

Assessing The Toxicity of Cotton Production

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Research Questions

1. How do we assess toxicity?
 - What Impact Methods
 - What Impact Categories
 - How do the Impact Methods Compare

2. How do different production practices compare?
 - By Seed Technology
 - By Irrigation
 - By Tillage

3. Future Analyses?
 - Risk by Population Exposure



Toxicity Method Requirements

- Looking for broad overview analysis
- Numerical index values for each pesticide
- Not capable of including parameters
 - (e.g. soil type; temperature and precipitation factors; application methods and timing)
- Do not include exposure analysis
 - (e.g. proximity to humans, or existing water quality)

Assessing Toxicity

- Impact Methods:

- Impact 2002+
- CML 2001
- ReCiPe
- TRACI
- EIQ

- Impact Categories:

- Human Toxicity
 - Carcinogen/Non-carcinogen
 - Applicator/Picker/Consumer
- Ecological Toxicity
 - Terrestrial
 - Marine: Aquatic/Sediment
 - Freshwater: Aquatic/Sediment
 - Birds/Beneficials



Impact Methods and Metrics

EIQ (41 out of 47 pesticides)

Impact 2002+ (40)

ReCiPe (38)

CML (17)

TRACI (16)

Human Toxicity

Farmworker
 Applicator
 Picker
 Consumer
 Direct user of product
 Indirect consumer
 through drinking
 water
No Units

Carcinogens
 Non-carcinogens
kg C2H3Cl eq / DALY

Human Toxicity
kg 1,4-DB eq / DALY

Human Toxicity
kg 1,4-DB eq

Carcinogens
 Non-Carcinogens
kg benzen/ toluen eq

Ecological Toxicity

Terrestrial
 Birds
 Bees
 Beneficials
 Aquatic
 Fish
No Units

Aquatic
 Terrestrial
*kg TEG eq/ PDF*m2*yr*

Freshwater
 Marine
 Terrestrial
kg 1,4-DB eq / species.yr

Freshwater Aquatic
 Marine Aquatic
 FreshwaterSediment
 Marine Sediment
 Terrestrial
kg 1,4-DB eq

Ecotoxicity
kg 2,4-D eq

1,4-DB: Para-dichlorobenzene
 2,4-Dichlorophenoxyacetic acid

C2H3Cl: Vinyl Chloride
 TEG: Triethylene-glycol

DALY: Disability Adjusted Life Year
 PDF*m2*yr: Potentially Disappeared Fraction

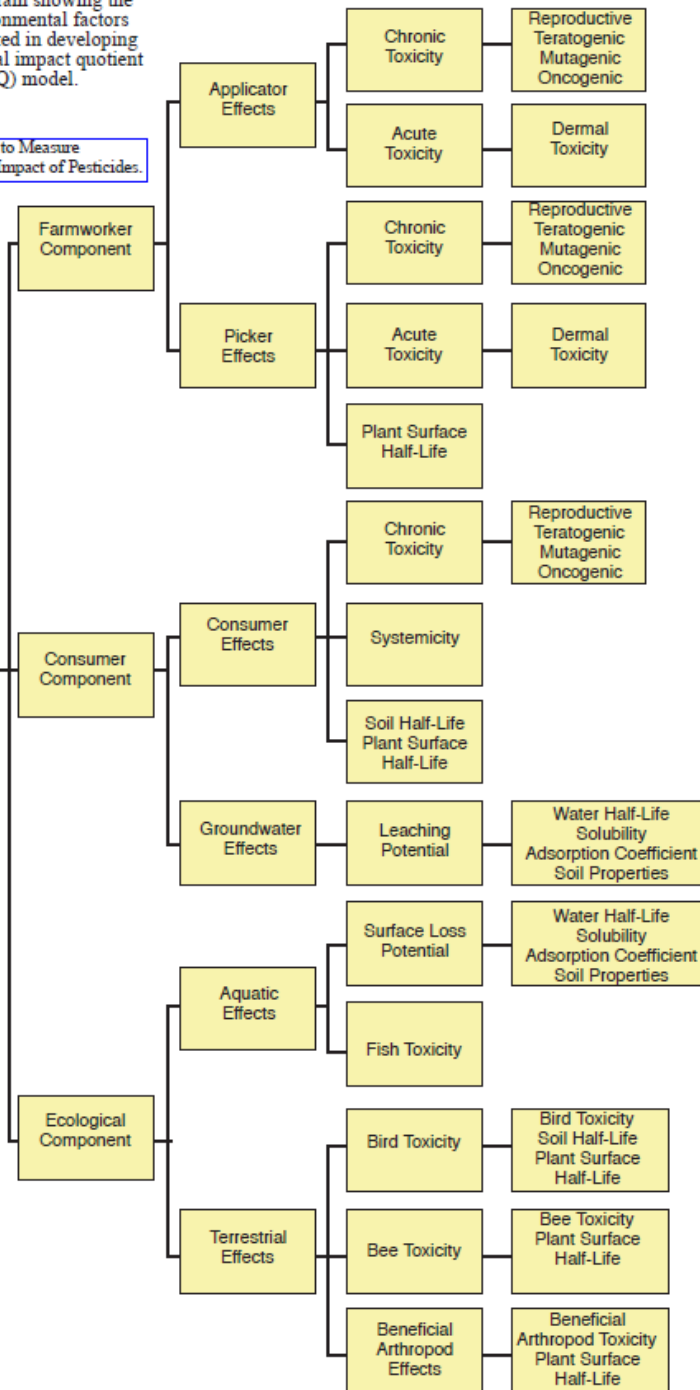
Figure I. A diagram showing the individual environmental factors that were evaluated in developing the environmental impact quotient of pesticides (EIQ) model.

return to A Method to Measure the Environmental Impact of Pesticides.

Single Score



Environmental Impact Quotient



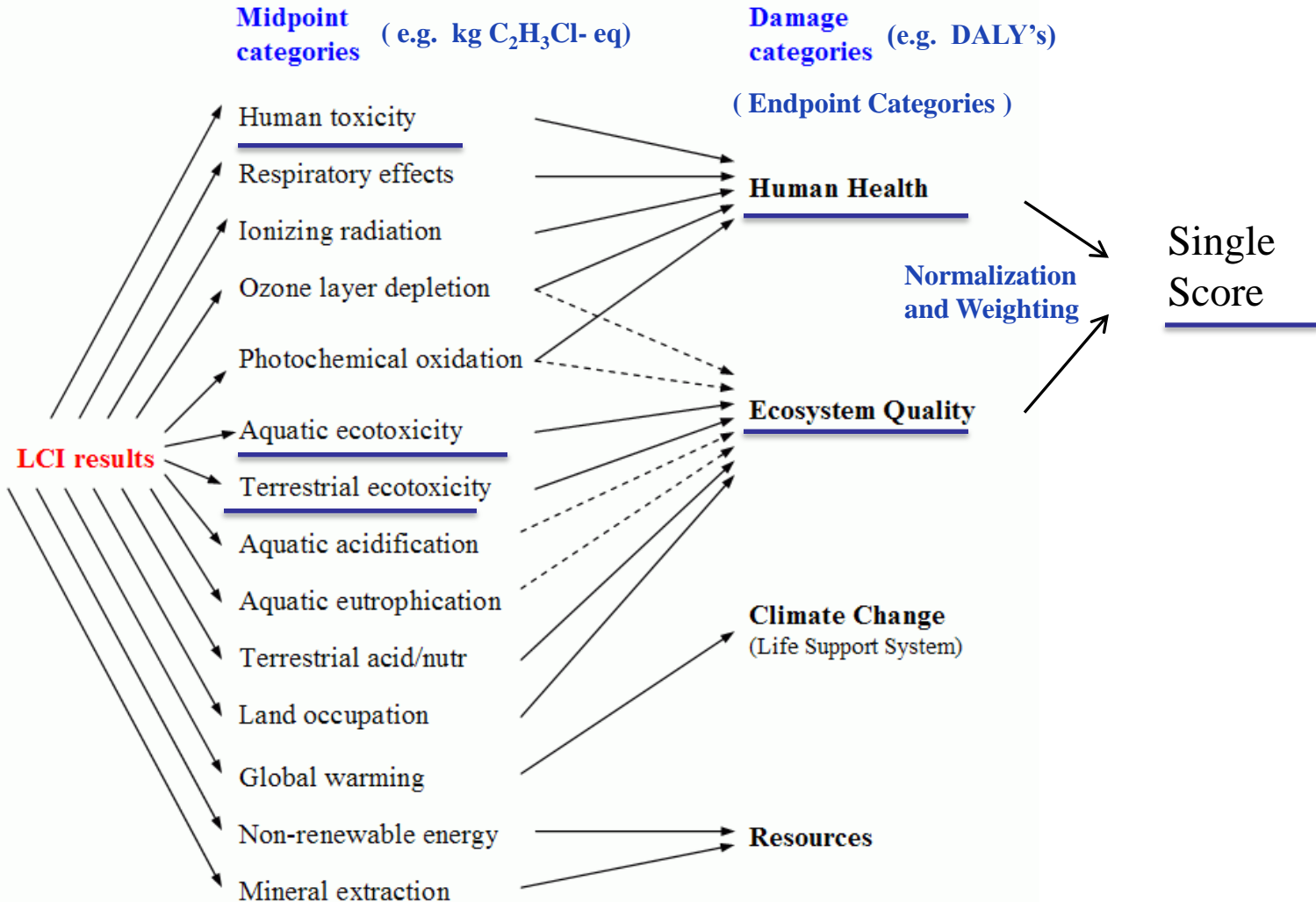
EIQ Method



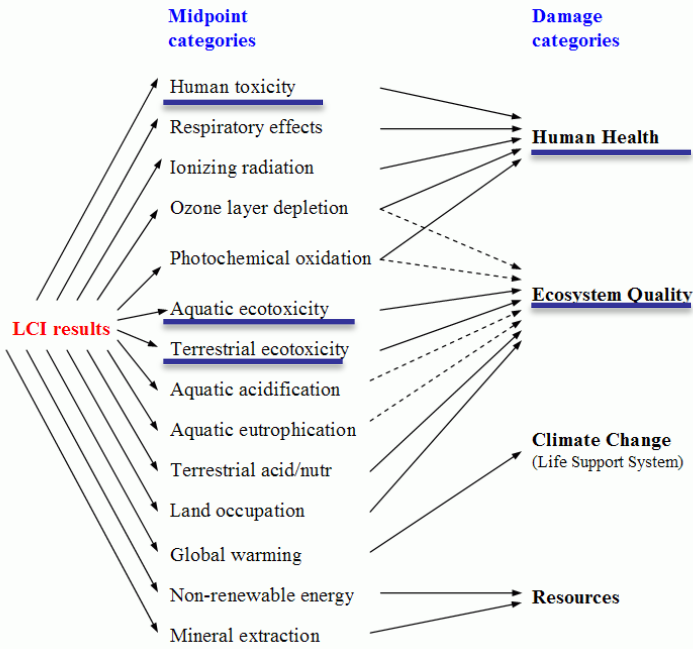
ReCiPe and Impact 2002+ Methods

High Confidence/ Lower Understanding

Low Confidence/ Greater Understanding



ReCiPe and Impact 2002+ Methods



Individual Pesticide Single Score (SS_i)

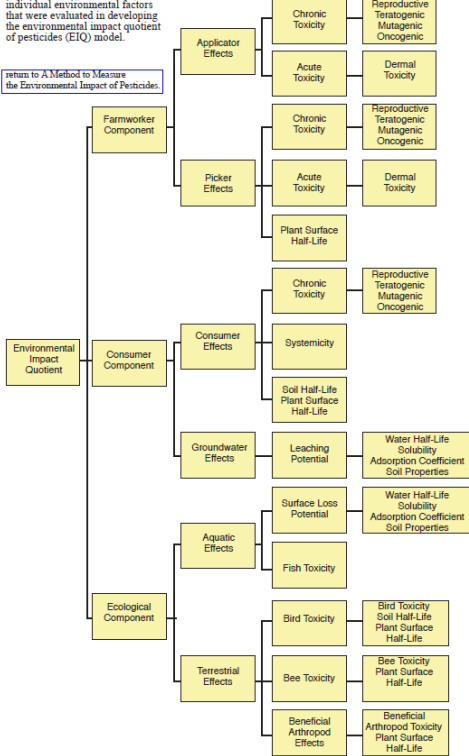


Production Method Score
 $\bullet \sum (SS_i) * (AR_i)$

AR_i = application rate of pesticide i
 SS_i = Single Score for pesticide i

EIQ Methods

Figure 1. A diagram showing the individual environmental factors that were evaluated in developing the environmental impact quotient of pesticides (EIQ) model.



Normalization and Weighting

- ReCiPe and Impact 2002+ normalize the impacts of each impact category based upon national averages
- ReCiPe then weights these categories based upon a philosophical method
- Impact 2002+ and EIQ have equal weighting across categories

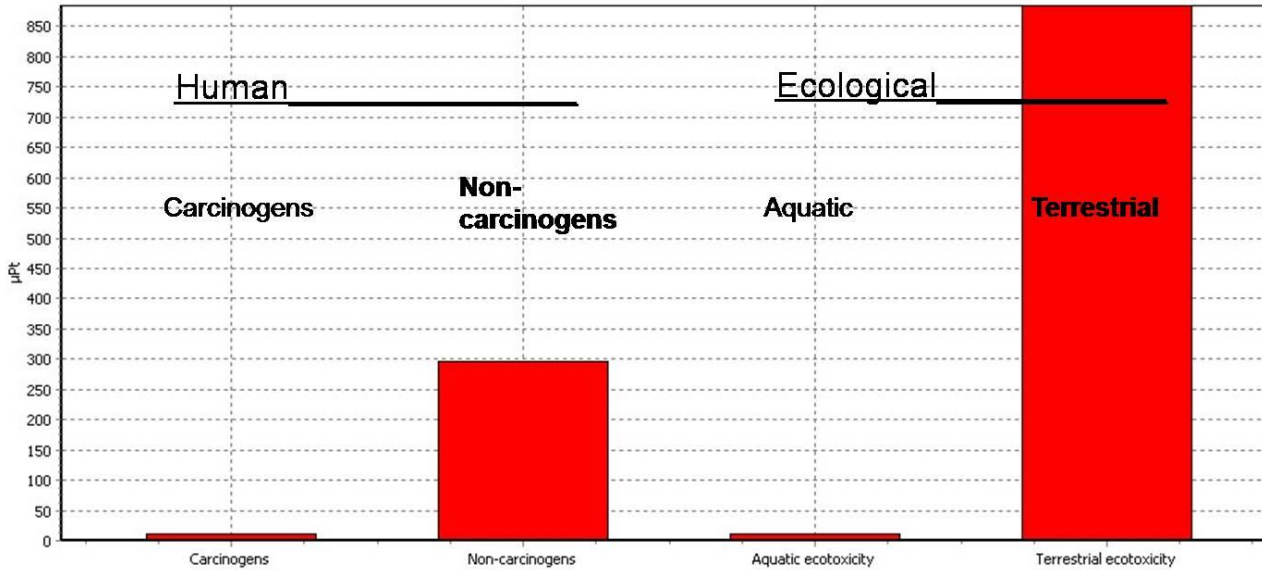
Toxicity: Impact 2002+

Human Toxicity

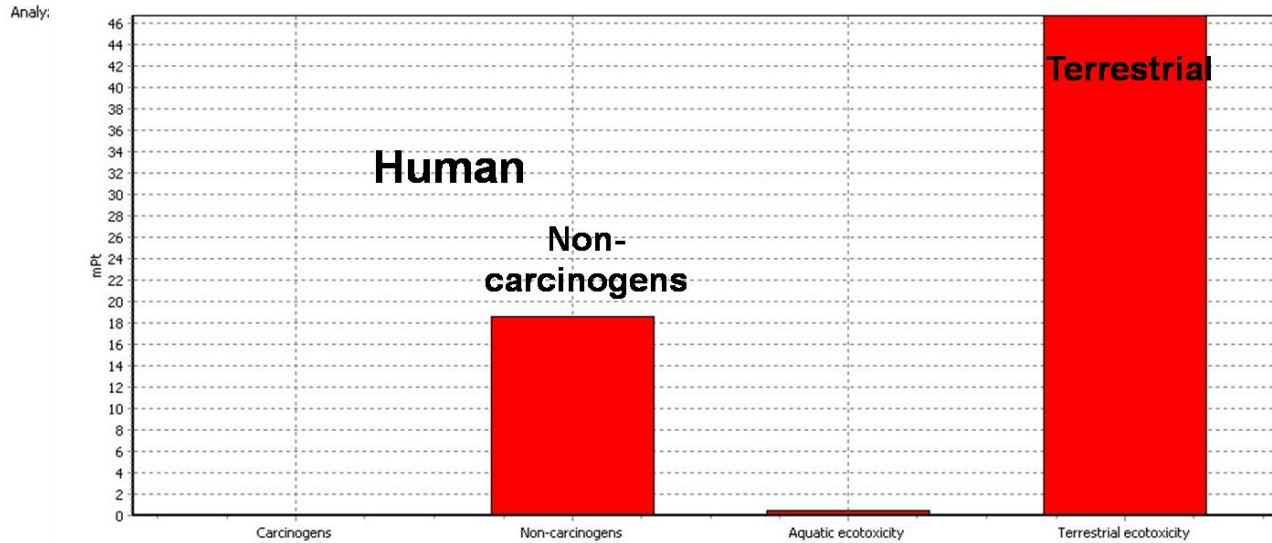
| | DALY | Normalized Points |
|--------------------|---------|-------------------|
| Carcinogens | 7.4E-08 | 1.0E-05 |
| Non-carcinogens | 2.1E-06 | 3.0E-04 |
| Total Human | | 3.1E-04 |

Ecological Toxicity

| | PDF*m2*yr | Normalized Points |
|-------------------------|-----------|-------------------|
| Aquatic | 1.6E-01 | 1.2E-05 |
| Terrestrial | 1.2E+01 | 8.8E-04 |
| Total Ecological | | 9.0E-04 |



Using All Pesticides (1kg)



Using Arkansas RRFlex Method

Arkansas Cotton furrow 12 Row RR Flex

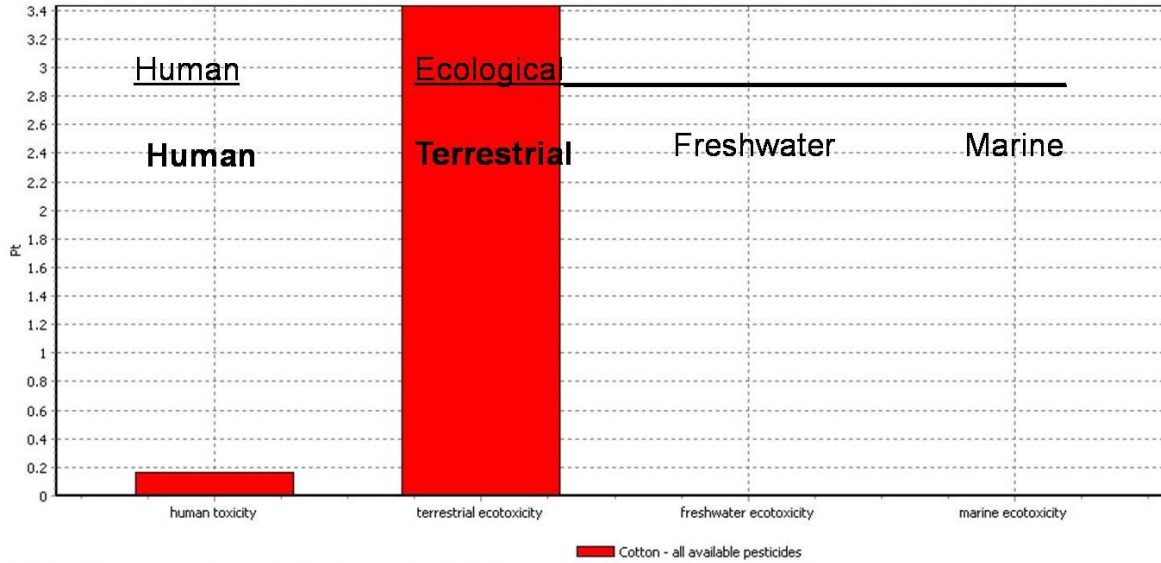
Toxicity: ReCiPe Endpoint (H)

Human Toxicity

| | DALY | Normalized Points |
|----------------|---------|-------------------|
| Human Toxicity | 5.6E-06 | 4.2E-04 |

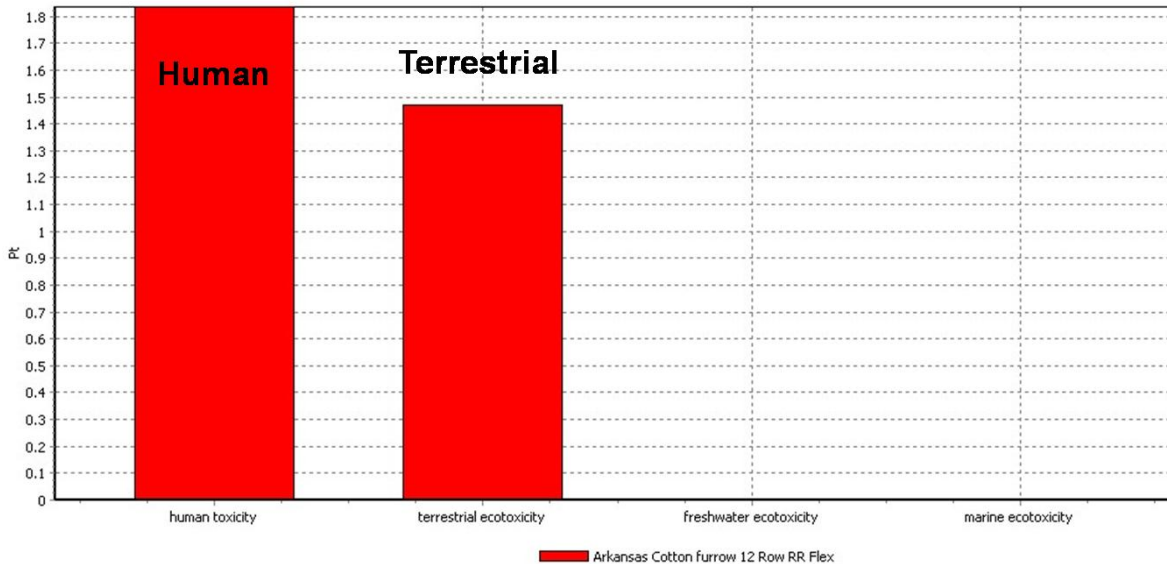
Ecological Toxicity

| | species.yr | Normalized Points |
|-------------------------|------------|-------------------|
| Terrestrial | 7.3E-06 | 8.6E-03 |
| Freshwater | 7.1E-09 | 8.3E-06 |
| Marine | 5.9E-12 | 7.0E-09 |
| Total Ecological | | 8.6E-03 |



Analyzing 1 kg 'Cotton - all available pesticides'; Method: Recipe Endpoint (H) V1.01 / World Recipe H/A / weighting

Using All Pesticides (1kg)



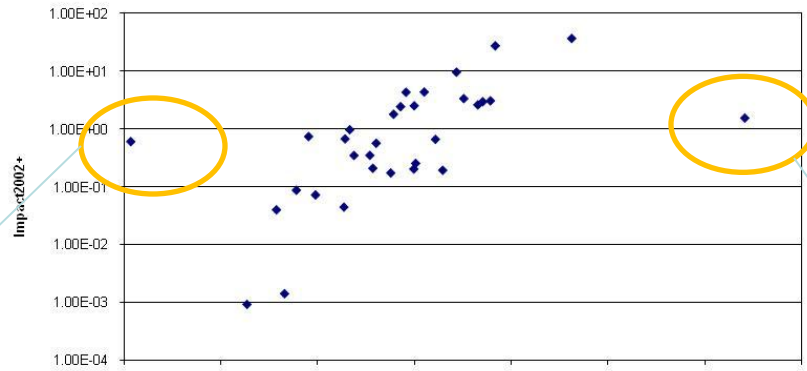
Analyzing 1 ha 'Arkansas Cotton furrow 12 Row RR Flex'; Method: Recipe Endpoint (H) V1.01 / World Recipe H/H / weighting

Using Arkansas RRFlex Method

Comparing Single Score Values for Individual Pesticides by Toxicity Method

Impact vs ReCiPe

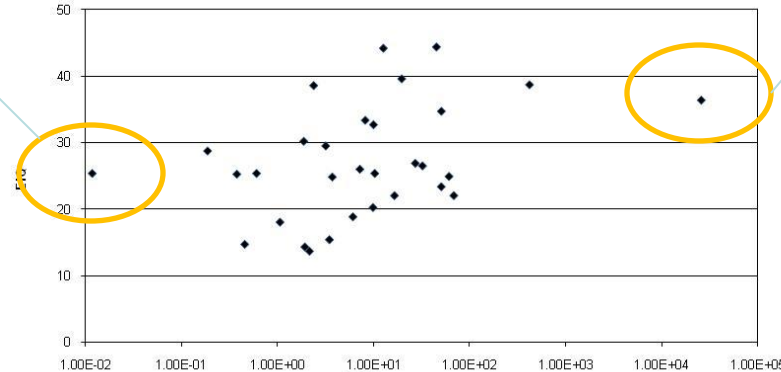
Glyphosate



Fairly Linear

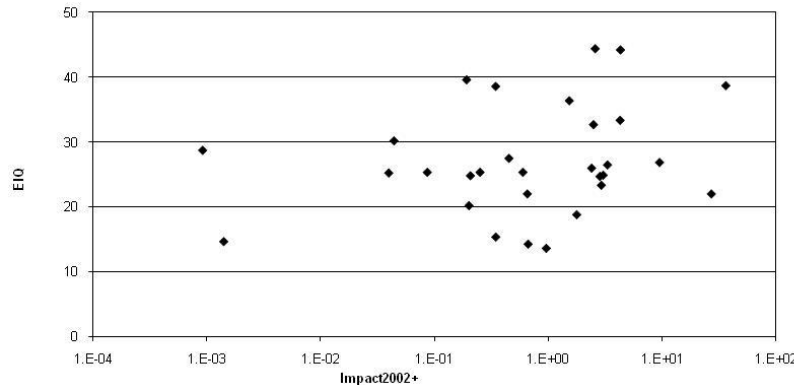
Cypermethrin

EIQ vs ReCiPe



Lower Correlation

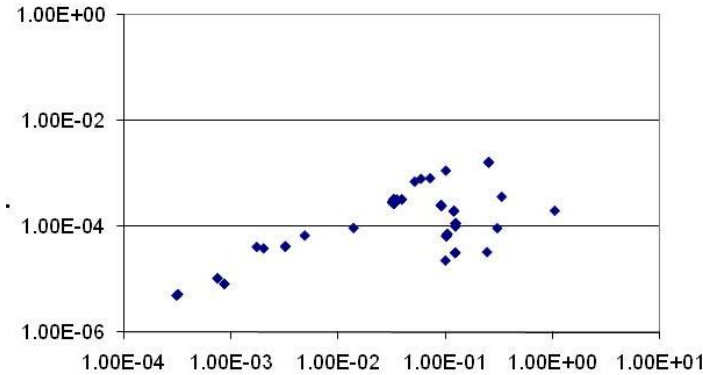
EIQ vs Impact



Lower Correlation

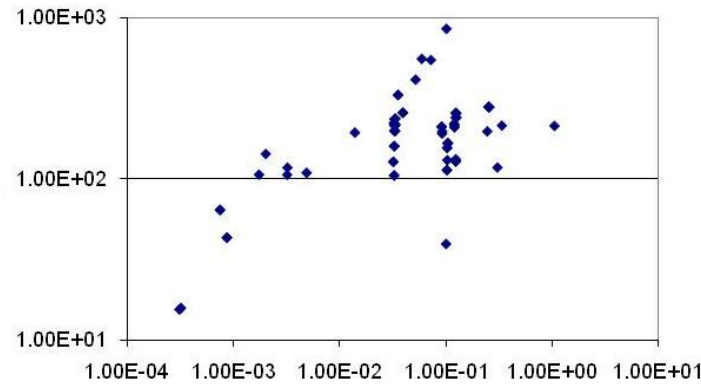
Comparing Single Score Values for Production Practices by Toxicity Method

Impact vs ReCiPe



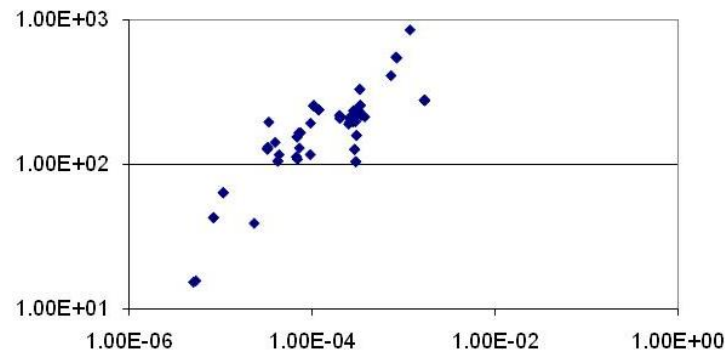
Fairly Linear

EIQ vs ReCiPe



Lower Correlation

EIQ vs Impact



Lower Correlation

Toxicity by Production Categories

Tillage:

- Low and No Till appear to have lower toxicity than Conventional Till

Irrigation:

- Dryland appears to have slightly lower toxicity than Irrigated

Seed:

- Currently broken down my too many categories to show meaningful results
- Need to figure out if there is a better way to categorize

Potential Future Directions:

Compare each Production Practice and minimize that category of impact that matters most

Impact 2002+

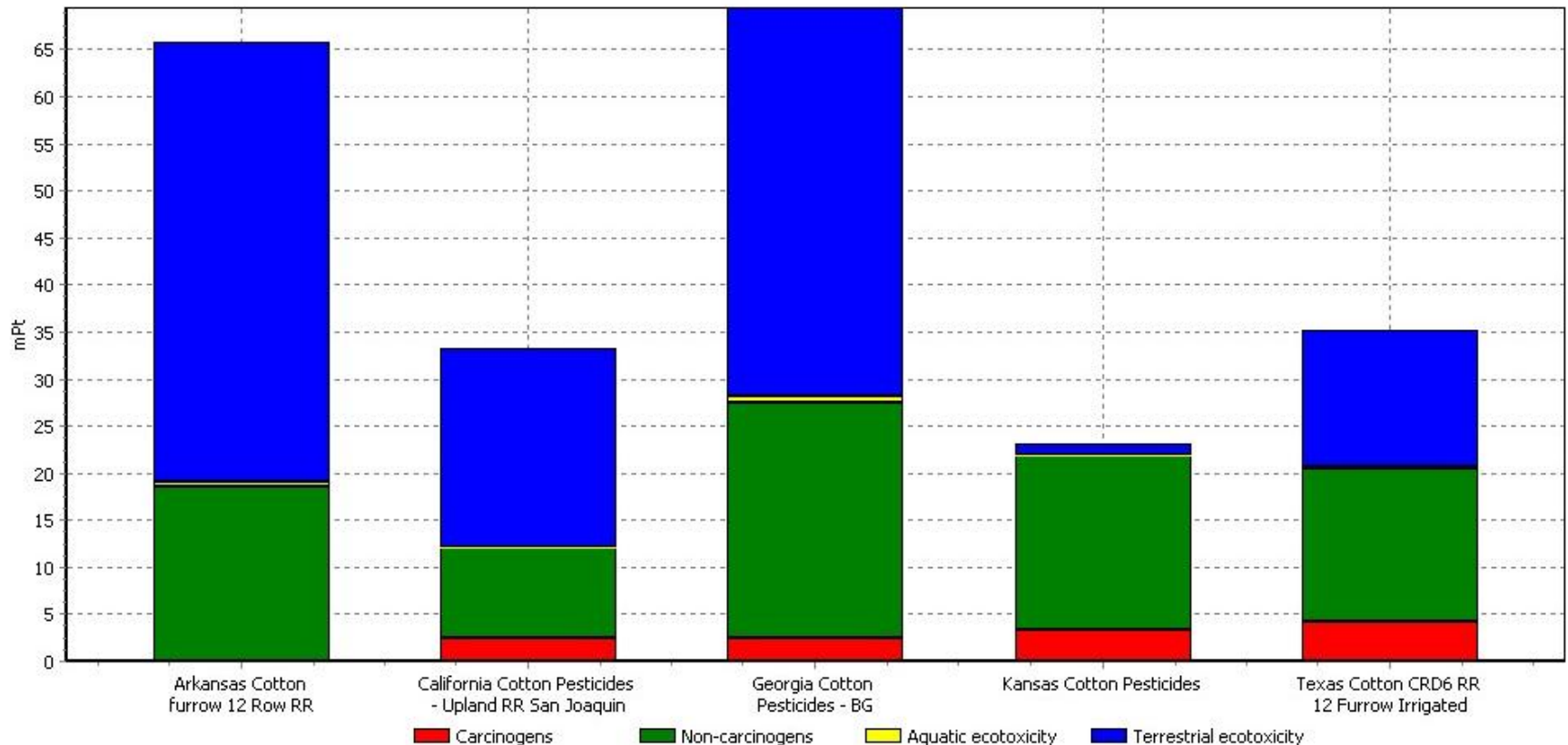
Arkansas

California

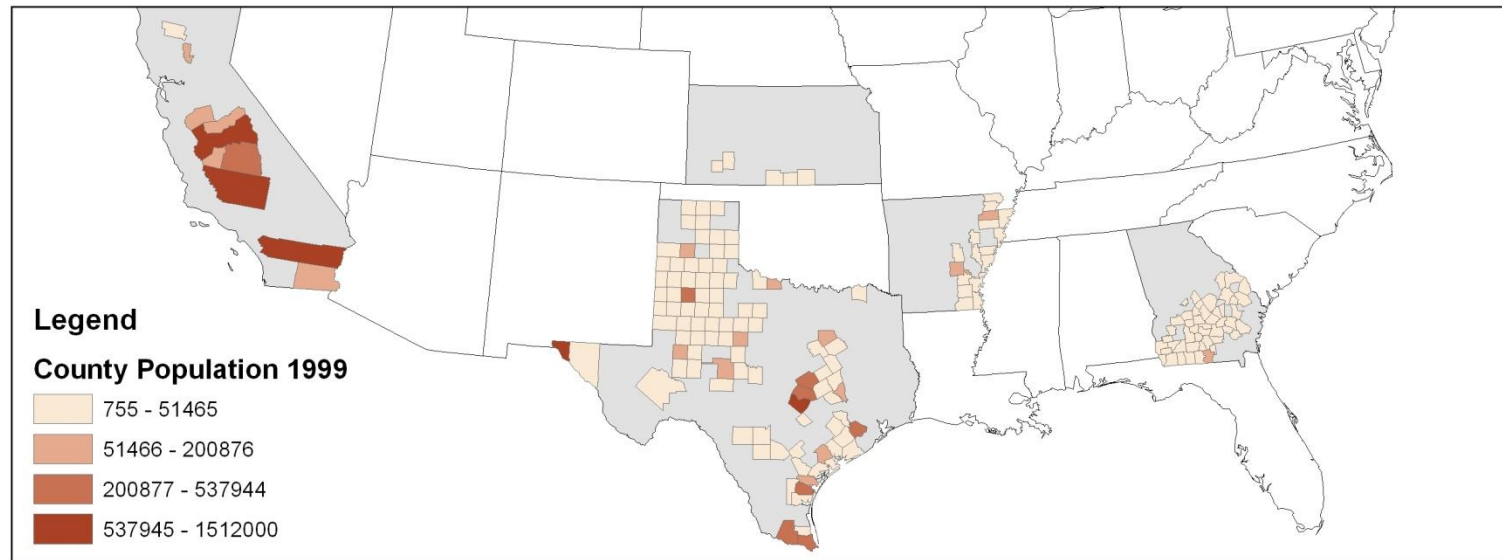
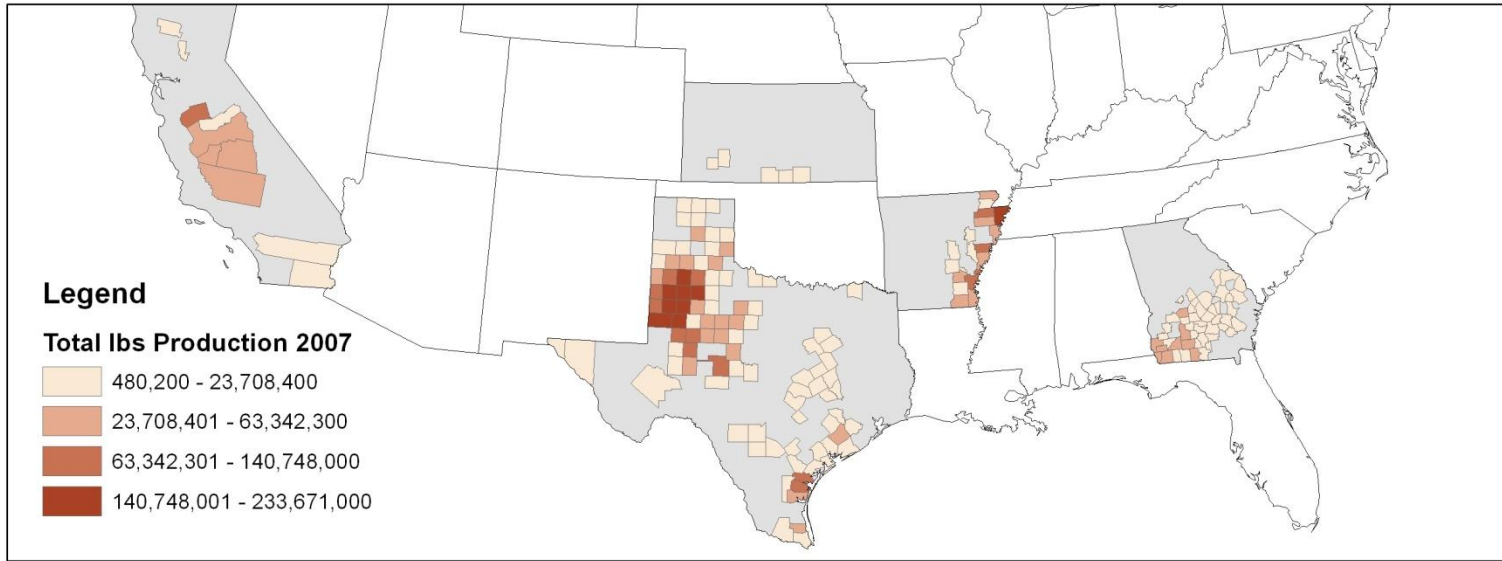
Georgia

Kansas

Texas



Production and Population: Risk Levels



Conclusions

- Impact Methods:
 - ReCiPe, Impact2002+ and EIQ are most thorough
 - Methods are somewhat but not fully consistent
 - Pesticides rankings are fairly different
 - Production practice rankings are more consistent
 - Selection of Method Matters –
 - Must take into account the missing elements
 - Weighting and Normalization methodology is key to how pesticides are analyzed
 - Selection of the method depends upon needs of analyst
 - Ease of Use
 - Specific pesticides of interest
 - Weighting methodology
 - Comparisons required
- Production Practice Comparisons:
 - Low- and No-Till appear to have lower toxicity
 - Dryland appears to have somewhat less toxicity than irrigated