Public Deliberation About Gene Editing in the Wild

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Acknowledgments

- Funding: Public Deliberations on Gene Editing in the Wild, National Science Foundation, Division of Social and Economic Sciences, Award Number 1827935

- Content for several background slides: Carolyn Neuhaus (NSF co-Investigator and Research Scholar, The Hastings Center)

Gene Editing in the Wild

- Emerging technologies for the genetic modification of organisms present unprecedented opportunities to alter wild populations of organisms
- Public health goals have been prominent in these proposals.
  - the Aedes aegypti mosquito transmits chikungunya, Dengue fever, and the Zika virus, and mosquitoes in the Anopheles complex transmit malaria.
  - Genetic strategies to interrupt the transmission of these diseases could have an enormous public health impact.
- Agricultural goals may also be advanced
  - Protecting crops from insect pests such as the diamondback moth, Plutella xylostella, which feeds on cabbage, broccoli, kale, and other crops, costing farmers around the world $4-5 billion per year.
  - Genetically modified diamondback moths might reduce reliance on pesticides to control moth pests and increase crop yields.

Calls for Broad Public Engagement (and Sometimes Deliberation) about Gene Editing in the Wild
(since CRISPR)

BIOTECHNOLOGY

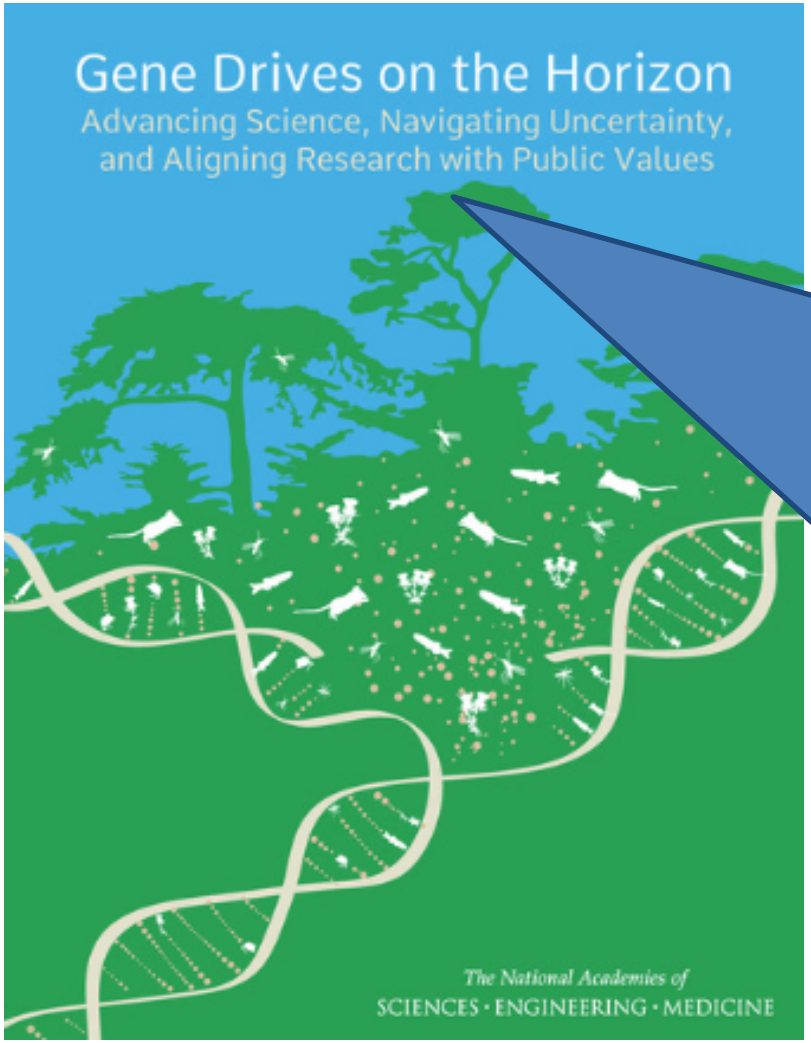
Regulating gene drives

Regulatory gaps must be filled before gene drives could be used in the wild

By Kenneth A. Oye,[1,2*†] Kevin Esvelt,[3*] Evan Appleton,[4] Flaminia Catteruccia,[5,6] George Church,[3] Todd Kuiken,[7] Shlomiya Bar-Yam Lightfoot,[2] Julie McNamara,[2] Andrea Smidler,[5,8] *and* James P. Collins[9]

SCIENCE 8 AUGUST 2014 • VOL 345 ISSUE 6197

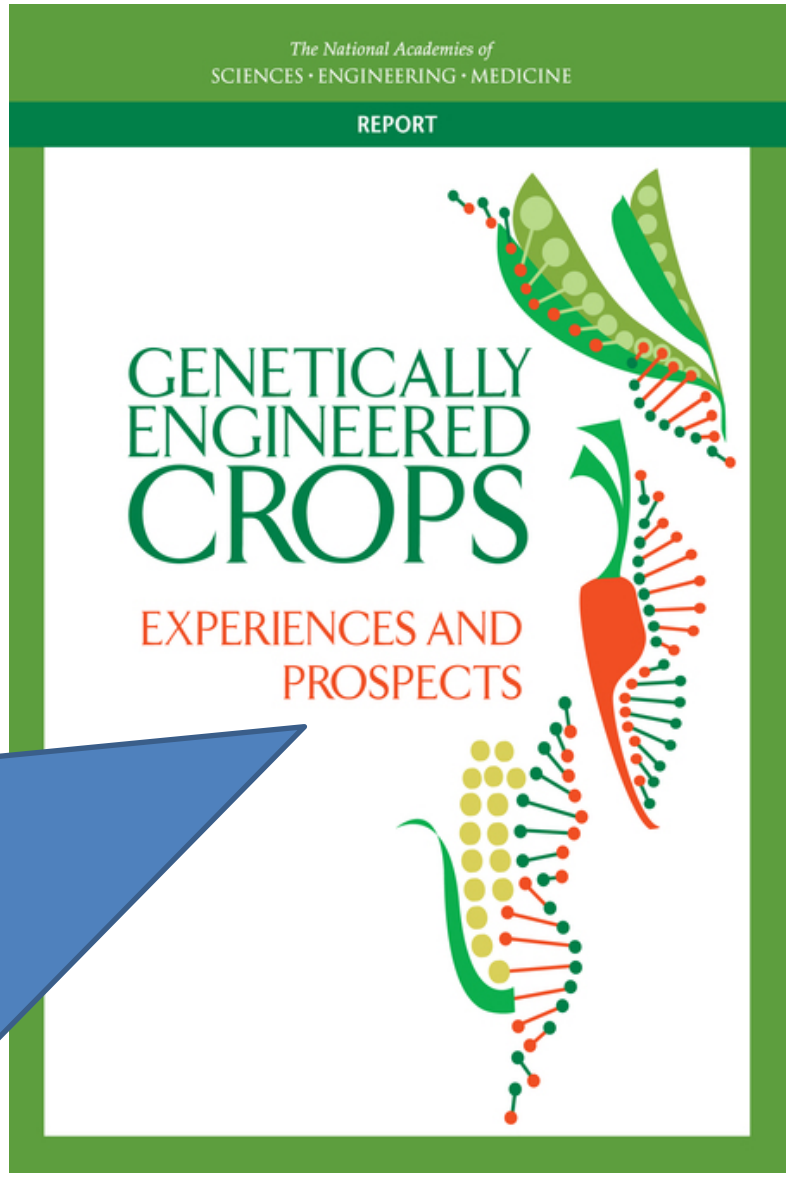
For emerging technologies that affect the global commons, concepts and applications should be published in advance of construction, testing, and release….**Most important, lead time will allow for broadly inclusive and well-informed public discussion to determine if, when, and how gene drives should be used.**



2016

Engagement with communities, stakeholders, and publics is an essential part of research on and development of emerging technologies, including gene drives…The question is not whether to engage communities, stakeholders, and publics in decisions about gene drive technologies, but how best to do so.

FINDING: Transparency and public participation have been shown by research to be critically important for appropriate, sound, and credible governance of all aspects of the development, deployment, and use of GE crops.
RECOMMENDATION: **Regulating authorities** should be particularly proactive in communicating information to the public about how emerging genetic-engineering technologies or their products might be regulated and about how new regulatory methodologies might be used. **They should also be proactive in seeking input from the public on these issues.**



2016

THE GENE-EDITING REVOLUTION

Keep CRISPR Safe

Regulating a Genetic Revolution

Amy Gutmann and Jonathan D. Moreno

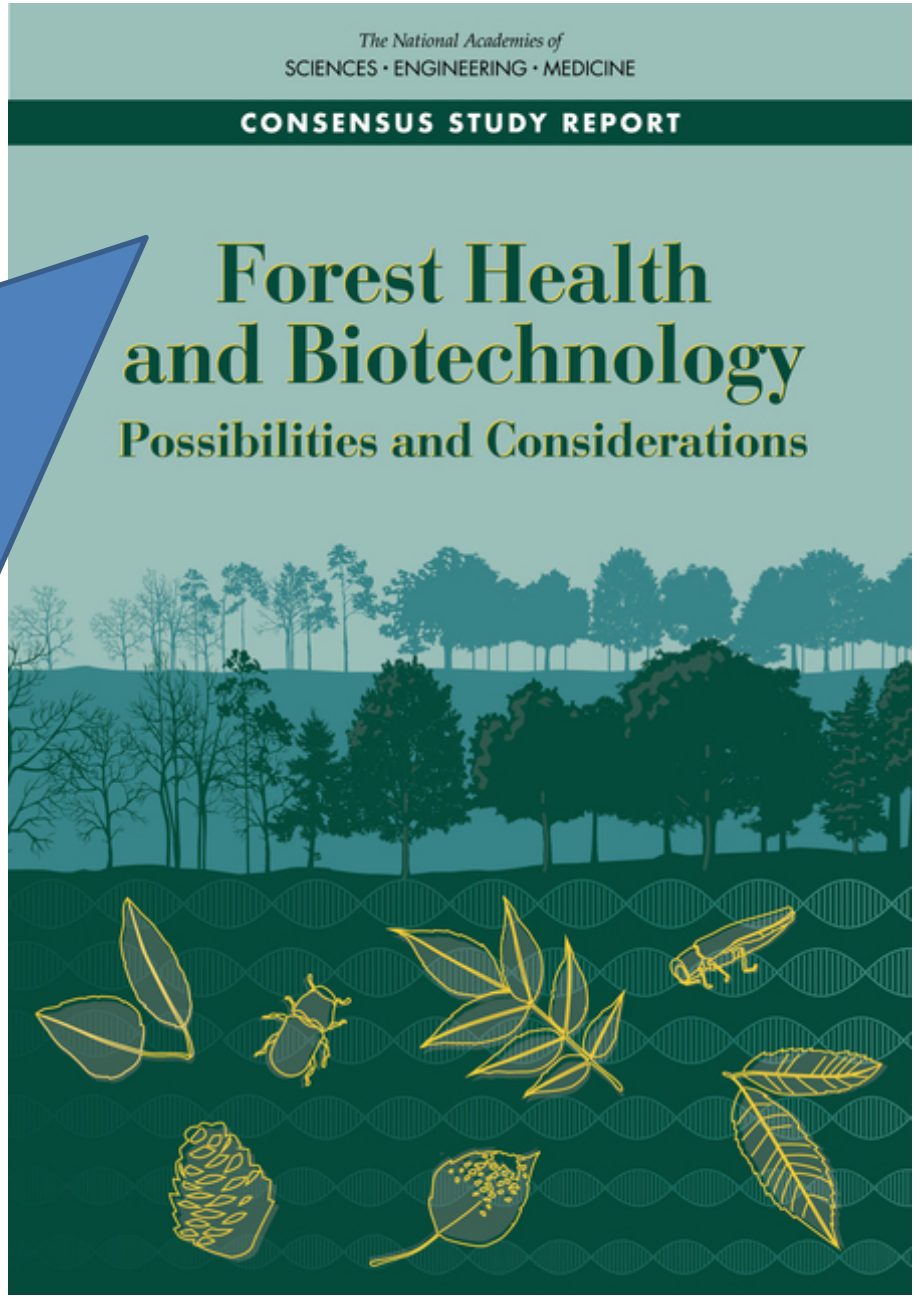
FOREIGN AFFAIRS

May/June 2018

Scientists disagree about how much and what kind of regulation and guidance will be required. So governments should follow the principle of regulatory parsimony, which dictates that they should impose only those restrictions necessary to maintain ethical standards and public safety…

The most effective standards for gene-editing research will come from the scientific community itself, through international summits of science academies and a continual process of intellectual exchange. **Those are the forums that can respond best to often unpredictable developments in the science and react sensitively to public opinion.**

Recommendation: Respectful, deliberative, transparent, and inclusive processes of engaging with people should be developed and deployed, both to increase understanding of forest health threats and to uncover complex public responses to any potential interventions, including those involving biotechnology.
These processes, which may include surveys, focus groups, town hall meetings, science cafés, and other methods, **should contribute to decision making** that respects diverse sources of knowledge, values, and perspectives.



2018

Rationales for
Using PD to guide policy

Potential Benefits of Deliberative Democracy

- Greater **understanding** and more **tolerance** for opposing views;
- A **public-spirited** way of thinking about social problems (as opposed to a self-interested view);
- Increased **clarification** and refinement of participants' positions on issues;
- **Learning** about the consequences of implemented policies and the reasons for past failures; and
- Policy outcomes considered more **democratically legitimate** when decisions emerge from an open and inclusive deliberative process.

Deliberative Democracy vs. Participatory Democracy

- Habermas and deliberation: process of reasoned exchange in which participants listen to others as well as voice their own opinions
  - may occur among relatively small, non-representative political actors
- Most advocates of deliberative democracy call for a more inclusive process.
  - may support the goals of deliberation
    - allows for a broader range views to be heard
    - more likely to encourage the participants to rethink their original policy positions.

From Why to Who: Defining Democratic Communities

NASEM: Identified 3 relevant groups for public engagement

- Communities
  - Those living near a potential field trial or release site
- Stakeholders
  - Those who may not be in geographic proximity to a potential release site, but they have personal or professional interests to justify engagement
- Publics
  - Those who lack a direct connection to a project but “nonetheless have interests, concerns, hopes, fears, and values that can contribute to democratic decision making”

NASEM Groups: Taking a closer look

Communities: Those living near a potential field trial or release site

- What does ”living near” mean?
- What is the outer limit of geographic proximity?
- Who in the communities? Everyone of legal age of majority?

- Lavery et al. (2010)
  - Adopted the principles outlined by Brunger and Weijer (2006)
    - “the community comprises at least those individuals who share identified risks associated with the proposed research project”
    - “the community is not pre-existing and established, but rather takes form progressively in response to specific aspects of the research and to the [community engagement] activities associated with the project.”

NASEM Groups: Taking a closer look

Stakeholders: Those who may not be in geographic proximity to a potential release site, but may be influenced by release

- Research funders/researchers who want studies to go forward?
- Commercial enterprises who may benefit: hold patents; sell field trial equipment, etc.?
- Agricultural context: farmers and those affected by food supply or lack thereof; others?
- Conservation context: those who want to protect/preserve flora, fauna, etc.?
- Public health context: those who might reap health benefits from the use of gene editing?
- Stakeholders who are hundreds or thousands of miles away from the potential release site?

NASEM Groups: Taking a closer look

Publics: Those who lack a direct connection to a project but "nonetheless have interests, concerns, hopes, fears, and values that can contribute to democratic decision making"

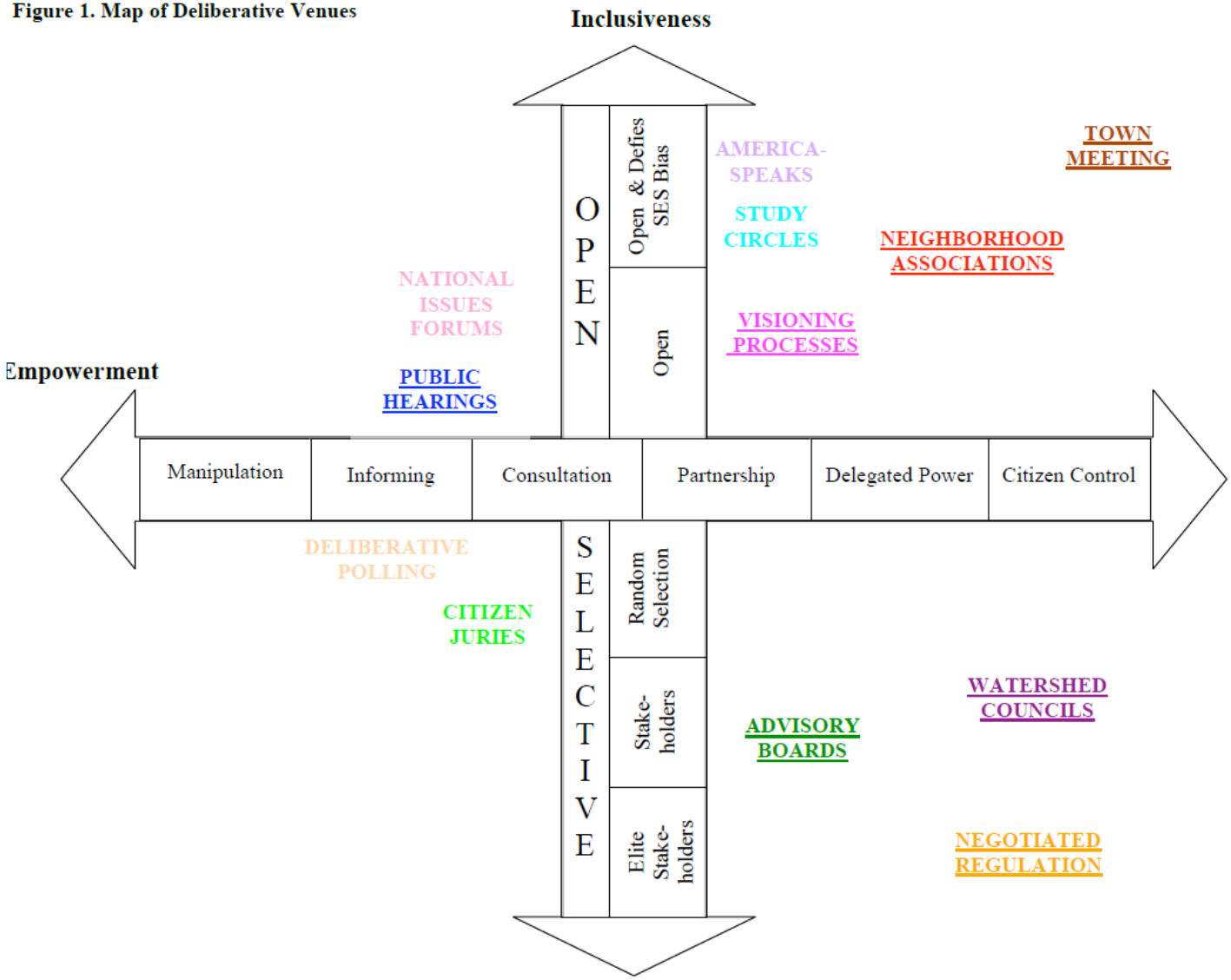
- Organizations, institutions and individual experts advocating for and against the use of gene drives?
- Anyone from the general public from any geographic proximity?
- When to place special emphasis on marginalized populations?
- Others?

From Who to How: Methods of Deliberating

Deliberative Polls or Small Group Deliberations?

- Fishkin argues that deliberations should capture the views of a "microcosm of the public" and use random sampling to ensure inclusion
  - **His question is: What would the public think should be done if they could consider the issue under good conditions**
- Others argue that, if we want to overcome entrenched social inequalities that tend to prevent participation, it may be important to oversample these populations
- What is the goal of the deliberation?

Figure 1. Map of Deliberative Venues



How to address power dynamics?

- All participants should have an equal opportunity to voice their concerns.
  - But representation alone may not be enough
- Background materials
  - Address broader social, political, and economic contexts of new technologies
- Involve marginalized groups in the logistics of the deliberation
  - Take time to learn about the historical trauma that may be associated with certain places, like universities
- Train facilitators to confront directly power imbalances that are relevant to gene editing
  - Give equal time to marginalized groups to address the potential that more powerful will dominate the conversation

Benefits and Pitfalls of Narrative

- Capturing narratives can be used to help the participants in broad public deliberations
  - introduce new ways of understanding
  - overcome the bias in favor of arguments that reflect dominant academic and political economic perspectives.
- Important to separate legitimate values from unhelpful emotional responses, and to eliminate manipulative and overbearing communications

Deliverables

- Who is the audience?
- Think creatively!
  - Ask participants what forms of outputs would be most accessible to the community at large and representative of the deliberations?
  - Consider including visual metaphors or diagrams that documenting collective understandings from deliberative activities

Why Genetically Modify Mosquitoes?

- Females of several species transmit serious, sometimes deadly, infectious diseases to humans: dengue, malaria, yellow fever, and Zika.
- Insecticides the primary method of eradicating mosquitoes. In many parts of the world, mosquito species are becoming insecticide resistant.
- In low-income countries, difficult for various reasons to supply affected populations with bed nets and pharmaceutical preventive and treatment interventions.

Oxitech: Friendly™ Mosquito Technology

- Genetically modified *Aedes aegypti* mosquito that transmits Zika virus, dengue, chikungunya and yellow fever.
- Zika infection can cause:
  - Severe brain defects in the fetus/newborn, including microcephaly.
  - Also linked to other pregnancy-related problems: miscarriage, stillbirth, and other birth defects.
  - In Zika- affected areas, increased reports of Guillain-Barré syndrome, an uncommon sickness of the nervous system.
  - No vaccines or medicines have been developed to prevent and treat the infection. (https://www.cdc.gov/zika/about/overview.html).

Oxitech: Friendly™ Mosquito Technology

- Male mosquitoes genetically modified to carry a protein that will inhibit survival of female offspring when GM males mate with wild female mosquitoes.
- Male offspring will have same genetic modification, providing multi-generational effectiveness.
- The self-limiting gene persists but declines over time, thus offering potentially multiple but still self-limiting generations of suppression for every GM male released.
- The self-limiting gene can be turned off with tetracycline to allow breeding the insects at a large scale without need for any additional genetic engineering.
- EPA requires Oxitec to monitor and sample the mosquito population weekly in field trial areas to determine how well they work for mosquito control and to confirm that modified genetic traits disappear from the male *Aedes aegypti* population.

https://www.oxitec.com/en/news/oxitecs-friendly-mosquito-technology-receives-us-epa-approval-for-pilot-projects-in-us

Concerns About GM Mosquitoes

- Transmission of different viruses, more virulent viruses, or the same viruses at a higher rate if different mosquito species move into an area where a specific species has been removed
- Non-sexual movement of genetic information between mosquito genomes, e.g., incoming DNA or RNA can replace existing genes or can introduce new genes into a genome.
- Mutation of GM mosquito into a more pesky or dangerous disease vector.
- Mosquitoes whose dominant lethal gene has been deactivated with tetracycline (the Oxitech mosquito) will not die if they come into contact with tetracycline in the environment, with unknown effect when they remain in their natural environment. Tetracycline is an antibiotic used in humans and nonhuman animals. More than 70% of tetracycline antibiotics are excreted and released in active form into the environment via urine and feces. https://link.springer.com/article/10.1007/s10311-013-0404-8

Oxitech: Friendly™ Mosquito Technology

- 2015 and 2016
  - Large outbreaks of Zika in Puerto Rico, U.S. Virgin Islands, and the America.
  - Some travel-associated cases reported in several U.S. states.
  - U.S. Centers for Disease and Control and Prevention data for 2018 and 2019: no reports of mosquito-transmitted Zika virus infections in the continental United States. (https://www.cdc.gov/zika/reporting/index.html)

Oxitech: Friendly™ Mosquito Technology

- Monroe County, FL (Florida Keys)
  - After U.S. Environmental Protection Agency and members of the Florida Keys Mosquito Control District approved research field trials, Oxitec released 12,000 mosquitoes in first phase in August 2021. Second phase to release several million.

- Harris County, TX (Houston is county seat and 4th largest city in U.S.)
  - After EPA approved field trials in U.S., county officials decided to postpone indefinitely determining whether to let Oxitech conduct field trials in the county

Hypothetical Public Deliberation in Harris County, TX

How should participation and deliberation be arranged given its demographics (2020 U.S. Census)?

- White alone: 69.6%
- Black or African American alone: 20.0%
- American Indian and Alaska Native alone: 1.1%
- Asian alone: 7.3%
- Native Hawaiian and other Pacific Islander alone: 0.1%
- Two or More Races: 2.0%
- Hispanic or Latino: 43.7%
- White alone, not Hispanic or Latino: 28.7%
- Foreign born persons, percent, 2015-2019: 26.1%
- Language other than English spoken at home, percent of persons age 5+, 2015-2019: 44.4%

Hypothetical Public Deliberation in Harris County, TX, part 2

- High school graduate or higher, percent of persons age 25 years+, 2015-2019: 81.4%
- Bachelor's degree or higher, percent of persons age 25 years+, 2015-2019: 31.5%
- Persons under 5 years: 7.4%
- Persons under 18 years: 26.4%
- Persons between 19 and 64: 55.3%
- Persons 65 years and over: 10.9%
- Median household income (in 2019 dollars), 2015-2019: $61,105
- Persons in poverty: 15.0%
- Persons without health insurance, under age 65 years: 24.2%