Optimizing ex situ genetic resource collections for Spanish livestock conservation

Rafael Silva, GAAFS, The University of Edinburgh
Oscar Cortes, Complutense University of Madrid
Dominic Moran, GAAFS, The University of Edinburgh
Rafael.silva@ed.ac.uk

Innovative Management of Animal Genetic Resources

Ghent, Belgium

28 Aug 2019

In-situ vs Ex-situ

Inside site

Outside site

- National parks
- Nature reserves
- Marine parks

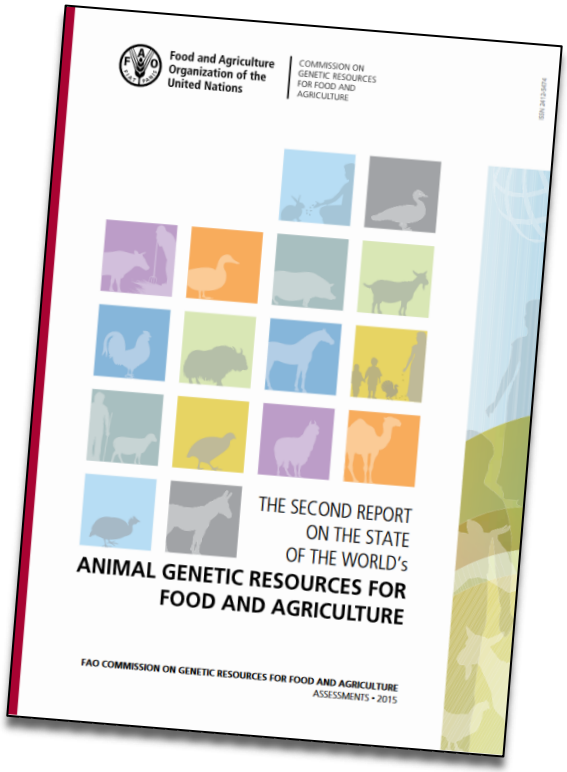
- Captive breeding zoos
- Botanic gardens
- Cryogenic banks (seeds, semen, embryos)

Context and challenge

- Challenges to *in situ* resource conservation, climate change and homogenisation of breeds.

- Increasing interest in monitoring breed status *in* and *ex situ.*

- Considerable focus on efficiency of *in situ* biodiversity conservation – by optimization algorithms



- We identify gap in harmonisation of *ex situ* livestock collections: genomic (e.g. DNA, blood, tissue) and reproductive germplasm (e.g. semen, embryos).

Resources are limited…
Thus collecting from all breeds is not an option

Ex situ conservation is costly

The main limitation is the need for special equipment, techniques and trained staff

Therefore we need to rationalize collections!

Research questions

Defining “rationalised” collections…

<u>Planning ahead based on</u>:

- Extinction risk (population status)
- How many doses (semen or embryo)?
- Where to collect?
- Where to store?
- When to collect?
- Costs minimization

Minimizing costs => more collections

Rationalizing collections

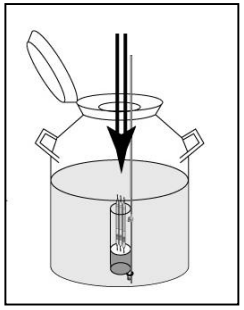
To identifying economically efficient *ex situ* collections considering the trade-offs with *in situ* population to prevent extinction.

Data and method

- A Stochastic Linear Programming model developed to:
  - Identify the optimal breed collection/storage in the gene banks at minimum cost
  - Subjected to geographic distribution of livestock breeds
  - Extinction risks (conservation targets)
  - Cryotanks capacity
  - Other logistical constraints

Spanish gene banks network

National GB (BNGA)
(backup only)



La Coruña
Gijón
Castropol
Oviedo
Santander
San Sebastián
Santiago
Lugo
ASTURIAS
CANTABRIA
Bilbao
PAIS VASCO
GALICIA
León
Vitoria
Pamplona
Pontevedra
Vigo
Orense
NAVARRA
Logroño
Port-Bou
Burgos
LA RIOJA
Gerona
CASTILLA
Aranda de Duero
CATALUÑA
Zamora
Valladolid
Zaragoza
Lérida
Calatayud
Barcelona
LEÓN
ARAGÓN
Tarragona
Salamanca
Guadalahara
Ávila
Balearic Sea
Madrid
Teruel
Castellón de la Plana
Tarancón
ISLAS BALEARES
Inca
Minorca
Toledo
Artá
Palma de Mallorca
Majorca
Cáceres
CASTILLA LA MANCHA
Valencia
Valencia de Alcántara
EXTREMADURA
Isla de Cabrera
Ibiza
Badajoz
Mérida
Albacete
Ciudad Real
Isla de Formentera
Alicante
Linares
Córdoba
Jaén
MURCIA
Murcia
Ayamonte
Sevilla
ANDALUSÍA
Huelva
Granada
Cartagena
Antequera
Almería
Jerez de la Frontera
Málaga
Cádiz
Algericas
Gibraltar (U.K.)

Spanish genebanks data collection

Survey

Costs

- Staff
- Sample Collection
- Maintenance

Capacity

- Tanks
- Tanks capacity
- Collect new samples

Breeds

- Semen/Embryo
- How much
- Donors

Breeds

Census since 2009 to 2018

- Females/Males registered each year
- Breeders
- Cattle, sheep, pig, goat, horse, chickens

Data and method

Survey applied to 18 Spanish gene banks and current allocation (stocks) of breeds

ID	GeneBank	City	Capacity (doses of 0.25 ml)	Fixed costs (EUR/yr)	Collection cost (EUR/dose)
GB1	BNGA	madrid	550000	13000	1
GB2	INIA	madrid	48000	4200	1
GB3	CERSYRA	ciudad_real	65000	4830.53	1
GB4	CTA	zaragoza	780000	25000	1
GB5	SEMILLA	illes_balears	16000	6000	1
GB6	CENSYRA-Badajoz	badajoz	1500000	100000	1
GB7	CENSYRA-Leon	leon	1600000	30000	1
GB8	SERIDA	asturias	2740000	20000	1
GB9	CRZG	ourense	780000	50000	1
GB10	CITA-IVIA	valencia	4899	314	1
GB11	CIFEA	murcia	532	34	1
GB12	UAB	barcelona	25347	1622	1
GB13	IEGRA	toledo	87234	5583	1
GB14	UoC	cordoba	9324	597	1
GB15	ACI	bilbao	2826276	180882	1
GB16	IMIDRA	madrid	277232	17743	1
GB17	ITACL	valladolid	5428	347	1
GB18	UCM	madrid	55741	3567	1

Data and method

Spanish Agricultural Census : Geographic distribution (52 cities) and population size for 180 livestock breeds.

Breed	Year	Breeding Animals		Total Animals		TOTAL	Breeders
		Females	Males	Females	Males		
Asturiana de los Valles	2018	64181	4276	93727	12087	105814	4143
	2017	63082	4182	91414	11606	103020	4147
	2016	60823	4127	87895	11021	98916	4084
	2015	59569	4083	86185	11084	97269	3969
	2014	58855	4016	83826	10856	94682	3947
	2013	61428	3796	88116	10059	98175	3986
	2012	62633	4489	86921	13132	100053	3982
	2011	59250	4103	80728	12410	93138	3896
	2010	56248	3711	75902	11037	86939	3878
	2009	53132	3615	72176	10747	82923	3834

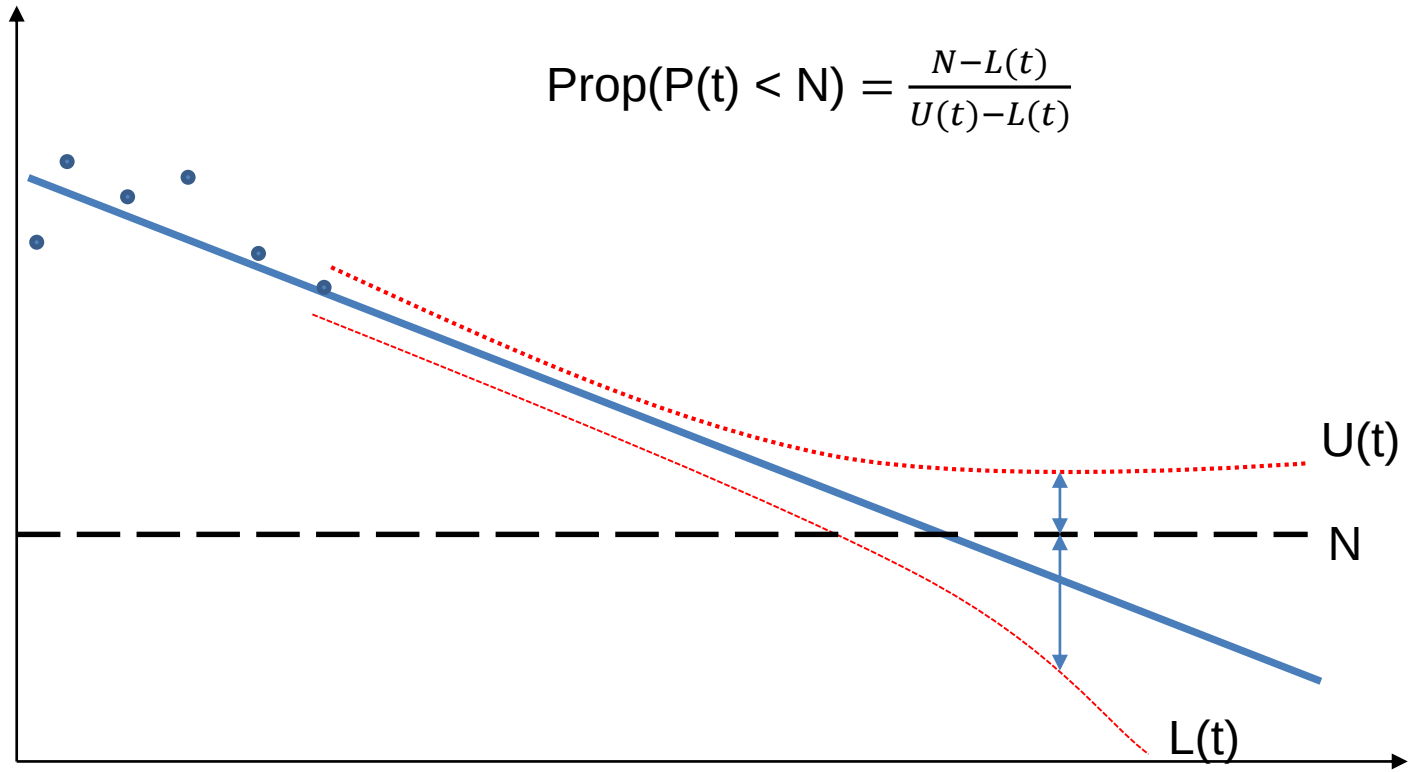
Risk scenarios

General guidelines to decide when to intervene for conservation of natural populations

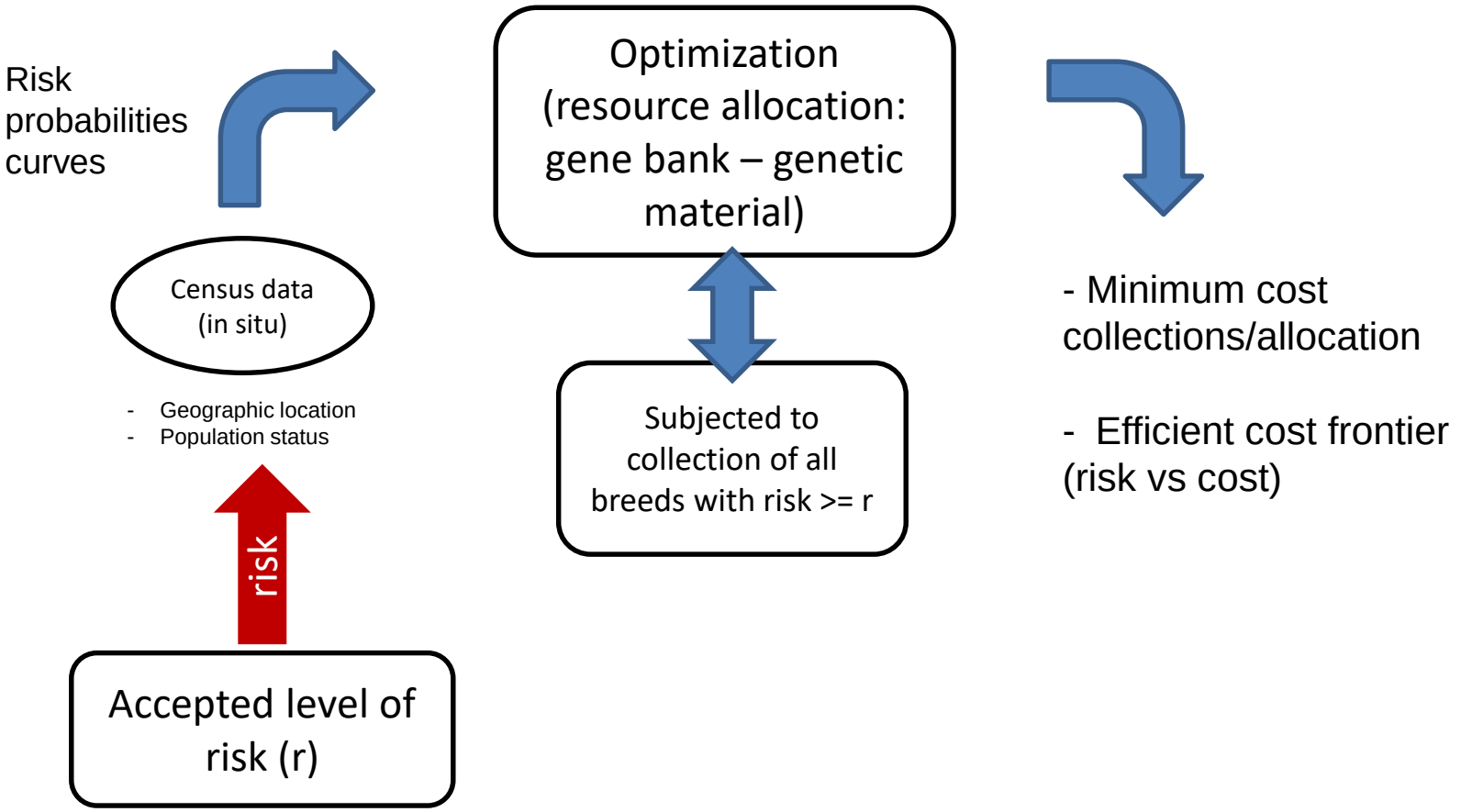
Priority	Population Status	Action
possibly	N < 100,000	At least serious surveillance of status and trends should be initiated
probably	N < 10,000	Well managed captive propagation programmes should be established, reproductive technology research should be vigorously conducted, and germinal tissues collected for storage, while there are an adequate number of animals to use as founders, subjects and donors.
certainly	N < 1,000	*Ex situ* programmes should be intensified while field (*in situ*) efforts are fortified for a 'last stand'; *ex situ* programmes are imperative.
urgently	N < 500	*Ex situ* programmes assume at least as much importance as field (*in situ*) efforts.

Extinction probability risk (r)

$$\text{Prop}(P(t) < N) = \frac{N - L(t)}{U(t) - L(t)}$$



Rationalizing collections for Spanish livestock breeds for 2018 to 2060

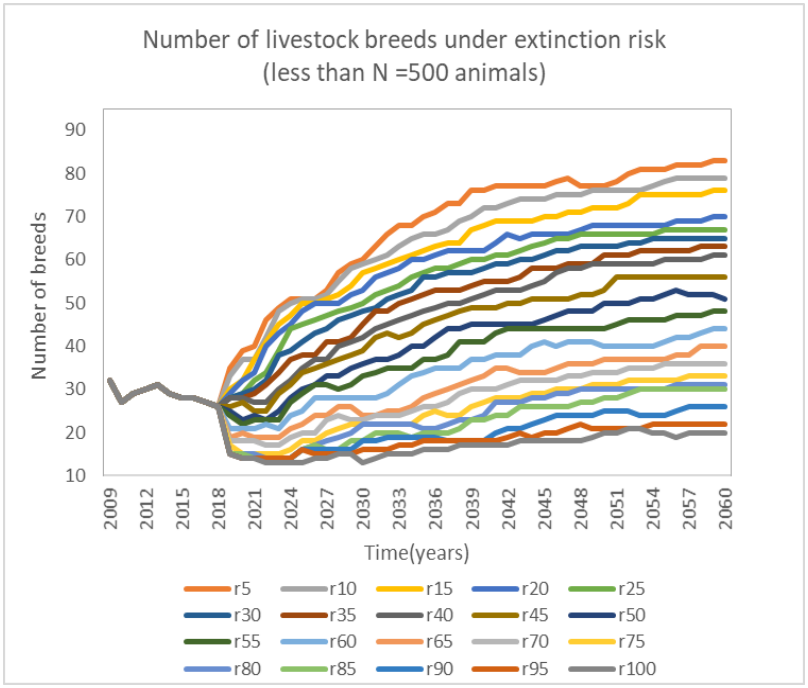


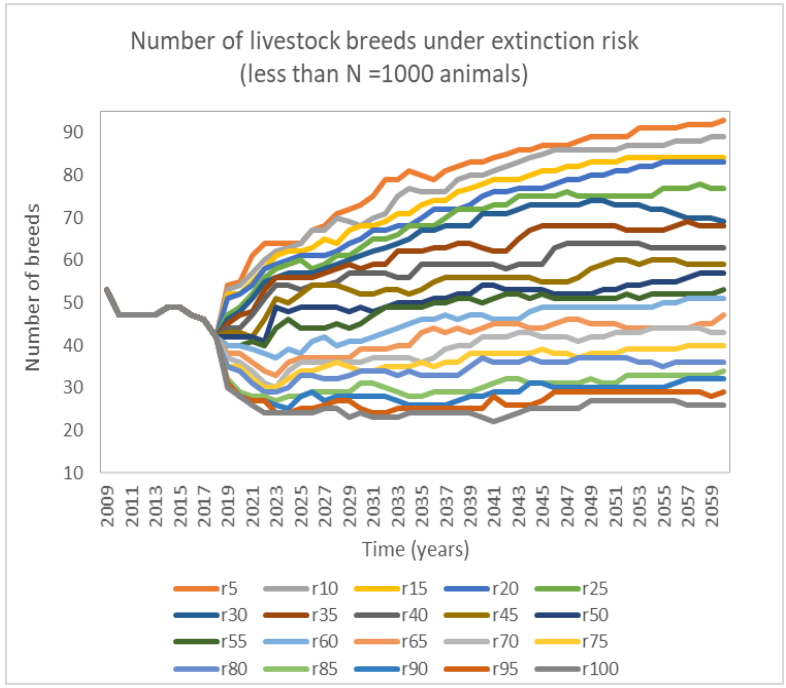
Results

Around 17% (30 out of 180) livestock breeds are currently below N = 500.

If no actions are taken:

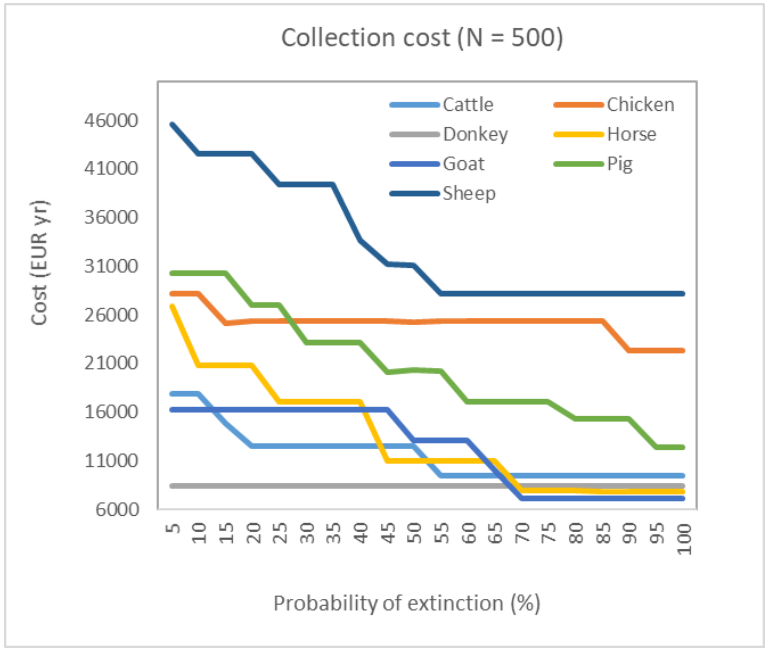
- Around 25% of Spanish livestock breeds will be under a 50% probability of being extinct between 2040 to 2060;
- Around 15% of the breeds will have a 75% to be at risk by 2040.
- Around 35% of the breeds will have 25% of extinction risk from 2040.



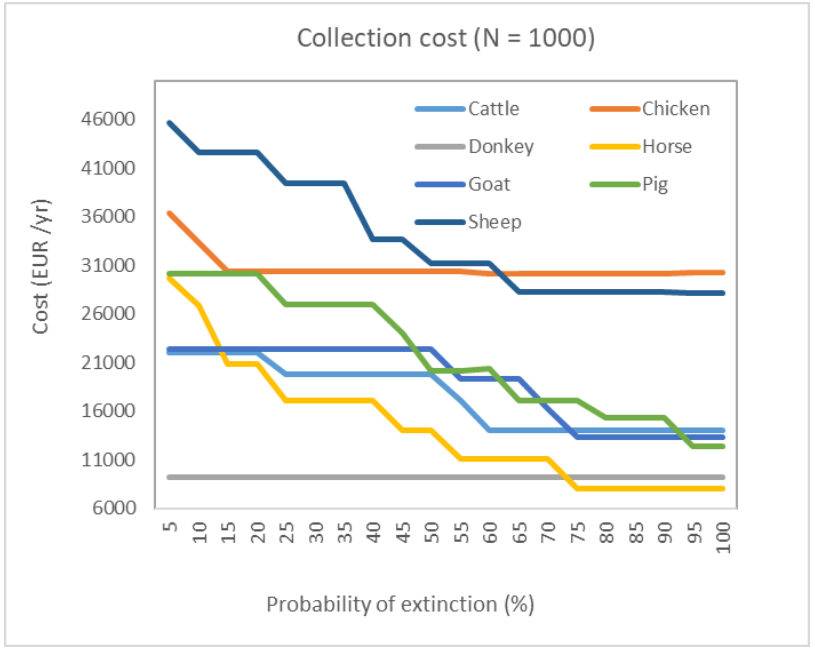


Results

Cost-efficient frontier curves



Total costs 95 k EUR/yr to 173k EUR/yr

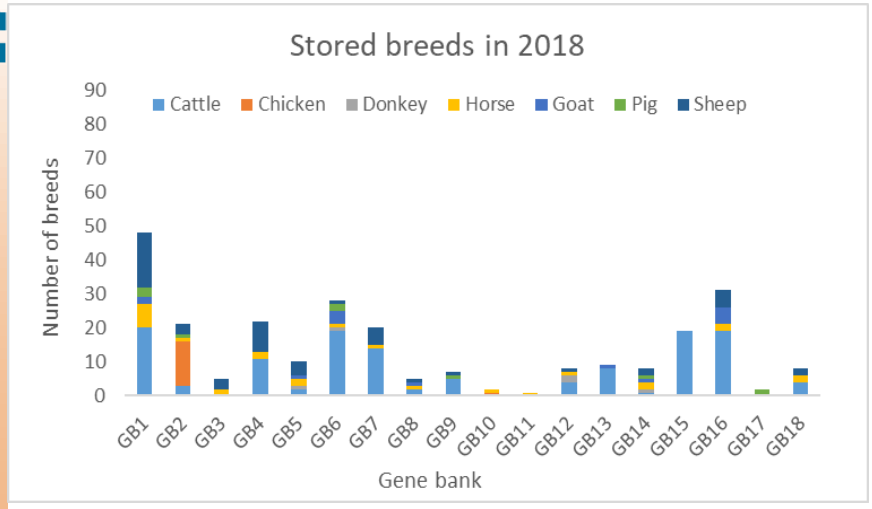


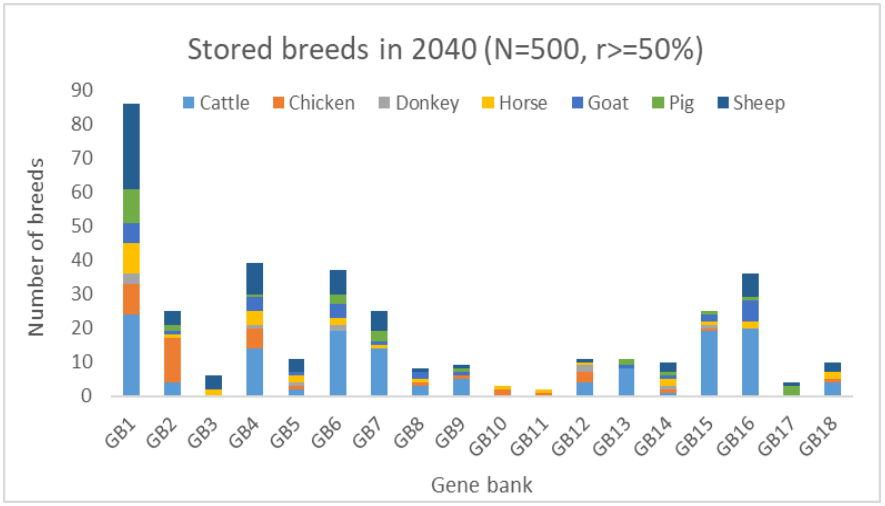
Total costs 115.94 k EUR/yr to 195k EUR/yr

Fixed costs = 463.72 k EUR/yr

Results

Efficient allocation





Number of breeds currently stored in the national GB are expected to double by 2040 if collecting all breeds with a 50% or more probability of extinction (for N=500).

Conclusions

- There is significant extinction risk for many Spanish livestock breeds.
- Uncertainty analysis using *in situ* projections revels *ex situ* actions are increasingly necessary to prevent extinction.
- Sheep, chicken and pig breeds are relatively more likely to become instinct than are cattle breeds.
- Intensifying *ex situ* efforts for population status of N= 500 or N=1000 does not change the costs significantly, and
- Costs also do not change significantly according to accepted endangerment levels (because of fixed costs)
- Spanish gene banks are currently underutilized and expansion (new cryotanks) is required at least up to 2060.

Acknowledgements

The research was conducted as part of:

- The IMAGE (Innovative Management of Animal Genetic Resources) project; the European Union's Horizon 2020 research and innovation program under grant agreement No 677353; and

- The Scottish Government's Strategic Research Programme 2016-2021 (2.3 Agricultural Systems and Land Management).

IMAGE
Innovative Management of Animal Genetic Resources