

Modeling feral alfalfa (*Medicago sativa*  
*subsp. sativa* L.) occurrence using  
topographical and environmental variables

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# Roundup®-Ready alfalfa

- Alfalfa was the first major perennial genetically-engineered (GE) crop
- Glyphosate-resistant varieties (+ RRA) were initially deregulated in 2005. In 2006, seeded on 80,000 ha. Seed pulled from market is 2007. In 2011 was deregulated



# Concern

➤ Alfalfa is a highly out-crossing perennial crop. Pollination is vectored by insects, mainly bees

➤ Feral plants frequently occur along road sides. There is a concern that these plants act as a reservoir and/or bridge to move transgenes into conventional fields



# 2011 Objective

Survey feral alfalfa to determine baseline levels of (+) RRA transgene presence (presumed from 2005-2007 plantings) to model feral and (+) RRA feral occurrence



# Methods

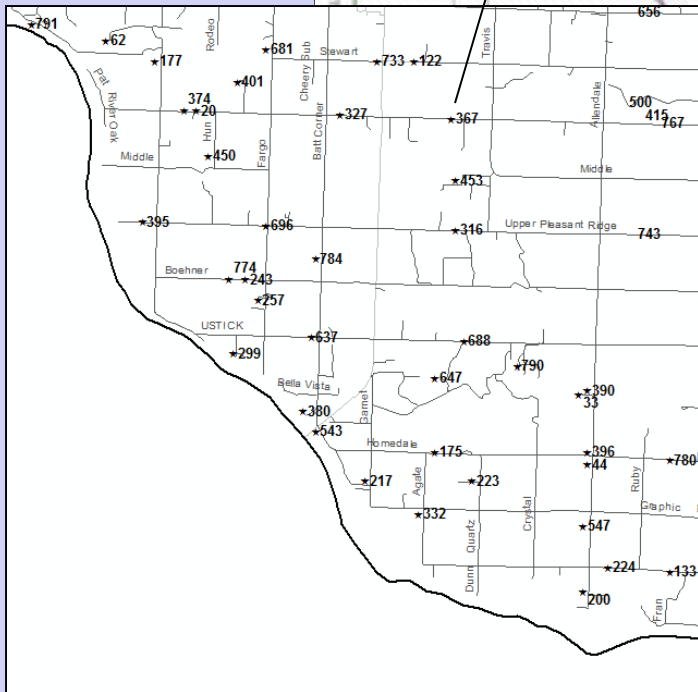
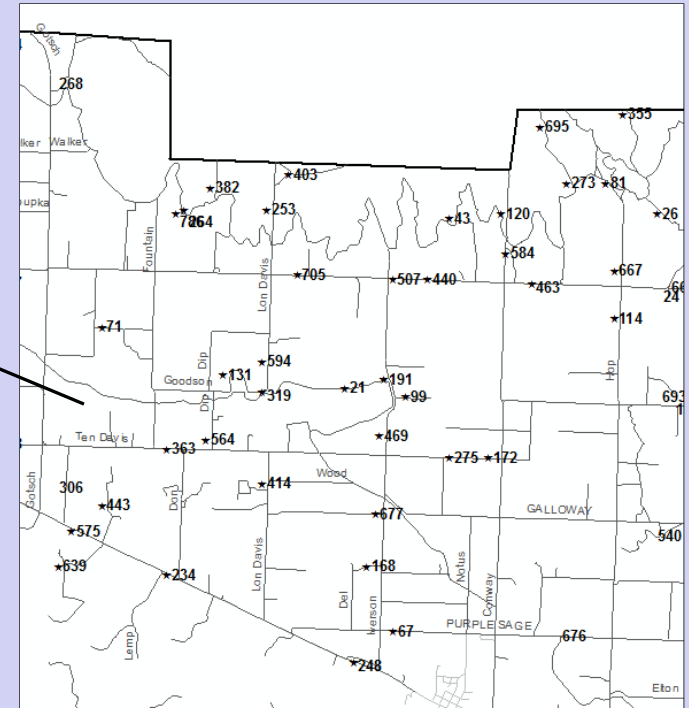
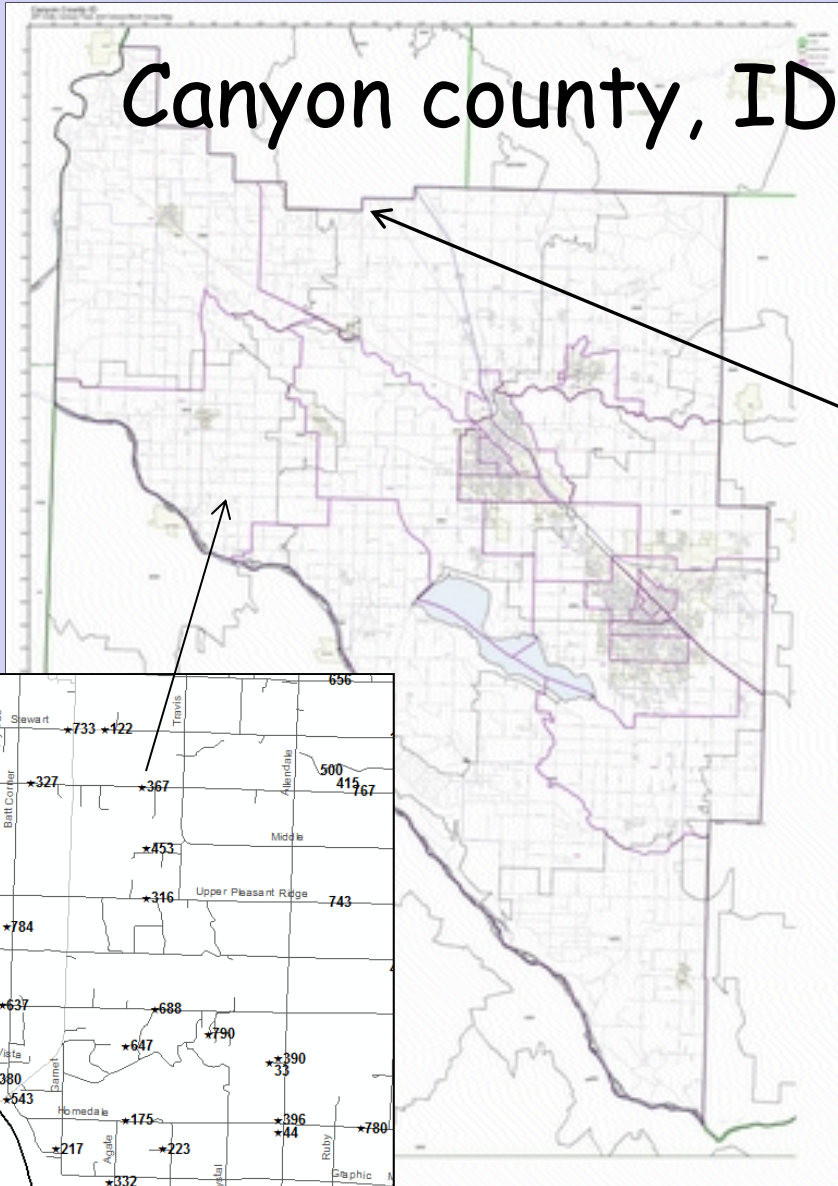
Survey seed production areas in Fresno Co, CA (600 km<sup>2</sup>), Canyon Co., Idaho (600 km<sup>2</sup>) , and Walla Walla Co., Washington (600 km<sup>2</sup>)

Sites selected using Spatially Balanced Sample Design (ARC GIS 10)





# Canyon county, ID



# 2011 Survey



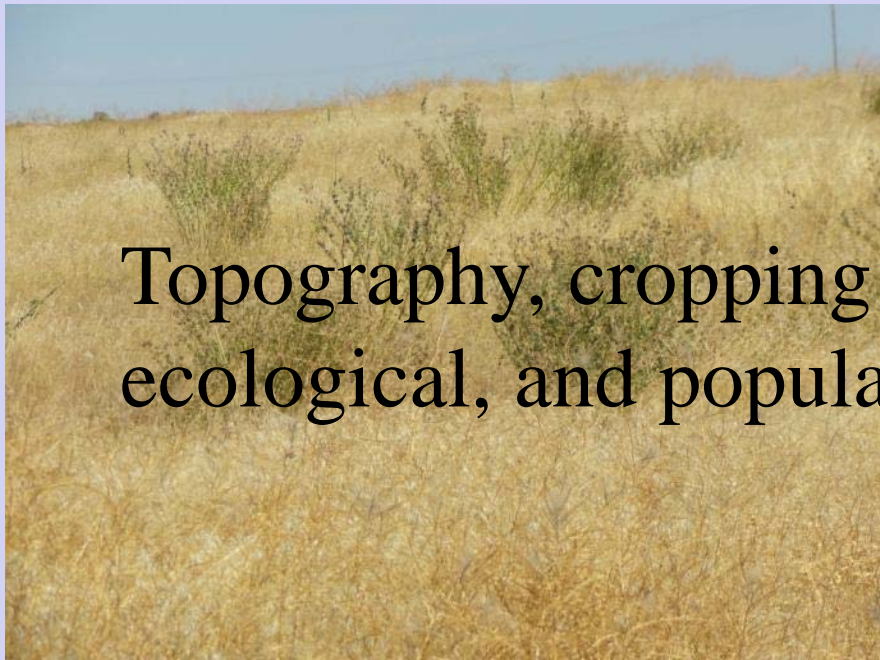


Leaf and seed samples were collected





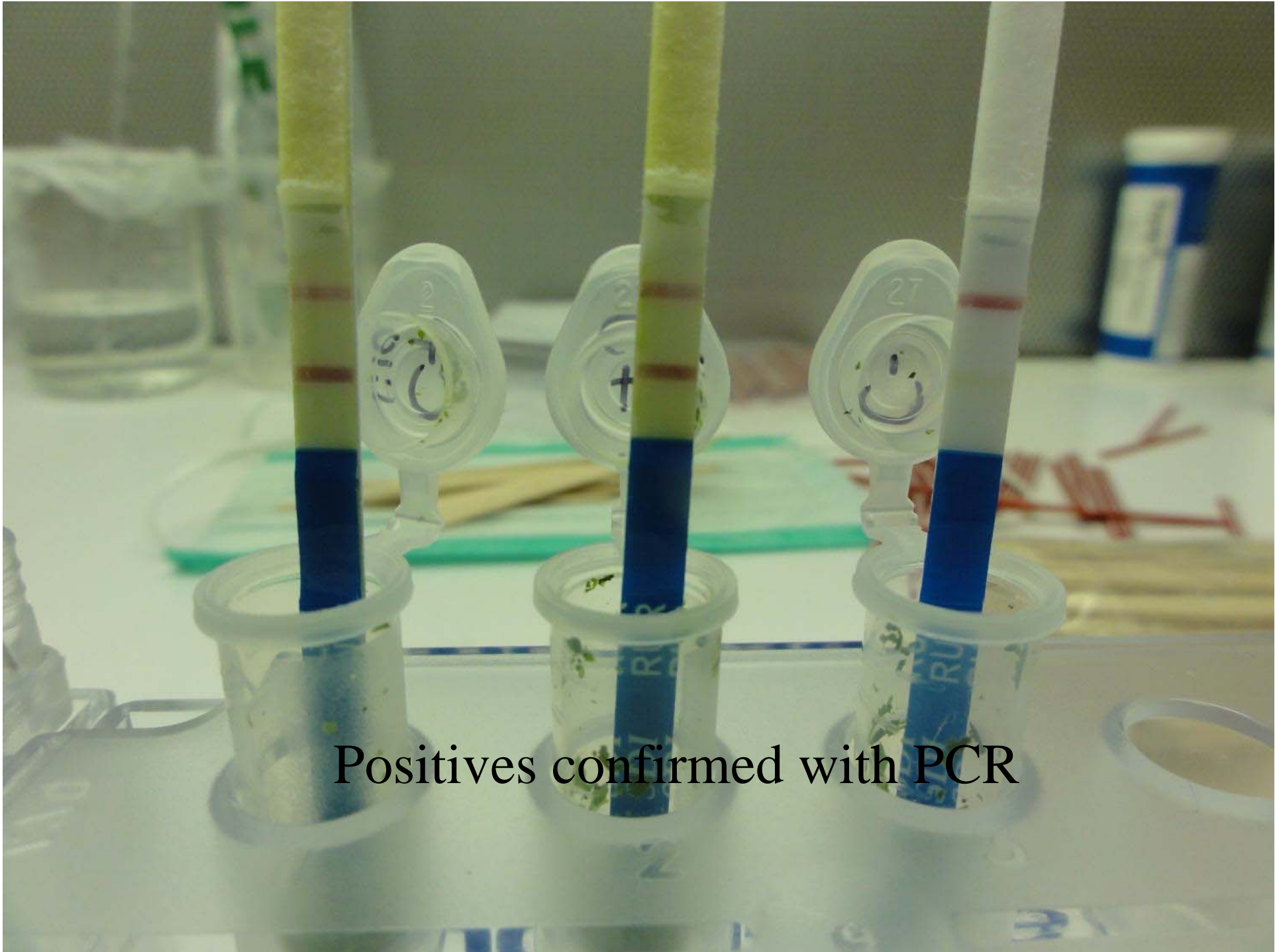
Topography, cropping pattern, habitat,  
ecological, and population factors recorded







Tested with RUR test strips



Positives confirmed with PCR



# Model development

## Dependant variables

- Occurrence of any feral plants
- Occurrence of (+) RRA feral plants

# Explanatory variables

## 1. Qualitative variables

- Cropping pattern
  - crop adjacent
  - crop behind
  - crop ahead
- Roadside weed management
- Habitat
  - species diversity
  - vegetation cover
  - vegetation height

# Explanatory variables

## 2. Quantitative variables

- Topography
  - elevation (m)
  - slope (%)
  - aspect (deg)
- Climate variables
  - precipitation (mm)
  - temperature maximum (deg C)
  - minimum (deg C)
  - mean (deg C)



# Statistical analysis-qualitative variables

Chi-square test of independence:

➤ To assess the relationship between the occurrence of feral plants and qualitative variables

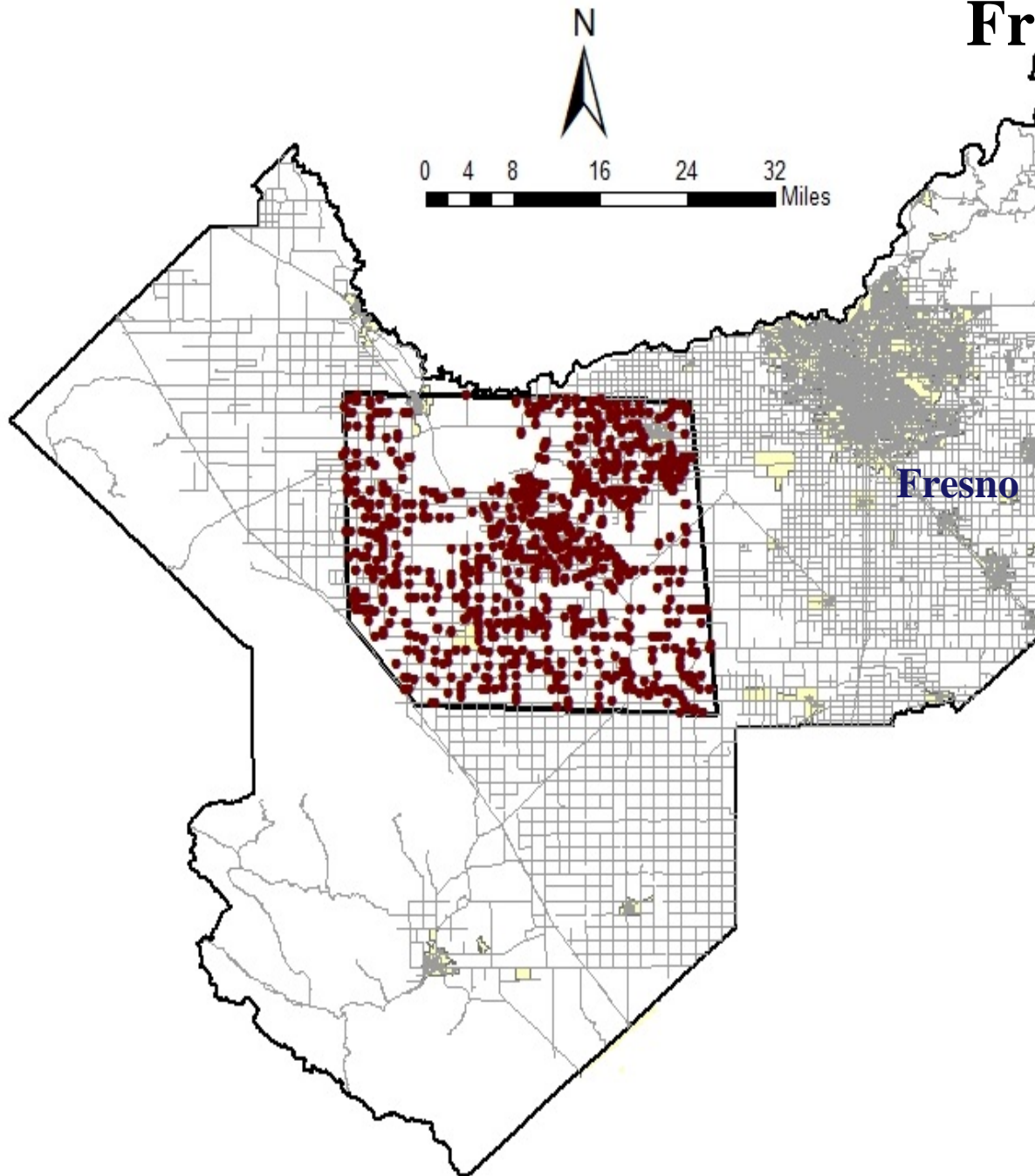
➤ To assess the relationship between the occurrence of (+) RRA feral plants and qualitative variables

# Statistical analysis-quantitative variables

## Binary logistic model:

- To assess the relationship between the occurrence of feral plants and quantitative variables
- To assess the relationship between the occurrence of (+) RRA feral plants and quantitative variables

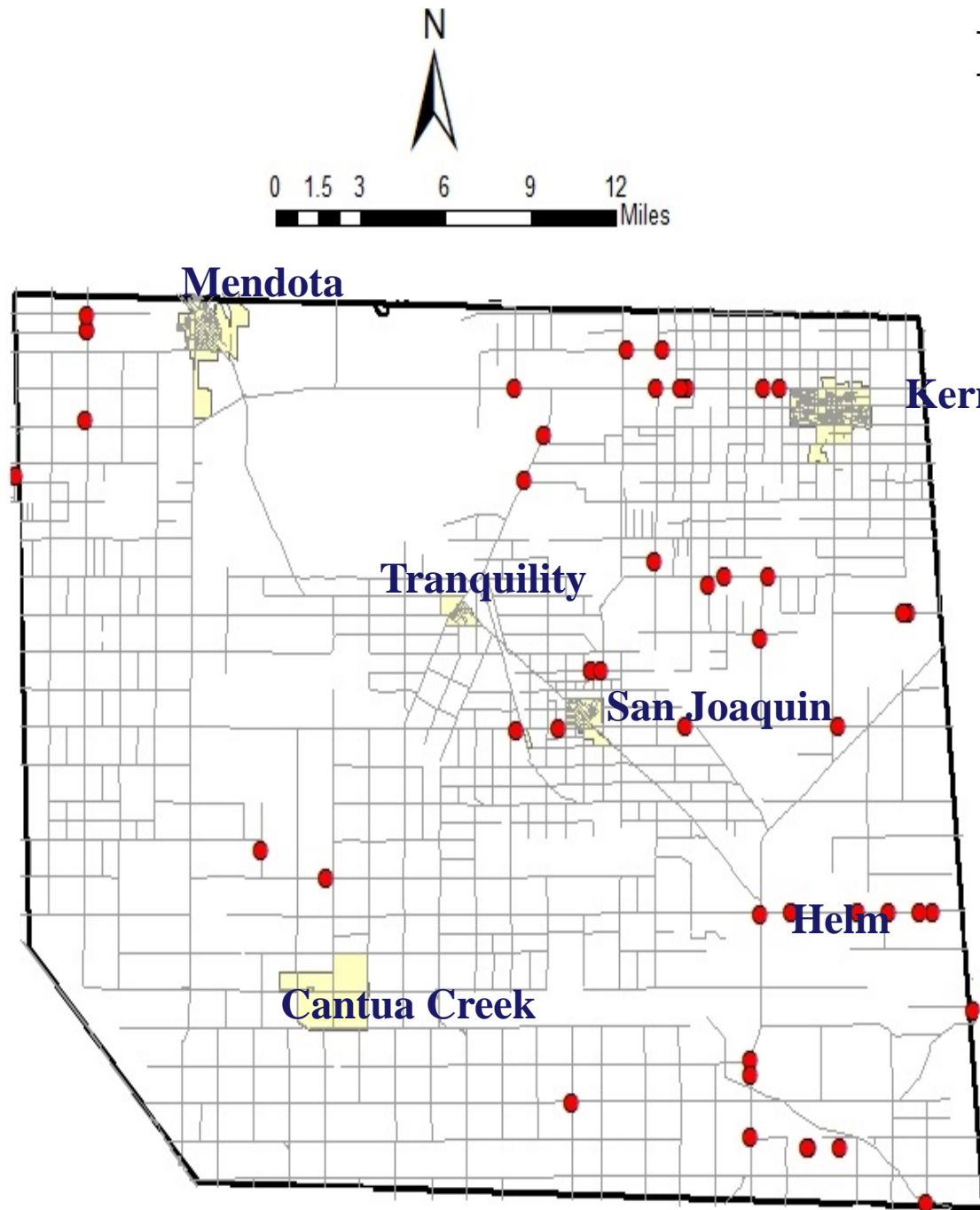
# Fresno County, CA



812 sites  
were  
surveyed



# Fresno County, CA



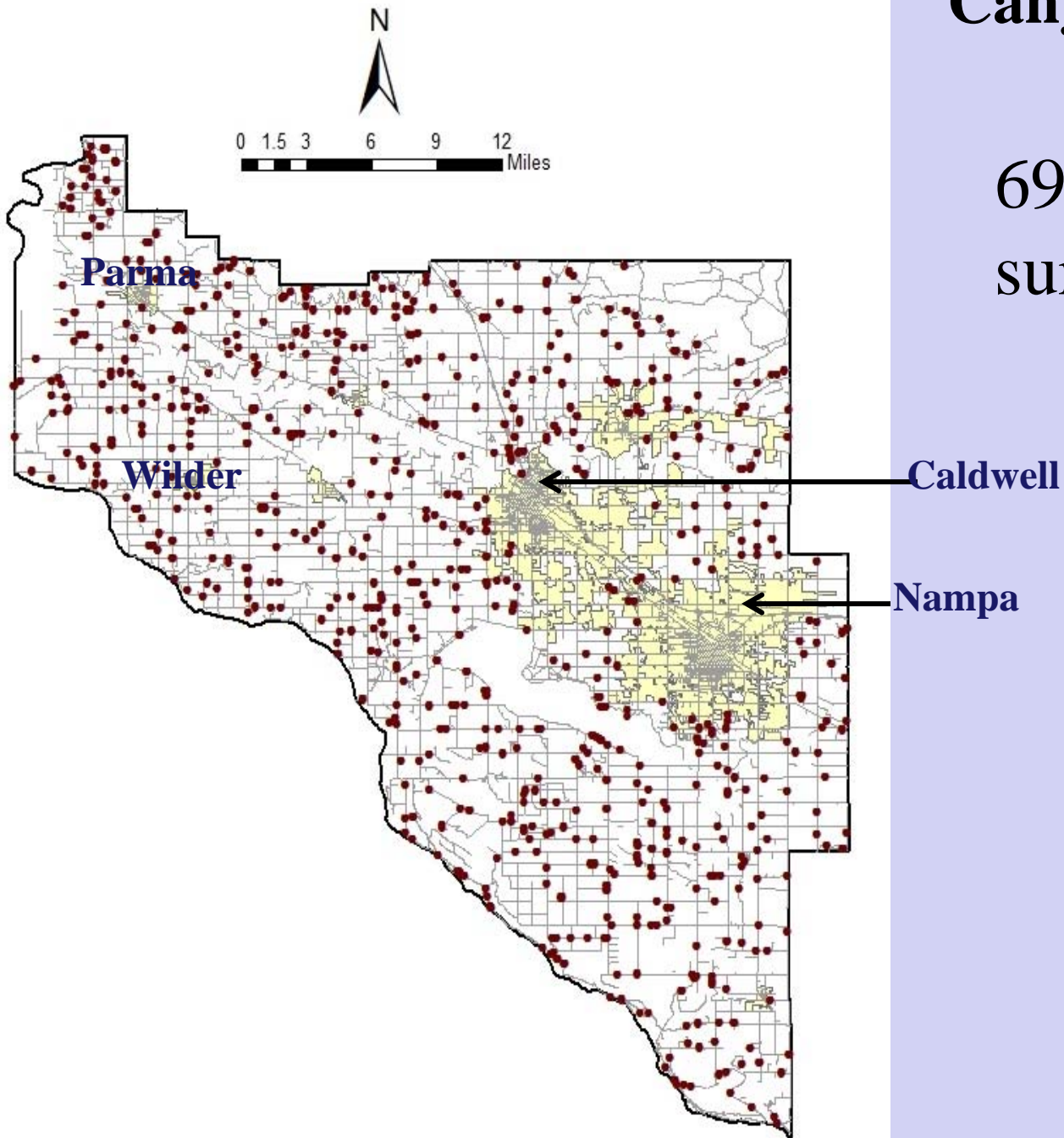
130 sites had feral plants

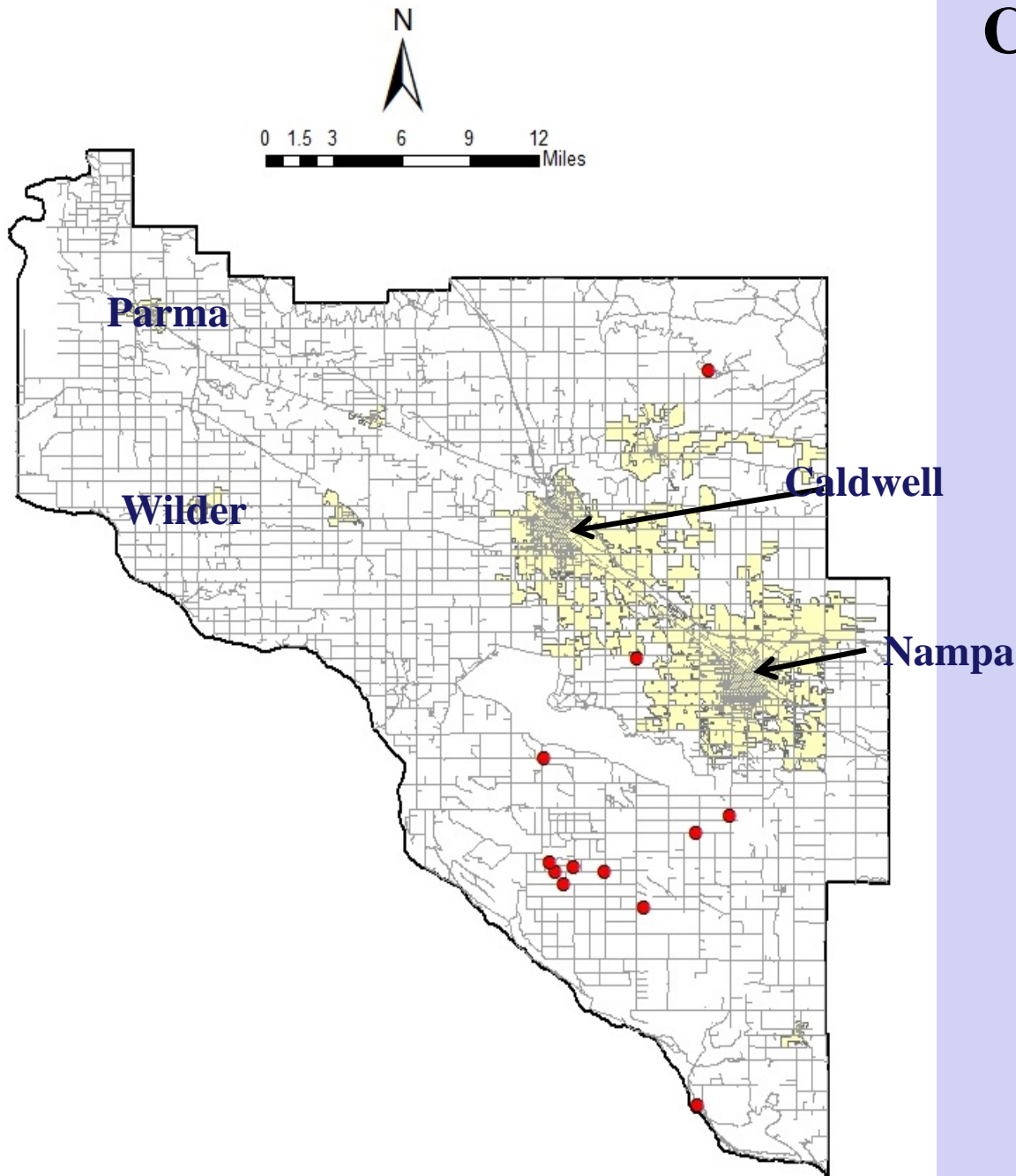
53 sites had (+) RRA feral plants

1 site had (-) RRA plants but (+) RRA seed

# Canyon County, ID

699 sites were surveyed





## Canyon County, ID

88 sites had feral plants

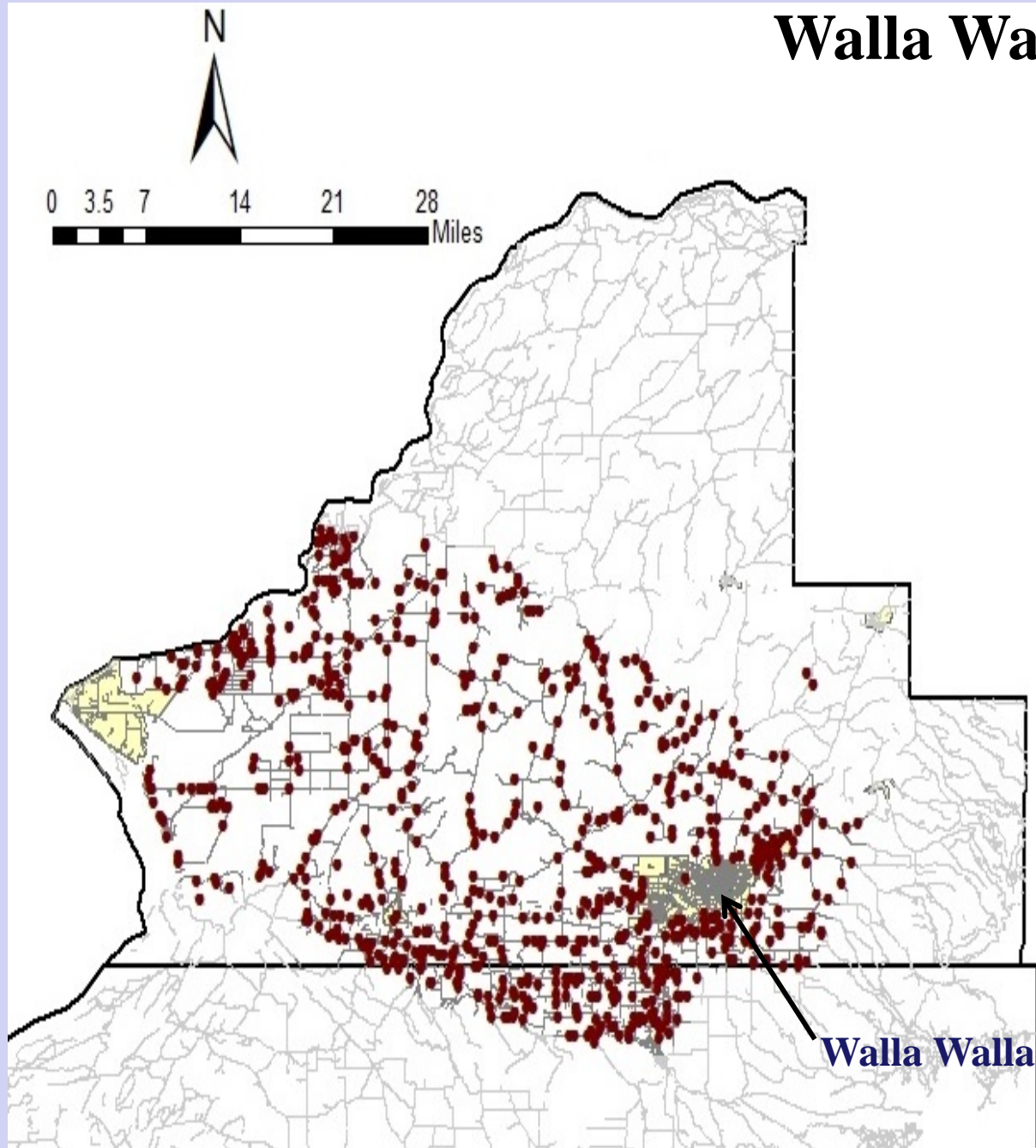
12 sites had RRA(+) feral plants

9 sites had (-) RRA plants but (+) RRA seed



# Walla Walla County, WA

786 sites were surveyed

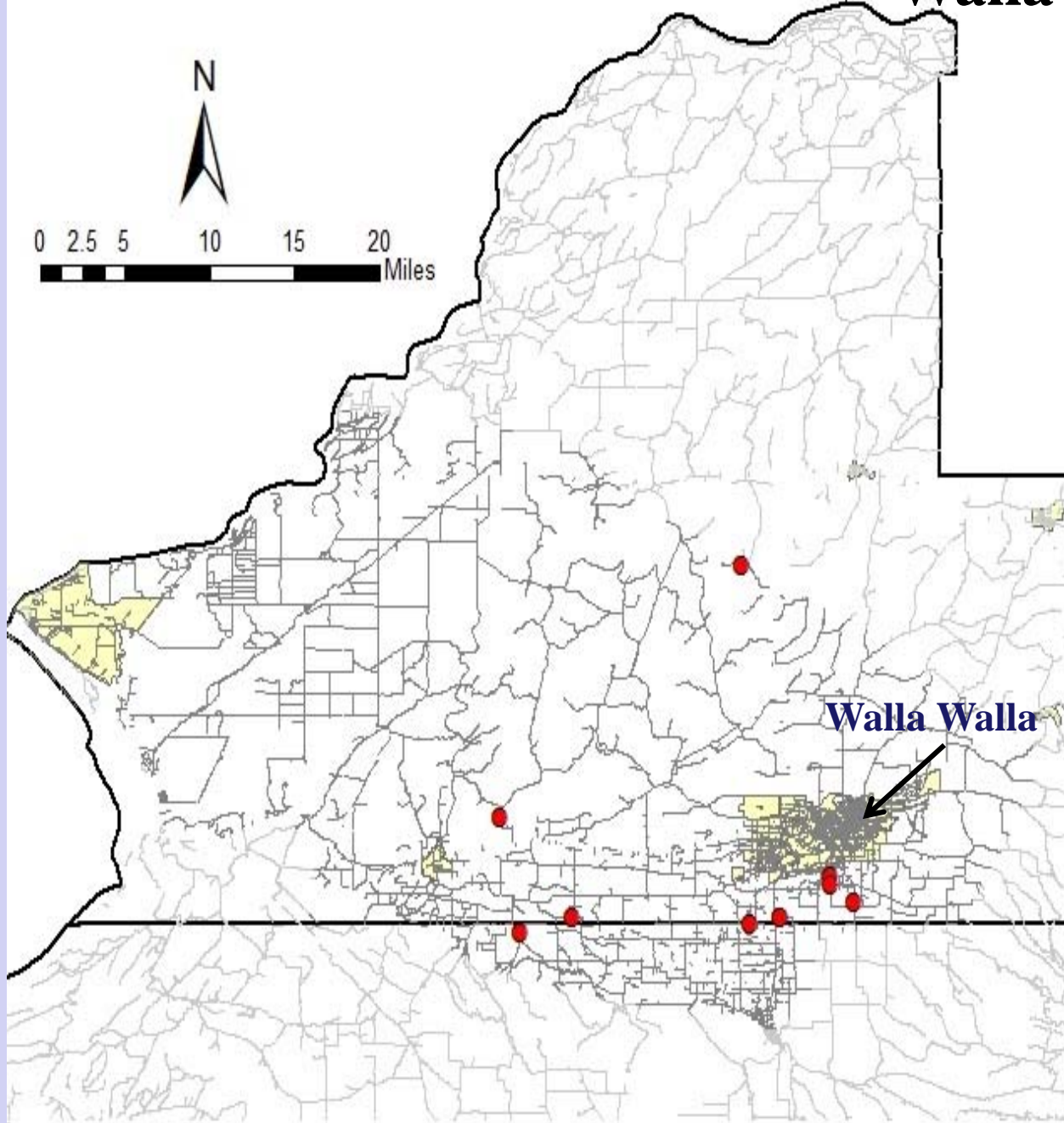


# Walla Walla County, WA

128 sites had feral plants

10 sites had (+) RRA feral plants

2 sites had (-) RRA plants but (+) RRA seed



# Chi square results

Variable	Canyon		Fresno	
	Feral	RRA feral	Feral	RRA feral
Crop adjacent	alfalfa, corn, range	NS	NS	alfalfa, almonds
Crop ahead	NS	NS	alfalfa, almonds	alfalfa, almonds
Crop behind	alfalfa, corn, range	NS	alfalfa, almonds cotton	alfalfa, almonds
Veg cover	patchy	patchy	patchy	NS
Veg height	NS	NS	short	short
Veg mang.	sprayed	NS	sprayed	No mang.
Sps. diversity	low	NS	low	NS

NS =significant

p <0.05

# Topography

Variable	Canyon		Fresno	
	Feral	RRA feral	Feral	RRA feral
Elevation	NS	NS	NS	NS
Slope	NS	NS	NS	NS
Aspect	NS	NS	NS	NS

NS =significant

$p < 0.05$



# Estimate of precipitation

Ppt.	Canyon		Fresno	
	Feral	RRA Feral	Feral	RRA Feral
Jan	-0.10	-0.23	-0.09	0.03
Feb	-0.13	-0.26	-0.02	0.09
March	-0.04	0.02	0.05	0.08
April	-0.10	-0.03	0.08	0.10
May	-0.02	0.31	0.11	0.25
June	0.25	0.57	0.11	0.08
July	-0.23	1.72	-43.5	0.00
Aug	-0.47	-1.80	-0.47	-2.39
Sept	0.28	1.36	-0.13	-0.66
Oct	-0.15	-0.31	0.03	0.28
Nov	-0.05	0.15	0.04	0.17
Dec	-0.02	-0.13	0.03	0.05

$P < 0.05$

# Estimate of maximum temperature

Max. temp	Canyon		Fresno	
	Feral	RRA Feral	Feral	RRA Feral
Jan	-0.27	0.65	-0.69	-0.05
Feb	-1.11	-1.51	0.15	1.55
March	-0.93	-1.82	0.28	0.98
April	-0.65	-2.03	0.55	0.49
May	-0.62	-1.94	0.08	-0.78
June	-0.63	-1.61	0.12	-0.34
July	-0.35	-1.25	0.20	-0.08
Aug	-0.20	-1.54	0.24	0.15
Sep	-0.13	-2.13	0.52	0.36
Oct	-0.13	-3.12	0.27	0.52
Nov	-1.32	-1.95	0.18	0.32
Dec	0.01	-1.75	0.02	0.56

$P < 0.05$

# Estimate of minimum temperature

Min. temp	Canyon		Fresno	
	Feral	RRA Feral	Feral	RRA Feral
Jan	0.36	2.95	-2.29	0.26
Feb	0.32	3.30	-1.20	-0.41
March	0.22	2.88	-1.38	-0.20
April	0.18	2.13	-1.37	-0.64
May	0.08	1.04	-1.56	-0.93
June	-0.02	2.45	-1.23	-0.94
July	0.16	1.94	-0.67	-0.40
Aug	0.22	1.35	-0.43	-0.79
Sep	0.23	0.90	-0.37	-0.80
Oct	0.41	2.60	-0.44	-0.19
Nov	-0.001	2.63	-0.83	-0.26
Dec	0.29	4.36	-0.009	-0.12

**P < 0.05**

# Summary

- Feral (+) RRA populations were detected 4 years after 2007 injunction, suggesting RRA transgene can persist in the environment
- Fresno and Walla Walla have similar prevalence of feral populations, Canyon had less
- Frequency of (+) RRA transgene was higher in Fresno and lower frequency observed in Canyon and Walla Walla



# Summary

- Although seed production locations had (+) RRA feral sites, sites were also located elsewhere, suggesting hay production may be source of feral and (+) RRA feral escapes
- In Fresno, feral and (+) RRA feral plants occurred adjacent to alfalfa and almonds fields
- In Canyon, feral plants occurred adjacent to alfalfa, corn, range while no such relationship observed in (+) RRA feral plants

# Summary

In general, feral and (+) RRA feral plants occurred in warmer climates in Fresno, while they occurred in average temperatures in Canyon

# Analysis still to be done

- Evaluate the relationship between feral plants and explanatory variables in Walla Walla County
- Assess the relationship between historical (+) RRA seed locations, (+)RRA hay fields distance and (+) RRA feral plants
- Incorporate wind speed, roads into the model for all the three counties
- Spatial models such as ordinary least squares (OLS) and geographically weighted least squares (GWLS) will be used for presence data to predict feral plant occurrence

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