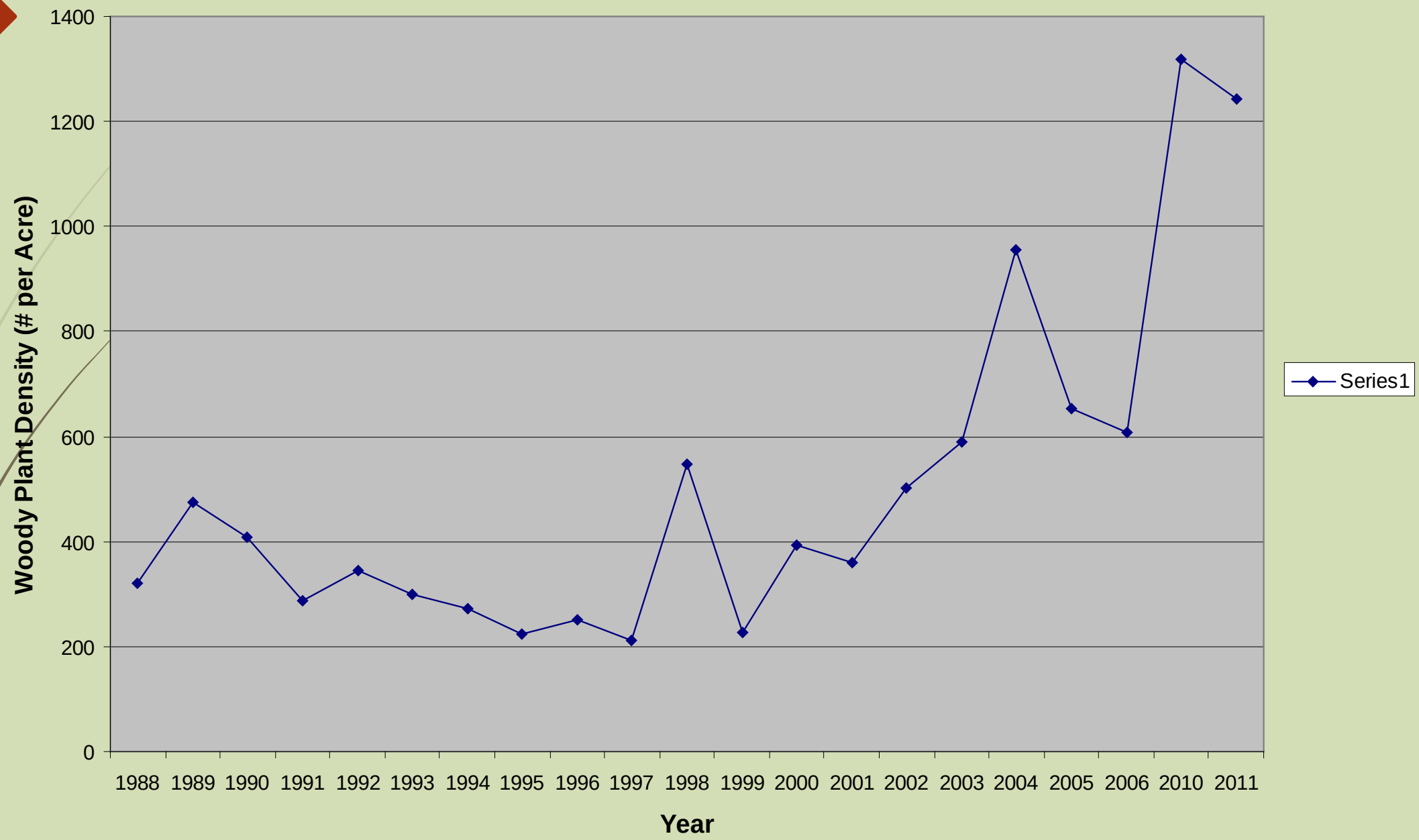
Plant Succession on Reclaimed Areas – Reflects Native Sagebrush Communities

Typical reclaimed area with establishing shrubs

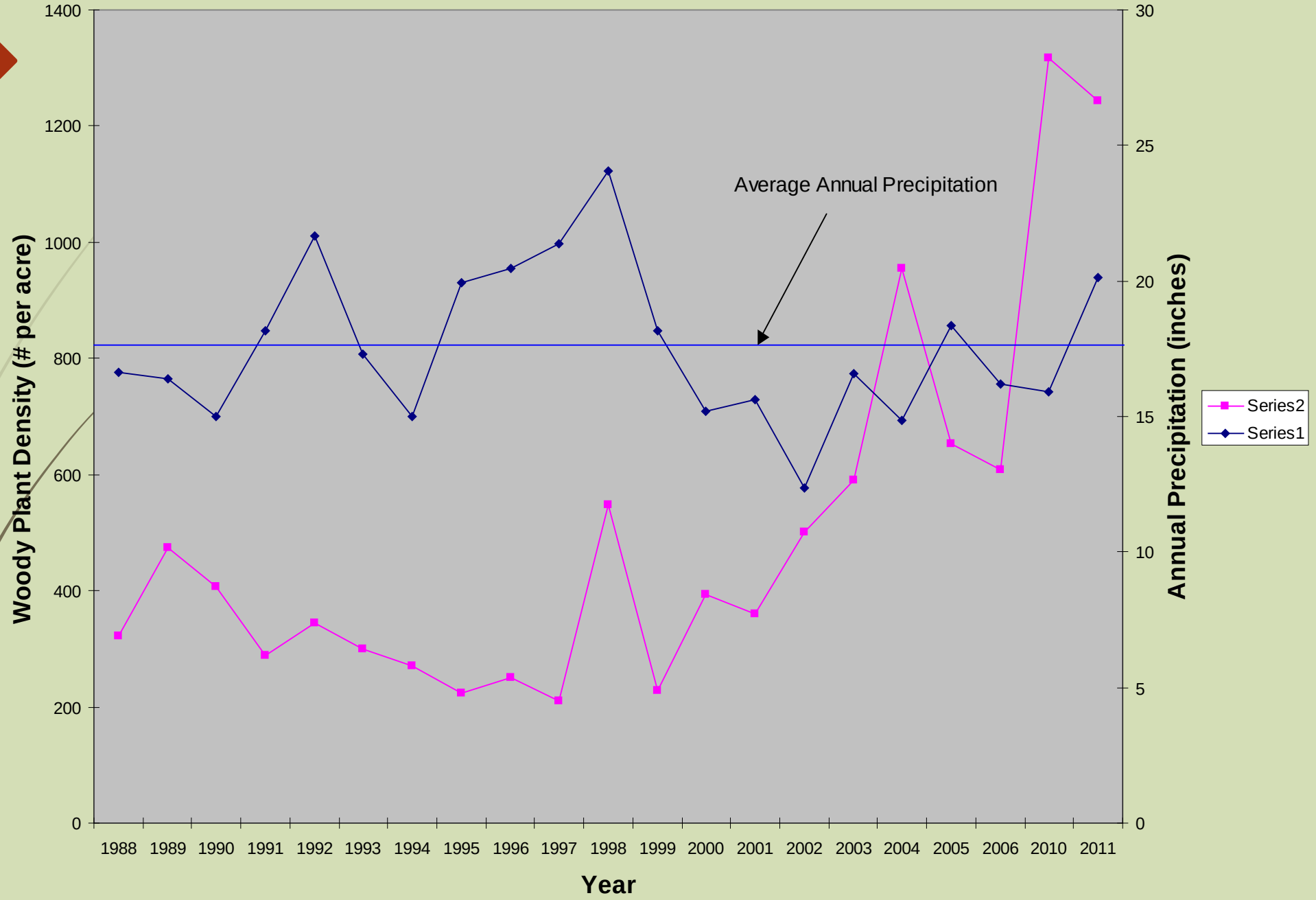
Maturing sagebrush and snowberry in reclamation

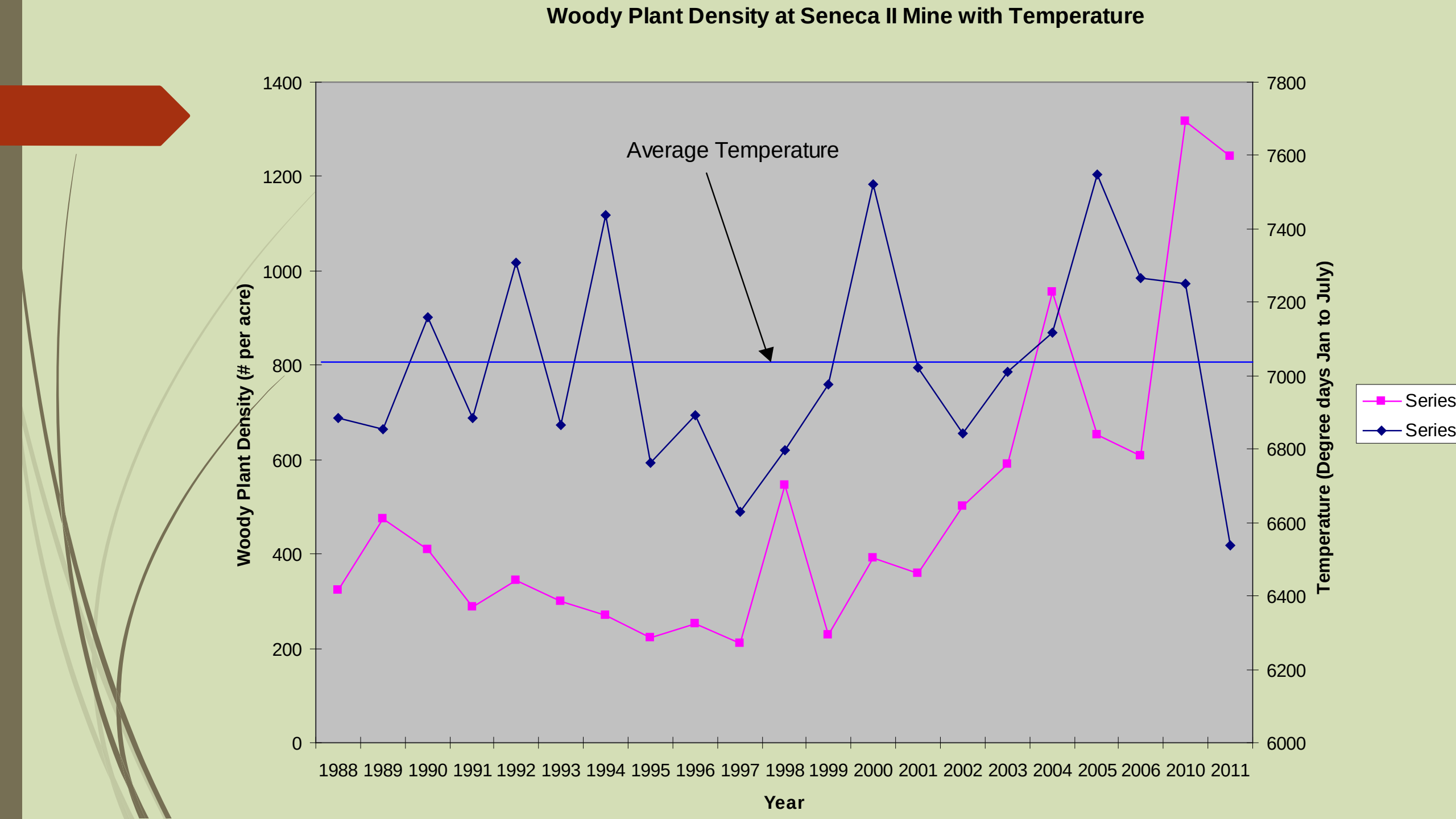
- Maturing mountain big sagebrush capable of producing large amounts of seed
- Mountain snowberry can regenerate by seed, root stocks or by layering
- Natural fluctuations in Environment allow for reduced herbaceous competition
  - Result: Shrub germination, establishment, and survival

Woody Plant Density at Seneca II Mine, Routt County, CO 1988 to 2011



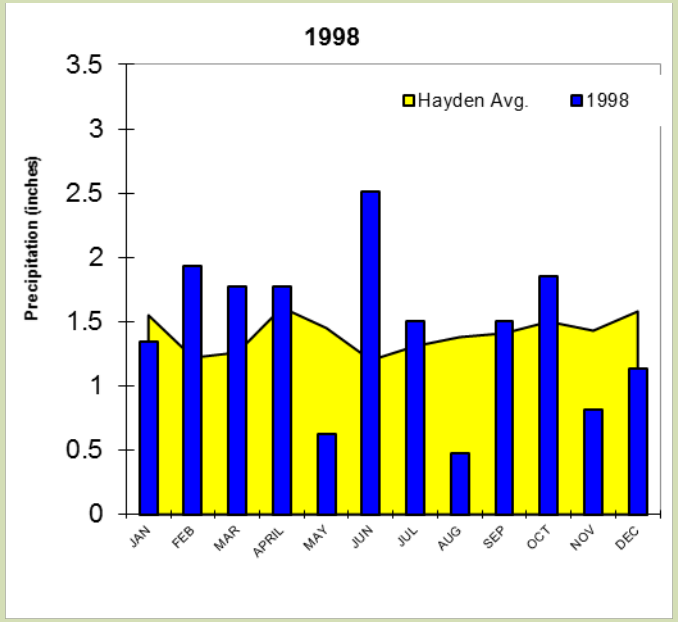
Woody Plant Density at Seneca Mine and Annual Precipitation

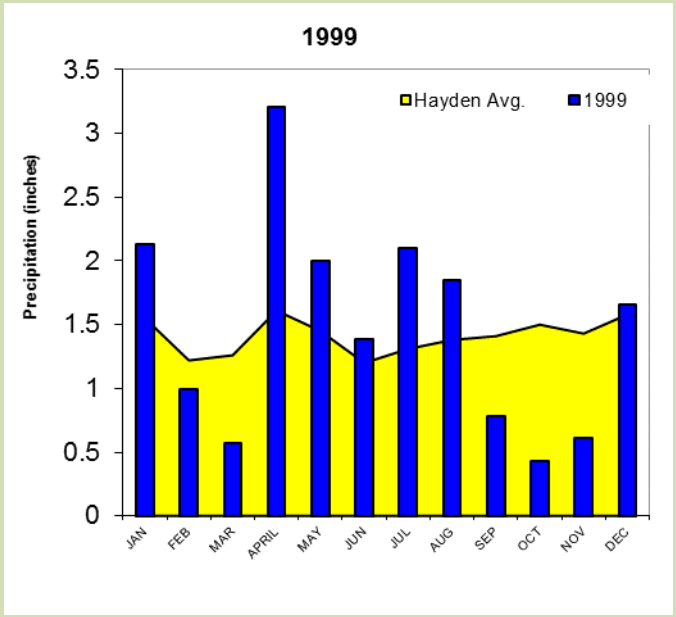



Woody Plant Density at Seneca II Mine with Temperature
Average Temperature
Woody Plant Density (# per acre)
Temperature (Degree days Jan to July)
Year
0
200
400
600
800
1000
1200
1400
6000
6200
6400
6600
6800
7000
7200
7400
7600
7800
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2010 2011
Series
Series

Within Year Climate Effects on Shrub Density – Wadge Pasture

	Wadge Pasture	
Year	1998	1999
Shrub stems/acre	547	227





Change of Community Composition 1988 to 2011

Seneca II Mine Reclaimed Land Vegetation Composition Changes (1988 - 2011)

	1988 Wadge Pasture			2011 Sample Area[1]		
	% Cover	Rel Cover	Freq (Constancy)	% Cover	Rel Cover	Freq (Constancy)
Perennial herbaceous	75.9	95.95		54.7	91.00	
Medicago sativa	33.5	42.35	100	8.4	13.98	93.3
Artemisia tridentata ssp vaseyana	0.2	0.25	23.3	2.8	4.60	73.3
Symphoricarpos rotundifolius	0.1	0.13	3.3	1.3	2.11	56.7
All shrubs	0.3	0.38	26.6	4.2	6.90	80.0
Average shrub density		322 stems/acre			1244 stems/acre	

[1]Phase III bond release sampling area inclusive of Wadge Pasture

- 1988 to 2011 reduction in herbaceous cover and a significant reduction in alfalfa

1988

2011

Reclaimed Lands Reflect Native Sagebrush after 25 years

Relative Shrub Composition in Seneca II Reclaimed Lands (2011) and a Native Sagebrush Community (1990)

	Reclaim Background Area Relative Density[1] 2011	Reclaim Concentration Area Relative Density[1] 2011	Native Sagebrush Relative Density[2] 1990
NATIVE SHRUBS			
Amelanchier alnifolia	1.1	1.2	3.2
Artemisia tridentata ssp vaseyana	65.8	78.4	41.7
Chrysothamnus nauseosus	2.7	0.2	0.5
Chrysothamnus viscidiflorus	0.4	>.1	13.6
Padus virginiana ssp. melanocarpa	0.2	0.8	0.8
Rosa sayi	1.6	>.1	0.3
Symphoricarpos rotundifolius	28.2	19.2	36.1
	100	100	96.2

[1] Phase III bond release sampling inclusive of Wadge Pasture (Concentration Area = 10.6% of sampling unit)

[2] Seneca IIW Mine baseline 1990

Gardening Best Practice Versus Site Ecology -- Both Needed to Achieve Success

- After Site Stabilization via Establishment of Herbaceous Cover there is need to

  Reduce herbaceous competition to increase shrub presence
- Reclamation best practices to restore ecosystem function and provide plant propagules
- Successional timeframes and maturing community
- The intent of SMCRA achieved