ANIMAL SCIENCE | CIAG | IOWA STATE UNIVERSITY | Animal Breeding & Genetics

How Whole Genome Selection may affect NCE

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What is Whole Genome Selection?

- WGS (or more correctly in this context, Whole Genome Evaluation) involves, in its simplest form, the calculation of an EPD for chromosome fragments (rather than animals)
- The EPD of an animal is the sum of the EPDs for all the chromosome fragments that are carried by the animal
- If it worked simply and perfectly, it would not require any pedigree or performance data

What is National Cattle Evaluation?

PEDIGREE & PERFORMANCE DATA

BREED ASSOCIATION SERVICING ENTITIES

EPD

R & D KNOW HOW

RELIABLE TIMELY COST-EFFECTIVE ESTIMATES OF TOTAL ECONOMIC MERIT

What is Whole Genome Selection ?

- WGS uses knowledge of the collective *inheritance* of chromosome *fragments* from the *entire genome* to predict genetic merit(s) (eg EPD, Comb. Abil.)
  - The size of the fragments is influenced by available marker technologies
    - Currently 50k SNP chip
  - Knowledge comprises recent (LA) and ancestral (LD) fragment inheritance/variation & analytical experience
    - Immature discipline

What is needed for WGS ?

- **Molecular technology** to reliably (and cost effectively) identify chromosome fragments
- High levels of linkage between identifiable chromosome fragments and genes contributing to variation in the trait
  - improved by denser marker panels (eg 50k / 500k / 1m / individual sequence)
  - influenced by recent & ancestral population structure

What is needed for WGS ?

- **Phenotypes** on suitable *resource* populations to enable calculation of the *effects* of chromosome fragments. Resource populations must consider
  - at least 4x animals as there are causal genes
  - sex, stage of life, envt, breed considerations
    - Dominance, Epistasis, GxE
- **Analytical technology** to robustly estimate effects with more explanatory variables (SNPs) than data

Operational WGS

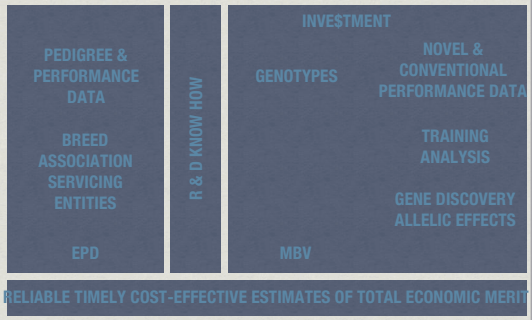
- Two-step Process
  - Step One: Bayesian Training
    - Molecular, phenotypic and analytical prerequisites
  - Step Two: MBV prediction
    - "Know how" from step one, and genotypes on new animals

Current Status of Bovine WGS

- Extensive research analysis being undertaken
- Correlations of MBV and EPD in range 0.5-0.7
  - 25% to 50% genetic variation can be accounted for using 50k markers
    - 50% to 75% variation not explained
      - can be predicted from PA &/or PT
- Nature and scope of routine delivery in the beef industry is uncertain

Industry Infrastructure

Industry Infrastructure



Future Status of WGS

- Compared to today:
  - Denser SNP panels (if not genomic sequence)
  - Heterogeneous panels according to animal "status" (i.e. more dense information on legacy sires and less dense panels on non-parents)
  - Greater account of available variation
    - Less value from adding NCE
  - Extension to epigenetic prediction

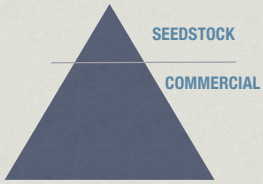
Role of Phenotypes in WGS

- Training (retraining)
  - Ongoing for new traits/environments
  - May need repeating (or continuous training) for epistasis
- Accounting for variation not captured by WGS
  - This will diminish if/as the predictive capability of WGS increases

Application of WGS

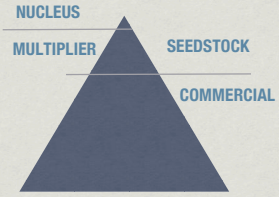
- Which animals would benefit from WGS?
  - Nucleus, multiplier, commercial parents
    - What is benefit relative to cost?
- Which people (or organizations) benefit from WGS?
  - Financial benefit is required to fund the servicing & other infrastructure costs

Everyone Must Benefit



GENOTYPING IN SEEDSTOCK TIER MUST BE PAID FOR IN BULL REVENUE

Everyone Must Benefit



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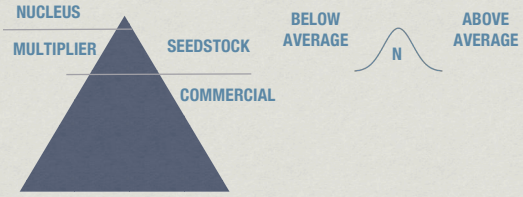

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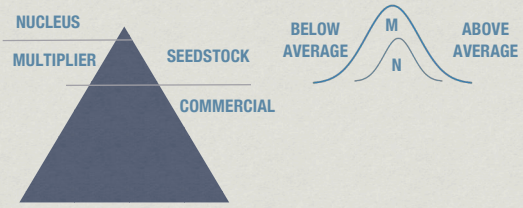

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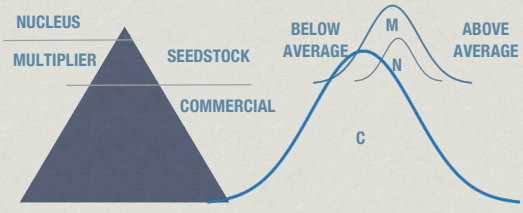

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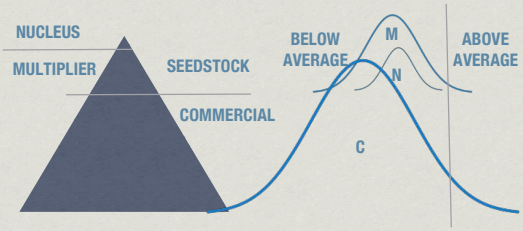
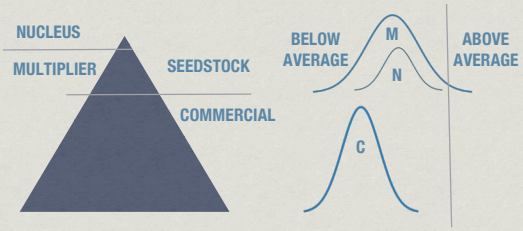


THERE ARE MORE ELITE ANIMALS IN COMMERCIAL THAN NUCLEUS

Current EPDs



THERE ARE MORE ELITE ANIMALS IN COMMERCIAL THAN NUCLEUS
BUT WE DON'T KNOW WHICH ONES THEY ARE

WGS

- Will empower the evaluation of prospective sires that do not currently enjoy EPDs (eg Commercial sector)
- The portfolio of WGS MBV will be more economically relevant (and futuristic) than the current portfolio of NCE EPD
- The commercial market size is greater than the seedstock (appealing to genomics companies)
- WGS will reduce demand for "average" seedstock bulls

Stakeholders in NCE

- Breed Associations
  - Bull Breeders (nucleus & multiplier)
  - Bull Buyers
  - AI Companies
- EPD Servicing Entities
- Researchers interested in NCE
- Others (BIF, NBCEC, Cooperative Extension)

Current Business Model

- Cash
  - Bull breeders collect data at own expense
  - Bull breeders pay Breed Associations
    - Breed Associations (partly) pay Service entity
- Non cash
  - Bull breeders "freely" contribute the IP contained in their pedigree/performance data for the collective benefit of others
  - Bull breeders receive EPDs that have benefited from collective data collection efforts of others
  - Researchers improve analyses motivated by data

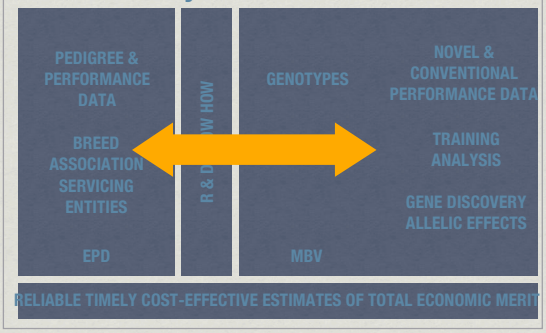
Stakeholders in WGS

- Genotyping Companies (currently Illumina)
- Genomics Companies
  - Bovigen/Catapult/Pfizer
  - Igenity/Merial
  - MMI Genomics/Metamorphix
- Breed Associations
- Researchers/Wannabe Gene Discoverers
- Owners/Controllers of Training Data

Future Business Model

- Who/How are bull breeders rewarded for better EPDs?
  - Need to pay for genotyping/analysis costs
- Who invests in collection/analysis of training data
  - USDA ARS, companies
- Who rewards those who invest in training data?
- Who does the servicing (EPDs, MGVs, merged)

Industry Infrastructure



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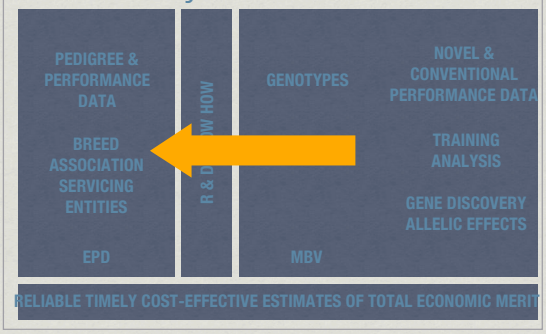

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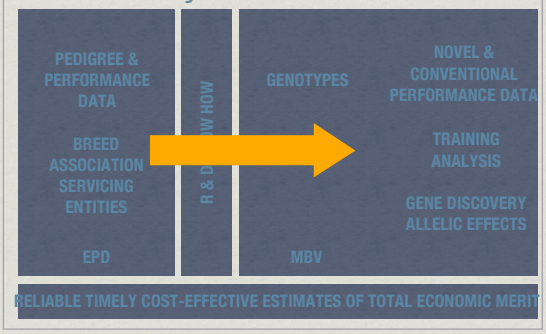

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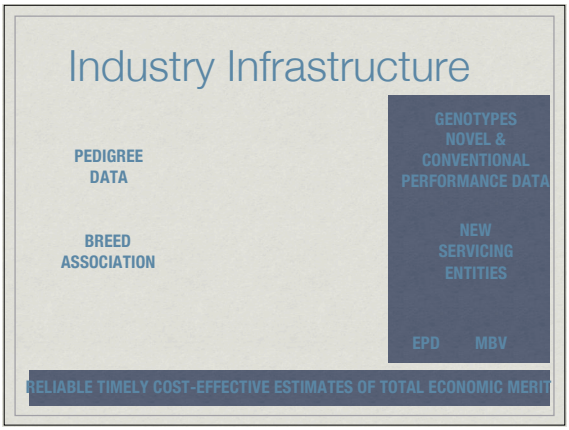

Summary

- Ultimately, the consumer/society will benefit
- In the short to medium-term, some early adopters will benefit, others may lose their shirt
- Late adopters will miss out on benefits
- The ultimate structure will be dictated by the collective action of a number of cultural, technological, economic and political factors operating in a period of many uncertainties