

Introduction to Bioengineering
BIOE/ENGR.80
Stanford University

Spring 2020 Class Slides

Day 24
1 June 2020

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Week 8 reprise

PROJECT
SKILL

Evolution as algorithm

- four step process (population, select, reproduce, perform)

Evolution as service

- direct & sculpt w/ evolution in lab (SELEX, YSD, PACE)

Evolution 2.0?

- synthetic genetic codes that hinder evolution, gene drives

<Evolutionary algorithm sandbox>

- how do population size, selection %, etc, impact outcomes?

Week 9 look ahead

CONCEPT
SKILL

Planet health

People health

Political health

<Parsing & “Playing” Politics>

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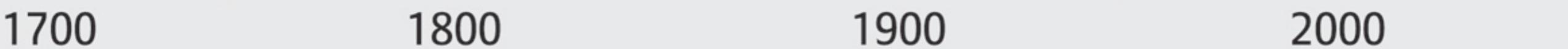
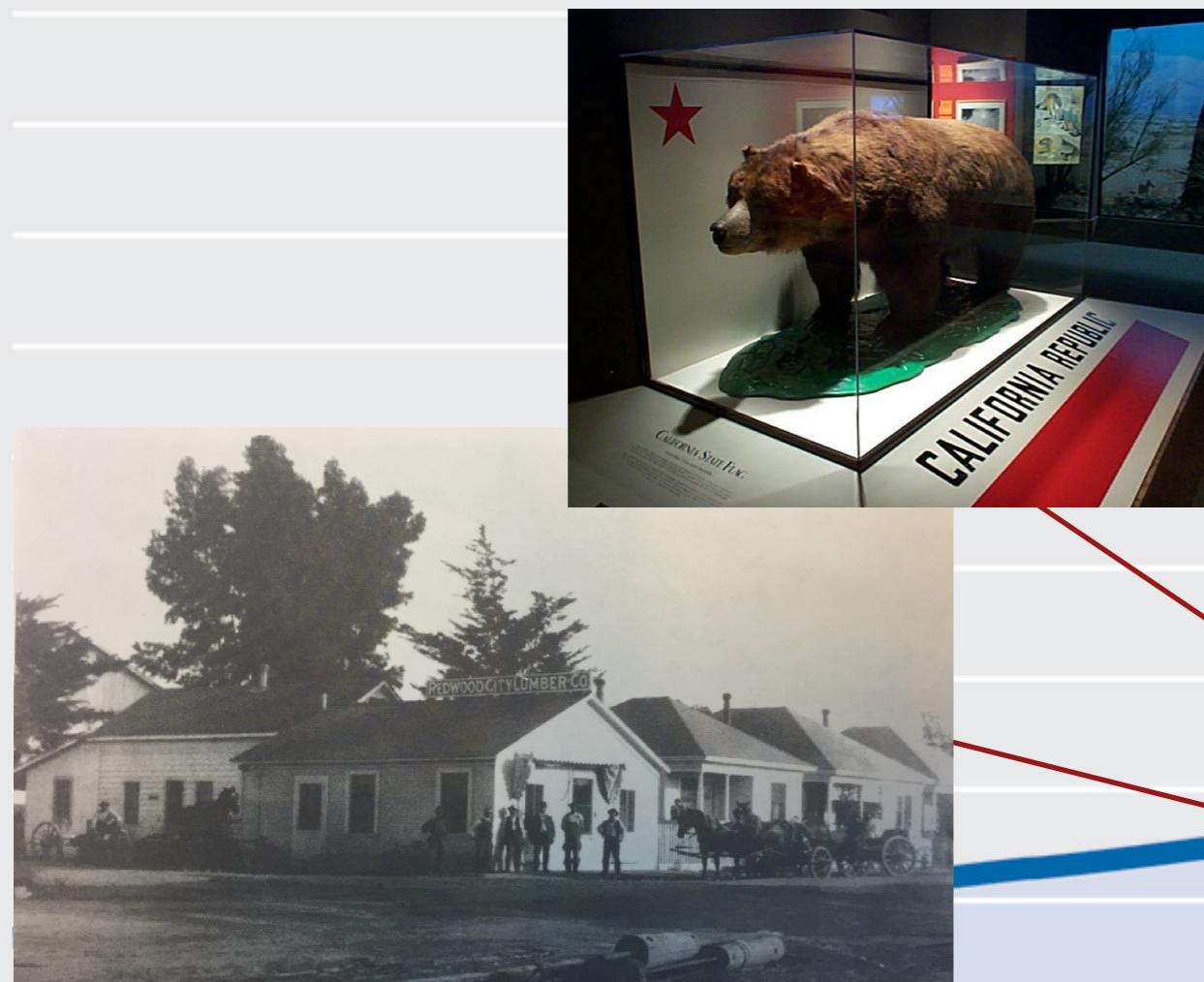
Day 5
15 April 2020

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POPULATION OF THE EARTH

Allianz 

Number of people living worldwide since 1700 in billions

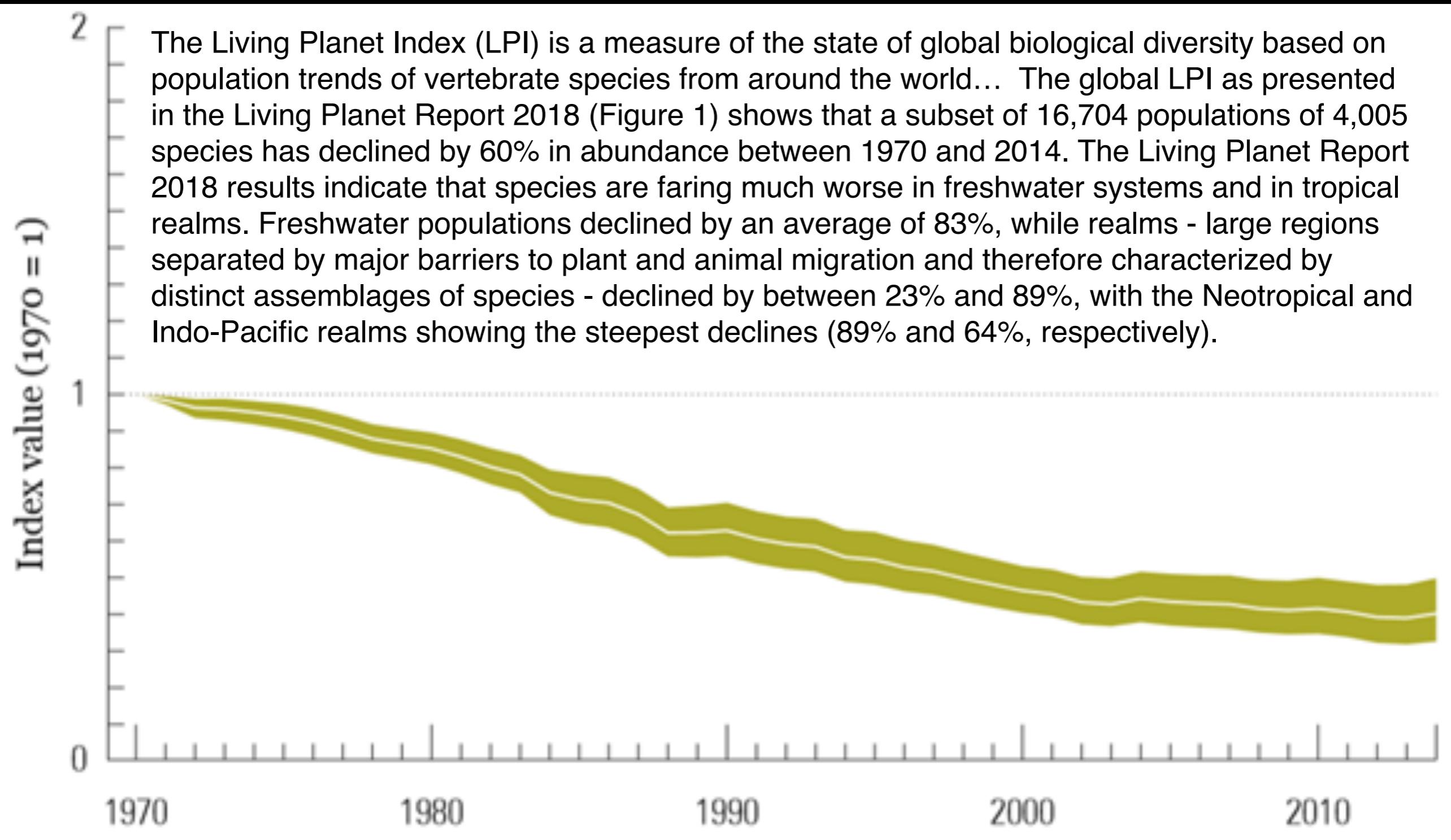


Source: United Nations World Population Prospects, Deutsche Stiftung Weltbevölkerung

For further information please visit: www.knowledge.allianz.com

Past ~50 years, humans x 2, animals / 2

The Living Planet Index (LPI) is a measure of the state of global biological diversity based on population trends of vertebrate species from around the world... The global LPI as presented in the Living Planet Report 2018 (Figure 1) shows that a subset of 16,704 populations of 4,005 species has declined by 60% in abundance between 1970 and 2014. The Living Planet Report 2018 results indicate that species are faring much worse in freshwater systems and in tropical realms. Freshwater populations declined by an average of 83%, while realms - large regions separated by major barriers to plant and animal migration and therefore characterized by distinct assemblages of species - declined by between 23% and 89%, with the Neotropical and Indo-Pacific realms showing the steepest declines (89% and 64%, respectively).



Accelerated modern human-induced species losses: Entering the sixth mass extinction

Gerardo Ceballos,^{1*} Paul R. Ehrlich,² Anthony D. Barnosky,³ Andrés García,⁴ Robert M. Pringle,⁵ Todd M. Palmer⁶

The oft-repeated claim that Earth's biota is entering a sixth "mass extinction" depends on clearly demonstrating that current extinction rates are far above the "background" rates prevailing between the five previous mass extinctions. Earlier estimates of extinction rates have been criticized for using assumptions that might overestimate the severity of the extinction crisis. We assess, using extremely conservative assumptions, whether human activities are causing a mass extinction. First, we use a recent estimate of a background rate of 2 mammal extinctions per 10,000 species per 100 years (that is, 2 E/MSY), which is twice as high as widely used previous estimates. We then compare this rate with the

species as evidence of gone extin years to indicating subsequen of opportu

Since 1900 alone, 69 mammal species are believed to have gone extinct, along with about 400 other types of vertebrates. Evidence for species lost among nonvertebrate animals and other kinds of living things is much more difficult to come by, the researchers say, but there's little reason to believe that the rest of life on Earth is faring any better.

- Land clearing for farming, logging and settlement
- Introduction of invasive species
- Carbon emissions that drive climate change and ocean acidification
- Toxins that alter and poison ecosystems



<https://youtu.be/ZZfBqdaafjA>



When what we add becomes a problem... ?



<https://youtu.be/ATXFCryzvgU>



DONATE **TODAY!**

[WHY ISLANDS](#)

[WHERE WE WORK](#) ▾

[ABOUT IC](#) ▾

[HOW TO HELP](#) ▾

[BLOG](#)

[CONSERVATION SCIENCE](#) ▾

OUR MISSION is to prevent extinctions
by removing invasive species from islands.



Which option would you choose?

Methods	Toxicants	Mechanical Methods	Biological Controls	Genetic Engineering*	No Methods Applied
Points of Comparison					* Speculative, as technology is not yet developed
Past attempts	Many. More successful for rats than mice	Not many for full eradication	Few	None	Yes
Monetary Costs	Millions of dollars and fixed	Thousands of dollars and fixed	Variable depending on invasive organism and treatment	Millions of dollars and likely decreasing over time	None
Social Acceptability	Controversial	Controversial	Controversial	Controversial	Controversial
Any current regulations?	Yes	Yes	Yes	Unclear	N/A
Species specific	No	No	Sometimes	Yes	N/A
Effective for eradication?	Yes, though more effective for rats than mice	No	No	Unknown	No

Extinction looms for native bird species on the Hawaiian island of Kauai



The i'iwi, a species of Hawaiian honeycreeper, on Kauai. Six out of seven of the studied species on the forested island could face extinction in the coming decades. (Jim Denny)

By **Sean Greene**

SEPTEMBER 16, 2016, 3:00 AM

Hawaiian honeycreepers have lived in the islands' tropical forests for millennia, but the colorful finch-like birds are facing "imminent collapse" on Kauai, experts say.



ADVERTISEMENT

In Case You Missed It



A GOP governor already is thinking of killing protection for preexisting conditions in his state

2 hours ago @ 10:05 am



Obama warned Trump not to hire Flynn two days after the election

2 hours ago @ 10:05 am



France's election proves it — America is now an example of

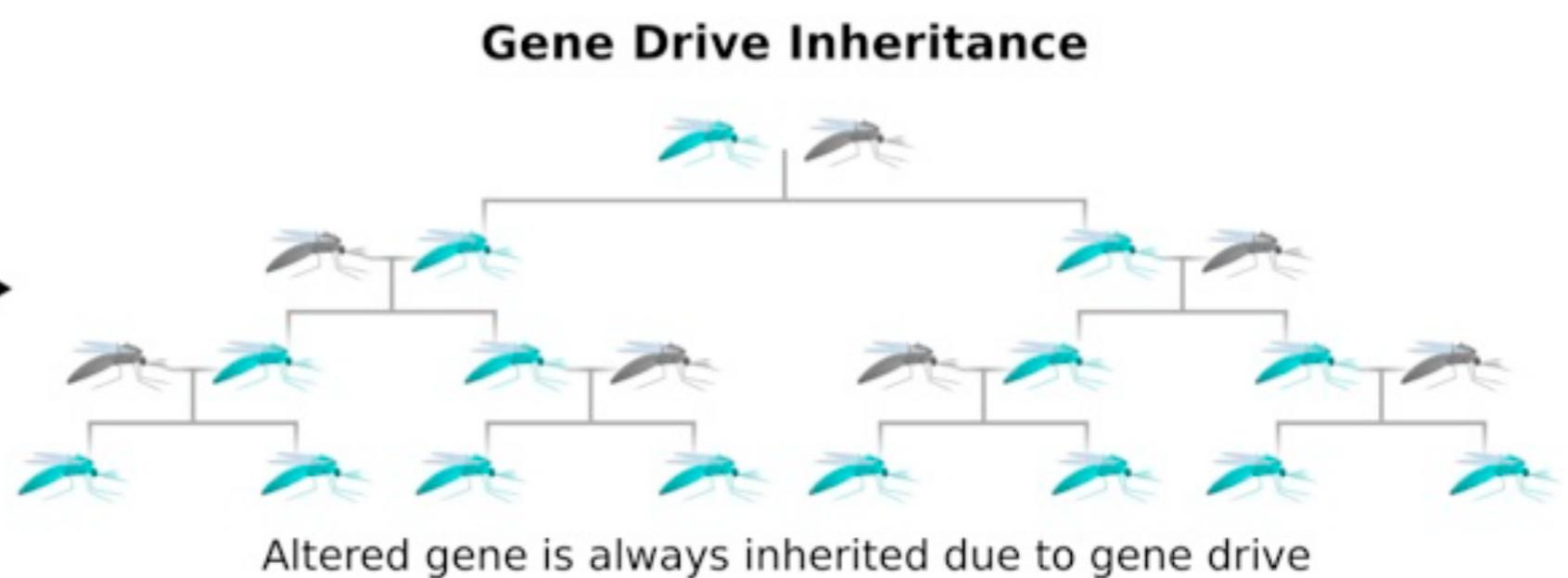
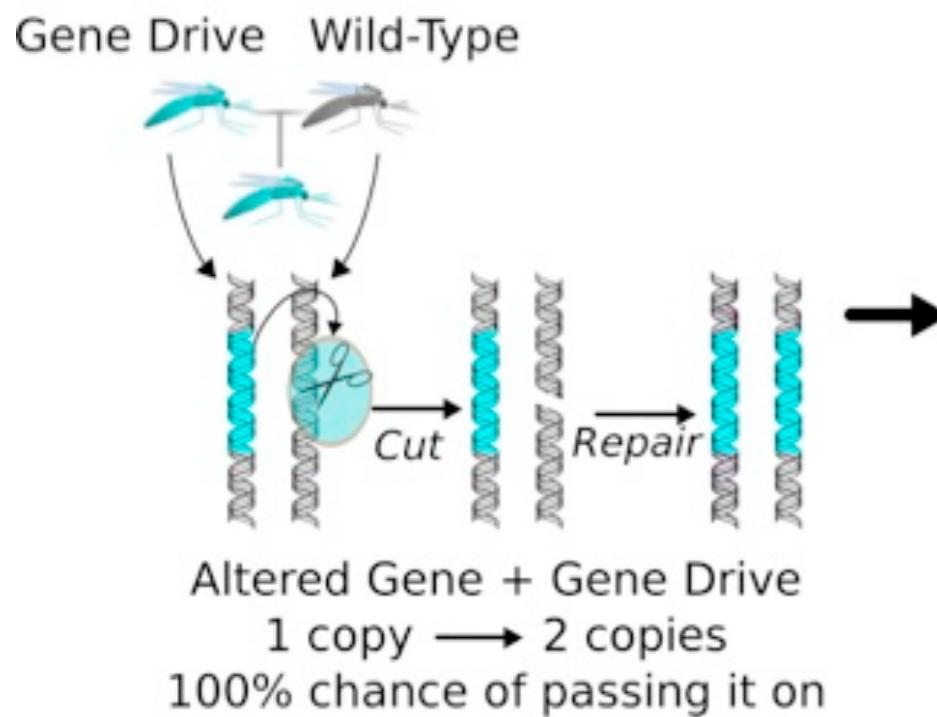
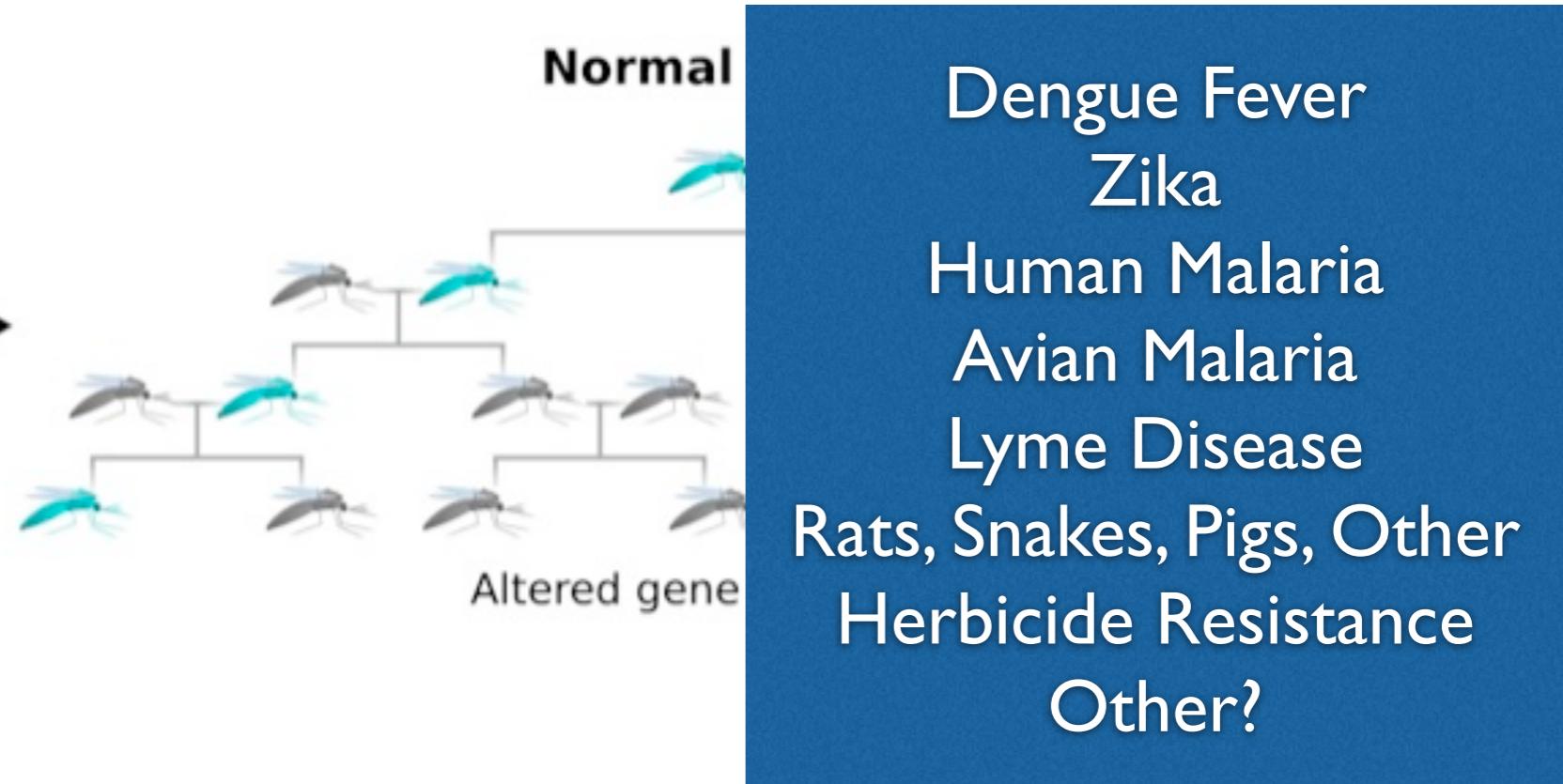
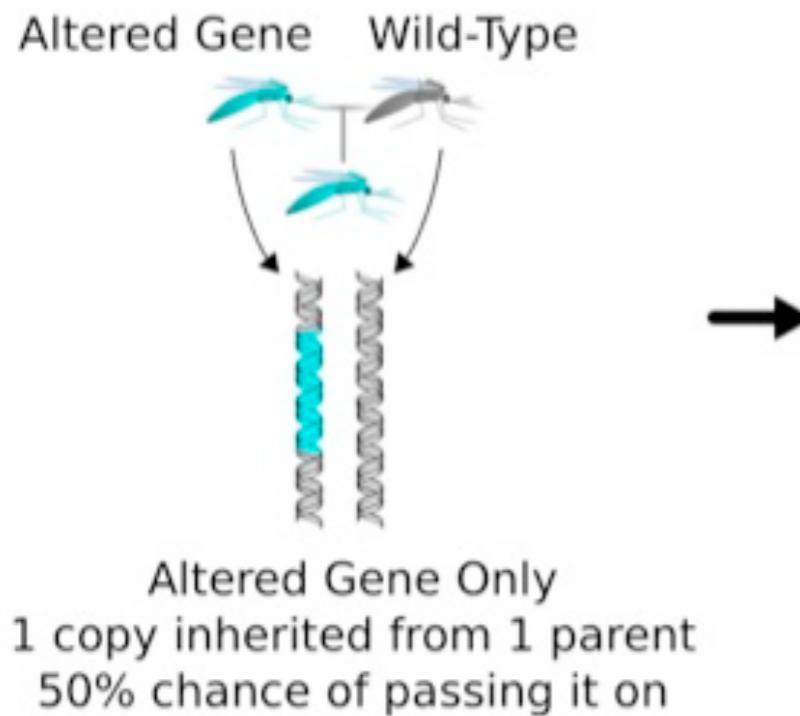
COULD GENETICALLY MODIFIED MOSQUITOES SAVE HAWAII'S ENDANGERED BIRDS?



By Michael Specter September 9, 2016

Every four years, thousands of environmentalists gather at the World Conservation Congress to assess the state of the planet, and to consider what might be done to protect it. This year's meeting ends Saturday, and the news this past week, with a few exceptions, has not been cheerful. Four of the six great-ape species are critically endangered, which means they are one step from extinction, according to the International Union for Conservation of Nature, which organizes the congress. So are thousands of other species. The eastern gorilla—the world's largest living primate—is in particular jeopardy.

“Drive” genes into wild populations





How will synthetic biology and conservation shape the future of nature?

A framing paper prepared for
a meeting between synthetic biology
and conservation professionals

Clare College, Cambridge, UK
9-11 April, 2013



“The modern field of conservation was born as a crisis discipline and it really was focused on trying to stop extinction.

So what does conservation want? What it wants is to conserve nature. Particular biodiversity and species and ecosystems with less emphasis on the genetic component.

It is based on a set of foundational values that focus on the natural and the wilderness.

It wants a world that doesn't change except by its own agency.

It embraces change but natural change.” — Kent Redford

<https://vimeo.com/225308429>

[https://secure3.convio.net/wcs/pdf/
Synthetic_Biology_and_Conversation_
Framing_Paper.pdf](https://secure3.convio.net/wcs/pdf/Synthetic_Biology_and_Conversation_Framing_Paper.pdf)

BREAKOUT BIOLOGICAL SPECULATION

Should conservations biologists and bioengineers work together? If yes then what's the limit? What's off limits?



International Union for Conservation of Nature

ISSUES BRIEF

www.iucn.org

SYNTHETIC BIOLOGY AND ITS IMPLICATIONS FOR BIODIVERSITY CONSERVATION

MAY 2019

- Synthetic biology refers to technologies that allow humans to make precise alterations to the genes of organisms.
- Synthetic biology applications have **important positive and negative implications for biodiversity conservation** depending on how they are designed and targeted.
- Potential benefits range from **protecting threatened species** to **providing synthetic alternatives** to wildlife products.
- Potential detrimental effects include **changes to ecological roles played by target organisms**, and **negative impacts on the livelihoods of indigenous and local communities** who largely depend on biodiversity.
- The use of synthetic biology needs to be informed by **case-by-case assessments**, guided by empirical evidence, and incorporating traditional knowledge, religious and ethical values in decision-making.

IUCN's mission is to "influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is equitable and ecologically sustainable".



THE IUCN RED LIST
OF THREATENED SPECIES™

IUCN has a membership of over 1400 governmental and non-governmental organizations. Some 16,000 scientists and experts participate in the work of IUCN commissions on a voluntary basis. It employs approximately 1000 full-time staff in more than 50 countries.

In December 2015, IUCN convened scientists and conservationists to a meeting in Bellagio, Italy to understand the relevance of synthetic biology to IUCN's mission and vision, to discuss the future of synthetic biology, its role in biodiversity conservation, and ways to influence the trajectory of the application of synthetic biology to conservation.

One outcome of the meeting was a motion that would become Resolution WCC-2016-Res-086 titled "Development of IUCN policy on biodiversity conservation and synthetic biology". In it, the Director General and IUCN Commissions are called to:

- *examine* the organisms, components and products resulting from synthetic biology techniques and the impacts of their production and use, which may be beneficial or detrimental to the conservation and sustainable use of biological diversity and associated social, economic, cultural and ethical considerations;
- *recommend* how IUCN, including its Commissions and Members, could approach the topic of synthetic biology and engage in ongoing discussions and deliberations with the synthetic biology community;
- *assess* the *implications* of Gene Drives and related techniques and their potential impacts on the conservation and sustainable use of biological diversity as well as equitable sharing of benefits arising from genetic resources;
- *develop IUCN guidance* on this topic, while refraining from supporting or endorsing research, including field trials, into the use of gene drives for conservation or other purposes until this assessment has been undertaken.

Proposed process and timeline for the development of an IUCN policy on synthetic biology

Early 2018: To address the requests in the Resolution, and building upon the work started by IUCN in Bellagio, a Task Force will be established to undertake a series of activities to develop an IUCN Synthetic Biology and Biodiversity Conservation assessment, and to develop policy recommendations for consideration by the IUCN Council before the 2020 World Conservation Congress.

2018: Part 1: Scientific and Policy Assessment. IUCN will conduct a broad assessment of the current state of science and policy around genomic technologies to identify potential applications and products that might impact conservation and the sustainable use of biological diversity, both negatively and positively.

End 2018 through 2019: Part 2: Engagement Activities. Regional leaders will be trained and run the consultation sessions in each Regional Conservation Forum. The consolidated feedback from each Regional Conservation Forum will be sent to the IUCN Synthetic Biology and Biodiversity Conservation Task Force that will then use it to help prepare the next draft of the policy. Complementary consultations will be run with international institutions and processes that are currently grappling with synthetic biology issues or that are strongly implicated by the assessment.

2019 through May 2020: Part 3: Policy Development. Finalize an IUCN policy to guide the Director General, Commissions, and Members on biodiversity conservation in relation to synthetic biology.

2020: Part 3: IUCN World Conservation Congress

<https://www.iucn.org/theme/science-and-economics/our-work/other-work/synthetic-biology-and-biodiversity-conservation/development-iucn-policy-synthetic-biology>

Critique of process integrity

Defense of process integrity



Driving Under the Influence?

A review of the evidence for bias and conflict of interest in the IUCN report on synthetic biology and gene drive organisms

Executive Summary

In May 2019, the IUCN published an assessment of a highly controversial field of biotechnology: synthetic biology. In reviewing those involved with this report, evidence suggests a majority of the authors hold a pre-existing bias towards strongly supporting synthetic biology and gene drives in particular. In addition, many of them have conflicts of interest, not all of which were disclosed in their signed Conflict of Interest statements to IUCN. The credibility of the resulting report, which advances a position strongly in favour of both synthetic biology and gene drive organisms, is rendered suspect due to the conflicts of interest, known biases of the authors and unbalanced constitution of the taskforce membership.

- In September 2016 the membership of the international Union for the Conservation of Nature (IUCN) passed a resolution requesting the organization undertake an assessment of the implications of the emerging field of synthetic biology and in particular controversial “gene drive” technologies while refraining from advocating for or supporting this technology.
- IUCN members might have made the reasonable assumption that the leadership of the IUCN would take a precautionary and even-handed approach to an assessment with such potentially far-reaching implications for biodiversity.
- Instead, the IUCN chose a different path, appointing a chair who is a well-known, enthusiastic advocate for the technology, Dr. Kent Redford.

- Redford in turn appointed a cohort of individuals whose track record clearly points to them being likely to take a strongly positive view of “gene drive” technologies and other developments in synthetic biology.

This document analyses the group of authors and taskforce members that IUCN chose for its synthetic biology assessment. It examines evidence of pre-existing biases as well as factors that could be perceived as conflicts of interest. Key findings include:

- Of the approximately 40 individuals associated with the report, over half display evidence of pre-existing bias in favor of the technology and/or potential conflict of interest. By contrast, not a single member of the group shows evidence of a pre-existing leaning towards critical views of synthetic biology. The group authoring this report was thus extremely unbalanced.

Many of the authors have conflicts of interest, not all of which were disclosed in their signed statements

- Three pro-synthetic biology interest groups appear to have had a disproportionate influence on the writing of this report: at least 15 members of the group appear to be associated with or employed by either Revive and Restore, Genetic Biocontrol of Invasive Rodents project (GBIRd) or Target Malaria. Those three organizations are among the world's most prominent and well-funded proponents of

Statement on the work of the IUCN Taskforce on Synthetic Biology and Biodiversity Conservation, August 2019

The explosion of knowledge that research on DNA has brought in recent years is extraordinary. The technologies that allow the alteration of the genes of organisms to make them do things that those organisms would not normally do is called synthetic biology. These rapidly evolving technologies may create opportunities in many fields, including new kinds of conservation approaches, but they also raise questions and complex challenges.

Given this, in 2016, IUCN's Members requested (WCC-2016-Res-086)^[1] an evidence-based assessment of the issues regarding synthetic biology that are relevant to and may have an impact – negative or positive – on the conservation and sustainable use of biological diversity. Specifically, the Resolution called on the Director General and Commissions to undertake an assessment to:

“examine the organisms, components and products resulting from synthetic biology techniques and the impacts of their production and use, which may be beneficial or detrimental to the conservation and sustainable use of biological diversity and associated social, economic, cultural and ethical considerations, and to recommend how IUCN, including its Commissions and Members, could approach the topic of synthetic biology and engage in ongoing discussions and deliberations with the synthetic biology community”



Current status?

Motion for consideration at 2020 congress.

What is the motion?

Principles (not policy) re: synthetic biology & gene drives. Formal policy as motion perhaps in 2024.

What is happening until Marseille?

Translate documents into many languages, present at IUCN Regional Conservation Fora, extended online engagement, receive and process proposed edits, engage CBD AHTEG, etc.

We're just a biological speculation
Sittin' here, vibratin'
And we don't know what we're vibratin' about

And the animal instinct in me
Makes me wanna defend me
It makes me want to live when it's time to die

Y'all, see my point
I don't mean to come on strong but I am concerned

I believe in God
Though I know that law and order must prevail
Oh, if and when the laws of man
Is not just equal and fair
Then the laws of nature will come and do her thing

Oh, she does not think
She just rectifies
She comes and balances the book
Y'all see my point?

