Summary of

Biodiversity and other risks of intensive and selective breeding

Ezemvelo KZN Wildlife & Scientific Authority

Intergovernmental Task Team

DEA Consultation, Pretoria, 2 December 2015

Definition:

Intensive and selective breeding

Deliberate selection of and breeding for selected animal traits, usually in controlled conditions

- E.g. coat colour & pattern; horn & body size
- Simple inheritance, recessive genes, more predictable (e.g. coat colour)
- Complex inheritance, Quantitative features, (e.g. horn length, body size)
  - E.g. German Shepherd hip dysplasia

Definition: Domestication

- **Domestication** (from Latin domesticus: "of the home") is the process whereby a population of living organisms is changed at the genetic level, through generations of selective breeding, to accentuate traits that ultimately benefit the interests of humans.

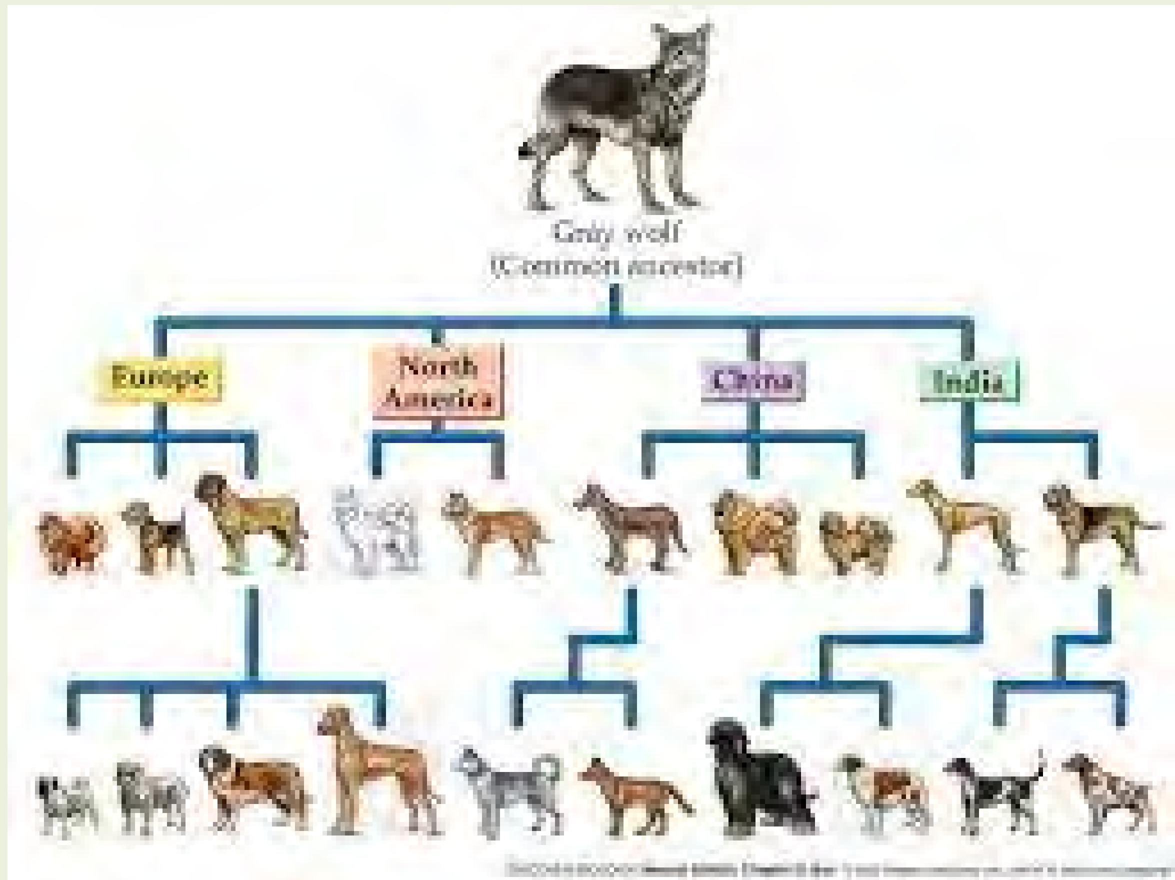
Therefore

Intensive & Selective Breeding

=

Domestication

The wolf….


Gray wolf
(Common ancestor)
Europe
North America
China
India

Evaluation of Biodiversity Impacts

- Spatial scale
  - Area
  - Processes impacted
- Number of species
  - Directly
  - Indirectly
- Numbers of individuals
  - Directly
  - Indirectly
- Likelihood
- Severity
- Permanence/ reversibility

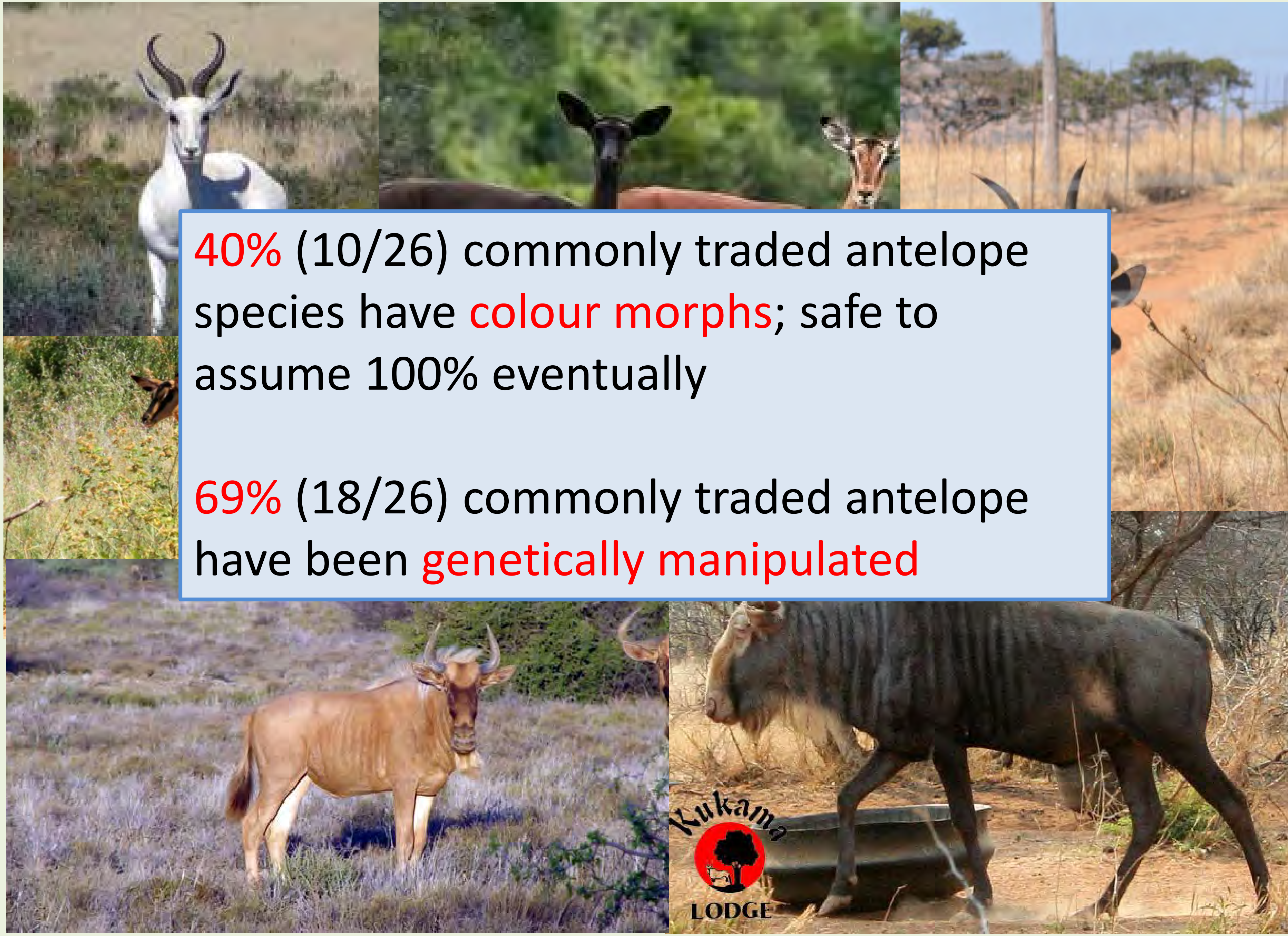
Number of species affected (colour morphs)

Species	Varieties	Names*
Springbok	4	Black, White, Copper, Coffee
Impala	6	Black, Saddled, Black-backed, Grey, Black nosed, White-flanked
Blue wildebeest	2	Golden, King
Blesbok	8	White, Yellow, Copper, Skilder, Woolly, Red, Speckled, Top Deck
Kudu	4	White, Black, Brown, Zebra-striped
Eland	1	Skilder
Red hartebeest	1	King
Gemsbok	4	Skilder, Gold, Cardinal, Scimitar
Plains zebra	1	Golden
Klipspringer	1	Spotted
Waterbuck	1	''White''


Selective Breeding

Hybridization

Species	Fertile	Notes
Black x Blue Wildebeest	Yes	Black x Blue = Red; >40% black wildebeest tested have introgressed blue wildebeest genes
Nyala x Kudu	?No	Deliberate hybridisation
Waterbuck x Lechwe	Yes?	Deliberate hybridisation
East African x southern African Buffalo	Yes	Breeding for long horns
Blesbok x Bontebok	Yes	>40% of blesbok tested have introgressed bontebok genes
Tsessebe x Red Hartebeest	No?	Accidental?
Western x Southern Roan	Yes	Deliberate hybridisation for body and horn size
Zambian x South African Sable	Yes	Morphological differences, not supported by genetic evidence



40% (10/26) commonly traded antelope species have colour morphs; safe to assume 100% eventually

69% (18/26) commonly traded antelope have been genetically manipulated

Risks of Intensive and Selective Breeding of Wildlife

Genetic

- Inbreeding, Outbreeding, directional change
- Reduced heterozygosity
  - Of captive stock
  - Of species as a whole if conservation only happens inside PAs
- Founder effects
- Loss of rare alleles/allelic diversity
  - Wildebeest simulations, agricultural examples
  - **Loss of adaptive potential to climate change**
- Impact related to size of wild population
  - e.g. roan
- Active hybridisation
  - e.g. Southern x Western Roan, Waterbuck x Lechwe

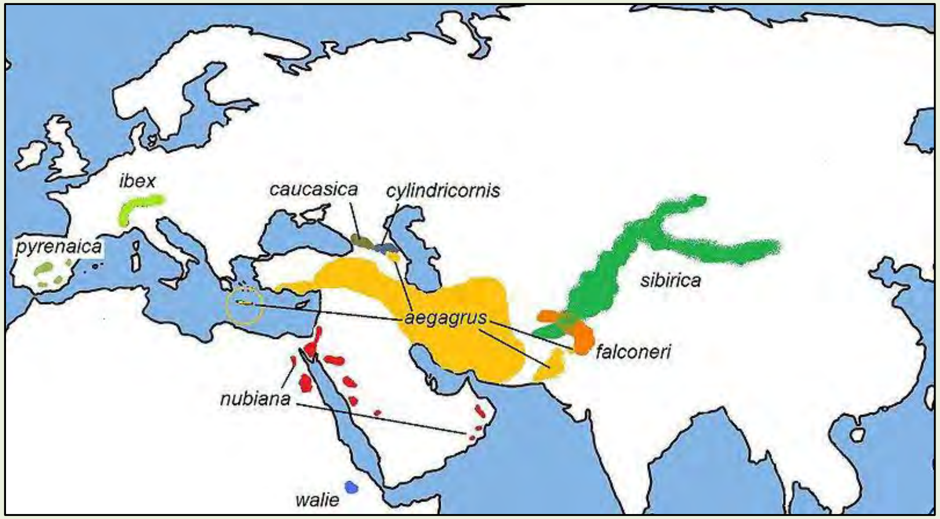
Example

Outbreeding Depression

Extrinsic mechanisms

- Alpine Ibex overhunted in European Alps and augmented by translocations from population in the Sinai Peninsula and Turkey

- Southern ibex breed earlier in the fall and hybrid young were born in the middle of alpine winters.



Habitat loss and fragmentation

- New trend is resulting in:
  – Habitat transformation
    - Small enclosures, high stocking rates, trampling, loss of habitat along fences
  – Habitat fragmentation
    - Additional fencing, disruption of processes of gene flow, dispersal and migration
  – Death of animals
    - Pangolins, tortoises, pythons
  – Does not trigger EIA process

Misuse of chemicals

- Large incidence of off-label use of agricultural remedies
  - Unregistered use of anthelmintics in game feed supplements
    - No control over dosage rate leading to **resistance**
    - Avermectin type anthelmintics that are ingested pass through rapidly and are deposited in the dung, posing a severe **risk to dung beetles**
    - Constant dosing **compromises natural immunity** against endoparasites
  - Unregistered use of ectoparasiticides with ''automatic applicators''
    - No control over dosage rate leading to **resistance**
    - Constant dosing **compromises natural immunity** against symbiotic ectoparasites
  - Translocation of hosts and/or ticks to non-endemic areas, and high stocking rates, resulting in necessity for treatment with acaricides
- Leading to resistant strains of parasites that could have impacts both on natural populations of game and on agriculture
- E.g. Schroder & Reilly (2013) concluded that the tick species *Rhipicephalus decoloratus* became resistant to the acaricide treatment being applied in intensive breeding camps.

Predator persecution

- High value animals protected at all costs
  - Fencing
  - Intolerance of (all) predators
  - Control of species that dig under fences e.g. porcupines
- (Large?) increase in (irresponsible and illegal) use of poisons
  - Predator control and prevent other species feeding on food provided to game
  - Non-selective
  - Non-target – vultures, ground hornbills, baboons
  - Scale difficult to document
- Endangered species impacts
  - Noted as a threat to ground hornbill reintroduction programme
  - Vulture deaths
  - Leopard DCA permits increase

Ecosystem-level impacts

- Predator-prey evolution
  - Species
  - Ecosystem as a whole
- Host-parasite evolution and resistance
- Natural selection
- Breakdown of functional ecosystems and ecosystem processes
  - Fire, dispersal, gene flow
- Disinvestment in extensive (= conservation compatible) land use

Behavioural changes

- Imprinting on colour morph
  - Rapid spread of recessive genes

Animal wellbeing

- Physiological
  - Springbok colouration is adaptive; white parallel to sun (cooling), dark perpendicular to sun (warming), camouflage
  - Black animals suffer more during high temperatures (Hetem et al., 2009, 2011)
  - ''Commodities'' moved to hotter/colder, drier/wetter environments than adapted to
  - Buying animals without experience, land etc.
- Cancers, melanomas, cataracts in white varieties
- Behavioural
  - Aggressiveness/docile
  - Naive to predators
- Loss of disease resistance
  - Mate choice designed to maximise immunity – MHC

Reputational

- Risk to tourism and hunting industry
  - Loss of support for hunting
  - Loss of land for conservation
- ‘’Brand South Africa’’

Parallels from Aquaculture, Agriculture, Wing-shooting

Parallels (1): Aquaculture

- Breeding for traits (size, growth rate), escape or release back into systems
  - E.g. Brook Charr
    - suggests that current stocking practices have the potential to *significantly* ***alter the functional genetic make-up of wild populations***
    - **stocking with a domestic strain *affects the genetic integrity of wild populations*** (change in diversity, homogenization of population structure, increased individual genetic admixture) not only at neutral markers, but also at coding genes
      - FABIEN C. LAMAZE, et al. 2012. Dynamics of introgressive hybridization assessed by SNP population genomics of coding genes in stocked brook charr (Salvelinus fontinalis). Molecular Ecology 21, 2877–2895

Parallels (2a): Agriculture

- **Loss of genetic diversity** through selective breeding

  e.g. Chinese pigs

  - *Haplotype diversity* in randomly bred populations was significantly greater than the selectively bred populations (h=0.732 vs. 0.425 and 0, exact test, P≤0.0036). These findings demonstrate that **selective breeding generated low genetic diversity** compared to randomly bred pig breeds.
  - Meeting some productive requirements *comes at the cost of diversity.*
    - QU Kai-Xing et al: 2011.Genetic differentiations between random and selectively breeding pig populations in Yunnan, China . Zoological Research 32(3): 255−261

  e.g. cattle, sheep & goats

  - Performance improvement of industrial breeds at cost of ***loss of genetic resources***
    - C R Biol. 2011 Mar;334(3):247-54. doi: 10.1016/j.crvi.2010.12.007. Epub 2011 Feb 1. Conservation genetics of cattle, sheep, and goats. Taberlet P et al.
  - The efficiency of modern selection methods successfully increased the production, but with a ***dramatic loss of genetic variability***. Many industrial breeds now suffer from inbreeding, with effective population sizes falling below 50.
    - Taberlet P. et al. 2008 . Are cattle, sheep, and goats endangered species?.Mol Ecol. 17(1):275-84

Parallels (2b): Agriculture

- **Domestic gene introgression** into wild populations is a problem throughout the world

e.g. free-living Soay sheep of St Kilda, and more modern breeds

  – The haplotype carrying the domesticated light coat colour allele was favoured by natural selection, while the haplotype associated with the domesticated self coat pattern allele was associated with decreased survival.
  – Admixture has the potential to facilitate rapid evolutionary change, as evidenced by the presence and maintenance of coat polymorphisms in the Soay sheep population.
    - Feulner PG, et al. 2013. Introgression and the fate of domesticated genes in a wild mammal population. Mol Ecol. 16):4210-21. doi: 10.1111/mec.12378.

- **Cancers and melanomas** with white varieties e.g. Hereford

Parallels (3): Wing-shooting

- Mallard Ducks in America, domesticated variety released for wing-shooting
  - differences in egg production, fertility, growth rates, and body weights linked to genetic differences
- Resulting in:
  - >10% wild mallards have introgressed domestic genes
  - **improper timing of migration and nest initiation, decreased broodiness leading to high rate of nest and brood abandonment**

Summary of Risks

	Biodiversity	Other
Direct	Genetics Habitat Loss Habitat fragmentation Predator persecution	Animal wellbeing
Indirect	Domestication Loss of parasite/disease resistance Disruption of evolutionary processes Diversion of scarce conservation resources	Reputational (=economic) Economic (pyramid scheme)

Note 1:
Natural selection can't be relied upon

- Colour morphs rare in nature, natural selection acts against
- Artificial selection, increase in frequency
- So won't natural selection quickly remove these genes from the population after introgression?

Consider:

- **Escapes will happen**
- **Frequency of escapes/introgression will increase**
  - Increase in numbers of populations
  - Deliberate mixing with natural populations for hunting
  - Values will drop, incentive to keep separate decreases
    - Bubble bursts
- **Natural selection no longer operational**
  - Selective pressures to remove colour morphs no longer operational e.g. predation, climatic extremes
  - Natural selection may select for domesticated traits (Saoy sheep example)

Note 2:
Can't manage PAs and farms separately

- Biodiversity mandate nation wide, not just protected areas (Public Trust)
- Insufficient numbers in PAs
- PA fences porous by design or neglect

Note 3:
Intensive and Selective Breeding is NOT Conservation Breeding

Risk	Conservation Breeding	Intensive & Selective Breeding
Objective	Specific objective of breeding for successful release into the wild to conserve the species	Breeding without specific objectives of release (sale to other breeders, hunters), other than for hunting shortly after release; no registered conservation programmes with plans to release to the wild
Inbreeding and loss of genetic diversity	Maximise diversity of founder population Maximise heterozygosity through managed stud books	Selection of specific traits as a small subset of overall gene pool Active inbreeding Stud books starting to be used, but to maintain traits not diversity
Behavioural changes	Maintain traits of wildness, adaptation to natural environment Wise to predators	Selection of docile animals No concern for maintaining/teaching predator avoidance
Evolution and adaptation	Widest possible range of alleles to confer future adaptation potential	No concern, or active selection of a subset of alleles coding for specific traits
Parasite and disease	Retain parasite and disease resistance so released animals are able to survive	Treated so no ongoing evolution of parasite and disease resistance; husbandry resulting in breeding of resistant parasites through use of products outside of registration Loss of resistance (MHC)

Who else is concerned?

- International Council for Game and Wildlife Management (CIC)
- IUCN Antelope Specialist Group, 2015
- Species Survival Commission of IUCN
- Association of Zoos & Aquariums, 2011
- NSPCA, 2015
- Hunting clubs/associations
  - SA Hunters and Game Conservation Association, 2014
  - Boone & Crockett Club, 2015
  - Confederation of Hunters Associations of South Africa
  - Professional Hunters Association of South Africa, 2015
  - Safari Club International, 2015
- All Provinces
  - KZN Wildlife, 2015
- SANBI, DEA

Conclusions

- Large areas of uncertainty, but important lessons from aquaculture, agriculture and the pet trade
- What it is NOT
  - Not conservation breeding
  - **Not contributing to conservation objectives/targets** e.g. Red List assessments
- What it IS
  - Is resulting in **significant long term risks to biodiversity and possibly the economy**
- What is NEEDED
  - **Risk averse regulatory approach** (regulatory authorities to take a risk averse approach to protect biodiversity and the broader economy in terms of the Public Trust)
  - Holistic view (direct and indirect impact)
  - Research to quantify risks