United States Environmental Protection Agency

Spatially Explicit Life Cycle Assessment for Biofuel Feedstock Production

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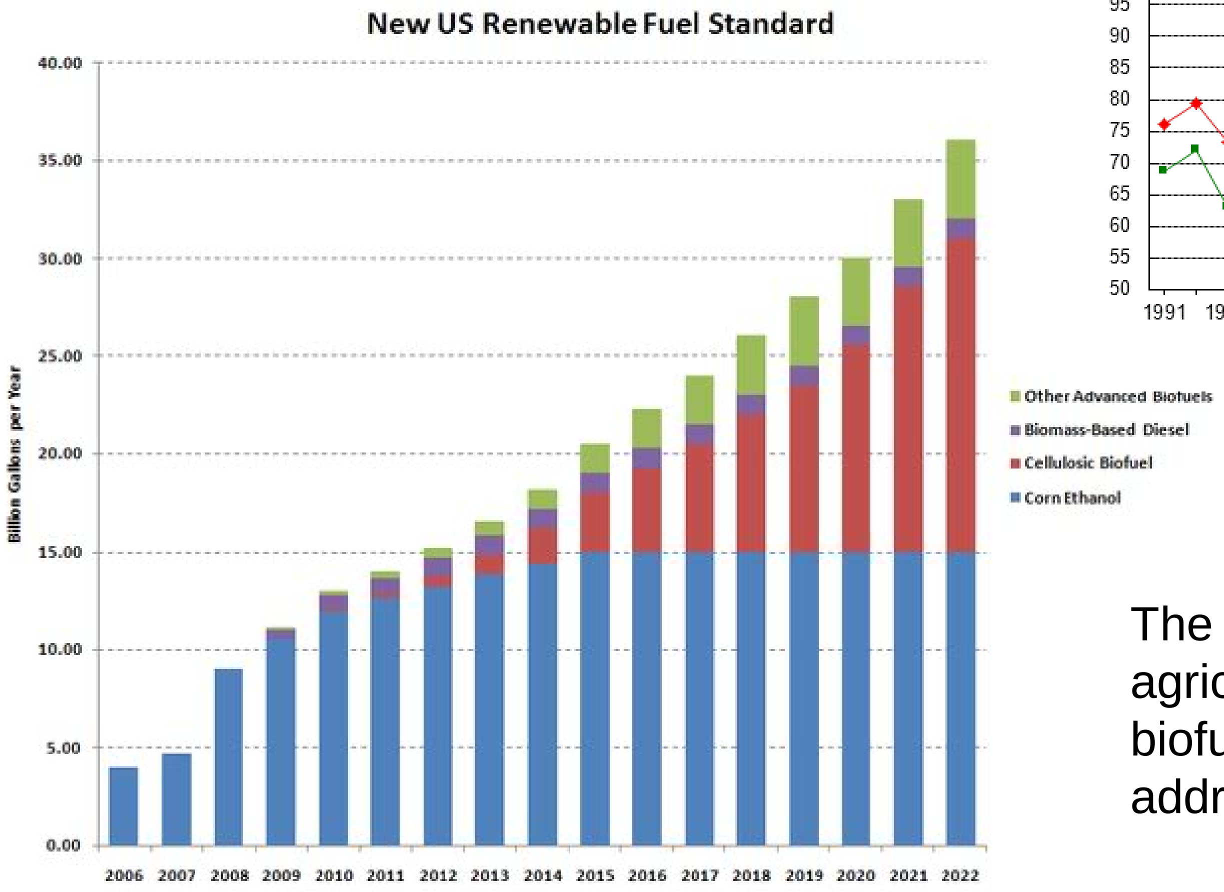
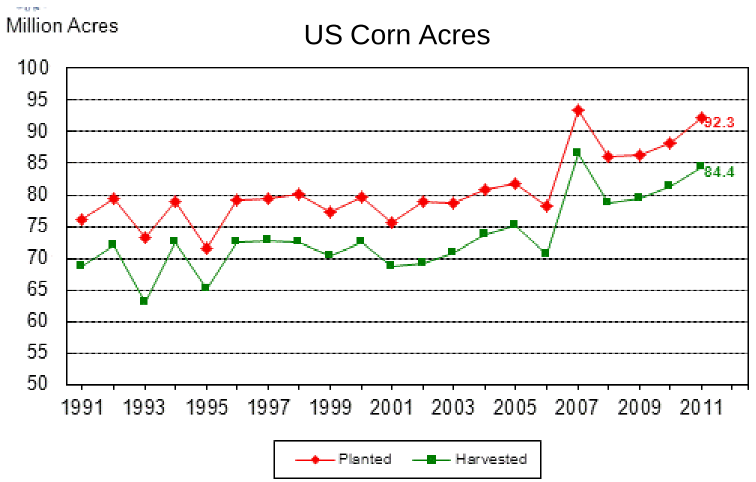
EISA and Biofuel Feedstock Production

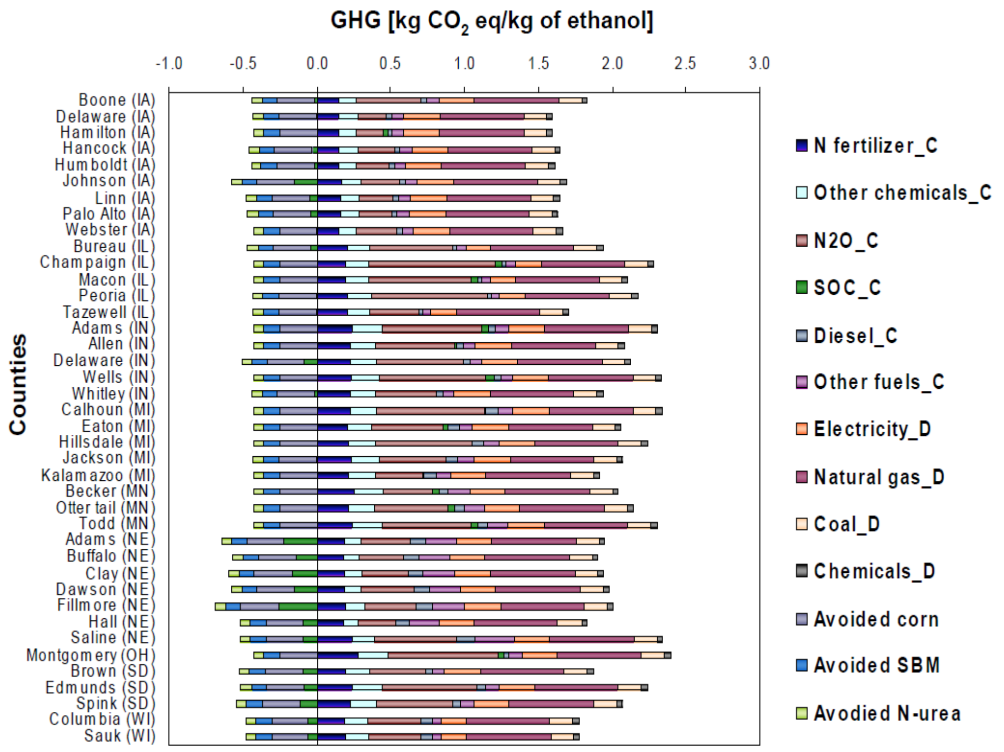




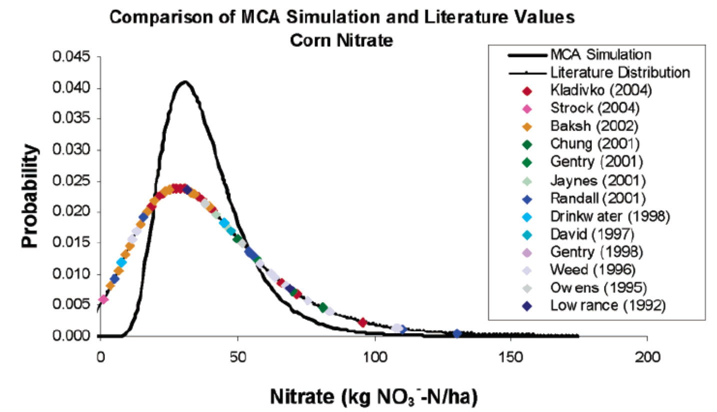
The environmental impacts of agricultural production within biofuel supply chain need to be addressed.

EISA and Biofuel Feedstock Production

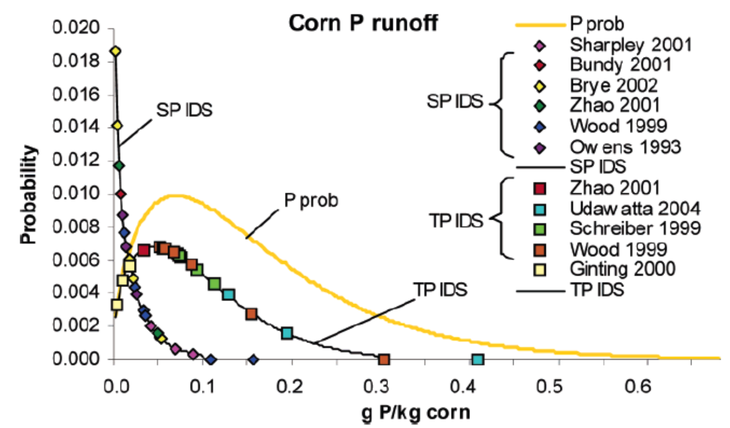
Soil, climate, and farming practices variability determines regional life cycle emissions for corn-ethanol.



Kim,S.& Dale, BE., International Journal of life cycle assessment, 14, 540-546,2009



Miller SA, et al., Environmental Science& Technology, 40, 2324-2332,2006



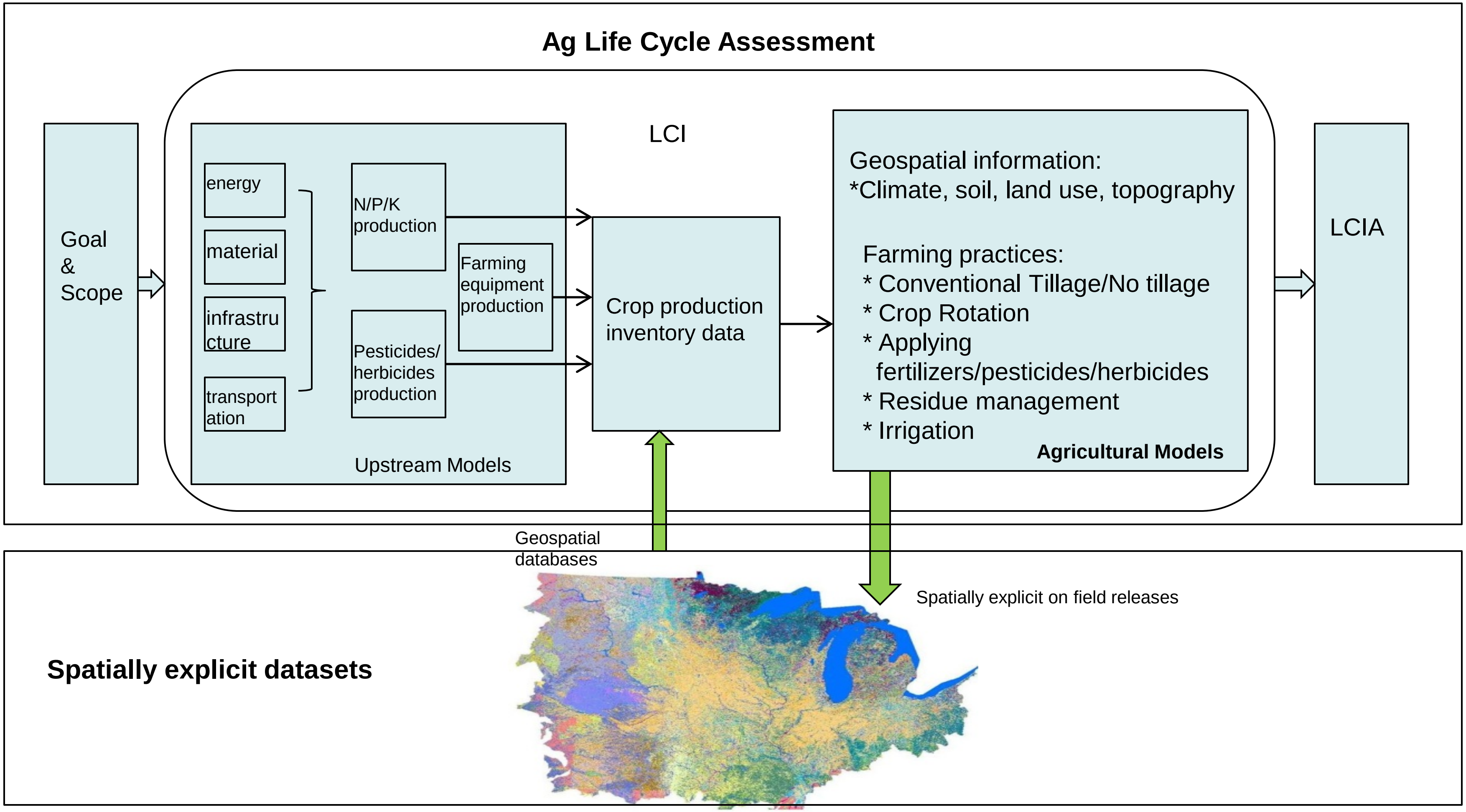
Landis AE, et al., Environmental Science& Technology, 41, 1457-1464,2007

Spatially-Explicit LCA of Biomass Production

- Impacts exhibit significant variability due to different farming practices and local conditions
- Extend beyond previous work on energy and greenhouse gases
- Integrate understanding of eutrophication, smog formation, soil quality, etc. within LCA studies

Methods

Integrate life cycle assessment (LCA) and ecosystem models



Geyer et al, International Journal of life cycle assessment, 5, 454-467,2010

Approach

Step 1. Create unit processes for biomass production including both on field activities and upstream activities

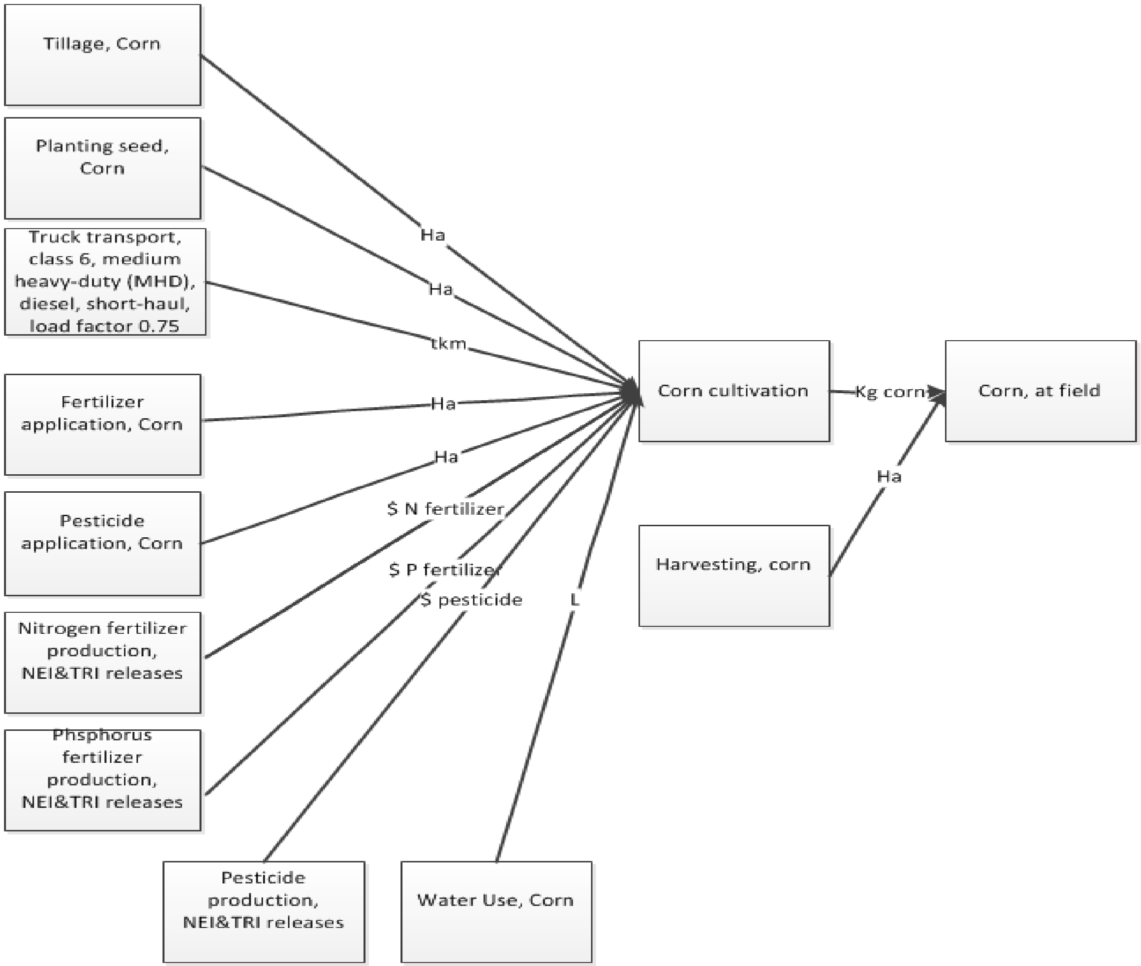
Step 2. Use agricultural models (including EPIC, PestLCI, and others) to calculate on field releases

Step 3. Integrate LCA and agricultural modeling results

Step 4. Map spatially explicit inventories/impacts of biomass production via GIS tools

Step 1 Creating unit processes for biomass production and associated upstream activities

Example: corn production



Step 1 Creating unit processes for corn production

Unit processes	Data sources
Tillage; Fertilizer application; Pesticides application; Planting seeds; Harvesting	USDA survey data, DOE biomass inventory, ecoinvent database, peer reviewed articles, NONROAD model
On field emissions	Country average releases were compiled using multiple publications. County level data is calculated in Step 2
Transporting agrochemicals	GREET model, ecoinvent database
N fertilizer(ammonium nitrate, nitric acid, urea) production; P fertilizer (Phosphoric acid) production; K fertilizer (K2O) production; Lime production; Pesticide (12 types) production;	ecoinvent database, EPA Toxic Release Inventory, EPA National Emission Inventory

Step 1 Creating unit processes for corn production

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A	B	C	D

Life Cycle Inventory Data Summary

Corn tillage

Reference Flow:

Reference Flow/Product:	Corn tillage
Reference Flow Amount	1
Units	1 ha corn farmland

Properties:

Category:	STD Biofuel
Subcategory:	Corn farming
Flow Property	mass
Infrastructure process?	0
Tags	<enter tags separated by commas>

Allocation:

Is this a multioutput	No
Allocation Applied:	no

Location:

Country/Region:	US
Description:	Representative of average US production
State:	NA

Info | Data Summary | Inputs-Outputs | Parameters | Reference Source Info | DQI | A

ady

Life Cycle Inventory Data
Process Documentation

Process Name:	corn tillage
Reference Flow:	1 ha of corn farmland
Brief Description:	This unit process includes tractor and till production; shed establishment; and the diesel usage during operation of farming equipment; and associated air emissions and water, soil releases as well.

Section I: Meta Data

Geographical Coverage: US **Region:** Midwest
Year Data Best Represents: 2008
Process Type: Installation Process (IP)
Process Scope: Cradle-to-Gate Process (CG)
Allocation Applied: No
Completeness: All Relevant Flows Recorded

Flows Aggregated in Data Set:

☒ Process ☒ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☒ Greenhouse Gases	☒ Criteria Air Pollutants	☒ Other
Releases to Water:	☒ Inorganic Emissions	☒ Organic Emissions	☐ Other
Water Usage:	☒ Water Consumption	☒ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Corn yield (Corn_yield_y)	*Represents the weight of corn grain acre per year.*

Tracked Input Flows:

Tractor, production	*Flow from agriculture equipment production, unit process.*
tillage machinery, production	*Flow from agriculture equipment production, unit process.*
Diesel [Crude oil products]	*Diesel (from crude oil) usage for tillage operations.*

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CP_Stage1_corn tillage_2011.08.doc

Step 2 Calculating on field emissions via agricultural models

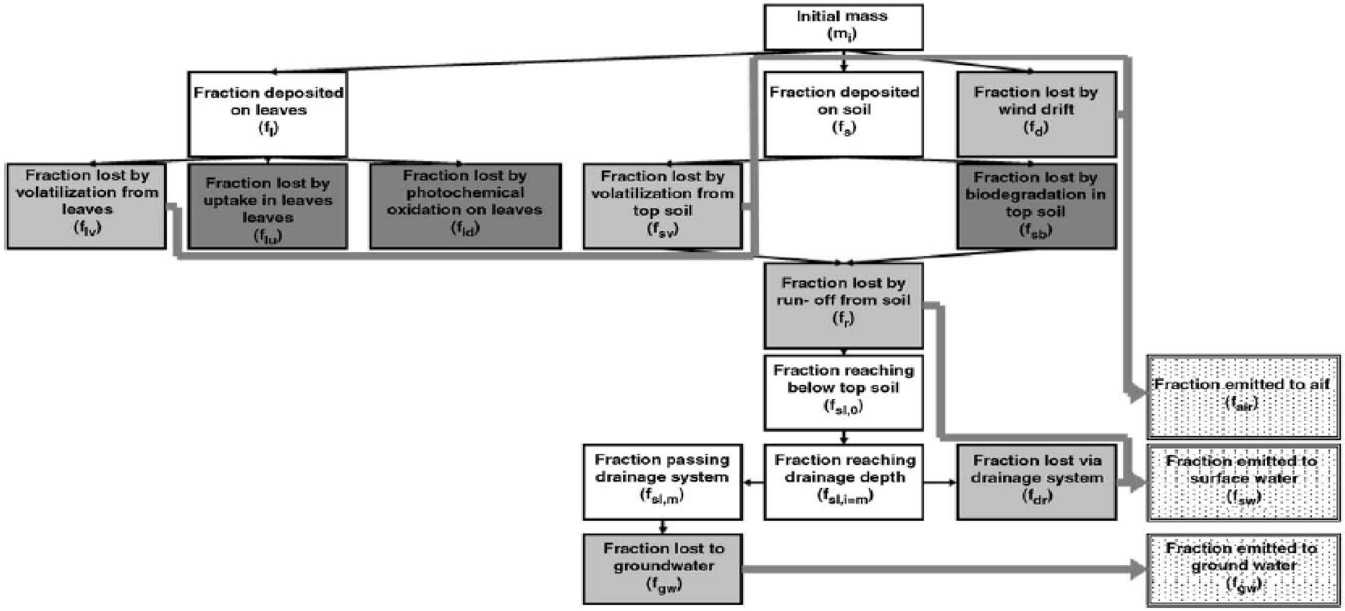
Environmental releases	Agricultural models	Data needs
Pesticide releases to environmental compartments	PestLCI	Climate, soil, pesticides' physiochemical properties
Nitrate, Phosphorus, Nitrous oxide, Ammonia, Soil erosion, Soil organic carbon change	EPIC (Erosion Productivity Impact Calculator)	Climate, soil, farming practices

Step 2 Calculating on field emissions via agricultural models

Example: pesticides

Model description

PestLCI is a modular model for estimation of pesticide emissions from field application to the different environmental compartments.

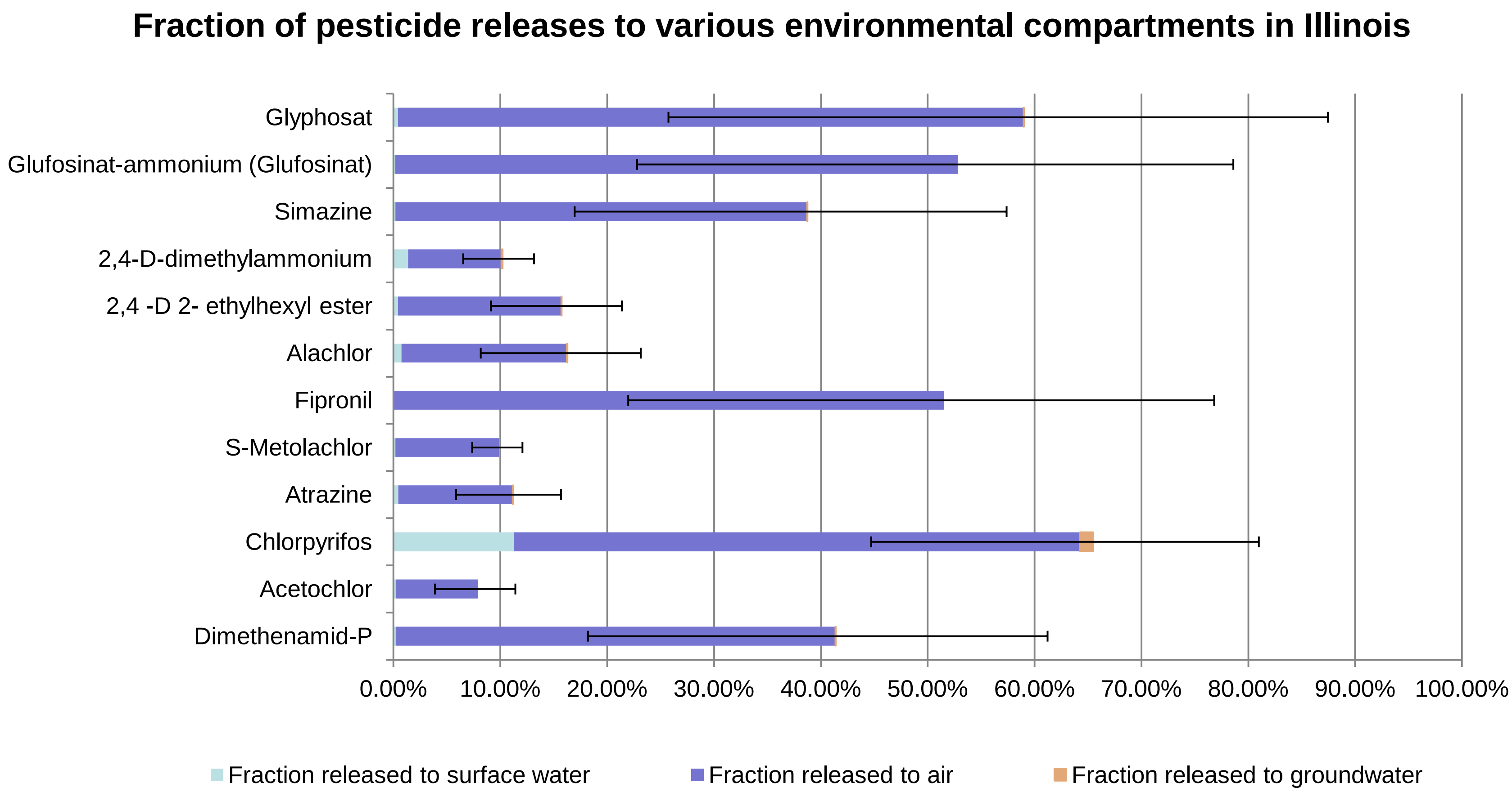


Birkved et al., Ecological Modeling, 198, 433-451,2006

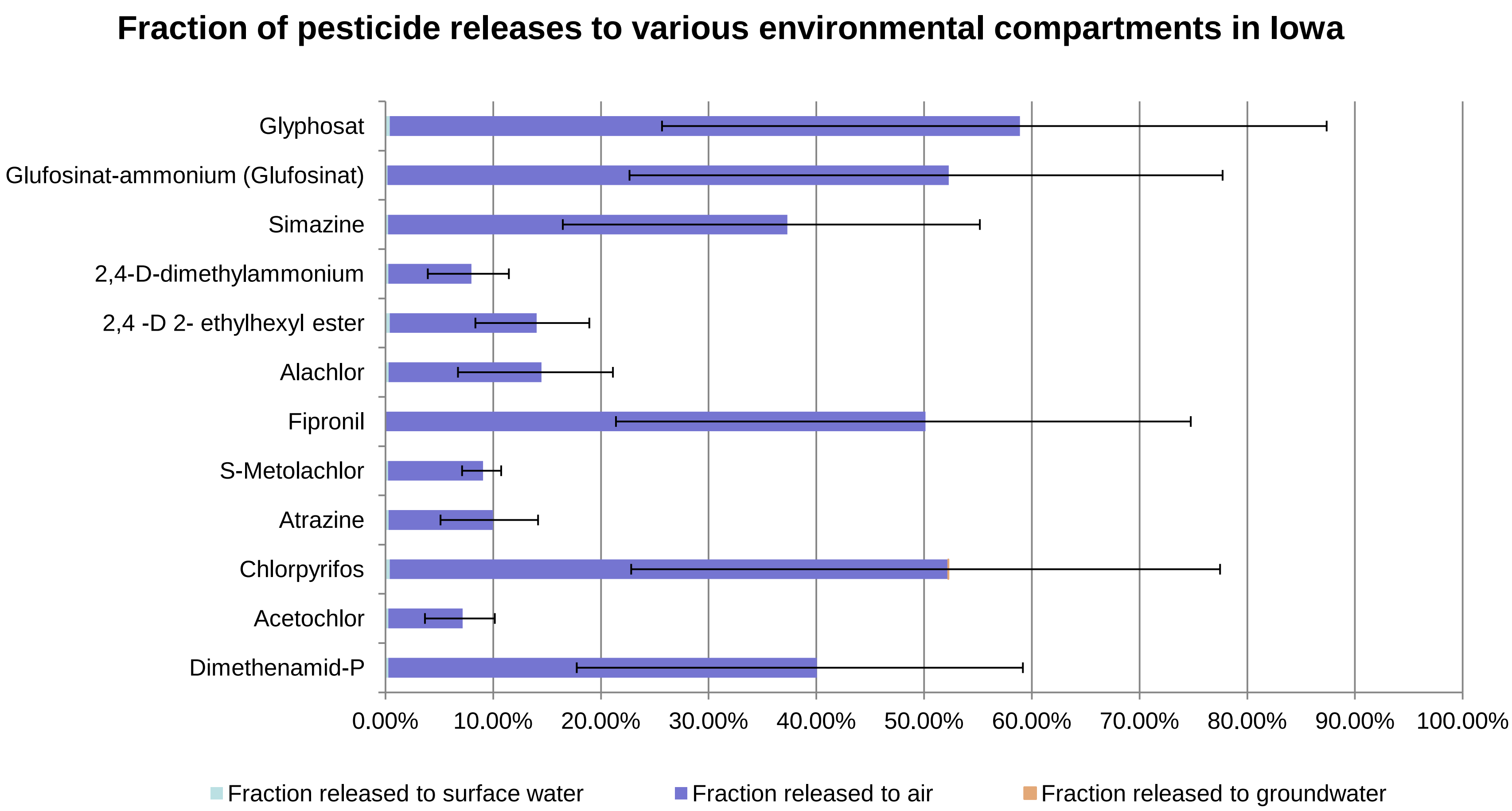
Model modifications:

- Adaptation with US weather, soil data
- Addition with 12 types herbicides/pesticides which were used in US Corn Belt states

Pesticide preliminary results



Pesticide preliminary results

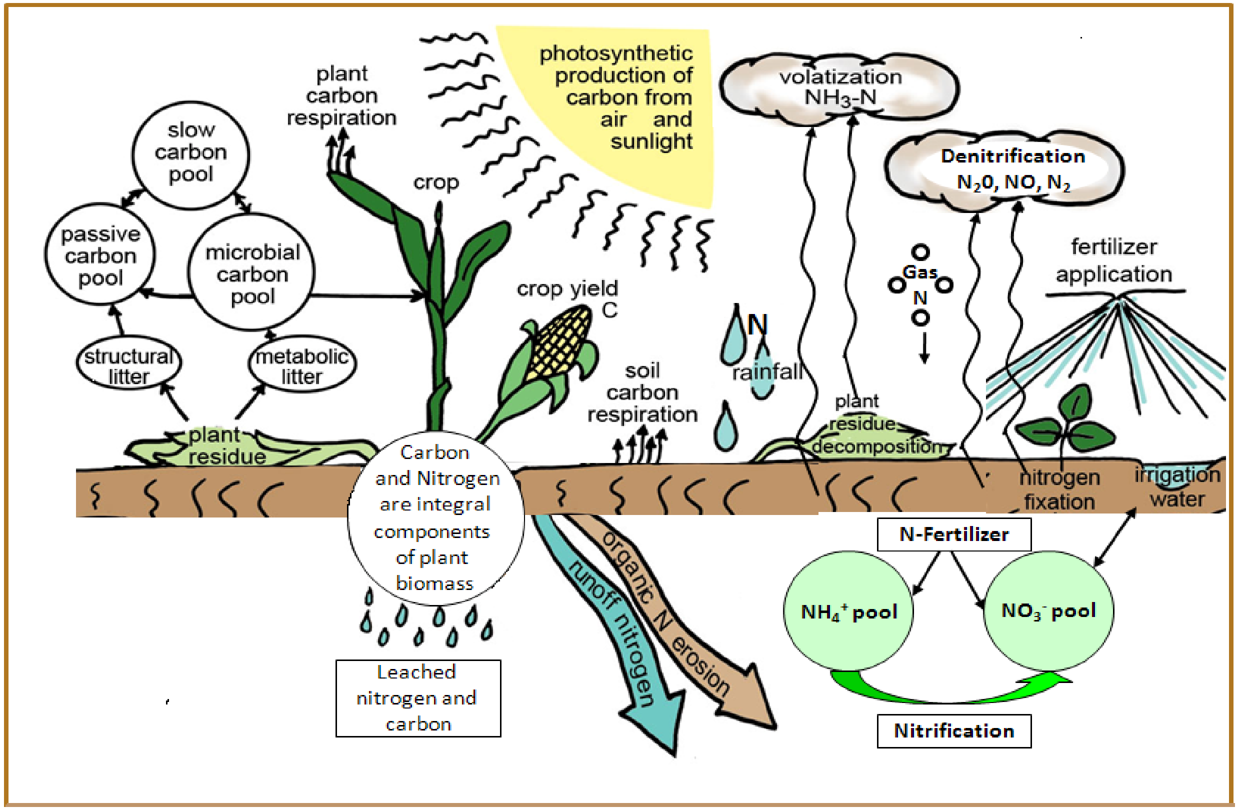


Step 2 Calculating on field emissions via agricultural models

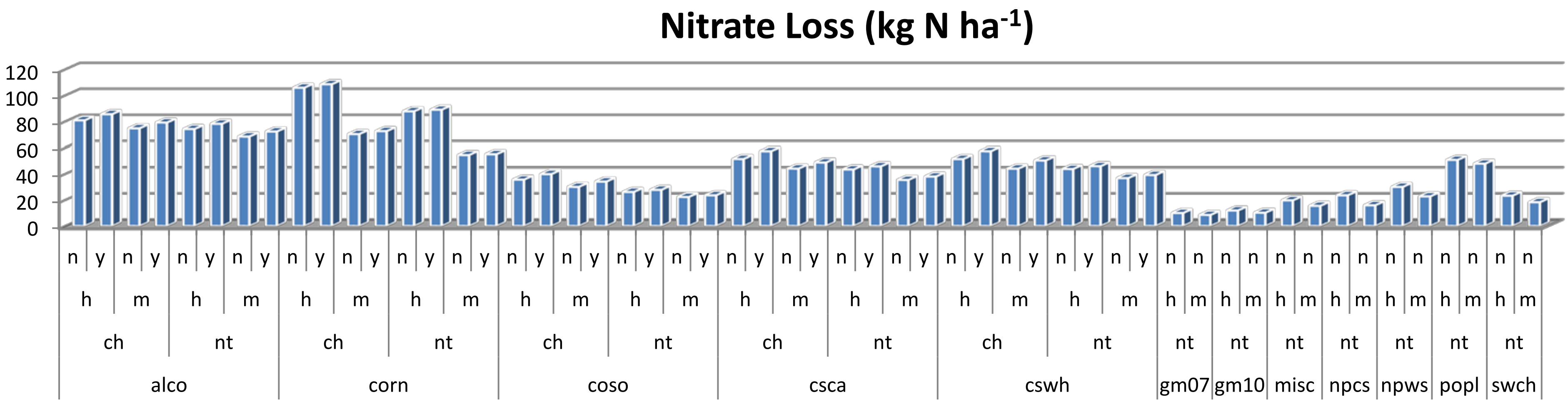
Example: EPIC model

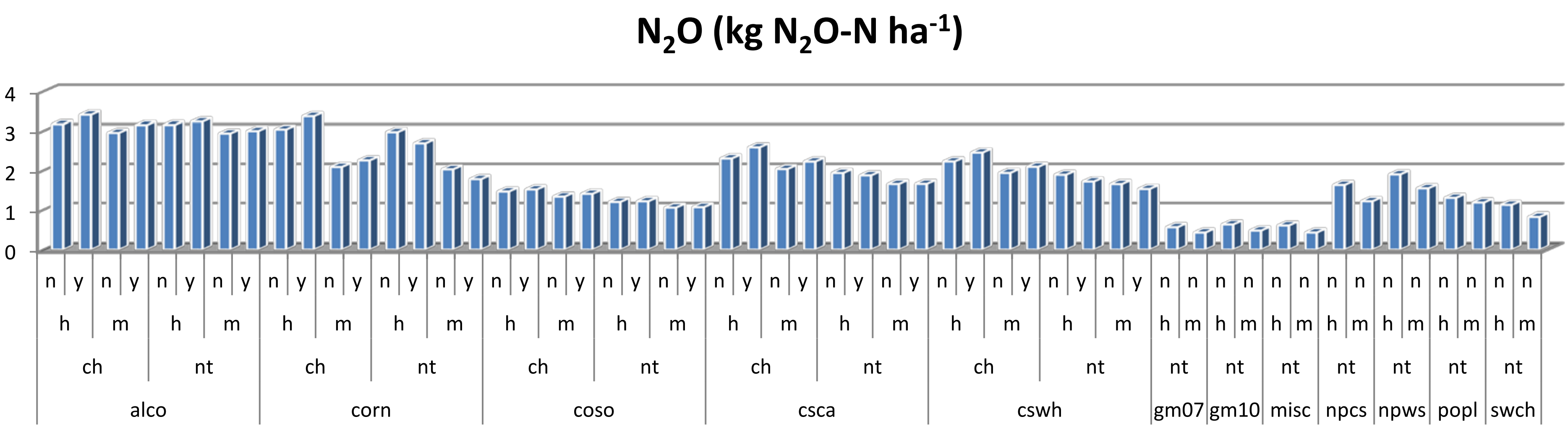
Model description

EPIC is a comprehensive, process-based terrestrial ecosystem model.



Previous experience with EPIC simulations





Zhang et al, GCB Bioenergy, 2, 258-277,2010

Future work

- Calculate on-field environmental releases
- Validate modeling results
- Integrate LCA and agricultural modeling results
- Compute site-specific life cycle impact results using openLCA
- Create maps of spatially-explicit inventories/impacts of biomass production

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Thank you

For questions and/or comments

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