

40 Years of Revegetation Monitoring and Success at Kayenta Mine Complex

Robin Bay (HMI, LLC)

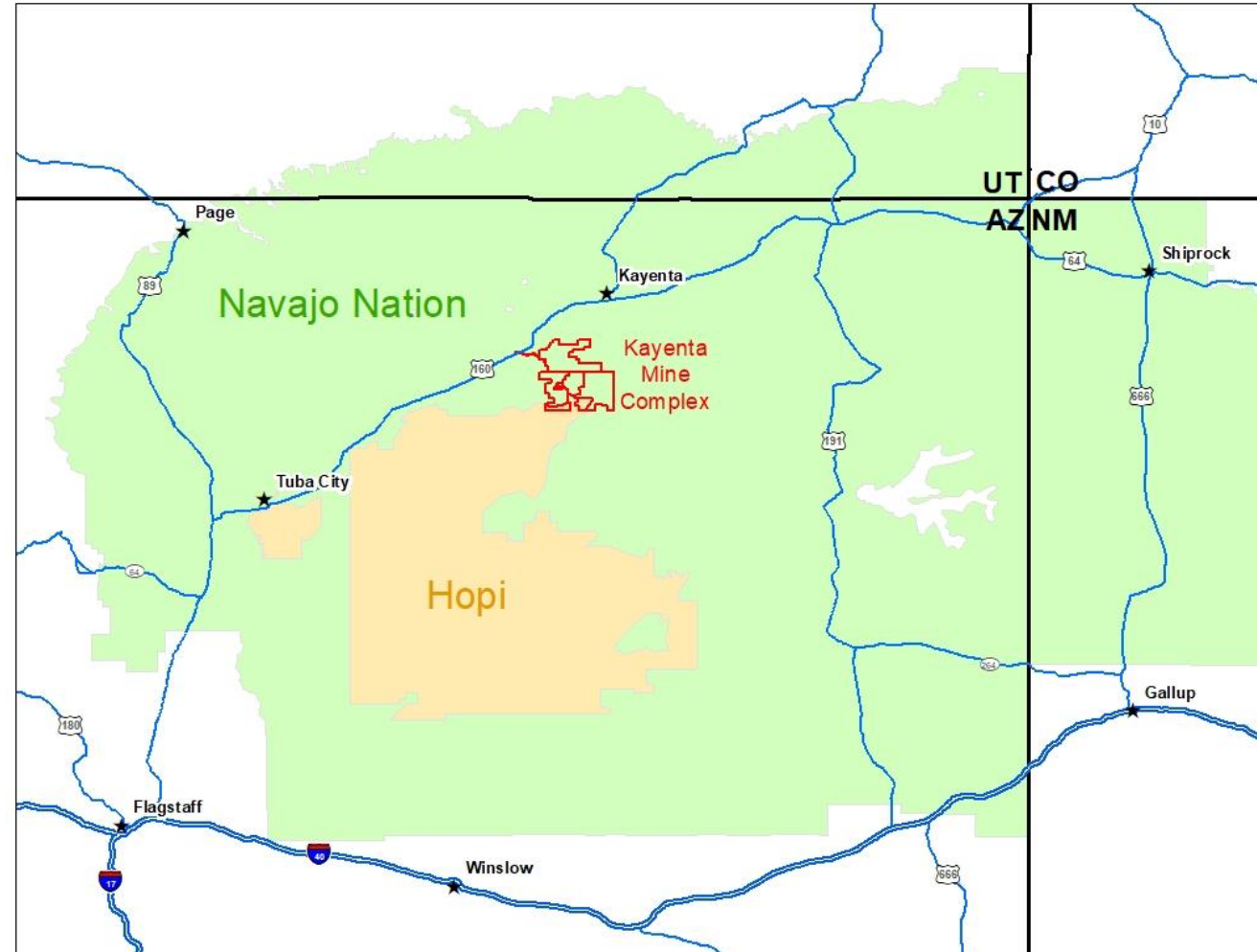
Anna Taugher (HMI, LLC)

Marie Shepherd, P.E. (Peabody Western Coal Company)



Kayenta Mine Complex

- Black Mesa & Kayenta Mines
- Mined coal 1970 – 2019
- ~65,000 acres leased from Navajo and Hopi tribes
- Operated by Peabody Western Coal Company
- Permitted by the Office of Surface Mining Reclamation and Enforcement (OSMRE)



Reclamation Progress

- Concurrent reclamation 1979 – 2019
- Final Reclamation 2019 – present
- 16,558 acres reclaimed to date
- 14,400 acres released from liability
 - Phase III or TOJ
- 2023 Excellence in Surface Coal Mining Reclamation Award



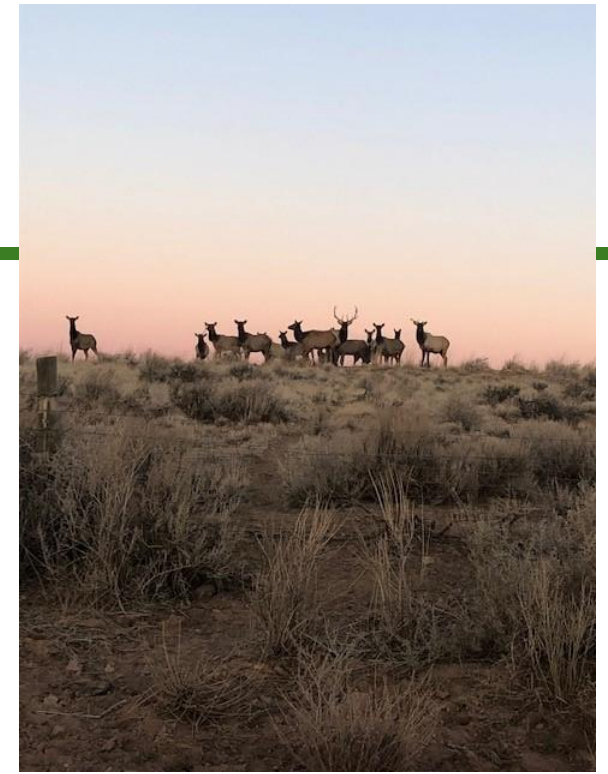
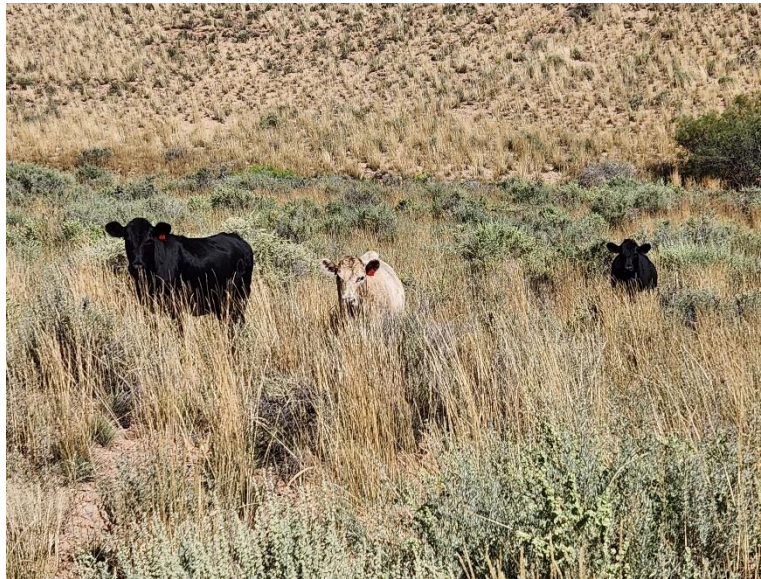
40 Years of Success

- Community Engagement
- Species Selection and Provenance
- Geomorphic Grading
- Dedication to Long-Term Reclamation Success Monitoring
- Continued Improvements to the Reclamation Program and Success Standards



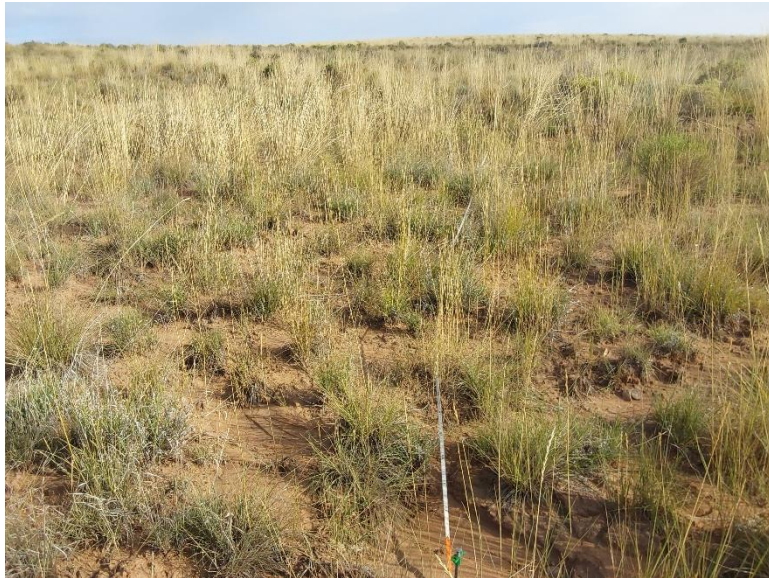
What is Success?

- Livestock Grazing
- Wildlife Habitat
- Cultural Plant Habitat



Reclamation Communities

- Grassland
- Shrubland
- Woodland (Red Rock Cultural Areas)



Reclamation Communities

Grassland & Shrubland Reclamation

- Same reclamation methods
- Delineated after establishment

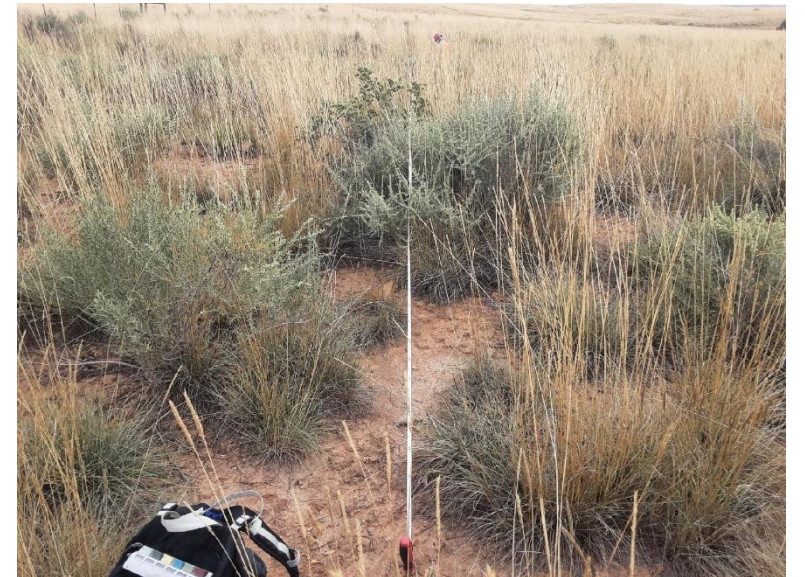
Uses & Standards

Grassland

- Grazing
- Mostly grasses
- Lower shrub density standard

Shrubland

- Browsing & Grazing
- Small wildlife cover
- Higher shrub density standard



Reclamation Communities

Woodland (Red Rock Cultural Areas)

- Cultural seed mixture
- Rocky surface soils
- Specialized planting of nursery stock

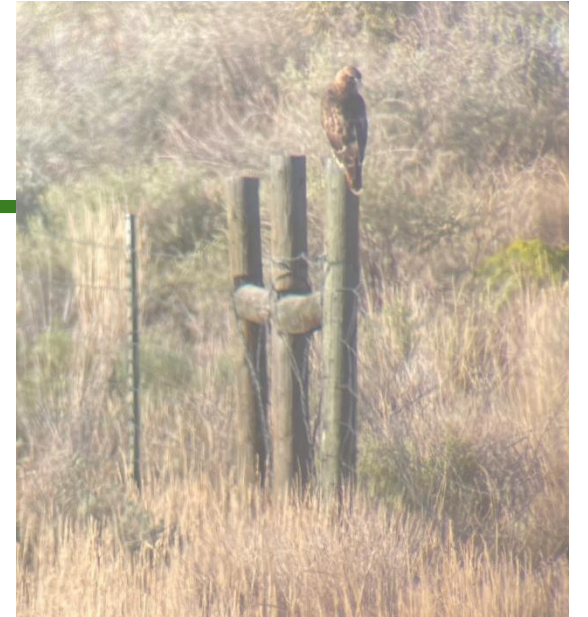
Uses & Standards

- Small wildlife cover
- Higher shrub density & diversity standards
- Tree density standard
- No cover or production standards



Reclamation for Wildlife

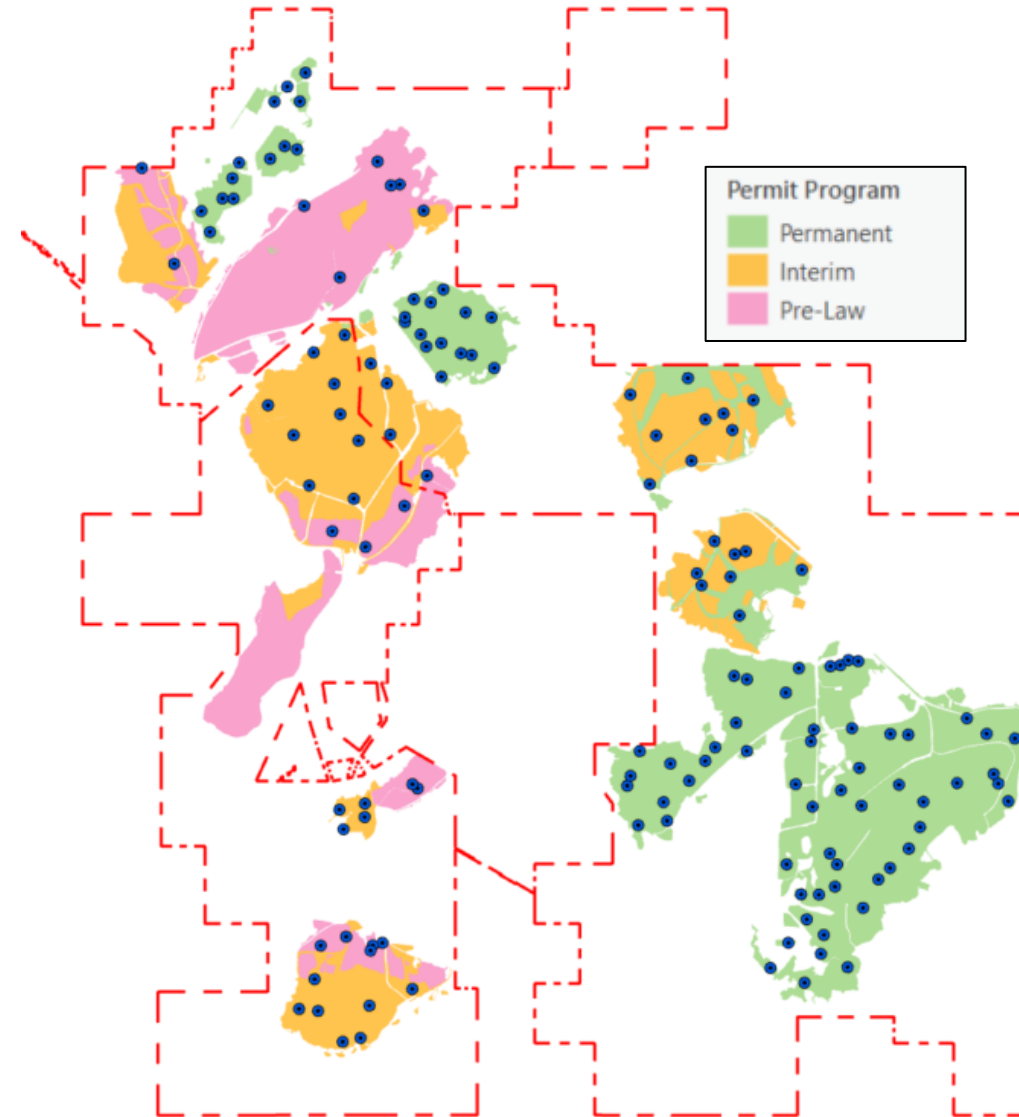
- Permanent ponds
- Critter condos
- Bird perches



Long-Term Reclamation Success Monitoring

Permanent Transect Monitoring

- 1992 – Present
- 144 locations
- Goals
 - Track reclamation success
 - Identify maintenance concerns
 - Grazing management
 - Watershed management
 - Improve Reclamation Success



Long-Term Reclamation Success Monitoring

Vegetation Database

- All vegetation data
- 1992 – Present
- Central Location
- Consistent Format



Informing Reclamation Success

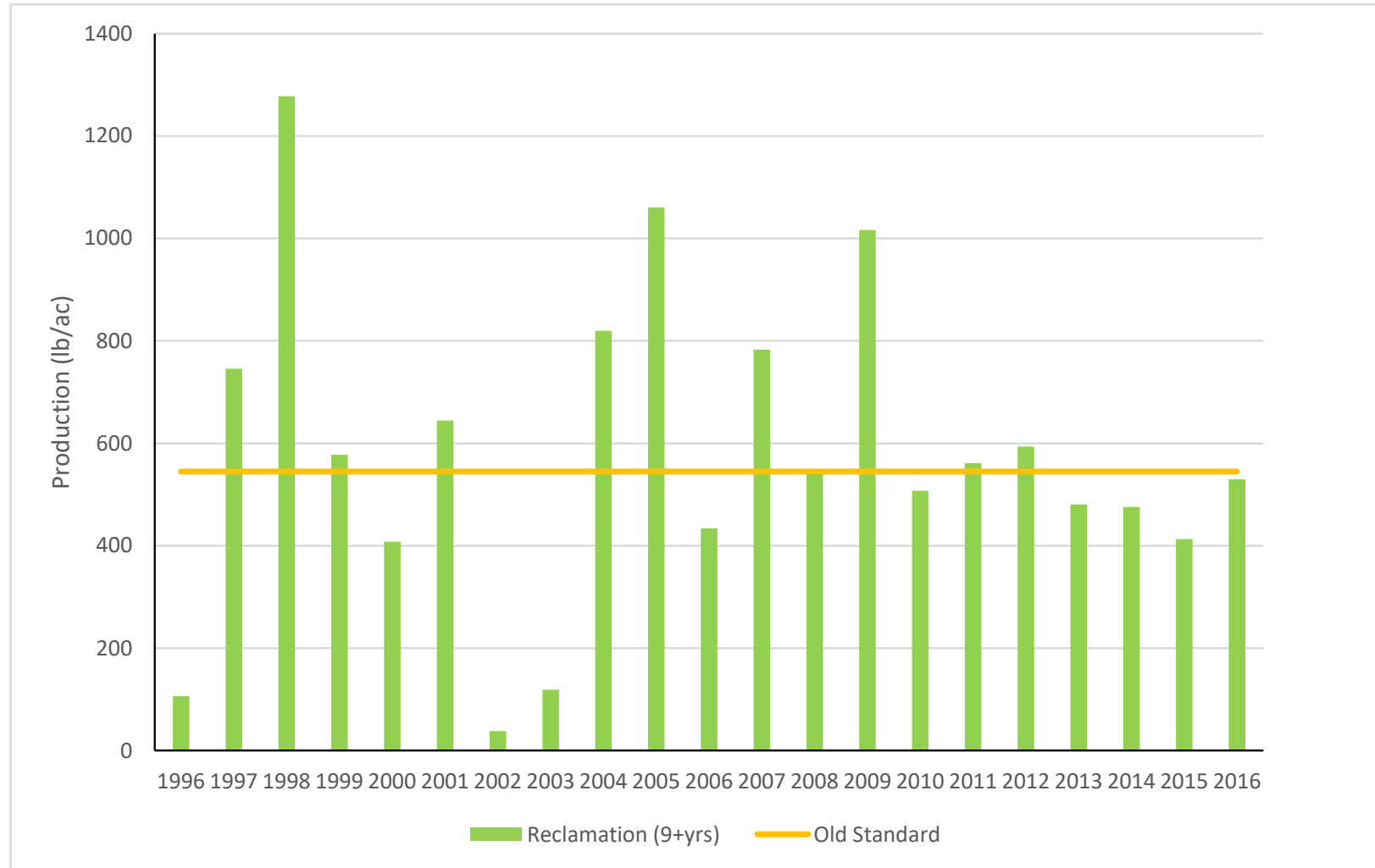
1. Climate Adjusted Production Standard
2. Interim Success Monitoring
3. Seed Mix Evaluation



Climate Adjusted Production Standard

Old Standard

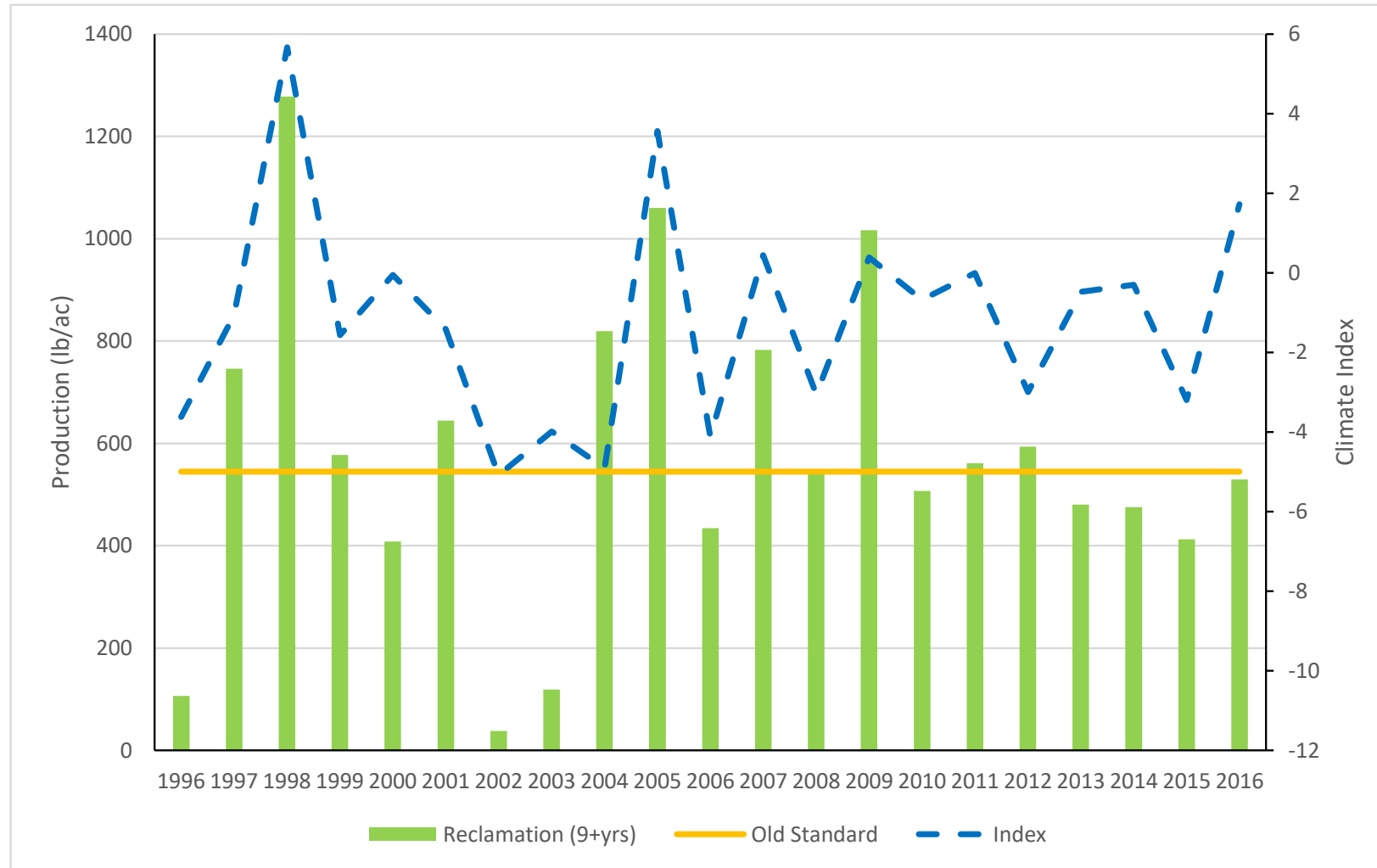
- 545 lb/ac
- Based on NRCS soil data



Climate Adjusted Production Standard

Climate Index

- ↑ Precipitation
= ↑ Index
- ↓ Precipitation
= ↓ Index
- ↓ Temperature
= ↑ Index
- ↑ Temperature
= ↓ Index



Climate Adjusted Production Standard

- Base standard = 375 lb/acre
- Adjusted based on the Climate Index
- $\text{Standard} = (42.434 * (\text{Index})) + 375$

Year	Difference from Average		Climate Index	Relative Climate	Standard (lb/acre)
	Precipitation	Temperature			
2021	-0.14	4.56	-4.70	Average & Hot	175.56
2022	4.06	4.86	-0.8	Wet & Hot	340.9
2023	3.53	-1.33	4.86	Wet & Cool	581.40
2024	1.23	5.87	-4.63	Wet & Hot	178.44
2025	-2.28	6.45	-8.73	Dry & Hot	4.72

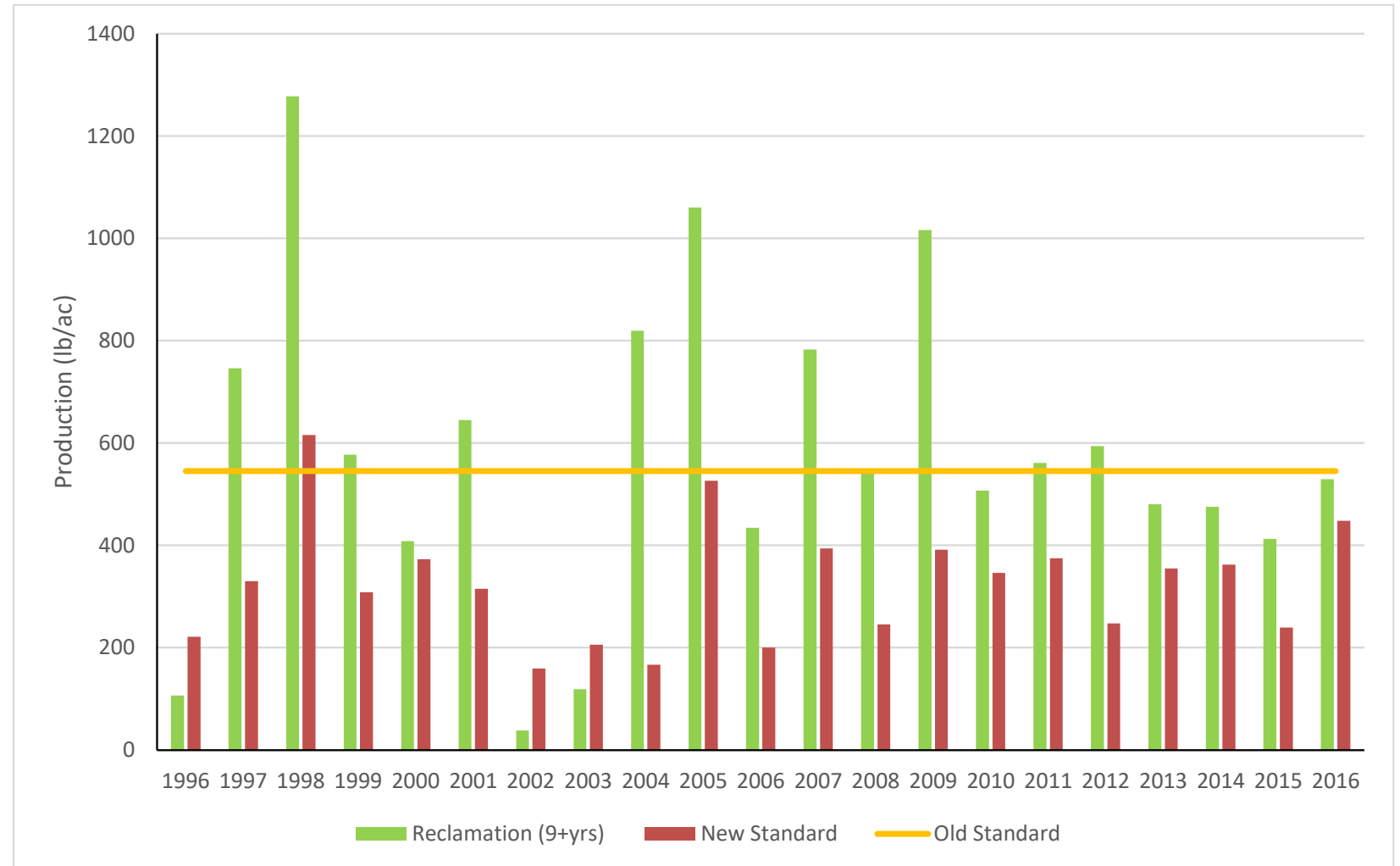
Climate Adjusted Production Standard

Old Standard

- Static
- Outdated basis

New Standard

- Variable with changing climate



Informing Reclamation Success

1. Climate Adjusted Production Standard
- 2. Interim Success Monitoring**
3. Seed Mix Evaluation

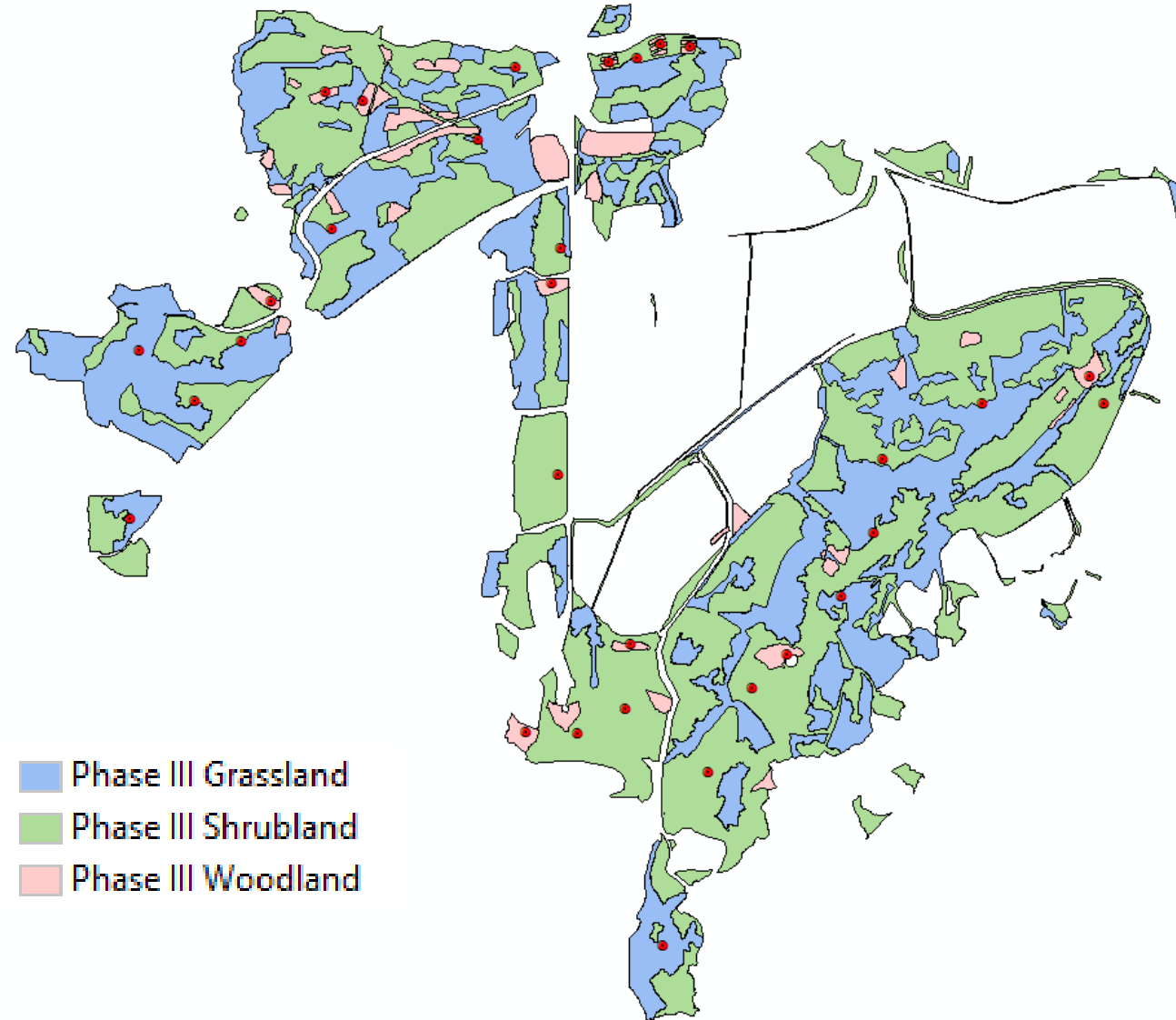


Interim Success Monitoring – J19/J21

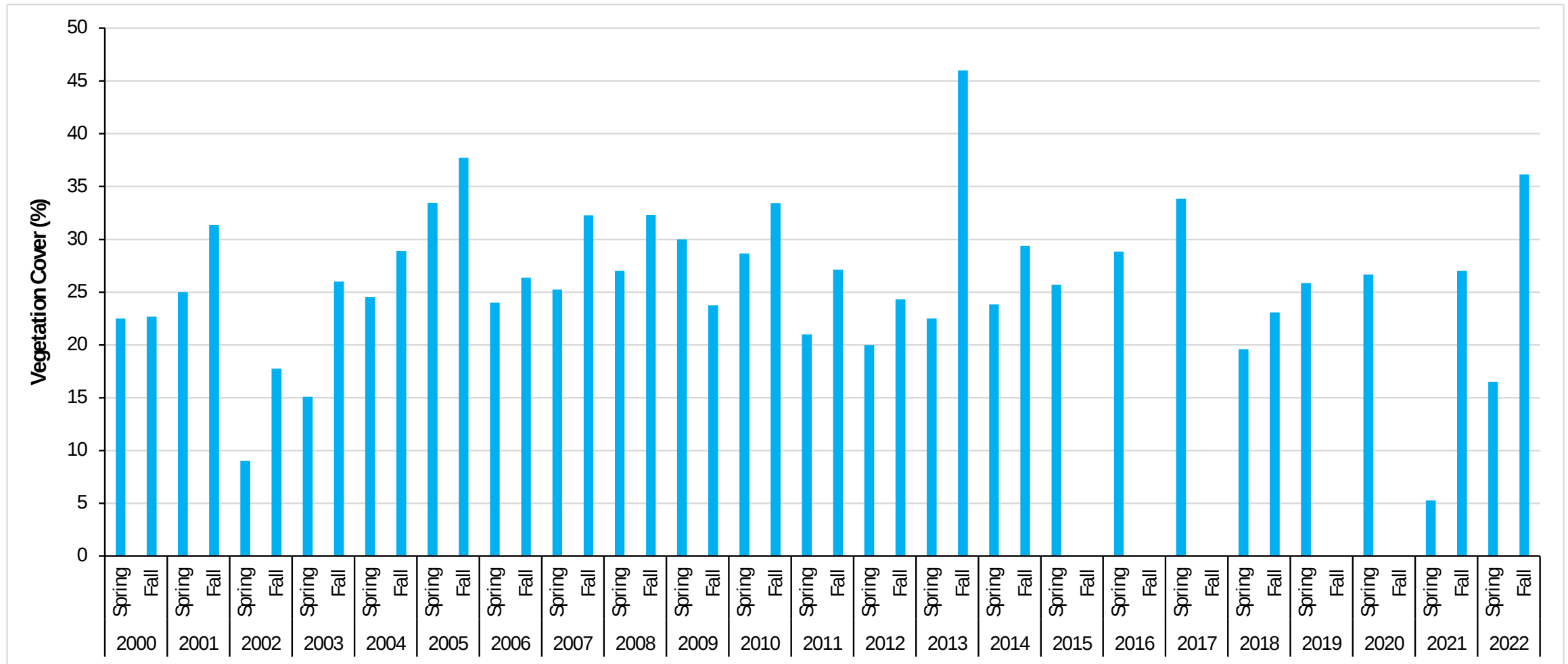
- 3,614 acres
- Monitored 2000 – 2024

31 Permanent Transects

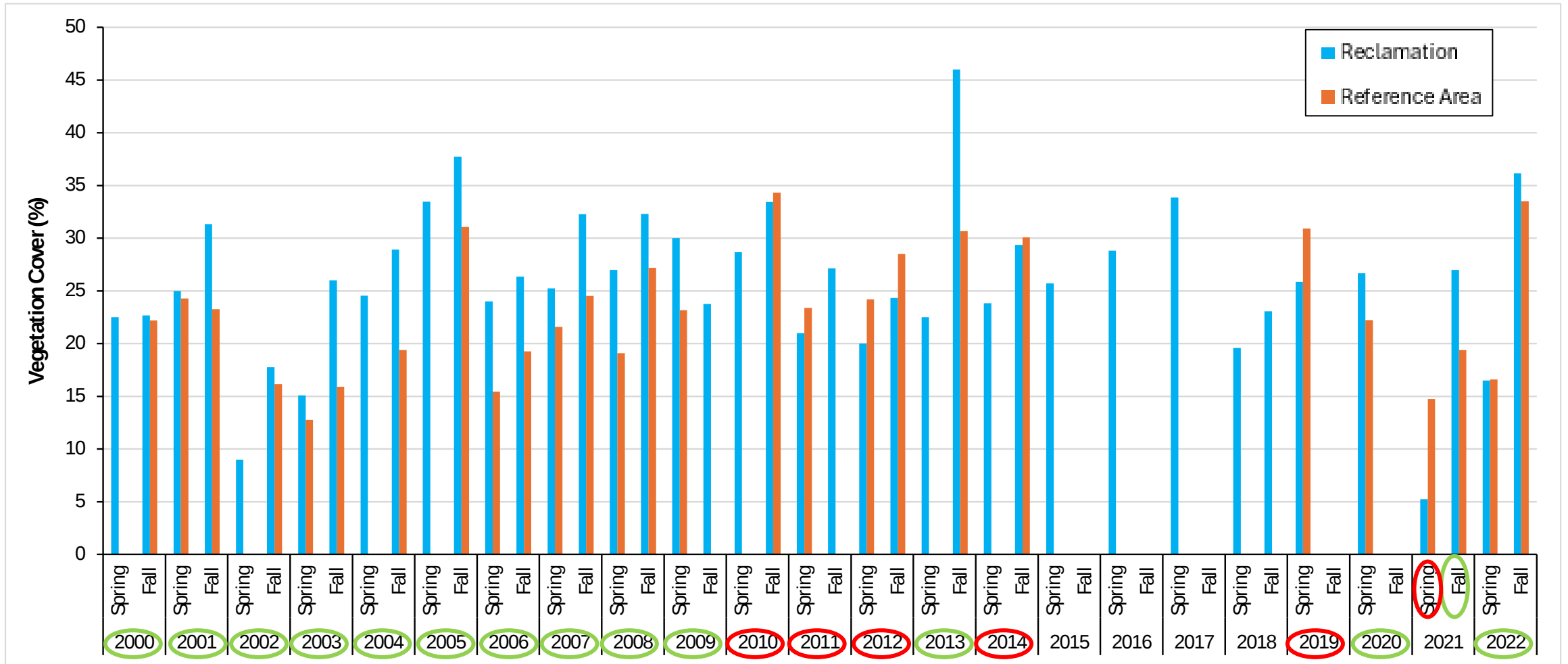
- 8 Grassland
- 12 Shrubland
- 11 Woodland (Cultural)



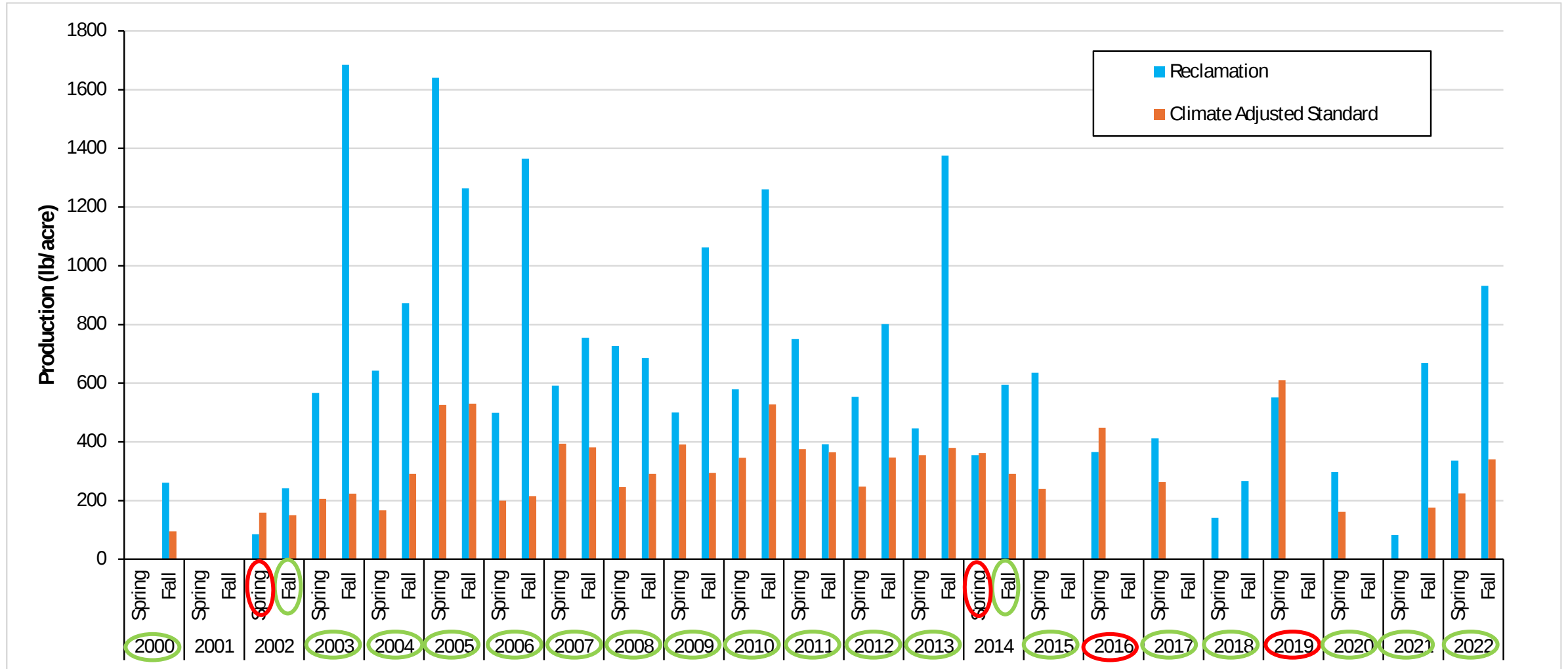
Interim Success Monitoring – J19/J21



Interim Success Monitoring – J19/J21



Interim Success Monitoring – J19/J21



Interim Success Monitoring – J19/J21

Areas of Concern

- Bare Areas
- Noxious Weeds
- Rills & Gullies
- Subsidence

Maintenance Needs

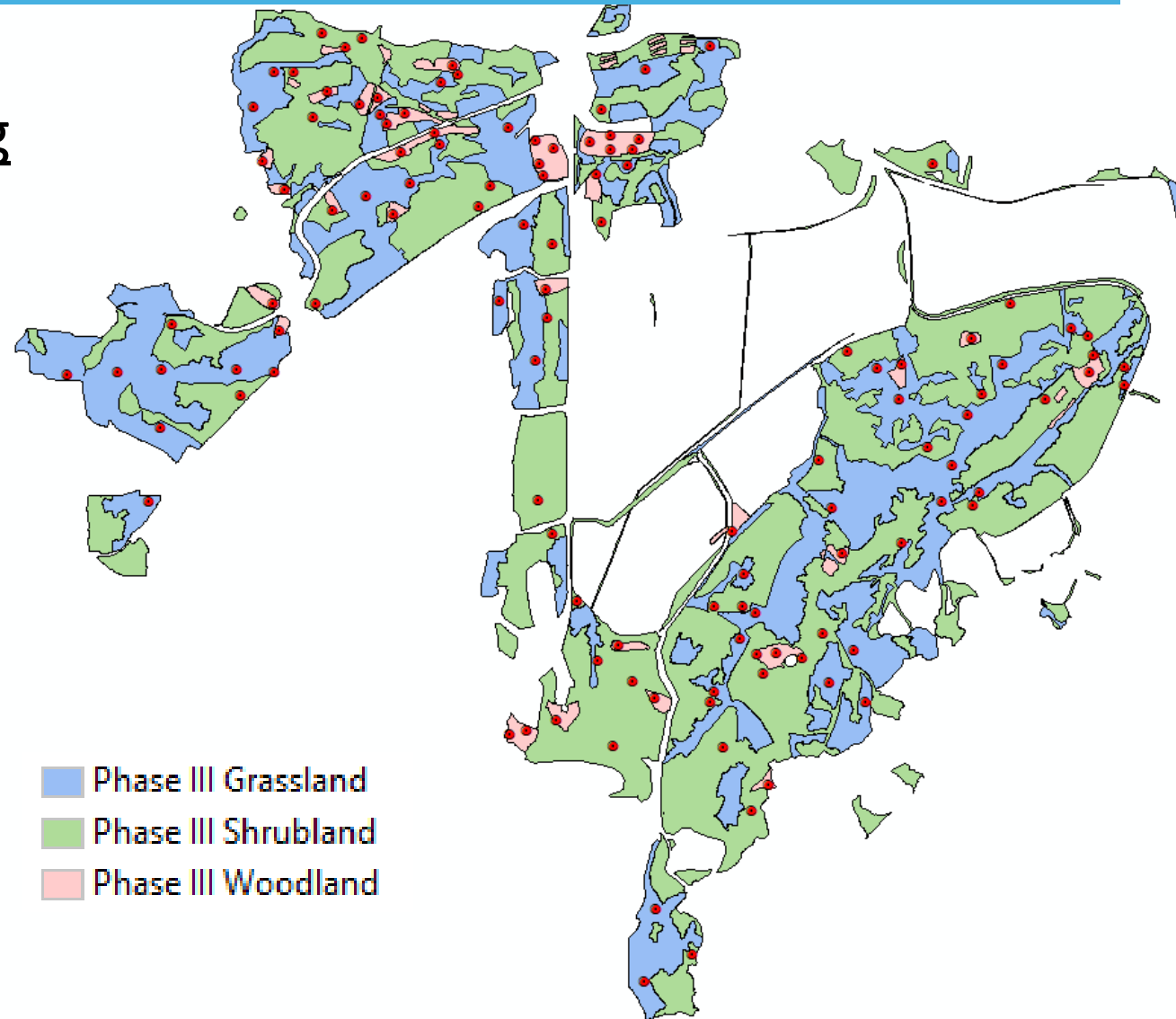
- Interseeding
- Weed Control
- Erosion Repairs
- Tree Planting



Final Success Monitoring – J19/J21

Phase III Bond Release Monitoring

- 2023 & 2024
- 40 transects in each community
- Passed Phase III Bond Release Standards with only 2 years of monitoring



Informing Reclamation Success

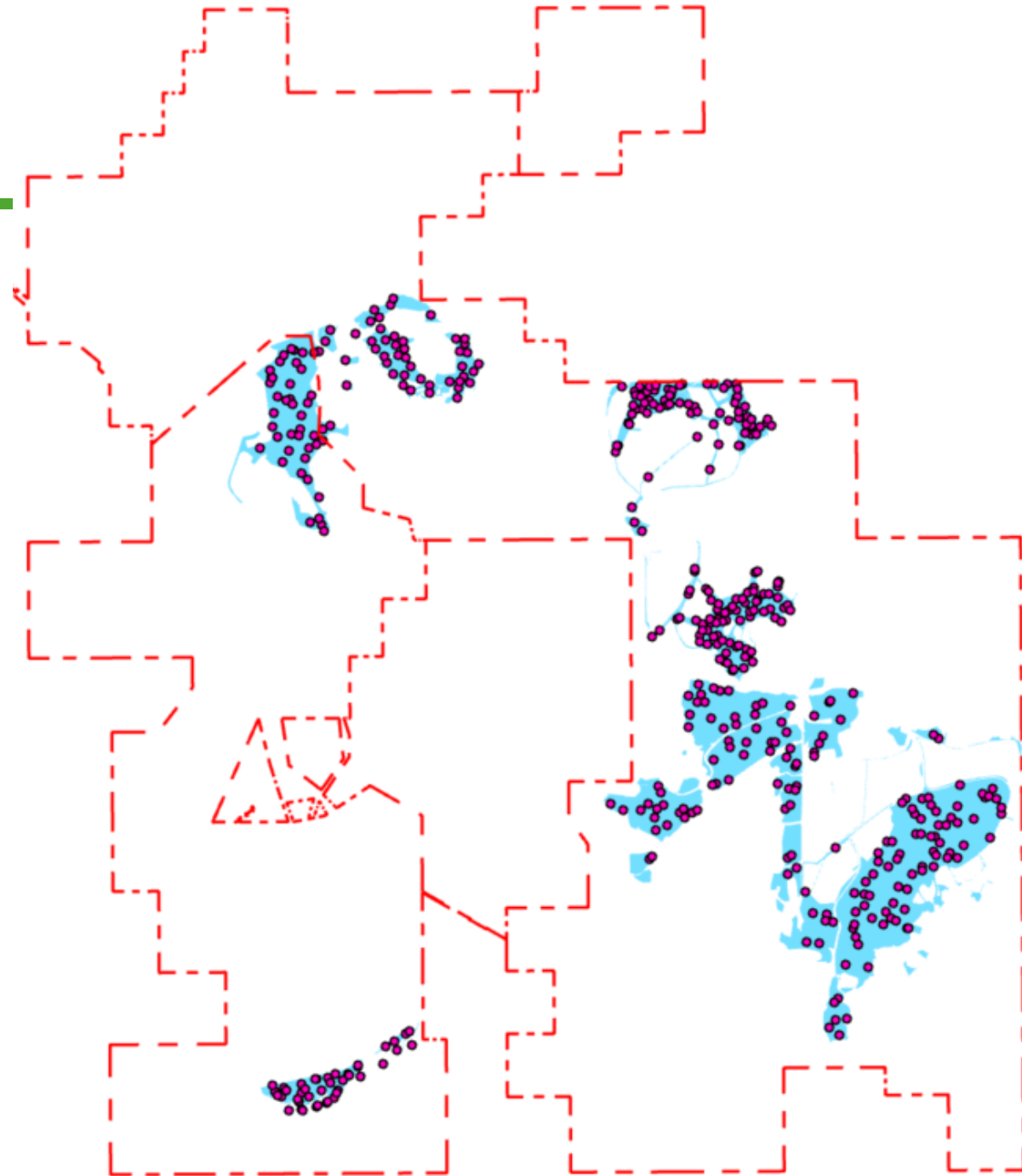
1. Climate Adjusted Production Standard
2. Interim Success Monitoring
- 3. Seed Mix Evaluation**



Seed Mix Evaluation

Final Reclamation

- 6 mine areas seeded after 2000
- Years Monitored: 2019 – 2024
- Sample Size: 445 Transects



Seed Mix Evaluation

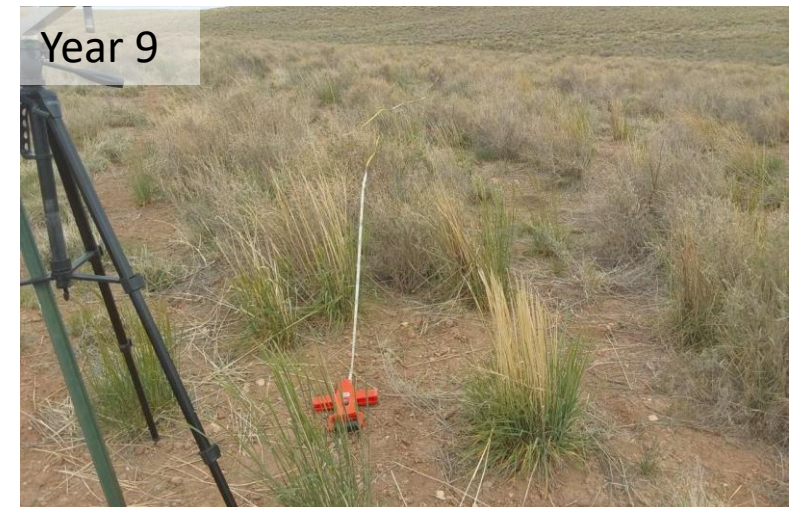
- Seed Mix = 94.6
 - Shrubs = 147.4 (19.9% rel. cov.)
 - Grasses = 102.4 (74.5% rel. cov.)
 - Forbs = 1.4 (0.2% rel. cov.)
- 6 species with establishment rating < 5

Scientific Name	Common Name	%of Mix	Establishment Rating
Grasses			
Achnatherum hymenoides	Indian ricegrass	5.0%	9.0
Bouteloua dactyloides	buffalograss	1.9%	9.0
Bouteloua gracilis	blue grama	15.2%	37.7
Elymus lanceolatus	thickspike wheatgrass	5.4%	31.6
Pascopyrum smithii	western wheatgrass	7.7%	58.5
Pleuraphis jamesii	James' galleta	6.0%	126.3
Psathyrostachys juncea	Russian wildrye	3.1%	1460.2
Pseudoroegneria spicata	bluebunch wheatgrass	2.0%	31.8
Sporobolus airoides	alkali sacaton	15.5%	49.9
Sporobolus cryptandrus	sand dropseed	9.3%	7.6
Thinopyrum intermedium	intermediate wheatgrass	1.7%	2.1
Forbs			
Astragalus cicer	chickpea milkvetch	2.3%	3.0
Linum lewisii	prairie flax	5.1%	0.0
Onobrychis viciifolia	sainfoin	1.1%	2.4
Ratibida columnifera	upright prairie coneflower	3.3%	0.5
Sanguisorba minor	small burnet	2.0%	3.9
Shrubs/ Subshrubs			
Atriplex canescens	fourwing saltbush	3.7%	373.0
Atriplex confertifolia	shadscale saltbush	2.3%	11.3
Bassia prostrata	forage kochia	3.6%	153.1
Krascheninnikovia lanata	winterfat	3.9%	7.3
Total			94.6

Seed Mix Evaluation

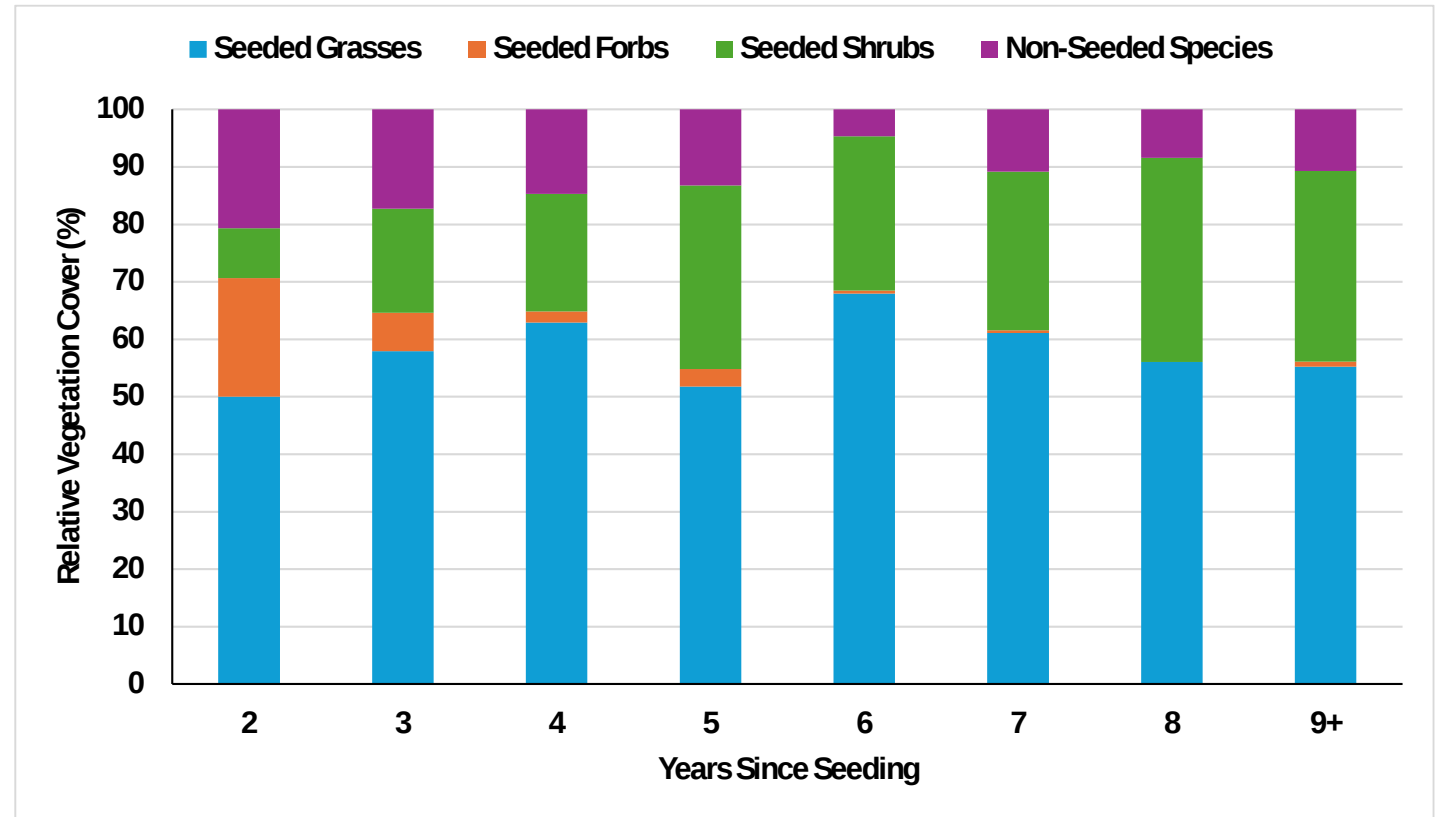
Permanent Transects over time

- 31 transects seeded after 2000
- Years Monitored: 2017 – 2024
- Reclamation Age: 2 – 15
- Sample Size: 90



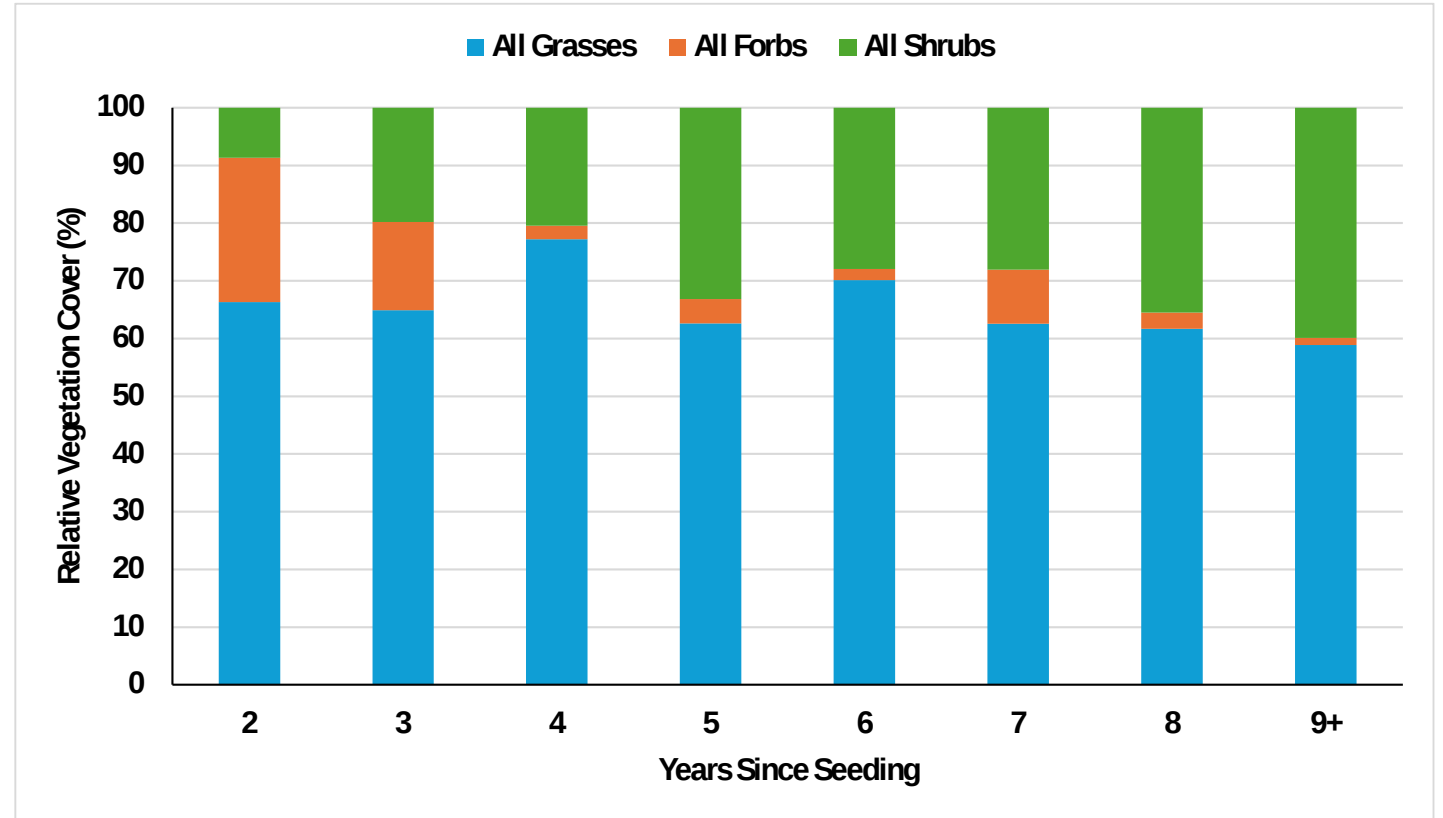
Seed Mix Evaluation

- Seed mix expression changes over time
- Seed Mix Relative cover
 - Total: 79% – 95%
 - Grasses: 50% – 68%
 - Forbs: 20% to <1% by Year 6
 - Shrubs 9% – 35%



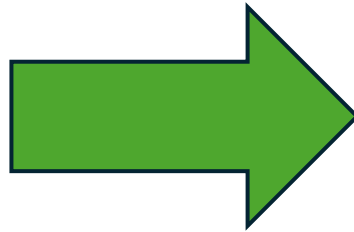
Seed Mix Evaluation

- Total Relative cover
 - Grasses: 59 – 77%
 - Forbs: 2 – 25%
 - Shrubs: 9 – 40%



Seed Mix Evaluation

- Poor performing forbs replaced with alternates



Thank You!

The logo for Peabody, featuring the word "Peabody" in a bold, blue, sans-serif font. A thick blue horizontal line runs underneath the letters "Peabody".