

GMO's and the Environment

Paul Gepts
Plant Sciences
UC Davis

ANR NRCC March 2, 2005

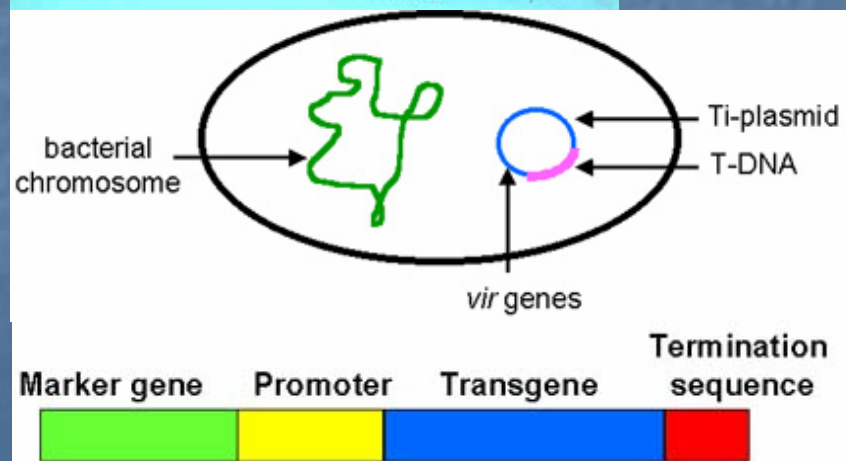
Introduction

- What is a GMO, i.e. **GEO** (Genetically Engineered Organism)?
 - Transfer of genes via **non-sexual** means:
 - *Agrobacterium*
 - Biolistics
 - Advantages and disadvantages:
 - Any gene from any source
 - Single-gene traits; lack of control over insertion location "events"

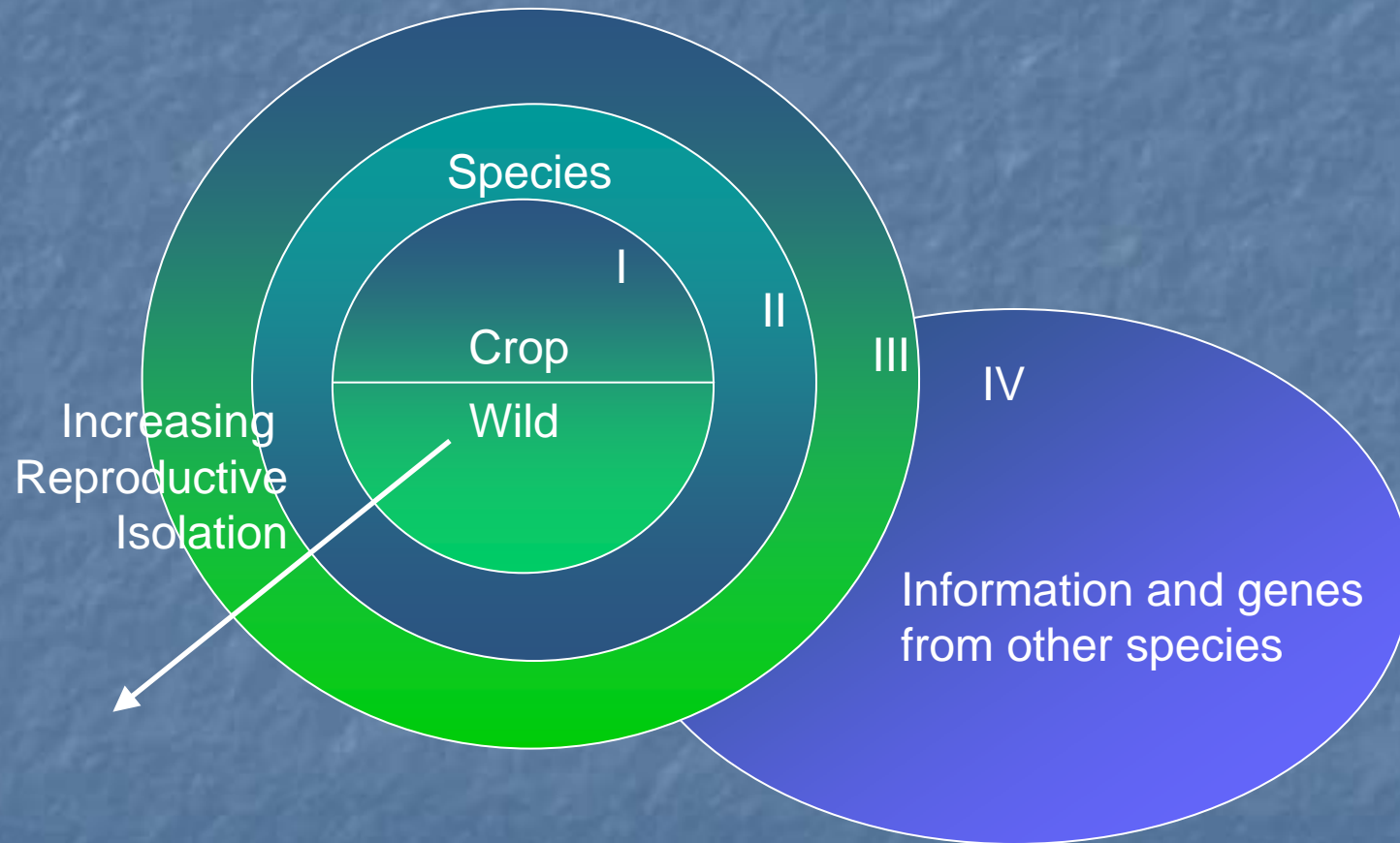
Gene transfer methods in genetic engineering



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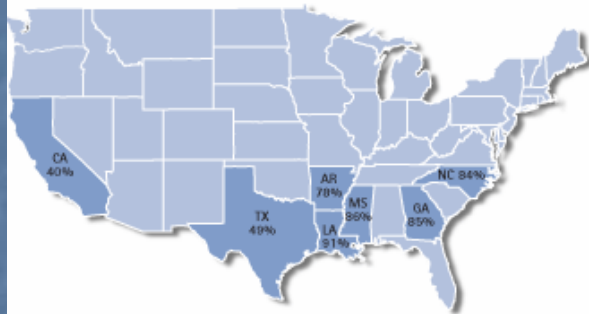
Crop Gene Pools



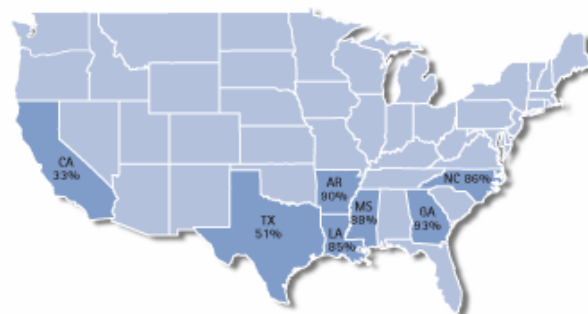
GE crops in CA

PRINCIPAL STATES GROWING GM COTTON

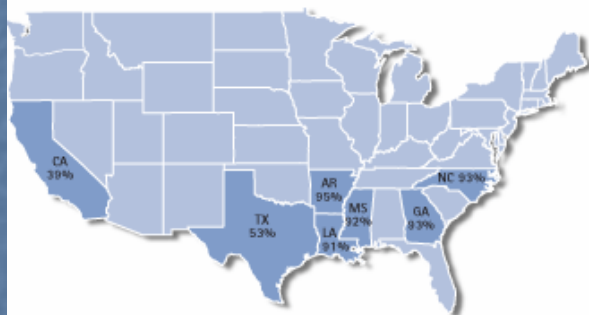
2001



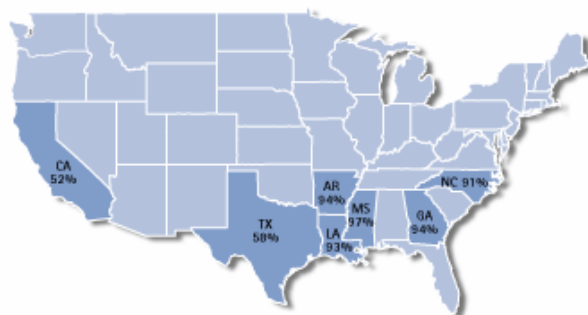
2002



2003



2004



Source: Figures based on N.A.S.S.

Acreage Reports, June 2002, June 2003, and June 2004.

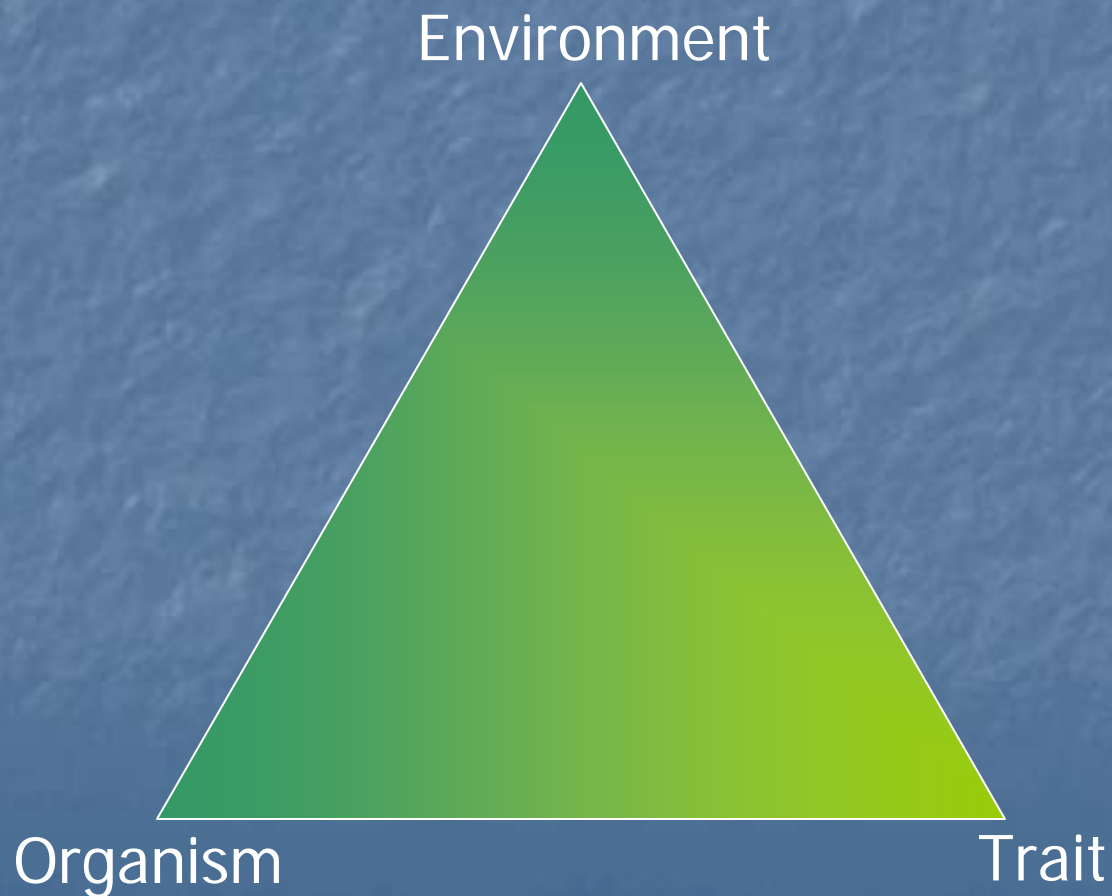
- Currently:
 - Cotton: Upland
 - Herbicide, Bt
 - Corn: small
- Short-term:
 - Alfalfa
 - Herbicide
- Potential
 - Rice
 - Herbicide

Other potential GE crops?

- Top CA commodities: milk and cream, nursery, **grapes**, **lettuce**, almonds, cattle and calves, strawberries, flowers, **tomatoes**, hay (**alfalfa**), **cotton**, broccoli, chickens, oranges, carrots, **rice**, avocados, walnuts, eggs and lemons.

The golden rule of GEO evaluation

Case by case



Potential Environmental Concerns

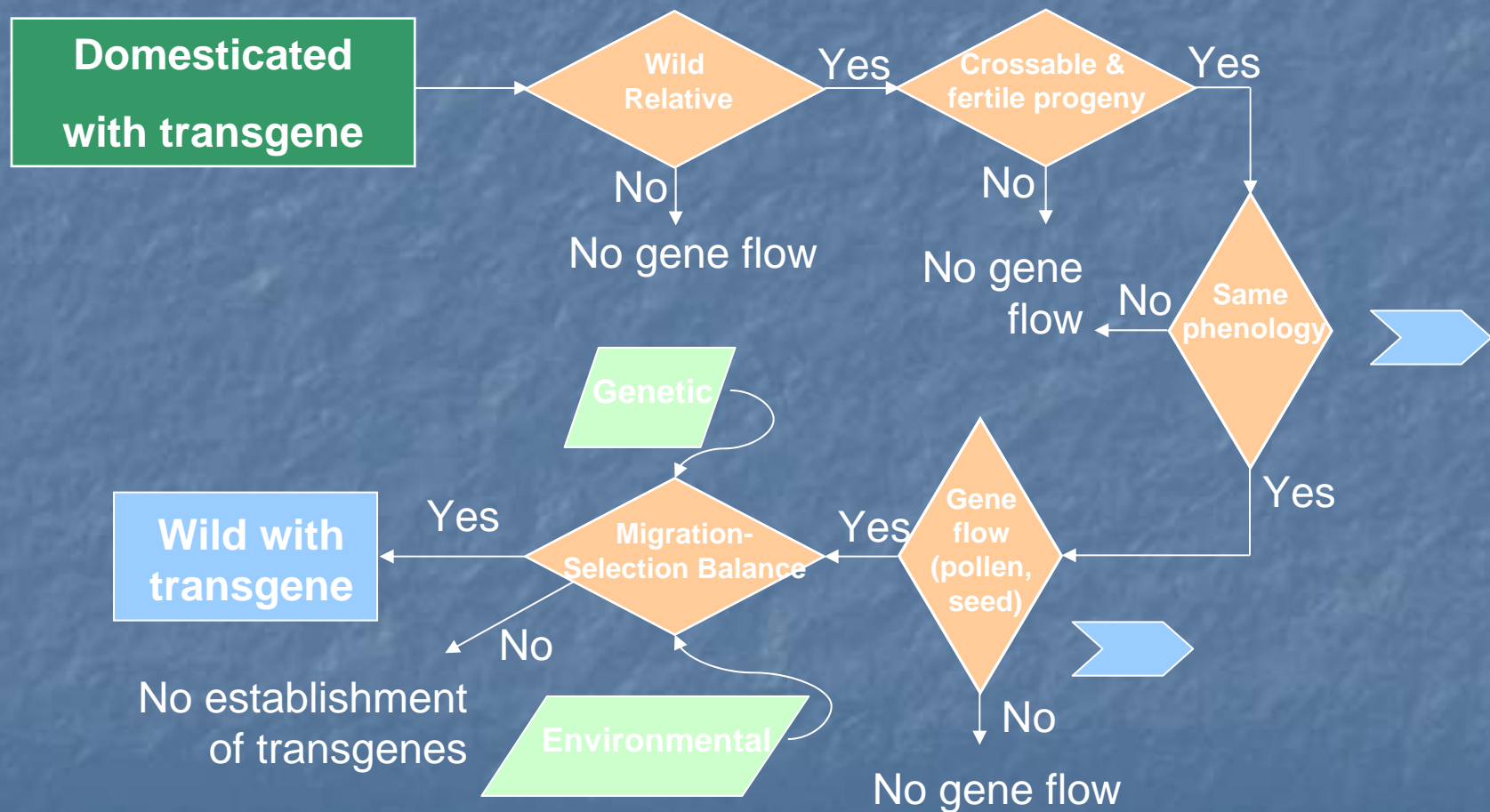
- Escape of transgenes from cultivated to wild or from cultivated to cultivated
- Effect on target organisms
- Effect on non-target organisms

Crops with wild relatives in California

- Same or different species
- Asparagus, broccoli*, canola, carrot, cauliflower*, celery, lettuce, onion, potato, strawberry, sugarbeet, sunflower, tomato*

* Short-lived escape from cultivation

Escape of (Trans)genes from Domesticated to Wild

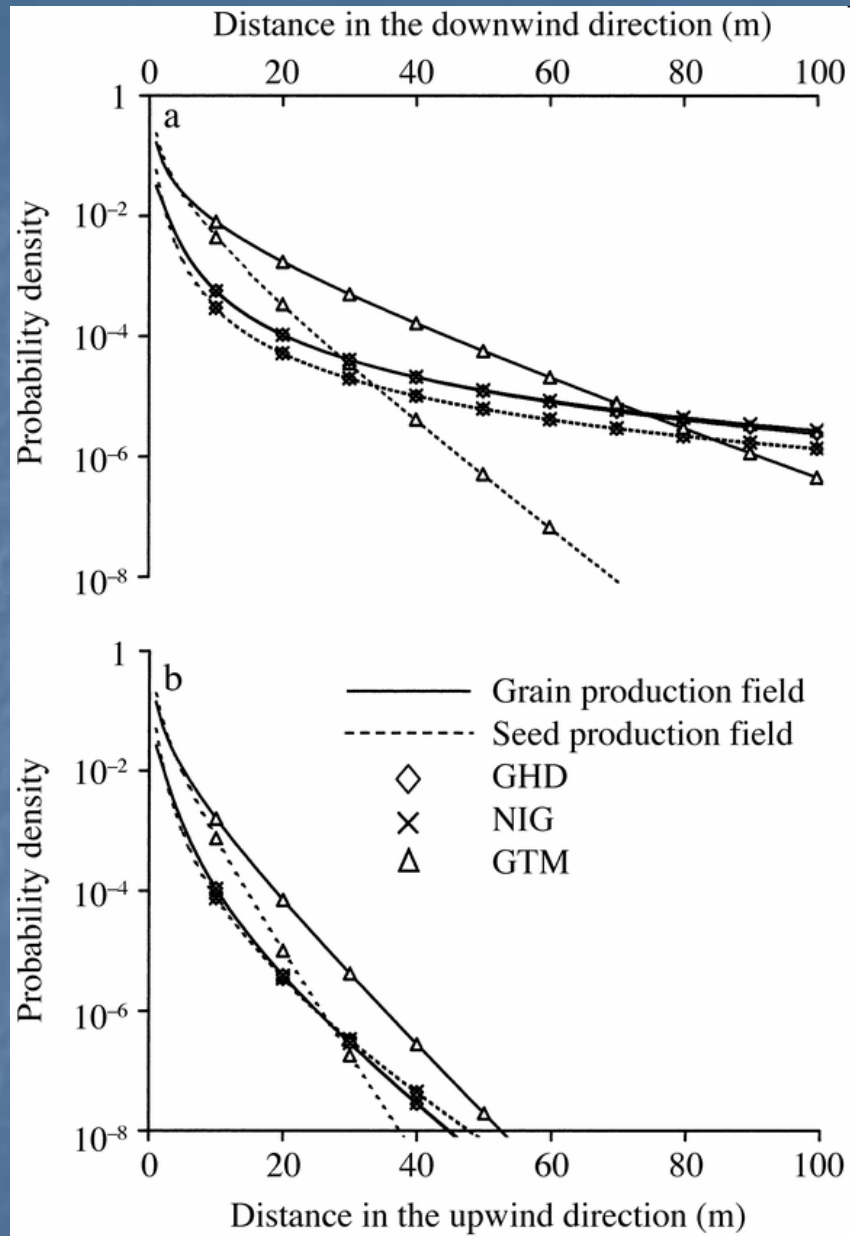


California's Ten Most Important Vegetable Crops and their Relatives in California

(from Ellstrand 1992 based on Muntz 1959)

| Crop | Same species in California flora? | Other congeners in California flora? |
|--------------------|--|---|
| Asparagus | Yes | 0 |
| Broccoli | Yes* | 8 |
| Carrot | Yes | 1 |
| Cauliflower | Yes* | 8 |
| Celery | Yes | 1 |
| Corn, sweet | No | 0 |
| Lettuce | No | 6 |
| Onion | No | 37 |
| Potato | No | 21 |
| Tomato | Yes* | 0 |

*** Only as a short-term non-persistent escape from cultivation**



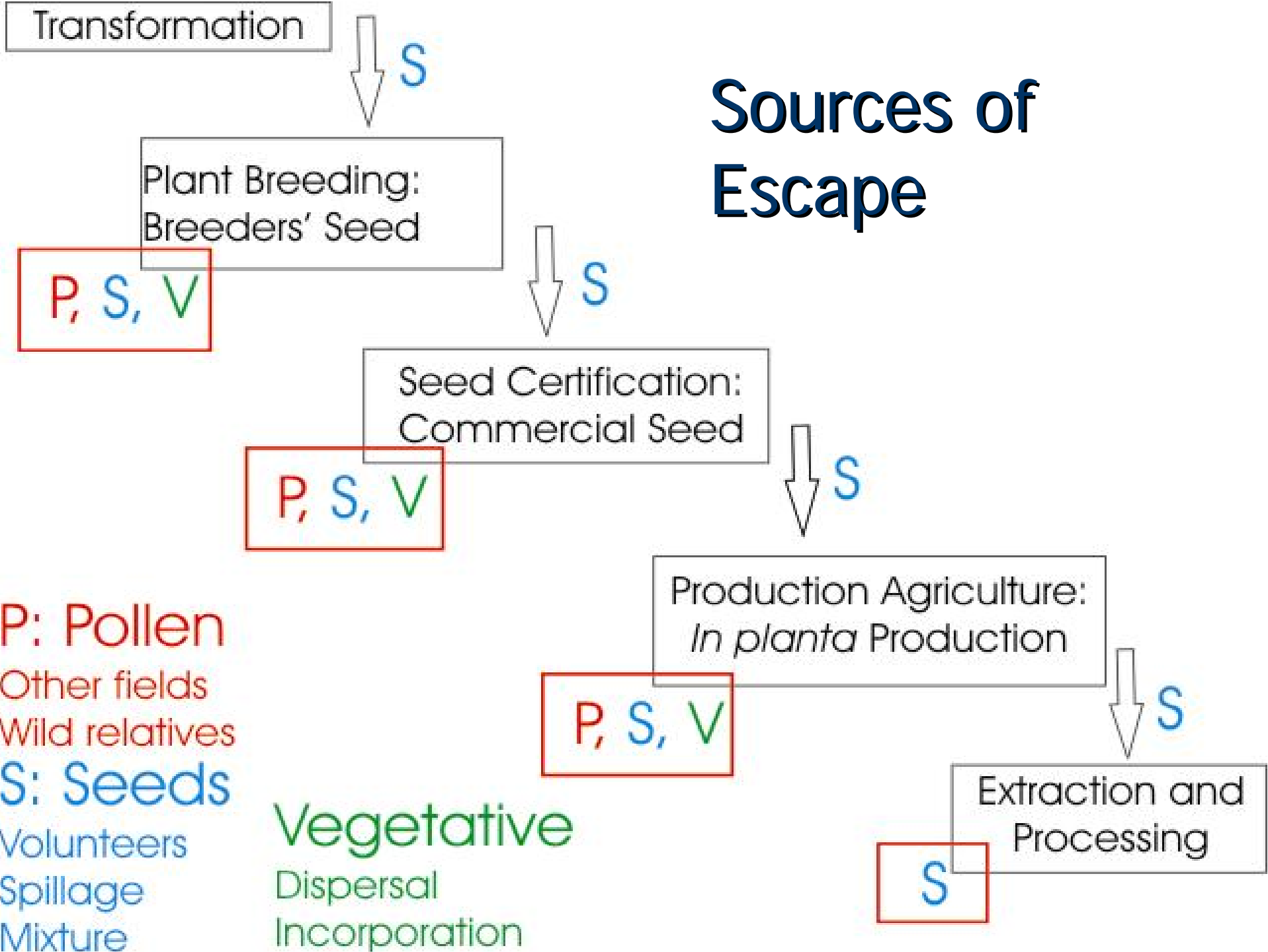
Corn pollen dispersal curves

- Rapid decline within 20 m; slower after that
- Detectable gene flow beyond isolation distance of 200m

Klein et al. Ecol. Monographs 2003

Henry et al. 2003

Sources of Escape

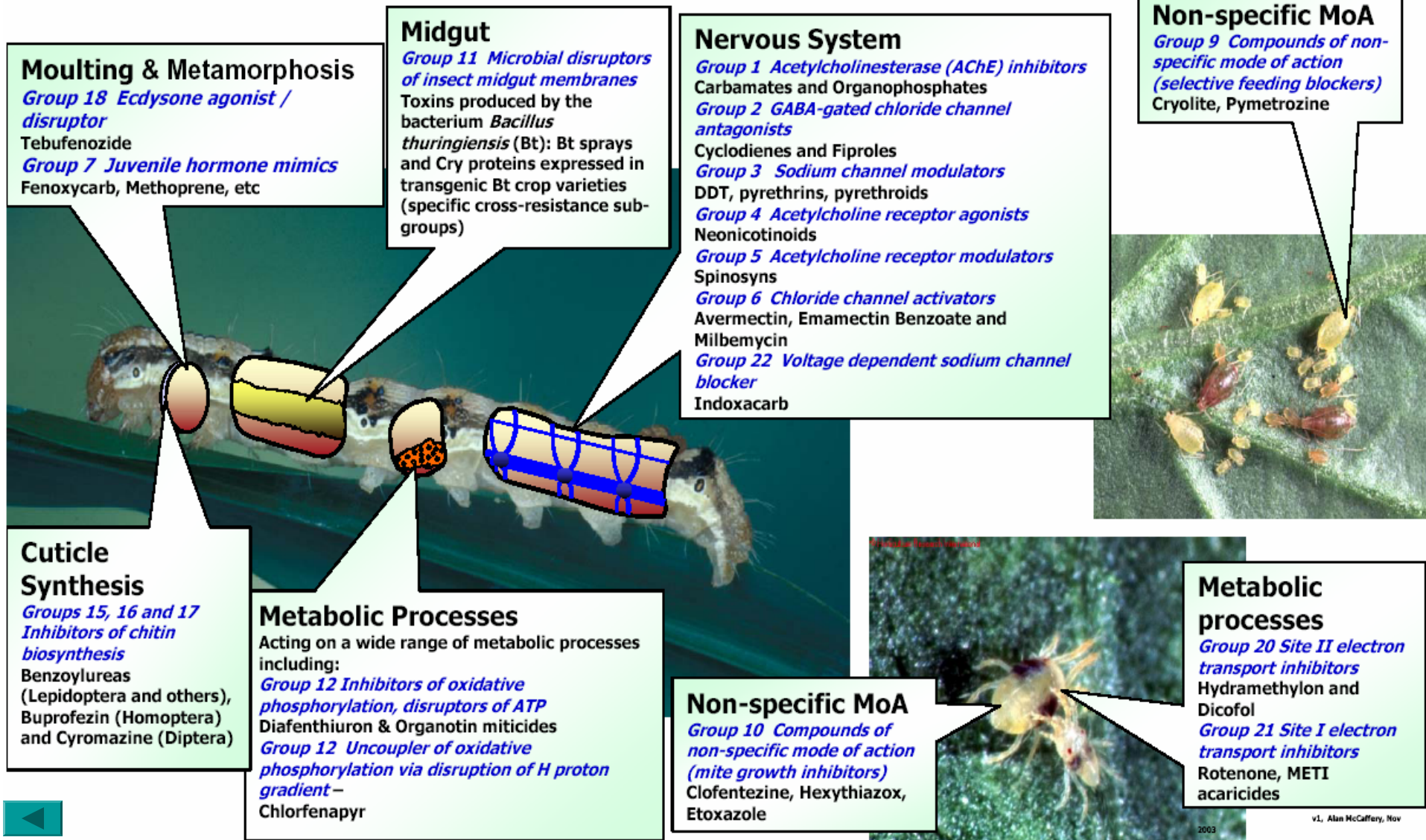


Bottom line: Escape of transgenes

- Gene flow will take place: pollen, seed
- Given the current GE crops (cotton, corn, alfalfa):
 - From crop to crop
 - Short distances: corn, cotton (< 100 m)
 - Long distances:
 - alfalfa (> 1.5 km) + volunteers, spillage
- Within these distances, gene flow will be of consequence, only if **repeated** and **abundant** opportunities

Effect on Target Organisms? Development of Resistance

- General strategy to limit development of resistance: **change the environment**:
 - *Bacillus thuringiensis* toxin:
 - Avoid unnecessary exposure + IPM
 - Refugia (high dosis/refuge strategy)
 - Pyramided toxins: *cry2Ab* + *cry1Ac*
 - Broader spectrum, smaller refuge
 - Except if used with single toxin cultivars
 - Different insecticides
 - Herbicide resistance:
 - Avoid unnecessary exposure + IPM
 - Alternate herbicides
 - Appropriate rotations and cropping practices



Effect on Non-Target Organisms?

- Positive effects:
 - Reduction in pesticide use
 - Reduction of secondary infections:
 - *Fusarium* infections: fumonisin (horse, swine; humans)
- Negative effects:
 - Effect on beneficial insects?
 - Effect on bystanders?



Effect of pesticides

(Pimentel and Raven 2000)

- 115×10^6 kg/yr of pesticides on corn:
 - corn rootworm: 45% yield reduction; other control: rotation
 - European corn borer: 20% yield reduction; difficult to control when inside the plant --> Bt
- Effect of pesticides:
 - pesticide poisonings, cancer
 - 35% of food samples have pesticide residues
 - 70×10^6 birds/yr killed
 - 10^9 s of insects, including beneficials: pollination, biological control
- Reasons for decline of monarch: insecticide use, loss of habitat

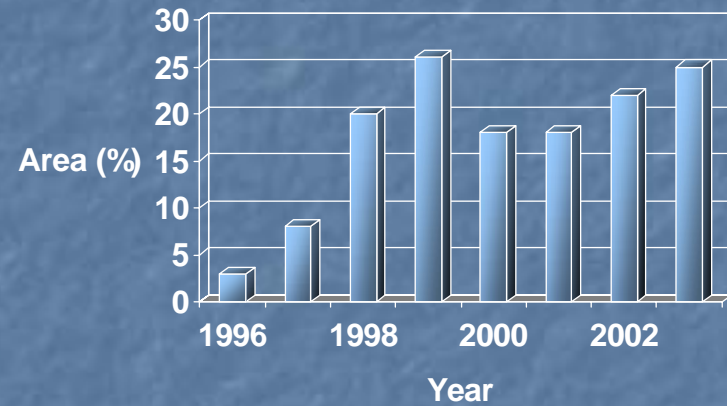


Is everything fine and dandy?

- Chronology of Bt maize:
 - 1996: First available
 - 1999:
 - Losey et al. Nature
 - BIO e-mail
 - 2001:
 - Publication of detailed studies in PNAS

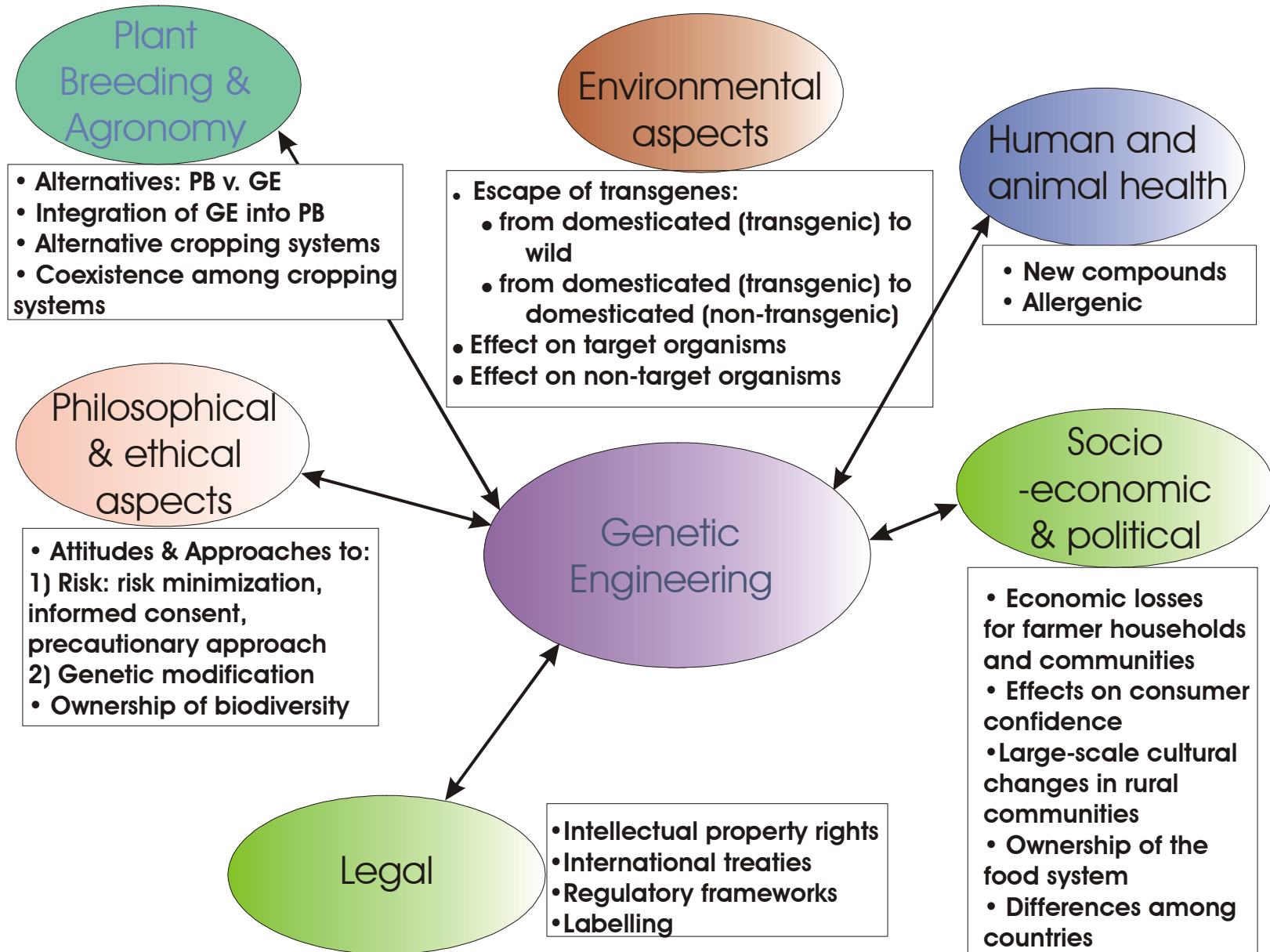
Why posterior analyses?

Adoption of Bt maize in the U.S.



E-mail: "BIO TALKING POINTS RE MONARCH BUTTERFLY BT CORN POLLEN"

Issues associated with the use of transgenics



Conclusions

- Case-by-case approach
- Fast moving technology
- Currently, probably limited environmental effects in the short term
- Role of UC:
 - Impartial information to the public

Sources

- Transgenic plants: <http://escience.ws/b572/L20/L20.htm>
<http://www.colostate.edu/programs/lifesciences/TransgenicCrops/>
<http://geo-pie.cornell.edu/gmo.html>
- Bacterial crown gall:
<http://ohioline.osu.edu/hyg-fact/3000/3301.html>
- Herbicide resistance management:
http://cottoninfo.ucdavis.edu/IMAGES/Field%20Check_June20_04.pdf
- Pharma crops:
http://www.ucsusa.org/food_and_environment/biotechnology/page.cfm?pageID=1561
- Seed contamination:
http://www.ucsusa.org/food_and_environment/biotechnology/page.cfm?pageID=1315