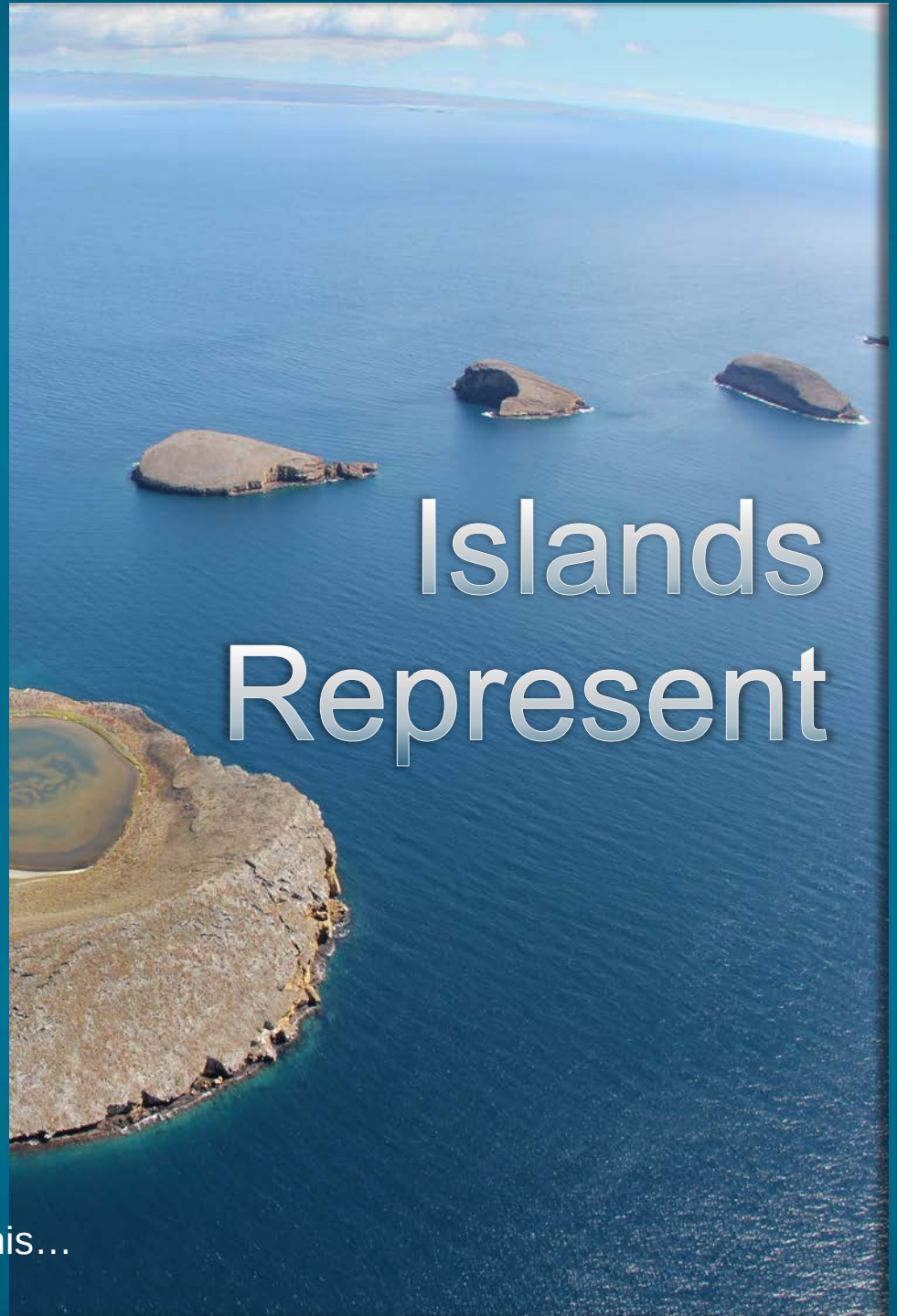
Potential game changers: a spotlight on selected emerging technologies.

Gene drives and RNAi applications for rodent eradication.

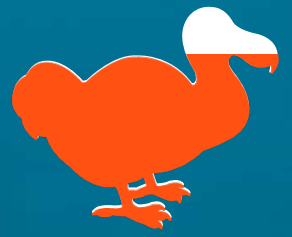
We can do this…



Islands Represent

Less than 5% of land mass

40% of endangered species

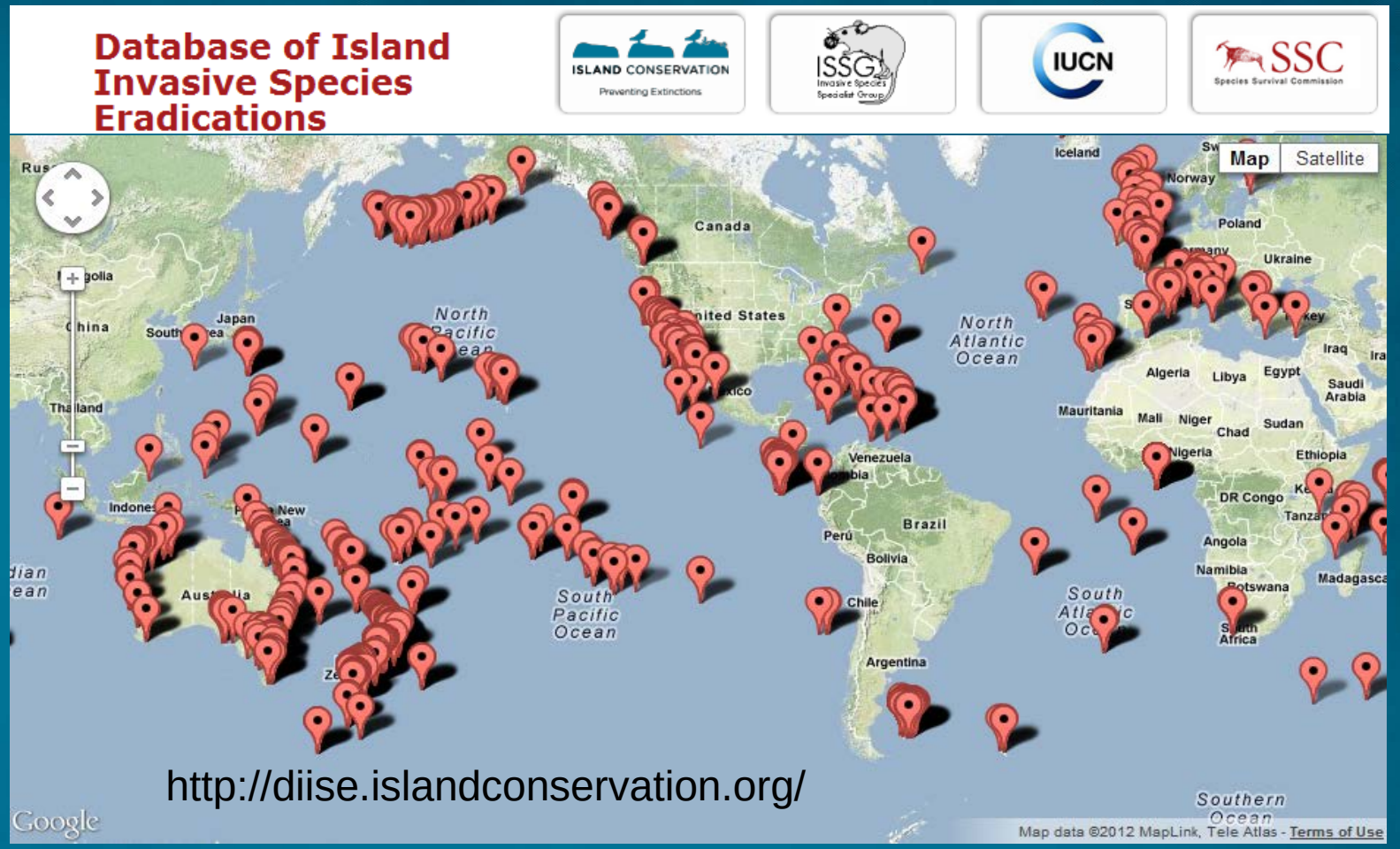


80% of extinctions since 1500

We can do this…

Invasive alien mammal eradications

- 1100 successful
- Result in native species recovery



http://diise.islandconservation.org/

PNAS

Invasive mammal eradication on islands results in substantial conservation gains

Holly P. Jones[a,b,1], Nick D. Holmes[c], Stuart H. M. Butchart[d], Bernie R. Tershy[e], Peter J. Kappes[f], Ilse Corkery[g], Alfonso Aguirre-Muñoz[h], Doug P. Armstrong[i], Elsa Bonnaud[j], Andrew A. Burbidge[k], Karl Campbell[c,l], Franck Courchamp[j], Philip E. Cowan[m], Richard J. Cuthbert[n,o], Steve Ebbert[p], Piero Genovesi[q,r], Gregg R. Howald[c], Bradford S. Keitt[c], Stephen W. Kress[s], Colin M. Miskelly[t], Steffen Oppel[n], Sally Poncet[u], Mark J. Rauzon[v], Gérard Rocamora[w,x], James C. Russell[y,z], Araceli Samaniego-Herrera[h], Philip J. Seddon[aa], Dena R. Spatz[c,e], David R. Towns[bb,cc], and Donald A. Croll[e]

We can do this…

Parque Nacional GALAPAGOS Ecuador

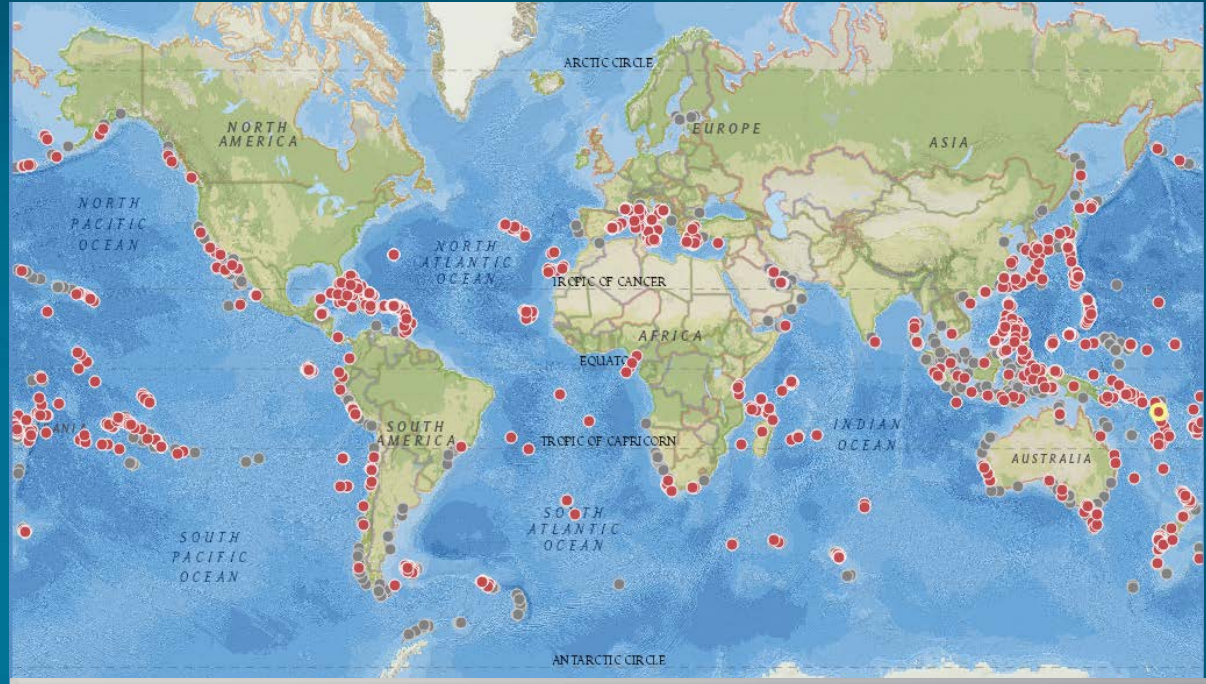
ISLAND CONSERVATION

Pinzon Giant Tortoise

Pinzon Island, Galapagos

We can do this…

Four spp. invasive rodents impact 88% of CR/EN vertebrate spp. on islands



Current methods feasible for islands holding 15% of those CR/EN spp.

We can do this…

http://tib.islandconservation.org

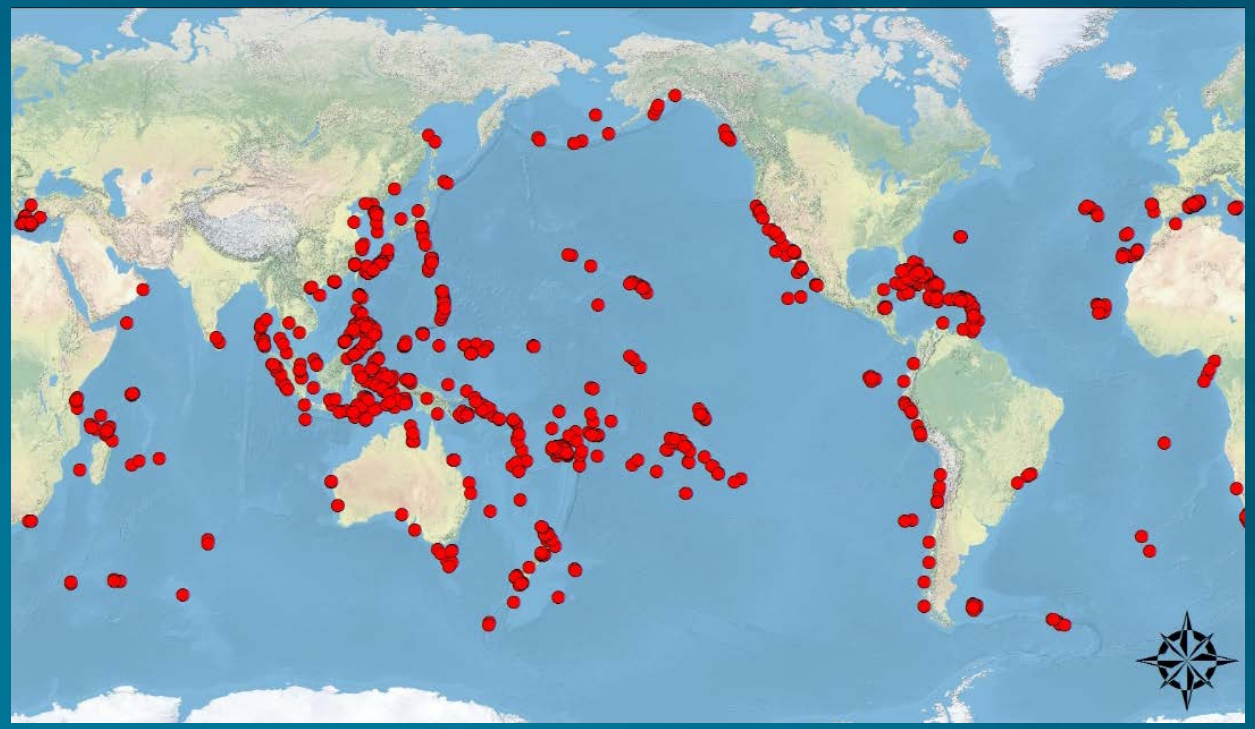
Innovation Strategy

Identify point of greatest impact
- Invasive rodents

Match technology to the need
- Horizon scanning

Select investments
- Incremental
- Transformative

We can do this…



Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

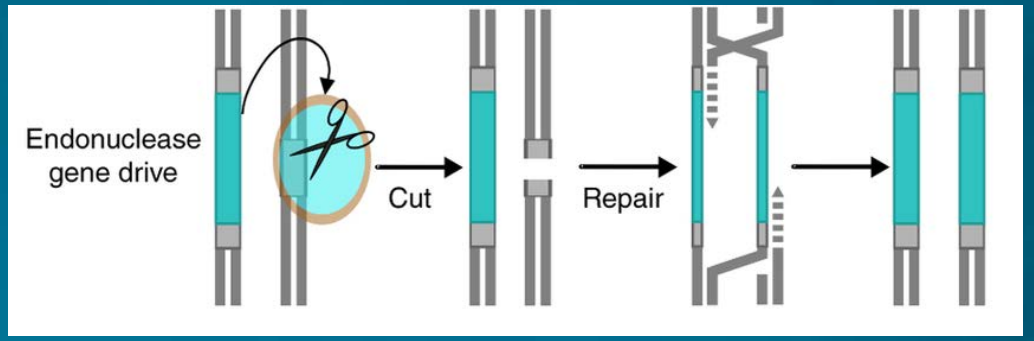
Special Issue Article: Tropical rat eradication

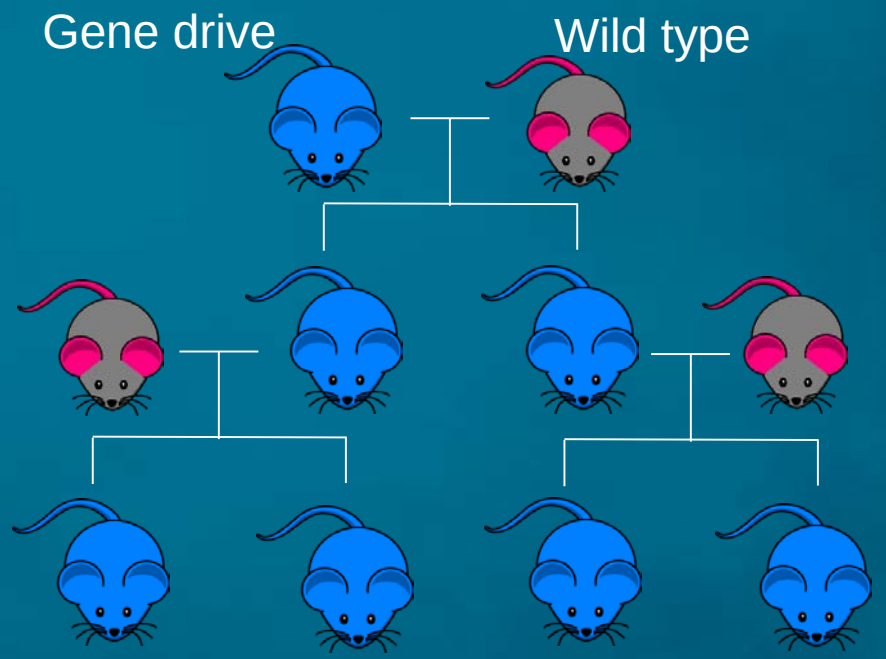
The next generation of rodent eradications: Innovative technologies and tools to improve species specificity and increase their feasibility on islands

Karl J. Campbell [a,h,*], Joe Beek [a], Charles T. Eason [c,d], Alistair S. Glen [e], John Godwin [f], Fred Gould [g], Nick D. Holmes [a], Gregg R. Howald [a], Francine M. Madden [h], Julia B. Ponder [i], David W. Threadgill [j,k], Alexander S. Wegmann [a], Greg S. Baxter [b]

Gene drives

- Cause genes to be inherited more frequently than normal – up to 100%
- Sexual reproduction
- Ability to modify wild populations *by design*
  - Insert new, modify or delete genes
- CRISPR-Cas9

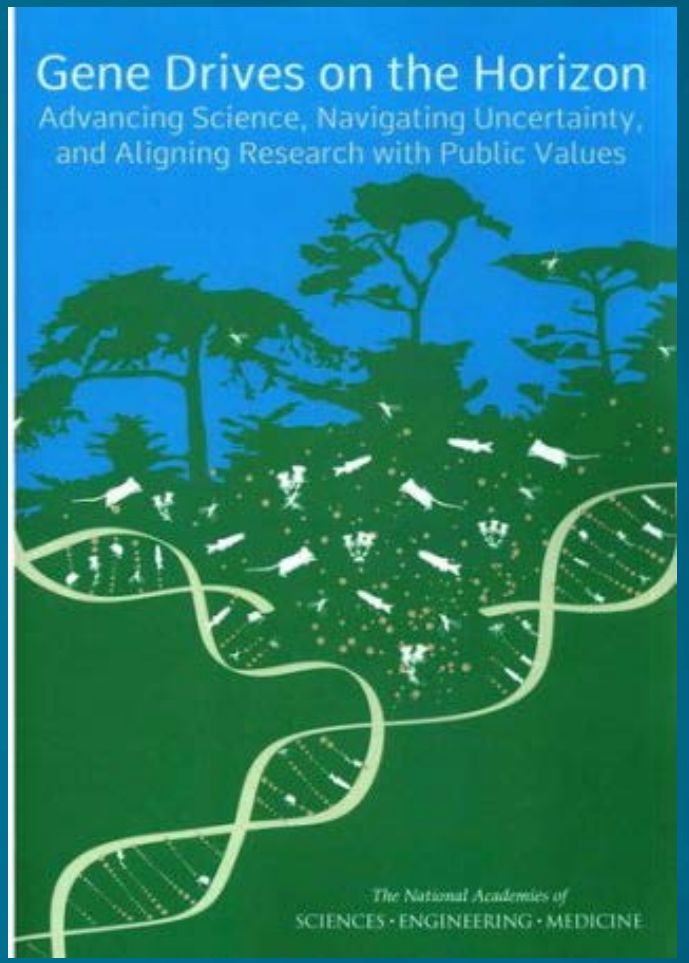




We can do this…

Gene drives

- Cause genes to be inherited more frequently than normal – up to 100%
- Sexual reproduction
- Ability to modify wild populations *by design*
  - Insert new, modify or delete genes
- CRISPR-Cas9
- Nascent fast-moving field
  - Pre-caution & phased approaches needed



We can do this…

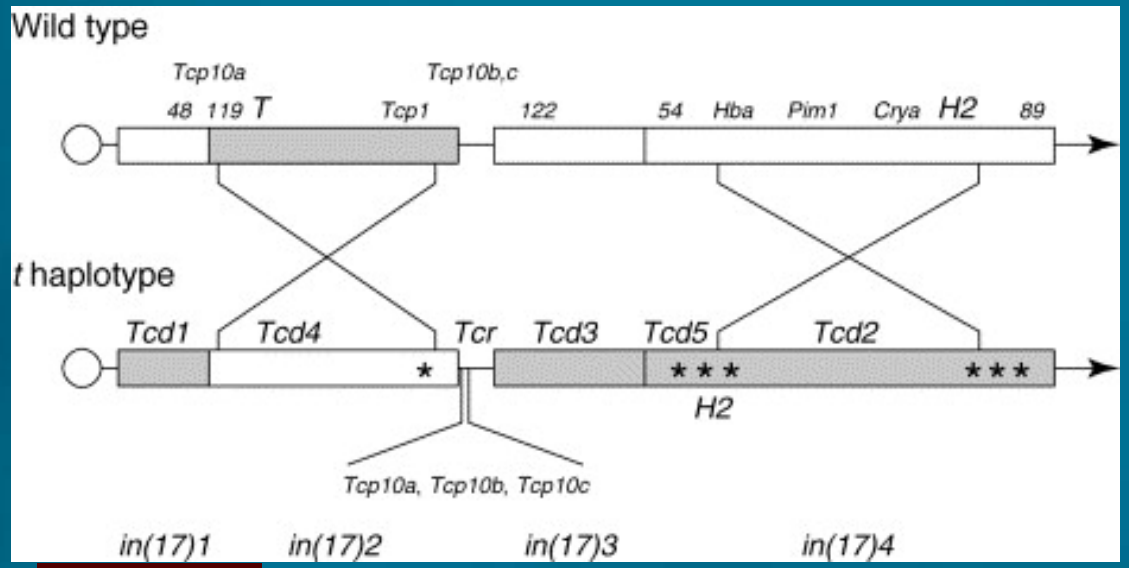
NASEM 2016; Kaebnick et al. 2016

Genetic Biocontrol of Invasive Rodents program

We can do this…

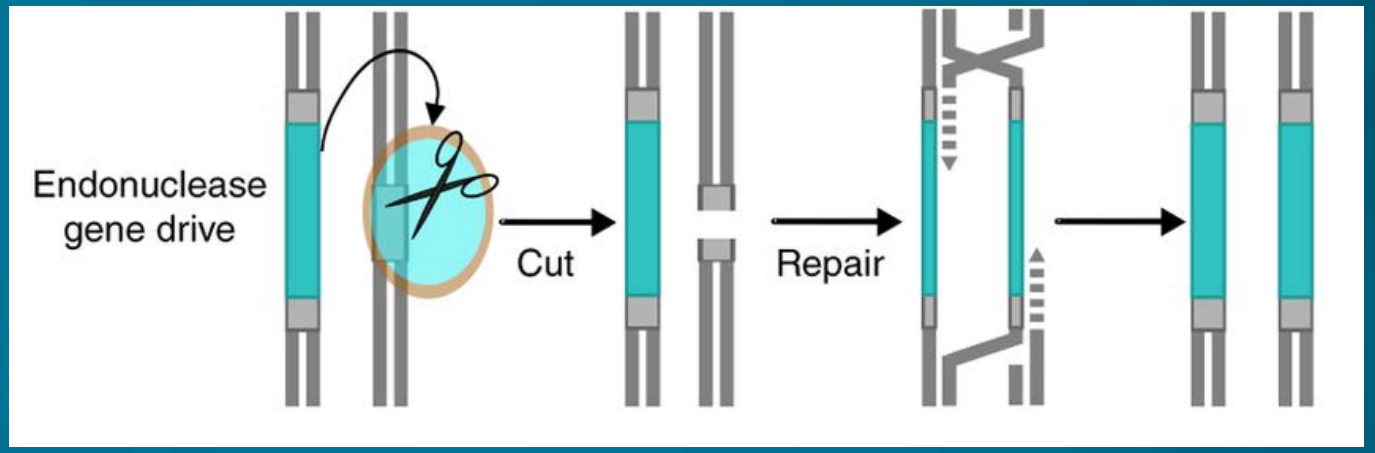
Gene Drive

T-Complex – natural



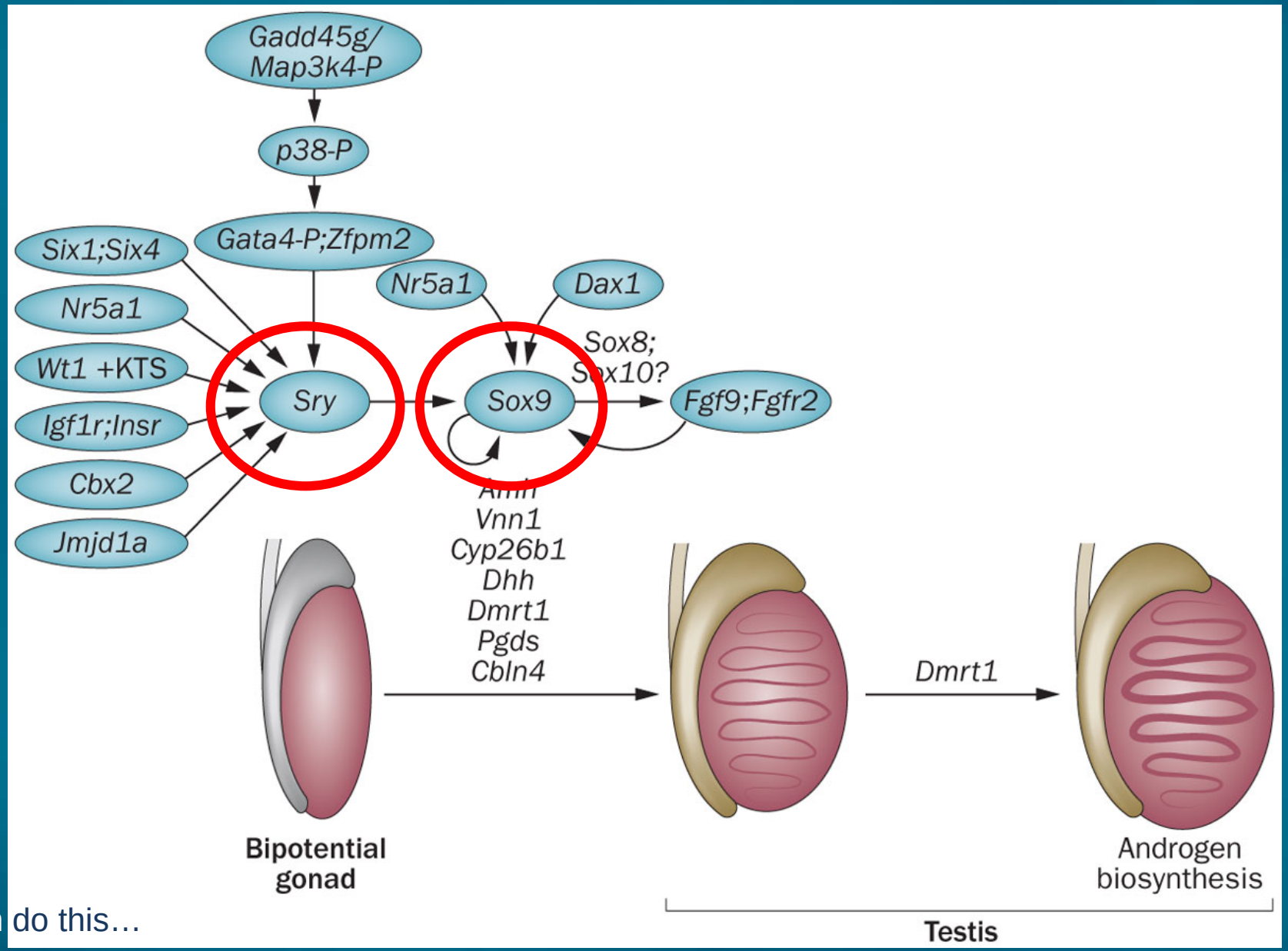
92% n = 691

CRISPR/Cas9 - synthetic



We can do this…

Mammalian Sex Determination



Bias sex ratio:

- Sry
- Sox9

We can do this…

Eggers *et al.* 2014

Genetic Biocontrol of Invasive Rodents

- *T-Complex/*Sry
- *CRISPR-Cas9/Sox9*
- Control mechanisms
- Risk assessment
- Mathematical models
- Breeding behavior
- Biocontainment
- Communications
- Island selection

- Genetic characterization of mouse populations & monitoring
- Regulatory (multi-national)
- Stakeholder/comm/public engagement
- Intellectual property
- Funding
- Program management
- Governance
  - Ethics committee
  - Advisory committee

We can do this…

NC STATE UNIVERSITY

USDA

CSIRO

TEXAS A&M UNIVERSITY

ISLAND CONSERVATION

THE UNIVERSITY of ADELAIDE

Leverage biology

- Population ~1000 house mice
- Released 42 male & 35 female mice from Eday Island
- After 18 months, all mice trapped were hybrids (n=70)
- Males were disproportionately responsible for ‘invasion’
- Leverage biology and promiscuity

We can do this…

Berry et al. 1991; Jones et al. 1995; Scriven 1992

RNA interference (RNAi)

Ribonucleic acid (RNA)

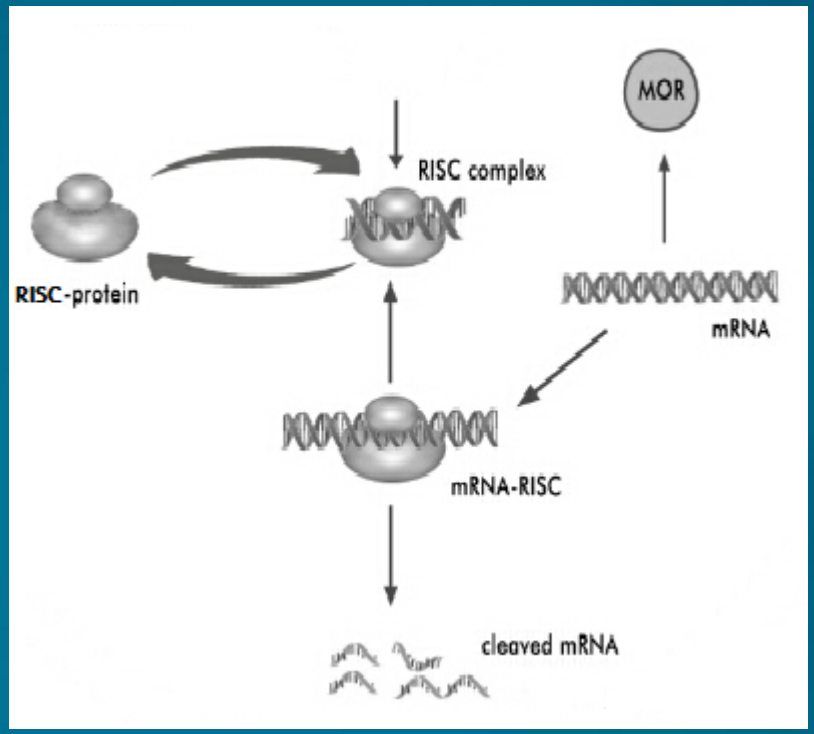
- Normally single stranded

Double-stranded RNA

- Elicits immune response
  - Double-stranded RNA and matching single-stranded RNA destroyed

Focus of a significant body of research:

- Invertebrate pest control
- Animal models (e.g. mice) as a potential cure for cancer and other diseases



We can do this…

RNA interference (RNAi)

Double-stranded RNA can be synthesized chemically

- Use as taxa-specific bio-pesticides

Can be synthesized biologically (species can produce it)

- Plants & animals can be vectors

Vertebrates digest RNA

- Nanoparticles as carriers

We can do this…

Gene drives & RNAi: Power-tools in the tool box?

Cautious investigation of opportunities required

Big picture

- –Reduce risks
- –Increase impact

We can do this…