Prediction of Field Germination Using Wet Thermal Accumulation

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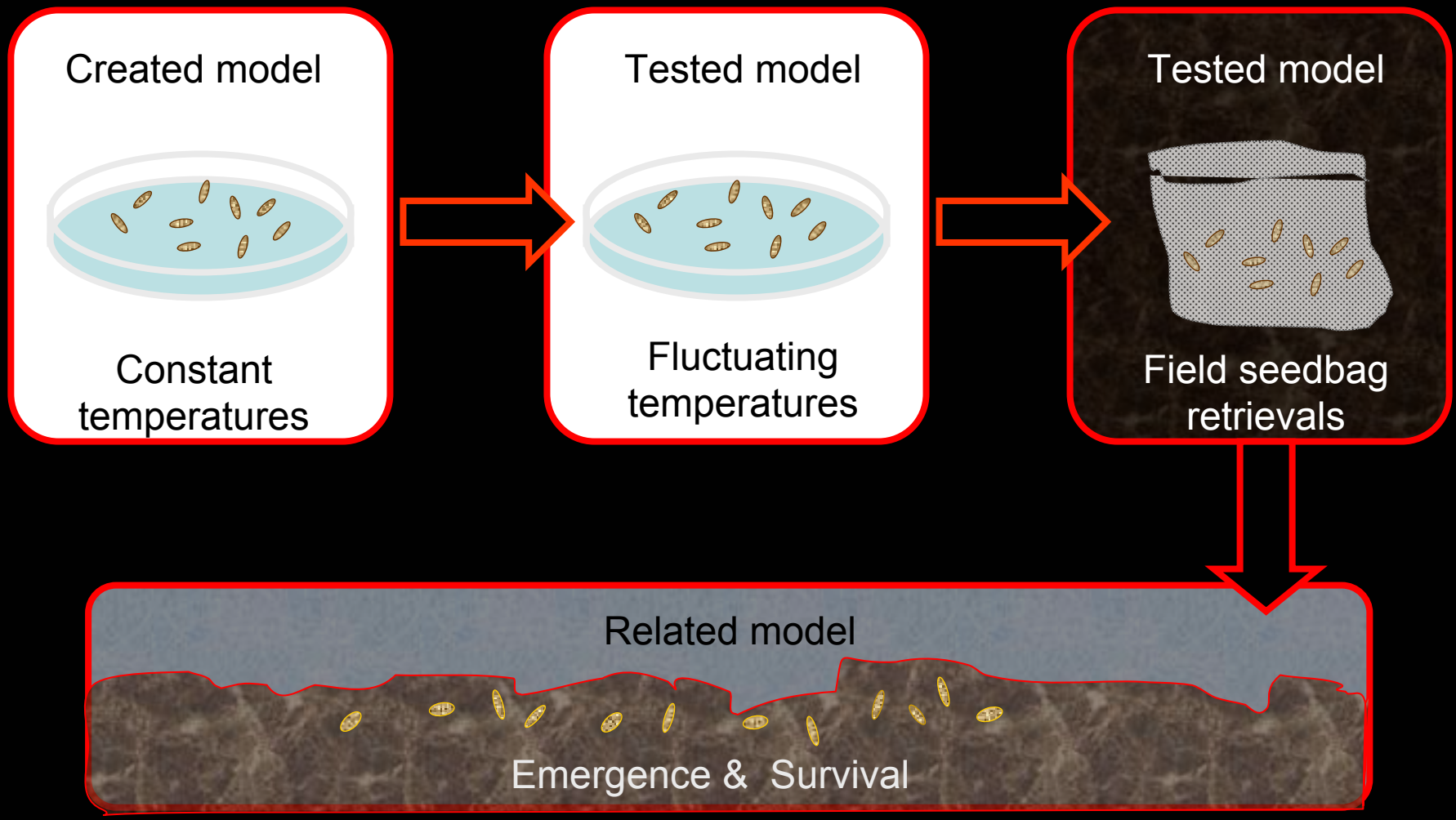
Study Methods



Model Development

- **Germination requirements**

  1) Water

  - **Above soil moisture threshold** (W_b)

  2) Temperature

  - **Above threshold base temperature** (T_b)
  - **Thermal time requirement** (degree days)

Model Development

Germination requirements ➢ *Agropyron cristatum*

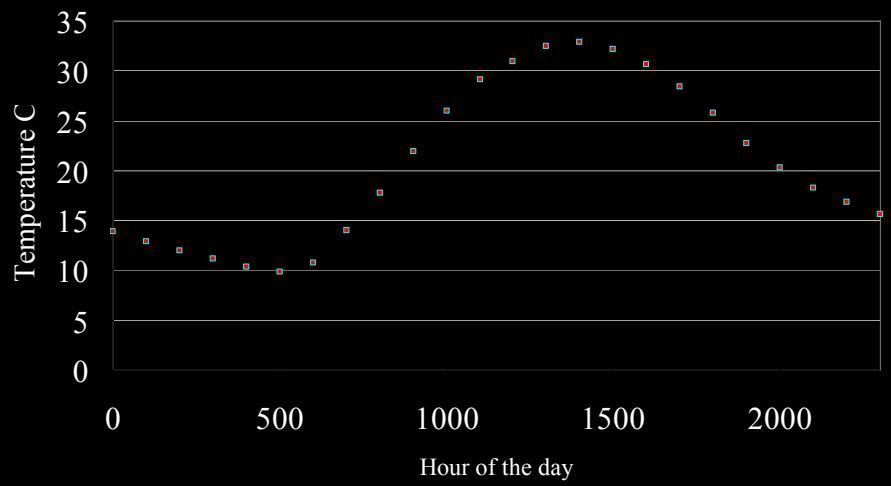
1) Soil moisture threshold ➢ W_b = -1.5 MPa
   - ➢ W = -1.0 MPa
2) Base temperature threshold ➢ T_b = 0°C
   - ➢ T = 20°C
3) Thermal time requirement ➢ 5 days at 20°C = 50%

$$(20°C - 0°C)*(5 \text{ days}) = 100 \text{ wet degree days}$$

Model Development

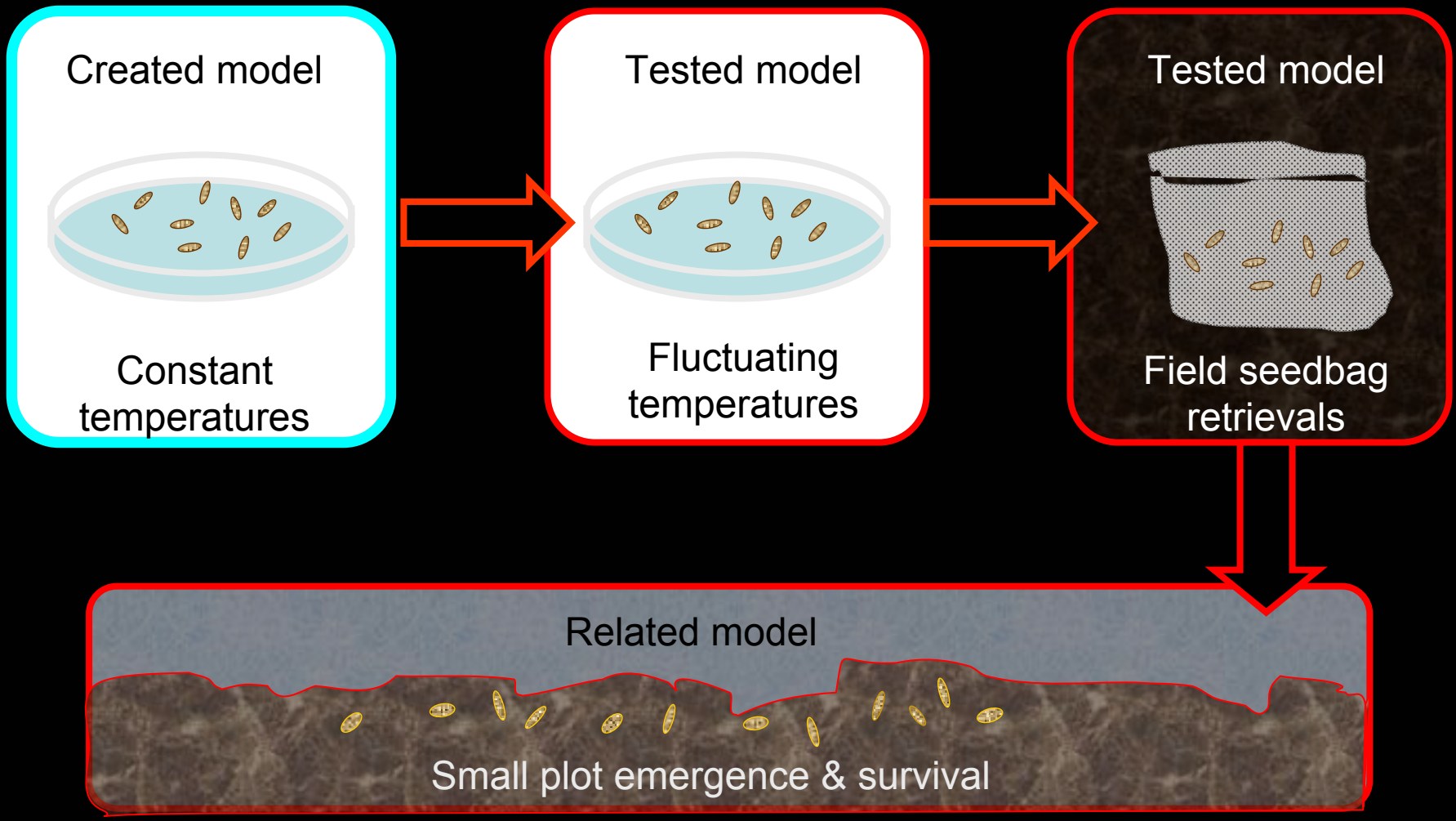
- Crested wheatgrass requires 100 wet degree days for 50% germination

- Days to 50% germination:
  - 100 at 1° C
  - 50 at 2° C
  - 5 at 20° C



Species	Common Name	Cultivar	Source	Year Collected
Achillea millefolium	eagle yarrow	N/A	Eastern Washington	2003
Linum perenne	blue flax	Appar	UDWR-commercially grown	2003
Agropyron cristatum	crested wheatgrass	Hycrest		2003
Psuedoroegneria spicata	bluebunch wheatgrass	Secar	Eastern Washington	2003
Elymus elymoides	squirreltail	Sanpete	Sanpete Co., UT	2003
Bromus tectorum	cheatgrass	N/A	Lookout Pass, UT	2005
Bromus tectorum	cheatgrass	N/A	Skull Valley, UT	2005

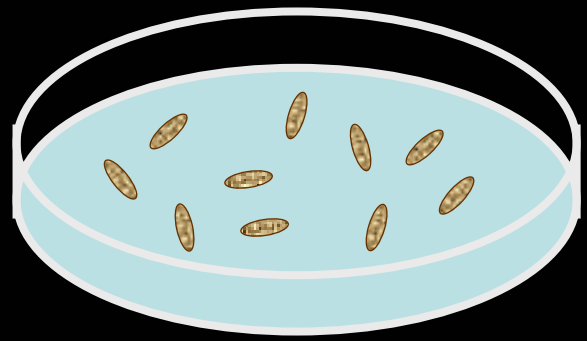
Study Methods



Model Development: Thermal time requirement

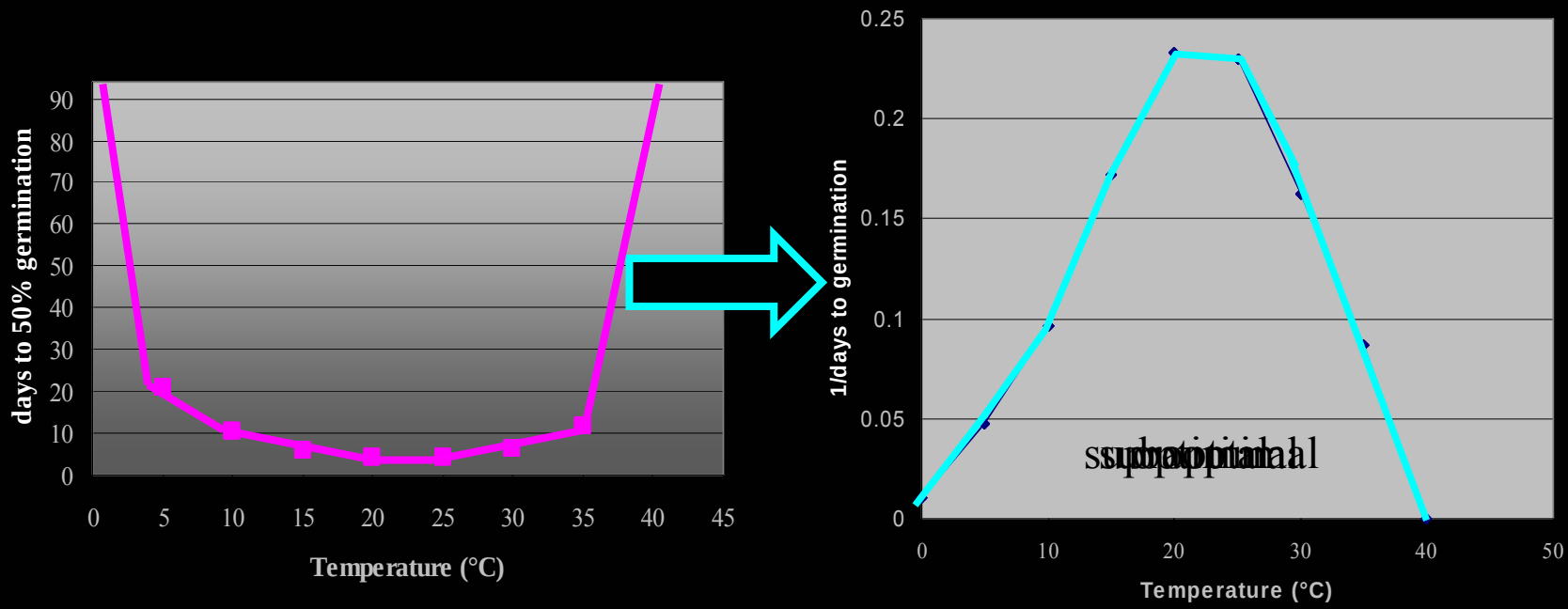
- Constant Temperatures:
  - 5-35 °C

- What we measured:
  - Time required for germination
    - 10%
    - 25%
    - 50%
- What we needed to know:
  - Germination rate (1/days to % germination)

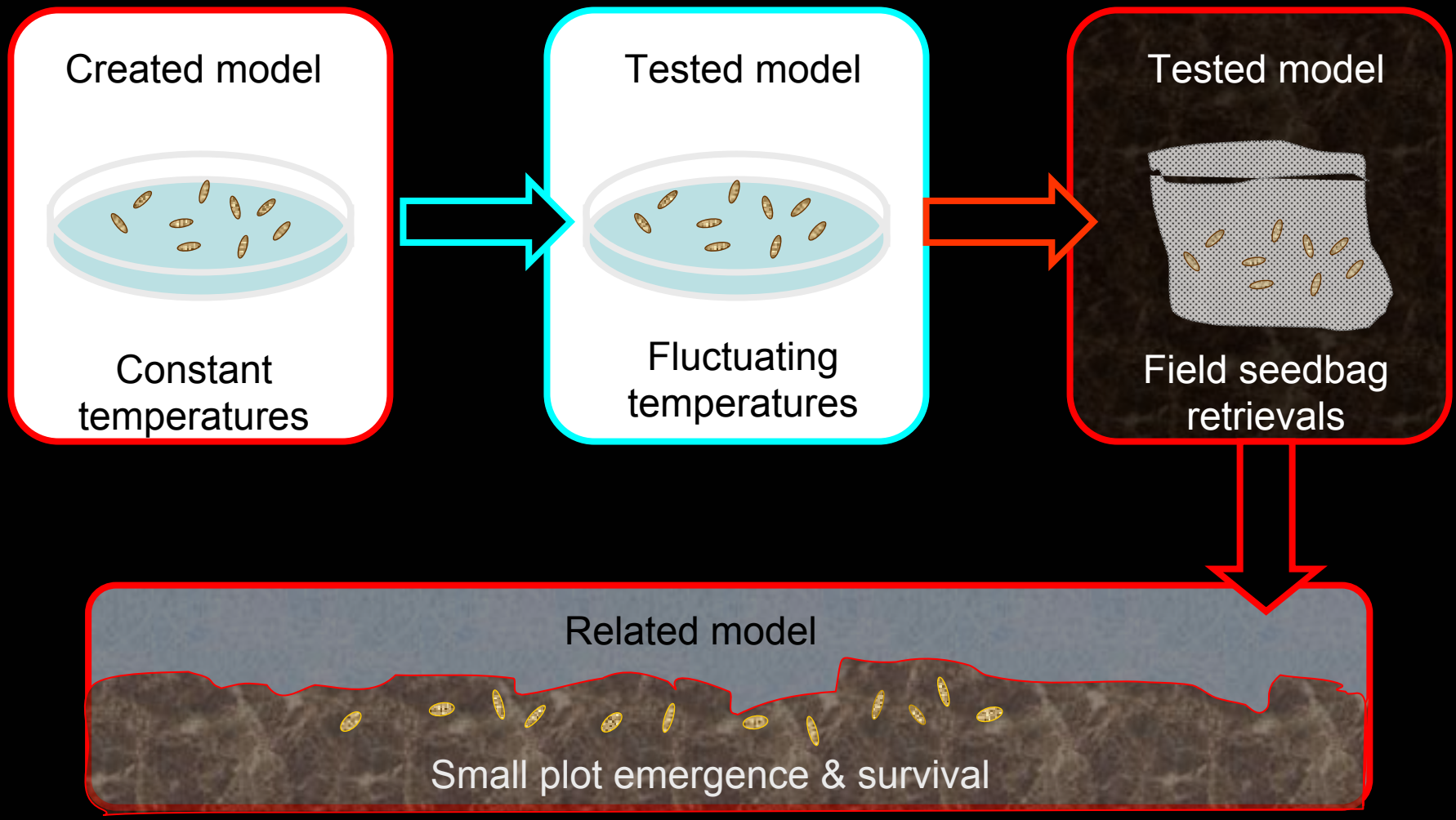


Model Development: Curve fitting

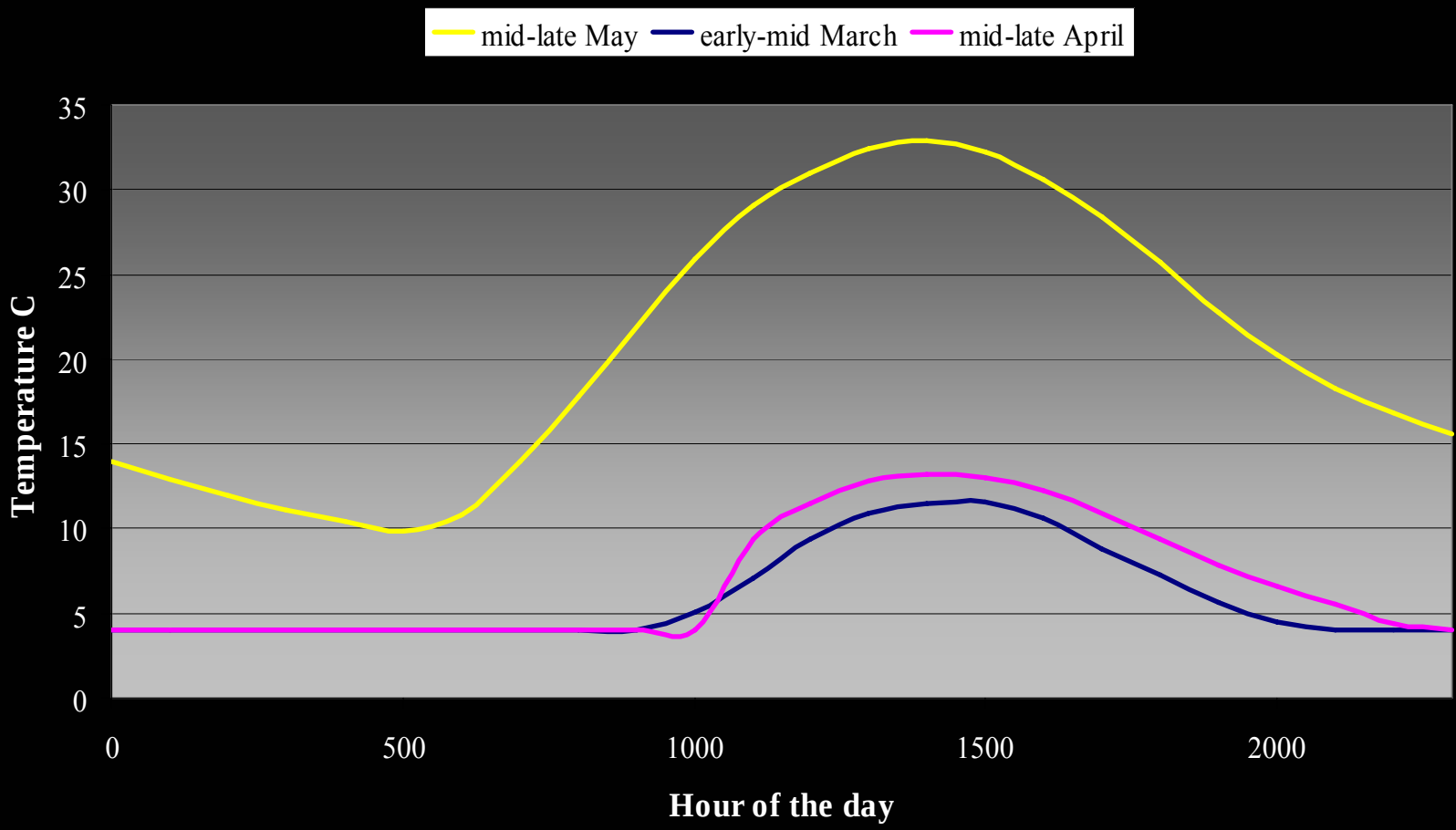
Elymus elymoides



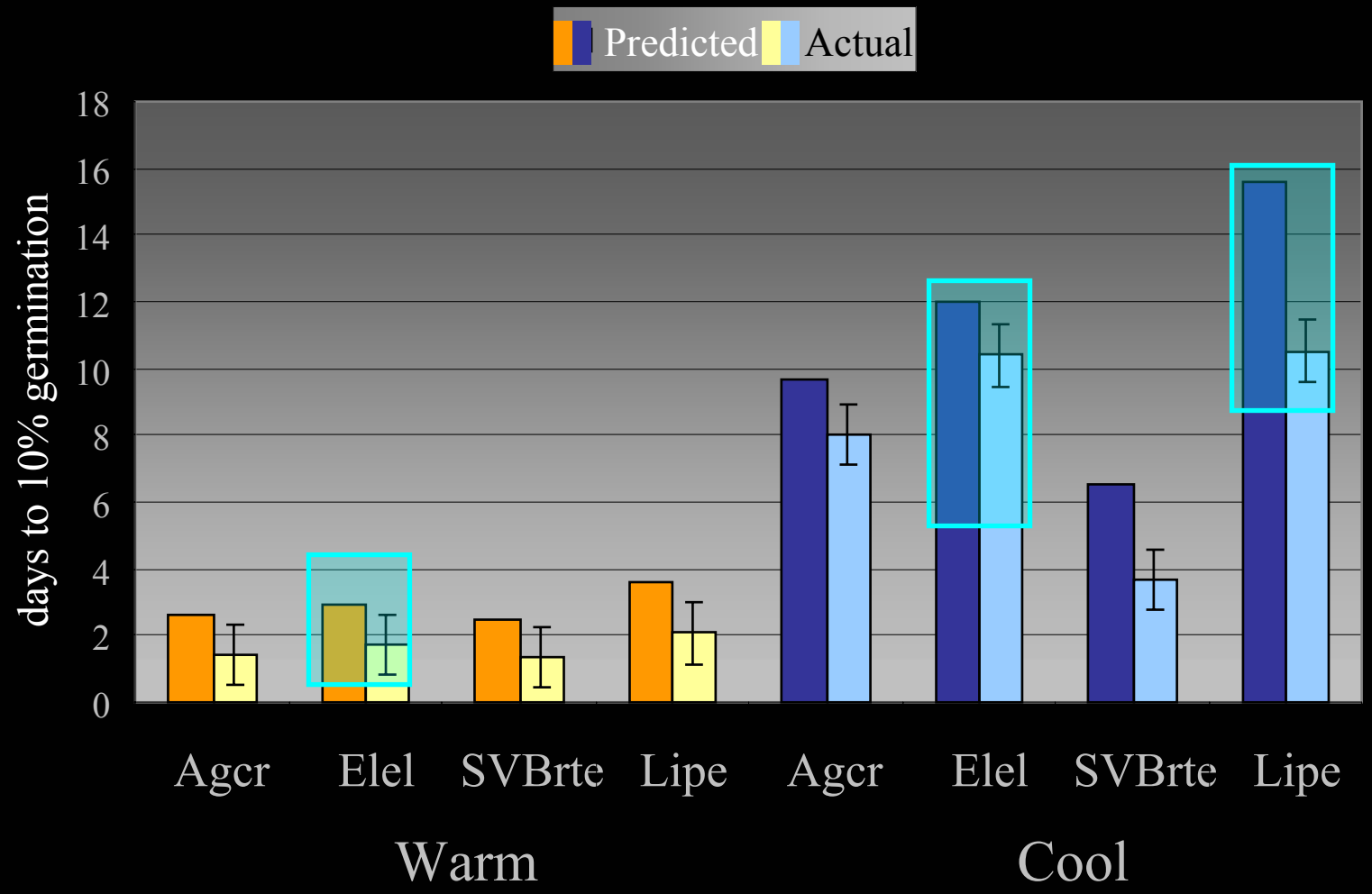
Study Methods



Lab verification: Spring temperature simulations



Lab verification: Spring simulation

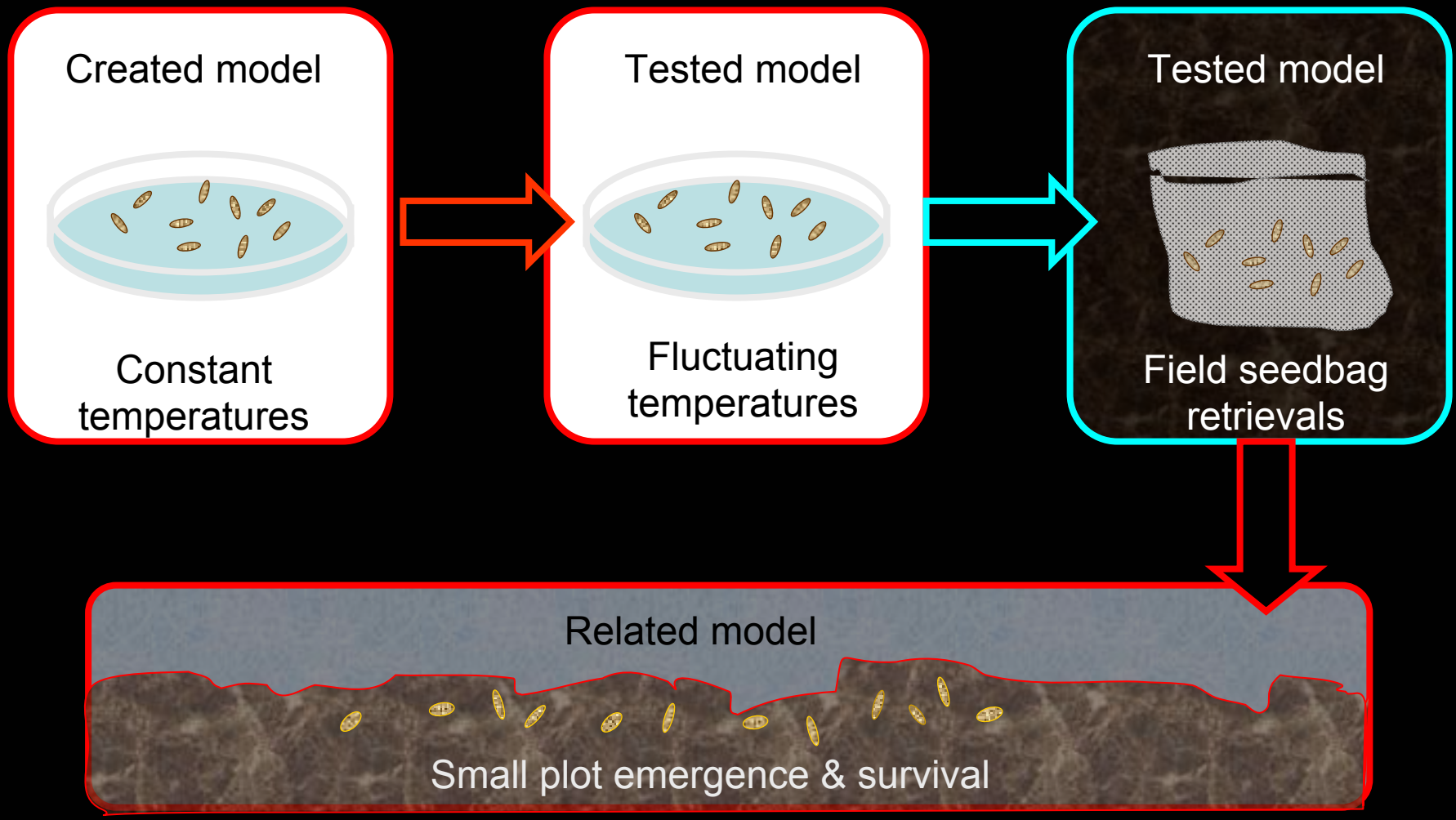


Lab verification: Conclusions

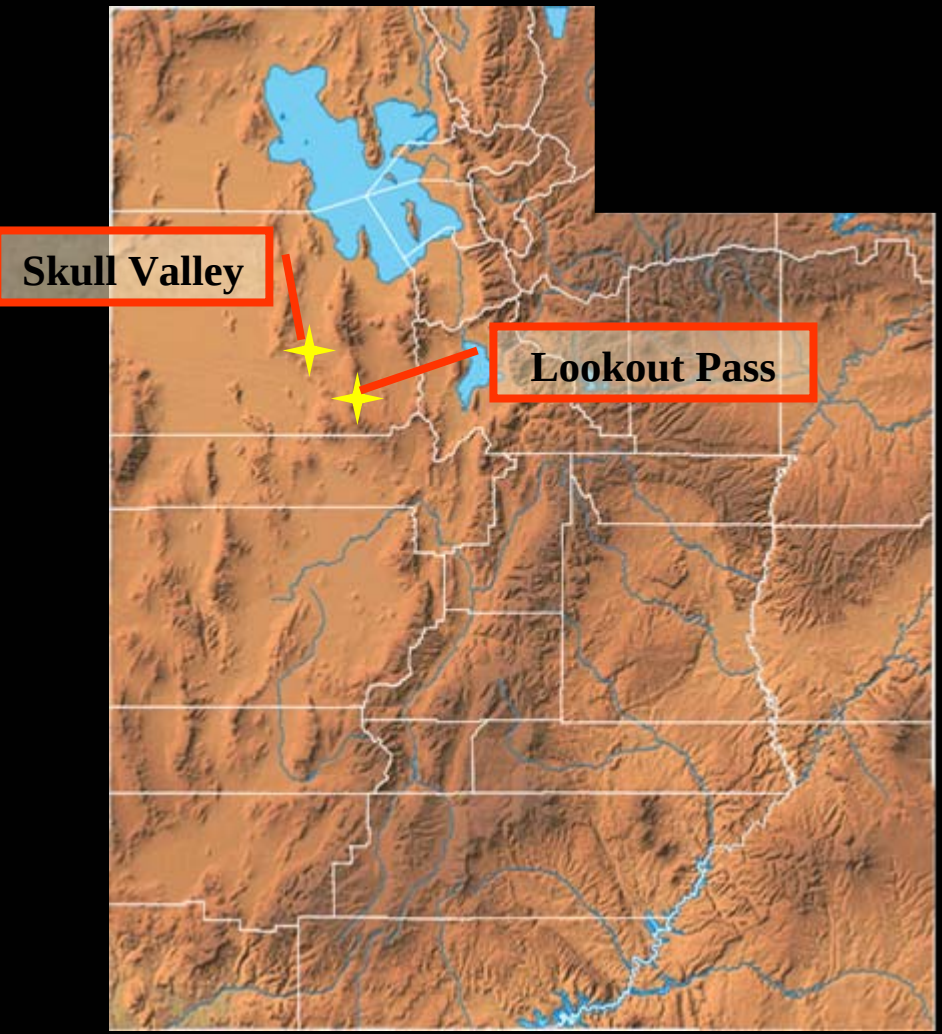
- Models can be used to predict germination response to fluctuating temperatures

❖Thermal accumulation requirement determined by constant temperature trials tends to overestimate time to germination

Study Methods



Field verification: Study Sites

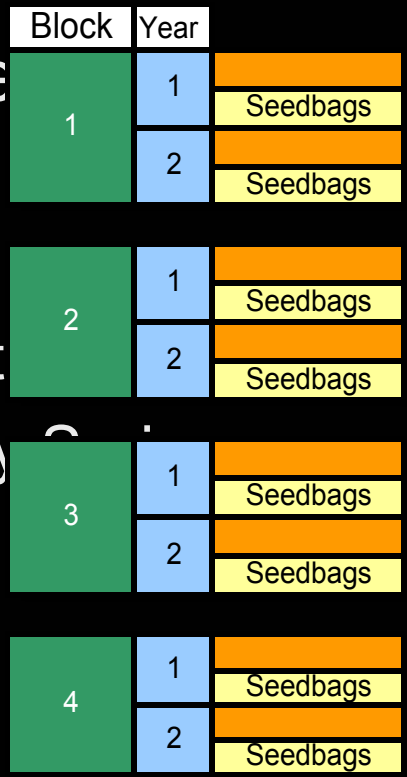


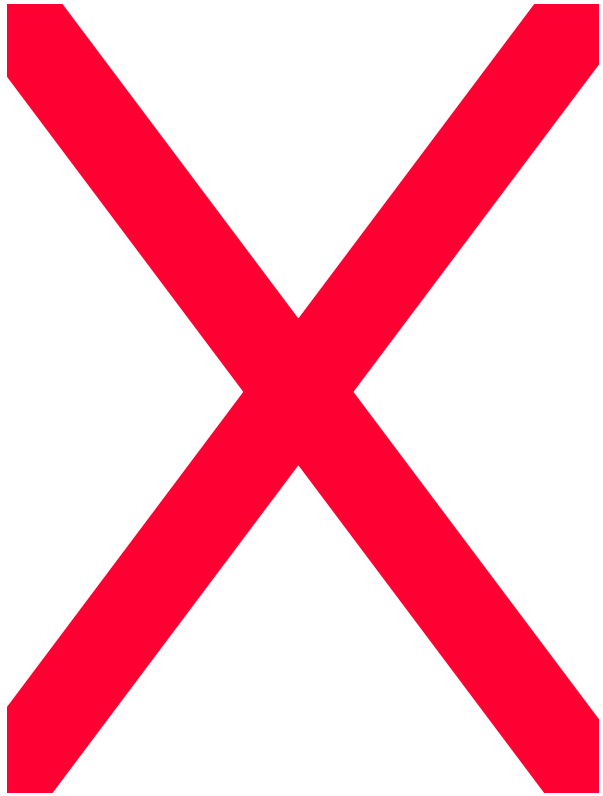
Seedbed Monitoring

- Temperature
  - Depths:
    - 1-3 cm
    - 13-15 cm
    - 28-30 cm
- Moisture
  - Depths:
    - 1-3 cm
    - 13-15 cm
    - 28-30 cm

Study Sites

- 19 see[illegible]als
  - Fall
  - Wint[illegible]
  - Early [illegible]
  - Late





Thermal accumulation: 2 methods

Warm

1) Thermal accumulation resumes = Σ wet periods

2) Thermal accumulation begins again = wet period

Germination stops

Unimbibed

Germination

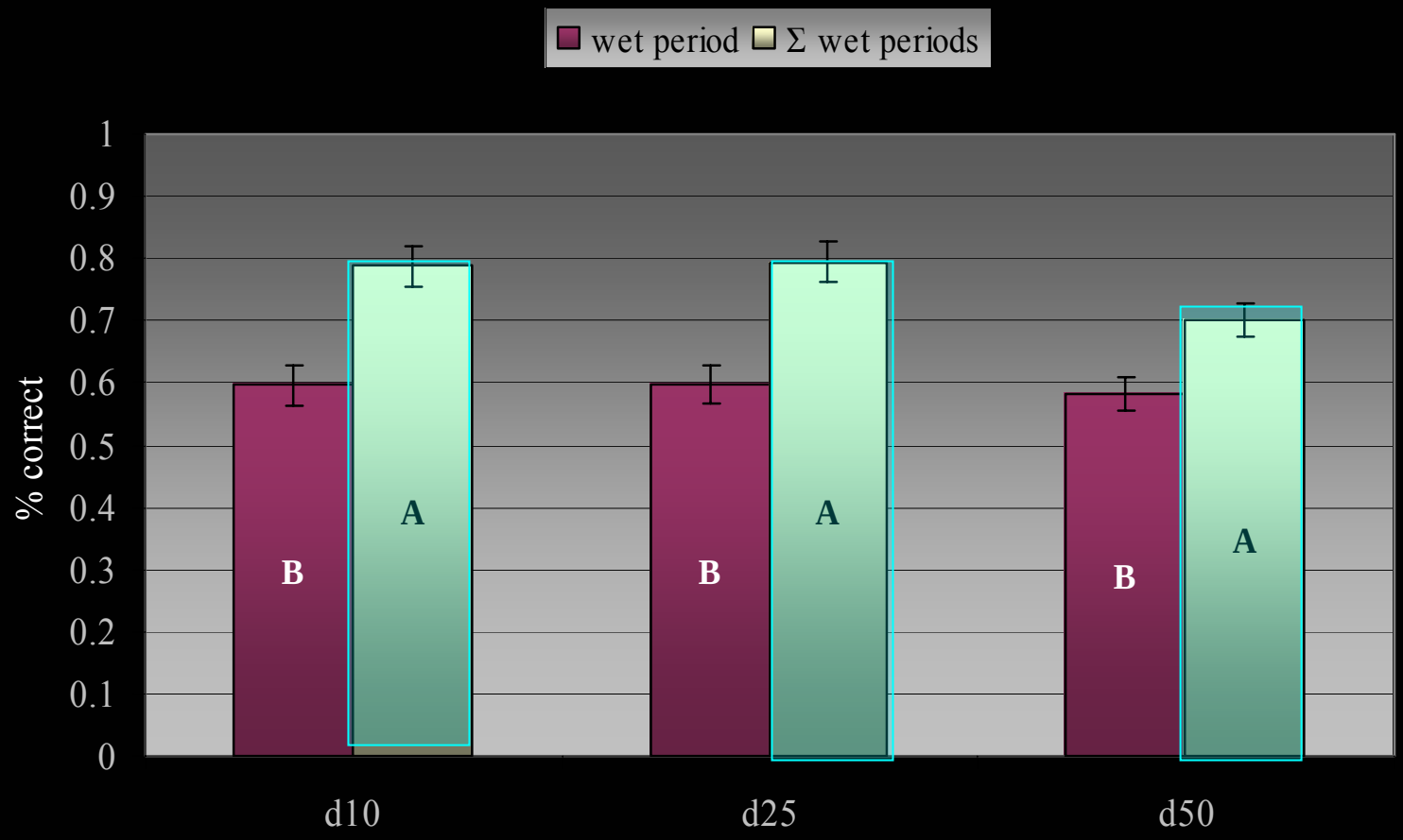
Wet

Dry

Field verification: Seedbag Retrievals

1) 2 methods
   - Thermal accumulation = each wet period
   - Thermal accumulation = Σ wet periods

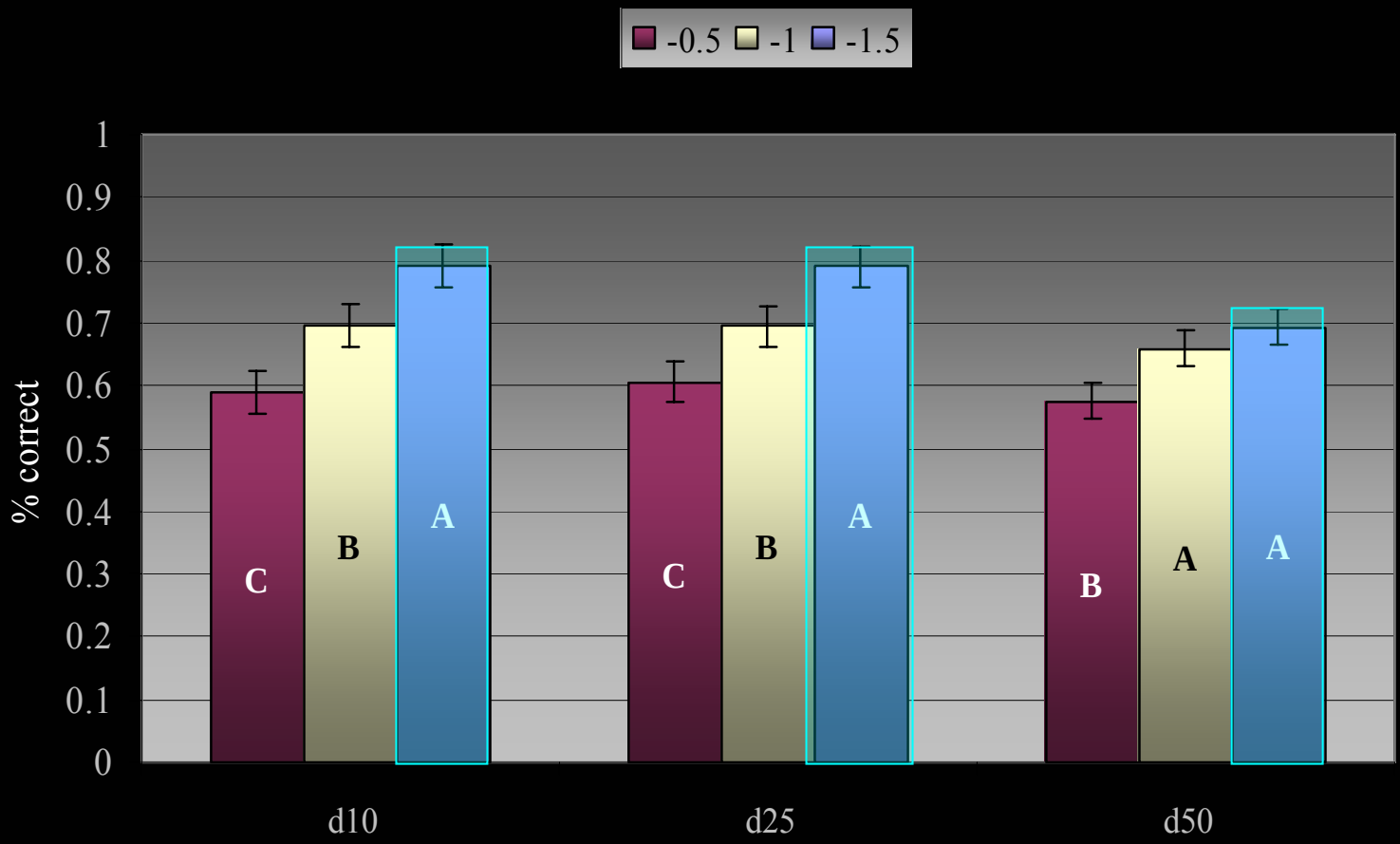
Model Accuracy: method = ∑ wet periods



Field verification: Seedbag Retrievals

1) 2 methods
   - Thermal accumulation = each wet period
   - Thermal accumulation = Σ wet periods
2) 3 soil moisture thresholds
   - -0.5, -1.0, -1.5 MPa

Model Accuracy: moisture threshold = -1.5 MPa



Field verification

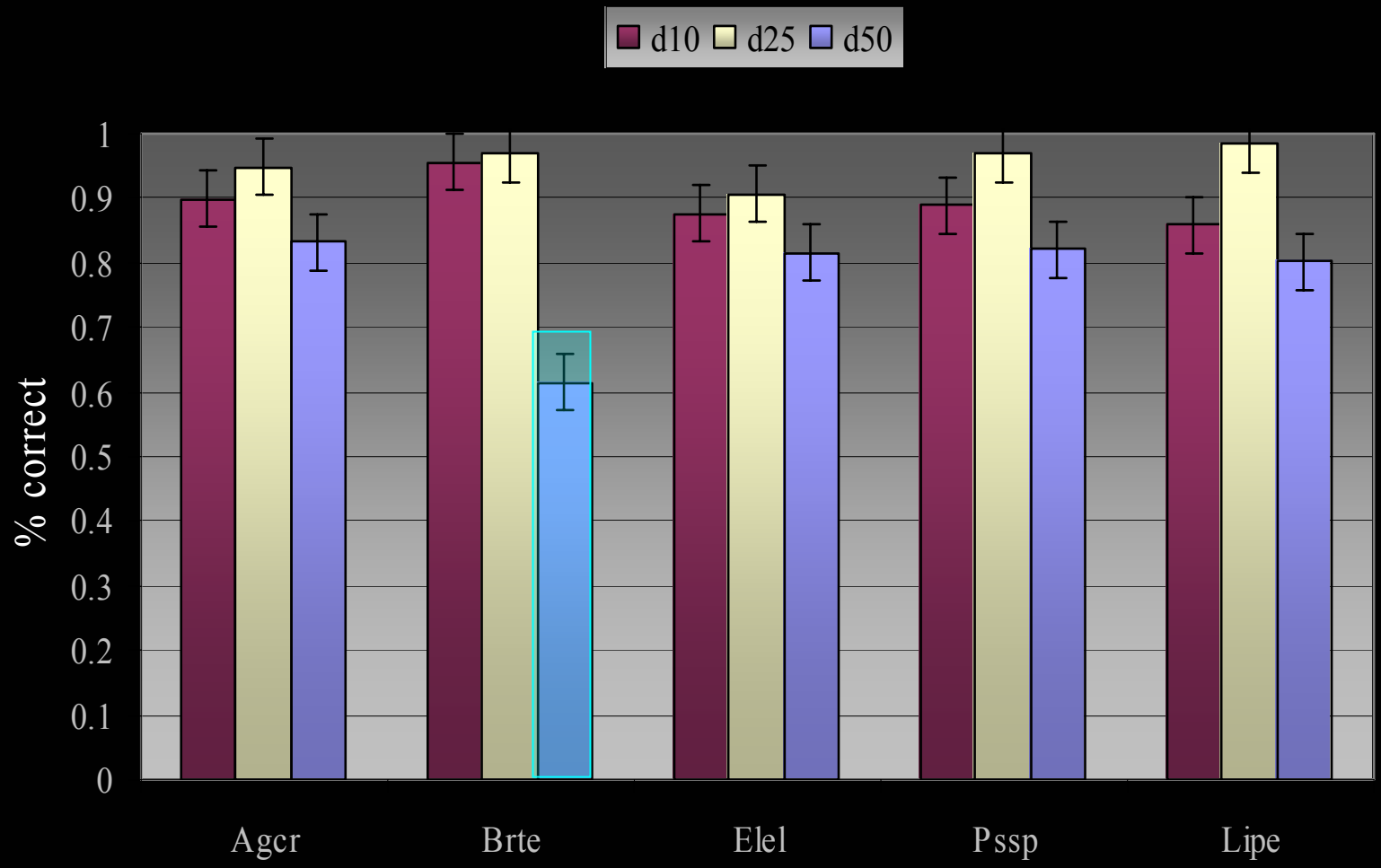
1) 2 methods
   - Thermal accumulation = each wet period
   - Thermal accumulation = Σ wet periods
2) 3 soil moisture thresholds
   - -0.5, -1.0, -1.5 MPa
3) 3 germination predictions
   - 10%, 25%, 50%

Model Accuracy:

Lookout Pass

method = ∑ wet periods

moisture threshold = -1.5 MPa

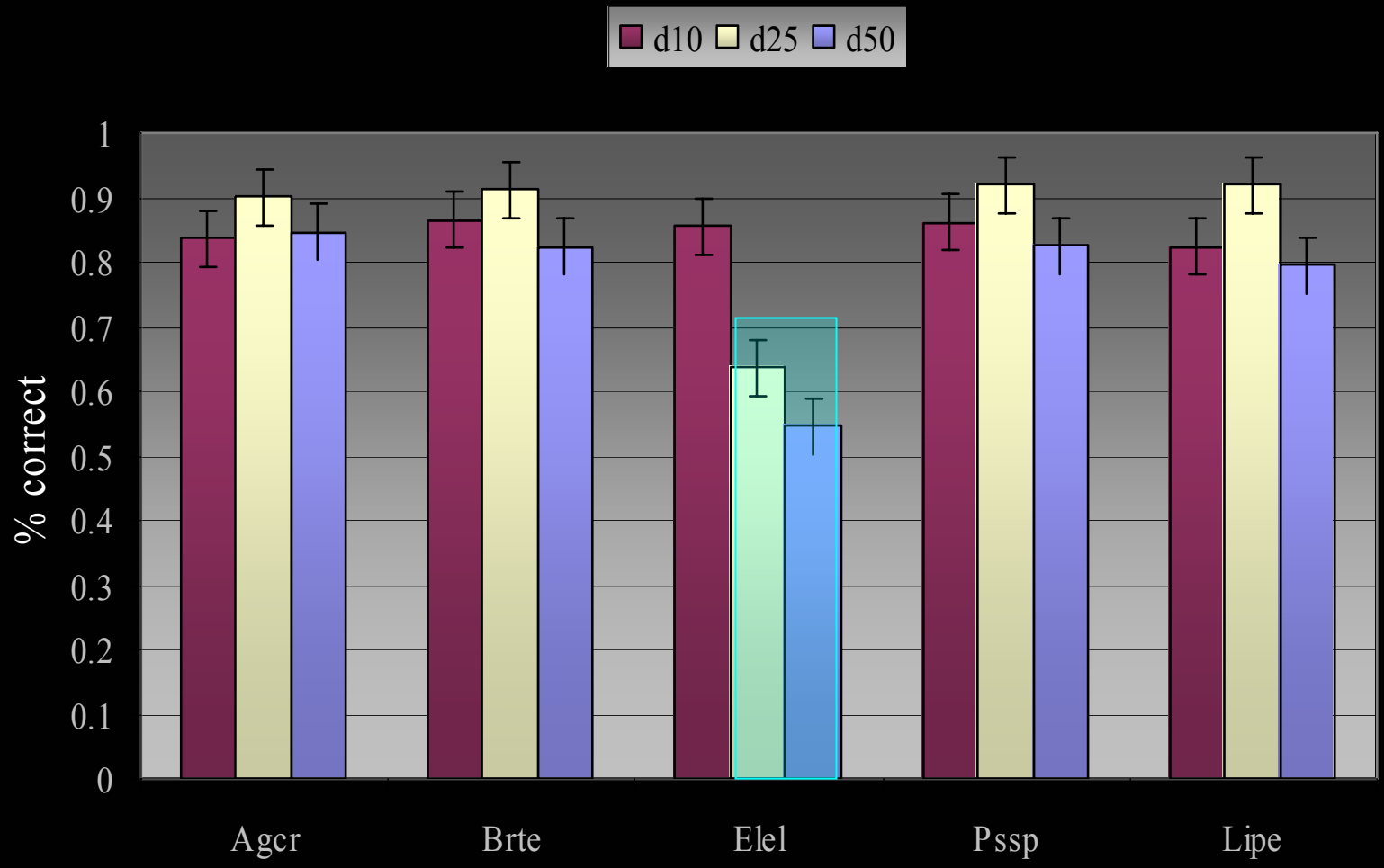


Model Accuracy:

Skull Valley

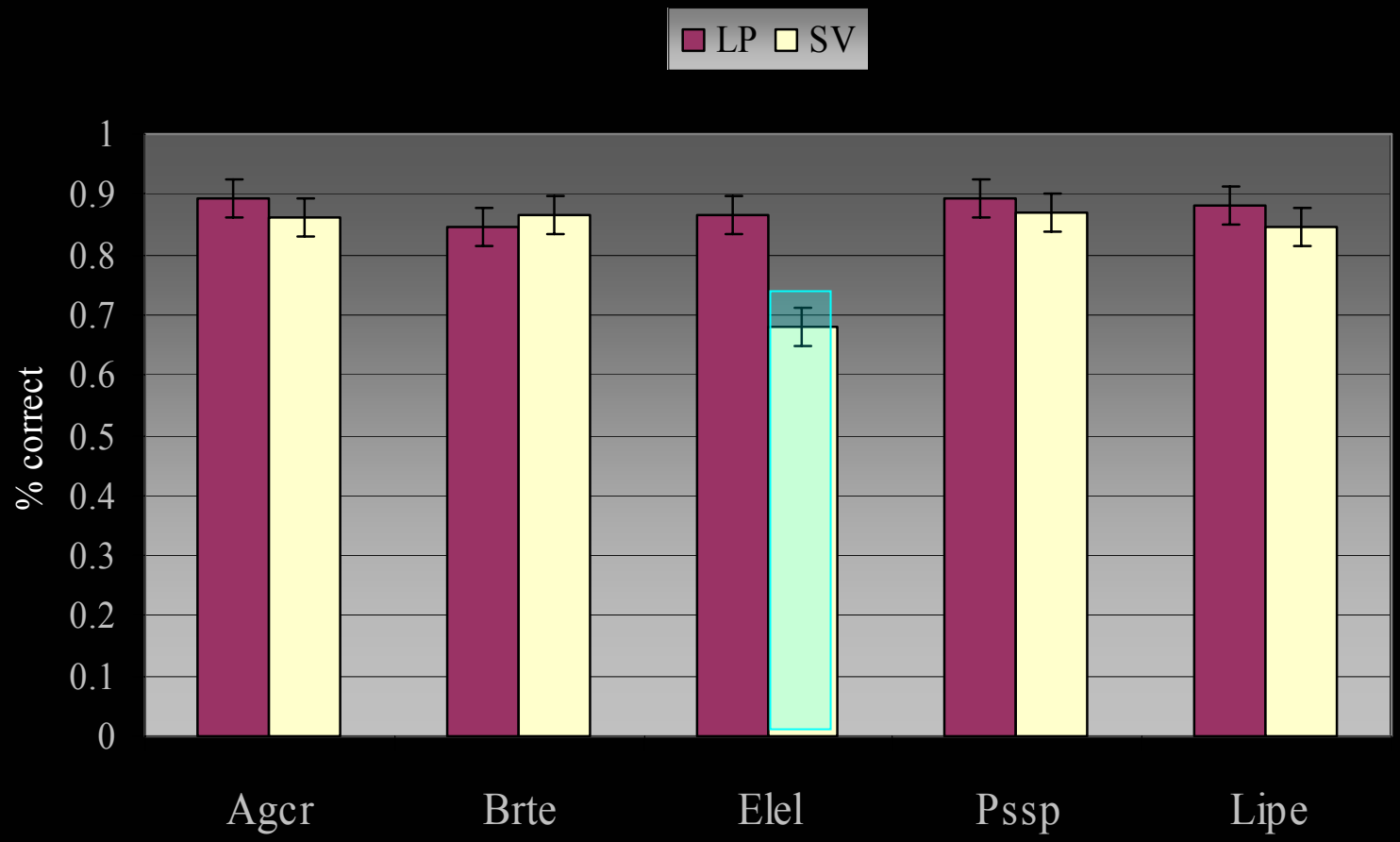
method = ∑ wet periods

moisture threshold = -1.5 MPa



Model Accuracy:

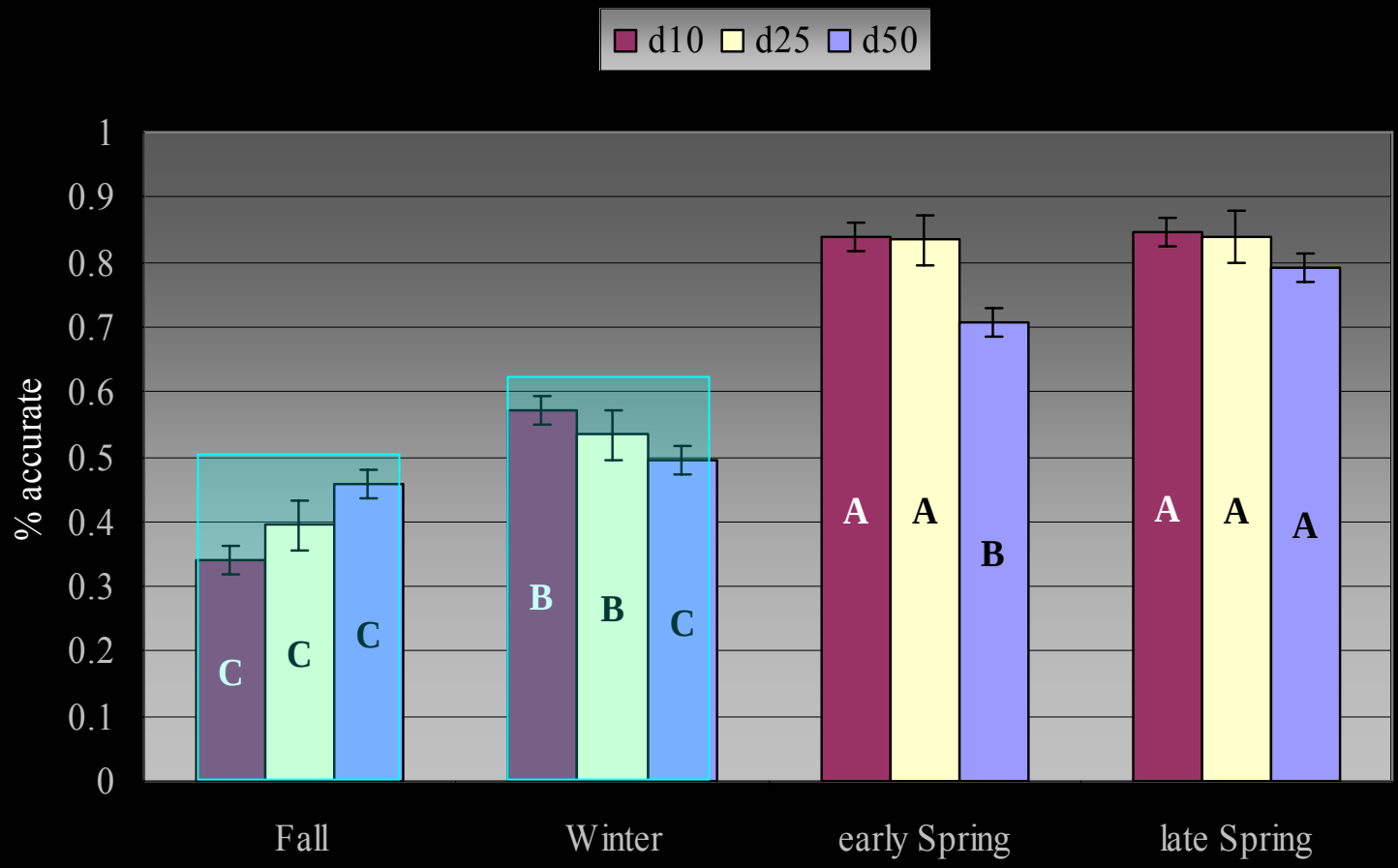
method = ∑ wet periods
wet base = -1.5



Field verification

1) 2 methods
   - Thermal accumulation = each wet period
   - Thermal accumulation = Σ wet periods
2) 3 soil moisture thresholds
   - -0.5, -1.0, -1.5 MPa
3) 3 germination predictions
   - 10%= 87% 25%=90% 50%= 77%

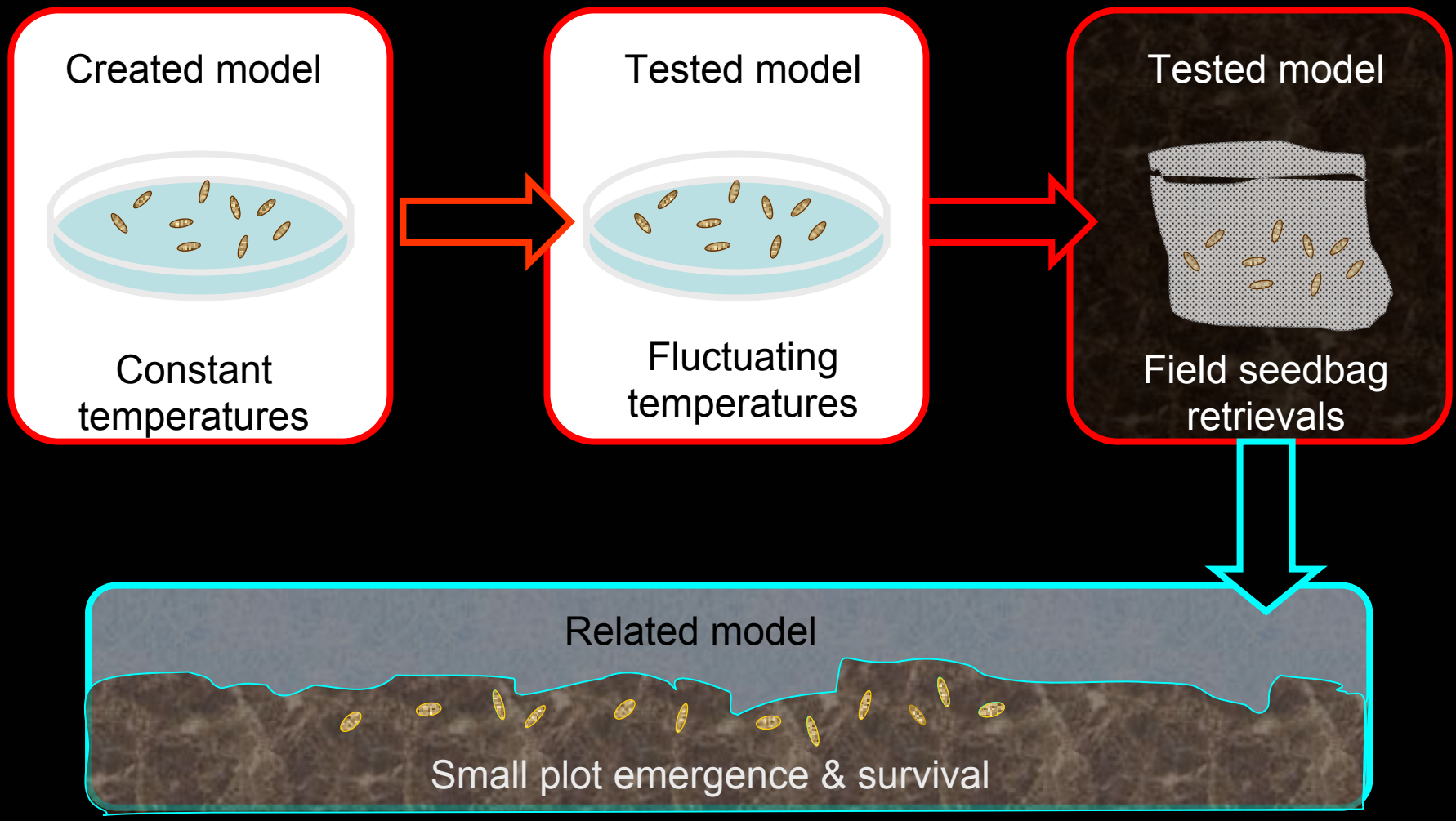
Model Accuracy: Season



Field verification: Conclusions

1) 2 methods
   - Thermal accumulation = each wet period
   - Thermal accumulation = Σ wet periods
2) 3 soil moisture thresholds
   - -0.5, -1.0, -1.5
3) 3 germination predictions
   - 10%= 87% 25%=90% 50%= 77%
4) Overestimates germination time with highly fluctuating temperatures

Study Methods



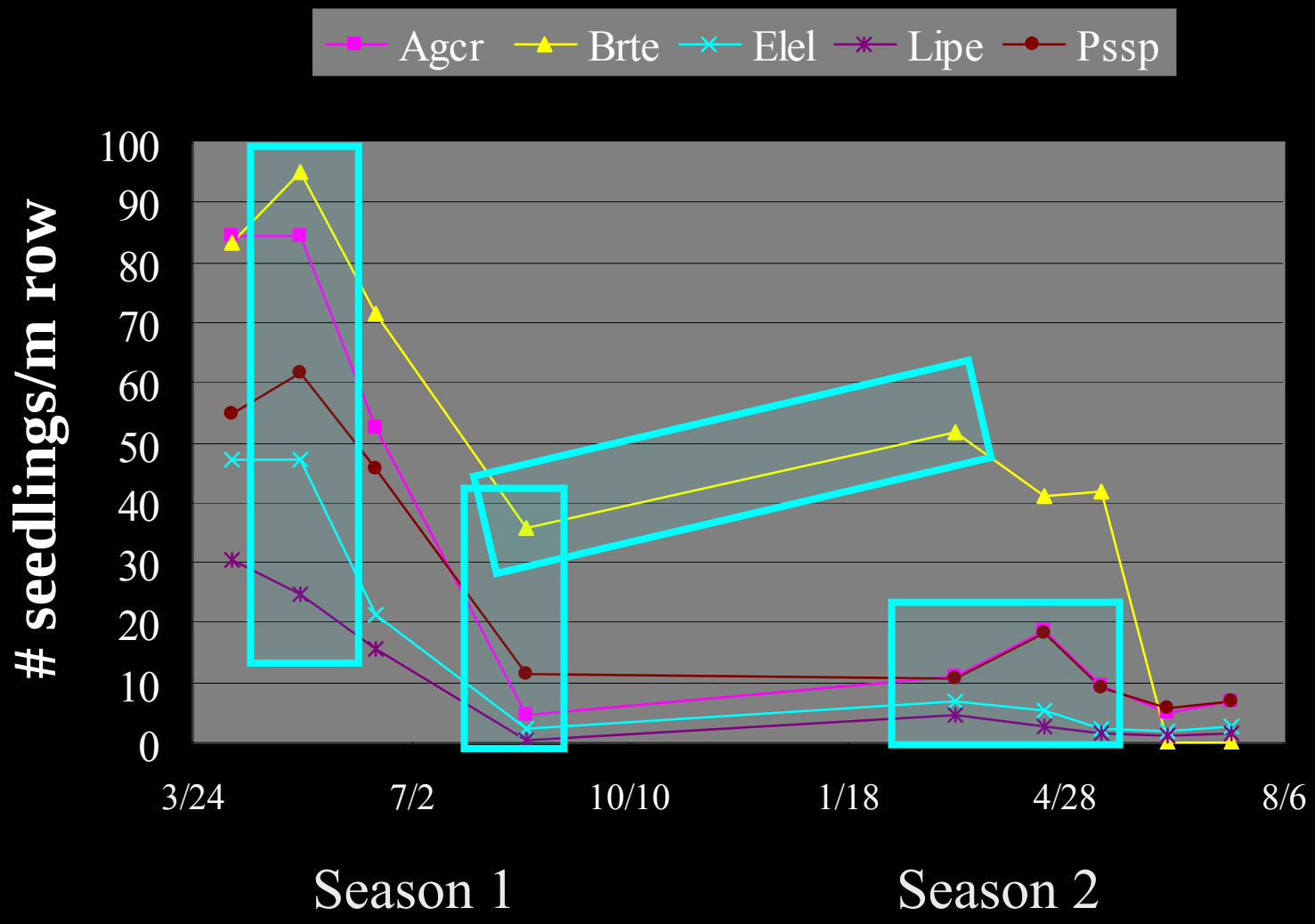
Small Plots

Block	Year	
1	1	Small Plots
		Seedbags
	2	Small Plots
		Seedbags
2	1	Small Plots
		Seedbags
	2	Small Plots
		Seedbags
3	1	Small Plots
		Seedbags
	2	Small Plots
		Seedbags
4	1	Small Plots
		Seedbags
	2	Small Plots
		Seedbags

Seedling Emergence:

Year 1 plots

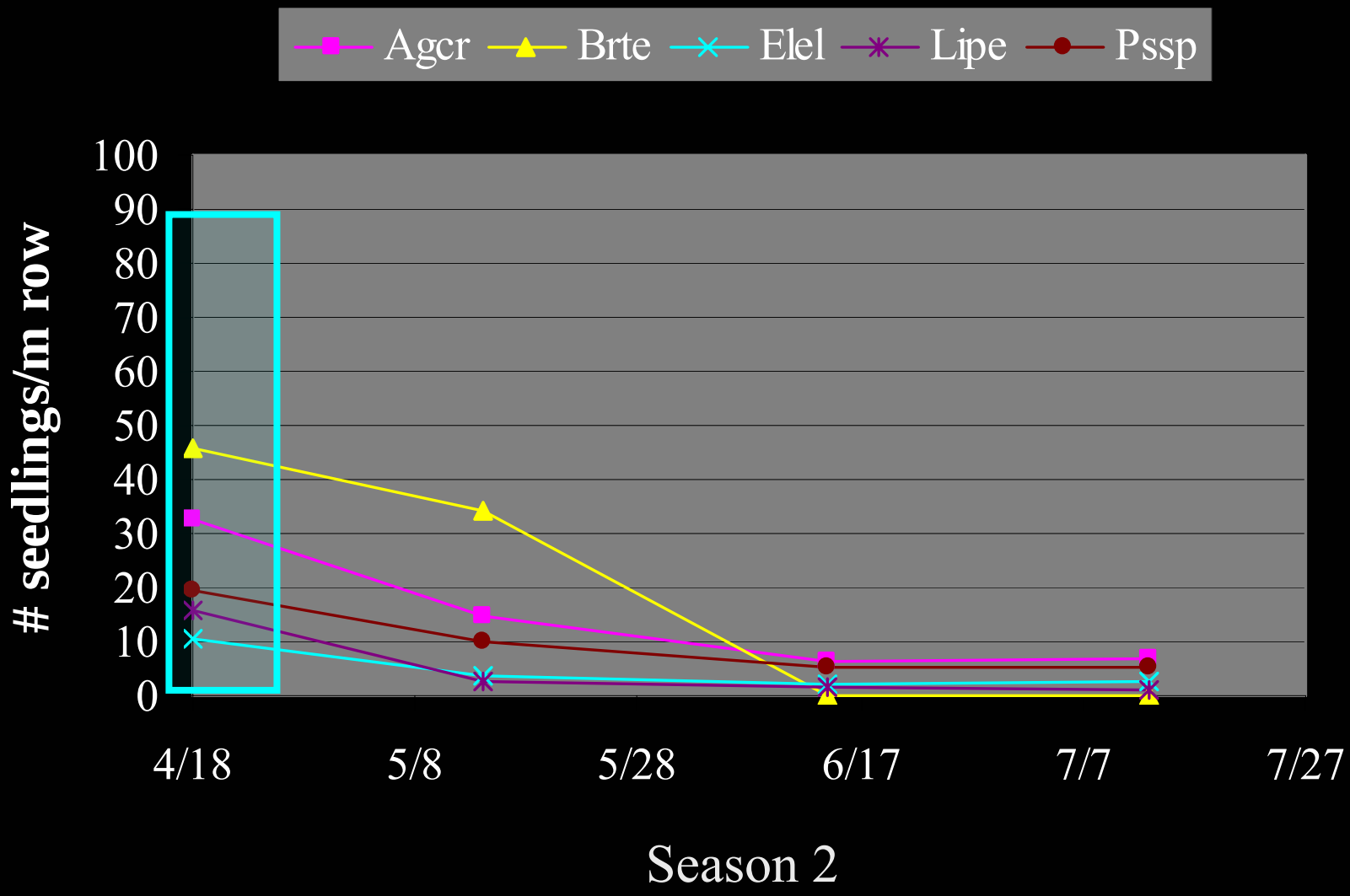
Lookout Pass



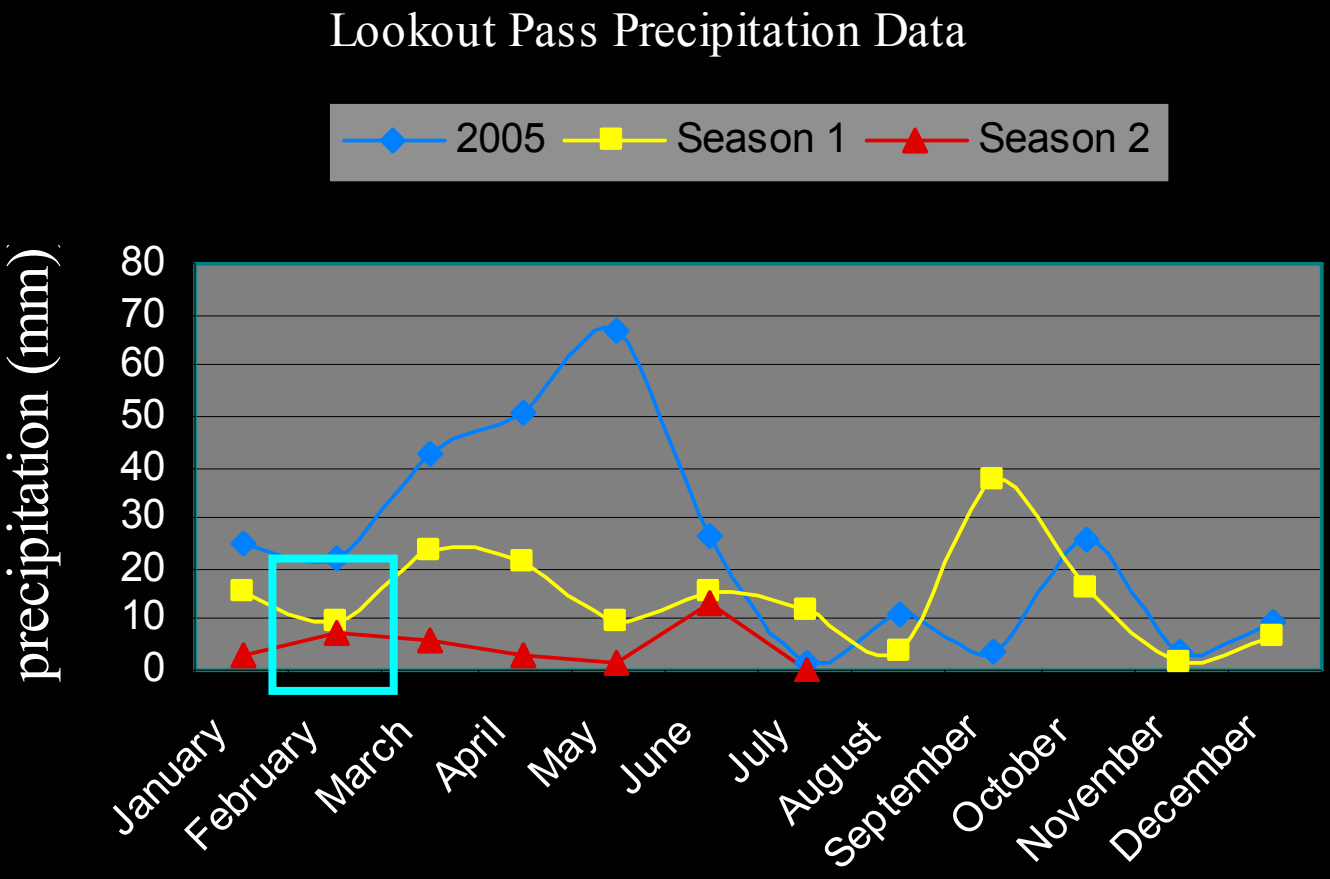
Seedling Emergence:

Lookout Pass

Year 2 plots

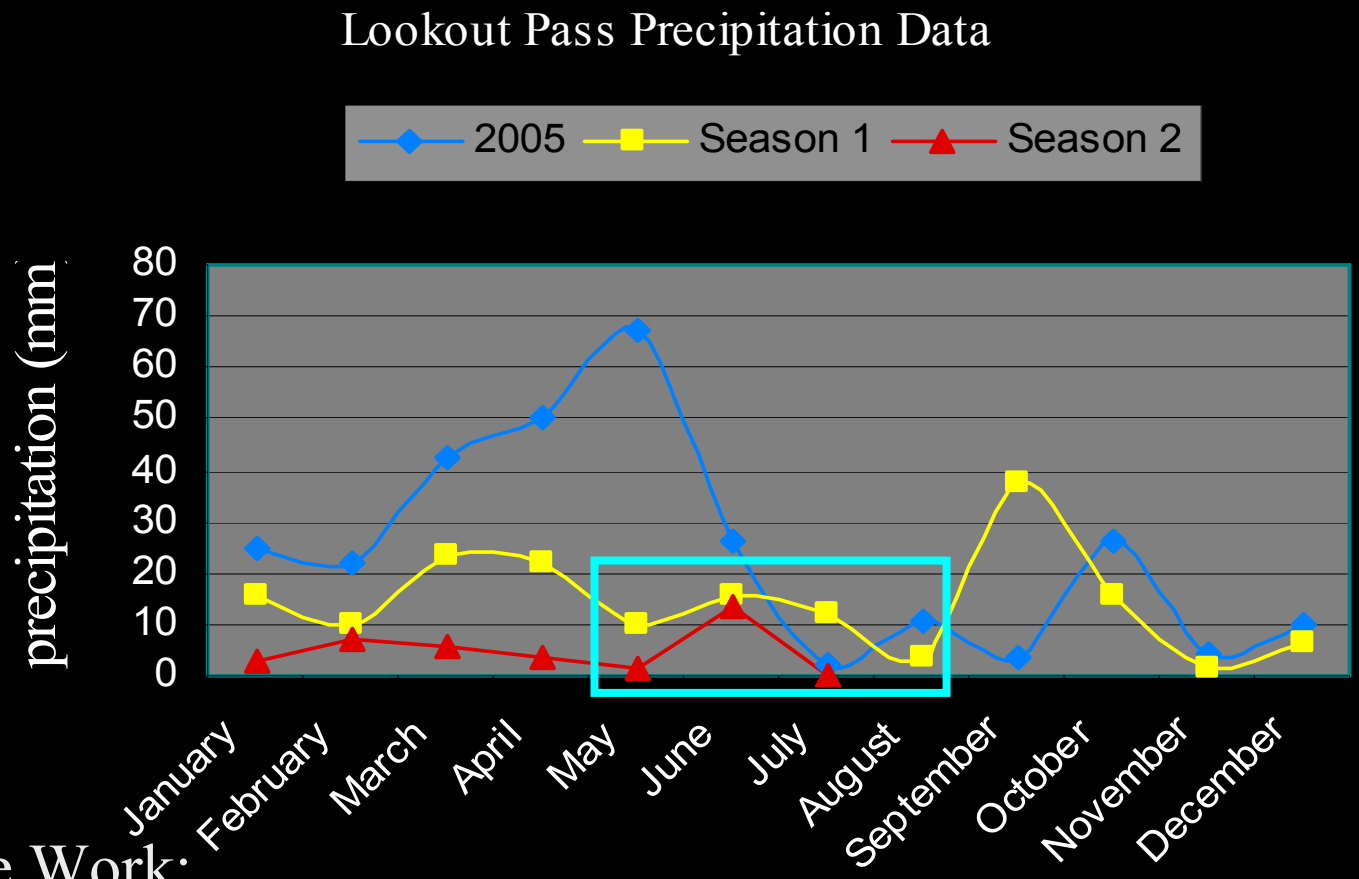


Seedling Emergence: Reduced yr 2 emergence



- Low temperatures for 2 weeks in Feb
- less germination = less emergence in Year 2 plots

Seedling Survival: Reduced season 2 survival

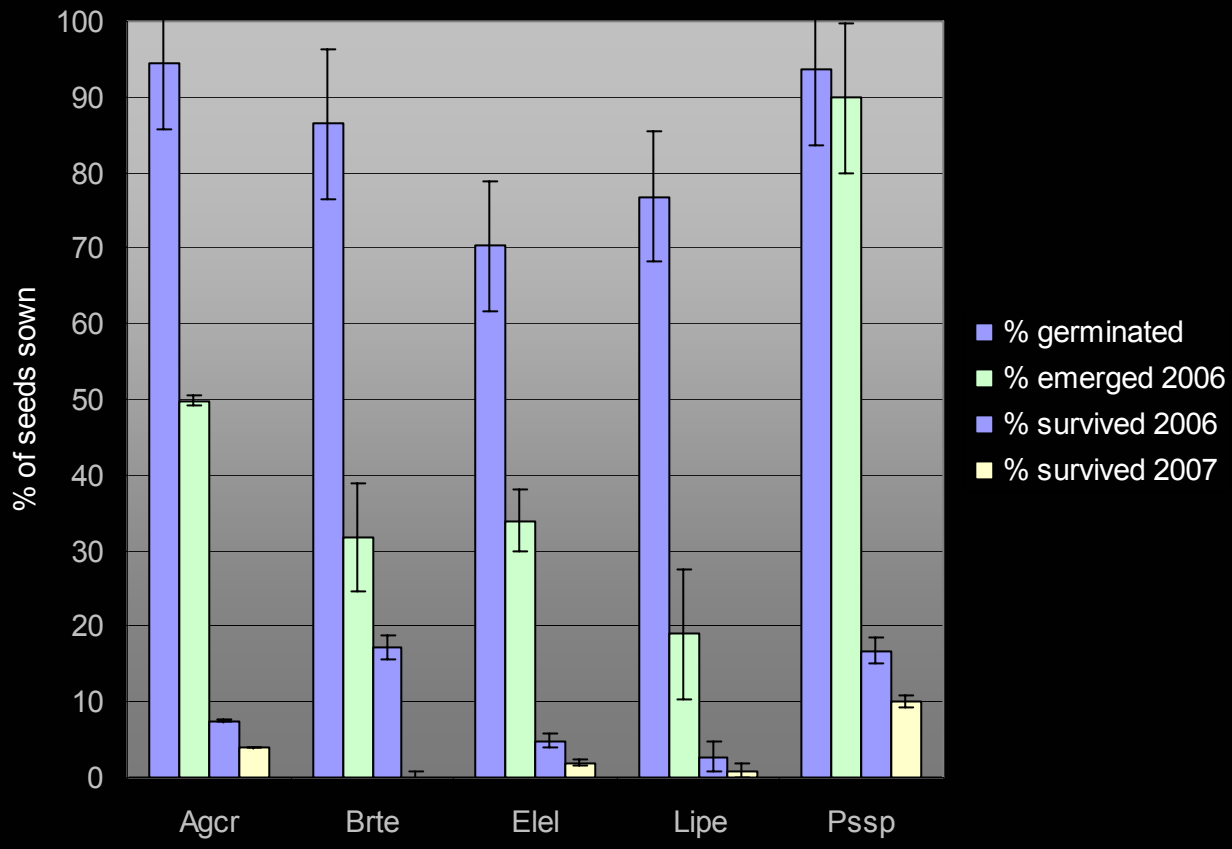


Future Work:

- High germination & emergence ≠ high survival
- **Deeper sensor analysis**
- **Root growth/survival modelling**

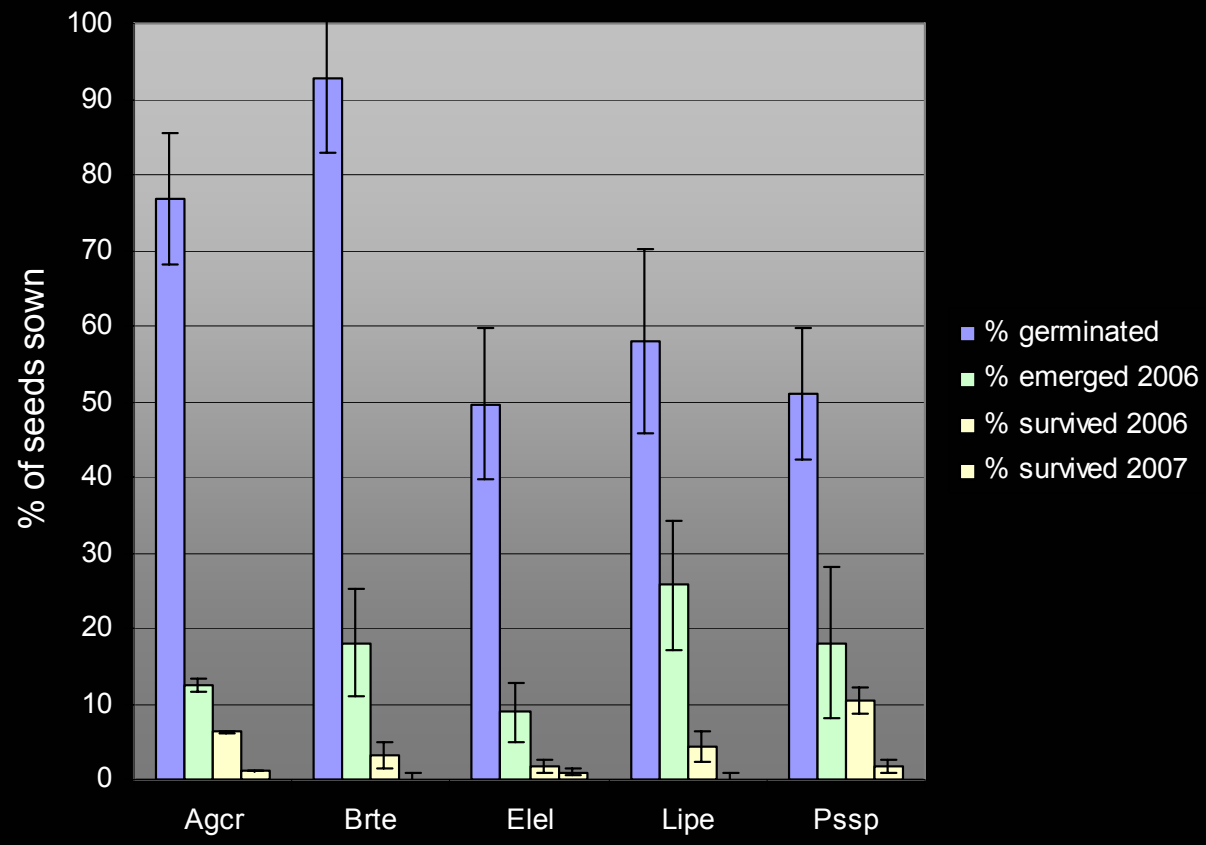
Seedling Emergence: Year 1 plots

Lookout Pass



Seedling Emergence: Year 1 plots

Skull Valley



Conclusions

- Can a wet thermal accumulation model be used to predict germination?
  - Yes, with about 80% accuracy
    - Exception: species with special requirements
    - Seedbag ≠ Seedbed conditions?
- Precautions:
  - Dry conditions
  - High temperature and moisture fluctuations

Management Implications:

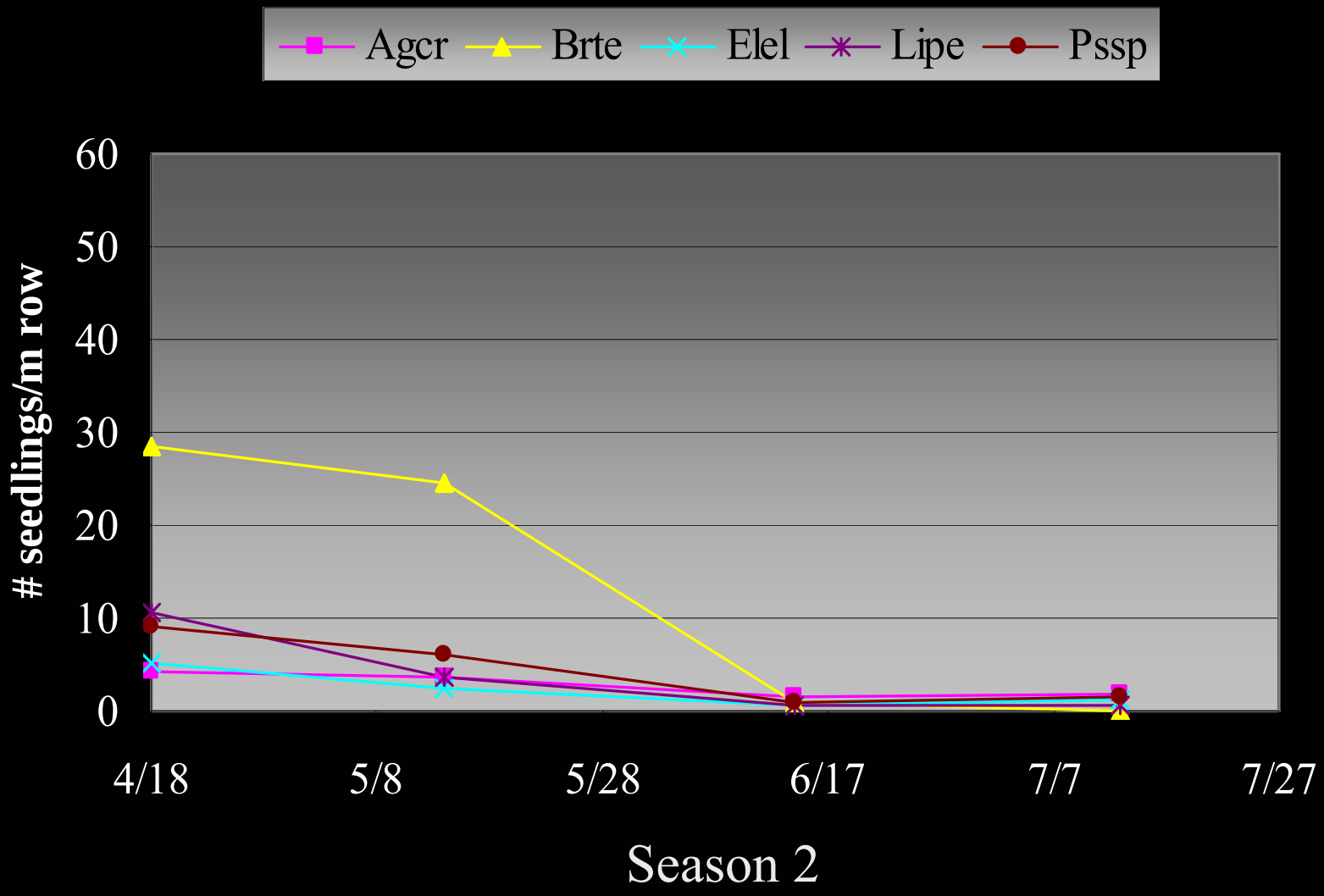
- So what?
  - Better selection of species
  - Specific herbicide application
  - Timed mechanical control
  - Weed vs. seeded emergence

Questions?

Seedling Emergence:

Skull Valley

Year 2 plots



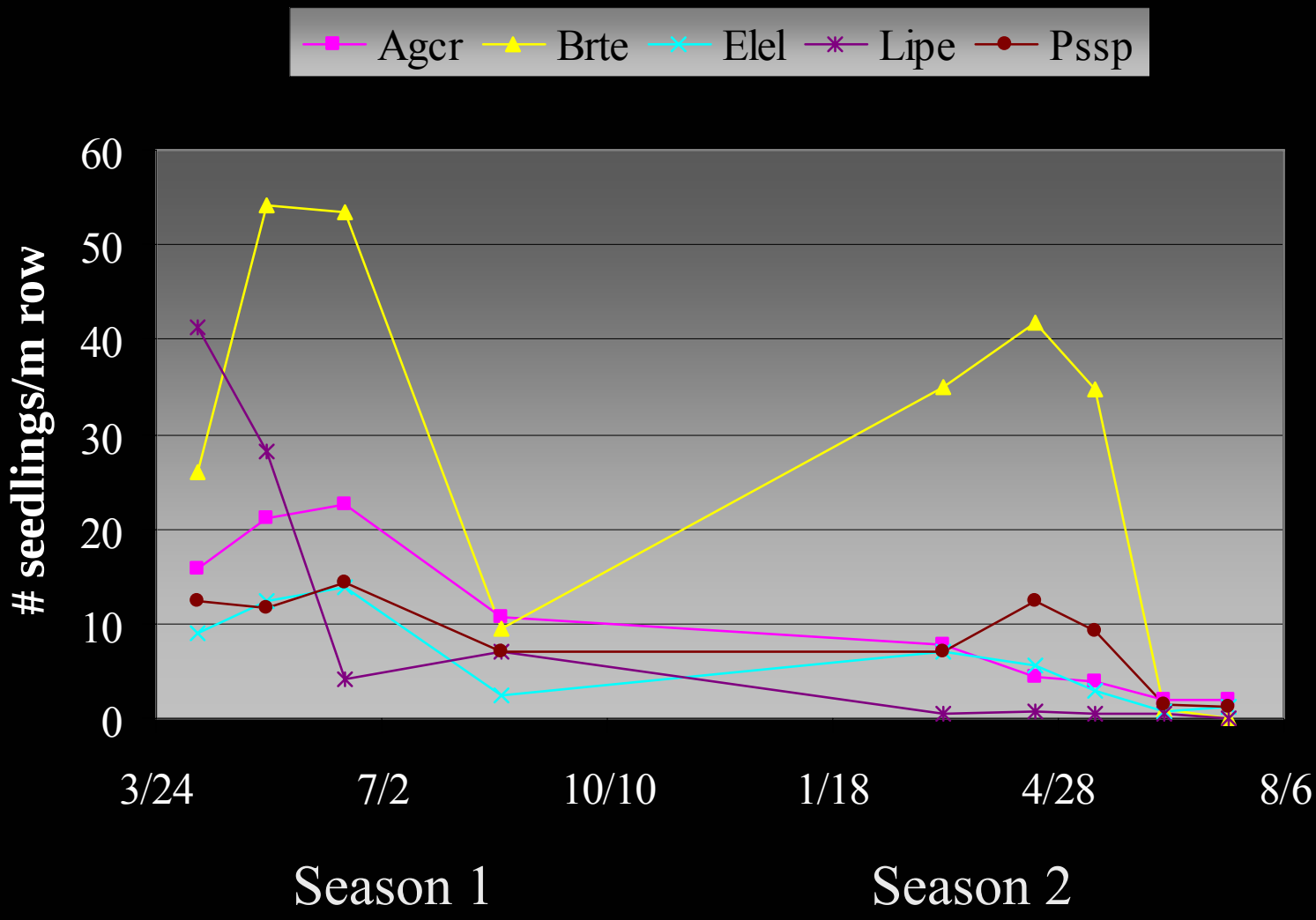
Seedling Survival: Season 2

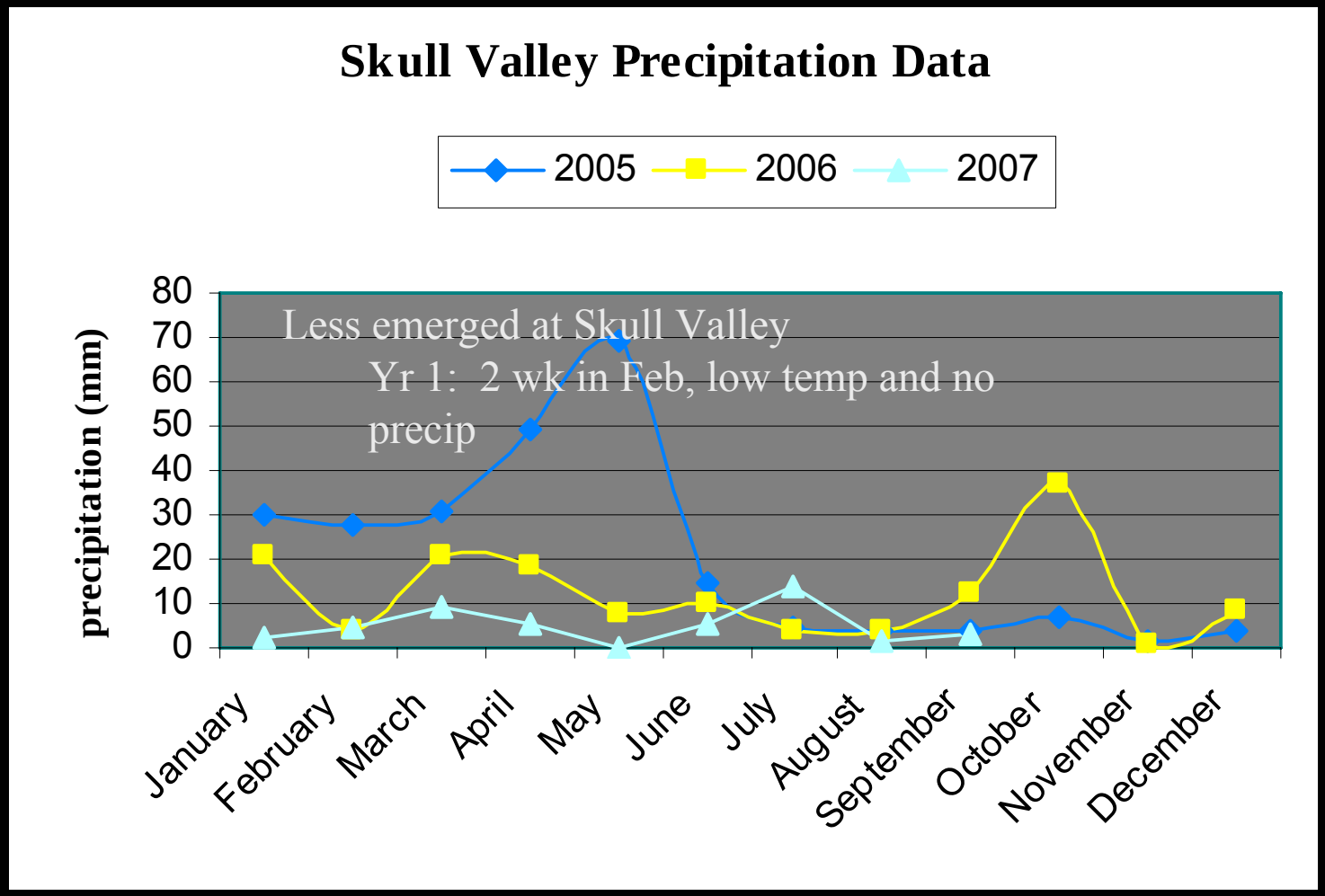
	Lookout Pass		Skull Valley	
Year seeded	1	2	1	2
Agcr	6.7	6.7	2	1.8
Elel	2.7	2.6	1.3	1.3
Lipe	1.3	1	0.1	0.7
Pssp	6.9	5.4	1.2	1.4

Seedling Emergence:

Skull Valley

Year 1 plots




Skull Valley Precipitation Data
2005
2006
2007
precipitation (mm)
80
70
60
50
40
30
20
10
0
Less emerged at Skull Valley
Yr 1: 2 wk in Feb, low temp and no precip
January
February
March
April
May
June
July
August
September
October
November
December

Model Accuracy: Retrievals 4-7