Biotechnology? OK, but so many more issues need to be resolved

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The Potential for Biotechnology to Address Forest Health
National Academy of Sciences
Crisis: 40+ species devastated

- redbay,
- sweetbay,
- swamp bay

- butternut
- eastern & Carolina hemlock
- ohi`a
- black ash
Gene-drive modified organisms hold promise for addressing difficult-to-solve challenges ... but ...

• proof-of-concept lab studies are not sufficient to support a decision to release gene-drive modified organisms into the environment

• existing risk analysis protocols (including NEPA) are not adequate
Not clear to me whether ...

- Genetic engineering of the host will result in faster development of pest resistance (separate from use of techniques to overcome specific issues in research/analysis)

- Genetic engineering will result in longer-lasting resistance (especially since resistance often results from interaction of multiple genes)
(continued)

• Does GE better facilitate programs addressing multiple pest threats to a tree host? (e.g., 6 pests threaten American chestnut)

• Is risk of unwanted non-target impacts greater or less using GE v. traditional breeding? Or does it vary by host, type of pest, whether the inserted genes are cisgenic or from distantly- or un-related species?
Retain regulation for years

Given the many unknowns – many of which cannot be resolved for decades – programs should not seek deregulation immediately; instead, retain regulation of large-scale test plots -- possibly hundreds of acres scattered across the full range of the tree species; a cautious, incremental approach

Although current regulatory regime is inadequate, is better than none.
Is clear to me:
Need Comprehensive Programs

As described by
- Campbell & Schlarbaum (2014)
- Wheeler, Steiner, Schlarbaum, Neale (2015)
- Sniezko & Koch (2017)

+ begin analyzing levels of genetic resistance in species early in the invasion
For each species, need to consider all components of a comprehensive program

• Most promising techniques for developing resistant genotypes;
• Use of pest-mitigation strategies, including biocontrol;
• Development and application of management techniques to plant out trees in the forest.

[some ideas from FHI table for “Decision Tree” (2012)]
SPECIFIC ISSUES (1)

What criteria to set priorities among host/pest targets

• Magnitude of mortality (measurable for established pests; difficult for new pests)
• Urgency of threat (rate of spread throughout range; inadequacy of existing containment strategies)
• Ecological importance of the host

• Maybe ...
  • How quickly can scientists gain adequate knowledge of pest/host interactions?
  • How quickly can scientists gain adequate knowledge of sylvics & host ecology (necessary for restoration planting)?
SPECIFIC ISSUES (2)

need comparisons among alternative tactics – through, e.g., “ecological risk assessment”

• Probability of success of breeding / likelihood of genetic resistance within species
  – Probability of pest overcoming bred resistance
  – Is GE more/less likely to speed resistance breeding?

• Probability of success of other strategies

• Are unwanted impacts on non-target organisms more/less likely using traditional or GE breeding?
Is it possible to generalize re: targeting host or pest?

E.g., when

- A single pest attacks numerous species?
- Insect v. pathogen?
  - Insect-vectored pathogen?
- Mortality results from attack by single or few organisms v. mass attack?
Value of traditional breeding

• Some (most?) tree species do show varying levels of resistance to pest -- detect & test, utilize

• New techniques to detect chemicals of interest -- Fourier-transform infrared (FT-IR) & Raman spectroscopy

• Challenges – time to reach flowering
  (however, in all cases need to let seedlings mature to ensure that resistance is lasting, not juvenile/transitory)
GE –

• Risks (More precise insertions with CRISPR – so less risk? But concern about gene drives ...)
• Might speed up some steps in process described above ... but does not affect other steps
• Lengthy approval process – even under current, inadequate procedures
• Public concerns might hamper or make impossible to introduce
• Might be more successful raising funds because exciting & new
All breeding efforts hampered by

Inadequate funding & infrastructure across the board –
- germplasm collection & storage
  (appropriate storage varies; need to represent full genetic variability)
- Research to detect & test potential resistance or tolerance
- Research to identify techniques for producing propagules
- Site acquisition – must be secure over decades
- Site preparation & planting
- Post-planting maintenance
- Monitoring to determine success or problems
Attempt to resolve those problems - Farm Bill proposal - research

A grant program managed by NIFA to provide long-term funding for research to restore tree species severely damaged by alien pests. Focus on:

- Biocontrol of pests threatening native tree species;
- Exploration of genetic manipulation of the pests;
- Enhancement of host-resistance mechanisms for individual tree species;
- Development of other strategies for restoration; and
- Development & dissemination of tools & information from research.

Entities eligible for funding under CISP proposal would include:

- Federal & State agencies & cooperative institutions;
- Universities with a college of agriculture or wildlife and fisheries; and
- Non-profit entities recognized under § 501(c)(3) of IRS Code.
Farm Bill proposal - application

**long-term funding** for research into & **deployment** of strategies for restoring pest-decimated tree species in the forest - funds from McIntire-Stennis. Similar eligible institutions. Projects would integrate the following components:

- Collection and conservation of native tree genetic material;
- Production of propagules sufficient for landscape scale restoration;
- Site preparation of former of native tree habitat;
- Planting of native tree seedlings; and
- Post-planting maintenance.

Multi-year competitive grants based on the following criteria:

- Risk posed to the forests of that state by non-native pests (e.g., # of such pests present in the state);
- The proportion of the state’s forest composed of species vulnerable to non-native pests present in the United States; and
- The pests’ rate of spread via natural or human-assisted means.
Conclusions

Proceed with caution

need for comprehensive approach that includes
needed infrastructure & funding
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