Online Ethics Center
FOR ENGINEERING AND SCIENCE

Readings

Description

Part of unit 5 of the Course on Genomics Ethics and Society, this section provides readings on genomics and its use in conservation and saving endangered species.

Body

Week 1

Everyone should read all three readings for Week 1!

The first reading this week reviews recent advances in genomics and breeding that now make de-extinction a real possibility. Skerkow and Greely (2013) discuss three viable approaches (back-breeding, cloning and genetic engineering) to bring back extinct species. The authors then briefly discuss the ethical and regulatory implications of doing so. Primary objections revolve around animal welfare, environmental harm, human health, political regulation, and moral obligation. Of course there are benefits too, such as reintroduction of lost ecosystem function and its associated service to humans.

1. Sherkow, J. S., & Greely, H. T. (2013). What if extinction is not forever? *Science, 5*, 32-33.

Questions for Reflection: This article identifies five categories each of benefits from and objections to de-extinction. In your view did the authors provide sufficient arguments for and against this technology? What other factors might you consider when deciding whether a plant or animal species should be brought back from

extinction?

The second reading by Steiner et al. (2013) provides an in-depth review of how new high throughput massively parallel sequencing, commonly termed Next Generation Sequencing (NGS), can produce enormous genomic datasets with the potential to transform how we understand and manage genomic biodiversity. Steiner et al. (2013) review NGS in the context of understanding gene flow, adaptive genomic variation, population fitness, hybridization, and disease susceptibility. The very nature of whole genome analysis is likely to allow comparative genomics to replace marker based analysis in the future allowing ecologists, biologists, and conservationists the ability to identify genomic regions directly responsible for phenotypic variations and thus better manage biodiversity. Warning: Undergraduates and non-scientists may find this reading a bit challenging. You don't need to understand all the finer points of the science here - just try to work out what the central thrust of the paper is.

2. Steiner, C. C., Putnam, A. S., Hoeck, P. E. A., & Ryder, O. A. (2013). Conservation genomics of threatened animal species. *Annual Review of Animal Biosciences, 1*, 261-281.

Questions for Reflection: Next generation sequencing is no magic bullet. What are the risks of putting so much emphasis on understanding a species' genome without considering the environmental interactions alongside it?

Finally, the last reading by Thomas *et al.* (2013) looks at genomic engineering to potentially facilitate adaptation *in situ* for an endangered organism. Genetic modification of plants, as we saw in unit 3, has allowed agricultural species to be made resistant to herbicides, to better withstand droughts, and to defend against pests. The same types of technology may allow animals to combat global ecological change, such as climate change and habitat fragmentation, by engineering their genomes. Thomas et al (2013) highlight three options for genomic engineering of animals through hybridization, facilitated gene flow, and, transgenics. The authors argue that these genomic approaches should be used to rescue biodiversity and that collaborative interdisciplinary research should be conducted to target the species that would most benefit from these approaches.

3. Thomas, M. A., et al. (2013). Gene tweaking for conservation. *Nature, 26* , 485-486.

Questions for Reflection: Thomas et al. (2013) make the case for using genomic engineering as a means of rescuing biodiversity. The authors briefly touch on some concerns about using such an approach, but stop well short of highlighting the many arguments for and against such a technology. Having read all three papers, what are your views on using genomics to conserve global biodiversity?

Week 2

Everyone should read both papers this week!

Gould (2007) takes a comprehensive look at a growing field of genomics that focuses on genetic pest management. Genetic pest management uses genetic and genomic technology to alter a disease vector's DNA to reduce its transmission. Gould reviews the history of the field, ranging from male sterilization programs and use of transposable elements, to more recent gene drive approaches using homing endonuclease gene (HEG) technology. Because of the rapid technological improvements and the rapid drop in costs associated with many of the approaches Gould (2007) argues that the field should be revisited, focusing on five aspects of the technology: 1. Genetic 2. Evolutionary 3. Ecological 4. Economic and 5. Ethical. Ultimately, because of the complexity of ecological systems, Gould (2007) makes an argument for increased interdisciplinary collaboration to tackle the problem of pest vectored diseases.

1. Gould, F. (2007). Broadening the application of evolutionarily based genetic pest management. *Evolution, 62*, 500-510.

Questions for Reflection: Thinking more specifically about biodiversity in natural populations, what ecosystem functions and services do "pest" species provide, aside from the undesirable transmission of diseases of human health concern? Are there any arguments to avoid eradication based on some of these functions?

Gould (2007) introduced the idea of genetic pest management as a way to combat diseases of public health concern. Gould et al. (2006) provides a more detailed review of the genetics of disease transmission in mosquito species and discusses ways in which genomic technology can be used to combat this transmission. Gould et al. (2006) highlights the role of "selfish" DNA approaches. These approaches include transgene transposable elements (transposons), homing endonuclease gene

(HEG) technology, and the use of Wolbachia bacteria to spread DNA to high frequencies in a population with no regard to its evolutionary fitness. These approaches are promising, and the technology is improving quickly. As In the case of GMO crops (discussed in Unit 3), genetically modifying animals does raise ethical concerns, even more so in the case of sentient animals. Gould et al. (2006) touches on some of the ethical challenges that must be considered when working with transgenic animals.

2. Gould, F., Magori, K., & Huang, Y. (2006). Genetic strategies for controlling mosquito-borne diseases. *American Scientist, 94*, 238-246.

Questions for Reflection: Gould et al. (2006) mentions that gene flow between mosquito populations is unaffected by national borders. Because genetic engineering of wildlife is generally regulated at the national level, how could international movement of transgenes be controlled, if at all? Should this be considered when deploying genetic pest management approaches?

Recommended Readings

- Sinkins, S. P., & Gould, F. (2006). Gene drive systems for insect disease vectors. *Nature Reviews Genetics, 7*, 427-435.

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