Holstein Effective Population Size Reducing

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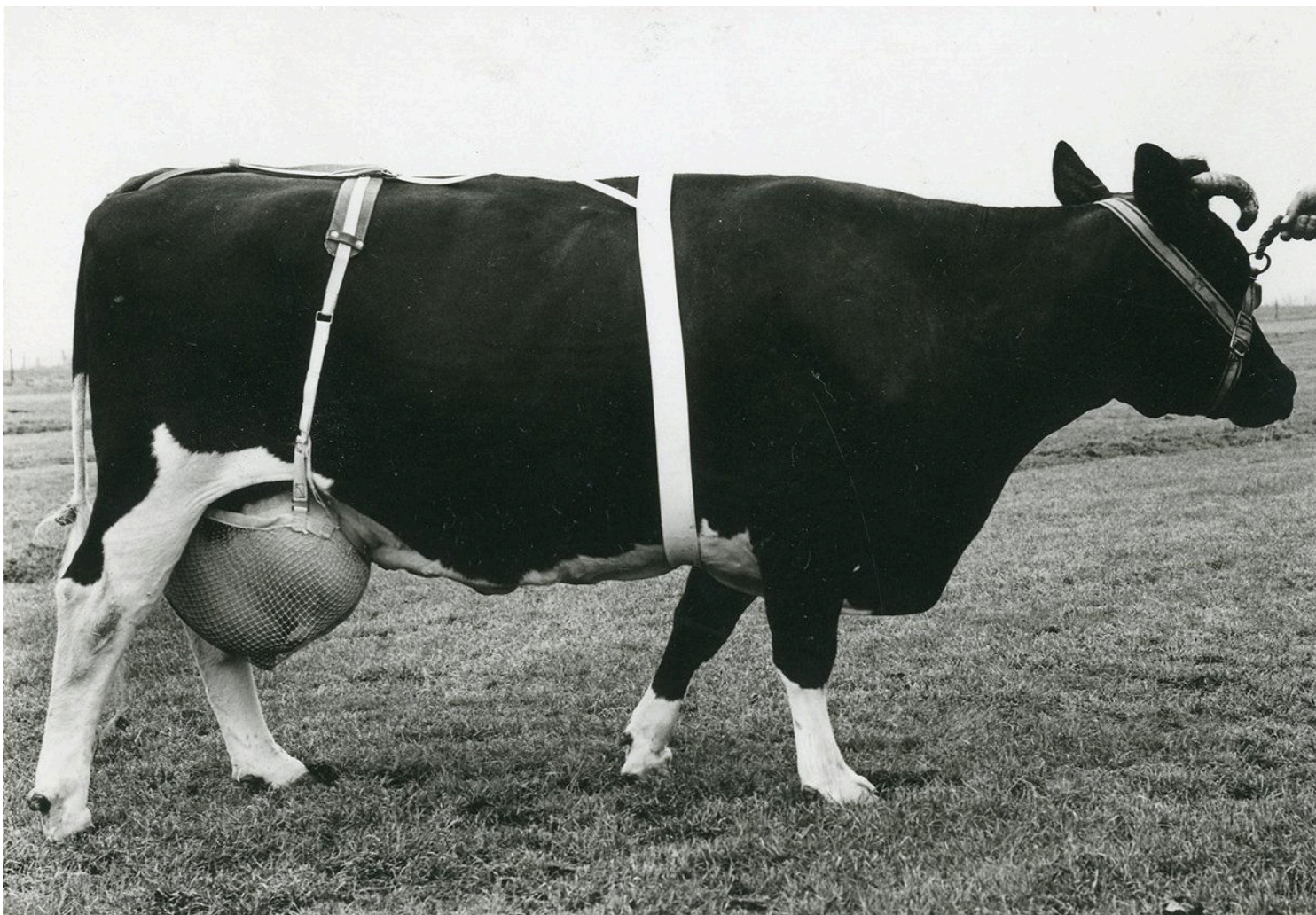
Objective of selection

- We select to <u>eliminate undesirable genetic variants</u>.
- So if we're successful then we get rid of a lot of undesirable genetic variants.

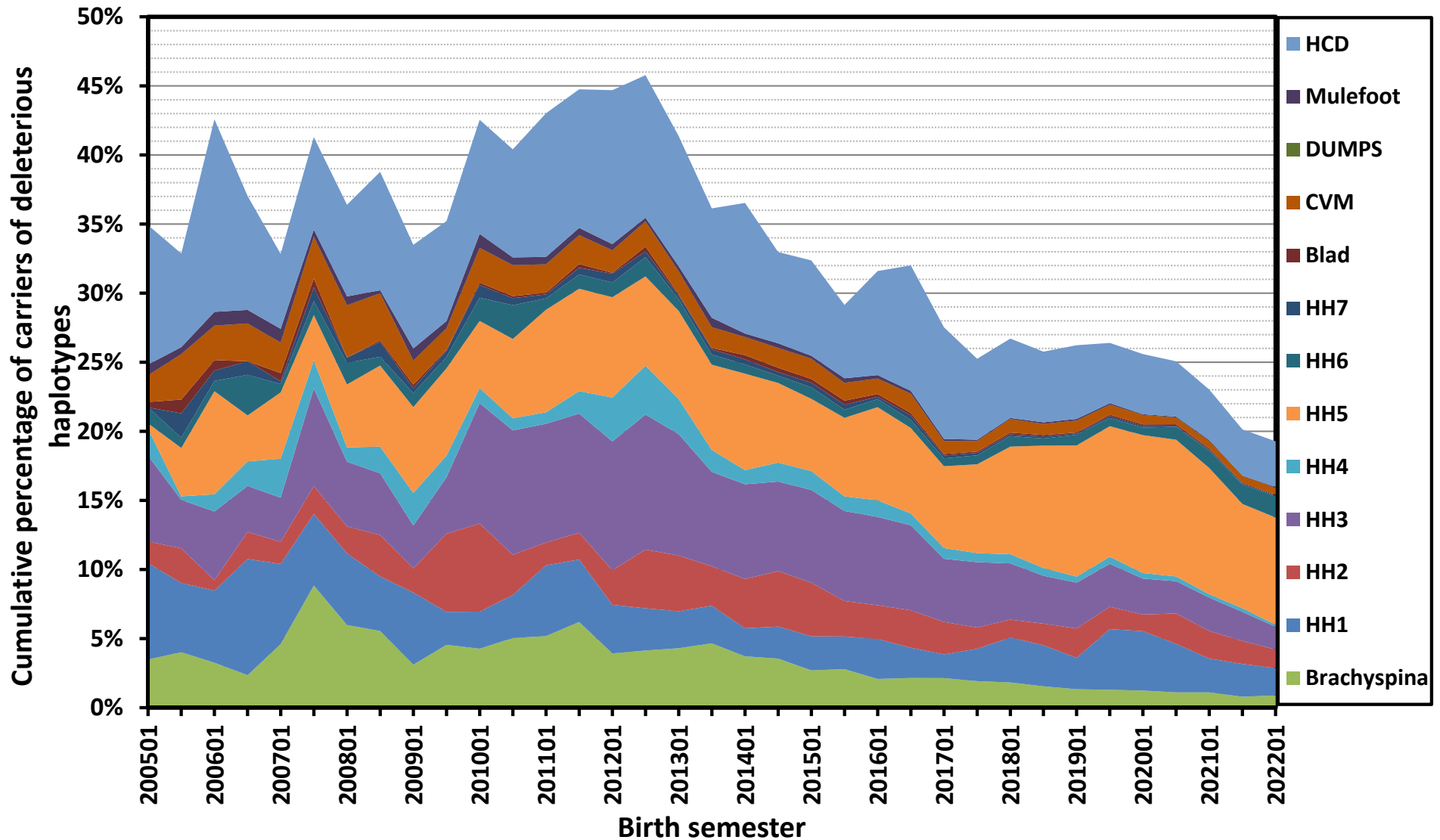- But then we complain that we lose genetic variation….
- BUT that is what we WANTED!!

- Losing 'good' variation would be a problem but:
- Is losing 'bad' variation a problem?

We got rid of undesirable variation…

"Udder net" developed by veterinarian Evert J.S. Bron (1963 NL)

Avoiding problems by decreasing deleterious defects

Loss of genetic variation

- Due to selection and/or drift:

- Any closed population ... **<u>also without selection</u>** would lose genetic variation if ignoring mutation.

- So to avoid loss of genetic variation:
  - Open the population i.e. take genetic variation from outside
  - Design breeding program to use a wide selection of parents
  - Premium for less related animals... or penalty for very related animals
  - Increase mutations?

What if we lose a lot of genetic variation?

- Cows become like bananas?

- Most bananas are actually **clones** of each other (**Cavendish**)

- Last century the much-loved **Gros Michel** banana variety had been wiped out as a result of the fungal disease, and now the replacement Cavendish variety is at risk.

- Too little variation makes our breeds vulnerable.

Avoid inbreeding/loss of genetic variation

- At the **population** level: **Selection** is key
- At the **individual** level: **Mating** is key

- For the population the individual matings are irrelevant.

- Most of the selection is done by AI centers … not by farmers.

- Solution therefore has to come mainly from AI centers.

- How to ensure AI centers maintain diversity?

- Competitive pressure pushes them to use mainly the elite dams/sires. But they MUST use a wide variety of sires and dams of sons.

Avoid negative effects

- Use a breeding goal including **many traits** so aim for **all-round cows**.

- Select against **undesirable** alleles.

- Avoid mating close relatives.

How many and which results from a genomic analysis?

Results	DGV	GEBV	Pedigree
Production	7	7	Sire
Type	20	20	Dam
Efficiency	1	1	Maternal grand dam
Longevity	2	2	Maternal great grand dam
Fertility	6	6	
Calving ease	2	2	
Milkability	1	1	
Heat tolerance	1	1	
Composites	6	6	

Up to 182 results from a DNA analysis

Health and welfare

Results	Factors	Haplotypes	Both
Milkproteins	16	0	0
Hear and skin	7	3	3
Polled	2	1	1
Deleterious defects	44	13	12

Use the whole Holstein population

- Americanism of Italian farmers is a **boomerang**.

Average increase in inbreeding per year

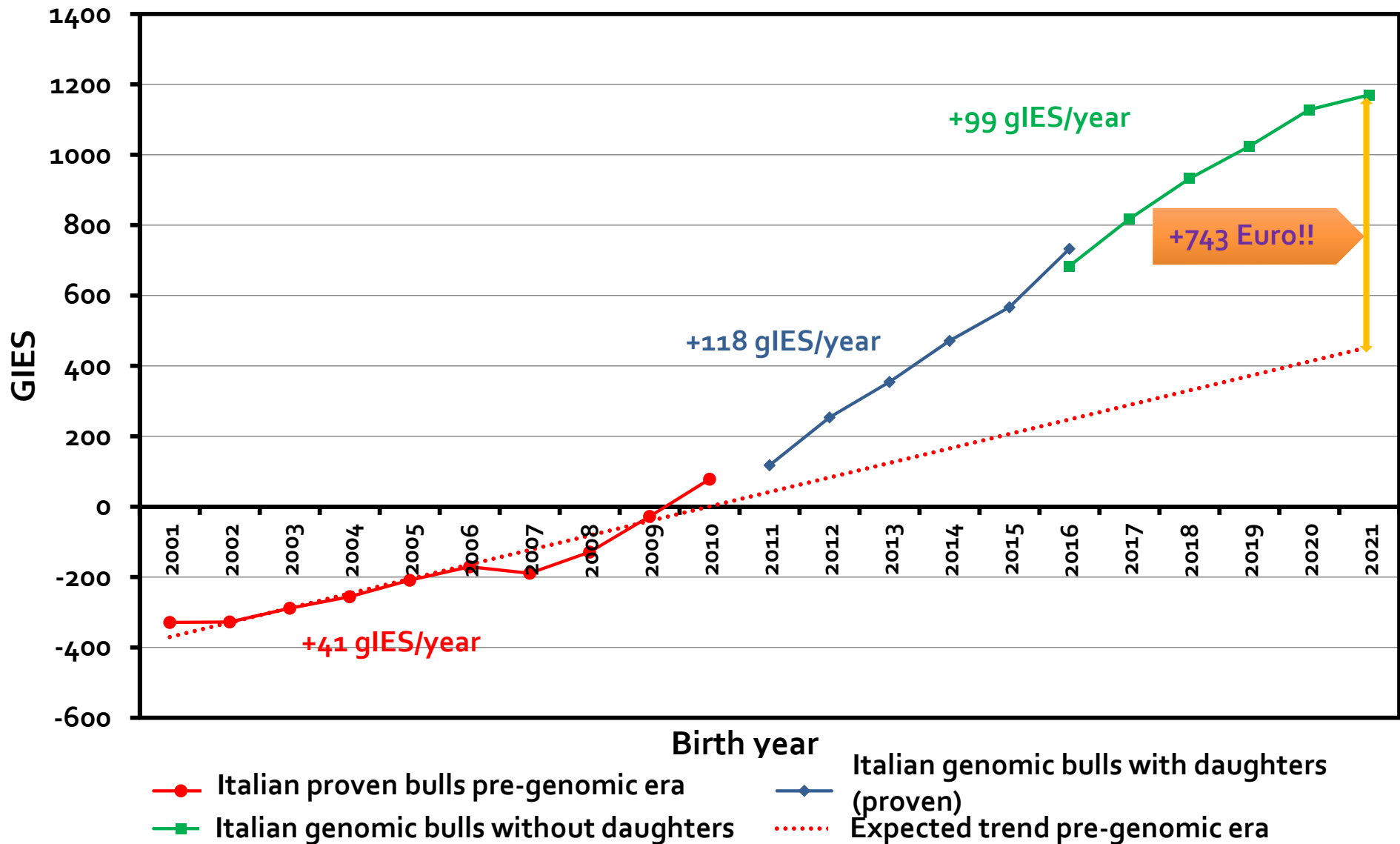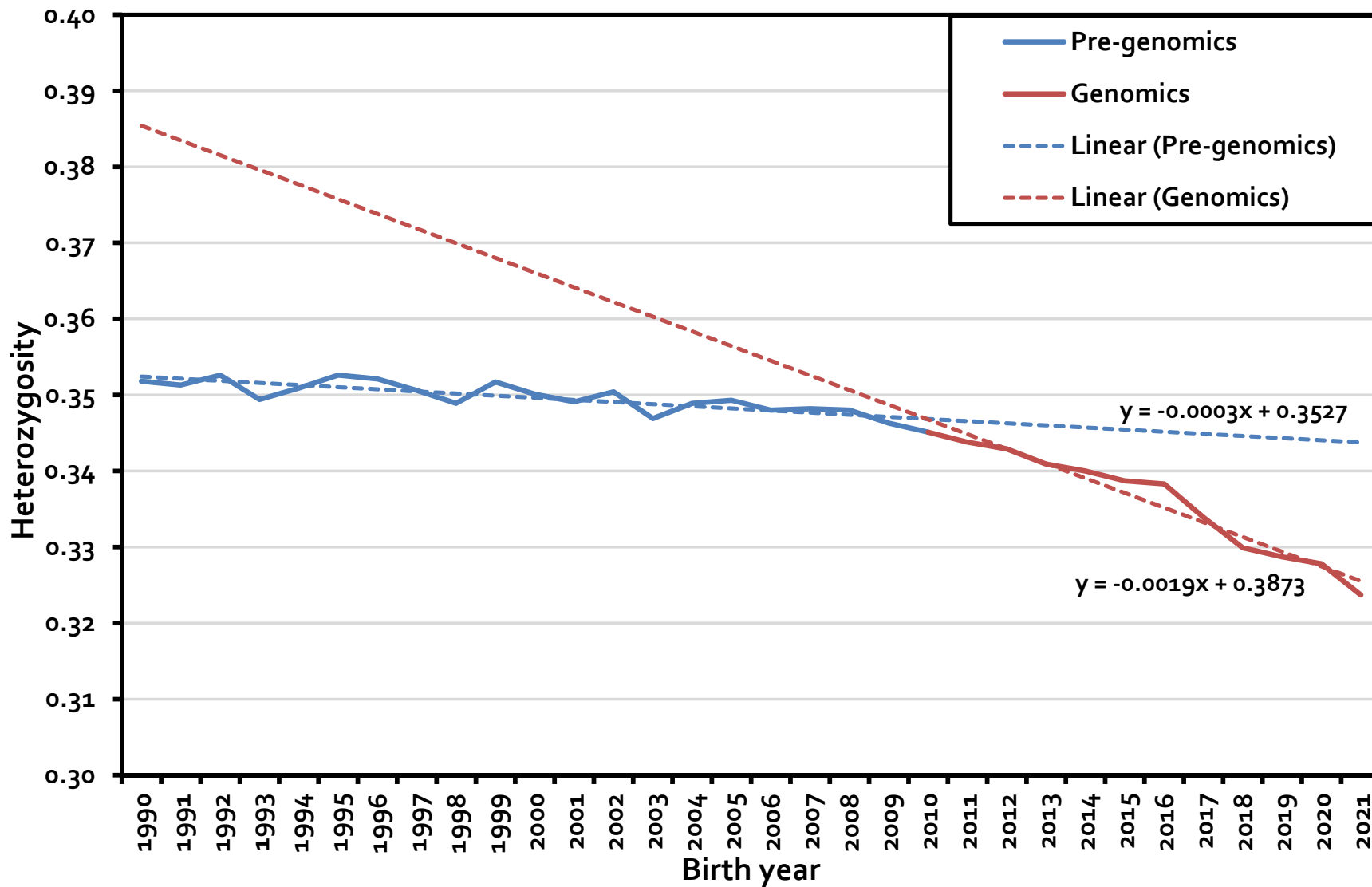| Birth Year	1980 to 1990	1990 to 2000	2000 to 2010	2010 to 2019	
ITA	0,02	0,18	0,14	0,26	difficult
USA	0,19	0,19	0,11	0,26	
CAN	0,10	0,26	0,08	0,23	
FIN	0,06	0,09	0,19	0,20	
POL	0,20	0,10	0,16	0,20	
HUN	0,04	0,15	0,13	0,20	
ESP	0,13	0,24	0,13	0,20	moderate
CHE	0,10	0,13	0,09	0,19	
SLO	0,06	0,12	0,11	0,18	
NLD	0,24	0,17	0,03	0,16	
FRA	0,10	0,20	0,10	0,15	
DEU	0,11	0,16	0,08	0,15	
IRL	0,10	0,21	0,06	0,15	
GBR	-0,02	0,19	0,12	0,14	
AUT	0,00	0,09	0,10	0,14	
JPN	0,09	0,26	0,13	0,13	
SWE	0,06	0,19	0,13	0,12	
LUX	0,13	0,13	0,07	0,12	
NZL	0,02	0,09	0,03	0,11	
DNK	0,11	0,18	0,12	0,10	

Y chromosome

- **>99%** of the Y chromosomes: **Chief** & **Elevation**

- **~1%** of the Y chromosomes: **Ivanhoe**

- All Holsteins come from the same **3** sires!

From Two Bulls, 9 Million Dairy Cows

In the U.S., just two Y chromosomes exist within a population of 9 million Holsteins. Researchers want to know what traits have been lost over time.
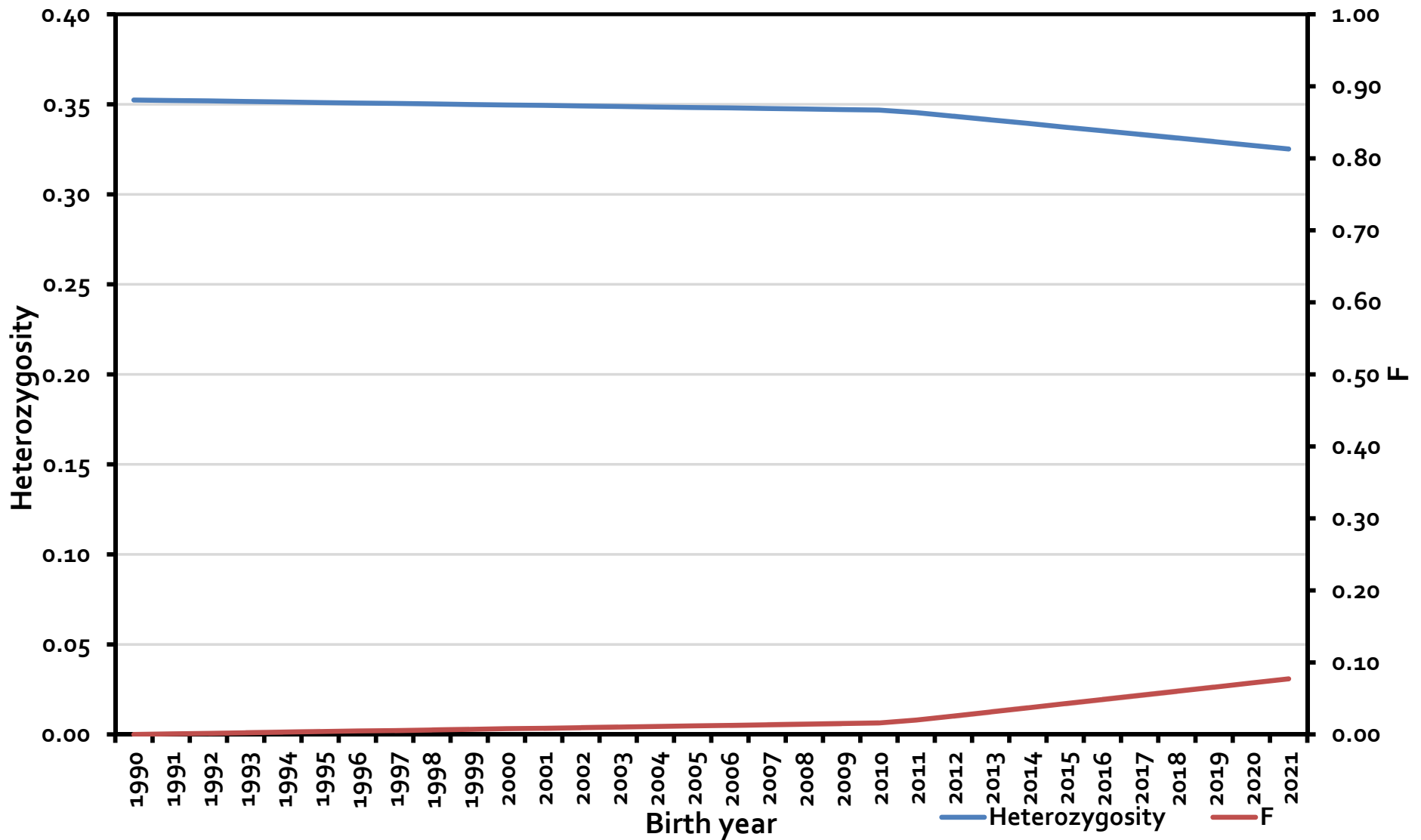
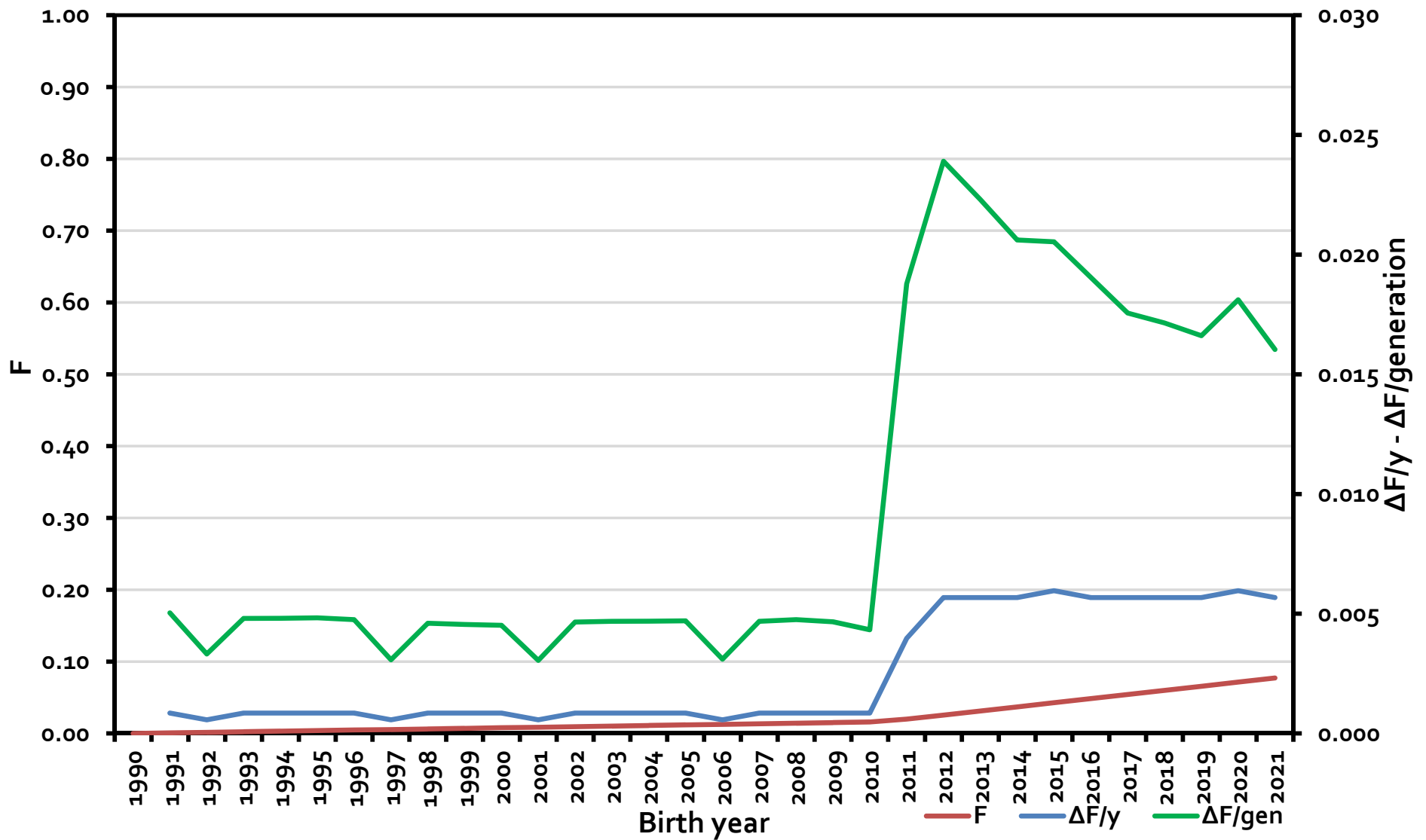# Boost of genetic trend due to genomics

Trend of SNP heterozygosity

How much time is left?

- If the SNP heterozygosity is 0.325 and the (linear) annual decline is 0.0019, then after 0.325 / 0.0019 = **170** years we are at a heterozygosity of **0.00**.

- North America + Italy: Mostly select North-American

- Europe: Select North-American + European

- Higher inbreeding tendency in countries that primarily limit selection to North America.

- More moderate trend in countries using North America and Europe.

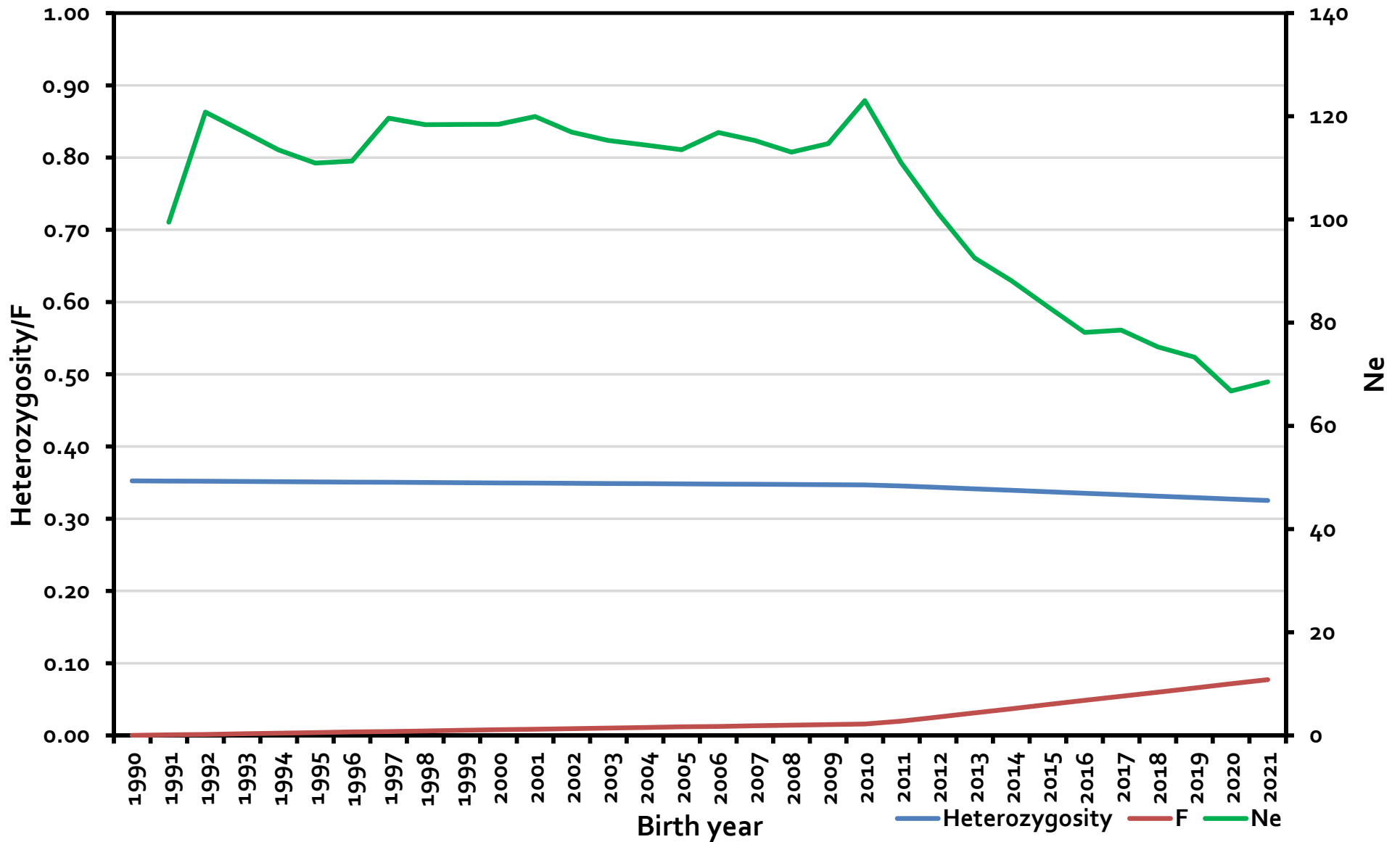- Convince breeders / AI centers to look beyond North America. We need the whole breed.
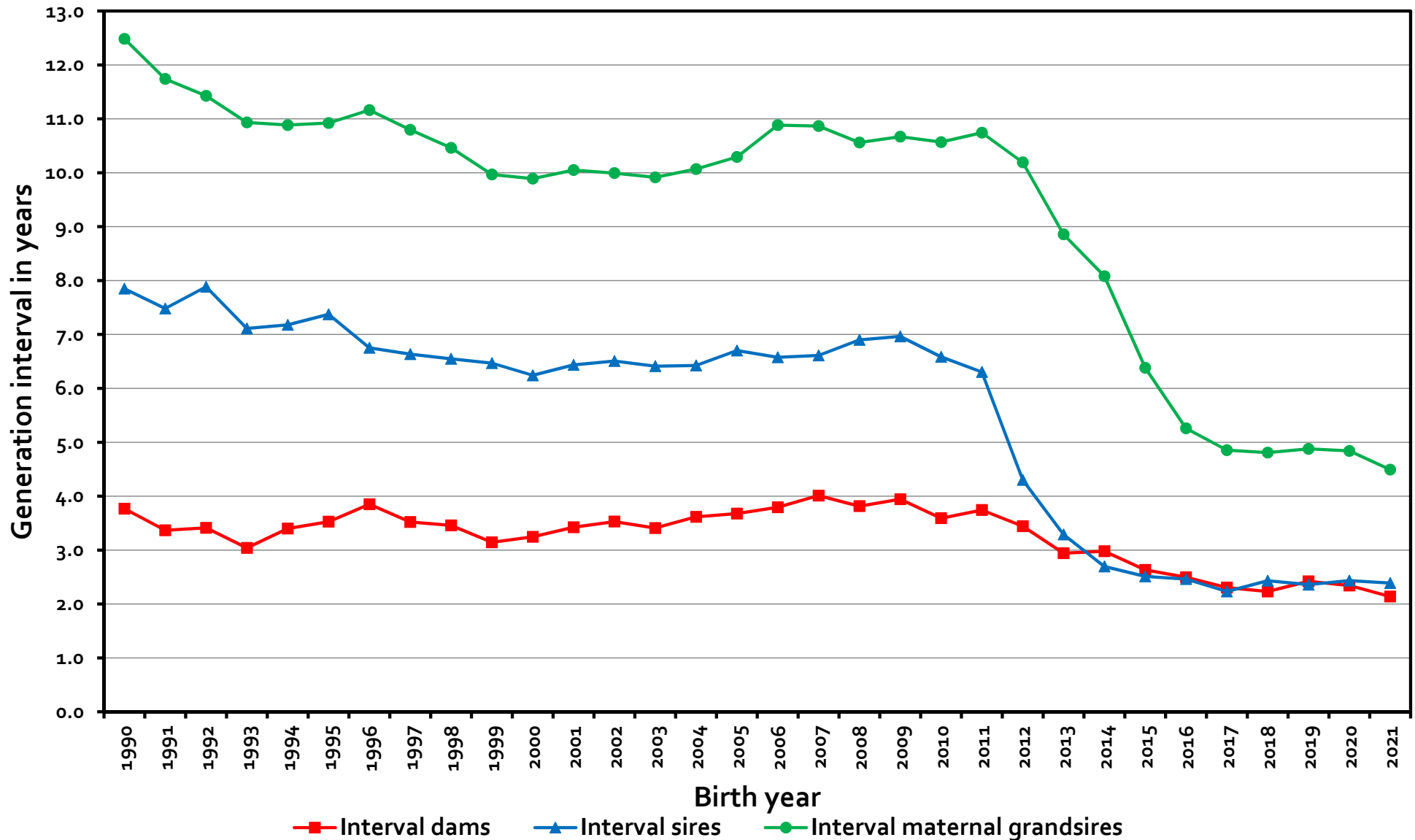
Heterozygosity and Inbreeding coefficient

Inbreeding coefficients

Effective population size: Decreasing since genomics

Generation interval Italian bulls: Drop due to genomics

Will we end up with crossbreeding or not?

- Some livestock species use crossbreeding:
  - Mainly meat animals… the crossbred animals are the final product.
  - In dairy cattle… cows are also dams of future generations.
  - Genomic selection full speed in Holsteins, less in smaller breeds, little in crossbreds.

- Are there suitable breeds to cross with Holstein?
  - Apart from Holstein, probably the 2 main dairy breeds worldwide would be Jersey and Simmental.
  - Other breeds seem small, mostly local and losing the competition.
  - Jersey is different size, this would give to much variation in offspring.
  - Does that mean only Simmental could be a suitable breed to cross with?
  - Genomic selection goes full speed in Holstein… can other breeds follow? Or will they be left behind?

- Maybe Holstein won the battle of the dairy breeds…
  - In other words… all the others lost.

Take home message

- At the **population** level: **Selection** is key.
- At the **individual** level: **Mating** is key, at population level individual matings are irrelevant.
- Most of the selection is done by AI centers… not by farmers.
- AI centers MUST use a wide variety of sires and dams of sons.
- We need to use the whole Holstein population, rather than just a piece.
- Breeding programs need to be 're'-designed to avoid genetic bottleneck.
- Select against undesirable alleles.
- Maybe Holstein won the battle of the dairy breeds. In other words… all other breeds lost.
- Will inbreeding win the battle with the Holstein?

Future Italian dairy cow?

Thank you for your attention!