IRISH CATTLE BREEDING FEDERATION

Multi-breed Genomic Evaluations for 1 million Beef Cattle in Ireland.

A.R. Cromie, R.D. Evans, J F Kearney, M. McClure, J. McCarthy and D.P. Berry

Department of Agriculture, Food and the Marine
An Roinn Talmhaíochta, Bia agus Mara

Overview of Talk.

1. Setting the scene.
2. The Irish Cattle Breeding Industry.
3. The Breeding Goal in Beef.
4. The Irish Beef Genomics Scheme.
   - Overview of the scheme.
   - Technical challenges encountered.
5. Conclusions.

1. What's important for Ireland?

- Ag Food Industry.
  - 9% of GDP. 80% milk & meat are exported.
  - ~5%/annum growth in output.
- Rural Ireland.
  - 1.3m dairy & 1m beef cows. 15k dairy & 50k beef farms.
- "Smart & Green"
  - Using best science to support indigenous industries.
- Environment & Climate.

National News Headlines 20 July 2016

https://www.rte.ie/news/2016/0720/803561-en

Ireland must cut carbon em...

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Ireland must cut carbon emissions by 20% by 2030

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LATER News at One

Agriculture is responsible for 47%, with suckler cows being worst "offenders"!

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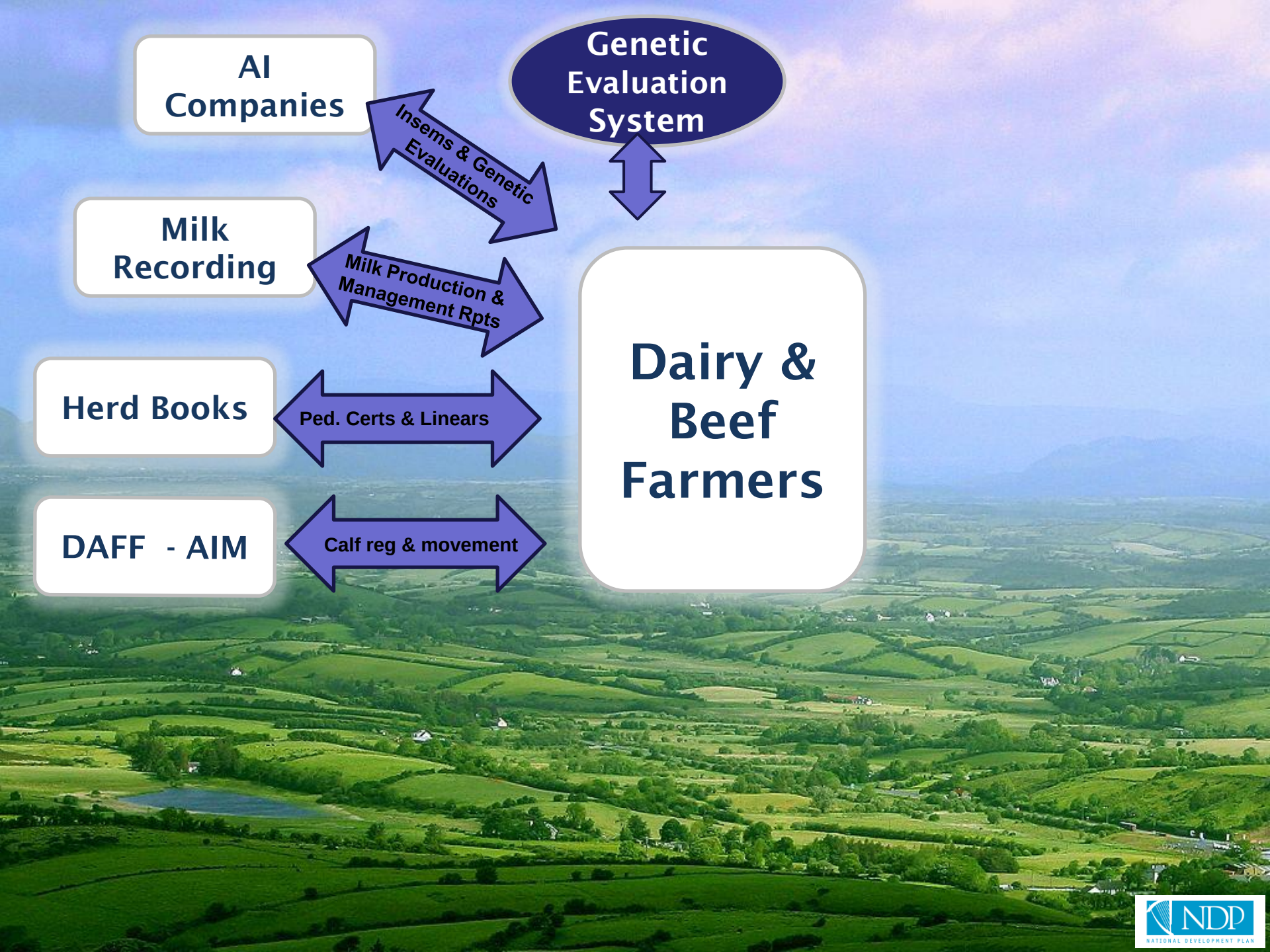
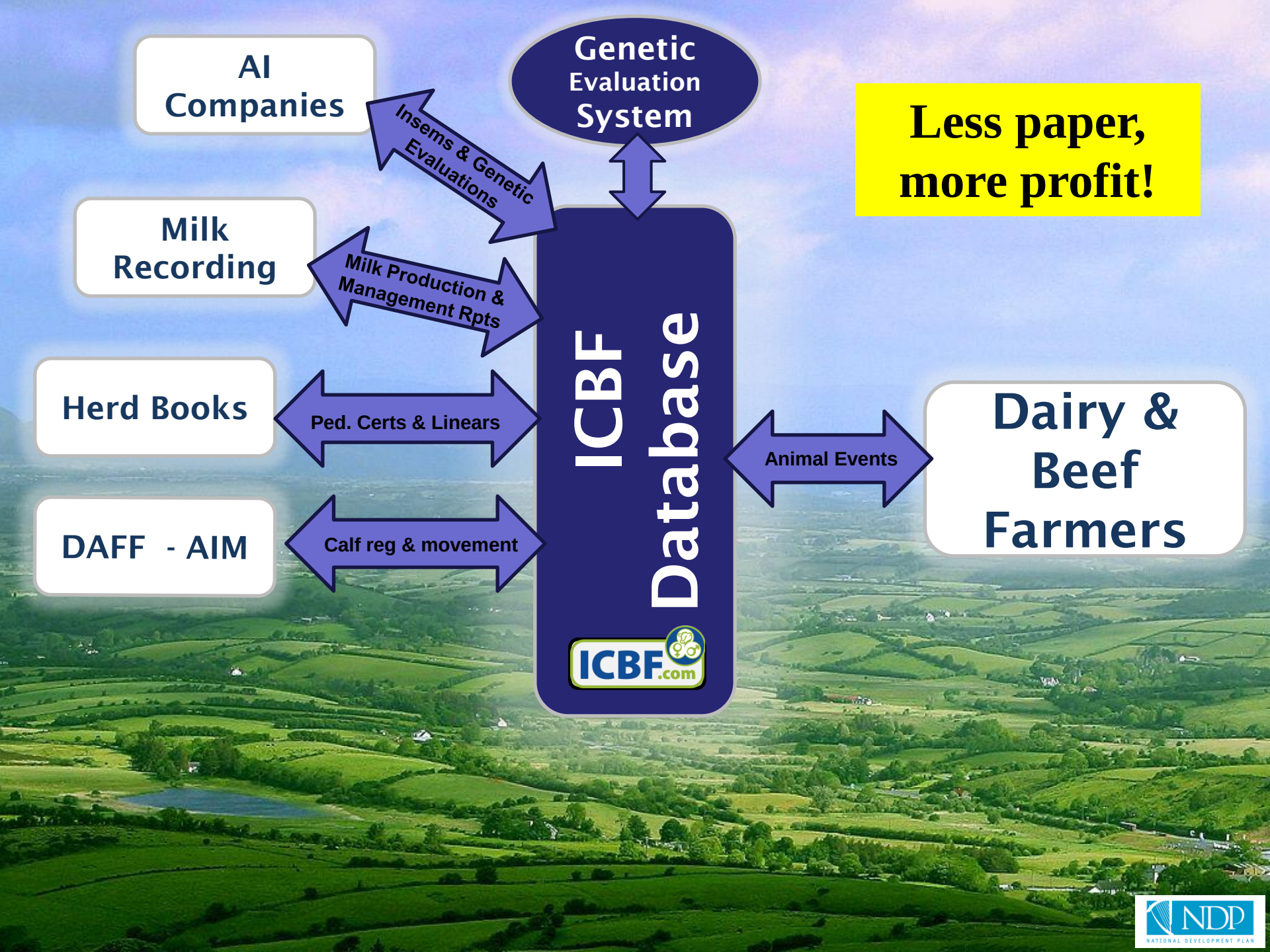
ICBF.com

2. Irish Cattle Breeding.

- Co-ordinated by ICBF.
  - ICBF => a co-operative of 30 cattle breeding organisations (AI, HB + MRO's) + 2 Farm Organisations.
  - Established the central database in 2002. Now the key cornerstone for Irish AgFood industry.
  - Turnover ~€8m. Funded by industry & government (DAFM).
- Focused on "profit from science".
  - Key relationship with Teagasc (govt research & extension)
  - Genetics/genomics cornerstone of industry strategy.
- World-leading (research => implementation).
  - 2nd in world to launch dairy genomics, after US.
  - Beef Genomics => largest livestock genomics project globally.


AI Companies
Genetic Evaluation System
Insems & Genetic Evaluations
Milk Recording
Milk Production & Management Rpts
Herd Books
Ped. Certs & Linears
DAFF - AIM
Calf reg & movement
Dairy & Beef Farmers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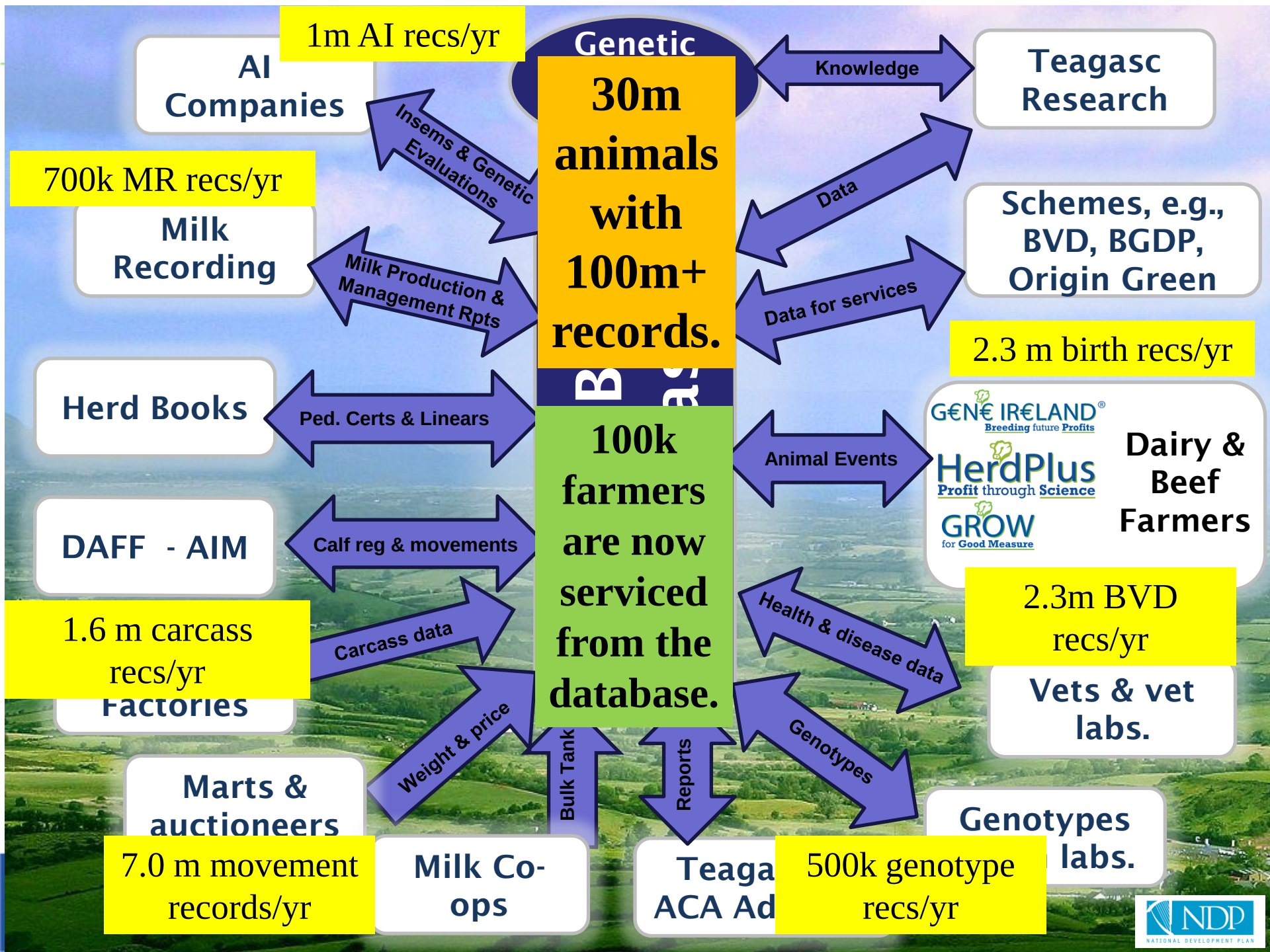
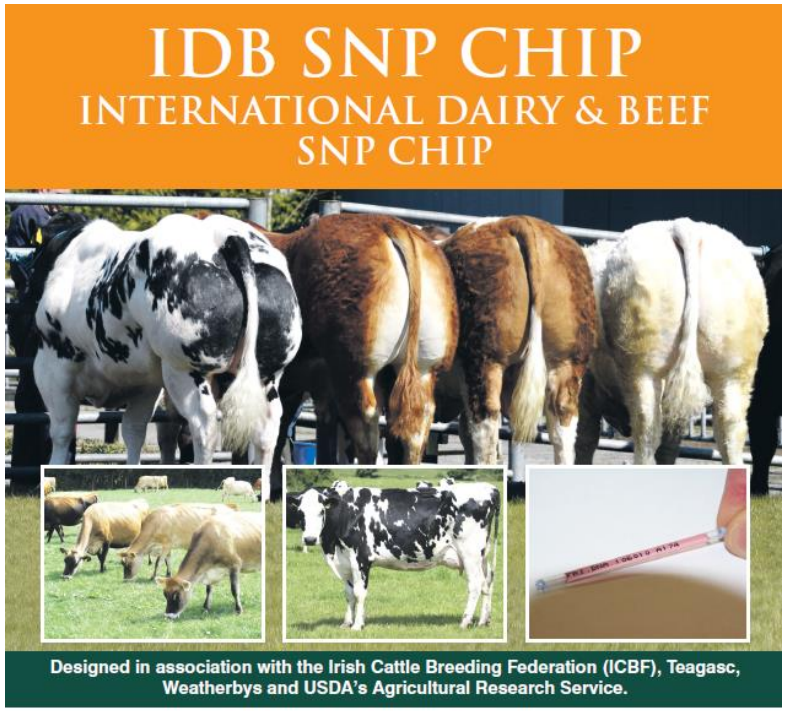
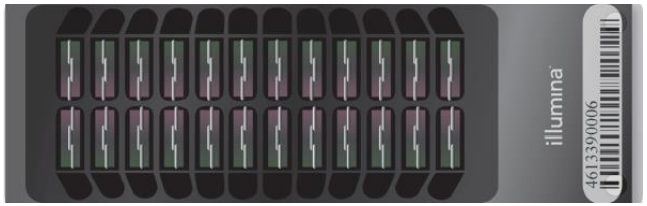
Calf reg & movement
ICBF Database
ICBF.com
Animal Events
Dairy & Beef Farmers
Less paper, more profit!
NDP
NATIONAL DEVELOPMENT PLAN


1m AI recs/yr
AI Companies
Genetic
Knowledge
Teagasc Research
Insems & Genetic Evaluations
30m animals with 100m+ records.
700k MR recs/yr
Milk Recording
Milk Production & Management Rpts
Data
Schemes, e.g., BVD, BGDP, Origin Green
Data for services
2.3 m birth recs/yr
Herd Books
Ped. Certs & Linears
100k farmers are now serviced from the database.
Animal Events
GENE IRELAND Breeding future Profits
HerdPlus Profit through Science
GROW for Good Measure
Dairy & Beef Farmers
DAFF - AIM
Calf reg & movements
2.3m BVD recs/yr
1.6 m carcass recs/yr
Carcass data
Health & disease data
Factories
Vets & vet labs.
Weight & price
Bulk Tank
Reports
Genotypes
Marts & auctioneers
Genotypes labs.
7.0 m movement records/yr
Milk Co-ops
Teaga
ACA Ad
500k genotype recs/yr
NDP
NATIONAL DEVELOPMENT PLAN

IDB Chip – The database in 54k SNP's!





- The International Dairy & Beef Chip.
- Developed in Ireland, with Illumina. Currently on v3.
- 54k SNP's.
  - 40k core, 6k for better imputation, 7k for "regions of interest" & 1k for major genes/defects.
- 160 Major genes/defect.
  - Database will drive this.
- V4+ - use of sequence data.

3. The Breeding Goal in Beef.

- The ideal suckler cow must;
  - Calve herself.
  - Calve each year.
  - Have enough milk to rear her calve.
  - Be not too big.
  - Have a good quality calf at foot.
  - In summary, a “balanced” cow.
- She needs to produce more output from less input => more profitable, more sustainable, more carbon efficient.

A balanced cow!

An Irish 5-Star cow.

One of David's best cows. This nine-year-old SI X cow has a Replacement Index of €169 (5 star, top 1%). She calved for the first time at 24 months, has had eight calves with an average calving interval of 364 days and she weaned the heaviest calf of David's 2015 calf crop. She is sired by the old Simmental AI bull Hurtig (HRG).

€uro-Star Replacement Index.

Trait	Goal	Relative wt
Calvi		16%
Feed		%
Carca		%
Mater		%
Femal	More	29%
Docility	More	4%

Emphasis:

Cow traits 71%

Calf traits 29%

Does it work? Cow Analysis.

- 162,363 females that were born in 2011 and subsequently entered the suckler herd as female replacements.
  - Across a range of breeds.
- Compared performance of 5 star females (top 20% rank on replacement index), relative to 1 star females (bottom 20% rank on replacement index).
- Are the 5 star females better for the key profit traits?

5 Star Cows Leaving More Profit....

All Suckler Cows

Cow Details				Milk Performance		Fertility Performance			Progeny Carcass Performance		
Star Rating	No. of Cows	Replacement Index	% Still Alive	Calf Weaning Weight (kg)	Cow Milk Score (1-5)	Age 1st Calving (months)	Calving Interval (days)	No. of Calvings	Carcass Weight (kg)	Carcass Value	Age at Slaughter (days)
★★★★★	33,493	€108	83%	336	4.08	30.2	403	2.69	358	€1,474	697
★★★★	24,317	€76	80%	324	3.87	30.9	407	2.56	356	€1,469	712
★★★	21,644	€60	79%	319	3.74	31.3	411	2.47	356	€1,470	715
★★	20,908	€43	76%	315	3.61	31.5	416	2.40	357	€1,475	721
★	23,911	€12	72%	309	3.36	32.1	423	2.25	357	€1,477	726
Difference 5 Star V's 1 Star		**+€96**	**11%**	**27kg**	**0.72**	**-1.9 months**	**-20 days**	**0.44 calves**	**0kg**	**€-2**	**-29 days**

Performance of all suckler females, born in 2011, when ranked on new generation test proofs

Does it work? Herd Analysis.

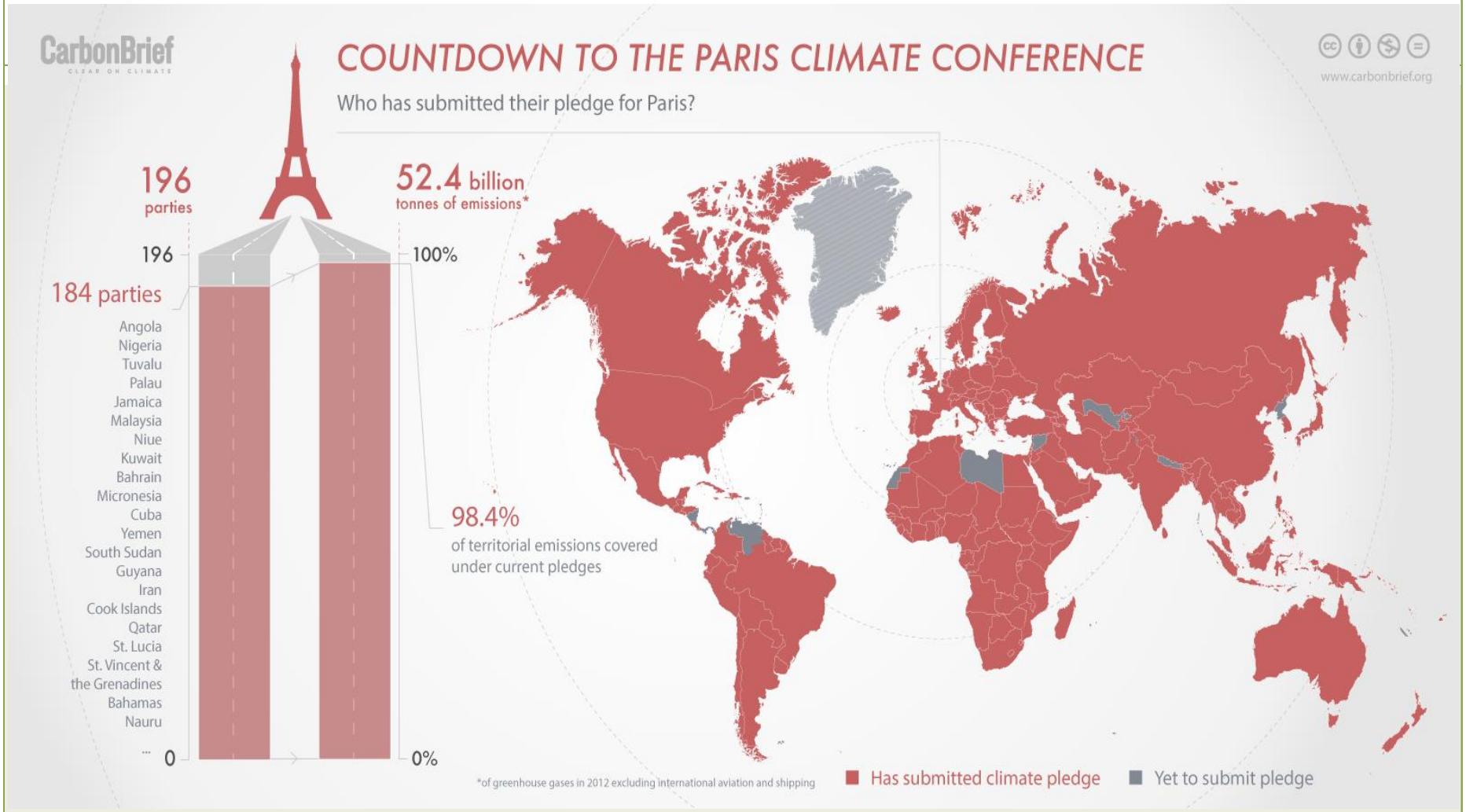
- ICBF Replacement Index.
  - Average replacement index for herd.
- Bord Bia Carbon Navigator.
  - Data collected on a number of herd metrics including; (i) numbers animals by age, (ii) length grazing season, (iii) manure management etc….=> Herd Assessment of CO_2 emissions produced per Kg beef
- Are herds of higher genetic merit for Replacement Index more carbon efficient?
  - Analysis based on 1550 herds with data.

High Genetic Merit Herds are More Carbon Efficient.

Table 1. Relationship between Herd Replacement Index & Carbon Emissions per kg Beef.

	Herd Replacement Index		Carbon Emmisions per kg Beef	
Herd Rank	Herd Ave	Change in profit/cow/year	Herd Average	% Diff
Top 10%	€109.4		12.44	
2	€94.6	-€29.6	12.68	1.9%
3	€88.3	-€42.2	12.62	1.4%
4	€83.7	-€51.3	13.09	5.2%
Mid 50%	€79.3	-€60.3	12.87	3.4%
6	€75.1	-€68.6	13.05	4.9%
7	€71.0	-€76.9	13.20	6.1%
8	€65.8	-€87.2	13.28	6.7%
9	€58.6	-€101.5	13.49	6.8%
Btm 10%	€43.1	-€132.5	13.54	8.8%

We have all made climate change pledges.



John Muldowney, DAFM, 2016

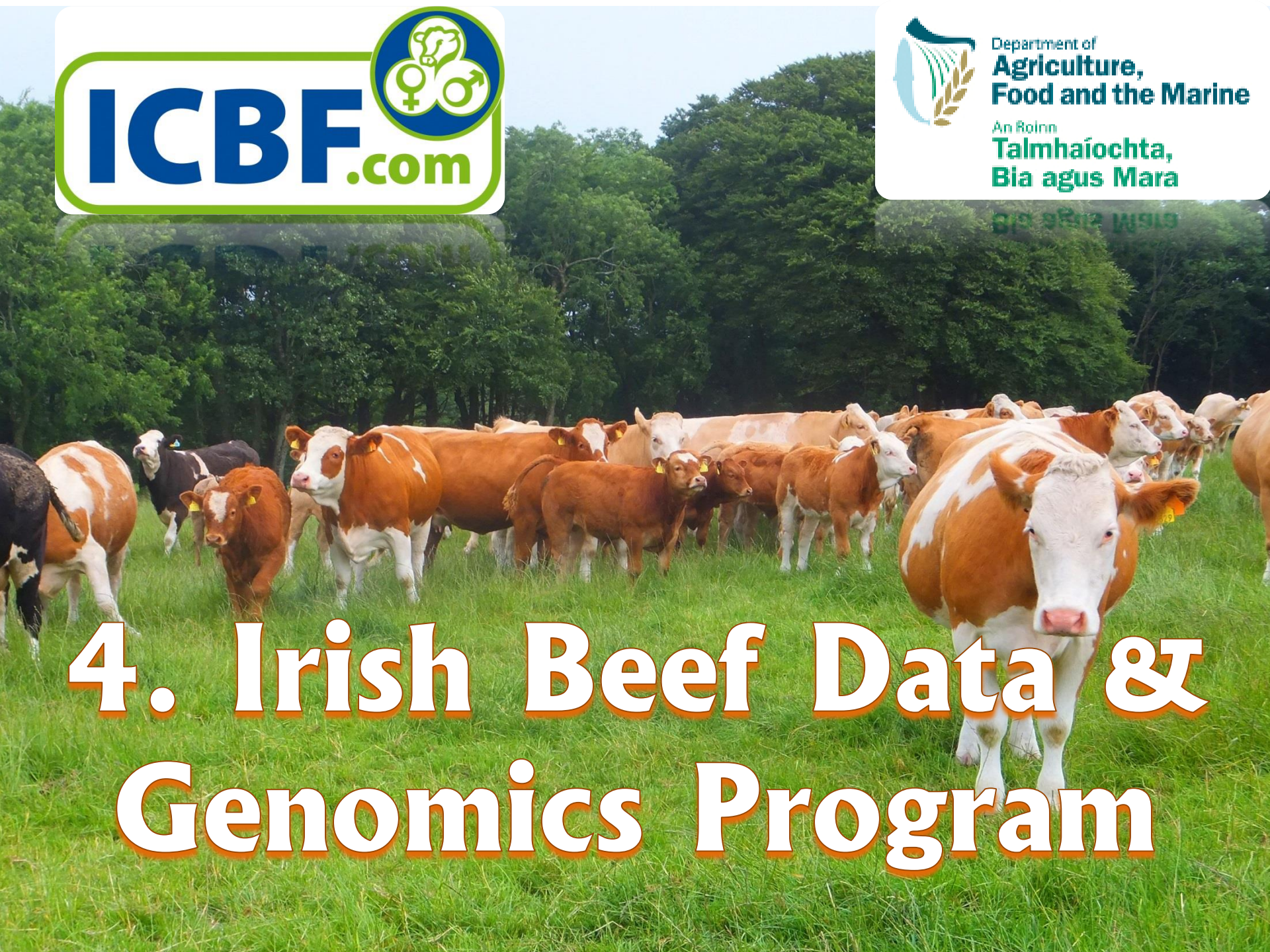
The EU is strongly committed.

EU council conclusions (Climate Change Report, Oct 2014), Paragraph 2.14

- .....to ensure coherence between the EU's food security and climate change objectives.
- .....to examine the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation.....

As a net food exporter, IRE must do more!

John Muldowney, DAFM, 2016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4. Irish Beef Data &
Genomics Program

Beef Data & Genomics Program (BDGP) launched May 2015

https://www.agriland.ie/farming-news/over

Over 1,000 farmers a day a...

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Over 1,000 farmers a day applying for new beef genomics scheme

Ciaran Moran 2:52 pm - May 18, 2015

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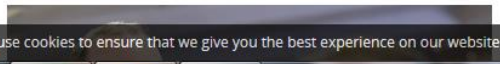
Over 5,000 farmers have now applied to join the Beef Data and Genomics Programme and applications are coming into the Department at a rate of more than 1,000 per day, according to the Minister for Agriculture, Simon Coveney.

The scheme is a key measure under Irelands Rural Development Plan and will see investment of some €300m into suckler farming over the next six years.

Commenting on the applications to date the Minister said it shows that beef farmers have decided that engagement with the scheme represents good business planning.

He said the scheme remains on target for the envisaged participation rate of 35,000 farmers in total for which funding of €52m per year has been provided in Department's Rural Development Programme.



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How the EU Voluntary Milk Reduction scheme will work

Total of 24k farmers, with ~550k cows signed up to scheme.

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The Irish BDGP Scheme.

- Focused on breeding more profitable , sustainable and carbon efficient cows.
- Funded from EU Rural Development Program.
  - Co-funded by Irish government (DAFM).
- €300m total funding 6 years (2015-2020)
  - Farmers paid ~€90/cow/year to complete key actions re: the scheme.
  - ~€40m allocated towards cost genotyping. ~500k animals genotyped to-date.
  - ~2.5m animals in total will be genotyped during period of scheme. ~30k/wk at max. Now!

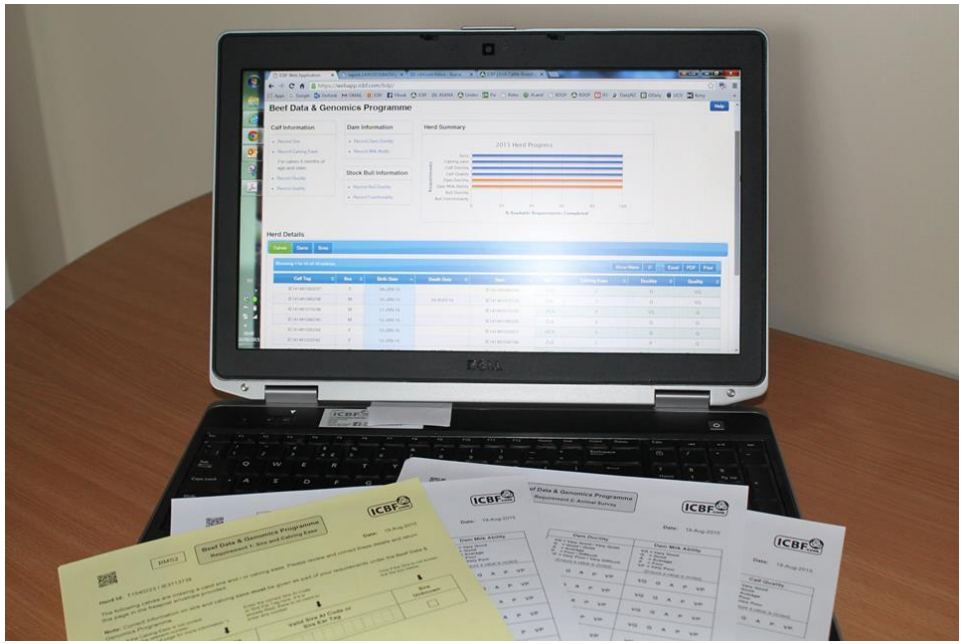
Key Project partners.

- **DAFM/EU**; Scheme "owners" and responsible for scheme delivery.
- **ICBF**; Data collection, genotyping, delivery of genetic/genomic evaluations & reports.
  - Role of Scientific Advisory Committee (Amer, Garrick, Mantysaari, Meuwissen & Veerkamp).
- **Teagasc**; Research, extension & training.
- **Illumina**; Delivery of IDB 54k cust chip.
- **Weatherby's/Eurofins**; Lab services.
- **Bord Bia;** Carbon Navigator.

Key Actions; Tagging

- Started with tagging cows (for reference population), now moving more toward female calves => potential female replacements.
- Pedigree males also prioritised.

Key Actions; Data Recording



- Farmers receive forms regularly re: data recording (including any animals that are missing data).
- Paper based and electronic recording.

Key Actions; Data recording

Beef Data & Genomics Programme

Calf Information

- Record Sire
- Record Calving Ease
- Record Birth Size
- Record Vigour

For calves 5 months of age and older:

- Record Docility
- Record Quality
- Record Scour
- Record Pneumonia

Dam Information

- Record Dam Docility
- Record Milk Ability
- Record Culling Reasons

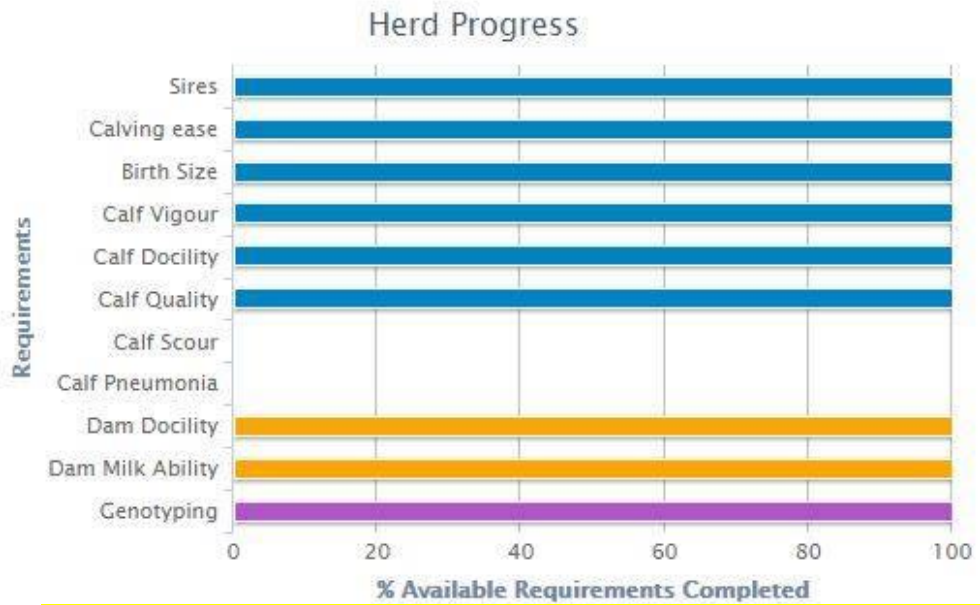
Stock Bull Information

- Record Bull Docility
- Record Functionality
- Record Culling Reasons

Genotype Information

- View Genotype Details

Herd Summary



Very good h2 estimates for farmer recorded traits, e.g., 0.25 for cow milk score with an rg of 0.8 with maternal weaning weight

Key Actions; % 4 & 5 star females.

Commercial Females

Report Date: 18-May-16 (May 2016 Evaluation)
Herd: T1560143 / IE3113852
Herd Owner: THOMAS MCGOWAN JNR

All commercial females are listed here, by order of Replacement Index.
A commercial female is a female not recorded as purebred in the ICBF database.

Jumbo	Tag	Date of Birth	Calvings	Breed (Blue Card)	Dam	Sire	Replacement Index		Genomic Eval.
							Index	Euro-Stars Across Breed	
2496	IE311338662496	21-May-15		HEX	IE311338632007	IE251141240404	€115	★ ★ ★ ★ ★	Yes
106	IE311385230106	11-Feb-09	5	BBX	IE311385280060	TZA	€65	★ ★ ★	Yes
183	IE311385270183	04-Apr-15		LMX	IE311385230147	EBY	€63	★ ★ ★	
184	IE311385280184	04-Apr-15		LMX	IE311385210145	EBY	€50	★ ★	
200	IE311385270200	17-Feb-16		LMX	IE231226920126	ZGM	€34	★ ★	

Farmers must have a minimum of 20% of breeding females as 4 or 5 stars by 2018 and 50% by 2020.
At least one breeding male must be 4 or 5 star by 2019.

Key Actions; Training.

BDGP
Beef Data & Genomics Programme

ADVERTISER'S ANNOUNCEMENT

For all your BDGP queries, contact the Irish Cattle Breeding Federation on 1850 625 626, email query@icbf.com or log on to www.icbf.com

5 Star Cows deliver on BETTER Farms

This is the clear outcome from analysis of the recently concluded Phase 2 of the Teagasc, Irish Farmers Journal BETTER Farm Beef Programme (2012-2015). Over 3,000 cows calved down in the 30 herds producing over 8,500 progeny over the course of the four year programme.

As part of the analysis the cows were divided up by their Replacement Index star rating (across breed) and compared on:

- Age 1st Calving
- Calving Interval
- Average Daily Gain of progeny (ADG).

As Table 1 outlines, the 5 star Replacement Index cows outperformed their herd mates across all of the key maternal traits.

Age 1st Calving
Less than 20% of suckler females calve for the first time between 22-26 months. An industry target is to get more herds to lower the age of 1st calving of heifers as close to 24 months as possible due to the increased output and subsequent economic benefits. In the programme herds, the 5 star females had an average age of 1st calving of 865 days (28.5 months). The 1 star females were 58 days older at 923 days (30.5 months).

Average Calving Interval
The calving interval of the national suckler herd stands at 407 days. The average Irish suckler cow is, therefore, losing 42 days (6 weeks) per year. This results in huge economic losses on suckler farms as well as increased labour through spread out calving patterns and longer breeding seasons. There was a difference of 11 days in the average calving interval between the 5 star and 1 star cows. The 5 star cows had an average calving interval of 378 days while the 1 star cows were at 389 days.

ADG of Progeny
The milk performance of suckler cows is measured through the weight gain expressed by their calves. While only a small percentage of suckler calves are weight recorded nationally each year, weighing was carried out routinely in the programme herds which ensured that there was sufficient weight data for analysis.

Progeny of 5 star cows had an ADG of 1.24 kg, while the progeny of 1 star cows had an ADG of 1.03 kg, a difference of 0.21 kg. Assuming a weaning age of 250 days this equates to an extra 52.5 kg at weaning. Depending on weanling price this would result in a €100-150 increase in the value of a weanling. When the sires of the progeny were analysed there was no significant difference found between the Terminal Indexes and carcass traits of the bulls mated to cows across all of the star ratings i.e. no group of cows had an unfair advantage by being mated to bulls with superior growth traits.

Genetic Influence
Of course, management practices on farms can have a huge impact on cow fertility performance and to a lesser extent on cow milk performance. That said, when differences as significant as those outlined in table 1 are found in a relatively large population of animals across many herds and many different management systems, then it is fair to say that genetics is undoubtedly a factor.

The high Replacement Index 5 star cows expressed the best performance across all of the key maternal traits outlined. The Beef Data & Genomics Programme is providing farmers with a financial incentive to introduce more of these high Replacement Index females into their herds in order to help them to improve efficiency and in turn increase output and profitability.

Photo : Keith Heneghan / Phocus.

Beef farmer Annie Kilgallon's herd on her farm in Ballina, Co. Mayo.

Table 1: Performance of cows by €uro-Star rating on key maternal traits

Star Rating	Cows	Avg. Rep Index (€)	Age 1st Calving (Days)	Avg. Calving Int. (Days)	ADG of Progeny (kg)
5 Star	1293	133	865	378	1.24
4 Star	575	86	903	382	1.16
3 Star	441	64	893	387	1.13
2 Star	401	44	912	386	1.1
1 Star	458	7	923	389	1.03
Difference 1-5 Star		+€126	-58 Days	-11 Days	+0.21 kg

DATES FOR THE DIARY

➲ 25th May 2016 - Newford Suckler Demonstration Herd National Open Day, Athenry, Co Galway, 2pm-7pm. For more info go to www.newfordsucklerbeef.ie.

FARMER FOCUS: PALLASKENRY AGRICULTURAL COLLEGE

Stars aplenty in North Mayo

Name: Annie Kilgallon, Mullauns, Ballina, Co. Mayo
Farming system: Suckler to weanling
Four- and five-star females: Cows: 13 Heifers: 24
Stock bull or AI: 100% AI.
Replacement strategy: Breed all my own.

Tell me about your farming system?
I run a twenty five cow spring calving herd calving from February to mid-April. Male progeny are sold as weanlings at the local mart in Ballina in late October. The herd is closed and has a high health status and we use 100% AI. Some of the weanlings heifers are sold with the remainder kept for breeding. Some of the heifers were sold at the Special Breeding Sale organised by ICBF, Teagasc and Mayo Sligo Mart last year. They were four and five star heifers out of the suckler herd with a maximum of one movement.

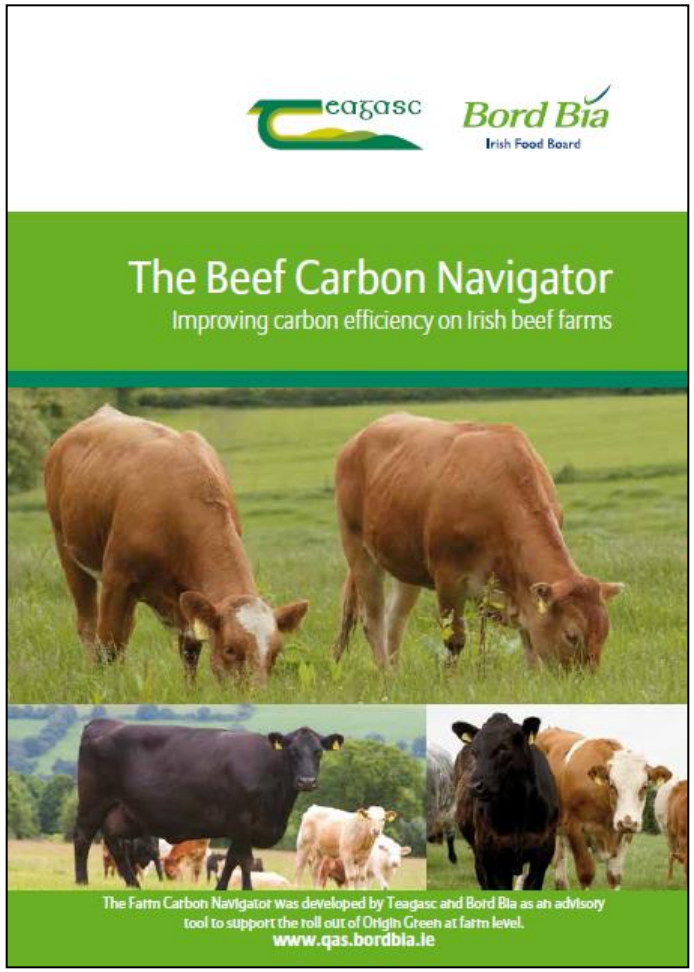
Has the BDGP had an influence on your breeding policy?
I have been keeping breeding records on the farm for the last twenty years. The farm was in milk until 2001, when it changed over to suckling full time. Replacements were bred from the original dairy cows and the milk stayed in the herd right up to the present day. There is a surplus of 4/5 star animals on the farm to meet the programmes replacement requirements at present. All AI used on the farm, with a big emphasis on heat detection. Bulls have been selected on the basis of:
(1) Easy calving – short gestation.
(2) Milk.
(3) Temperament.
(4) Fertility.
Advice is taken from Sean Caffrey, the local AI technician from Progressive Genetics.
Longevity of cows is quite good on the farm with many cows lasting over 10 years and culling rates are quite low. I look for a cow that has fertility, milk, calves herself easily, rears a good calf, goes back in calf again. I aim to select replacements from good milking cows. Cows are observed for AI four times a day – early morning, midday, evening and late at night. Heat detection aids are used in the form of kamars. It is positioned on the back bone of the cow, the patch bursts when the cow is mounted and the red dye is easily spotted. Cows are scanned at 55-60 days after AI.

What do you plan to do with your surplus heifers?
These will be sold at Mayo Sligo Mart at the next special breeding sale for 4/5 star replacements. Billy Loftus the mart manager along with local Teagasc staff have put a lot of work into these special sales in the past.
The temperament of the stock is very good as animals are used to being handled which is important when selling stock on to somebody else.

NEXT WEEK BETTER FARM €URO-STAR ANALYSIS

- All participants have to attend a 4-hour training session. Groups of 25 farmers.
- Undertaken by Teagasc.
- 24k participants will be trained by Nov 2016.
- Big focus on benefits of genetics.
- Hugely positive response to training.
- Supporting articles in IFJ.

Key Actions; Carbon Navigator



- On-line assessment of the carbon efficiency of each farm.
  - Key data such as number animals, age, gender, length grazing season, N fertiliser efficiency….
  - To be completed by end year with an advisor.
- Ongoing assessment => benchmark improvements.

ICBF.com

Evolution of ICBF Beef Evaluations.

2005	2007	2010	2013	2015
Within breed muscle and skeletal for LM, CH, SI (40k)	Across breed. New calving (200k recs) and carcass evaluations (100k recs)	New fertility and cow milk-ability evaluations First overall beef profit indexes	39 million pedigrees Calving 10m recs Live-weight 4m recs Calf Quality 2m recs Carcass 7m recs Fertility 4m recs 50,000 foreign ebvs	530,000 genotypes

Range of breeds & cross-breeds.

Breed Sire * Breed Dam	Num animals
HO_FR	55,258
LM_	28,943
CH_	26,777
LM_HO	25,212
LM_CH	23,346
CH_LM	21,569
LM_SI	19,408
AA_HO	14,619
LM_AA	14,246
LM_HE	14,235
AA_	13,908
HO_	11,627
CH_SI	11,617
HE_HO	10,715
LM_BB	10,385

- 533,093 animals with genotypes.
- 30 different breeds.
- 791 different sire breed * dam breed combinations.
- ~68% of data is from cross-bred animals.

Approach to Genomic Evaluations.

- Two step (SNP BLUP then blending) applied successfully in dairy cattle since 2009.
- Mix99 software used (Luke, Finland).
- Preference to use Single Step (SS) GBLUP.
  - Multiple breeds including cross-breds, cows & calves.
- "Hard" deadline of August 2016 for delivery of "official" genomic evaluations.
- After ~12 months intensive R&D, took a decision in May 2016 to proceed with 2-step, NOT 1-step.
- **Farmers needed proofs to make decisions ahead of 2018 and 2020 replacement deadlines.**

Experience with ssGBLUP.

- Existing evaluations were developed to utilise all available data.
  - Beef performance evaluation was a 29 trait model with 7m records, to predict 6 goal traits.
  - Models needed to be simplified to incorporate genomics.
- Some traits were not converging as well as others, e.g. cow survival & maternal weaning weight.
- Computer resource quickly became a problem
  - RAM (Random Access Memory) to create H-Inv
  - Hard disk space: huge temporary files

Solutions investigated.

- Short term.
  - Purchase more computer resource.
  - Split evaluation into multiple runs with core group of genotypes in each run.
  - Concentrate on males only initially.
- Long term
  - Use the SAC to investigate longer term options.
    - LUKE: Application of APY method.
    - WUR and Iowa State University: Variations of Single Step Bayesian Regression.
    - NMBU: ssGBLUP by genotype imputation.

Computer requirements for ICBF evaluations

I phone 5
1 GB RAM

Cerus x **2**
Ram 6,000 GB
Disk 40,000 GB

lgen2
Ram 760 GB
Disk 4,000 GB

198
Ram 356 GB
Disk 1,500 GB

151
Ram 120GB
Disk 1,800GB

143
Ram 64GB
Disk 698GB

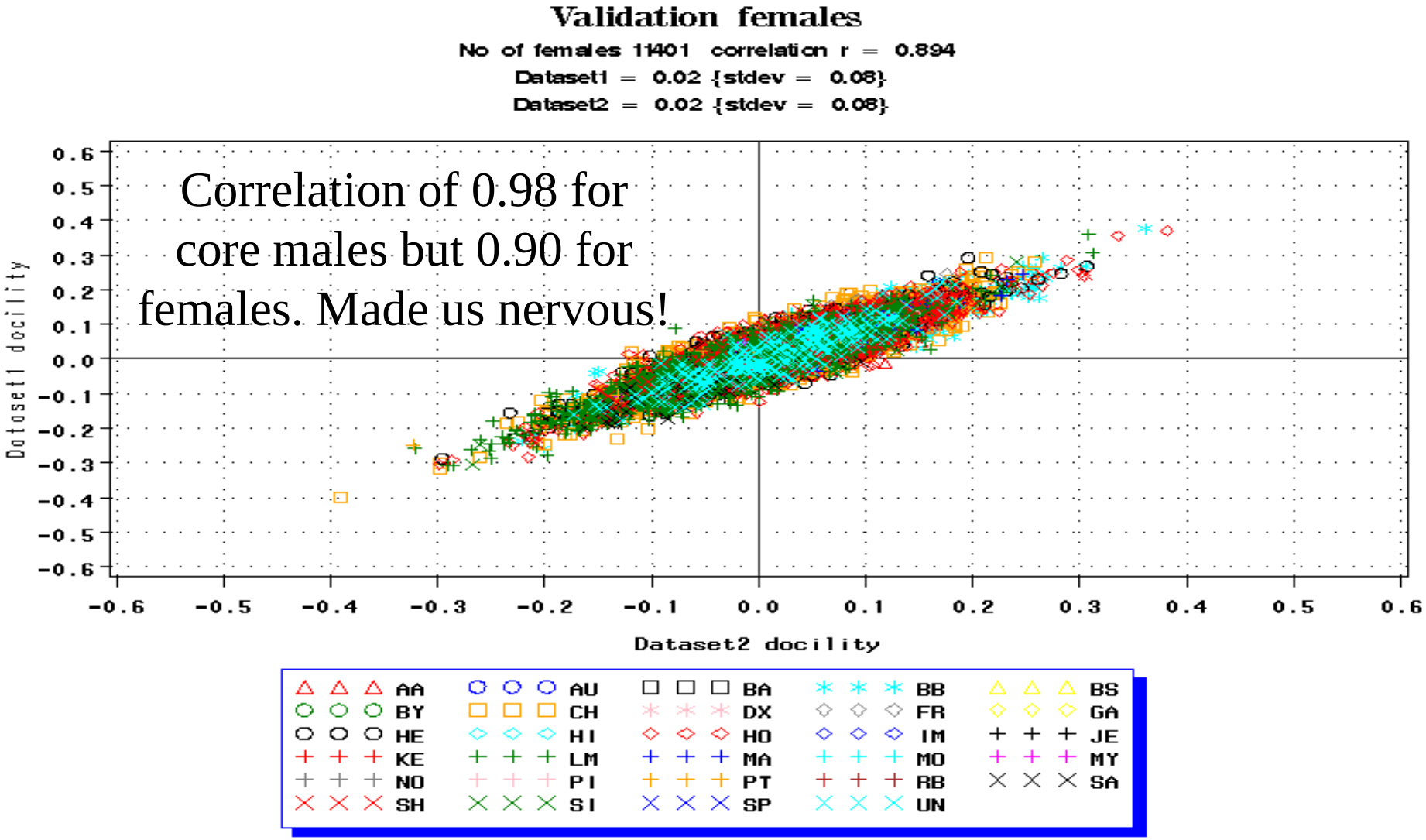
109
Ram 16GB
Disk 279GB

163
Ram 2GB
Disk 80GB

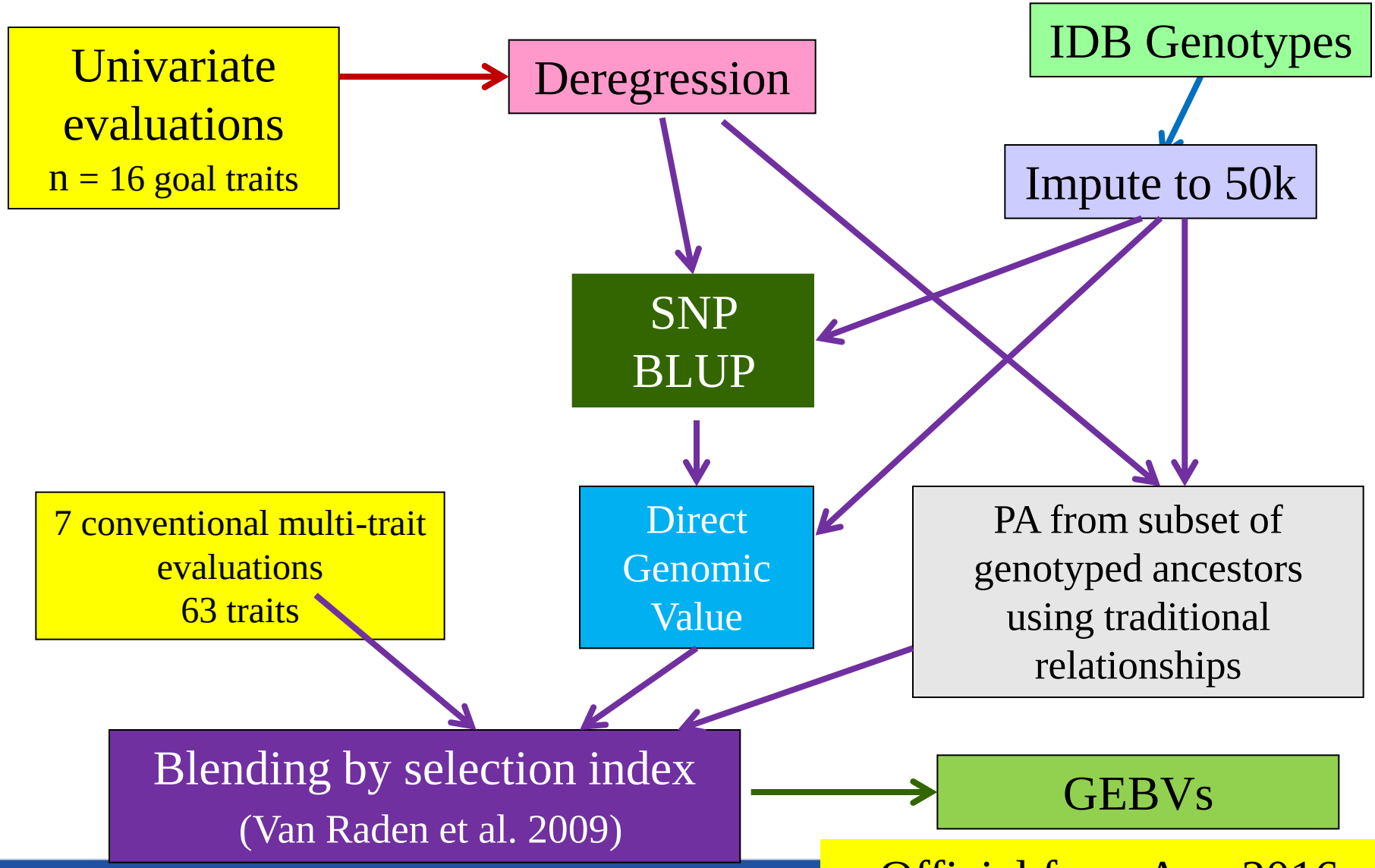
2005	2007	2010	2013	2015

Experience with ssGBLUP

- Solution 1: Splitting evaluations into subsets



2-Step Genomic Evaluation



Official from Aug 2016, running ~monthly

Correlation in proofs.

Index1	Index2	AA	AU	BA	BB	CH	HE	LM	PI	PT	SA	SH	SI	ALL
		256	61	79	322	474	161	421	73	57	66	89	216	2275
Replacement_Off	Repl_New_Geno	**0.92**	**0.96**	**0.92**	**0.89**	**0.89**	**0.90**	**0.92**	**0.94**	**0.91**	**0.92**	**0.81**	**0.91**	**0.91**
Replacement_Off	Repl_New_NonGeno	0.93	0.95	0.93	0.90	0.93	0.92	0.93	0.94	0.91	0.94	0.83	0.92	**0.92**
Repl_New_Geno	Repl_New_NonGeno	0.98	0.99	0.99	0.96	0.95	0.98	0.99	1.00	1.00	0.98	0.98	0.98	**0.98**
Carcass weight_Off	Carcwt_New_Geno	**0.95**	**0.97**	**0.97**	**0.96**	**0.92**	**0.97**	**0.91**	**0.96**	**0.96**	**0.96**	**0.99**	**0.97**	**0.96**
Carcass weight_Off	Carcwt_New_NonGeno	0.98	0.97	0.98	0.98	0.95	0.98	0.94	0.97	0.97	0.97	0.99	0.99	**0.97**
Carcwt_New_Geno	Carcwt_New_NonGeno	0.98	1.00	0.99	0.98	0.96	0.98	0.97	1.00	0.99	0.99	1.00	0.98	**0.98**
Cow Survival_Off	CowSurv_New_Geno	**0.80**	**0.76**	**0.86**	**0.67**	**0.72**	**0.85**	**0.79**	**0.88**	**0.73**	**0.79**	**0.81**	**0.85**	**0.79**
Cow Survival_Off	CowSurv_New_NonGeno	0.82	0.72	0.86	0.73	0.83	0.86	0.81	0.89	0.77	0.86	0.83	0.88	**0.82**
CowSurv_New_Geno	CowSurv_New_NonGeno	0.98	0.96	0.98	0.90	0.90	0.97	0.98	1.00	0.94	0.92	0.96	0.99	**0.96**

- Correlations fairly consistent across breeds.
- Correlations are lower for some traits, mainly due to simplification of models.
- Using genomics, reliability of evaluations for young animals have doubled from 20% => 40%+

Other Challenges.

- Pedigree errors, especially for herdbook registered animals.
  - ~15% sire-calf errors.
    - Farmers generally happy. With genomics can predict 50%+ of these and increasing.
    - Moving to DNA-based calf registration from next year => Removal of pedigree errors.
- Lab/human errors.
  - Even at 0.5% =1500 problems to resolve!

Next Steps.

- Now that we are operational, more time for R&D.
  - Continue work toward single step genomic evaluations.
  - Impact of using cross-bred data?
  - Impact of using data from one breed to predict a second breed?
  - Approach to validation?
- Further update at EAAP Belfast 2016!

5. Conclusions.

- Genetic/genomics can contribute positively to profitability and carbon efficiency.
  - High genetic merit herds => €130/cow/yr more profit with 9% less CO2/kg beef produced.
- At present, 2-step methods are best to deliver a stable genomic evaluation service.
  - 1-step methods are better. How soon?!
- Move to simpler models.
  - Let genomics/biology be drivers, not predictors.
- The BDGP has had a huge impact on the uptake/interest in genetics.

Final Thought.

- Climate change is one of the “major” issue for governments.
- Genetic/genomics can play a key part.
- Other benefits will accrue, e.g., identification, ancestry, traceability, genetic gain (for other traits)…..international collaboration.
- Develop projects linking genomics with climate. Think “BIG” as the money will be spent elsewhere!

Acknowledgement.

- Irish Department of Agriculture, Food and Marine (DAFM) & EU for the "Beef Data and Genomics Program".
  - For more information, please see ICBF and DAFM websites.
  - Contact myself acromie@icbf.com.
- All partners involved in the Irish Beef Data and Genomics Project.
- DAFM FIRM/Stimulus for travel support