

The EPIC/APEX Process Models: Improvements, Multi-run Management Software, Supporting Data, and Examples

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APEX:

- a multiple-drainage-area version of EPIC for simulating heterogeneous farm fields, whole farms, and small watersheds
- EPIC simulates a single homogeneous area with water movement and water borne effluents tracked to the edge of the area and to the bottom of the root zone

- APEX can simulate a farm or small watershed divided into many (1,000s) small sub-areas or fields
 - Hydrology, weather, plant growth, nutrient, pesticide, carbon cycling, etc., simulated within each sub-area with EPIC routines
 - APEX allows extending soil layers below the root zone
 - Overland and sub-surface flow between sub-areas, channels, flood plains, ponds, etc., within or adjacent to sub-areas can all be simulated with APEX
 - APEX output includes EPIC output for each sub-area. The output includes net outflow of water borne nutrients, sediment, carbon, and pesticides. Deposition and leaching are accounted for.
 - Grassed waterways, various buffer strips, wind breaks, constructed channels, etc., can be simulated

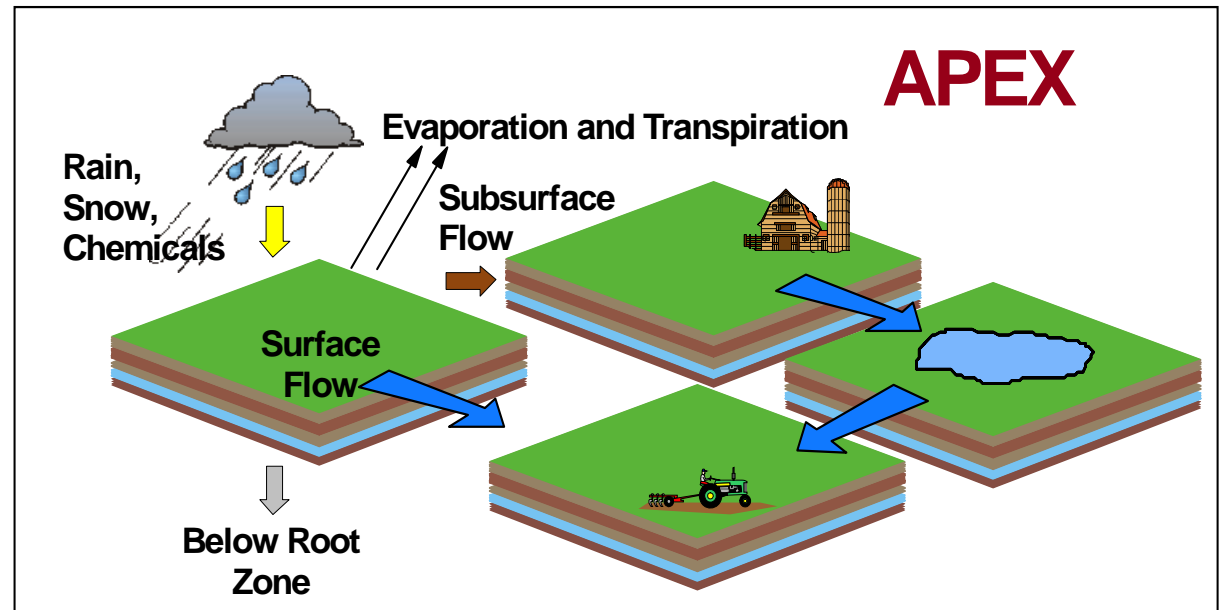
APEX COMPONENTS

1. Sub Area - EPIC

2. Routing

3. Groundwater

4. Reservoirs



Recent Model Improvements

- Century Soil Carbon routines
 - Active, Slow, and Passive Pools for soil organic matter
- RUSLE estimate of sheet and rill soil erosion
- Various changes for CEAP analysis:
 - Reporting of harvest quantities for both grain and stover
 - Plant population/seeding rate
 - Over seeding of second crop
 - Pesticide fate
 - Code had to be expanded in many ways to account for the wide variety of crops and cropping practices across the U.S.

APEX Model – N cycle representation

- N sources
 - Fertilizer
 - Manure
 - Atmospheric deposition
 - Organic matter mineralization
- N processes
 - Denitrification
 - Nitrification
 - Mineralization
 - Immobilization
 - Volatilization
 - Crop growth
- N losses
 - Nitrate Leaching
 - Nitrate in Runoff
 - Organic Matter with Sediment (water and wind)
 - Crop removal
 - Volatilization

Planned Improvements

- Gas diffusion accounting rather than mass balance for components of N and C cycles
 - Explicit representation of denitrification
 - N₂O and NO₂ flux within and from soil
 - CO₂ emissions from soil
 - Methane flux
- Sediment borne nutrients, carbon, and soil particles explicitly added to soil profiles in deposition areas
- RUSLE2 (currently have USLE, MUSLE, MUST, RUSLE options)
 - More explicit (daily), divided, and computed sub-factors and processes for runoff and erosion factors

Multi-run Management Tools

- I_EPIC
 - http://www.public.iastate.edu/~elvis/i_epic_main.html
 - Todd Campbell and Phil Gassman
- I_APEX
 - <http://www.public.iastate.edu/~marks/>
 - Mark Siemers and Phil Gassman
- CroPMan (WinEPIC)
 - <http://cropman.brc.tamus.edu/>
 - Evelyn Steglich and Tom Gerik
- WinAPEX (under development)
 - An ArcGIS based software
 - Data selected and loaded from digitized GIS based sources
 - Planned addition to NRCS field office tool kit
 - M. Lee Norfleet and Tom Gerik

* Rather than individual text files for each simulation (approximately 20 files per run), data are held in Access databases. The tool sequentially extracts data from Access tables for each simulation, writes the input files, performs the simulation, writes output to Access tables, and then goes on to the next simulation.

Available Soil Data

- Historically the models were distributed with 800+ soil data sets
- Model developers have available data sets of up to 20,000 soils
- Utility programs available for conversion of NRI linked soils data to EPIC/APEX model soils data sets
- NRI generally used as basis for choosing soil data sets by area and land use

Soil Data Choice

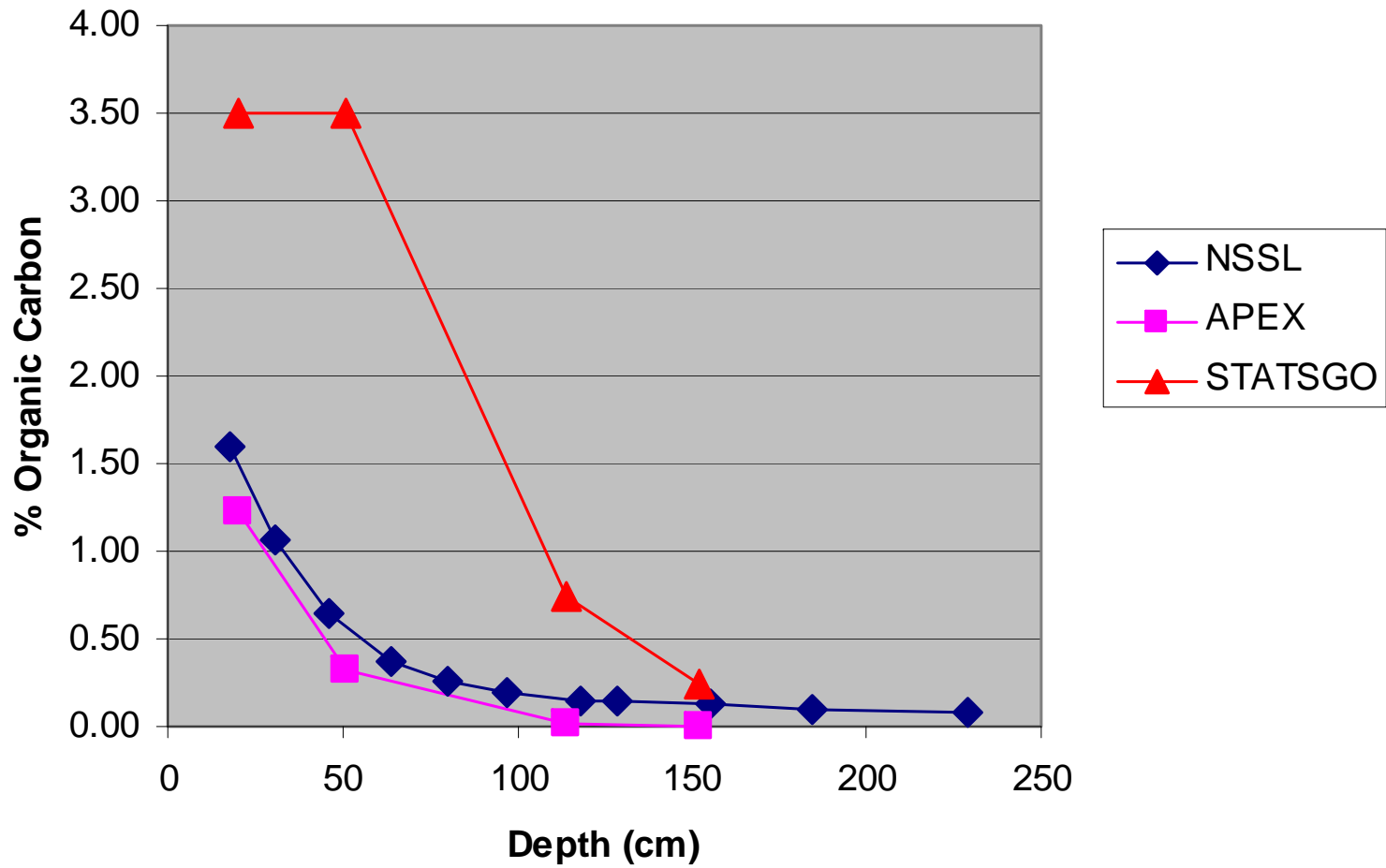
Caution:

- Soil data developed for broad land use *interpretations*, e.g., historically distributed with NRI and STATSGO was not intended for site specific simulation modeling
 - MUIR, SOILS5, SURGO-STATSGO-NATSGO all developed for land suitability interpretations (specific crops, road construction, sewage, etc.)
 - These are all now available through the Soil Data Mart
 - <http://soildatamart.nrcs.usda.gov>
 - Require augmentation and adaptation for proper use
- Data more suitable for site specific simulation modeling will be available from the Soil Survey Laboratory (SSL) Research Database
 - <http://ssldata.nrcs.usda.gov>
- Our group is currently using the best of the available *interpretations* data with some corrections based on SSL data

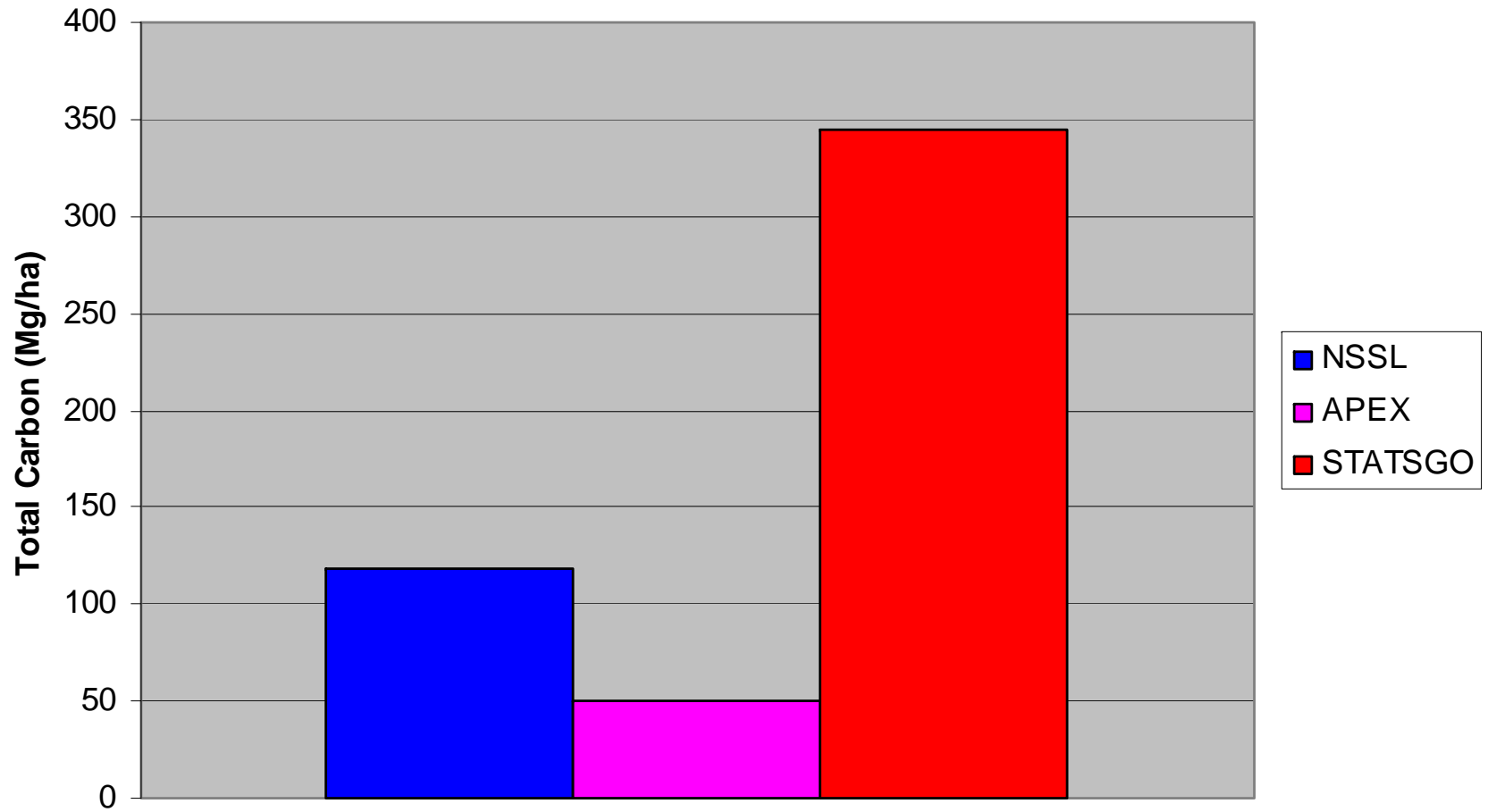
Two Corrections to Available Soils Interpretation Data

- Layer redefinition:
 - Problem: Layer 1 sometimes extending to a 2 meter depth with soil C level observed in top horizon (8 inches or so) recorded for the entire depth
 - Correction: Layers redefined to a maximum 20 cm depth, with properties of each new layer calculated as depth weighted average of original layer contributions
- Soil C correction (non-organic soils only)
 - Some soil data sets from non-cultivated condition (no Ap horizon) so large C%
 - Statistical estimation of equation for soil C by region, hydrologic group, and depth based on subset of soils having an Ap horizon
 - Equations used to set soil C for newly defined layers
- *Reduces initial pool of soil C (and calculated organic N)*
 - *Loss estimates of C and N are then reduced for cultivated cropping*
 - *Estimated Benefits of reduced tillage, CRP, and other practices may be smaller*

Comparison of Soil Carbon Data Sources Kenyon Soil



Total Carbon Stores (Mg/ha)



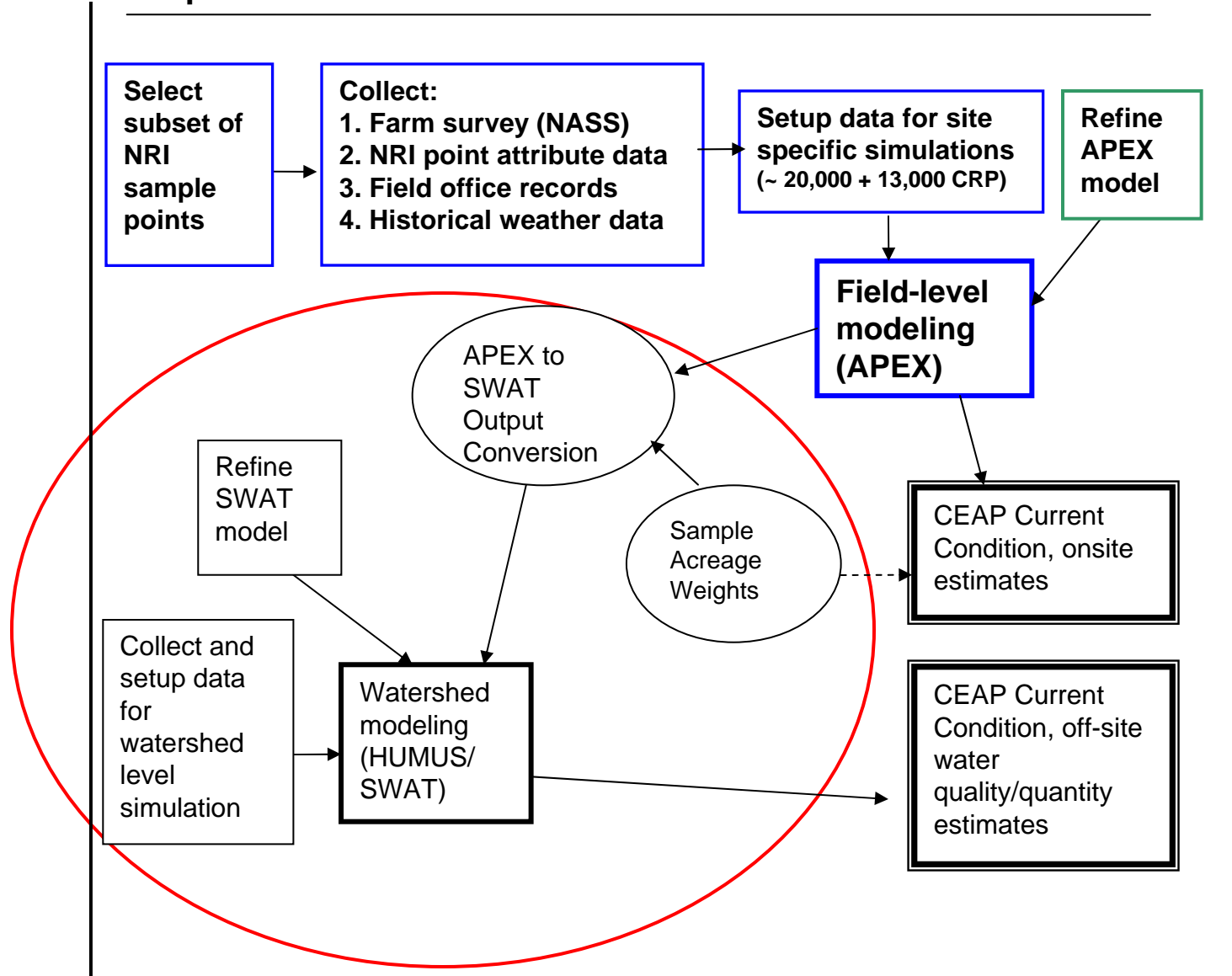
Weather Data

- Minimum input requirement
 - Daily precipitation and temperature min and max
 - Latitude and Longitude
- Additional weather input
 - Wind speed, prevalence and direction
 - Storm intensity
- Models can generate daily weather from monthly average weather data input
- Data can be obtained from NASA, NRCS, and other sources for differing periods of record and spatial coverage

Weather Data Issues

- When APEX results are input to a regional watershed scale model, require input of same daily weather at each simulated APEX field as used for the watershed model
- Average of data for multiple stations in a small watershed results in:
 - Average weather (more cloudy rain days with less rain each)
 - Distortion of emission events and crop growth estimates
- For mountainous regions, elevation must be accounted for in GIS selection of weather stations to represent each watershed

Example 1. Activities for Construction of the CEAP Current Condition.



Basic APEX Setup for CEAP

- Simulations are 42 years in length, with actual weather data for 1960 to 2001 (*Serially Complete Time Series (Eischeid, et al., 2000)*)
- CEAP crop management survey data “snapshot” interpreted as a crop rotation to be repeated over 42 year duration
 - Wide variety of crops, crop sequences, machine schedules, fertility management, irrigation, etc. (“pushing model limits!”)
- Slope data and soil identification from NRI
- Practice data from survey, NRCS district office supplement, and NRI
- Visual Basic program used to compile data and write the I_APEX simulation input database

Common CEAP Crop Data Edits

- Interpretation of reported 3-year snapshot as rotation repeated over time
- Reconcile N and P fertilizer and manure reporting units and quantities
- Correct obvious data coding errors
- Assign specific species for reported generic crops (e.g., “all wheat”)
- Reconcile cases of apparent:
 - Crop failure/abandonment/replanting to same or other
 - Grazing rather than/or in addition to machine harvested
 - Differing management on parts of field in one or more years
 - Small date overlaps of crop harvest and tillage for subsequent crop
- Procedures to add crop (s) (years) of data to complete the rotation for samples reporting hay and other perennial crops
- Procedures to “borrow” data to “fill in” missing sections in some surveys

Example 2: The National Nutrient Loss and Soil Carbon Database

<http://www.nrcs.usda.gov/technical/NRI/ceap/croplandreport/> (database is available)

By State (48)

By Climate Clusters (208 climate zone parts of states)

By Soil Clusters (6,698 soil/climate parts of states)

By Crop (16)

By Dry/Sprinkler/Furrow

By Conservation Practice System (8)

By Fertilizer Treatment (avg. 20/state)^b

By Manure Farm Type (5)^c

By Tillage Types (3)^d

Defines^a

33,068 Unique

Homogeneous

Resource Units

^aNational Resources Inventory (NRI)

(all units representing less than 1000 acres were excluded, cumulatively < 1% of total acres)

^bCropping Practice Survey (CPS)

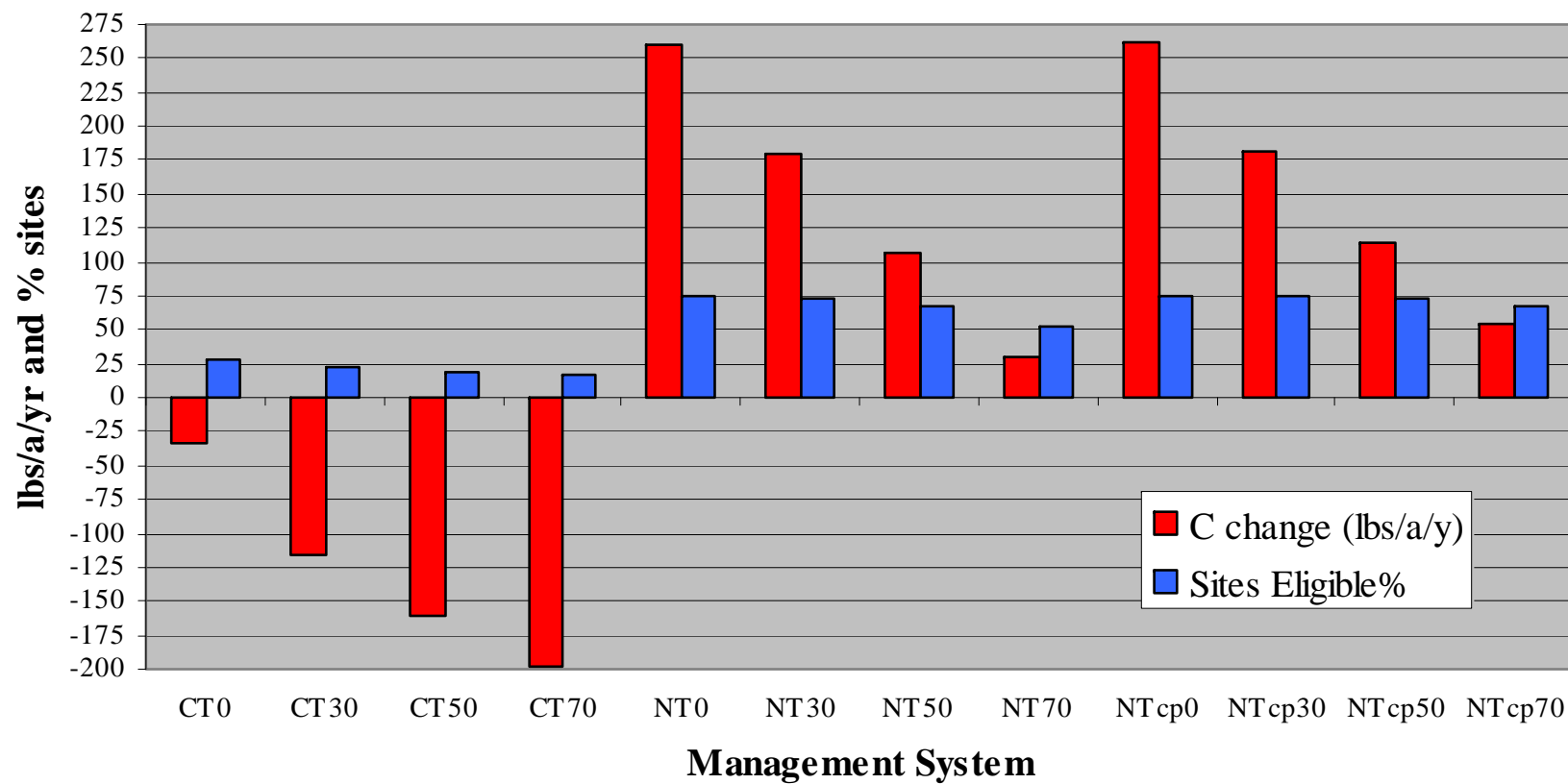
^cCensus of Agriculture (CEN)

^dCrop Residue Management Survey (CRM) (conventional, mulch, no-till)

Example 3: Can CRP lands be safely converted to corn production?

- Sample of CRP sites across the US (2,400+)
- Management alternatives
 - Notill and Conventional Tillage
 - Removal of 0, 30, 50, and 70% stover
 - Use of supporting erosion control practices or not
- Environmental criteria (assumed requirement):
 - USLE \leq T
 - Wind erosion \leq T
 - Corn yield \geq 100 bushels
 - C loss \leq 100 lbs/acre annually
 - Organic soils excluded

Figure 2. Average C change (lbs/acre/year) and sites eligible(%) by system.



Example 4: Effect of increased corn proportion in corn-hay rotations (average of 2400+ sites)

