# Predicting Carbon Sequestration in Agricultural Soils with the Carbon Balance Model 'CQESTR'

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## Introduction:

The prospect of storing carbon in soil, as organic matter, provides an opportunity for agriculture to contribute to the reduction of carbon dioxide in the atmosphere. However, a description of management effects on soil organic matter (SOM) is necessary to assess carbon storage in soil. A mathematical model, CQESTR, pronounced sequester, has been developed to evaluate the changes in SOM at the field scale.

## Description of CQESTR:

It is a Windows based program that was recently modified to include the effects of soil texture and drainage classes on decomposition rate. It computes the rate of biological decomposition of crop residue or organic amendments as they convert to SOM in each soil layer.

## Data Required:

➢ The program uses Revised Universal Soil Loss Equation (version 1) c-factor files for crop rotation, yield, tillage and weather data.

➢ Additional required data includes the number and thickness of soil layers, soil texture, soil drainage class, starting organic matter content and bulk density for each layer, and nitrogen content of the organic residues. Residue nitrogen content can be estimated from tables provided in the program if actual analyses are not available.

## CQESTR: Basic C budget and decomposition

**Fundamental carbon balance equation applied to each layer on a daily time-step is:**

$$C = (C_{SOM} - C_{DOM}) + (C_S - C_{DS}) + (C_R - C_{DR}) + (C_A - C_{DA})$$

**$C$ = Total organic carbon in the soil (weight/area)**
**$C_{SOM}$ = Carbon in the soil organic matter**
**$C_{DOM}$ = Decomposed organic matter lost as $CO_2$**
**$C_S$ = C in shoot residues added**
**$C_{DS}$ = C lost as $CO_2$ from decomposed shoot residues**
**$C_R$ = C in root residue added from crop roots**
**$C_{DR}$ = C lost as $CO_2$ from decomposed root residues**
**$C_A$ = C in amendments added such as manure**
**$C_{DA}$ = C lost as $CO_2$ from decomposed amendments**

**Decomposition model used is as follows:**

$$R_r = R_i * \exp(k * fN * fW * fB * fX * fD * CDD)$$

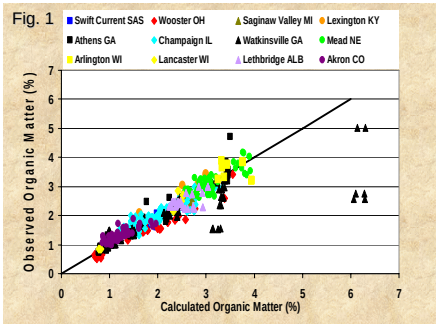
**$R_r$ = Residue remaining at the end of decomposition period**
**$R_i$ = Initial Residue added**
**$k$ = Decomposition rate constant**
**fN = Nitrogen Content Factor**
**fW = Water Factor**
**fB = Biomass Type Factor**
**fX = Soil Texture Factor**
**fD = Soil Drainage Factor**
**CDD = Cumulative Degree Days**

## Calibration and Validation:

➢ The program was calibrated using information from 60-year old long-term wheat-fallow rotation experiments conducted near Pendleton, OR and validated with long-term organic matter databases from various parts of North America (Fig.1 & 2).

➢ Loss of C from erosion or soil macro fauna is not accounted for by CQESTR (e.g. Watkinsville, GA).

Fig. 1



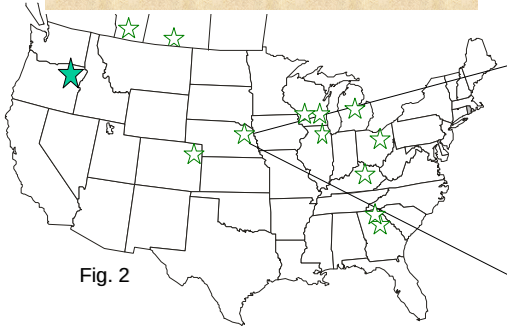



Fig. 2

## Results and Discussions:

➢ Initial simulations predict that management practices that remove crop biomass or promote microbial decomposition consume existing SOM (Fig. 3). Practices that increase residue return can increase SOM and improve soil quality.

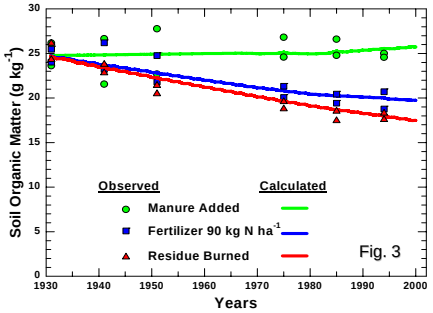



Fig. 3

➢ Tillage practices that increase contributions to biomass, limit inversion tillage and provide annual root and shoot biomass return to the soil promote C storage (Fig. 4).

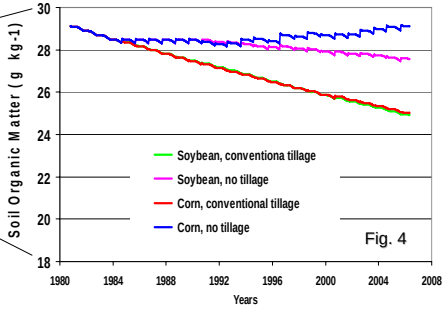



Fig. 4