MARKER ASSISTED BREEDING FOR ALFALFA FORAGE PRODUCTIVITY IN ARID & MESIC ENVIRONMENTS

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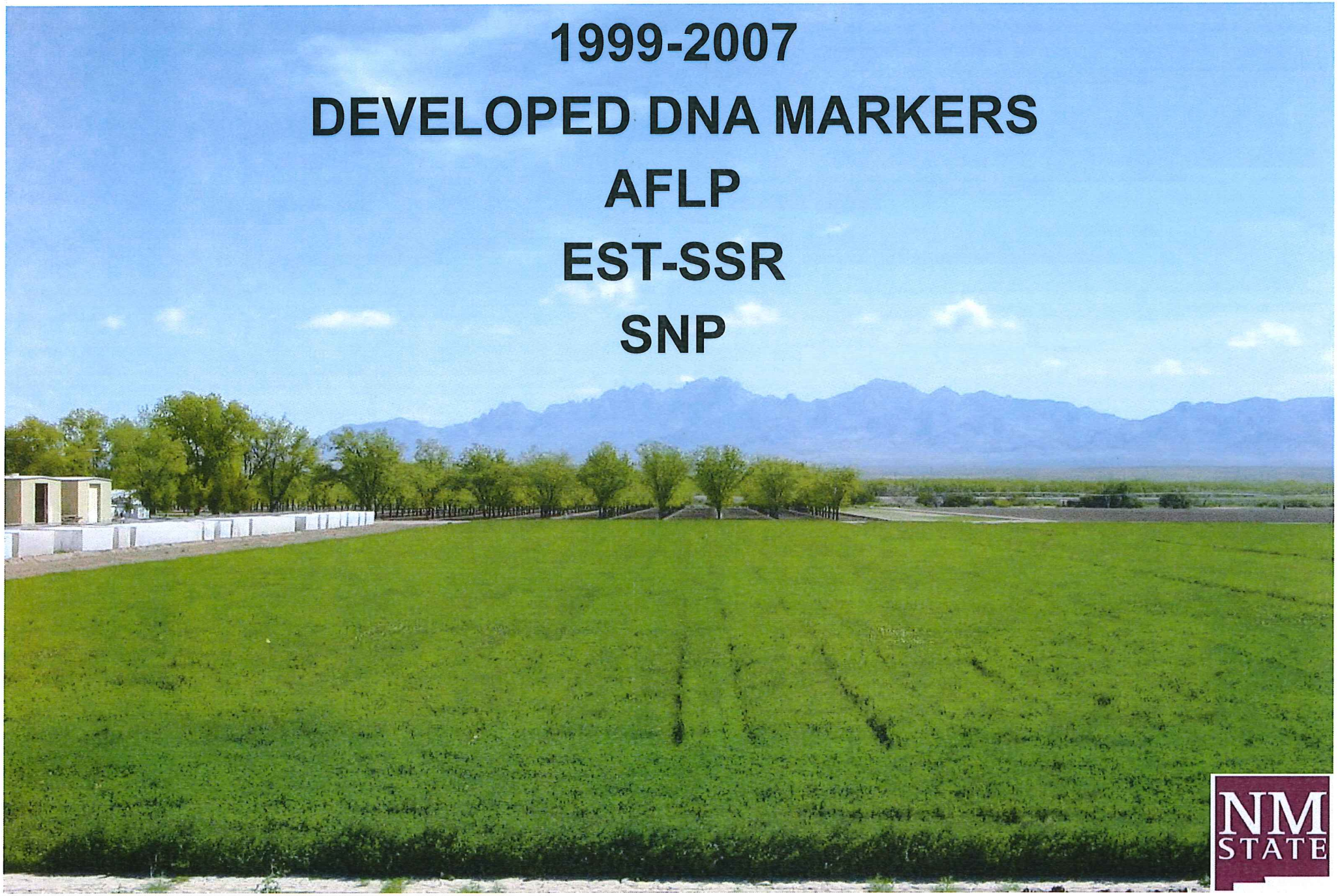
1999-2007
DEVELOPED DNA MARKERS
AFLP
EST-SSR
SNP
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YIELD DATA COLLECTION
(28-D FLOOD IRRIGATION INTERVAL)
2005, 2006, 2007

END OF STUDY 2007
ROOT/CROWN BIOMASS COLLECTION (1,230 plots)
25cm soil depth

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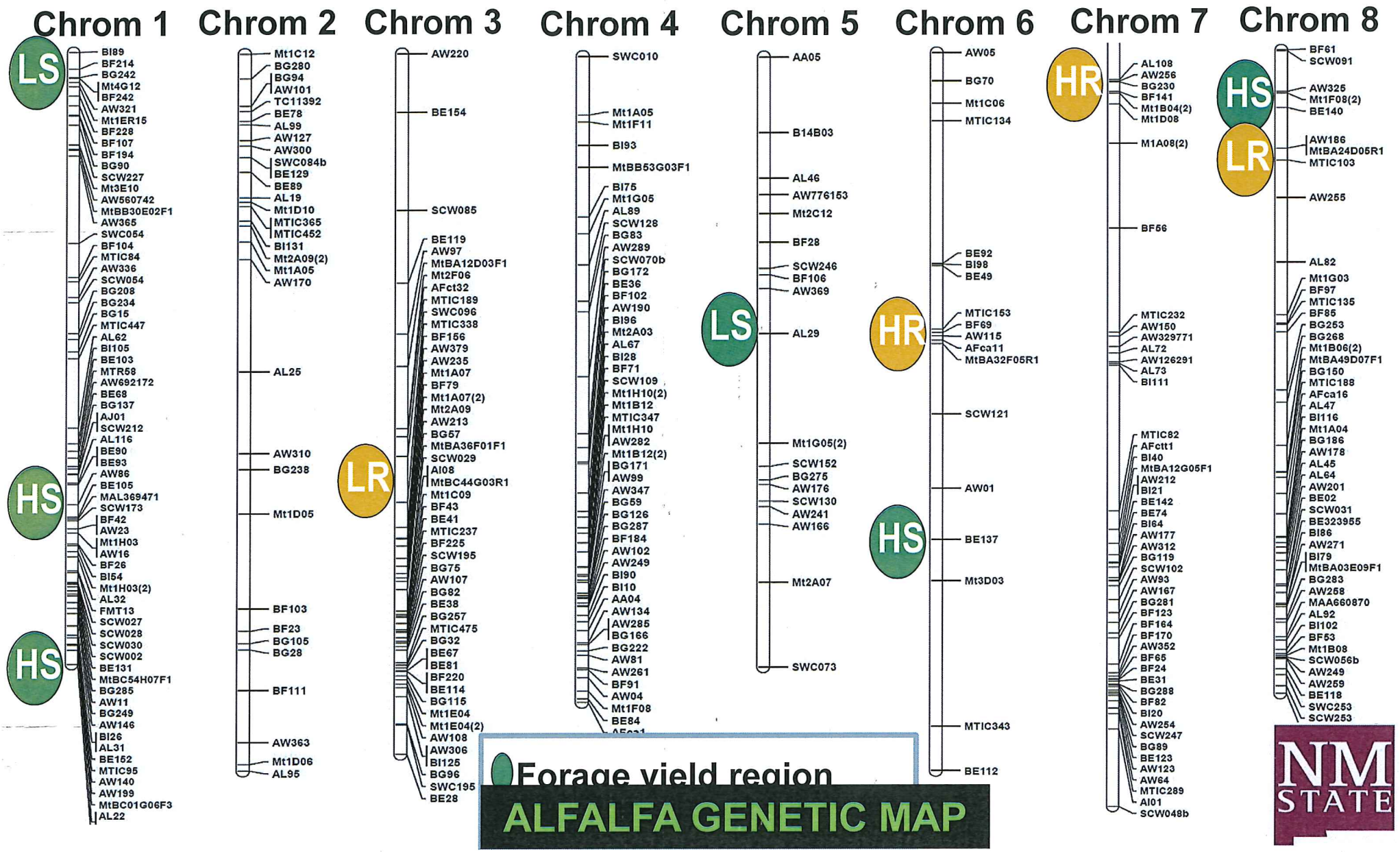
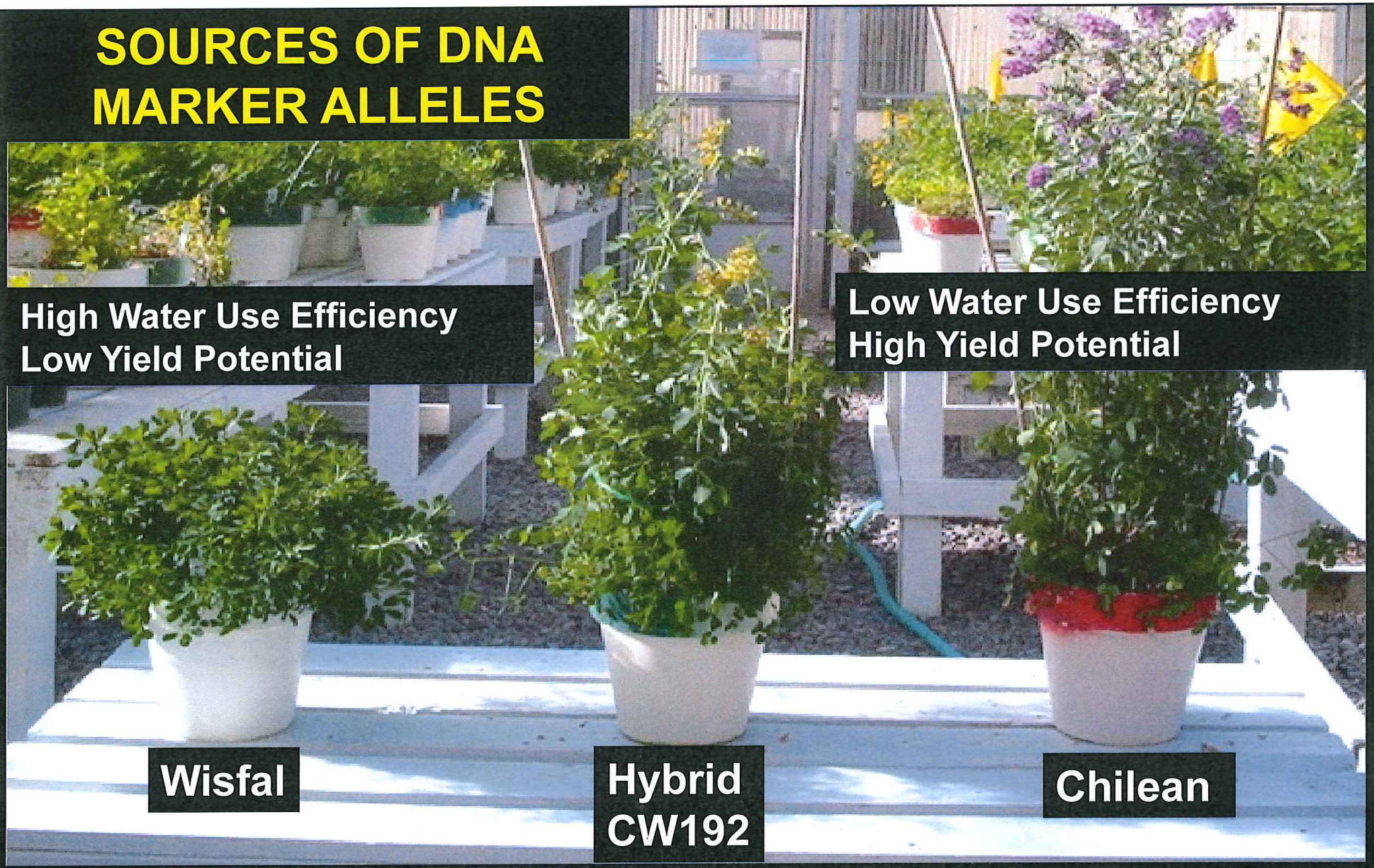
Alfalfa Chromosomes & Yield



SOURCES OF DNA MARKER ALLELES



Transferring Biomass DNA Markers into Cultivars

X Malone Cultivar

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Base Population (Cycle0 n=200)

Analyze each plant for presence or absence of 10 DNA markers (i.e. 4HS, 2LS, 2HR, and 2LR markers)

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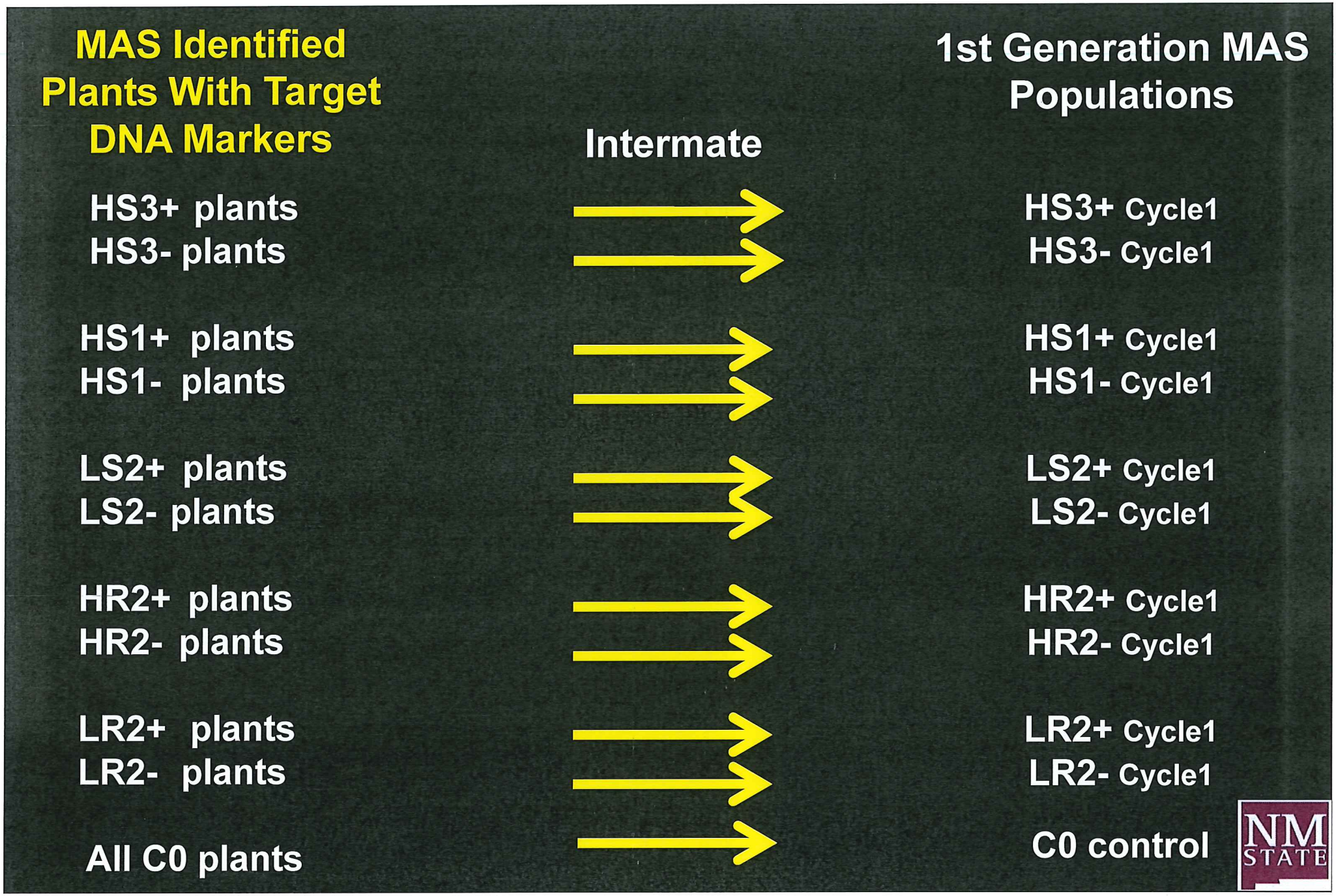
MAS Identified Plants With Target DNA Markers
Intermate
1st Generation MAS Populations
HS3+ plants
HS3- plants
HS3+ Cycle1
HS3- Cycle1
HS1+ plants
HS1- plants
HS1+ Cycle1
HS1- Cycle1
LS2+ plants
LS2- plants
LS2+ Cycle1
LS2- Cycle1
HR2+ plants
HR2- plants
HR2+ Cycle1
HR2- Cycle1
LR2+ plants
LR2- plants
LR2+ Cycle1
LR2- Cycle1
All C0 plants
C0 control
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Populations Seeded October 2010
14-day Flood Irrigation Interval Management
6 Harvests/year
2011-2013
RWC=87%

Populations Seeded October 2010
28-day Flood Irrigation Interval Management
6 Harvests/year
2011-2013
RWC=68%
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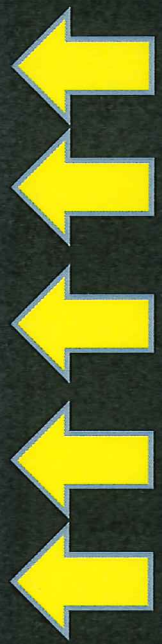
1st Generation MAS Populations Seasonal Yield Under Deficit Irrigation

Population comparisons	Dry Matter Yield 3-yr Avg. (Mg/ha)	Phenotypic effect (%)
HS3+ vs. HS3-	10.53 vs. 8.81*	+19
HS1+ vs. HS1-	9.09 vs. 7.82^{ns}	+16
HR2+ vs. HR2-	9.43 vs. 7.95*	+19
LS2+ vs. LS2-	9.92 vs. 10.01^{ns}	-1
LR2+ vs. LR2-	9.21 vs. 10.65*	-15



Cycle 1: High Shoot and High Root Biomass Markers Benefited Forage Yield During Drought

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Five Cycle 1 Populations Possessing Specific Markers (HS3+, HS1+, LS2+, HR2+, LR2+) and C0 control

Intermated with 3 Elite Populations

NM Bill Melton
31% yield loss under drought

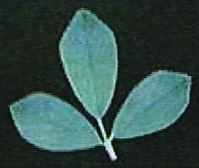
Malone
34% yield loss under drought

MLHQ
40% yield loss under drought

6 Hybrids

6 Hybrids

6 Hybrids



2nd Generation MAS Populations

Melton-MAS Hybrids: Seasonal Forage Yield under Drought and Well-Watered Conditions.

	Population	3-Year Avg. Yield (Mg/ha)
2%	Melton	14.00 a
	MeltonHS1+	13.66 a
	MeltonHS3+	13.57 a
	MeltonHR2+	13.33 ab
19%	MeltonC0	12.89 ab
	MeltonLR2+	11.47 bc
	MeltonLS2+	11.44 bc
	C0	8.77 d

Values followed by same letter are not significantly different at P≤0.10. HS3+ & HS1+, high shoot biomass markers present. LS2+=low shoot , HR2+=high root , and LR2+=low root biomass markers present

Malone-MAS Hybrids: Seasonal Forage Yield under Drought and Well-Watered Conditions.

	Population	3-Year Avg. Yield (Mg/ha)	
3%	MaloneHS3+	13.21	a
	Malone	12.83	ab
	MaloneLS2+	12.06	abc
27%	MaloneLR2+	11.37	bc
	MaloneHS1+	10.85	c
	MaloneHR2+	10.81	c
	MaloneC0	10.44	cd
	C0	8.77	d

Values followed by same letter are not significantly different at P≤0.10. HS3+ & HS1+, high shoot biomass markers present. LS2+=low shoot , HR2+=high root , and LR2+=low root biomass markers present

MLHQ-MAS Hybrids: Seasonal Forage Yield under Drought and Well-Watered Conditions.

14%

20%

Population	3-Year Avg. Yield (Mg/ha)	
MLHQLS2+	13.78	a
MLHQHS1+	12.87	ab
MLHQLR2+	12.87	ab
MLHQ	12.07	ab
MLHQHR2+	11.97	ab
MLHQHS3+	11.53	b
MLHQC0	11.47	b
C0	8.77	c

Values followed by same letter are not significantly different at P≤0.10. HS3+ & HS1+, high shoot biomass markers present. LS2+=low shoot , HR2+=high root , and LR2+=low root biomass markers present

CONCLUSIONS 1st generation MAS populations

Drought stressed conditions (50% Malone background)

- Yield among Cycle1 populations differed by 36%
- Selection FOR high shoot and high root biomass markers improved alfalfa yield by 16 to 19%.
- Selection AGAINST low shoot and low root biomass markers improved alfalfa yield by 1 to 15%.

Well-watered conditions (50% Malone background)

- Yield among Cycle 1 populations differed by 11%
- Selection for HS3+ high shoot biomass markers improved yield by 10% while other markers showed limited impact (0 to 3%).

CONCLUSIONS 2nd generation MAS populations

Drought stressed conditions (75% elite background)

Yield ranges: Melton hybrids (19%), Malone hybrids (27%), MLHQ hybrids (20%)

2% yield loss of MeltonHS1+ hybrid (best) vs Melton

3% yield gain of MaloneHS3+ hybrid (best) vs Malone

14% yield gain of MLHQLS2+ hybrid (best) vs MLHQ

Well-watered conditions (75% elite background)

Yield ranges: Melton hybrids (15%), Malone hybrids (13%), MLHQ hybrids (15%).

6% yield gain of MeltonHS1+ hybrid (best) vs Melton

5% yield gain of MaloneHS3+ hybrid (best) vs Malone

4% yield gain of MLHQLS2+ hybrid (best) vs MLHQ

GENERAL CONCLUSIONS

DNA marker assisted breeding has good potential to improve alfalfa productivity in drought-prone and well-watered environments.

Greatest improvements were observed in the most drought sensitive germplasm.

We gratefully acknowledge the following financial supporters of this research

NEW MEXICO HAY ASSOCIATION

THE SAMUEL ROBERTS NOBLE FOUNDATION

Alforex Seeds™

NM STATE UNIVERSITY

Agricultural Experiment Station

CSREES EDUCATION · RESEARCH · EXTENSION USDA

National Research Initiative Agricultural Plants & Environmental Adaptation Program Award #2005-35100-16268

USDA- S.W. Consortium Plant Genetics & Water Resources

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Not pictured: Gina Babb, Lei E, Johnny Maruthavanan, Nina Klypina, Tracy Sterling, Alexis Ray, Hem Singh Bhandari, Rossio Kersey.

Special Thanks to Noble Fdn Collaborators (Past & Present):
Mary Sledge, Greg May, Joe Bouton, Maria Monteros, YuanHong Han