Gene flow issues with GE-crops

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Goal: **Discuss the issues related to gene flow of GE-crops to develop a framework for transgene containment**

Objectives:

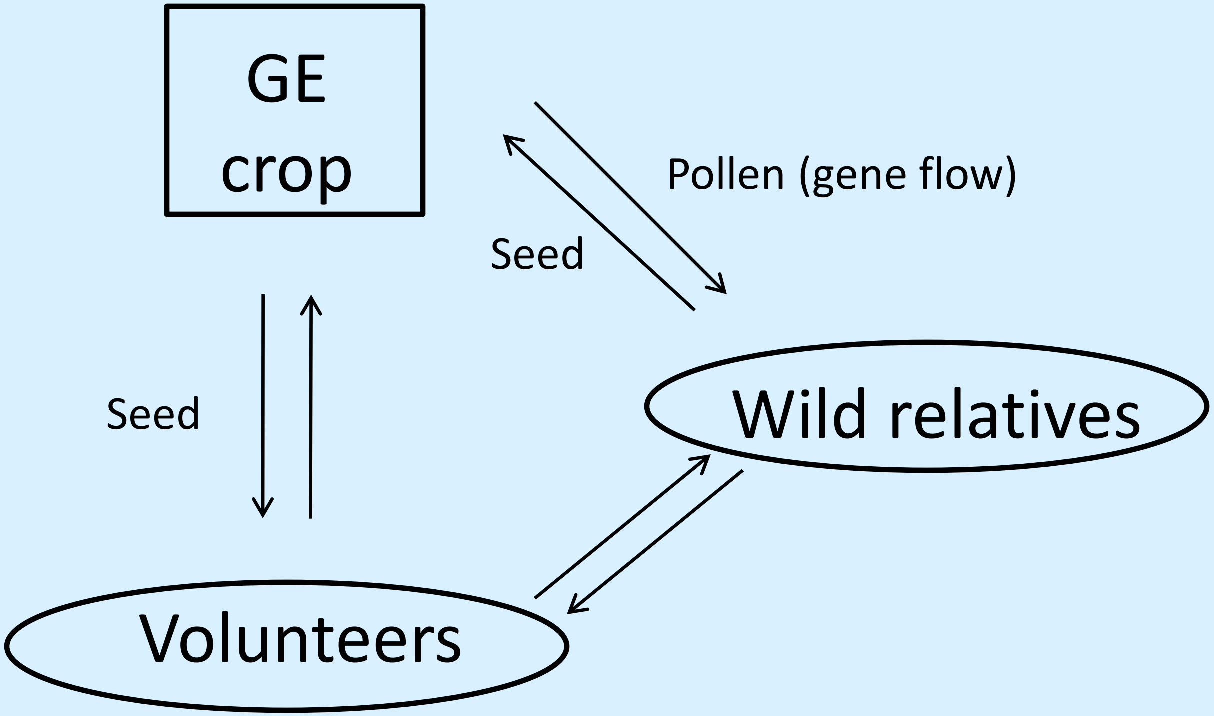
At the end of the session, participants will be able to

- **Explain the factors affecting on horizontal gene flow**
- **Describe why gene flow has to be controlled**
- **State rice-transgene combinations in the pipeline**
- **Analyze the biological aspects of rice that regulate outflow of transgenes**
- **Analyze the Sri Lankan context for the outflow of trangene and synthesize plans to test the hypotheses**

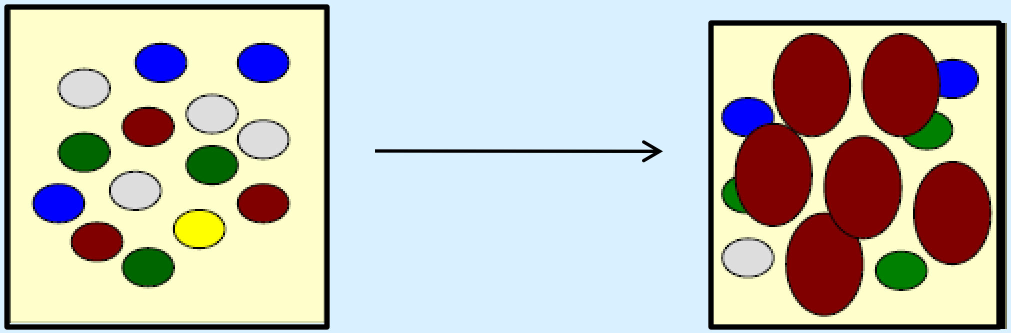
Possible environmental risks associated with a GE crop:

- Nontarget effects of novel toxins.
- Development of resistance in pests.
- Whether the transgene will alter crop fitness* and competitive ability making it more invasive.
- Whether pollen flow from the GE crop will alter native species fitness and competitive ability making it more invasive.

Potential crop – wild interactions:

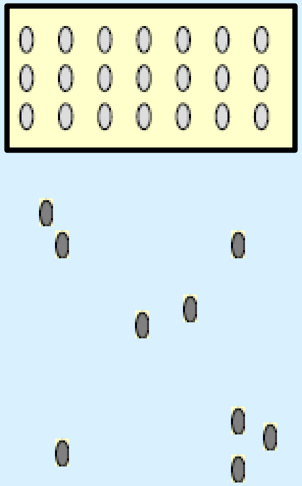


The overall concern is that the GE crops and related species could become more invasive and reduce biodiversity.

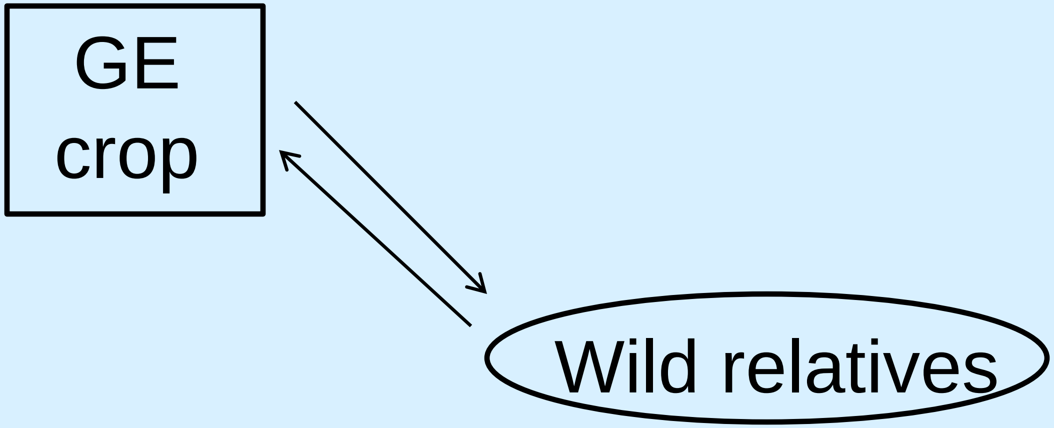


Several factors can slow rates of "gene flow" when crops are grown adjacent to wild relatives

- Breeding system
  - Selfing vs. outcrossing
- Agent of pollination
  - Wind vs. insect
- Type of seed dispersal
- Flowering time

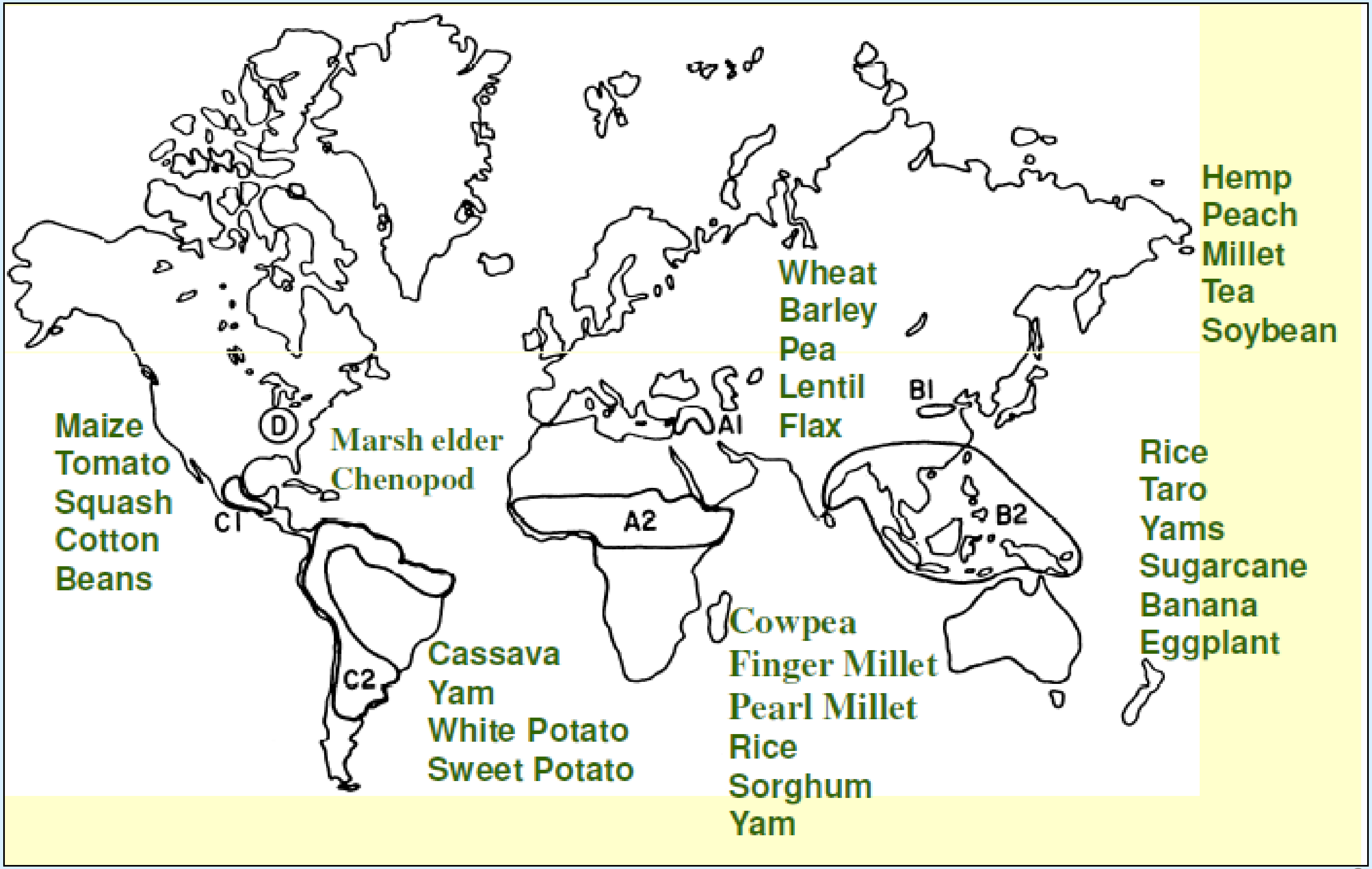


BUT ! Successful crop/wild hybridizations are relatively common, regardless of life history



This means that transgenes will eventually escape as long as a compatible relative is nearby

All crops have relatives somewhere:



Because genes will ‘escape’ if a relative is nearby:

Three major factors determine the environmental risk of GE crops

1. Is a compatible relative present?
2. Is the crop or native relative highly invasive?
3. Will the engineered trait significantly effect the invasiveness of the crop or native relative?

The need for new experimentation for regulatory approval should be based on what scientific information is already available.

The level of invasiveness can be put into three general categories:

- Non-persistent
  - Carrot, cotton, chickpea & maize
- Persistent but non-invasive
  - Asparagus, blueberry, cassava & yam
- Persistent & invasive
  - Rapeseed, rice & sorghum

The invasiveness of crops is also indicated by the number of "weedy" traits they carry

- Broad germination requirements
- Discontinuous germination
- Long lived seeds
- Rapid growth to flowering
- Continuous seed production
- Self pollinated
- Unspecialized pollinators
- High seed output
- Seeds produced in many habitats
- Short and distant seed dispersal
- Vigorous vegetative reproduction
- Brittle propagules
- Vigorous competitors
- Polyploid

% Weediness traits in crops

0 – 40	Cabbage, cassava, carrot, citrus, lettuce, maize, potato, radish, soybean & squash
40 – 50	Rice, bean, peanut, sweet potato & tomato
50 +	Sorghum, wheat & rapeseed

We need to worry most about those crops and native species that persist and carry high numbers of weedy characteristics

Relative fitness impact of transgenes

1: Neutral in the native environment (Marker genes)

2: Detrimental in the native environment (Male sterility)

3: Herbicide resistance - depending on invasiveness of crop or native relative

4: Pest resistance - depending on level of resistance in natural populations

5: Advantageous in the native environment (Cold, drought & metal tolerance)

Levels of experimentation needed before release of a transgenic crop

1. Safe to deploy without any further experimentation
2. Require further experimentation
3. Probably shouldn't be done without fertility control

Actually three tiers

New genes for rice

- *Bt*-genes
- Cowpea trypsin inhibitor gene (*CpT1* gene)
- Insect pest management
- Herbicide resistance
- Male sterility
- Marker genes
- Do we care if wild relative acquire transgenes for ß –carotene?

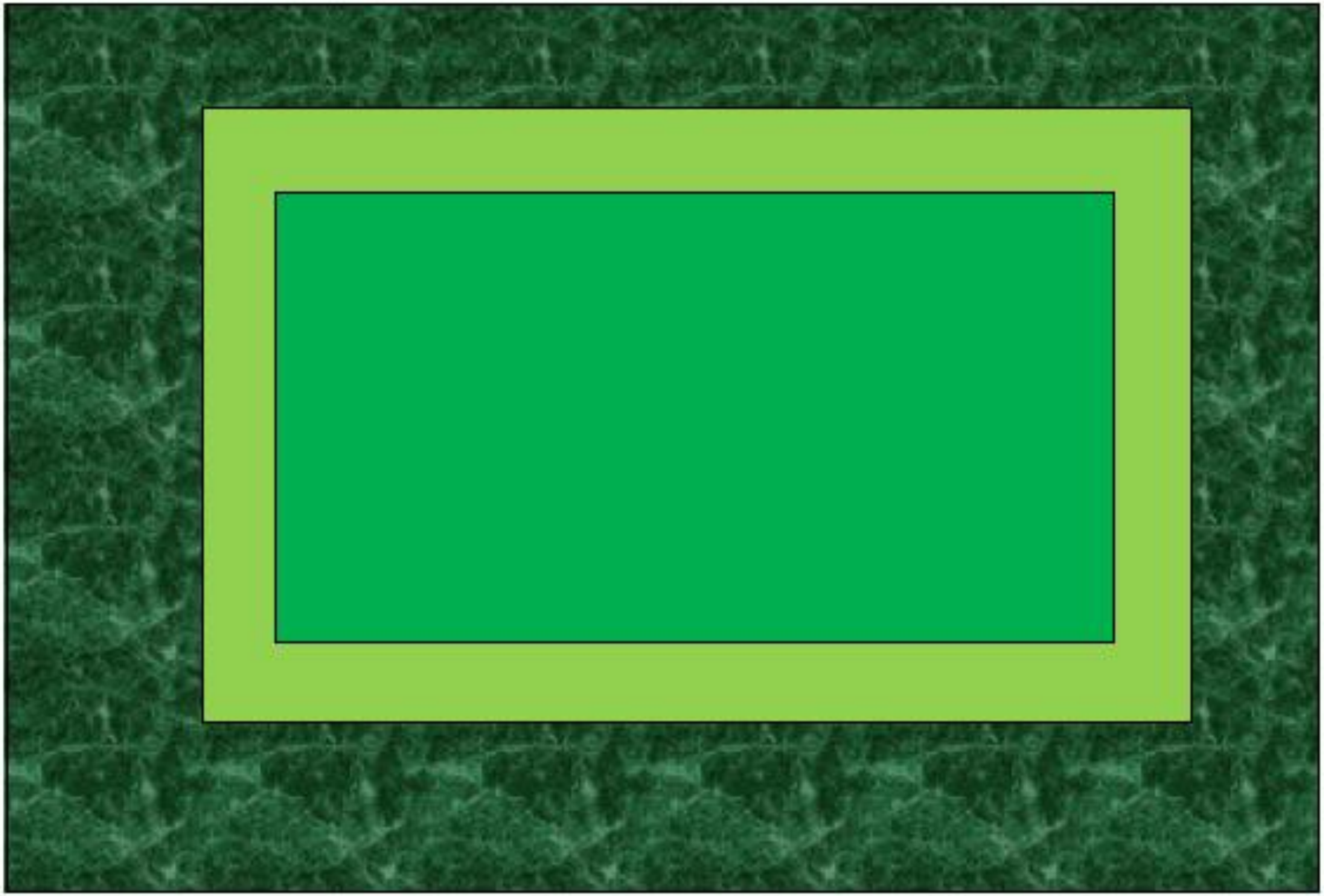
Prevention of gene flow from Bt-rice

- 99% self pollination in rice is big relief
- However, 1% of ………………….. is there?
- Refuge or buffer zone
- The minimum distance between the GE rice crop and wild relative: ~ 10 m
- That 10 m has to be a refuge

Sri Lankan context

- Richness of related biodiversity to rice
- List of relatives
- Are these relatives exchanging genes with rice crop?
- List of real concerns
- How can GE rice be introduced?
- Smallness of rice fields is the biggest issue as required distances cannot be maintained.

Experimental plan test the hypothesis of transgene escape



Appreciation

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- **Special thank goes to Ms. P. Janaththani for technical assistance**

Biotech products in medicine

Table 1.1 TOP-TEN BIOTECHNOLOGY DRUGS (WITH SALES OVER $1 BILLION)

Drug	Developer	Function (Treatment of Human Disease Conditions)
Procrit	Johnson & Johnson	Anemia
Epogen	Amgen	Anemia
Enbrel	Amgen & Wyeth	Rheumatoid arthritis
Aranesp	Amgen	Anemia
Remicade	Johnson & Johnson and Schering-Plough Corp.	Rheumatoid arthritis
Rituxan	Roche Holding Ltd.	Non-Hodgkin's Lymphoma
Neulasta	Amgen	Increases white blood cell count in cancer patients
Avonex	Biogen Idec Inc.	Multiple sclerosis
Neupogen	Amgen & Roche	Increases white blood cell count in cancer patients
Lantus	sanofi-aventis	Diabetes

Biotech products in medicine

Table 1.2 EXAMPLES OF PROTEINS MANUFACTURED FROM CLONED GENES

Product	Application
Blood factor VIII (clotting factor)	Used to treat hemophilia
Epidermal growth factor	Used to stimulate antibody production in patients with immune system disorders
Growth hormone	Used to correct pituitary deficiencies and short stature in humans; other forms used in cows to increase milk production
Insulin	Used to treat diabetes mellitus
Interferons	Used to treat cancer and viral infections
Interleukins	Used to treat cancer and stimulate antibody production
Monoclonal antibodies	Used to diagnose and treat a variety of diseases including cancers
Tissue plasminogen activator	Used to treat heart attacks and stroke

Top Biotech companies

Table 1.3 TOP-FIVE BIOTECHNOLOGY COMPANIES AND TOP-FIVE PHARMACEUTICAL COMPANIES BY REVENUE

Biotech Companies	Revenue ($Millions)
Amgen	$12,022
Genentech	$6,633
Genzyme	$2,597
Biogen Idec	$2,377
Chiron	$1,921
Pharma	
Pfizer	$51,298
Johnson & Johnson	$50,656
Merck & Co.	$22,000
Bristol-Myers Squibb	$19,207
Eli Lilly & Co.	$14,645

Adapted from: Ernst & Young, *Beyond Borders: Global Biotechnology Report 2006* (www.ey.com/beyondborders). Revenue based on preliminary results reported by companies.