Re-Designing Alfalfa for Increased Yield and Quality

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Trait Targets

- Agronomic Traits (input traits)
  - Herbicide tolerance
  - Pest resistance
  - Abiotic stress tolerance
  - Increased yield per se

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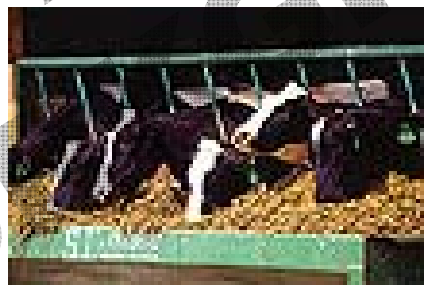
Quality Traits

Plant Science ⇄ Animal Science



Dairy Producers

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Consortium for Alfalfa Improvement

USDFRC

THE SAMUEL ROBERTS NOBLE FOUNDATION

PIONEER®
A DUPONT COMPANY

Forage Genetics International

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Re-Designing Alfalfa for Improved Forage Quality

- The CAI concept:
  - Interdisciplinary, inter-institutional collaboration
  - Ruminant nutrition
  - Biochemistry
  - Plant molecular biology
  - Plant breeding/agronomy
- CAI target traits – “re-designing alfalfa”
  - Increased cell wall digestibility
  - Improved efficiency of protein utilization

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Reduced Lignin Alfalfa

- Lignin increases with advanced maturity in alfalfa.
- Lignin is indigestible, and binds with cellulose/hemicellulose – reducing fiber digestibility.

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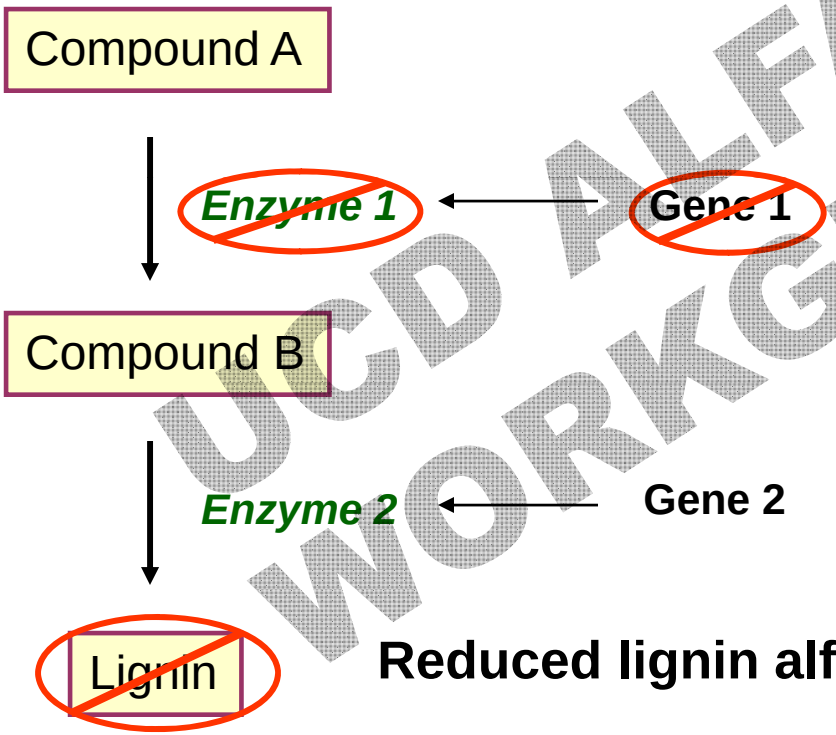
Gene knockout to modify lignin pathway



Reduced lignin alfalfa

Use genetic engineering to knockout/silence “lignin gene(s)” in alfalfa

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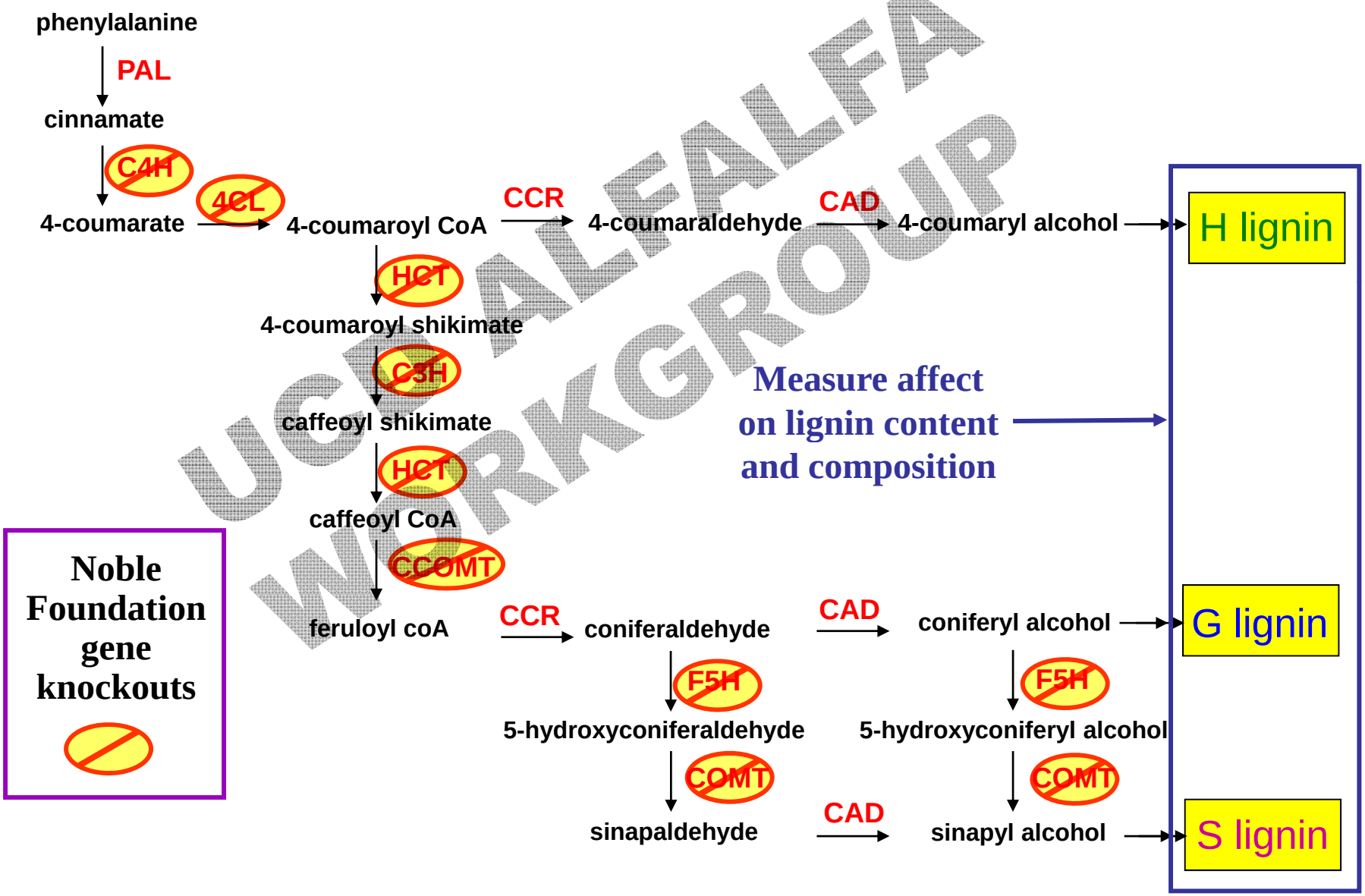
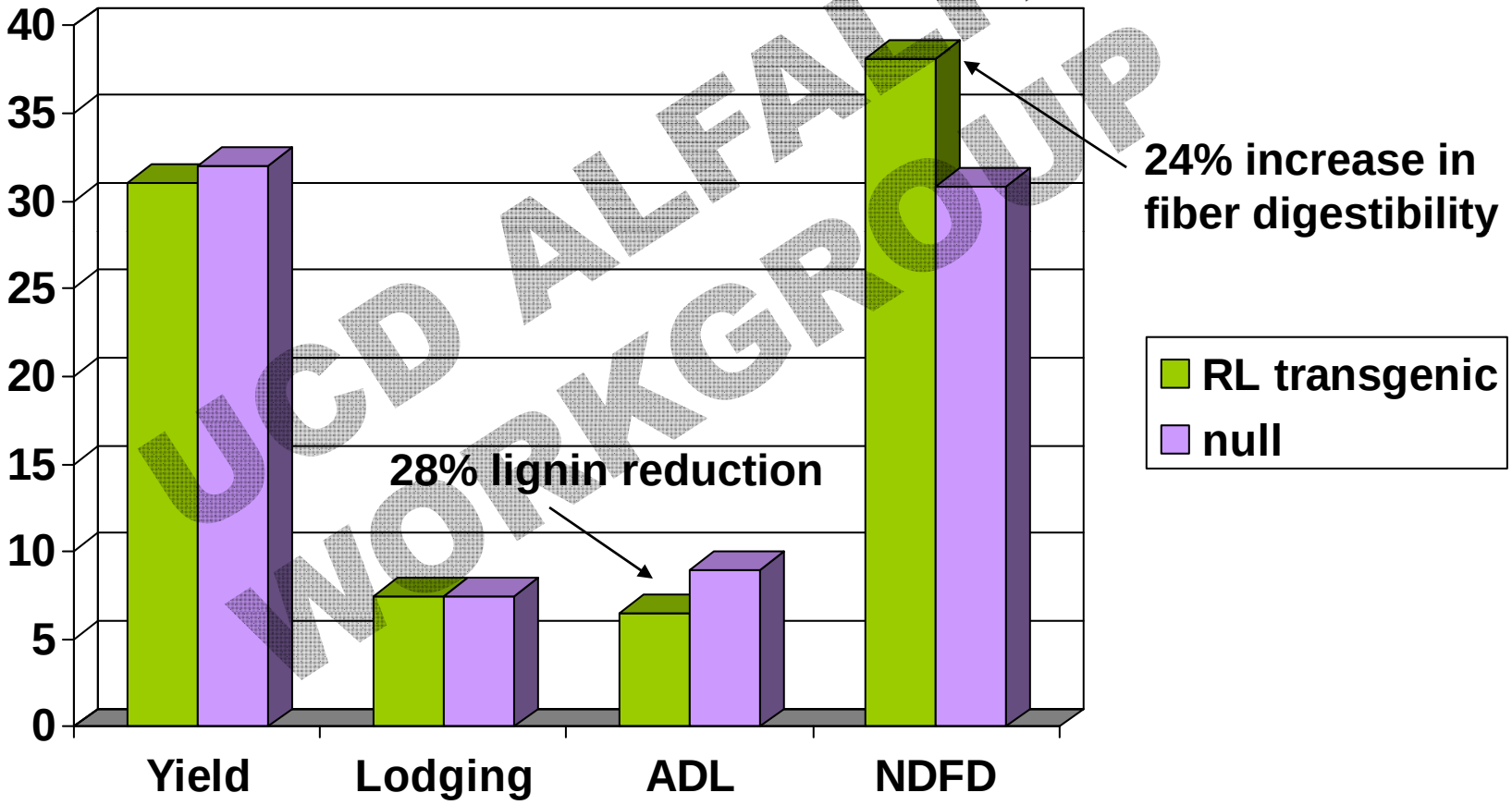
Lignin Biosynthetic Pathway



2008 Summary – RL1 Alfalfa



Note: lower stem samples, CAI equation, average of 25 elite events

Nampa, ID May 30, 2007

RL1

RL1 NULL

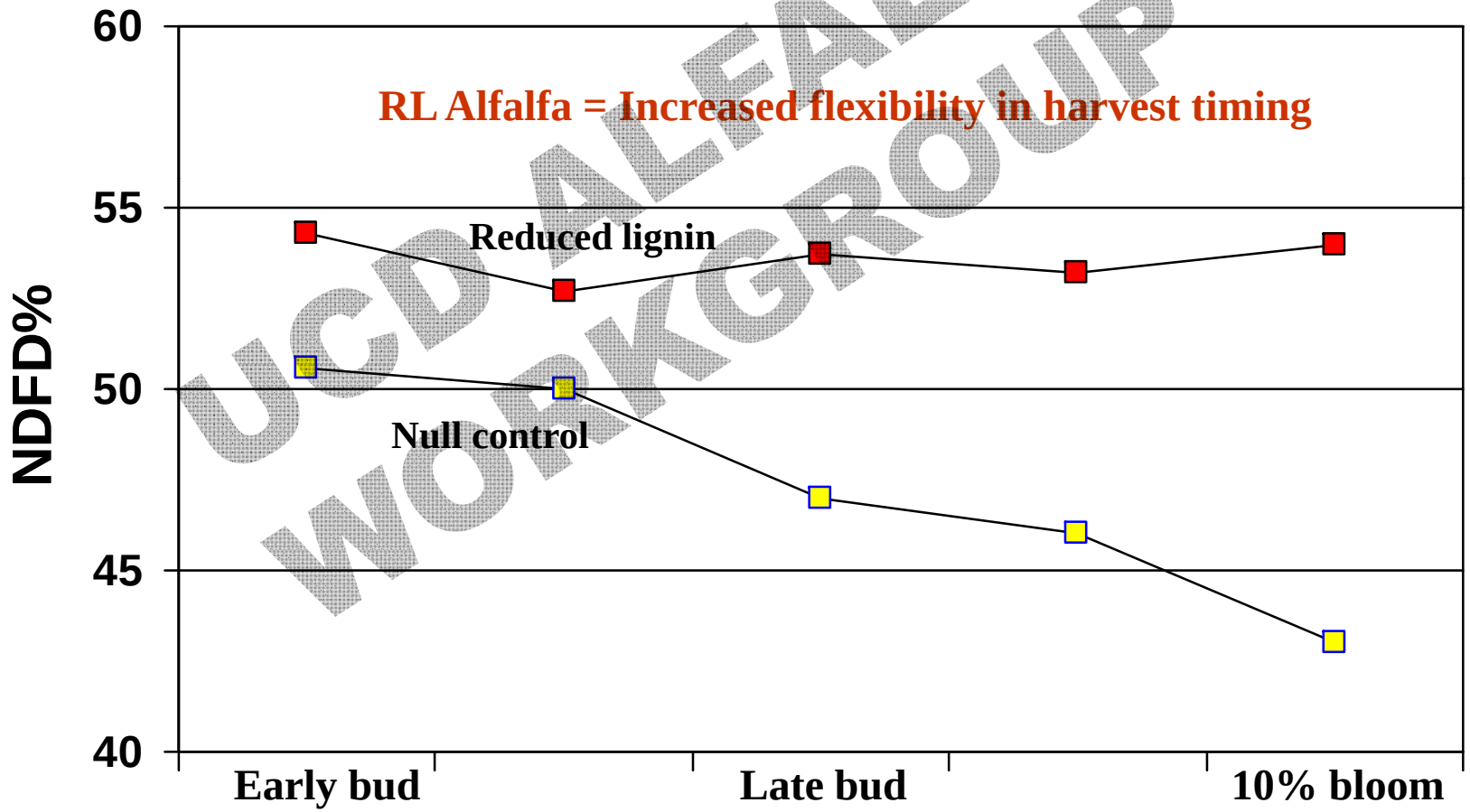
RL2

RL2 NULL

677
623
Land O' Lakes Purina Feed
Large Animal Metabolism Unit (LAMU

USDFRC Sheep Feeding Studies

RL1 Alfalfa
Changes in NDF Digestibility over Time



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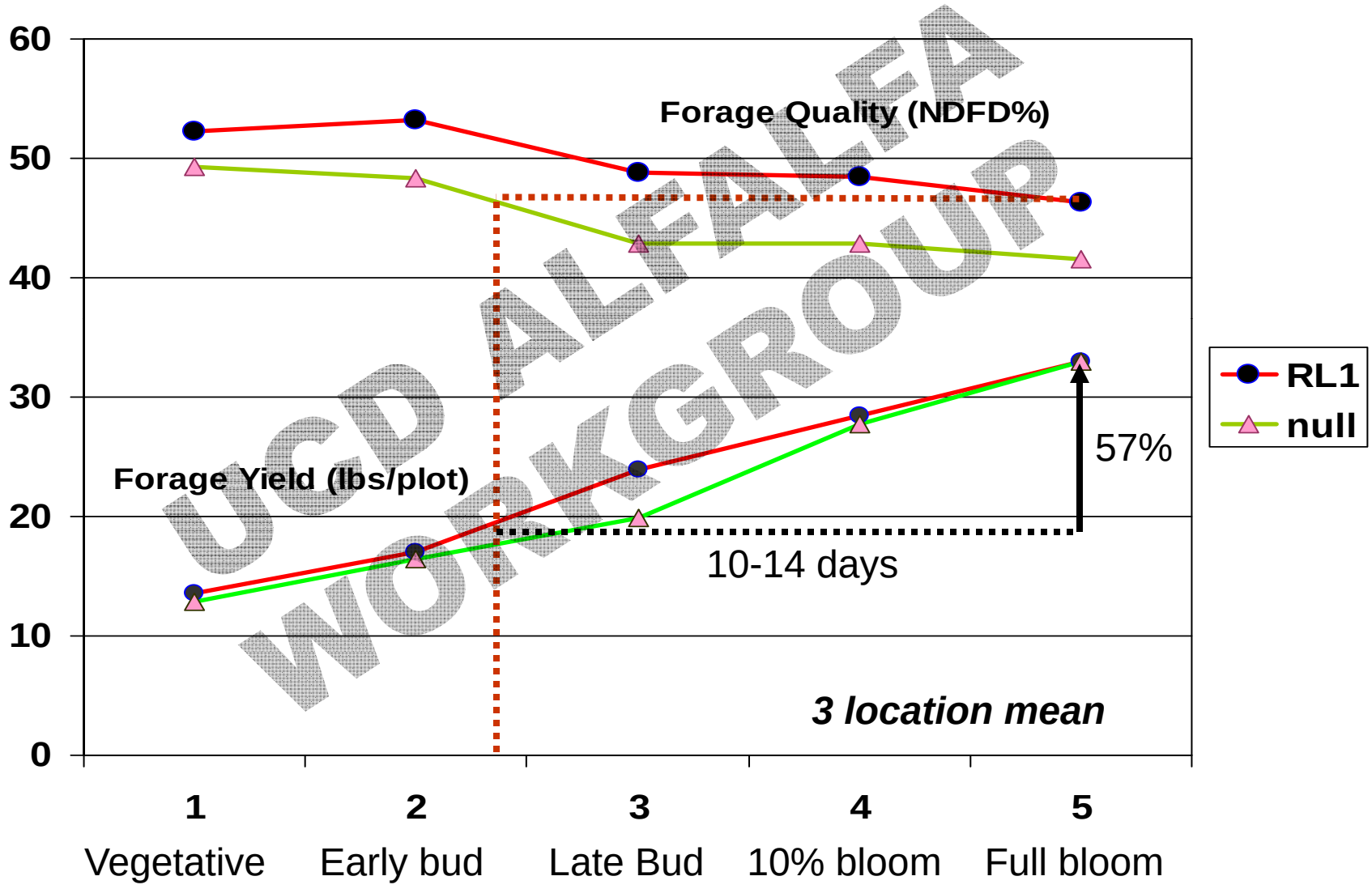
Cutting Management Trial at Arlington, WI

2008 Cutting Management Trials (WI, MN)



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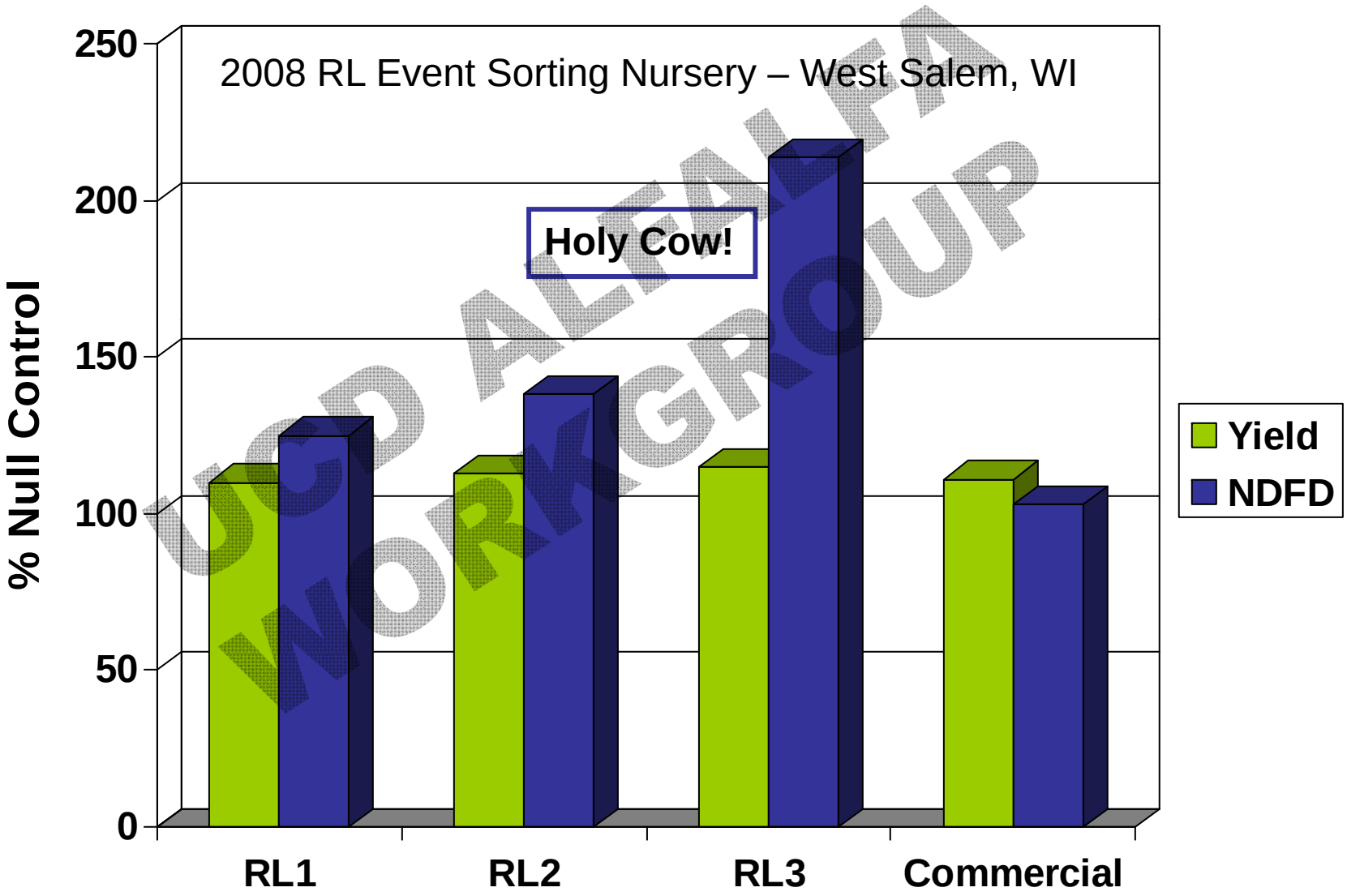
RL Construct Comparison



Reduced Lignin Summary

- Gene knockouts can be used to signficantly change lignin content and composition
- RL alfalfa identified with good agronomic performance
- RL alfalfa has increased NDFD and slower change in quality with advancing maturity
  - More flexibility in harvest timing
  - Fewer harvests per season = $$$

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Tannin Alfalfa

- FGI/Noble/USDFRC collaboration to improve efficiency of alfalfa protein utilization for dairy.
- Tannins bind with protein, slowing rate of rumen degradation and increasing RUP (bypass protein).
  - Increasing RUP 20% → 30% would eliminate need for protein supplements
- Condensed tannins can be found in alfalfa seed coats, but not leaves or stems.
  - Genetic engineering can be used to modify gene expression, producing Tannin Alfalfa.

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Transgenic Tannin Alfalfa – Research Approach

MtLAP in *Medicago*

Tannin Alfalfa

Lc
MtLAP

anthocyanins

BAN

catechin
epicatechin

??

Condensed tannin

Increase metabolic feed for pathway

Production of tannin monomers

Tannin polymerization

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Tannin Alfalfa

- USDFRC MW dairy model for tannin alfalfa:
  - 60% reduction in protein feed supplementation
  - Up to 12% increase in net return for dairy
  - 25% reduction in N losses
- Tannin containing forages are non-bloating
  - Worldwide alfalfa related bloat losses > $200M

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Agronomic Traits

- Roundup Ready Alfalfa
- Abiotic Stress Tolerance
  - Drought tolerance/WUE
- Delayed flowering

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MONSANTO
imagine®

Forage Genetics International

Drought Tolerance

- Drought tolerance and water use efficiency will become critical with increasing cost and decreasing availability of irrigation water in the West.
- Drought tolerance genes have been identified and will be commercialized in several crops, including alfalfa.

Drought tolerance screen

Control Transgenic

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Drought Tolerance Field Trials

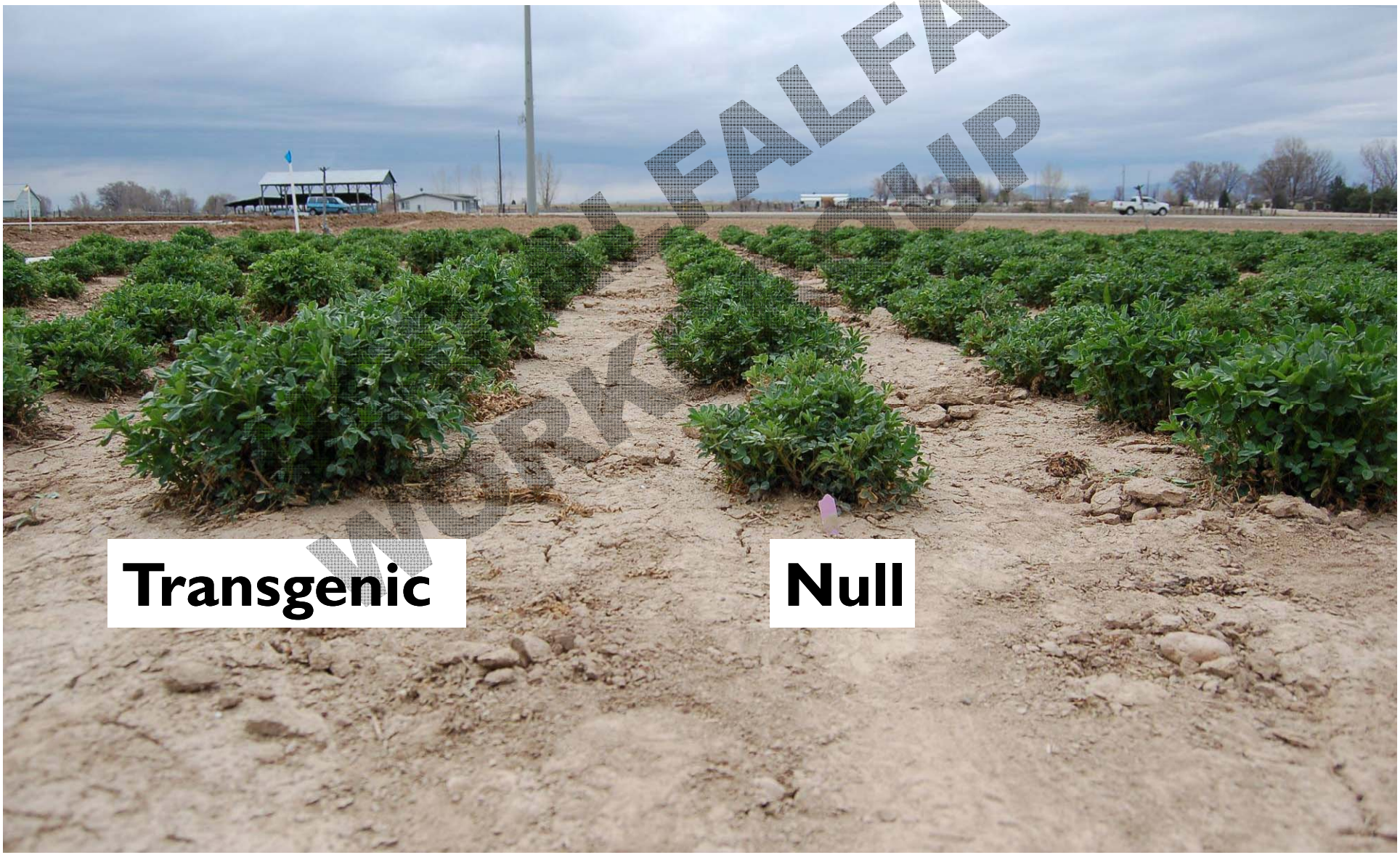
Control Transgenic

Drought tolerant corn trials:
Grain yield on 80% moisture

Drought tolerance in soy

Monsanto website

Drought tolerance trial
Nampa, ID April 8, 2009



Delayed flowering

- Genetic basis of flowering control is well understood.
- Transgenic approaches to modify flowering time are being evaluated.
- Important tool for increasing forage yield in alfalfa.

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ALFALFA ROUP

Delayed flowering in soybeans