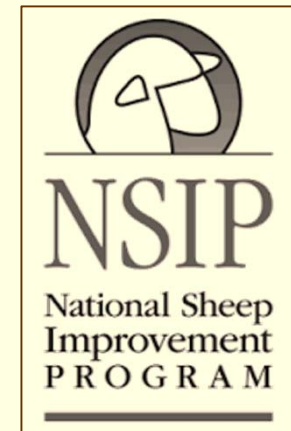


The future of genomic technology in the U.S. sheep industry

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NSIP Regional Meeting
12th Annual Katahdin Hair Sheep International Expo & Sale

Tennessee Tech Univ., Cookeville, TN
Aug. 4, 2016



My talk

■ Genomics road trip

- Map
- Major genes
- Genetic markers
- Genome-enhanced BV

■ Bumps along the road

- Reference populations
- Costs

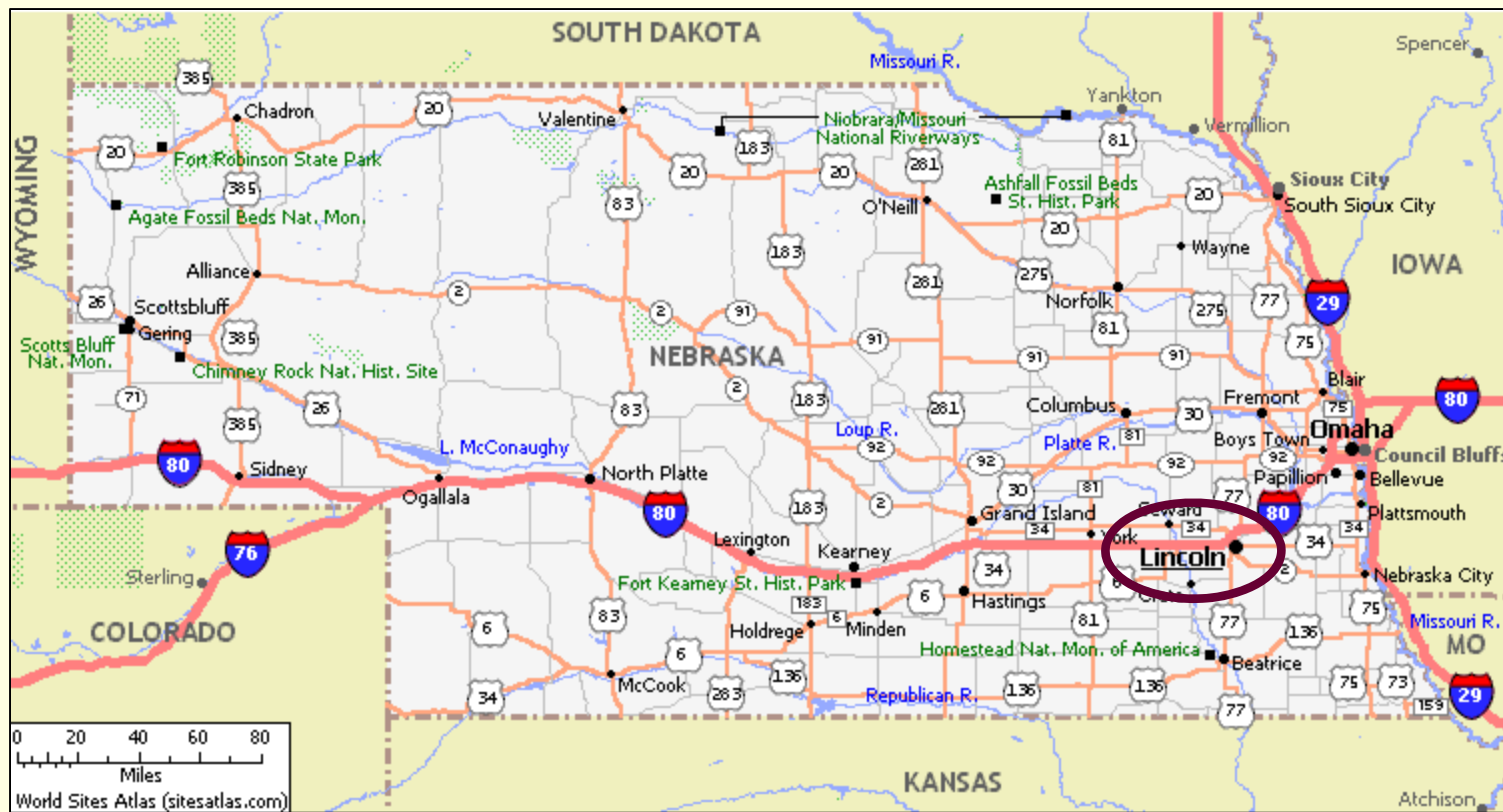
■ Reflecting on the trip

- Key equation
- A better pedigree
- Improving hard-to-measure traits

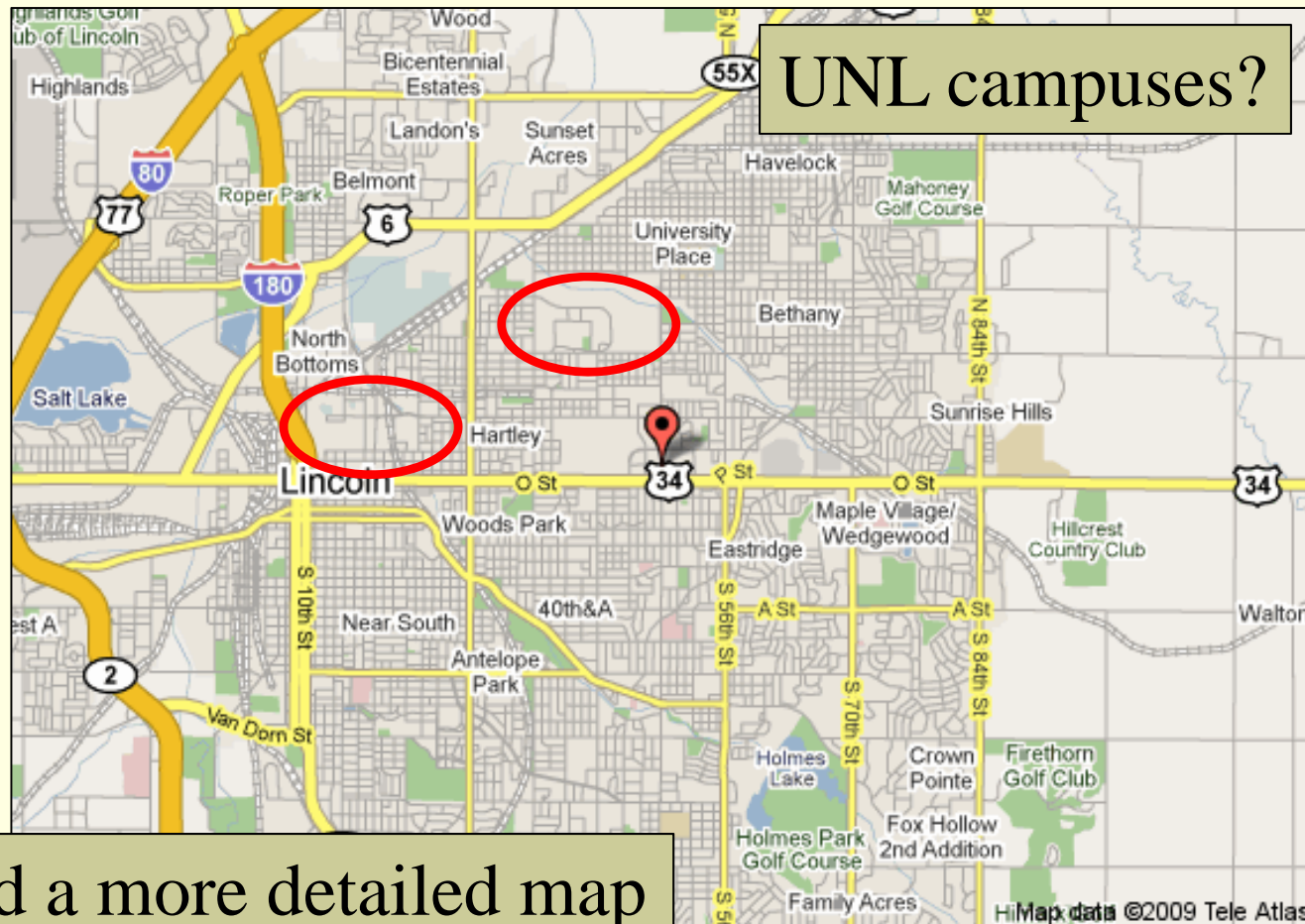
■ Starting a new trip

- Who to visit
- Sharing the road

A road map

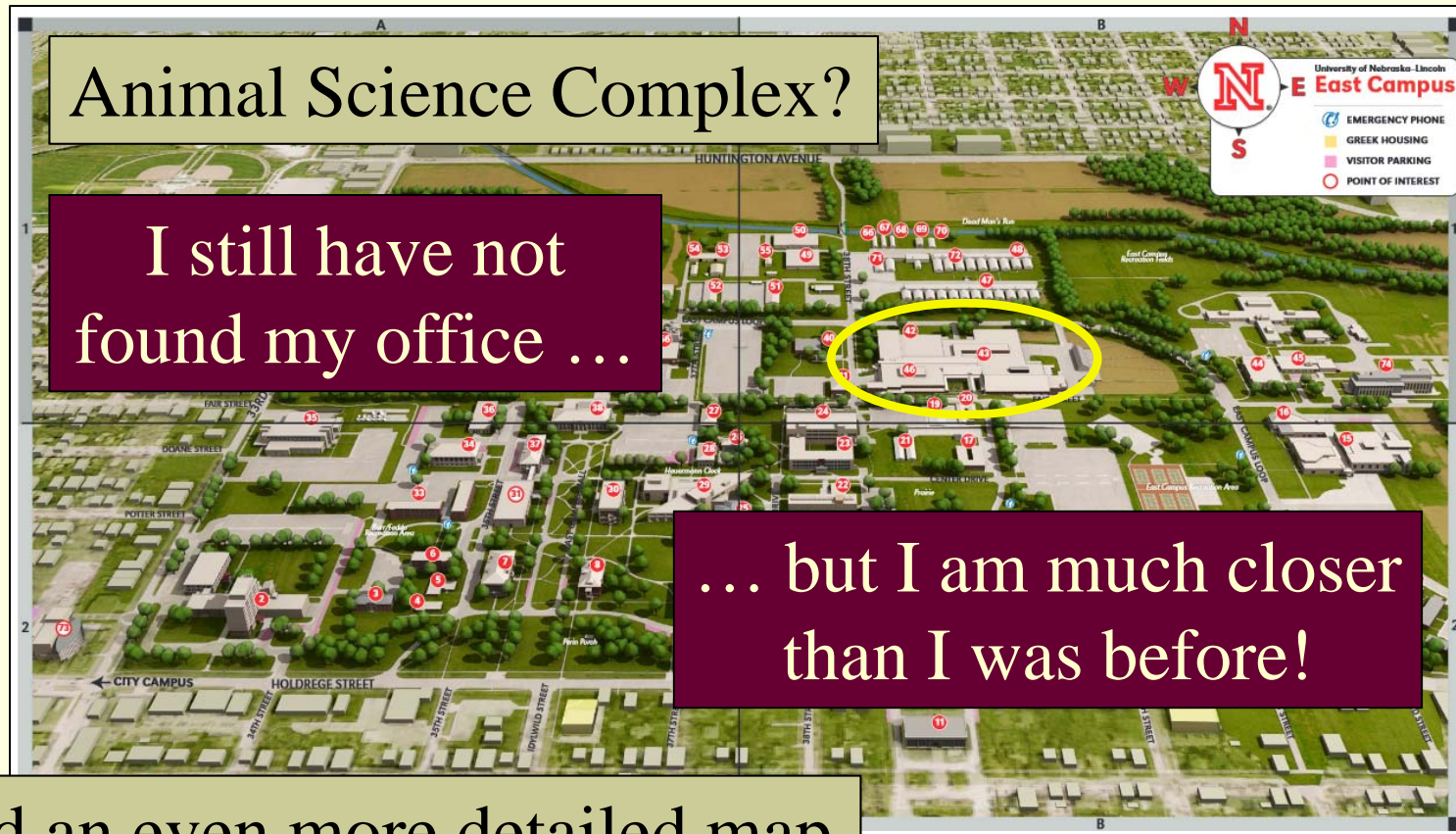


A road map



Need a more detailed map

A road map



Animal Science Complex?

I still have not found my office ...

... but I am much closer than I was before!

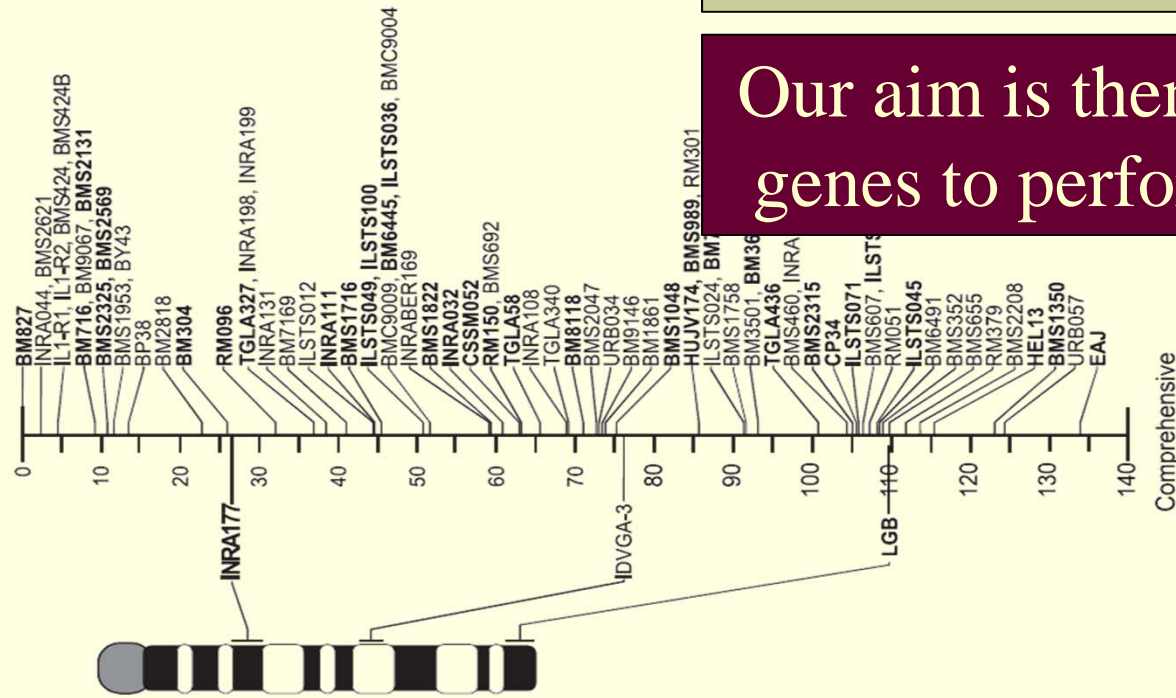
Need an even more detailed map

A chromosomal road map

- A map locating positions of genes at loci along a chromosome

With a more detailed map, we locate more, although not all, genes

Our aim is then to link genes to performance



Major genes

- For some traits of economic interest, we have found genes with major causative effects
- Examples
 - Fecundity (Demars et al., 2013; Martin et al., 2014)
 - Mastitis susceptibility (Rupp et al., 2015)
 - Muscling (Cloup et al., 2006)
 - OPP virus resistance (Heaton et al., 2012)
 - Scrapie resistance (Elsen et al., 1999; Barillet et al., 2009)
 - Spider syndrome (Cockett et al., 1999)

Major genes

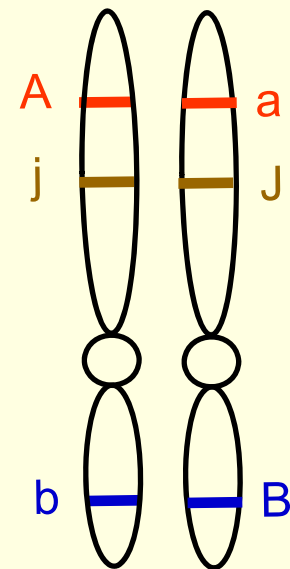
- For some traits of economic interest, we have found genes with major causative effects
- Yet major genes are comparatively rare
 - Traits of interest have proven to be more complex than anticipated
 - Most traits are influenced by thousands of genes, each gene having a small effect

Needed a broader
approach

(Meuwissen, Hayes and Goddard, 2001)

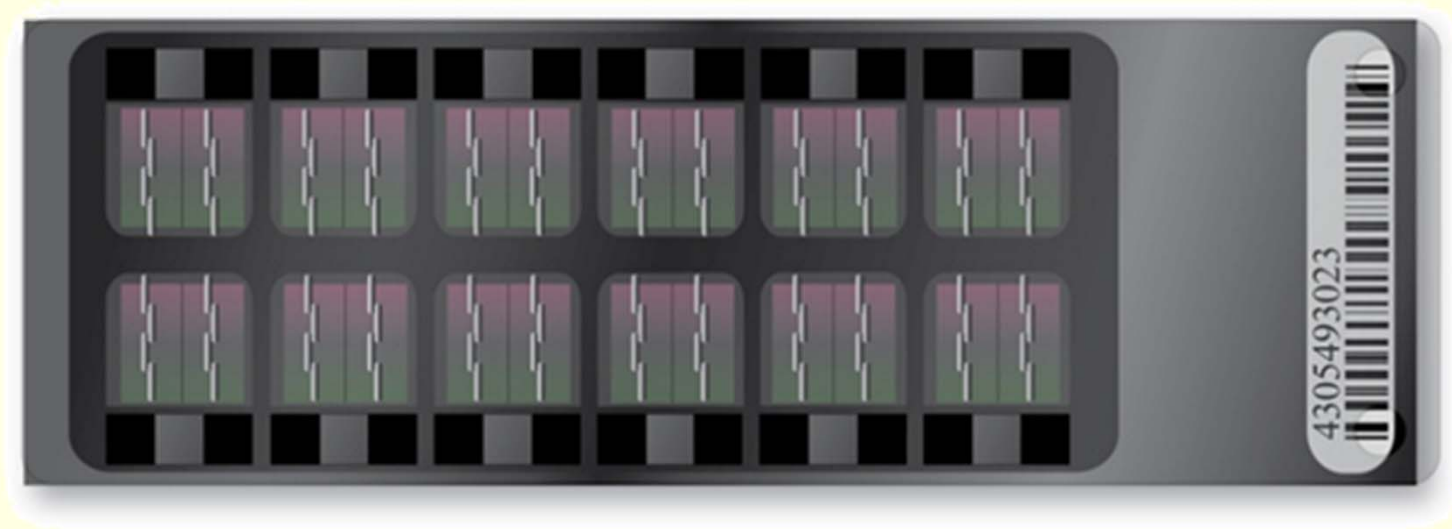
Genetic markers

- A detectable gene at one location on the chromosome used to mark a causative gene at a nearby location
- When the locations are physically closer, there is less opportunity for recombination, making markers more informative



Illumina OvineSNP50 Beadchip

- Provides 54,241 evenly spaced markers across the sheep genome (chromosomes)



Genome-enhanced breeding values

- Each marker typically explains a small proportion (< 1%) of genetic variation in a trait
- **Genome-Enhanced Breeding Values (GEBV)** are predicted from the sum of the effects of all markers across the entire genome
- As an outcome, GEBV **can** more accurately indicate an animal's true genetic merit

Predictions are based on associations between markers and actual performance for traits of interest

Gain in accuracy

Traits	Gain in accuracy	Location	Reference
Carcass, meat quality	5 – 10%	Australia	Daetwyler et al., 2012
Meat, fleece, litter size	5 – 27%	New Zealand	Auvray et al., 2014
Milk production	10 – 20%	France	Baloche et al., 2014

The extent of gain in accuracy is closely tied to the amount of available genomic **and** performance information

Reflecting on the trip

- Key equation
- A better pedigree
- Improving hard-to-measure traits

Key equation

- Key equation

$$\Delta BV_X / t = \frac{r_{BV_X, P_X^*}(i_X) \sigma_{BV_X}}{L}$$

- Genomic tools allow

- Increased accuracy ($\uparrow r_{BV_X, P_X^*}$)
 - Because of GEBV
- Decreased generation interval ($\downarrow L$)

Form a better pedigree

- Challenges in recording pedigree information
 - Particularly in multiple-sire and extensive systems
- Parentage panel
 - With a limited number of markers, can reliably determine pedigree (Heaton et al., 2014)



Increases
accuracy

Improve difficult-to-measure traits

- Traits expressed later in an animal's life
 - Longevity
- Traits expressed in only one sex
 - Fertility, litter size, mastitis
- Traits that are expensive and/or challenging to measure
 - Lamb survival, maternal bonding, aseasoonality
 - Carcass & eating quality
 - Feed efficiency
 - Methane emissions?

Increases accuracy &
decreases generation
interval

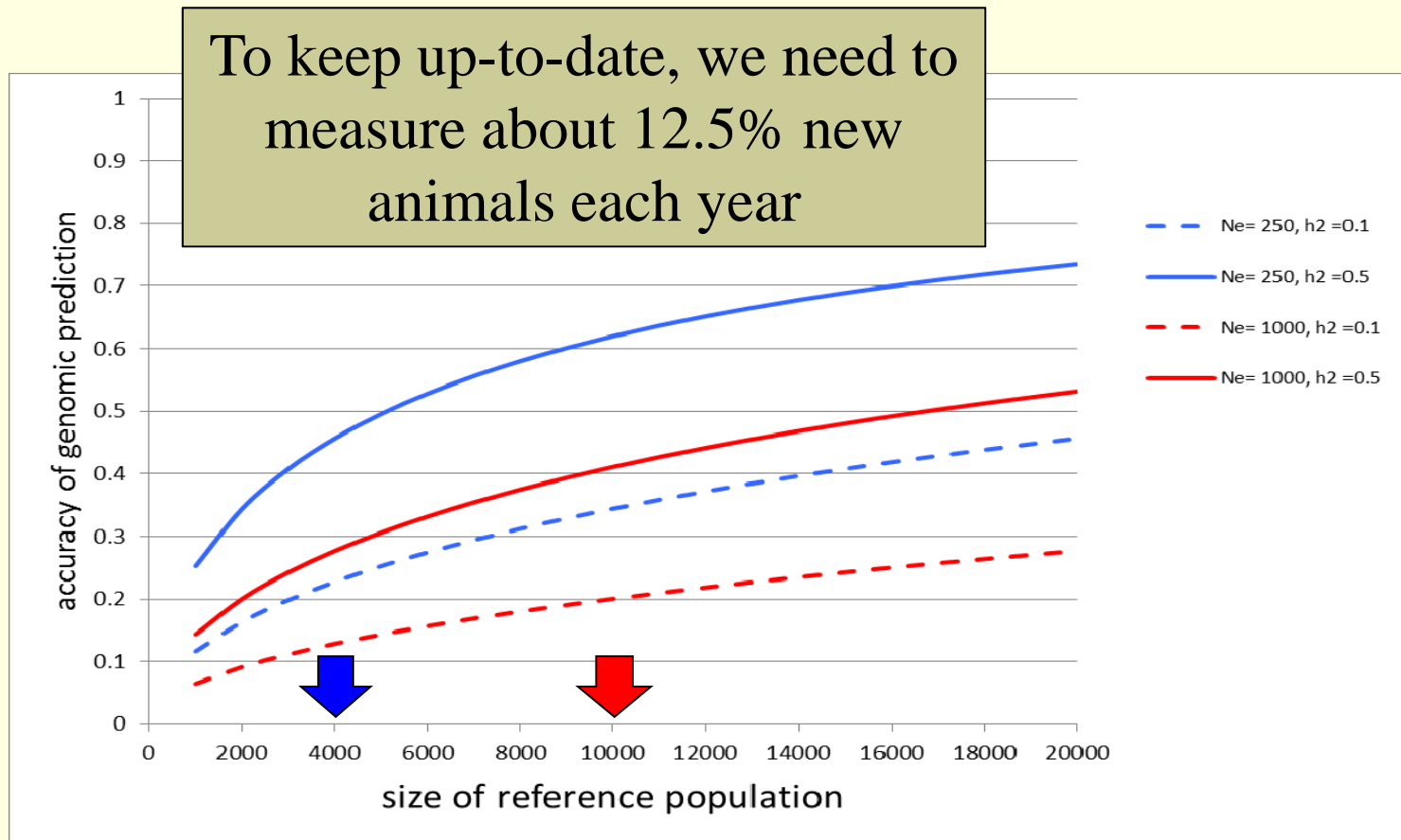
Bumps along the road

- Reference populations
- Costs

Reference populations

- Accuracy of GEBV depends on availability of substantial genomic and performance information
- Requires large reference populations in individual breeds
 - “Large” to capture genetic diversity within a breed
 - “Within breeds” because genomic predictions do not extend well across breeds
 - We have lots of breeds
 - Validation (training) must be ongoing
 - Accuracies deteriorate as ancestors used to form genomic predictions become more distant

Reference populations



(Goddard, 2009; Hayes et al., 2009; van der Werf et al., 2011)

Costs of genotyping

- Value of an animal is relatively low in sheep
 - Yet, per animal, cost of genotyping is nearly the same across species
 - Hopefully costs will continue to fall

Costs of genotyping

- Need to consider alternative strategies
 - Higher density (more detailed) genotyping of key sires
 - Lower density genotyping of others with imputation
 - Younger animals
 - Mature ewes with good phenotypic data



Costs of genotyping

- Need to consider alternative strategies
 - Higher density (more detailed) genotyping of key sires
 - Lower density genotyping of others with imputation
 - Parental panel with key major genes

Starting a new trip

- Who to visit
- Sharing the road

Who to visit

- Let's Grow funding
 - “Engaging the New Biology: establishing the foundation for genome-enhanced breeding values in the U.S. sheep industry”
- Objective one
 - Provide producer education on genomic tools
- Objective two
 - Devise efficient strategies to collect genomic data



Who to visit

■ Sampling strategies

- Four approaches will be considered, including the closeness of genetic relationships (disconnectedness)

■ Samples collected

- Blood cards
- On 1,000 Suffolk & 1,000 Rambouillet NSIP recorded sheep

■ Intended outcome

- A reservoir of genomic samples on performance recorded sheep as the first step toward establishing reference populations

Sharing the road

- Incorporating genomics into the U.S. sheep industry will necessitate
 - Extensive and on-going performance recording
 - Strategic genotyping
 - Substantial costs
 - Both in dollars and in enthusiasm
- It can only be achieved together

Thanks for listening

- I appreciate the support from ASI and the Let's Grow committee, and from NSIP

Questions?

