From: geneticrescue-bounces@list.longnow.org on behalf of Andy Newhouse <andynewhouse@yahoo.com>
Sent: Tuesday, November 14, 2017 1:36 PM
To: Ben Novak; Ryan Phelan
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] why are NGOs skeptical of gene editing
Attachments: ATT00001.txt

I've been reading and thinking about this article for a few days, and I think it's worth a little more consideration.
First, to Ben's point about the author affiliation - they directly address this at the end of the article:
"*The authors declare that they have no conflict of interest. LO'N's position as co-author represents her key role facilitating contact with research participants who have been traditionally hard to access. LO'N was a focus group participant, who was not interviewed and played no part in research design or data analysis...*"
Perhaps similarly, I have co-authored papers with scientists who have or had ties to for-profit biotech companies. I can honestly say those companies had no influence on the content of the papers, and I'd be offended if readers dismissed my work for that reason. But - even if this paper *is* inherently biased, the point is to describe why certain groups are skeptical - and that seems like a valuable insight.

Given that, I think most of us as biotechnology practitioners or proponents would benefit from an open-minded reading/skimming of this paper. (I'm not defending it *per se*, and there are definitely some points I still have issue with, but that doesn't mean it's not valuable.) First, one of their main points is that skepticism often stems from problem framing, or what people see as the real issue. To use an example from the paper: instead of seeing the issue as "is this food safe", the actual concern might be "who should be producing our food". Those two questions should be approached in entirely different ways - the first can be addressed with data, the second can't. Throwing more science at that second question won't help. That's a hard thing for us as scientists to accept, and it doesn't mean we all need to become ethicists and social science experts, but I've found this a helpful reminder in various discussions recently.

Additionally, the title of this paper is about "genome editing", and yet *all* of the examples and discussions are about agricultural applications of that technology. The authors even mention repeatedly that their interviewees had a hard time separating agricultural biotechnology from intensive agriculture more generally, which in turn shapes many of their opinions about the technology. As all of us on this list are well aware, there are numerous non-agricultural applications being developed; it would have been very interesting for the authors to include some non-ag, not-for-profit, conservation-focused examples to help their focus groups think about the technology outside of agriculture. How do we foster appropriate discussions of non-agricultural biotechnology, outside the familiar realm of science & data? I know some of us are already exploring that area - let's keep that up and contribute where we can. Do you have other thoughts or suggestions along those lines?

Overall, I think the authors make a valuable point that not all opposition to biotechnology is based on "emotion and dogma". It's unfortunate that this has become a polarizing debate, but in that reality, I think both "sides" still have much to learn if we want to reach some consensus and move forward.

Andy Newhouse
SUNY-ESF
American Chestnut Research & Restoration Project
On Sunday, November 12, 2017, 9:25:13 PM EST, Ryan Phelan wrote:

Spot-on Ben

Ryan Phelan
Executive Director and Co-founder
Revive & Restore
415-710-9409 cell

On Nov 12, 2017, at 9:06 PM, Ben Novak <ben@reviverestore.org> wrote:

> It's interesting that one of the author's affiliations is "GM Freeze", a group that is peddling misinformation on GMOs and calling for a moratorium on the technology in agriculture - doesn't sound biased at all.
>
> On Mon, Nov 13, 2017 at 6:05 AM, Kent Redford <redfordkh@gmail.com> wrote:

Kent Redford
Archipelago Consulting
Portland, ME 04112, USA

Cell: ++ 914-263-6163
Skype: Kent.H.Redford
redfordkh@gmail.com

From: geneticrescue-bounces@list.longnow.org on behalf of Kent Redford <redfordkh@gmail.com>
Sent: Sunday, November 12, 2017 1:06 PM
To: Genetics Listserve
Subject: [Geneticrescue] why are NGOs skeptical of gene editing
Attachments: Helliwell et al. 2017. NGOs genome editing.pdf; ATT00001.htm; ATT00002.txt

From: geneticrescue-bounces@list.longnow.org on behalf of Kent Redford

Sent: Wednesday, November 08, 2017 2:36 PM
To: Genetics Listserve
Subject: [Geneticrescue] societal risk assessment for synbio
Attachments: Cummings and Kuzma. 2017. synbio Societal risk eval.pdf; ATT00001.htm; ATT00002.txt

A new piece on societal risk assessment of synbio.
Kent

Synthetic biology (SB) applies engineering principles to biology for the construction of novel biological systems designed for useful purposes. From an oversight perspective, SB prod- ucts come with significant uncertainty. Yet there is a need to anticipate and prepare for SB applications before deployment. This study develops a Societal Risk Evaluation Scheme (SRES) in order to advance methods for anticipatory governance of emerging technologies such as SB. The SRES is based upon societal risk factors that were identified as important through a policy Delphi study. These factors range from those associated with traditional risk assessment, such as health and environmental consequences, to broader features of risk such as those associated with reversibility, manageability, anticipated levels of public concern, and uncertainty. A multi-disciplinary panel with diverse perspectives and affiliations assessed four case studies of SB using the SRES. Rankings of the SRES components are compared within and across the case studies. From these comparisons, we found levels of controllability and familiarity associated with the cases to be important for overall SRES rankings. From a theoretical standpoint, this study illustrates the applicability of the psycho- metric paradigm to evaluating SB cases. In addition, our paper describes how the SRES can be incorporated into anticipatory governance models as a screening tool to prioritize research, information collection, and dialogue in the face of the limited capacity of gover- nance systems. To our knowledge, this is the first study to elicit data on specific cases of SB with the goal of developing theory and tools for risk governance.

OPEN ACCESS

Citation: Cummings CL, Kuzma J (2017) Societal Risk Evaluation Scheme (SRES): Scenario-Based Multi-Criteria Evaluation of Synthetic Biology Applications. PLoS ONE 12(1): e0168564. doi:10.1371/journal.pone.0168564

Editor: Igor Linkov, US Army Engineer Research and Development Center, UNITED STATES

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Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Funding: This study was funded by the Alfred P. Sloan Foundation; Looking Forward to Synthetic Biology Governance: Convergent Research Cases to Promote Policy-Making and Dialogue (#556583). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

From: geneticrescue-bounces@list.longnow.org on behalf of Daniel Tompkins <TompkinsD@landcareresearch.co.nz>
Sent: Monday, August 28, 2017 1:48 PM
To: Kevin Esvelt; Heath Packard
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] computer model estimates that gene-drive technology could wipe out populations of an invasive mammal on islands
Attachments: ATT00001.txt

Dear All
I would just like to add to this conversation from the perspective of the NZ 'Predator Free 2050' program. There is currently no set research program for PF2050, and so the statement "scientists involved in the program have placed their hopes in engineered gene drives" is incorrect.
The technical details of the research strategy for PF2050 *are* reaching the end-game of construction, and I'm hopeful that they will be made available publically by the end of September. What *is* public knowledge is that the technical developments being focussed on are in two areas:

- New genetic controls tools. This acknowledges that there are fast-moving developments internationally that have sufficient potential value to PF2050 to warrant further exploration. Note that this consideration is not restricted to CRISPR/Cas9.
- Eradicating the last 1 %. This acknowledges that operational predator-control in NZ can already reliably get >95% control of PF2050 target pest species using current tools. Also, even should development of any new genetic tool be successful, the risk of leaving survivors will increase as the spatial scale of application goes up.

Best wishes, Dan.
From: geneticrescue-bounces@list.longnow.org [mailto:geneticrescue-bounces@list.longnow.org] **On Behalf Of** Kevin Esvelt
Sent: Tuesday, 29 August 2017 4:24 a.m.
To: Heath Packard
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] computer model estimates that gene-drive technology could wipe out populations of an invasive mammal on islands
Indeed - kudos to Paul and coworkers!
I'd like to add a note of caution about the strategy, though: this is standard CRISPR-based gene drive, which is *extraordinarily* invasive (more on this soon). As Paul and co. note in their excellent work, any rodent eradication effort on an island would take well over a year, so there would be an extended window in which gene drive rodents could stow away or be deliberately moved by people with economic motivations. Unless the drive system can be targeted to specific mutations that are unique to the local invasive population, this is a potentially dangerous approach - and I for one am not willing to risk the social consequences of accidental spread.
On resistance: three different groups have now created models suggesting that the multiple guides approach will solve the problem of resistant alleles as originally predicted. Note that none of this means that other forms of resistance will not arise. Indeed, it's quite likely. However, I personally suspect that destroying the genetic basis of resistance at the fertilization stage using an orthogonal maternally- or paternally-deposited CRISPR system would likely overcome the vast majority of potential forms of resistance.
Bluntly, those concerned about off-target cutting should not be, as recent experiments using Cpf1 enzymes and higher-specificity SpCas9 variants have lowered it to borderline undetectable levels. It's also worth noting that in a gene drive configuration, a 1% or even 10% off-target cut rate would at worst cause a fitness loss, and in a rodent with a large genome is likely to do nothing whatsoever. Jumping to a different species via hybridization can and should be tested in advance; we're currently developing a nematode platform that hopefully will be able to detect one such event in a billion potential hybridizations. Admittedly this will be in nematodes with HDR rates tuned to match the target species rather than the target species itself, but this is DNA and CRISPR, so meh.
Cheers,
Kevin
On Mon, Aug 28, 2017 at 11:58 AM, Heath Packard <heath.packard@islandconservation.org> wrote:

Good one-

http://www.the-scientist.com/?articles.view/articleNo/50180/title/Driving-Down-Pests/

Driving Down Pests

A computer model estimates that gene-drive technology could wipe out populations of an invasive mammal on islands.

By Amy Lewis | August 28, 2017

The government of New Zealand has a goal: to wipe out the most damaging introduced predators in the nation by the year 2050 through the Predator Free 2050 program. At present, rats, possums, and stoats have pushed native species such as the kakapo to near extinction and cost the country NZ$70 million (USD$50.5 million) in pest control measures and NZ$3 million (USD$2.2 million) in agricultural losses annually.

Acknowledging that the existing pest-control methods are not going to be enough for this ambitious project, scientists involved in the program have placed their hopes in engineered gene drives: a technology that involves meddling with the rules of inheritance and increasing the likelihood a deleterious gene will be passed to the next generation of a species. With the advent of the gene-editing tool CRISPR-Cas9, which allows scientists to alter DNA at precise locations using a single guide RNA and a DNA-cutting molecule called Cas9, the idea of using gene-drive technology to turn populations on themselves is now within reach.

In a study published August 9 in the *Proceedings of the Royal Society B*, researchers at the University of Adelaide have provided modeling evidence that gene drives could indeed be an effective means to wipe out entire populations of invasive vertebrates on islands.

“The most obvious potential advantage to using gene-drive technology for this purpose is species specificity,” says Luke Alphey, a genetic pest management expert at the Pirbright Institute in the U.K. and a cofounder of Oxitec, which is commercializing other genetic-modification methods to control insects. “Genetic approaches are transmitted through mating, so the direct effect is only on the target species.”

The researchers conclude that a single introduction of just 100 mice carrying one of these gene drives could destroy an island mouse population of 50,000 individuals within four to five years.

“That aspect alone is phenomenally powerful if we are talking about working in an ecologically fragile environment,” notes Alphey, who was not involved in the study. He says the current approach for managing invasive species consists predominantly of “harmful mass poisoning.”

See “Using Gene Drives to Limit the Spread of Malaria”

In this recent study, the scientists chose to test gene-drive strategies on a simulated island population of 50,000 mice that they constructed in silico. Invasive rodents are likely responsible for the greatest number of extinctions and ecosystem changes on islands, according to a 2006 study. The house mouse (*Mus musculus*) in particular has been shown to have a devastating effect on seabird colonies in places such as Gough Island in the South Atlantic and New Zealand’s Antipodes Islands.

“We also focused on islands because in the long term . . . if this technology is deemed a good idea and acceptable by society, islands will be the first place it is carried out as it is easier to control,” explains coauthor Paul Thomas. “There’s a long way to go before we think about using it, but we wanted to conduct this study to see if it could be a possibility.”

Using a mathematical model, the scientists tested four CRISPR-based gene-drive strategies that could be readily developed based on what is within the current literature. The “heterozygotic XX sterility” strategy, also known as the “daughterless strategy,” involves using the gene drive to spread a male sex-determining gene so that all carriers develop as males regardless of their sex chromosomes. As a result, there will be a deficiency of females and the population will eventually crash.

“Heterozygotic XX sex reversal” is a similar technique, but contains additional genetic cargo that enables XX males to transmit the gene drive. “Homozygotic XX sterility” achieves population suppression through the infertility of homozygous females. The final strategy, “homozygotic embryonic non-viability,” causes embryonic fatality through gene mutation. All of these strategies were based on the basic CRISPR-Cas9 system using a single guide RNA.

The heterozygotic XX sterility strategy failed to present itself as a viable method, the researchers found, as carrier XX males are infertile and therefore unable to pass on the gene drive. The paper notes that this method would only prove effective on the basis of a continuous release of gene drives into a population, a process that would be costly and time-consuming.

The remaining three strategies proved capable of causing rapid population decline to the point of elimination. The researchers conclude that a single introduction of just 100 mice carrying one of these gene drives could destroy an island mouse population of 50,000 individuals within four to five years.

If this technology is deemed a good idea and acceptable by society, islands will be the first place it is carried out as it is easier to control.—Paul Thomas,

University of Adelaide

The researchers acknowledge that, for all of these strategies, the potential for the formation of resistant genes poses a problem, as has been observed in laboratory studies of mosquito gene drives. However, by conducting further tests that involved targeting several different DNA sequences with more than one guide RNA, they found that the possibility of this resistance is reduced.

Michael Wade, who studies population genetics and mating at Indiana University, is not convinced that this solution to resistance comes without consequence. He says that by using multiple guide RNAs as the authors suggest, one could increase the risk of targeting the genome at unintended sites, which may lead to other problems.

“Release of this type of construct raises the risk of reducing the target specificity of CRISPR-Cas9 and increasing the possibility of it jumping to a different species, possibly an endemic relative of the invader species targeted for eradication,” he writes in an email to *The Scientist*.

See “Gene Drive's Achilles Heel”

Concerns have been raised by members of National Academies of Sciences, Engineering, and Medicine in a consensus study report about the potential consequences of using gene drives for species eradication, including the unintentional spread to other populations, unpredictable negative effects on the ecosystem, and ethical implications. Thomas and his colleagues are “very conscious” of these worries, he says.

“I think this method definitely has potential but we do need to do more studies, have the conversation around whether it is safe to use, and see if the benefits outweigh the risks. We are keen to engage with all members of the community,” he says. His team has now begun conducting a mouse-based gene-drive experiment in the laboratory.

T.A.A. Prowse et al., “Dodging silver bullets: good CRISPR gene-drive design is critical for eradicating exotic vertebrates,” *Proc Royal Soc B*, doi:10.1098/rspb.2017.0799, 2017.

Tags

pests, new zealand, mouse models, invasive species, genetics & genomics, gene drive, computer modeling and computational biology

Heath Packard

Director of Marketing & Communications

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From: geneticrescue-bounces@list.longnow.org on behalf of Kevin Esvelt <kesvelt@gmail.com>
Sent: Monday, August 28, 2017 11:24 AM
To: Heath Packard
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Cheers,
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Heath Packard

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From: geneticrescue-bounces@list.longnow.org on behalf of Ryan Phelan <ryan@reviverestore.org>
Sent: Thursday, July 27, 2017 10:04 AM
To: Genetics Listserve
Subject: [Geneticrescue] Training for effective conservation translocations
Attachments: ATT00001.txt

Revive & Restore is looking for expertise in multi-stakeholder engagement—and if I were in London this Nov I'd be inclined to attend this workshop. I'm wondering who amongst the faculty listed below might have the greatest expertise in this area? Comments welcome.

This IUCN RSG 4-day training workshop is aimed at conservation biologists and managers working on conservation transloations and reintroductions.

The IUCN Reintroduction Specialist Group aims to create profound benefits for nature and people by saving species and restoring the function of ecosystems. To do so it supports conservation biologists and managers in designing and managing the complexities surrounding conservation translocations in terms of multi-stakeholder interests, biological uncertainties and risk. Through this workshop it hopes to ultimately increase knowledge to plan, courage to act, certainty to secure resources, skill to respond to challenges, and support the achievement of successful conservation outcomes.

Faculty

Workshop facilitators are leading experts in the field and include those involved in writing and/or evaluating the IUCN Guidelines on Reintroductions and Other Conservation Translocations.

- **Stefano Canessa, FWO post-doctoral fellow at the University of Gent**

Stefano's research focuses on demographic modelling and decision-making for endangered species management, particularly disease mitigation and conservation translocations. He has been involved in species recovery plans in Europe and Oceania, ranging from frogs and turtles to birds and bats.

- **Sarah Converse, Unit Leader of the Washington Cooperative Fish and Wildlife Research Unit**

Sarah is an Associate Professor in the School of Environmental and Forest Sciences (SEFS) and the School of Aquatic and Fishery Sciences (SAFS) at the University of Washington in Seattle. Her research program is built around two themes – quantitative population ecology of endangered species and decision analysis applications in endangered species management.

- **Jamie Copsey, Director of Training for the IUCN Conservation Planning Specialist Group (CPSG)**

Jamie has worked as a professional trainer and facilitator in the field of conservation biology for more than 16 years and also lectures extensively around the topic of conservation management as well as publishing in an eclectic range of topics including conservation leadership, invasive species management, amphibian conservation and capacity development. In his new role with the CPSG Jamie is responsible for determining how the IUCN SSC can scale up capacity for species conservation planning globally.

- **John Ewen, Senior Research Fellow at the Institute of Zoology, Zoological Society of London**

John's research focuses on reintroduction biology and threatened species recovery. He is co-chair of New Zealand's Hihi (Stitchbird) Recovery Group and is involved in a growing number of projects including birds and mammals spanning New Zealand, Australia and Mauritius.

- **Axel Moehrenschlager, Chair of the IUCN SSC Reintroduction Specialist Group**

Axel is motivated to amplify translation, policy integration, training, and application of the IUCN Guidelines for Reintroductions and Other Conservation Translocations to help more species, ecosystems, and people worldwide. He is the Director of Conservation & Science at the Calgary Zoo, Adjunct Associate Professor at the University of Calgary, and Research Associate at Oxford University where he received his PhD.

- **Phil Seddon, Professor of Zoology and Director of the Postgraduate Wildlife Management Programme at the University of Otago**

Over the last 25 years Phil has been involved in a number of bird, mammal and reptile reintroduction projects in New Zealand, Australia, SE Asia, and the Middle East.

From: geneticrescue-bounces@list.longnow.org on behalf of Dan Gluesenkamp <dgluesenkamp@cnps.org>
Sent: Wednesday, July 12, 2017 9:29 PM
To: 'Carl Zimmer'; 'sb'
Cc: 'Genetics Listserve'; 'True Nature Foundation'
Subject: Re: [Geneticrescue] 6th extinction
Attachments: ATT00001.txt

Hi gang
I also believe that some of what we are doing is likely to result in a net increase in low-level taxonomic diversity, in the long term, assuming we don't Venus the place. For example, thousands of CNPS members are planting California native plants in their yards; given what we know about plant diversification in California, it is likely that this will result in countless new plant types in thousands of locations –centuries from now we will have "South Central LA manzanita" and "Beverly Hills manzanita" in addition to the "Vine Hill manzanita," "Franciscan manzanita," etc.
However. These are shallow branches on the tree. They are variations on a theme. They are ephemeral. We are losing some deep branches, and stand to lose terribly deep clades. Ancient lineages.
A metaphor: music is like species. A song can generate almost endless variations simply by changing a bit of the code. It's great that "Summertime" has given rise to so many wonderful new variations. But it would be no substitute for the loss of Brubeck, Zeppelin, Bach, Poppy, and Ono/Lennon. Much less the loss of deep clades of music, like jazz or gamelan.
That is what we face today with evolved diversity: we may be gaining a few new hybrid animal or plant types or an seeing a fun ebullience of little new variations, but that is no consolation when we stand to lose…wait for it.. substantial parts of Salamandra? Too much of Amphibia?!?!? Bats?!? Snakes (Harry?)? Substantial chunks of Plantae?

Of course, the hope is that this group will play a role in stopping that. We need to keep those old lineages that represent deep diversity.
Net diversification is fun to think about, but we want to save the whole panoply of variation. It's not just numbers. You wouldn't value the Louvre no matter how many versions of the Mona Lisa it had, if it did not also have other art, other art forms. More pragmatically, if we are going to live on this planet indefinitely we want those old deep solutions to survival, not just a large number of newcomers.
So THANK YOU to Revive and Restore, and to everyone on this list who is for working on stopping those diseases!
-Dan
Dan Gluesenkamp, Ph.D.
Executive Director
The California Native Plant Society
2707 K Street, Suite 1
Sacramento, CA 95816
916.447.2677 x201
http://CNPS.org


Please consider including CNPS in your estate plan.
From: geneticrescue-bounces@list.longnow.org [mailto:geneticrescue-bounces@list.longnow.org] **On Behalf Of** Carl Zimmer
Sent: Wednesday, July 12, 2017 4:11 PM
To: sb
Cc: Genetics Listserve; True Nature Foundation
Subject: Re: [Geneticrescue] 6th extinction
Thee's a lot of debate about the apparent increase in species in recent geological time. Maybe it's an artifact of the fossil record (better fossils in recent rocks). Since thefossil record is dominated by marine animal species, maybe it has to do with long-term geological changes to the sea floor, creating more niches. Etc.
c

Carl Zimmer

Matter, a weekly science column for the New York Times

Friday's Elk, a weekly newsletter
More information at carlzimmer.com
@carlzimmer
On Thu, Jul 13, 2017 at 12:02 AM, sb <sb@longnow.org> wrote:
Roughly the same rate, but the last 200 million years has brought many more species at a pretty steady rate -- more than erasing the effects of the last two mass extinctions.
That's part of what Chris Thomas is referring to.
--Stewart

On Jul 12, 2017, at 12:18 PM, True Nature Foundation <info@truenaturefoundation.org> wrote:

> An excerpt from the article
> "There is no doubt that the rate at which species are dying out is very high, and we could well be in for a "Big Sixth" mass extinction. This represents a loss of biological diversity. Yet, we also know that the Big Five mass extinctions of the past half billion years ultimately led to increases in diversity. Could this happen again? It seems so, because the current rate at which new animals and plants (such as the apple fly, the Italian sparrow and Oxford ragwort) are coming into existence is unusually high – and it may be the highest ever. We are already on the verge of Genesis Number Six – a million or so years from now, the world could end up supporting more species, not fewer, as a consequence of the evolution of Homo sapiens"
> Add "assisted evolution" or "deliberate de-extinction", and we might have a complete new (and positive) way of looking at the future...
> Op 12 jul. 2017 21:10 schreef "True Nature Foundation" <info@truenaturefoundation.org>:
> Yep, see https://m.phys.org/news/2017-07-sixth-mass-genesis-species-faster.html
> Instead of destroying, we are also creating and reshuffling.
> Op 12 jul. 2017 18:41 schreef "Stewart Brand" <sb@longnow.org>:
> There's a new book from ecologist Chris Thomas in UK that says we are now in the midst of a human-caused mass speciation. He documents widespread creation of new species to adapt to changes that humans have wrought, especially global warming. A major engine of all that, it turns out, is hybridization—as creatures and plants on the move find distant cousins and mate with them.
> The book is
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> # Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction
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> It's so far only available from UK, here:
> https://www.amazon.co.uk/Inheritors-Earth-Nature-Thriving-Extinction/dp/0241240751/ref=sr_1_1
> There's a good long review of it by our friend Matt Ridley (who is working with us on de-extincting the great auk):
> http://www.rationaloptimist.com/blog/mass-speciation/
> --Stewart
>
> > On Jul 12, 02017, at 5:28 AM, george church <gc@harvard.edu> wrote:
> > Lots of discussion of this month's PNAS paper on The Sixth Extinction.
> > A half-baked question: What would the signature of "net species creation" (rather than "net annihilation") look like?
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> > --george
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From: geneticrescue-bounces@list.longnow.org on behalf of Ben Novak

Sent: Wednesday, July 12, 2017 8:59 PM
To: Carl Zimmer
Cc: Genetics Listserve; True Nature Foundation
Subject: Re: [Geneticrescue] 6th extinction
Attachments: ATT00001.txt

Coming from a paleontology education background and a student of mass extinctions for many years, I have to reiterate Carl's caution about interpreting rises in biodiversity - this is most likely wrong. Paleontologists widely accept, based on well researched data in rock units around the world, that the "rise in biodiversity" seen in the fossil record is the result of preservation bias - as time goes on there's simply more chances of a fossil getting destroyed or buried too deep to find.

In direct response to Carl's comment - The fossil record is dominated by marine taxa because fossilization requires water - only certain sediment environments are conducive to fossilization, and all marine habitat types foster fossilization, while only a small percentage of terrestrial habitats are good for fossilization. Almost all terrestrial fossils ever found come from lacustrine sediments (lakes, bogs, swamps, etc). In truth, we have absolutely no idea what a desert living dinosaur actually looked like - because we've never found one. This is something highly skewed by popular paleo-artistry - the deserts we find dinosaurs in today were wet environments when they lived.

Biodiversity has likely, just like a species' population number, oscillated about a global carrying capacity for the past 200-300 million years - essentially once life colonized land and all modern phyla evolved we should consider that biodiversity levels reached modern equivalence - and the mass extinctions are the major events that reset the clock.

I hesitate to change the rhetoric of the 6th mass extinction by citing new evolution, no matter how high the rates, as making the 6th mass extinction something not to be concerned about. And I will reference this statement from the excerpt Henri sent:

"We are already on the verge of Genesis Number Six – **a million or so years from now**, the world could end up supporting more species, not fewer, as a consequence of the evolution of Homo sapiens"

A million years or so?! So we'll have a brand new boon of diversity over 10,000 human lifetimes from now. So for 50,000 generations the world is in a recovering planet, assuming that humans continue to foster speciation and conserve what we can of the existing species.

I'm in the business of positive attitudes about conservation, and with a huge concerted global effort I believe we can stave off the brunt of the 6th Mass extinction and have conservation success, but new species are not the same as new diversity as measured by the fossil record - the fossil record doesn't measure "breeds", "strains", "subspecies", or even "species" - the measure of diversity in the fossil record is "family" levels of taxa. And Stewart, in the past it has taken 10-30 million years to "erase" the effects of mass extinctions. 10-30 million years for normal rates of evolution to recover pre-extinction diversity levels - in that time there are a bunch of fleeting taxa that evolve fast to fill niches, but go extinct just as fast - because their niche only existed as the result of a reshuffling ecosystem. I would caution that new taxa arising in the anthropocene could be very short-lived species... unless humanity drastically changes how we use resources. I see reason for hope every day, but I don't see enough global adoption of sustainable strategies to throw caution to the wind.

While our motivations for conservation shouldn't be extinction rates - no one working in conservation can afford to take the 6th mass extinction lightly.

-Ben J. Novak

On Thu, Jul 13, 2017 at 9:11 AM, Carl Zimmer <carl@carlzimmer.com> wrote:

> Thee's a lot of debate about the apparent increase in species in recent geological time. Maybe it's an artifact of the fossil record (better fossils in recent rocks). Since thefossil record is dominated by marine animal species, maybe it has to do with long-term geological changes to the sea floor, creating more niches. Etc.
>
> c

Carl Zimmer

Matter, a weekly science column for the New York Times
Friday's Elk, a weekly newsletter
More information at carlzimmer.com
@carlzimmer

On Thu, Jul 13, 2017 at 12:02 AM, sb wrote:

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There’s a good long review of it by our friend Matt Ridley (who is working with us on de-extincting the great auk):

http://www.rationaloptimist.com/blog/mass-speciation/

--Stewart

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--george

Geneticrescue mailing list Geneticrescue@list.longnow.org

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From: geneticrescue-bounces@list.longnow.org on behalf of Todd Kuiken <tkuiken@ncsu.edu>
Sent: Wednesday, June 28, 2017 8:58 AM
To: Genetics Listserve
Subject: [Geneticrescue] Link to UN CBD online forum
Attachments: ATT00001.txt

The open online forum for synthetic biology starts July 3rd. Here is a link to the forum where you can see the schedule, topics and a glimpse of how it works:

https://bch.cbd.int/synbio/open-ended/discussion/

Todd

--
Todd Kuiken, Ph.D.
Senior Research Scholar
Genetic Engineering & Society Center
North Carolina State University
Campus Box (or CB) 7565
Raleigh, NC 27695 -7565
Phone: 919-515-2593
email: tkuiken@ncsu.edu
@drtoddoliver
Program Website: https://research.ncsu.edu/ges

From: geneticrescue-bounces@list.longnow.org on behalf of Michael Archer <m.archer@unsw.edu.au>
Sent: Thursday, June 22, 2017 11:53 PM
To: 'Philip Seddon'
Cc: 'Genetics Listserve'
Subject: Re: [Geneticrescue] Gene-editing OK to remove invasiives but not for de-extinction, some New Zealanders say
Attachments: ATT00001.txt

Hi Phil,
No arguments there—but of course I AM focused on species, not individuals. As a member of IUCN committees (e.g., SULi; https://www.iucn.org/commissions/commission-environmental-economic-and-social-policy/our-work/specialist-group-sustainable-use-and-livelihoods-suli), it is increasingly clear to me that to facilitate survival of species, individuals may need to be 'used' to achieve CSU--conservation through sustainable use of native species. I'm certainly not arguing that the welfare of individual animals should dictate conservation policy—far from it; that would be the worst possible constraint. My argument and publications focused on defending the conservation value of valuing and sustainably harvesting kangaroos, as well as keeping native animals rather than just introduced alien animals as human companions, are built on arguments of this kind.
But that is a bit different than the points I'm making in the email below. My concern is more with those who think that what we should be trying to do is 'preserve' (rather than 'conserve') the natural world, which is in effect to condemn it to a jar of formalin or tomorrow's fossil record, because it HAS to change, whether human environmental impacts are involved or not—the world changes and life has to change to adapt to those changes. For some of the respondents to the NZ survey who evidently are committed to 'preserving' the natural world, genetic engineering native species to enhance survival would no doubt be a worry if not an anathema. But this is precisely why, in the interests of facilitating conservation, we have to embrace the almost inevitable need to engineer rapid change in organisms, strategic translocations, etc, because the pace at which we are inflicting new conditions on the natural world will not enable natural selection to produce required adaptive changes fast enough.
Hence my argument is with those who think that somehow all of our efforts should be focused on 'preserving' the natural world because they are not only wasting precious time, but almost certainly precious resources. You have argued that pursuit of DeExtinction programs could be a waste of money and result in a net loss of more species. I'm suggesting that failure to embrace and deploy genetic engineering technologies, including those involved in DeExtinction such as optimising interspecific SCNT technologies, etc., in order to focus instead on 'preserving' the natural world in a futile effort to keep it the way it is, are likely in the long run to be responsible for a far greater loss of species and waste of money.
Not to be argumentative of course! But in the end, surely we need ALL strategies on the table for synergistic use in whatever combinations work best. No single approach is going to accomplish what needs to be done. About this, I suspect most of us on this list will be in broad agreement.
Cheers,
Mike
Professor Mike Archer
PANGEA Research Center
School of Biological, Earth & Environmental Sciences
UNSW Australia (University of New South Wales)
Sydney, NSW 2052, AUSTRALIA
+61 293 853 446
http://www.pangea.unsw.edu.au/people/academic-research/michael-archer
http://www.create.unsw.edu.au/team/marcher/

PANGEA

From: Philip Seddon [mailto:philip.seddon@otago.ac.nz]
Sent: Friday, June 23, 2017 11:43 AM
To: Michael Archer
Cc: Stewart Brand; Genetics Listserve
Subject: Re: [Geneticrescue] Gene-editing OK to remove invasiives but not for de-extinction, some New Zealanders say
Hi Mike
We need to separate out individual animal welfare issues (e.g. your child, or that animal) and population-level conservation concerns.

I follow your arguments from a welfare point of view, but I can also understand how some poeple might feel genetic manipulation to produce some future, altered versions of a species might be a step too far.
To take your analogy - yes you would do anything to preserve the life of your own child, but at the same time, and without contradiction, you might have reservations about the prospects of genetic engineering in the production of future human embryos.
Often the two pespectives can clash and people end up arguing at cross purposes.
- Phil

> On 23/06/2017, at 12:56 pm, Michael Archer <m.archer@unsw.edu.au> wrote:
> I find it difficult to understand the viewpoint that it would be better to have an endangered native species go extinct than save it by genetically engineering an aspect of its genome that will assist its survival in the wild. I have the same difficulty trying to understand those who tell me an animal endangered in the wild would be better off dead than being cared for by conservationists in captivity. Some humans appear to be immune to concerns about the wishes of the animals they so readily condemn to death if they can't be preserved in their current environment. Would they as easily consign their own children to the grave rather than allow genetic manipulation to save them? In a world whose requirements for survival are undergoing massive, rapid changes that appear to be unstoppable, is it smart to superglue ourselves and the world's wildlife to the goals of three-dimensional preservation rather than strategies to engineer four-dimensional conservation? Doing the latter is what nature has always done—blindly but with millions of years of time up its sleeve to make zillions of mistakes along the way. Life doesn't have that luxury of time anymore and we do have the technology to minimise error. What's the problem?
>
> **From:** geneticrescue-bounces@list.longnow.org [mailto:geneticrescue-bounces@list.longnow.org] **On Behalf Of** Stewart Brand
> **Sent:** Friday, June 23, 2017 10:05 AM
> **To:** Genetics Listserve
> **Subject:** [Geneticrescue] Gene-editing OK to remove invasiives but not for de-extinction, some New Zealanders say
> http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11880620
> It would be interesting to repeat this study from time to time.
> --Stewart
>
> _____
> Geneticrescue mailing list
> Geneticrescue@list.longnow.org
> http://list.longnow.org/mailman/listinfo/geneticrescue

****

Prof. Philip Seddon
Director / Kaiwhakahaere
Postgraduate Wildlife Management Programme

Department of Zoology / Te Tari o Mātai Kararehe
University of Otago / Te Whare Wānanga o Otāgo
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Postal: Department of Zoology, P.O. Box 56, Dunedin 9054
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Research and Teaching
http://www.otago.ac.nz/Zoology/staff/otago008934.html

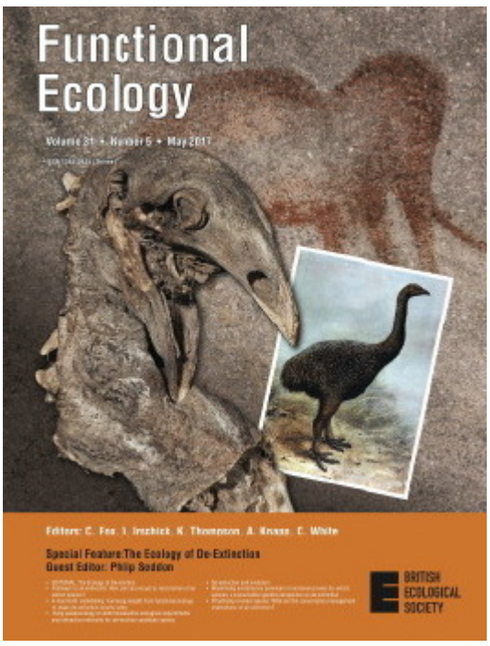
Research citations
http://scholar.google.co.nz/citations?hl=en&user=lGQsAMcAAAAJ

Postgraduate Diploma, Masters and MSc in Wildlife Management
http://www.otago.ac.nz/wildlife/

IUCN/SSC Re-introduction Specialist Group
http://www.iucnssc rsg.org/organization_structure.php

New publication
The Ecology of De-extinction

free download from:
http://onlinelibrary.wiley.com/doi/10.1111/1365-2435.12856/full



From: geneticrescue-bounces@list.longnow.org on behalf of Burgiel, Stanley <stanley_burgiel@ios.doi.gov>
Sent: Wednesday, June 21, 2017 10:58 AM
To: Genetics Listserve
Subject: [Geneticrescue] NAS Call for Nominations on Biotechnology and Forest Health
Attachments: ATT00001.txt

FYI - recent call for nominations from the National Academies of Sciences:

Potential for Biotechnology to Address Forest Health
New Study - Call for Nominations
The Board on Agriculture and Natural Resources will conduct a study to examine the potential use of biotechnology for mitigating threats to forest health; identify the potential ecological and economic consequences of deploying biotechnology in forests; and develop a research agenda to address knowledge gaps about its application. The study will describe measures or characteristics of forest health (and threats to forest health) as a context for evaluating the risk of releasing trees protected from pests and pathogens using biotechnology as compared to other approaches to address forest health. In addition to reviewing the literature on ecological risks and economic impacts, the study will draw on existing public opinion research for insights into the social, philosophical, and other dimensions of using biotechnology in trees.
Nominate an expert » http://nap.us4.list-manage1.com/track/click?u=eaea39b6442dc4e0d08e6aa4a&id=4c52864c00&e=3e0b6f7dc3

~~~
National Invasive Species Council (NISC) Secretariat
1849 C Street, NW, Room 3524, Washington, DC 20240 USA
o +1.202.208.4163, c +1.202.297.5143, stas_burgiel@ios.doi.gov

*"...we can do this..."*
~~~

From: geneticrescue-bounces@list.longnow.org on behalf of Kent Redford

Sent: Tuesday, May 09, 2017 10:33 AM
To: Genetics Listserve
Subject: [Geneticrescue] Responsible research and innovation
Attachments: Gregorowius and Deplazes-Zemp. 2016. Synbio societal impacts.pdf; ATT00001.htm; ATT00002.txt

I don't think most of you will find much new in this piece about public consultation but it's worth knowing about.
Kent

From: geneticrescue-bounces@list.longnow.org on behalf of Todd Kuiken <tkuiken@ncsu.edu>
Sent: Monday, May 01, 2017 9:30 AM
To: Genetics Listserve
Subject: [Geneticrescue] Participation in CBD process
Attachments: CBD_Onlineforum_2017.docx; ATT00001.txt

Hi Everyone,

I hope everyone had a good weekend.

I wanted to draw your attention to the The UN Convention on Biological Diversity. It has begun (again) its process of examining the impacts of synthetic biology and now also gene drives. There are a few steps in the process, the first of which is the call for submissions of research/data/reports etc. that focus on certain topics (attached word document).

The deadline for these submissions is June 16th. The next step in the process will be an open-online forum which begins in July. Both of these require you to be "formally" recognized inside the CBD. This can be accomplished by having the head of your organization or dean sending a letter recommending you to the process and stating that you are an expert.

https://bch.cbd.int/synbio/calendar.shtml

I can't stress enough how important it is that scientists and members of the conservation community participate in this process. I sit on the AHTEG, which is a fancy acronym for the advisory committee on synthetic biology for the CBD and basically we are only allowed to utilize information that is submitted through this process to develop our recommendations for the Treaty. And the last round was lacking input from this community.

I am happy to talk in more detail with anyone who has questions/concerns. I can also share with you the letter of recommendation that I have used in the past to become recognized in the process.

Todd

--
Todd Kuiken, Ph.D.
Senior Research Scholar
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email: tkuiken@ncsu.edu
@drtoddoliver
Program Website: https://research.ncsu.edu/ges

UN CBD OVERALL CHARGE FOR SYNTHETIC BIOLOGY (and gene drives):

(a) To conduct research on the benefits and adverse effects of organisms, components and products of synthetic biology on biodiversity, with a view to filling knowledge gaps and identifying how those effects relate to the objectives of the Convention and its Protocols;

(b) To promote and enable public and multi-stakeholder dialogues and awareness-raising activities on the potential benefits and potential adverse effects of organisms, components and products of synthetic biology on biodiversity, involving all relevant stakeholders and with the full and effective engagement of indigenous peoples and local communities; and

(c) To cooperate in the development of guidance and capacity-building activities with a view to assessing the potential benefits and potential adverse effects of organisms, components and products of synthetic biology and, if necessary, updating and adapting current methodologies for risk assessment of living modified organisms to organisms resulting from synthetic biology, as appropriate.

NEED INPUT ON THE FOLOWING:

(a) Research, cooperation and activities noted in the sub-paragraphs (a) through (c) above;

(b) Evidence of benefits and adverse effects of synthetic biology vis-à-vis the three objectives of the Convention;

(c) Experiences in conducting risk assessments of organisms, components and products of synthetic biology, including any challenges encountered, lessons learned and implications for risk assessment frameworks;

(d) Examples of risk management and other measures that have been put in place to avoid or minimize the potential adverse effects of organisms, components and products of synthetic biology, including experiences of safe use and best practices for the safe handling of organisms developed through synthetic biology;

(e) Regulations, policies and guidelines in place or under development which are directly relevant to synthetic biology; and

(f) Knowledge, experience and perspectives of indigenous peoples and local communities in the context of living in harmony with nature for comparison and better understanding of the potential benefits and adverse effects of synthetic biology.

From: geneticrescue-bounces@list.longnow.org on behalf of Tammy Steeves <tammy.steeves@canterbury.ac.nz>
Sent: Thursday, March 23, 2017 6:07 PM
To: True Nature Foundation; Beth Shapiro
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] European Bison Hybrids and genetic survival
Attachments: ATT00001.txt

Hello Henri/Beth, Hello everyone –
Apologies in advance for the (academic) preamble. Here is a link to a dropbox folder that contains all of the papers I mention below.
https://www.dropbox.com/sh/0cpwyg5lpro9b2p/AAAt97QYOy_ckW8UYmUDN4R1a?dl=0
There is extensive debate about the risks and benefits of intra/interspecific hybridisation to enhance species recovery in the conservation literature. The risk here is outbreeding depression (reduced hybrid fitness, attributed to the break-up of co-adapted gene complexes or the disruption of local adaptions). A classic example of the latter is when individuals from different subspecies of ibex from Turkey and the Sinai were introduced to assist recovery of an ibex population in (then) Czechoslovakia and the resulting hybrids birthed calves too early causing the entire population to go extinct.
Briefly, current best practice for informing whether or not to mix isolated populations of the same species (intraspecific hybridisation) is to refer to the decision tree in Fig 1 (Frankham et al. 2011). The general idea here is that we should avoid mixing individuals from locally adapted populations (to avoid outbreeding depression) but several meta-analyses (published before and after Frankham et al. 2011) indicate that the risk of outbreeding depression is relatively low when mixing individuals from relatively similar populations.
Having said this, there is a lively conversation being had in the conservation literature about facilitating adaptation via interspecific hybridisation between closely related species (or different ecotypes of the same species, currently a no-no as per the above), largely driven by questions about the ability of populations/species to adapt to a rapidly changing climate. For example, see the recent tête-à-tête in *Conservation Biology* between Hamilton and Miller, and Kovach et al.
Related to this, we're only just beginning to learn what genetic rescue means in a genomic sense – e.g., do we see fitness gains following the introduction of individuals from populations elsewhere because the introduction of new alleles increases genome-wide heterozygosity or is it because of the introduction of new (advantageous) alleles, or both? It's early days, but one particularly eloquent study in bighorn sheep (Miller et al. 2012, attached) suggests that it's the former, which has exciting implications for de-extinction.
So, to answer your original questions/to follow up on Beth's comments:
1. I don't know enough about bison to say whether it would be more/less appropriate to use wood or plains bison, but it's absolutely a robust conversation worth having.
2. If introgression is facilitated the 'old fashioned way', I personally wouldn't call it de-extinction, but I wouldn't be-grudge you if you did.
Cheers - Tammy

From: on behalf of True Nature Foundation
Date: Friday, 24 March 2017 at 10:20 AM
To: Neil Gemmell
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] European Bison Hybrids and genetic survival

Dear Beth and all,
thank you very much for your summary of the two papers/researches.
The 'boring' thing is; i totally agree with your opinions :-)
Your second point really takes it home for me: introgression can be used as a 'genetic engineering tool' in a sense. The drawback is that you need to weed out unwanted combinations and recessive genes. But at least you don't have to second guess unknown genes and attached possible drawbacks, such as described by Thom Gilbert in the article just send by Philip Seddon. Thom has a valid point there i think.
Best wishes,
Henri
Op 23 mrt. 2017 20:30 schreef "Neil Gemmell" <neil.gemmell@otago.ac.nz>:

> Probably relates to Haldane's rule
> https://en.m.wikipedia.org/wiki/Haldane's_rule
> MtDNA nuclear incompatibles, discussed a little following recent paper by Geoff Hill, likely are one part if the explanation.
> Neil
>
> On 24/03/2017, at 08:20, Stewart Brand <sb@longnow.org> wrote:
>
> > Great lore here, Beth.
> > One question: is there any *genetic* reason for the cross-breeding to be so one-directional sexually? Is there some advantage in preserving only one line of mtDNA?

—Stewart

> On Mar 23, 02017, at 12:00 PM, Beth Shapiro <b
> wrote:
> Hi everyone,
> To contribute to this thread, I will first provide some facts (as the current genetic data suggest) and then some opinions.
> Facts from Genomics (subject to new data and interpretations, of course):
> about wisent:
> Wisent have been a bit of a bison mystery for a while. Their mitochondrial DNA, which is inherited only from mom, suggests that they are more closely related to cattle than to American bison (by this, I mean *all* American & Pleistocene/Siberian bison: wood bison, plains/prarie bison, and extinct steppe bison). Their Y-chromosome (inherited only from Dad) and nuclear DNA, however, group them with other bison rather than with cattle. Recently, a genome-wide study suggested that wisent are actually a hybrid species, which evolved prior to 100,000 years ago or so, because of admixture between steppe bison (dad) and the ancestor of aurochs (mom).
> about plains/wood bison
> Bison first entered North American only ~160,000 years ago. These are steppe bison (the same lineage that contributed Y chromosomes to the wisent lineage). When the ice sheet coalesced on top of North America during the last ice age (~20-25,000 years ago), the ancestors of both wood and plains bison (who were a single population) were trapped to the south of that ice. Wood and plains bison therefore probably share a common ancestor within the last 20,000 years, with considerable admixture between the subspecies until the late 1800s when they nearly all went extinct. (that last link is NOT a peer-reviewed paper!)
> In conclusion, all bison and cattle are all very closely related and can all hybridize (American bison continue to hybridize with cattle)
> Given this, my *opinions* are that:
> (1) it doesn't matter (once the decision to hybridize has been made) whether you choose wood or plains bison
> (2) outbreeding, or perhaps genetic engineering, should be considered as potential tools to facilitate bison conservation and survival.
> best wishes,
> Beth

Geneticrescue mailing list
Geneticrescue@list.longnow.org
http://list.longnow.org/mailman/listinfo/geneticrescue

From: geneticrescue-bounces@list.longnow.org on behalf of Harry W. Greene <hwg5@cornell.edu>
Sent: Monday, March 20, 2017 9:59 PM
To: Philip Seddon
Cc: Genetics Listserve; True Nature Foundation
Subject: Re: [Geneticrescue] NY Time de-extinction story
Attachments: ATT00001.txt

The “first do no harm” bit is really a red herring—how many people faced with stage 4 pancreatic cancer wouldn’t take a risky proposed treatment? In a conservation context, first do no harm is the easy way out, no risk professionally and for that reason, at some level, cowardly, H

> On Mar 20, 2017, at 6:22 PM, Philip Seddon <philip.seddon@otago.ac.nz> wrote:
>
> We could slot Assisted Colonisation in there somewhere too.
>
> But I’m not sure we can characterise either AC or Ecological Replacement as “ok" - I have had serious push back from the invasion biologists on both of those issues.
>
> E.g.
>
> > P. J. Seddon et al. warn that loss of animal species can disrupt ecological communities, cause cascading effects, and alter ecosystem functions. Introduced nonnative animals can have similar consequences. Burgeoning evidence implicates nonnative species as driving biodiversity loss (1–3) and a host of other ecological disruptions (4). Whereas some can have positive effects on ecosystem services, others have disproportionately large negative effects. Risk assessment of these outcomes is undermined by context-dependence and time lags (4, 5). An introduced species that has negligible effects in some areas, or whose population is threatened in its native range, can have strong impacts when translocated elsewhere (6, 7). Such species may appear innocuous for decades—well beyond the attention span of monitoring programs— before suddenly becoming problematic (8). Moreover, their impacts may be subtle, but nonetheless great, and remain unrecognized until damage is incurred and containment is impossible (9). Even carefully planned introductions for conservation purposes can have devastating consequences (10, 11). These considerations are largely ignored by Seddon et al. in their discussion of assisted colonization and ecological replacements—deliberate introductions of species beyond their native range. Although Seddon et al. reassuringly cite new approaches (quantitative risk analysis, active adaptive management, and structured decision-making) for managing what could go wrong, none of the cited references offer reliable methods for predicting impacts of nonnative animal releases.
>
> Fauna in decline: First do no harm
>
> - Anthony Ricciardi1,*,
>
> - Daniel Simberloff2
>
> *Science* 22 Aug 2014:
>
> Vol. 345, Issue 6199, pp. 884
> DOI: 10.1126/science.345.6199.884-b
>
> > On 21/03/2017, at 10:09 am, sb <sb@longnow.org> wrote:
> >
> > There's a gradient...
> >
> > Ecological replacement is more radical (but okay) than de-extinction (suspicious!), which is more radical than reintroduction (celebrated), which is more radical than a small remnant wild population re-expanding (celebrated).
> >
> > Of those 4, Revive & Restore works on #2 and #4 with applied conservation genomics.
> >
> > --Stewart
> >
> > On Mar 20, 2017, at 1:38 PM, sb <sb@longnow.org> wrote:
> >
> > > I propose that the helpful study would be of the many wildlife reintroductions--beavers, wolves, pandas, falcons, ferrets, condors, etc. They were all de-expirtations

How many of those resulted in net loss of biodiversity? Did any? How about loss of funding for still-locally-wild endangered species?

The logic of the Bennett paper suggests that once a species is extinct in the wild, it should go all the way extinct to save money for other conservation efforts.

--Stewart

On Mar 20, 2017, at 10:49 AM, True Nature Foundation <info@truenaturefoundation.org> wrote:

> Forgot to add; one positive thing the original paper does is make us aware that we should include the positive impact on ecosystems in our presentations to the public.
>
> Op 20 mrt. 2017 18:42 schreef "True Nature Foundation" <info@truenaturefoundation.org>:
>> Many thanks.
>>
>> I find it surprising that Mr Bennett (as quoted here and in the previous article mind you, i don't know the guy) seems to have a limited understanding of what a keystone species actually does. Just like the trophic cascades of wolves in Yellowstone, Banff, Bialowieza and elsewhere (C2 in Einstein's formula as applied to ecosystems), keystone herbivores create trophic cascades (C1) as well. De-extinction is, like Stewart explained, focused on bringing back keystone species to restore/complete an ecosystem and maximise/balance biodiversity in the process. And what's with the maintenance costs? A healthy ecosystem is all about checks and balances. In case of the Aurochs: they keep vegetation in check and either feed humans (food health) and/or predators. Those predators in turn keep other herbivores in check, etcetera.
>>
>> An ecosystem is a foodweb, not a 2-dimensional model. We are trying to revive and restore that web.
>>
>> Anyway, i am probably preaching to the choir here.
>>
>> Best wishes,
>>
>> Henri
>>
>> Op 20 mrt. 2017 17:17 schreef "Ryan Phelan" <ryan@longnow.org>:
>>> Happily for us— a bit more balanced coverage on the Bennett paper:
>>>
>>> The article is up: https://www.nytimes.com/2017/03/20/science/revive-restore-extinct-species-dna-mammoth-passenger-pigeon.html.
>>>
>>> _____
>>> Geneticrescue mailing list
>>> Geneticrescue@list.longnow.org

> http://list.longnow.org/mailman/listinfo/geneticrescue

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****

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Harry W. Greene
Emeritus Professor and Stephen H. Weiss Presidential Fellow
Department of Ecology and Evolutionary Biology, Corson Hall, Cornell University, Ithaca, NY 14853

My 2nd book: http://www.ucpress.edu/book.php?isbn=9780520232754
How snakes eat: http://www.youtube.com/watch?v=Mm9h6KE-ZOk&feature=youtu.be
Conservation dilemmas: http://naturalhistoriesproject.org/conversations/ambulance-driver
Teaching the Tree of Life: http://www.youtube.com/watch?v=F_C6e6rHYqM
De-extinction: http://www.humansandnature.org/conservation-extinction-harry-w.-greene#sb=https://www.youtube.com/watch?v=7ii9dh0S9Q4

From: geneticrescue-bounces@list.longnow.org on behalf of Stewart Brand <sb@longnow.org>
Sent: Monday, March 20, 2017 9:54 PM
To: Genetics Listserve
Subject: Re: [Geneticrescue] NY Time de-extinction story
Attachments: ATT00001.txt

Hmm. There appear to be two importantly different forms of failure for intentional wildlife translocations:

- 1) The translocated species just doesn't succeed in the new location. This seldom seems to be fretted about by people outside the project. It happens frequently.

- 2) The translocated species badly disrupts the ecology of the new location in unexpected and unwelcome ways. This is routinely hugely fretted about by people outside the project. Does it happen frequently (at all?) *when the project is done by conservation biologists for conservation reasons?* (E.g. not cane toads.)

—Stewart

> On Mar 20, 02017, at 6:30 PM, Philip Seddon <philip.seddon@otago.ac.nz> wrote:
>
> Stewart - The Torreya pine example is a climate motivated assisted colonisation, and, again in NZ, there is modelling indicating some endemic birds (hihi/stitchbird) might need to be moved outside their range as the climate changes.
>
> There is similar work in Australia on western swamp tortoise, now proceeding to contentious trials: you might (and others on the listserv) be quite interested in the quotes below:
>
> > "It's a bold thing to do and it's a good thing to try," says conservation biologist Hugh Possingham from the University of Queensland, St. Lucia, in Brisbane, Australia, who is not involved in the trial.
> >
> > But others worry that such introductions could disrupt existing species, and that negative impacts may not become apparent for decades. Anthony Ricciardi, an invasive species biologist at McGill University in Montreal, Canada, sees assisted colonization as "ecological gambling." The impacts of assisted colonization—"planned invasions," he calls them—are notoriously difficult to predict.
>
> Hihi http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12150/abstract
>
> Swamp tortoise http://www.sciencemag.org/news/2016/08/relocating-australian-tortoise-sets-controversial-precedent
>
> UNassisted colonizations are just **re-colonizations** if species are moving back to occupy their former range.
>
> btw Might that be lynx, rather than hyena for Western Europe?
>
> - Phil
>
> > On 21/03/2017, at 2:17 pm, Stewart Brand <sb@longnow.org> wrote:
> >
> > Are there examples of climate-change assisted colonizations yet?

And, what is the term, if any, for UNassisted colonisations—like wolves, bears, hyenas, etc translocating themselves back into western Europe?

—Stewart

> On Mar 20, 02017, at 6:12 PM, Philip Seddon <philip.seddon@otago.ac.nz> wrote:
>
> Working e.gs.:
>
> Kakapo (or any number of other NZ species) to offshore exotic-predator-free islands.
>
> Tasmanian devils to disease-free Maria Island
>
> Florida Torreya http://www.torreyaguardians.org/extinction.html
>
> > On 21/03/2017, at 1:40 pm, Stewart Brand <sb@longnow.org> wrote:
> >
> > A wonderful service well defined.
> >
> > What are the famous examples of Assisted Colonisation working? And non-working?
> >
> > —Stewart
> >
> > > On Mar 20, 02017, at 5:28 PM, Philip Seddon <philip.seddon@otago.ac.nz> wrote:
> > >
> > > > a. Assisted colonisation is the intentional movement and release of an organism outside its indigenous range to avoid extinction of populations of the focal species.This is carried out primarily where protection from current or likely future threats in current range is deemed less feasible than at alternative sites.The term includes a wide spectrum of operations, from those involving the movement of organisms into areas that are both far from current range and separated by non-habitat areas, to those involving small range extensions into contiguous areas.

From: geneticrescue-bounces@list.longnow.org on behalf of Philip Seddon <philip.seddon@otago.ac.nz>
Sent: Monday, March 20, 2017 8:30 PM
To: Stewart Brand
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] NY Time de-extinction story
Attachments: ATT00001.txt

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There is similar work in Australia on western swamp tortoise, now proceeding to contentious trials: you might (and others on the listserv) be quite interested in the quotes below:

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>
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Hihi http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12150/abstract

Swamp tortoise http://www.sciencemag.org/news/2016/08/relocating-australian-tortoise-sets-controversial-precedent

UNassisted colonizations are just **re-colonizations** if species are moving back to occupy their former range.

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> > feasible than at alternative sites.The term includes a wide spectrum of operations, from those involving the movement of organisms into areas that
> > are both far from current range and separated by non-habitat areas, to those involving small range extensions into contiguous areas.
>
> From: IUCN Guidelines 2013
>
> Phil
>
> > On 21/03/2017, at 1:07 pm, Stewart Brand <sb@longnow.org> wrote:
> >
> > Fair point, Phil.
> >
> > What's the current definition of Assisted Colonisation? (Not to mention Assisted Colonization, when done by Americans.)
> >
> > —Stewart
> >
> > > On Mar 20, 02017, at 3:22 PM, Philip Seddon <philip.seddon@otago.ac.nz> wrote:
> > >
> > > We could slot Assisted Colonisation in there somewhere too.
> > >
> > > But I'm not sure we can characterise either AC or Ecological Replacement as "ok" - I have had serious push back from the

invasion biologists on
both of those issues.

****

Prof. Philip Seddon
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IUCN/SSC Re-introduction Specialist Group
http://www.iucnsscrsg.org/organization_structure.php

From: geneticrescue-bounces@list.longnow.org on behalf of Mike Kjelland

Sent: Saturday, March 11, 2017 5:50 PM
To: Harry W. Greene; Michael Archer
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Fw: "De-extinction probably isn't worth it"
Attachments: ATT00001.txt

Hi Dr. Greene! Thanks for sharing that letter. It makes me feel a little better about one that I and colleagues recently received concerning a manuscript that we had submitted. I and others spent a couple of years working on the experiments and manuscript only to have the potential publication rejected on the first attempt. Oh, that has happened before but this response was a little out of the ordinary. The associate editor took it upon himself to quickly reject it and given that we didn't see any other reviewer comments, it appeared as though it wasn't even sent out for review. So I would like to share our letter with you also. I have deleted certain parts and replaced them with "#" or "....." to secure anonymity because I do value the opinions of others, just don't always see eye to eye with them.

Dear Dr. Kjelland,

Thank you for submitting you paper to Journal of ####, however I cannot recommend that we consider reviewing it further. ……Table 1 is just a compilation of hypothetical egg sizes of charismatic species you believe may be candidates for de-extinction, with little justification for the choices.

My biggest problem with your study is the concept of de-extinction in the first place. This is ethically corrupt and ecologically dangerous idea. The thought that unregulated private groups of molecular biology enthusiasts are working towards making it feasible without any wider discussion among scientists or society about its desirability or risks, and no legal framework in place, is appalling to me.

Functionally it will not be possible to recreate a cell from an extinct species because no matter what one does to reconstitute the nuclear genome of an organism, just putting that into the cell of a surrogate will not be the same as the original. The mitochondria and other cytoplasmic factors are crucially important too and they will not be recreated. The social/biotic environment and learned behaviours will also never be recreated because we will never know what they were. At best, one will come up with some sort of chimeric monster, shadow organism of what once existed. A de-extincted passenger pigeon will not be a passenger pigeon.

Ecologically the reintroduction of such organisms could be disastrous. First of all, many of the habitat and other factors that lead to extinctions may still exist. Second, the ecosystems that extinct species inhabited have now changed and adding a new, and possibly dysfunctional, species now may create other problems and put other species at risk.

Ethically, de-extinction is flawed. Like human and other cloning it needs to be debated widely and will likely be outlawed. These species were driven to extinction, mostly by human activities and working to bring back some kind of pseudo-version of them just to make humanity feel better is a delusion. For me it's akin to trying to bring back the dead. In fact a week ago I was at a conference where a member of one of the Great Lakes First Nations was speaking. She talked extensively about the relationship of her people with the Passenger Pigeon and to them, de-extincting this species is like trying to bring a grandparent back to life. They mourn the loss but do not want the memory desecrated. Humans need to protect what is still alive on the planet and not be given a moral out by believing that in the future we will just be able to reconstitute organisms when we want. So why bother stopping extinction now?

I suggest if you want to do more for bird conservation that you devote your efforts to protecting habitats and understanding why population declines are occurring. Working on de-extinction methods is a huge distraction of valuable time and funds that could be better spent. I think that the de-extinction movement has no idea what reaction it will face when this debate happens.

Best wishes,

####

From: geneticrescue-bounces@list.longnow.org on behalf of Harry W. Greene
Sent: Saturday, March 11, 2017 11:23 PM
To: Michael Archer
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Fw: "De-extinction probably isn't worth it"

Wow, watching this back and forth is major de ja vu in terms of Josh, myself, et al. publishing the Pleistocene rewilding papers more than a decade ago now…among several interesting themes, persistent mis-characterizations etc. One person told me we'd said so and so, I said you'll look in vain for any such things in our paper, and the critic said "Well that's what you MEANT!" How can one debate what someone else erroneously thinks you meant? In any case, with apologies if I already posted this to the list, check out the attached, received by snail mail shortly after our first PR paper came out. Onward, H

Harry W. Greene
Emeritus Professor and Stephen H. Weiss Presidential Fellow
Department of Ecology and Evolutionary Biology, Corson Hall, Cornell University, Ithaca, NY 14853

My 2nd book: http://www.ucpress.edu/book.php?isbn=9780520232754

Tracks and Shadows

www.ucpress.edu

Intellectually rich, intensely personal, and beautifully written, Tracks and Shadows is both an absorbing autobiography of a celebrated field biologist and a ...

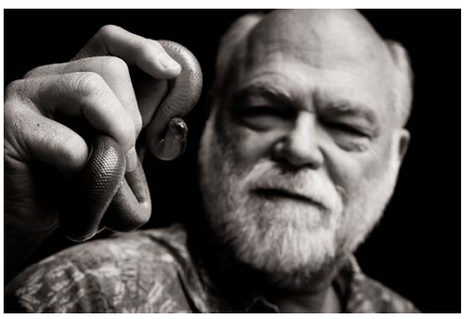
How snakes eat: http://www.youtube.com/watch?v=Mm9h6KE-ZOk&feature=youtu.be

Can snakes unhinge their jaws? Harry Greene explains ...

www.youtube.com

Harry Greene debunks snake myth. Watch the documentary "The Snakes of Paraguay." http://youtu.be/nmCmJOkEaIQ

Conservation dilemmas: http://naturalhistoriesproject.org/conversations/ambulance-driver

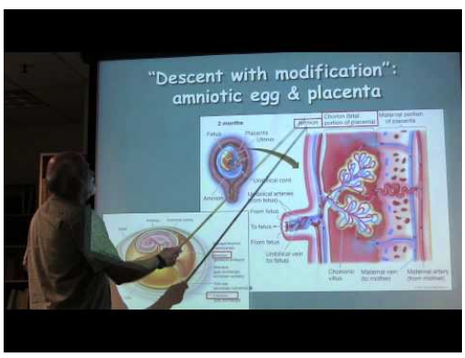


Ambulance driver | The Natural Histories Project

naturalhistoriesproject.org

As a young man I was an ambulance driver, and so I used to be intimately involved in making very rapid decisions in which sometimes neither alternative was pretty ...

Teaching the Tree of Life: http://www.youtube.com/watch?v=F_C6e6rHYqM



Harry W. Greene - May 22, 2013 - YouTube

www.youtube.com

Walkin' and Talkin' the Tree of Life: Why and How to Teach about Biodiversity: Director of Graduate Studies, Cornell University, Dept of Ecology and ...

De-extinction: http://www.humansandnature.org/conservation-extinction-harry-w.-greene#sb=https://www.youtube.com/watch?v=7ii9dh0S9Q4

From: geneticrescue-bounces@list.longnow.org on behalf of Stewart Brand <sb@longnow.org>
Sent: Thursday, March 09, 2017 8:36 PM
To: Genetics Listserve
Subject: [Geneticrescue] Fwd: Final Summary Report: "To Restore a Mosquito-Free Hawaii"
Attachments: Report on Mosquito Free Workshop v4[2].pdf; ATT00001.htm; ATT00002.txt

The mosquito busters that met on the Big Island in September labored and heaved and produced an exemplary report.

—Stewart

From: Kenneth Kaneshiro <kykanesh@hawaii.edu>
Subject: Re: Final Summary Report: "To Restore a Mosquito-Free Hawaii"
Date: March 9, 02017 at 2:04:56 PM PST
To:

Aloha All,

Attached is the Final Summary Report on the outcome of the workshop. It will be posted on our websites shortly; I will send links as soon it is posted.

Mahalo to all of you for your contributions to this document. It took a while but thanks to Durrell and Joshua's efforts and perseverance, we have, I believe, a great document which we will be able to use in various ways to promote and pursue next steps in achieving our broader vision to suppress and hopefully eliminate mosquito borne diseases as a pilot project in Hawaii with potential application elsewhere. We are in communication with funders who appear to be interested in providing the necessary resources to carry out such a project in Hawaii but our next steps will be to conduct public meetings to engage the broader community in a discussion about the feasibility of implementing such a project in Hawaii. Will keep you posted on these initiatives.

Several of you signed an MOU with the Hawaii Exemplary which I handed out during the Workshop. The MOU is an agreement "…to collaborate on opportunities and projects of mutual interests…", which will demonstrate to the funding organizations that we have engaged some of the top experts in the field of mosquito biology, ecology, genetics, etc., in future activities involving this project. I will check to see who has and who has not yet signed the MOU and will encourage those who have not to do so because it will most certainly strengthen our ability to secure the funds we will need to carry out a successful campaign if we have the endorsement of the community.

On behalf of the co-organizers of the workshop, Durrell, Joshua, Ryan and myself, MAHALO NUI LOA for your participation and continued support. We hope you will remain interested in collaborating as we move forward with next steps.

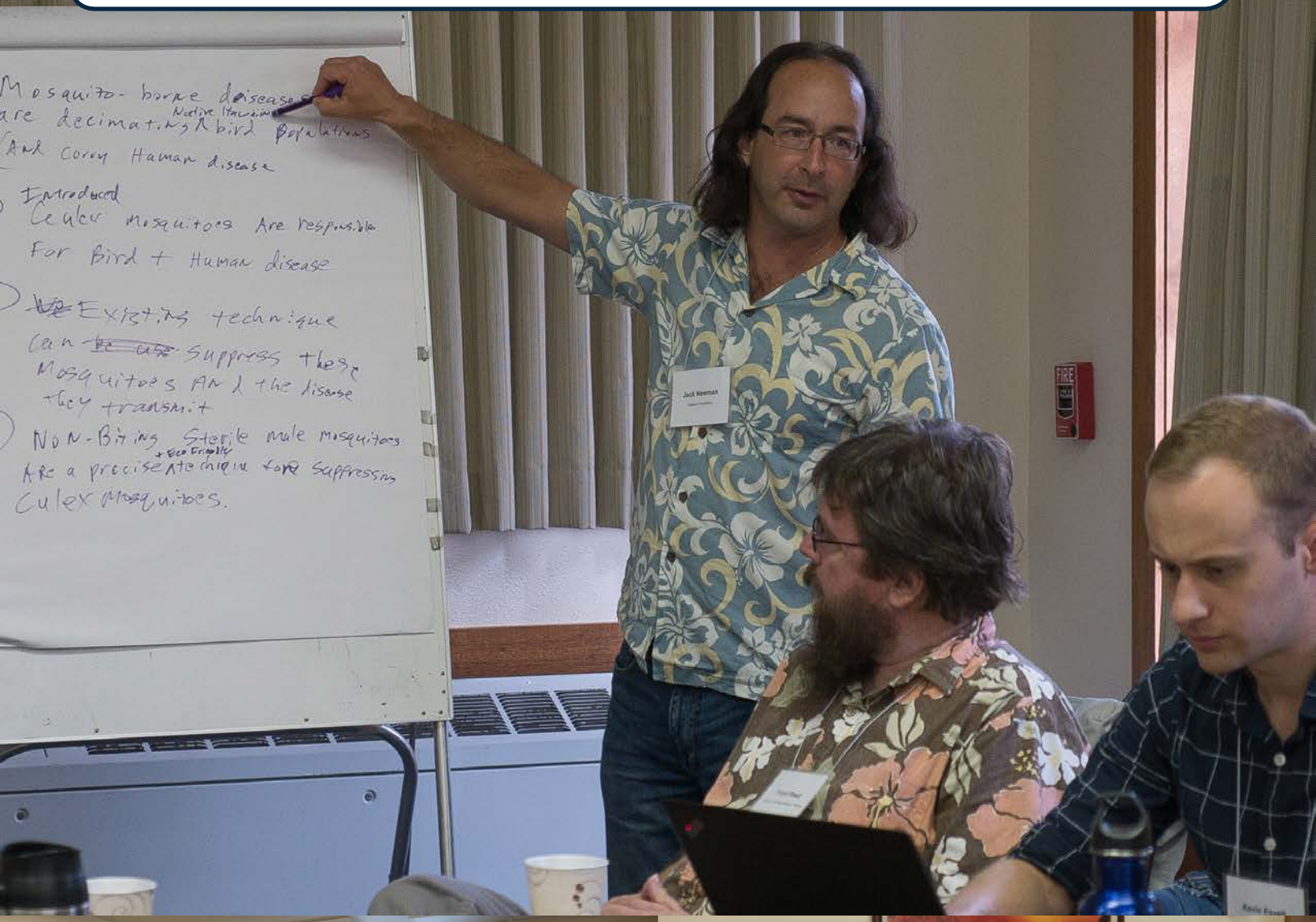
Aloha and Mahalo nui,
Ken

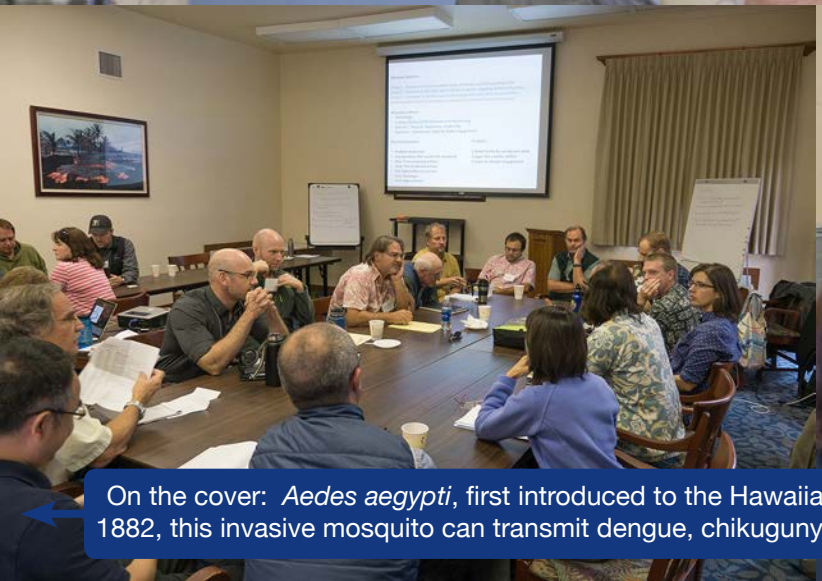
****
Kenneth Y. Kaneshiro, Ph.D.
Director
Center for Conservation Research & Training
University of Hawaii at Manoa
3050 Maile Way, Gilmore 406
Honolulu, Hawaii 96822
Ph. 808-956-6739
Fax 808-956-2647
Email: kykanesh@hawaii.edu
****

To Restore a Mosquito-Free Hawai‘i

Summary Report of the Workshop to Formulate Strategic Solutions for a “Mosquito-Free Hawai‘i”

A workshop was convened on September 6-7, 2016, to seek strategic solutions to eliminate mosquito-borne diseases affecting humans and wildlife. Workshop participants ranged from experts in mosquitoes and mosquito-borne pathogens to local leaders, public health and wildlife specialists. The discussions focused on novel technologies to **transform, suppress and ideally eliminate alien mosquito vectors from the Hawaiian Islands using an integrative systems thinking approach**. Attendees concluded that broad support to engage the public, develop the science and put resources to work on locally appropriate solutions is critical to combat serious threats of mosquito-transmitted diseases to protect both Hawai'i's public health and unique biodiversity. This white paper is a summary of the discussions of the workshop.





On the cover: *Aedes aegypti*, first introduced to the Hawaiian Islands after 1882, this invasive mosquito can transmit dengue, chikugunya and Zika virus.

To Restore a Mosquito-Free Hawai‘i

Summary:

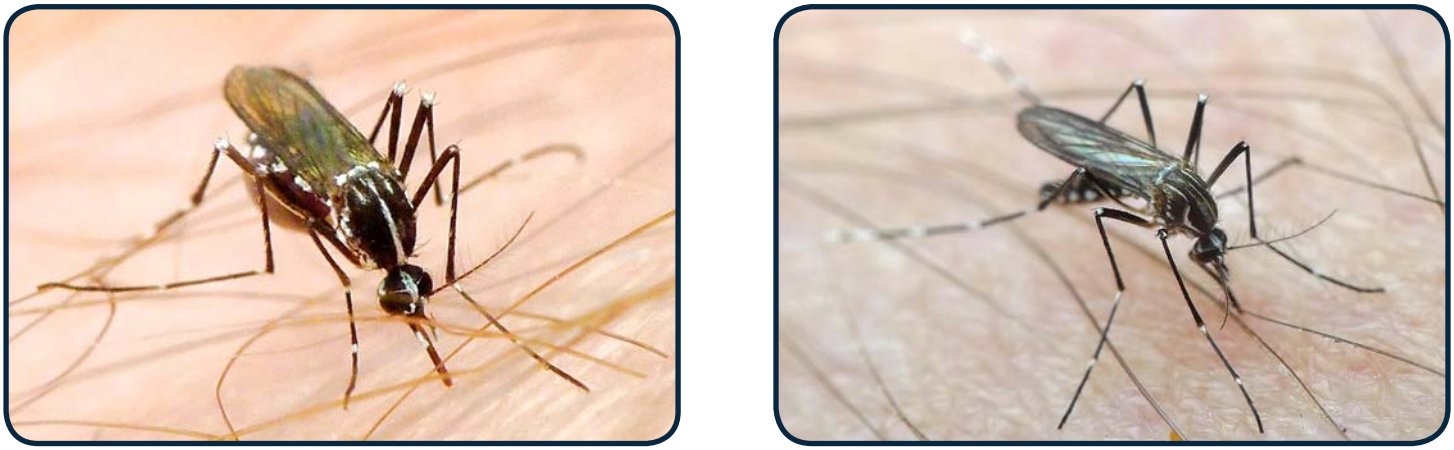
- Mosquitoes are non-native to the Hawaiian Islands.
- Mosquito-borne diseases are decimating native Hawaiian birds and threaten human health.
- There are new solutions to suppress or eliminate mosquitoes at an island-wide scale.
- A partnership with an engaged public, local experts, and a supportive government will be necessary to capitalize on this opportunity.
- For the first time, a path forward to re-establish a “mosquito-free” Hawai‘i is achievable.

Abstract:

Introduced mosquito species transmit diseases that threaten Hawai‘i’s public health, native forest birds, culture and economy. These existing mosquito-borne diseases, combined with impending threats of novel pathogens, have galvanized interest in new techniques to combat mosquitoes in Hawai‘i. Several targeted and effective strategies for mosquito suppression are currently available, and in five to ten years, more advanced tools may be available to completely restore a mosquito-free Hawai‘i.

Introduction:

Mosquitoes were introduced to Hawai‘i in the early 1800’s[1]. Six non-native mosquito species have become established since then, including two serious vectors of human diseases that threaten health, quality of life and the economy, as well as one vector of avian diseases that has contributed to the decline or extinction of many of Hawai‘i’s iconic native forest birds[2].



Mosquito species *Aedes albopictus* (L) *and Aedes aegypti* (R) can both transmit dengue, chikungunya, and Zika virus - Photos: (c) Durrell D. Kapan

The presence of mosquitoes in Hawai‘i represents a persistent and serious threat to public health, as well as to the economy and ecosystems. Diseases such as chikungunya, dengue, and yellow fever affect hundreds of millions of people worldwide, causing debilitating symptoms and sometimes death[3]. More recently, the Zika virus began to spread through the Americas, causing birth defects and neurological disorders[4]. These human diseases are transmitted by two mosquitoes, the yellow fever mosquito (*Aedes aegypti*) and the Asian tiger mosquito (*Aedes albopictus*), natives of Africa and Asia respectively. Both of these species have invaded Hawai‘i[1] and are responsible for sporad-

ic outbreaks of imported dengue fever[5,6]. Similarly, either of these two species could sustain a Zika virus outbreak sparked by the arrival of an infected traveler[7]. Additionally, the Southern house mosquito (*Culex quinquefasciatus*) transmits avian malaria parasite and avian pox virus, major factors in the extinction of more than half of Hawai‘i’s honeycreepers. The Southern house mosquito can also transmit West Nile virus which has not yet reached the islands[8]. This mosquito and the pathogens it carries threaten imminent extinction of most of the remaining 17 species of these unique birds that are found nowhere else on Earth[9].

Standard mosquito control methods cannot permanently suppress or eradicate mosquitoes in Hawai‘i. They are too costly, labor intensive, and often employ non-specific pesticides all of which are not effective or appropriate in rural and especially remote roadless forests where disease-sensitive native birds live. However, novel approaches offer new hope to control and even eliminate mosquitoes in Hawai‘i. Recent dengue outbreaks, combined with the threat of a local Zika virus epidemic, highlight Hawai‘i’s vulnerability to mosquito-borne pathogens and have galvanized efforts to look beyond standard methods to minimize the risk of mosquito-borne diseases in the islands. Removing mosquitoes from the Hawaiian Islands would eliminate the threat of vector-borne diseases that currently impact human and native forest bird populations.

Mosquitoes in Hawai‘i Workshop: Novel approaches to confront mosquito vectors and mosquito-borne pathogens in the Hawaiian Islands

With the support of Hawai‘i County Mayor Billy Kenoi, a group of biologists, biotechnology experts, wildlife managers, and public health specialists gathered at Hawai‘i Volcanoes National Park on September 6 & 7, 2016, to discuss possible solutions to the problem of invasive mosquitoes in Hawai‘i. The following summarizes the discussion of mosquito-borne diseases in Hawai‘i and methods to control them by suppressing or eliminating mosquitoes at the landscape scale.

Mosquitoes are not native to the Hawaiian Islands and transmit non-native pathogens: Prior to the arrival of European ships and trade, the Hawaiian Islands had no native mosquitoes[1]! The first invasive species, the Southern house mosquito (*Culex quinquefasciatus*), was introduced around 1826 when sailors drained their water barrels on Maui[10]. Subsequently, the yellow fever mosquito (*Aedes aegypti*) and the Asian tiger mosquito (*Aedes albopictus*) were introduced between 1892 and 1900. Soon after their introduction, the Southern House Mosquito spread avian malaria and avian pox to Hawai‘i’s unique forest birds, and the yellow fever and Asian tiger mosquitoes spread dengue fever to people. During the next century, three additional mosquito species were introduced to Hawai‘i, but they are not known to be vectors of pathogens detrimental to humans or Hawai‘i’s native wildlife[1,11].

To Restore a Mosquito-Free Hawai‘i

Mosquito-borne pathogens threaten the health of all people living in or visiting Hawai‘i: The dengue virus hit Hawai‘i less than a decade after the introduction of *Aedes aegypti* and *Aedes albopictus*. Over 30,000 people contracted dengue fever in 1903[12]. Since then, at least four additional outbreaks have occurred, including outbreaks on O‘ahu (2001-02, 2011) and most recently, on Hawai‘i Island (winter of 2015 and spring of 2016) with over 260 confirmed dengue cases [6,13]. With increases in travel, population size and mosquito density, people in Hawai‘i can expect mosquito-borne illnesses such as dengue to rise in the future. Additionally, viruses new to Hawai‘i such as chikungunya, West Nile, and Zika could rapidly spread through the immunologically-naive human population of Hawai‘i because they are easily transmitted by mosquito species already present.

Mosquito-borne pathogens are decimating Hawai‘i’s vulnerable native forest birds: Due to the extreme isolation of the Hawaiian Islands, Hawai‘i’s native landbirds have the highest percentage of unique *endemic* species (98%) in the world[14]. These birds play important ecological roles and are also highly significant in Hawaiian culture[2]. While Hawaiian native forest birds are threatened by habitat loss, habitat degradation from invasive plants and invertebrates, introduced predators and competitors, it is widely accepted that introduced avian malaria and avian pox virus are responsible for ongoing range contractions and declining populations of many of these species. With no prior exposure or natural immunity, the native birds are highly susceptible to these non-native pathogens transmitted by the Southern house mosquito (*Culex quinquefasciatus*). Prior to the introduction of this mosquito and the pathogens it transmits, there were at least 50 native forest bird species in the main Hawaiian Islands. *More than 50% of these bird species have gone extinct, and more than half of those that still remain are currently on the brink of extinction, in large part because of mosquito-borne avian malaria and pox*[15]. As global temperatures rise, mosquitoes and the diseases they carry are moving into higher elevation forests, causing rapid population declines in many of the surviving bird species, including ‘I‘iwi (*Drepanis coccinea*), ‘Akikiki (*Oreomystis bairdi*), ‘Akeke‘e (*Loxops caeruleirostris*), ‘Anianiau (*Hemignathus parvus*) and Kaua‘i ‘Amakihi (*Chlorodrepanis stejnegeri*)[16]. The disease-cycle in bird populations can only be broken by suppressing or eradicating mosquitoes. Unless this action is taken , avian malaria and avian pox are expected to spread to all remaining disease-free forest habitats and lead to the extinction of the rarest of Hawai‘i’s unique honeycreepers[16–18].

‘Apapane (*Himatione sanguinea*), a crimson red Hawaiian honeycreeper, being bitten by the alien invasive mosquito *Culex quinquefasciatus*. Photo: (c) Jack Jeffrey

In summary, non-native mosquitoes in Hawai‘i have caused human disease epidemics and the severe loss of biodiversity. If mosquitoes remain unchecked, they will continue to negatively impact human health and cause the extinction of most of the remaining Hawaiian forest bird species.

To Restore a Mosquito-Free Hawai‘i

Potential Solutions:

Conventional methods will not solve the mosquito problem: The approaches most often employed for mosquito control in urban areas cannot address the unique challenges of Hawai'i at the landscape scale. The cornerstone of mosquito control, source reduction, aims to limit the watery habitats where mosquitoes breed by eliminating refuse, used tires, covering cisterns, cleaning gutters, and emptying other containers[19,20]. Insecticides are often used during health emergencies to try to knock down potentially infected adults that are transmitting a disease, but factors such as vegetation make this problematic in Hawai'i[19,20]. Other mosquito control tools include biological insecticides developed from the bacterium *Bacillus thuringiensis* (Bti), which are applied to watery breeding habitats to eliminate mosquito larvae[21]. These approaches can be somewhat effective when used to control the yellow-fever mosquito (*Aedes aegypti*), when found breeding in accessible urban habitats[22]. However, these methods are not feasible for landscape level control of mosquito species that can breed in rural, forested and wilderness habitats in Hawai‘i. Broad application of insecticides to forested areas inhabited by native birds is not feasible not only because it would be logistically difficult and expensive, but also because it would have undesirable effects on native species, watersheds and human health [23]. Another control option is to place traps with chemicals that attract and kill females that seek water in which to lay eggs[5], known as the lethal ovitrap method[24]. This approach has been used during recent dengue outbreaks in Hawai‘i, and it can help control *Aedes aegypti* around homes and people[25.]. However, lethal ovitraps are impractical for broad landscape level application in forests and rural areas because a very large number of traps would need to be placed, monitored and maintained. Moreover, once chemicals degrade, the traps themselves can become mosquito breeding grounds.

We can use alternative methods to address the mosquito problem: A different class of methods solves many of the problems described above by targeting the mosquitoes directly using their own unique biology. New applications of the Sterile Insect Technique (SIT) provide the opportunity for the precise suppression of mosquitoes with no direct effects on other species and no negative impacts on human health[26]. In its simplest form, male mosquitoes are sterilized and released into the wild so that when they mate with females, they either produce no offspring or their offspring cannot effectively survive and reproduce. Over time, and with enough sterile male releases, fewer and fewer mosquitoes survive and breed, and eventually the mosquito population crashes. Importantly, male mosquitoes do not bite, and their release poses no health concerns. Notably, since sterile males die without successfully reproducing, these SIT methods are 'self-limiting' meaning the mosquitoes do not persist in the wild.

SIT was developed in the 1950s to eliminate agricultural pests in the United States[27]. This technique successfully eliminated screwworms, a livestock pest, from all of North and Central America, the island of Curaçao, and regions of Africa. SIT also has been used to eradicate the Mediterranean fruit fly in Mexico and California, the Oriental fruit fly and the melon fly in Okinawa, and to help control the tsetse fly in Africa[27].

Available SIT technologies: There are three types of self-limiting SIT that have been tested in the field and are now available to use individually or in combination to control or eliminate non-native mosquitoes with no direct non-target effects[28].

(i) Releases of male mosquitoes sterilized by irradiation: For the last 50 years, SIT has been achieved by sterilizing male insects with irradiation. Irradiated males are then released to seek out and mate with females of their own species. Because the males are sterile, any females they mate with will not produce offspring. With sufficient releases of sterile male mosquitoes, the wild population will eventually be reduced to a very low level or be locally eliminated[27]. Because irradiated males don't produce viable offspring and die after one to two weeks, this approach requires sustained releases of sterile males to maintain effective suppression. Hawai‘i has an existing agricultural irradiation facility that can sterilize mosquitoes, making it possible to apply SIT to mosquito species in Hawai‘i[29]. Although irradiation-based SIT has been successfully used for multiple agricultural pests such as the screwworm and medfly, irradiated mosquitoes do tend to have reduced fitness compared to wild-type males[30]. Specifically, the irradiation dose required to fully sterilize male mosquitoes can also cause the males to be less competitive for mates. Several laboratories are actively working to overcome this complication.

(ii) Releases of male mosquitoes carrying the bacterium *Wolbachia*: Suppression and elimination of mosquito populations can also be achieved by releasing male mosquitoes that carry insect specific bacteria called *Wolbachia*. Because these bacteria are highly specialized and cannot survive outside mosquito cells, they are completely harmless to humans and birds. Many different strains of *Wolbachia* are naturally found in about half of all insects[31], including those native to Hawai‘i[32]. In nature, *Wolbachia* are passed on from females to their offspring, but scientists can also introduce new strains of *Wolbachia* into insects in the laboratory. Various strains of *Wolbachia* have been successfully introduced into the yellow fever mosquito, the Asian tiger mosquito and the southern house mosquito in the laboratory, and it was discovered that these *Wolbachia* suppress the development of viruses like dengue, chikungunya, West-Nile and Zika in mosquito tissues[33,34]. *Wolbachia* can also work as a SIT known as the Incompatible Insect Technique (IIT)[35,36] through a mechanism called cytoplasmic incompatibility[30]. Namely, matings between male and female mosquitoes with different, incompatible strains of *Wolbachia* will fail to produce living embryos[30], so when many incompatible males are released to mate with local females, this causes mosquito populations to crash[36]. *Wolbachia* male-based IIT programs have shown progress in controlling local populations of *Aedes* and *Culex* mosquitoes around the globe[30,37,38] and this approach has received federal, state, and local approvals allowing field trials in California, Florida, and Kentucky[39]. These *Wolbachia*-male technologies could be readily adapted for populations of *Aedes aegypti*, *Aedes albopictus*, and *Culex quinquefasciatus* in Hawaii. Given that *Wolbachia* are passed only from mother to offspring, released males cannot spread the novel *Wolbachia*. This makes the *Wolbachia*-male method self-limiting, meaning novel *Wolbachia* cannot spread into the wild mosquito population. However, because laboratory females that carry novel *Wolbachia* can be accidentally released alongside males, sex separation is required to ensure only males are released[30]. Current sex separation techniques are not 100 percent effective, therefore they are the focus of intense research and development, along with continued work to au-

The Southern house mosquito, *Culex quinquefasciatus*, is a vector of avian malaria and avian pox

tomate and reduce the costs associated with the mass rearing of mosquitoes[40].

(iii) Releases of irradiated male mosquitoes that carry *Wolbachia:* To overcome the issue of imperfect sex separation and accidental releases of females that carry novel *Wolbachia*, another approach has been developed. This approach combines the best aspects of methods from (i) and (ii) to reduce or eliminate mosquito populations. A much lower dose of radiation is required to sterilize female mosquitoes than males[41]. Thus, irradiating *Wolbachia*-infected mosquitoes can reliably sterilize the very small number of residual females that may be mixed with males intended for the release. At the same time, the *Wolbachia*-infected males mate with the wild-type females and affect their reproductive capacity as described in (ii) above[41]. This combined technique prevents accidental local establishment of the novel *Wolbachia* in mosquito populations. The combination approach has been used in a release of five million male mosquitoes per week in southern China, reducing local populations of *Aedes albopictus* by >90% (Zhiyong Xi pers. comm.). A similar method could be readily developed for local populations of *Wolbachia* and each invasive mosquito to achieve landscape level control.

(iv) Release of Self-Limiting male mosquitoes: A fourth method that is field-ready is the application of ‘Self-Limiting’ insects. The approach uses genetic technology to provide a means of preventing survival of the offspring of released males in the field, without the fitness reduction associated with methods that rely solely on irradiation. Males carrying edited genes are released into the field, where they seek and mate with females of their species, but they either do not produce offspring or their offspring die at immature stages (larvae and pupae)[26]. Because Self-Limiting males don’t produce viable offspring, the edited gene does not persist in the environment. Like the other techniques, the Self-Limiting method also requires sustained releases to maintain effective control. The self-limiting strategy has demonstrated field success against *Aedes aegypti* by reducing target populations by >90% in several localities around the globe[42], has received a regulatory finding of no significant impact (FONSI) by the FDA[43], could be readily implemented to control this mosquito in Hawai‘i, and can be applied to other important disease-transmitting mosquitoes such as *Aedes albopictus*[44].

New technology on the horizon: New genetic approaches for mosquito population suppression are being investigated under laboratory conditions. These differ fundamentally from SIT methods outlined above by employing a mechanism, termed gene drive, to increase the inheritance of particular genes in breeding populations of organisms[45,46]. By ensuring that they are always inherited, such gene drive systems can increase the frequency of specific traits, even if these don’t benefit the organism. For example, one application might ensure that all mosquito offspring are male, or might cause infertility in females whenever both parents carry the drive system. Either way, natural mating will cause the change to spread through the local population, steadily decreasing the number of newly-hatched mosquitoes. In principle, this could allow permanent removal. Some potential long-term advantages of such approaches include many fewer releases, much lower cost, no direct impact on non-target species, and the ability to swiftly and cheaply eliminate any population that re-invades the islands[47,48]. Several milestones are absolutely necessary before society in general, and scientists specifically, could safely test gene drives to control mosquitoes in the wild. These include procedures to mitigate unanticipated outcomes during development as well as reliable methods of limiting the impact to a particular area or region.[48] Any project seeking to develop these systems must be fully transparent and engage in close consultation with communities in Hawai‘i to be considered for future use[47].

To Restore a Mosquito-Free Hawai‘i

Issues:

Data needs: In order to consider and effectively deploy any of these methods, additional key information is needed to better inform stakeholders. Ecological data on *Culex quinquefasciatus* in Hawai‘i Volcanoes National Park and other rural and forested habitats in Hawai‘i[49–54], plus historic data and relatively recent vector control surveys for *Aedes aegypti* and *Aedes albopictus* provide an excellent beginning[5,55]. However, there is still a need for further information such as the baseline distribution, range of habitats, population structure and population sizes of each species of mosquito. This information is critical to assess the feasibility of various approaches and how they may scale to the landscape level. If a particular project is approved, ongoing monitoring will be needed to accurately assess progress towards suppressing or eliminating mosquitoes from Hawai‘i, and to detect any reinvasion of mosquitoes to areas once they have been removed.

Mosquito ecology and native species: Mosquitoes are not native to Hawai‘i, and any ecological role they may fill as prey, pollinators, or resource processors, will have originated recently. Therefore, native species are not likely to have become dependent upon them as a critical resource. Although adult mosquitoes could be potential food for Hawai‘i’s native insectivores (‘ōpe‘ape‘a, the Hawaiian hoary bat; *Lasiurus semotus*[56,57], or the three endemic species of ‘elepaio, monarch flycatchers in the genus *Chasiempis*), they are not thought to form a significant fraction of these insectivores’ diets due to their small body size compared to larger, more preferable prey items. Even if the removal of a particular mosquito species does not have a direct negative effect on a native species, it is important to understand potential indirect effects. Although mosquitoes are not native to Hawai‘i, further studies should be conducted to better understand the role mosquitoes play in Hawaiian ecosystems.

Community Engagement: Participants at the mosquito workshop in Hawai‘i Volcanoes National Park unanimously agreed that transparency, education, and community outreach are integral components of any landscape scale mosquito control aimed at protecting people’s health and preventing forest bird extinctions. At the workshop, which was attended by several local leaders, numerous participants called for active community guidance of any proposals from the earliest stages. Achieving a mosquito-free Hawai‘i would require authentic and sustained engagement among local communities and a wide range of other stakeholders. Success will be unlikely without their unique knowledge and contributions. Therefore, it is essential that appropriate community engagement strategies are designed and implemented from the outset and sustained throughout[58].

Next steps: First and foremost is the question of how to involve all residents in determining the ecological and public health future for Hawai‘i. A forum is needed to hear from groups and communities that are most affected by mosquitoes. A broad coalition must be established to study the dimensions of the problem to collectively work towards sustainable solutions. A plan should be mapped out that can address both social and technical concerns related to these technologies. All planning must include relevant community input, and funding must be secured to accomplish this essential component of any mosquito control plan. Simultaneously, it will be necessary to devote additional resources to conduct further research and development of safe, targeted, efficient mosquito control technologies appropriate for Hawai‘i.

To Restore a Mosquito-Free Hawai‘i

Putting resources to work, engaging the public, and developing the science are vital first steps in order to halt the extinction of Hawai‘i’s unique forest birds and to take measures to address the serious threats that mosquito-transmitted diseases pose to public health in Hawai‘i.

Conclusion:

Mosquito species introduced within the last two hundred years threaten Hawai‘i’s public health, endemic forest birds, culture, and economy. The urgency of problems such as Zika and the imminent extinctions of several of Hawai‘i’s forest birds have galvanized a critical mass of support to investigate the application of sterile insect techniques to re-establish a mosquito-free Hawai‘i. Mosquitoes that carry human diseases are a natural starting point to target for elimination or control with existing tools. Regional elimination of mosquitoes carrying bird diseases is also a feasible goal and is the best chance to avert the impending extinction of the endemic honeycreepers, ‘Akikiki, ‘Akeke‘e, ‘Anianiau, Kaua‘i ‘Amakihi. Several targeted and effective strategies for mosquito suppression are currently available, and in five to ten years, more advanced genetic tools may be available. Support of the residents of Hawai‘i will be critical to re-establish a mosquito-free Hawai‘i.

Unless immediate action is taken, people will continue to suffer from mosquito-borne diseases, and avian diseases will continue to threaten the existence of Hawai‘i’s unique passerines.

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From: geneticrescue-bounces@list.longnow.org on behalf of Neil Gemmell <neil.gemmell@otago.ac.nz>
Sent: Tuesday, March 07, 2017 1:23 PM
To: Hank Greely
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] genetic rescue--human welfare and poverty and greed
Attachments: ATT00001.txt

Dear Hank et al.

Sorry, but I think that billion dollar figure is about right - at least with current tech.

The sequencing is cheap(ish), the cost of editing not bad, but the cell/embryo culture is enormously expensive. We costed this out, back of envelope, some years back at a G10K meeting. I do so again below just on editing and cell culture costs. Everything is estimated - others with more time can update, with better/newer data if they so desire.

Let's assume mammoths and elephants differ by about 1% at the genome level and there are, give or take 3 billion bases in their genomes (ie typical mammals). We therefore may seek to make up to 30,000,0000 edits to develop a facsimile of that mammoth genome from the elephant precursor. Let's assume that only 1/3 of these changes is important/necessary, so we limit ourselves to 10,000,000 edits.
I believe with current technologies we can achieve about 15 edits simultaneously. Let's assume this jumps to 100 in the next few years (keeps the math easy too). This would mean we have to sequentially make 100,000 cell line edits to get a rough approximation of the original mammoth.

The editing constructs might be $50, but the cell culture will cost thousands per line, just in reagents, let alone person time. Maybe you could automate this to reduce costs, but the reagents, such as foetal bovine serum, are very expensive. A quick look finds charges in core facilities of $500 set up and $100 a day, with media costs on top. So, I reckon you are looking at $2000 per cell line (minimum). Allow for errors, failures, contamination, redundancy and likely $10k per cell line is easily achieved.

So, 100,000 cell lines at $10,000 a piece is a $ billion. Sure, it might be cheaper with tech development and rationale compromises (every one of which makes this proposal less about recreating a mammoth, and more about creating a large, hairy, elephant), but just getting to an edited cell line/embryo could easily be a billion. Likely it will be more as I haven't even factored in embryo culture, development.

Cheers

Neil

P.S. Rob De Salle is an evolutionary geneticist and a pretty good one.

On 8/03/2017, at 7:11 am, Hank Greely <hgreely@stanford.edu> wrote:

> Um, who is Rob DeSalle at the American Museum of Natural History? He says, on the video, that sequencing the mammoth and elephant genomes “all have huge costs appended to them and there’s also a huge cost appended to injecting that modified genome into an egg and getting that to grow up. You want me to throw a number at you, maybe a billion dollars. I have no real ideas.”
>
> He’s right about one thing - he has no idea. And seems to have no idea that mammoth and elephant genomes have already been sequenced - for pennies on his $1 billion figure - and that, if it works, turning a cell line into an embryo and then into a baby (something) should also be relatively cheap.
>
> A billion dollars is an outrageously high, and ill-informed guess, for the cost of creating an individual from an extinct species (assuming, of course, it can be done at all). Now, MAYBE, if you want to create artificial elephant wombs AND you want to recondition Siberia for the offspring AND you want to factor in the cost of feeding and caring for 100 mammophants for a century . . . maybe you could get to a billion.

But he seems to be talking about just making one. And not talking at all reasonably or responsibly.

That's really disappointing.

On Mar 7, 2017, at 9:28 AM, Mike Kjelland <mkjelland@hotmail.com> wrote:

> Hi! A couple of sad stories in the news:
>
> 1) Elephant -
>
> http://news.nationalgeographic.com/2017/03/africa-tusker-elephant-satao/
>
> 2) Rhino -
>
> http://www.bbc.com/news/world-europe-39194844
>
> That brings us to a "Billion-Dollar Baby":
>
> https://www.forbes.com/video/5339861998001/
>
> The same old question, how do we protect them and make it economically feasible? Assuming something other than a lock and key facility for a cloned mammoth, then 24 hour armed guards, keep the tusks cut off, poison laced horns, or combinations thereof? Are the current techniques with extant species working effectively and in a sustainable manner? If so, has anyone crafted a plan for a cloned mammoth and re-introduction as of yet?
>
> Mike

Geneticrescue mailing list
Geneticrescue@list.longnow.org
http://list.longnow.org/mailman/listinfo/geneticrescue

From: geneticrescue-bounces@list.longnow.org on behalf of Kent Redford <redfordkh@gmail.com>
Sent: Friday, March 03, 2017 8:01 AM
To: Genetics Listserve
Subject: [Geneticrescue] more on public views of synbio
Attachments: Akin et al. 2017. Synbio public attitudes.pdf; ATT00001.htm; ATT00002.txt

BioScience 67: 290–300.
doi:10.1093/biosci/biw171 Advance Access publication 13 January 2017

From: geneticrescue-bounces@list.longnow.org on behalf of Owain.Edwards@csiro.au
Sent: Thursday, March 02, 2017 1:05 PM
To: redfordkh@gmail.com; Geneticrescue@list.longnow.org
Subject: Re: [Geneticrescue] gene drive problems
Attachments: ATT00001.txt

http://biorxiv.org/content/early/2016/11/17/088427

Modelling also shows that this resistance issue can be overcome by using multiple guide RNAs.

Owain

Sent from my iPad

On 2 Mar 2017, at 11:35 pm, True Nature Foundation <info@truenaturefoundation.org> wrote:

> A quote from the article: "*Discussions of modifying specific genes at the population level had been mostly theoretical, **because genetic edits pushed through a population also tended to have a "fitness cost," decreasing the life span of altered individuals, or rendering them sterile**.*"
>
> Excuse me, has a de-extinction experiment already been carried through that i am unaware of?
>
> Best wishes,
>
> Henri Kerkdijk-Otten
>
> True Nature Foundation
> www.truenaturefoundation.org
> www.facebook.com/truenaturefoundation
>
> phone: 0031 6 36180142
> email: truenaturefoundation@gmail.com
>
> TRUE NATURE FOUNDATION
>
> *"People who wonder whether the glass is half full or half empty miss the point. The glass is refillable."*
>
> 2017-03-02 13:00 GMT+01:00 Kent Redford <redfordkh@gmail.com>:
>> https://www.sciencedaily.com/releases/2017/03/170301130511.htm
>>
>> Kent H. Redford
>> Archipelago Consulting
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>> archipelagoconsulting.com
>> RedfordKH@gmail.com
>> ++ 914-263-6163
>> Skype: Kent.H.Redford
>>
>> _____
>> Geneticrescue mailing list
>> Geneticrescue@list.longnow.org
>> http://list.longnow.org/mailman/listinfo/geneticrescue

From: geneticrescue-bounces@list.longnow.org on behalf of Stewart Brand <sb@longnow.org>
Sent: Wednesday, March 01, 2017 12:18 PM
To: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution --creates more press
Attachments: ATT00001.txt

Tammy, thank you for a helpful counter-critique re the Bennett paper.

Titles are what get translated most directly into popular press. The title for the paper could have been: "The Most Important Measure of De-extinction Success Is its Impact on Net Biodiversity." And then the paper spells out how that can play out in a zero-sum situation in terms of funding and competitive species protection programs.

The important message is: de-extinction can be done badly, and here's one way to anticipate that and head it off.

A less conjectural study could draw on existing experience comparing translocation reintroduction with extinct-in-the-wild reintroduction, which is usually more difficult and expensive. Beavers in Scotland versus California condors on the US west coast. Did those programs play out in zero-sum terms? What has been their actual effect on net biodiversity?

I understand the need to have closely comparative extant endangered species and potential de-extincted species for the Bennett paper, but it raises plausibility questions. Is anyone seriously considering de-extincting the Chatham bellbird? Or even the Forbes' snipe?

I gather there is interest in de-extincting moas. What effects would that have on New Zealand conservation? The answer might be: 1) forget it, or 2) it could only work if done in the following way.

I apologize if I appeared to suggest that translocation is engineering. Given the idiosyncracies of species, habitat situation, funding, public acceptance, and ecology's nonpredictability, it must be a high art. Thank you for all coal-face work in that field.

I was trying to draw attention to the lab aspect of de-extinction, which is largely taken as a given in de-extinction debates. Except for Beth Shapiro's HOW TO CLONE A MAMMOTH, there is very little technical discussion in the literature on how it is proceeding and can proceed. It is still mostly science, really hard to predict. Genome editing suddenly leaped forward with CRISPR. Cloning has quietly improved dramatically. But we can't clone birds (or reptiles or amphibians), and the chimeric-parent workarounds have yet to prove out with wild species. (Many on this listserv are working hard on that.) Meanwhile, bioinformatics, which guides all editing decisions, is slow and fraught. Eventually these matters could become engineering, but we are far from that point.

There are so far 5 excellent books on de-extinction, and 2 more are in the works—which is remarkable considering that no actual de-extinction has occurred yet. It will arrive slowly, by stages, and in one unique instance after another, with abundant, highly visible failures along the way.

It's still worth doing.

—Stewart

> On Mar 1, 02017, at 4:51 AM, Tammy Steeves <tammy.steeves@canterbury.ac.nz> wrote:
>
> Kia ora koutou/Hello everyone –
> As one of the 'et al.' authors in Bennett et al., I must applaud the passion, enthusiasm and intellect demonstrated by this community as it debates the merits of our recent contribution to the de-extinction discourse.
> Indeed, I have (happily) muttered under my breath at least a couple of times: that's an excellent point – it would bephenomenal to develop this further *in the peer-reviewed literature.*
> I say this not because I am an 'armchair' scientist, but because my co-authors and I are 'coalface' scientists that, like so many on this listserve, are striving for better conservation outcomes. To achieve this, we have collectively spent decades developing, conducting and implementing evidence-based

conservation translocation stratgies to prevent extinction and enhance species recovery. With all due respect to Stewart, conservation translocations never have been, and never will be, engineering.
Beyond this, I am deeply saddened that some have received our contribution as a direct challenge to their raison d'etre. Granted, given the sensationalism we're seeing in the press (thankfully, not (yet) as dire as the recent mammoth cloing fake news debacle: https://tinyurl.com/mammothcloningfakenews), I am not terribly surprised that it's prompted such a visceral response.
But, given that we are living in a post-truth, post-trust, post-fact world (and, all bias included, we need critical, vigilant, engaged scientists more than ever), I was genuinely appalled by the tone of several responses that appear to insinuate that our contribution is disingenuous and obstructive and, as such, has no place in (and no value for) the de-extinction community.
From where I stand, engaging in robust scientific dialogue will accelerate, not decelerate, progress. And I am hopeful that moving forward, similar contributions will be received as intended.
Ngā mihi mahana/Warm wishes - Tammy

From: geneticrescue-bounces@list.longnow.org on behalf of Tammy Steeves <tammy.steeves@canterbury.ac.nz>
Sent: Wednesday, March 01, 2017 6:52 AM
To: Genetics Listserve
Cc: True Nature Foundation
Subject: Re: [Geneticrescue] Nature Ecology & Evolution --creates more press
Attachments: ATT00001.txt

Kia ora koutou/Hello everyone –
As one of the 'et al.' authors in Bennett et al., I must applaud the passion, enthusiasm and intellect demonstrated by this community as it debates the merits of our recent contribution to the de-extinction discourse.
Indeed, I have (happily) muttered under my breath at least a couple of times: that's an excellent point – it would be phenomenal to develop this further *in the peer-reviewed literature.*
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From where I stand, engaging in robust scientific dialogue will accelerate, not decelerate, progress. And I am hopeful that moving forward, similar contributions will be received as intended.
Ngā mihi mahana/Warm wishes - Tammy

From: on behalf of True Nature Foundation
Date: Wednesday, 1 March 2017 at 10:24 AM
To: Ben Novak
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution --creates more press

Dear Ben,
i agree with your outline.
Let me break this down for the Aurochs:
1) money that goes into Aurochs genetic research is not taken away from conservation. Two totally different worlds. If i ask a molecular biologist what he makes of an Aurochs then i will get an answer like: "an Aurochs for me is nothing more than a test-tube". Seriously.
2) the Aurochs project somehow is 'sexy' and draws new funding opportunities for genetic projects.
3) in the Eastern part of the Netherlands i was able to incorporate it in a regional identity. Suddenly farmers wanted to breed the Aurochs and volunteers have been streaming gradually. A whole new market has opened up, actually adding to the "conservation market" for lack of a better term. I think the same could be said of a Mammoth. It will draw more attention and more public.
4) we use cattle breeds we normally would be using in natural grazing projects, crossbreed and select them, and use the offspring in natural grazing projects. Net difference = zero.
5) in the breeding process we optimize the food to meat conversion, meaning cattle that grazes more optimally.
6) we focus on a so-called keystone species. Not an umbrella species in the way you use it Ben, but a species with a disproportionately large effect on its surroundings and which absence is sorely missed. I think by now we are all familiar with the idea/concept of a keystone species, so i will not elaborate on the positive effects such a species has. Reintroducing trophic cascades and completing the E=MC^2 formula.
In Europe, much of the conservation funds are being structured along the lines of species and sometimes keystone species. By adding the Aurochs to the palette, we actually add more funding opportunities, we add more "markets" like explained and we bring back a keystone species. A win-win for funding and ecology.
So i honestly cannot identify our project with what's being said in the paper.
I could also argue along another line: instead of philosophical debate, why not get a spade and get to work? I mean: writing all those articles... isn't that diverting money/attention/energy from true conservation as well?
Ben, i agree that much of the people criticising our work are so-called "armchair generals". Can get really tiresome.
And now, if you all excuse me, I have an Aurochs to de-extinct.
Best wishes,
Henri

Op 28 feb. 2017 20:13 schreef "Ben Novak" <bennovak@longnow.org>:

> While the publishing authors may have had the best of intentions, and even be advocates of pursuing de-extinction responsibly - as can be seen by the resulting press, the article does not convey that tone. As such, I've been asked by several reporters for comments on the publications, and I thought I'd share my comments with the list serve that I have provided to reporters.
>
> The study by Bennett et al. does little for the developing use of de-extinction aside from add to the growing literature of hypothetical hyperbole - in which de-extinction is considered in a bubble of future consideration independent of its actual foundations. The vast wealth of peer reviewed literature (and derived media) on de-extinction has been led by bio-ethicists, philosophers, and scientists with no actual ties to ongoing de-extinction efforts. The problem with this growing bubble of de-extinction debate is that it is far removed from reality, in which Revive & Restore's efforts are rooted.
>
> And while Sandler makes good counter arguments, he also does little to reflect the reality of de-extinction developments, and instead focuses heavily on esoteric debate.
>
> To clarify, there are only 6 active de-extinction projects in the world, and 2 projects developing the use of biotechnology for endangered species. These are:
>
> **De-extinction Projects**
>
> *Woolly Mammoth* (Revive & Restore, active gene editing work)
>
> *Passenger Pigeon* (Revive & Restore, studying genomics & de-extinction ecology)
>
> *Heath Hen* (Revive & Restore, studying genomics & developing avian reproductive techniques)
>
> *Quagga* (The Quagga Project, 7th generation of back-breeding)
>
> *Aurochs* (True Nature Foundation, new initiative to use Aurochs genome to guide back-breeding decisions)
>
> *Gastric Brooding Frog* (The University of New South Wales, have produced early stage embryos but no offspring)
>
> **Endangered Species:**
>
> *Black-footed Ferret* (Revive & Restore, still in proposal development)
>
> *Northern White Rhinoceros* (San Diego Zoo, active cellular research)
>
> Something immediately noticeable is that half of the world's efforts are being lead by Revive & Restore, yet none of the large body of literature publishing on this topic cites this or considers the development of these actual projects. It is also important to note that all of Revive & Restore's projects, meetings, and outreach concerning Genetic Rescue biotechnologies have been funded by private donors or through institutional grants falling outside the realm of conservation dollars - all our operating costs to date has been "new money", and certainly has not been any form of missed opportunity for extant species.
>
> Revive & Restore has been working for 4 years to collaboratively develop criteria for the development and use of de-extinction for the benefit of biodiversity, and this is a strict lens with which we view our projects. The outcome of any de-extinction effort must have long-term benefits that outweigh the costs of the program in many aspects, but especially in regard to alternative strategies. Revive & Restore's members were among hundreds of scientists and conservationists that reviewed and shaped the IUCN's guidelines for de-extinction which state explicitly: "…The priority must remain the preservation and enhancement of extant biodiversity, with proxy species creation in an attempt to restore biodiversity being undertaken only when consistent with preserving existing biodiversity". This is the criteria through which we filter managing our de-extinction programs, and we have been open in our support and alignment with IUCN criteria (noted on our website here).
>
> The IUCN guidelines are based heavily on the use of reintroductions to restore ecosystem functions and benefit biodiversity, yet the cost-benefit of reintroductions are not referenced by Bennett et al. I believe it is irresponsible to paint de-extinction with a broad brush of negativity so early in it's development, especially after so many successful reintroduction programs that have proven the value of restoring ecosystem function by reactivating the role of a lost species. Examples of reintroductions and their trophic benefits are growing, including wolves in Yellowstone and Beaver in Scotland. In fact, seemingly contradictorily, coauthor on the Bennet et al. study, Phil Seddon, has published extensively on the uses and benefits of reintroductions and ecological replacements and was also one of the committee members that formed the IUCN guidelines for de-extinction largely in positive light.
>
> The main tenet of the study's claim that de-extinction will cause a net loss of biodiversity rests on the assumption that opportunity costs are mutually exclusive between de-extinction and extant species conservation - this is a poor assumption to make, as it has been the opposite of reality experienced by Revive & Restore's fundraising. It also makes the problematic assumption that de-extinction cannot be done as a means to conserve extant species, which is entirely the goal of de-extinction projects managed by Revive & Restore.
>
> The study attempted to analyze scenarios in which a de-extinction program could benefit extant species, yet sadly failed to reference the very real use of umbrella and focal species in conservation - which has yielded net gains under constricted funds. Disproportionate spending on the Giant Panda, an iconic charismatic species, for instance, is actually protecting a larger number of species in China than if the funds were distributed differently. The same approaches have protected a wide range of species in Africa (Rondinini & Boitani 2006, Caro 2003). De-extinction candidates offer the same opportunity for focal/umbrella conservation of ecosystems.
>
> And the reason that I find it most offensive to paint de-extinction pursuits in a negative light, is that for many living extant species the reason for endangerment is the lack of an ecological partner or some link in the food web. Mostly an academic

topic to date, termed "evolutionary anachronism", the reality of this phenomenon's conservation significance has been slowly realized by botanists with respect to mutual seed dispersers and pollinators. To quote Aslan et. al. directly : "*Declines in populations following mutualism loss have appeared in a growing number of case study organisms, such as vertebrate-dispersed trees in Peru [9], bird-pollinated plants in New Zealand and Hawaii [10], [11], and ant-tended trees in Africa [12].*" Scientists recognize more and more that megafaunal extinctions globally have lingering negative effects on shifting states of biodiversity, highlighting that conservation paradigms need to consider these effects. Extinctions of large birds in Hawaii have been associated with ecosystem decay, which has since been ameliorated through ecological replacement with tortoises. Yet the cost-benefit analysis of ecological replacements was also void in reference to de-extinction considerations.

While the initial costs of generating a de-extinct population were omitted from the study, the techniques to develop viable populations of de-extinct proxies is invaluable to managing and enriching closed-captive populations of endangered species. This is one aspect being pioneered by Revive & Restore's Black-footed Ferret program proposals. Fringe benefits to extant species exceed the simplistic view of protecting the same areas of habitat during the latter half of a de-extinction program. Opportunity costs extend greatly to the intake of new funds from de-extinction technologies, which stem from functional genomics, evolutionary genomics, and various biotechnology based grant and donor sources - NOT conservation dollars.

The insights of the paper may apply to New Zealand and New South Wales, but there should be strong skepticism with applying these findings to other areas of the world. There are numerous ways to build mutual benefit to extant species and avoid opportunity conflicts. Four very strong ways to do so are 1) to work with new donors that otherwise would not have interest in conservation, 2) to work with private land owners rather than government managed properties, 3) to act synergistically with citizen science groups for monitoring purposes, and 4) to engage biotech corporations that otherwise would have little overlap with conservation goals.

The paper does two things very well:

1) It highlights very serious problem of limited funding and heavy competition for limited resources in conservation; a problem we all need to work at alleviating. Overall, the paradigm of financial funding in conservation needs a drastic change globally.

2) De-extinction can be pursued in ways that benefit extant species rather than take away from extant species.

Aside from these two aspects, the paper drifts far away from pragmatism and worse, further from the constructive developments for de-extinction practice that Revive & Restore and many others have spent years and tireless work to build for conservation benefit.

-Ben J. Novak

On Mon, Feb 27, 2017 at 6:24 PM, Ryan Phelan <ryan@longnow.org> wrote:

> It's very disappointing and frustrating to see the field of de-extinction evaluated and dismissed based on a "one-size fits all" approach to cost/benefit—with estimates based on 11 extinct New Zealand species, and 5 extinct species from New South Wales.
> More press is following:
>
> # Resurrecting extinct animals might do more harm than good
>
> ## But it depends on the species and the context
>
> By SARAH FECHT 9 HOURS AGO
>
> **De-extinction dilemma: reviving dead species may doom the living | New Scientist 2/27/17, 6(18 PM**
>
> COMMENT 27 February 2017
>
> **De-extinction dilemma: reviving dead species may doom the living**

Geneticrescue mailing list
Geneticrescue@list.longnow.org
http://list.longnow.org/mailman/listinfo/geneticrescue

From: geneticrescue-bounces@list.longnow.org on behalf of True Nature Foundation <info@truenaturefoundation.org>
Sent: Tuesday, February 28, 2017 3:25 PM
To: Ben Novak
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution --creates more press
Attachments: ATT00001.txt

Dear Ben,

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From: geneticrescue-bounces@list.longnow.org on behalf of True Nature Foundation <info@truenaturefoundation.org>
Sent: Tuesday, February 28, 2017 3:25 PM
To: Ben Novak
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution --creates more press
Attachments: ATT00001.txt

Dear Ben,

i agree with your outline.

Let me break this down for the Aurochs:

1) money that goes into Aurochs genetic research is not taken away from conservation. Two totally different worlds. If i ask a molecular biologist what he makes of an Aurochs then i will get an answer like: "an Aurochs for me is nothing more than a test-tube". Seriously.
2) the Aurochs project somehow is 'sexy' and draws new funding opportunities for genetic projects.
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De-extinction dilemma: reviving dead species may doom the living

From: geneticrescue-bounces@list.longnow.org on behalf of Owain.Edwards@csiro.au
Sent: Monday, February 27, 2017 8:28 PM
To: hgreely@stanford.edu; sb@longnow.org
Cc: Geneticrescue@list.longnow.org
Subject: Re: [Geneticrescue] Nature Ecology & Evolution articles on de-extinction cost/benefit
Attachments: ATT00001.txt

What is completely ignored is the unique knowledge gained from the comparative genomics analysis that forms the basis for each de-extinction project. It is my personal view that these comparisons are worth pursuing irrespective of whether they lead to a de-extinction outcome - and therefore should not be lumped into the costs without considering the broader benefits.

Owain

From: geneticrescue-bounces@list.longnow.org [mailto:geneticrescue-bounces@list.longnow.org] **On Behalf Of** Hank Greely
Sent: Tuesday, 28 February 2017 10:19 AM
To: Stewart Brand
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution articles on de-extinction cost/benefit

The concluding sentences of the abstract are hard for me to argue with:

"**If conservation of resurrected species populations could be fully externally sponsored, there could be benefits to extant threatened species. However, such benefits would be outweighed by opportunity costs, assuming such discretionary money could directly fund conservation of extant species. Potential sacrifices in conservation of extant species should be a crucial consideration in deciding whether to invest in de-extinction or focus our efforts on extant species."**

But the paper and its general tone ignore them and act as if de-extinction money is either directly coming from money that would otherwise be used to preserve extant species or indirectly, because the donors would otherwise have been able to be convinced to support conservation of extant species.

Happily, Sandler's piece pushes on that point, with particular relevance to the heath hen work, both for its private funding and for its spillover effects on habitat conservation.

It is true that the amount of conservation money being spent in NS Wales (Sydney's state) is tiny and NZ, though better, still insufficient. I can see their concerns, but the underlying beef of most of the conservation biologists still seems to be that, somehow, in some way, money spent on de-extinction would otherwise be spent on "us." Assumes a fact not in evidence, one might say.

> On Feb 27, 2017, at 6:08 PM, Stewart Brand <sb@longnow.org> wrote:
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From: geneticrescue-bounces@list.longnow.org on behalf of Ryan Phelan <ryan@longnow.org>
Sent: Monday, February 27, 2017 8:24 PM
To: Genetics Listserve
Subject: [Geneticrescue] Nature Ecology & Evolution --creates more press
Attachments: page1image1800.jpeg; ATT00001.htm; Resurrecting extinct animals might do more harm than good Popular Science.pdf; ATT00002.htm; page1image1688.png; ATT00003.htm; De-extinction dilemma reviving dead species may doom the living New Scientist.pdf; ATT00004.htm; ATT00005.txt

It's very disappointing and frustrating to see the field of de-extinction evaluated and dismissed based on a "one-size fits all" approach to cost/benefit—with estimates based on 11 extinct New Zealand species, and 5 extinct species from New South Wales.

More press is following:

COMMENT 27 February 2017

De-extinction dilemma: reviving dead species may doom the living

The resurrection of extinct species may soon be feasible – but expensive
Moviestore Collection/REX/Shutterstock

By **Olive Heffernan**

The resurrection of extinct species, as depicted in the 1993 film *Jurassic Park*, was until recently regarded as pure science fiction. Today, de-extinction looks increasingly feasible and is being heralded as a way of turning back the clock on biodiversity loss.

But with scarce resources available for conservation, it may have the opposite effect, increasing the rate of extinction. We must tread carefully.

It's easy to see the appeal of bringing back obliterated creatures. While most of us don't wish to live alongside dinosaurs, who isn't saddened by the loss in recent decades of the platypus frog – the only species to use its stomach as a womb and give birth from its mouth?

And who wouldn't like to see the skies of North America once again darken with great flocks of passenger pigeons, or wish that the Tasmanian tiger could live another day in the sun?

This is not a new idea. But the science to make it possible is suddenly making great strides. Earlier this month, Harvard geneticist George Church claimed he's just two years away from creating a hybrid woolly mammoth-elephant embryo. If successful, it will be the closest thing to a woolly mammoth that Earth has seen for nearly 4000 years.

The embryo would be the result of splicing mammoth characteristics – long shaggy hair, layers of subcutaneous fat and cold-adapted blood – into the genome of an Asian elephant, its closest living relative. The hope is that, eventually, the embryo could develop into a foetus and reach full term. That's still many years away, and will require development of an artificial womb – all at great expense.

Reviving species like the platypus frog reflects a desire to make right the wrongs of our past
Auscape/UIG via Getty

Even then, to be saved from extinction a resurrected species must be reintroduced to the wild in sufficient numbers and then protected. But with each day that passes, as many as 100 more species disappear and so, arguably, that's money that could be better spent on saving living, threatened species.

That trade-off has now been quantified. A new study looks at funding de-extinction over existing species conservation in New Zealand and in Australia's New South Wales and shows that choosing the former could be perilous for the latter, with a net loss of species.

Specifically, it finds the cost of reintroducing and protecting 11 extinct species in New Zealand – eight birds, two plants and a frog – is equivalent to the amount needed to preserve 31 existing species. In New South Wales, funding the revival of five extinct species – two birds, two plants and a marsupial – could pay to conserve 42 existing species.

While there's a benefit to local biodiversity of returning recently extinct species to their former stomping grounds, the simple fact is that there's only so much money in government coffers for conservation, and difficult choices must be made.

But cost is not the only concern.

The woolly mammoth is long gone. How do we know that a species that lived 4000 years ago would survive in a world undeniably altered by humans? And the mammoth-elephant hybrid would be an analogue, not a replica, of the original – perhaps casting further doubt on its relevance for conservation.

That's not to say that de-extinction will never be worthwhile. Far from being the folly of rogue scientists, it reflects a deeply ethical desire to restore what we have destroyed, to make right the wrongs of our past. But with limited funds and time for conservation, great care must be taken in how this burgeoning ability is used.

Journel reference: *Nature Ecology & Evolution*, DOI: 10.1038/s41559-016-0053

Olive Heffernan is a freelance environment writer

From: geneticrescue-bounces@list.longnow.org on behalf of Hank Greely <hgreely@stanford.edu>
Sent: Monday, February 27, 2017 8:19 PM
To: Stewart Brand
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution articles on de-extinction cost/benefit
Attachments: ATT00001.txt

The concluding sentences of the abstract are hard for me to argue with:

"**If conservation of resurrected species populations could be fully externally sponsored, there could be benefits to extant threatened species. However, such benefits would be outweighed by opportunity costs, assuming such discretionary money could directly fund conservation of extant species. Potential sacrifices in conservation of extant species should be a crucial consideration in deciding whether to invest in de-extinction or focus our efforts on extant species.”**

But the paper and its general tone ignore them and act as if de-extinction money is either directly coming from money that would otherwise be used to preserve extant species or indirectly, because the donors would otherwise have been able to be convinced to support conservation of extant species.

Happily, Sandler’s piece pushes on that point, with particular relevance to the heath hen work, both for its private funding and for its spillover effects on habitat conservation.

It is true that the amount of conservation money being spent in NS Wales (Sydney’s state) is tiny and NZ, though better, still insufficient. I can see their concerns, but the underlying beef of most of the conservation biologists still seems to be that, somehow, in some way, money spent on de-extinction would otherwise be spent on “us.” Assumes a fact not in evidence, one might say.

> On Feb 27, 2017, at 6:08 PM, Stewart Brand <sb@longnow.org> wrote:
>
> > **If conservation of resurrected species populations could be fully externally sponsored, there could be benefits to extant threatened species. However, such benefits would be outweighed by opportunity costs, assuming such discretionary money could directly fund conservation of extant species. Potential sacrifices in conservation of extant species should be a crucial consideration in deciding whether to invest in de-extinction or focus our efforts on extant species.**

From: geneticrescue-bounces@list.longnow.org on behalf of Stewart Brand <sb@longnow.org>
Sent: Monday, February 27, 2017 8:09 PM
To: Genetics Listserve
Subject: Re: [Geneticrescue] Nature Ecology & Evolution articles on de-extinction cost/benefit
Attachments: ATT00001.txt

I'm surprised the Bennett et al paper didn't draw parallels with the many reintroduction experiences—beavers in Scotland, Yellowstone wolves, east coast hybrid peregrine falcons etc etc. In the (Phil Seddon-led) de-extinction guidelines from IUCN, de-extinction is described as basically a reintroduction or ecological replacement exercise.

Are the authors suggesting that reintroduction is a bad cost/benefit deal?

—Stewart

On Feb 27, 02017, at 5:43 PM, Ryan Phelan <ryan@longnow.org> wrote:

Spending limited resources on de-extinction could lead to net biodiversity loss

Joseph r. Bennett[1]*, richard F. Maloney[2], tammy e. Steeves[3], James Brazill-Boast[4], Hugh P. Possingham[5,6] and Philip J. Seddon[7]

There is contentious debate surrounding the merits of de-extinction as a biodiversity conservation tool. Here, we use extant analogues to predict conservation actions for potential de-extinction candidate species from New Zealand and the Australian state of New South Wales, and use a prioritization protocol to predict the impacts of reintroducing and maintaining popula- tions of these species on conservation of extant threatened species. Even using the optimistic assumptions that resurrection of species is externally sponsored, and that actions for resurrected species can share costs with extant analogue species, public funding for conservation of resurrected species would lead to fewer extant species that could be conserved, suggesting net biodiversity loss. If full costs of establishment and maintenance for resurrected species populations were publicly funded, there could be substantial sacrifices in extant species conservation. If conservation of resurrected species populations could be fully externally sponsored, there could be benefits to extant threatened species. However, such benefits would be outweighed by opportunity costs, assuming such discretionary money could directly fund conservation of extant species. Potential sacrifices in conservation of extant species should be a crucial consideration in deciding whether to invest in de-extinction or focus our efforts on extant species.

DE-EXTINCTION

Costs, benefits and ethics

Cost–benefit analysis suggests that the costs of de-extinction could imperil conservation of extant biodiversity in many cases. But there is also an ethical dimension to this debate that cannot be ignored.

Ronald Sandler

--Stewart

From: geneticrescue-bounces@list.longnow.org on behalf of Ryan Phelan <ryan@longnow.org>
Sent: Monday, February 27, 2017 7:43 PM
To: Genetics Listserve
Subject: [Geneticrescue] Nature Ecology & Evolution articles on de-extinction cost/benefit
Attachments: s41559-016-0053.pdf; ATT00001.htm; s41559-017-0105.pdf; ATT00002.htm; ATT00003.txt

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From: geneticrescue-bounces@list.longnow.org on behalf of Hank Greely <hgreely@stanford.edu>
Sent: Friday, February 17, 2017 10:11 AM
To: Ryan Phelan
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Harvard-led woolly mammoth de-extinction project gets closer to reality
Attachments: ATT00001.txt

I read that George says he hopes to invent an artificial elephant uterus in order to try this. THAT'S a big lift. He says mice have already been successfully taken through 10 of their roughly 20 day plus gestation period in an artificial womb and therefore….

I understand why he would not want either to put Asian elephant females at risk with this gestation - or to APPEAR to be willing to put Asian elephant females at risk - but this seems like a very serious self-imposed limitation. (Of course, maybe no one has figured out enough about Asian elephant reproduction to know when/how to transfer embryos…I don't know.) "Hopes" may give him wiggle room, but when he says, or is quoted as saying, "It would be unreasonable to put female reproduction at risk in an endangered species," it makes it hard to try the easier approach.

I only heard have this through an article yesterday in the Guardian - apparently George did a show and tell at the AAAS meeting that has prompted some press.

https://www.theguardian.com/science/2017/feb/16/woolly-mammoth-resurrection-scientists

Interesting that he is pushing the idea that this would be a mammophant, a hybrid.

It was also interesting to me that the biggest ethical objection mentioned in the story was the absence of other mammoths in this (presumably) social species.

Carl Zimmer tweeted about the Guardian article, which prompted a surprisingly (to me) long set of somewhat silly/not terribly insightful negative retweets.

On Feb 17, 2017, at 7:43 AM, Ryan Phelan <ryan@longnow.org> wrote:

> FROM TECH CRUNCH
>
> https://techcrunch.com/2017/02/17/havard-led-woolly-mammoth-de-extinction-project-gets-closer-to-reality/
>
> The woolly mammoth is long extinct, but it's beginning to look like they might make a comeback – or a comeback of sorts, as a hybrid elephant genetically edited to display many mammoth traits. A team of Harvard researchers presented their progress in making this happen at the American Association for the Advancement of Science's yearly meeting this week, and according to team leader Professor George Church, they're closer than you might've believed.
>
> You've probably heard about efforts to bring back the woolly mammoth, the last of which went extinct around 4,000 years ago. It's a popular exemplar used when discussing how far we've come with gene editing. Church's team really is using the CRISPR Car-9 gene editing technology to combine genes for mammoth traits including long hair, a layer of fat under the skin and other cold-weather hardiness features into the elephant genome.
>
> The researchers are only "a couple of years" away from getting to a place where they can make a embryo for their mammoth-like elephant, per The Guardian, which would actually be something new, rather than a resurrected woolly mammoth in

the way you might expect given popular depictions of extinct species resurrection in popular culture.

An embryo is not a fully grown animal, however, and it'll be some time more before we get there. The team says it'll be "many years" before they arrive at any kind of effort to create a real, living, breathing animal that you could go see in the engineered flesh. The current focus is on seeing what the effect of the edits are on the organism at increasingly complex stages of its development: first, the team was experimenting on cells, and now they're moving on to embryos.

Interestingly, the team suggests their work has a number of potential upsides in terms of helping to preserve the Asian elephant, which is on the endangered species list, in a novel way. It could also help alleviate some global warming concerns, the researchers suggest, by preventing tundra from melting by effectively aerating the permafrost with their steps.

Of course, critics suggest that the project is fraught with ethical concerns, including what it means to resurrect a social species, and whether efforts might be better spent on preservation of species we know are put in danger as a direct result of human interference, rather than an animal that lived so long ago.

The project is scientifically incredibly interesting, however, and it's unlikely to halt its progress now, ethical concerns notwithstanding.

Ryan Phelan
Co-founder and Executive Director
Revive & Restore
ryan@longnow.org
415-710-9409 cell

From: geneticrescue-bounces@list.longnow.org on behalf of Ryan Phelan <ryan@longnow.org>
Sent: Friday, February 17, 2017 9:44 AM
To: Genetics Listserve
Subject: [Geneticrescue] Harvard-led woolly mammoth de-extinction project gets closer to reality
Attachments: ATT00001.txt

FROM TECH CRUNCH

https://techcrunch.com/2017/02/17/havard-led-woolly-mammoth-de-extinction-project-gets-closer-to-reality/

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Ryan Phelan
Co-founder and Executive Director
Revive & Restore
ryan@longnow.org
415-710-9409 cell

From: geneticrescue-bounces@list.longnow.org on behalf of Stewart Brand <sb@longnow.org>
Sent: Tuesday, February 14, 2017 11:52 AM
To: Genetics Listserve
Subject: [Geneticrescue] Merging Paleobiology with Conservation Biology paper
Attachments: Merging paleobiology with conservation biology.pdf; ATT00001.htm; ATT00002.txt

Nice comparison here of "taxon-free" vs. "taxon-based" analysis of ecosystem health, particularly novel ecosystems.

And good expectations for the value of genomic insight.

--Stewart

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From: geneticrescue-bounces@list.longnow.org on behalf of Joanna Buchthal <buchthal@mit.edu>
Sent: Wednesday, February 08, 2017 9:15 PM
To: Genetics Listserve
Subject: Re: [Geneticrescue] Mosquito gene drive thwarted by rapid evolution
Attachments: Concerning RNA-guided gene drives for the alteration of wild populations.pdf; ATT00001.htm; smime.p7s; ATT00002.txt

Dear Stewart,

Kevin addressed these issues in detail in his 2014 eLife paper and has since backed it up with mathematical modeling.

Joanna

***For correspondence:**
kevin.esvelt@wyss.harvard.edu (KME); fcatter@hsph.harvard.edu (FC); gmc@harvard.edu (GMC)

Reviewing editor: Diethard Tautz, Max Planck Institute for Evolutionary Biology, Germany

From: geneticrescue-bounces@list.longnow.org on behalf of Todd Kuiken <tkuiken@ncsu.edu>
Sent: Friday, February 10, 2017 2:44 PM
To: Ryan Phelan
Cc: Genetics Listserve
Subject: Re: [Geneticrescue] Welcome aboard—new genetic rescue listserv participants
Attachments: ATT00001.txt

Welcome everyone! Also great to see some of the nano world (Hi Jo Anne!) come on board.

Todd

On Fri, Feb 10, 2017 at 3:02 PM, Ryan Phelan <ryan@longnow.org> wrote:

Honored to have you guys onboard.!
Feel free to share with this listserv any of your current work that involves the broad and emerging field of genetic rescue….

-all the best
Ryan

> On Feb 10, 2017, at 11:57 AM, Meghan Foley <meghan@longnow.org> wrote:
>
> Hello all!
>
> Please welcome aboard our new Genetic Rescue Listserv participants:
>
> **Larry Clarke, Ph.D.** – Director, National Wildlife Research Center, USDA-APHIS-WS
>
> **Paula Feldmeier** – Environmental attorney for U.S. Army Corps of Engineers
>
> **Edy MacDonald** – Social Science Manager of the New Zealand Department of Conservation - Te Papa Atawhai
>
> **Clare Palmer** – Cornerstone Fellow & Professor of Philosophy at Texas A&M University
>
> **Jo Anne Shatkin, Ph.D.** – President, Vireo Advisors, LLC

> _____
> Geneticrescue mailing list
> Geneticrescue@list.longnow.org
> http://list.longnow.org/mailman/listinfo/geneticrescue

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Geneticrescue mailing list
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