# IFSM

## The Integrated Farm System Model: Production, Economic, and Environmental Assessments

M. Dutreuil &
V.E. Cabrera

# OUTLINE

1. Introduction
2. Model inputs
3. Sub-models
4. Simulation
5. Model outputs
6. Case study

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# What is the IFSM ?

- A whole-farm simulation model of crop, dairy and/or beef production
- Performs simulations over many years of weather to determine long-term performance, environmental impact and economics
- Simulates major processes of crop production, harvest, storage, feeding, milk production, manure handling, and crop establishment
- Makes environmental assessments of nutrients use and gasses emissions

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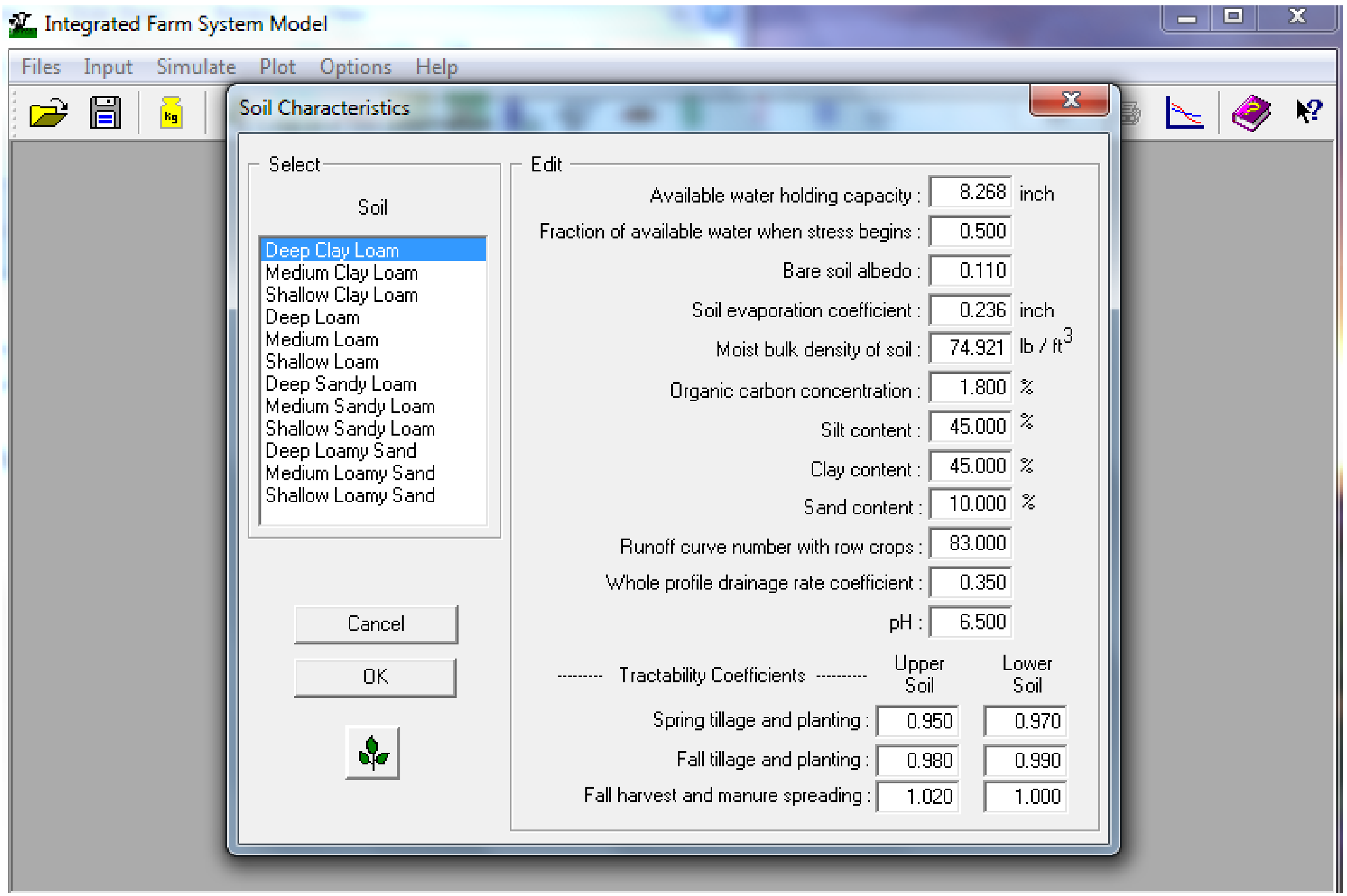
# INPUTS: 10 SECTIONS

1. Crop and soil
2. Grazing
3. Machinery
4. Tillage and planting
5. Crop harvest
6. Feed storage
7. Herd and feeding
8. Manure and nutrient
9. Economics
10. Weather

# CROP AND SOIL (1/2)

- Soil type and characteristics



# CROP AND SOIL (2/2)

- Farm topography
- Alfalfa: acreage, standing life, fertilization, irrigation
- Grass: acreage, standing life, fertilization, grasses and legumes %.
- Corn: plant population, fertilization, irrigation.
- Small grain: type, double cropped, fertilization, irrigation
- Soybeans: plant population, fertilization, irrigation.

# GRAZING

- Grazing area in the spring, summer and fall.
- Investment in perimeter and temporary fences
- Investment in watering system
- Annual cost of seeds and chemicals
- Labor for grazing management
- Grazing strategy:
  - Heifers only
  - Heifers and dry cows
  - Lactating cows only
  - Heifers and all cows
  - All animals during grazing season
  - All animals all year round (outwintered)

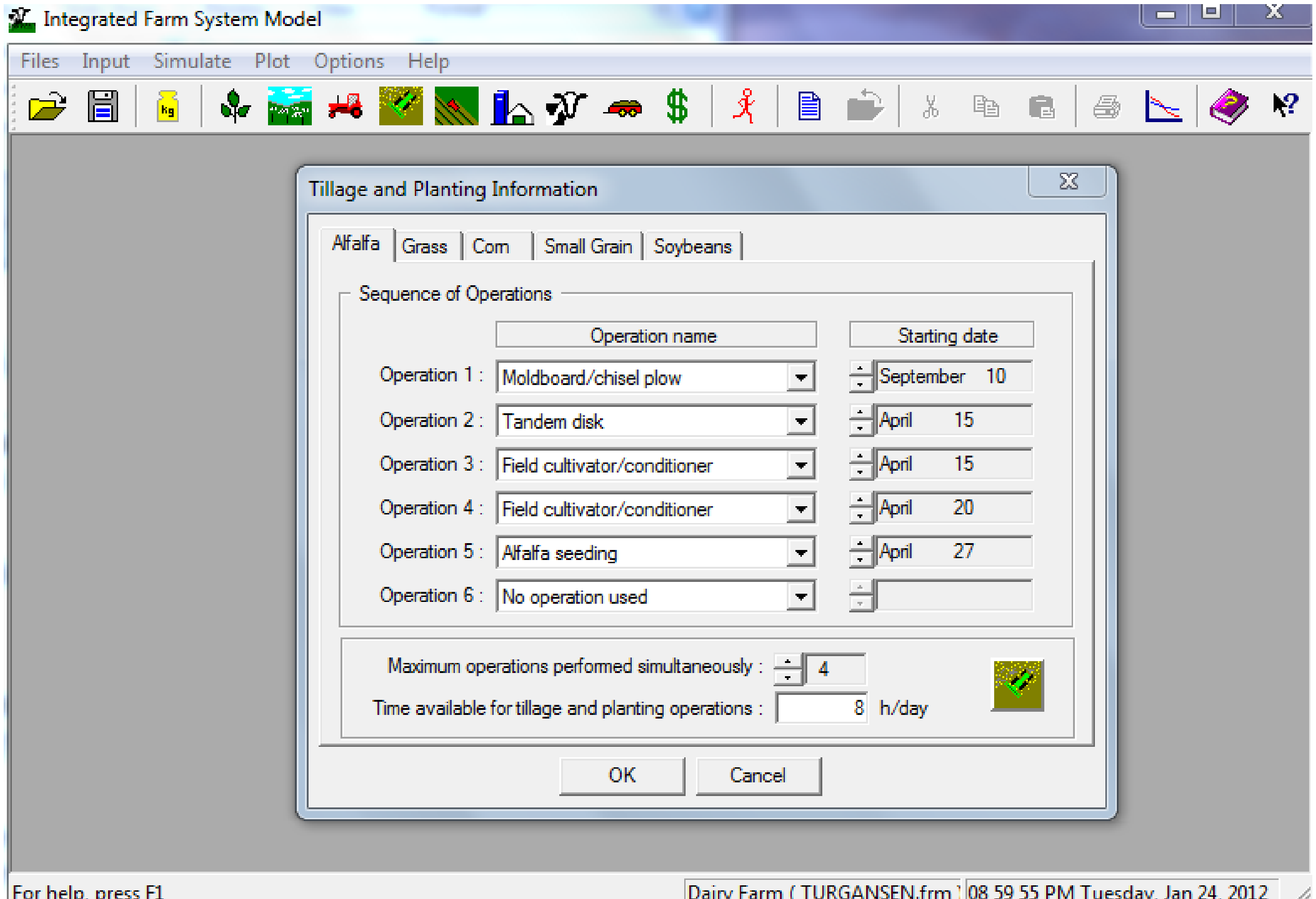
# MACHINERY

- All the machineries used for harvesting, feeding, tillage operation and planting are described.
- Each machine is associated with 1 tractor when necessary.
- All tractors are described by their power, their weight, their price, their age and the engine type.
- Machineries for transport are also described.
- Some operations can be custom operations when the machineries are not available on the farm.

# TILLAGE AND PLANTING (1/2)

- For each crop (alfalfa, grass, corn, small grain or soybean) a total of 6 operations is possible.
- For each operation, a starting date can be indicated.
- The number of operations performed simultaneously (from 1 to 6) can also be indicated.
- The time available for tillage and planting operation each day can be modified.

# TILLAGE AND PLANTING (2/2)



# CROP HARVEST (1/2)

- ALFALFA AND GRASS:
  - Up to 5 cuts.
  - Type of harvest, starting date and NDF content indicated for each cut.
  - Time available each day for harvesting can be adjusted.

- CORN:
  - Dates for harvesting as silage, high moisture corn or dry corn
  - Corn silage cutting height
  - Corn silage processing
  - Type of high moisture corn

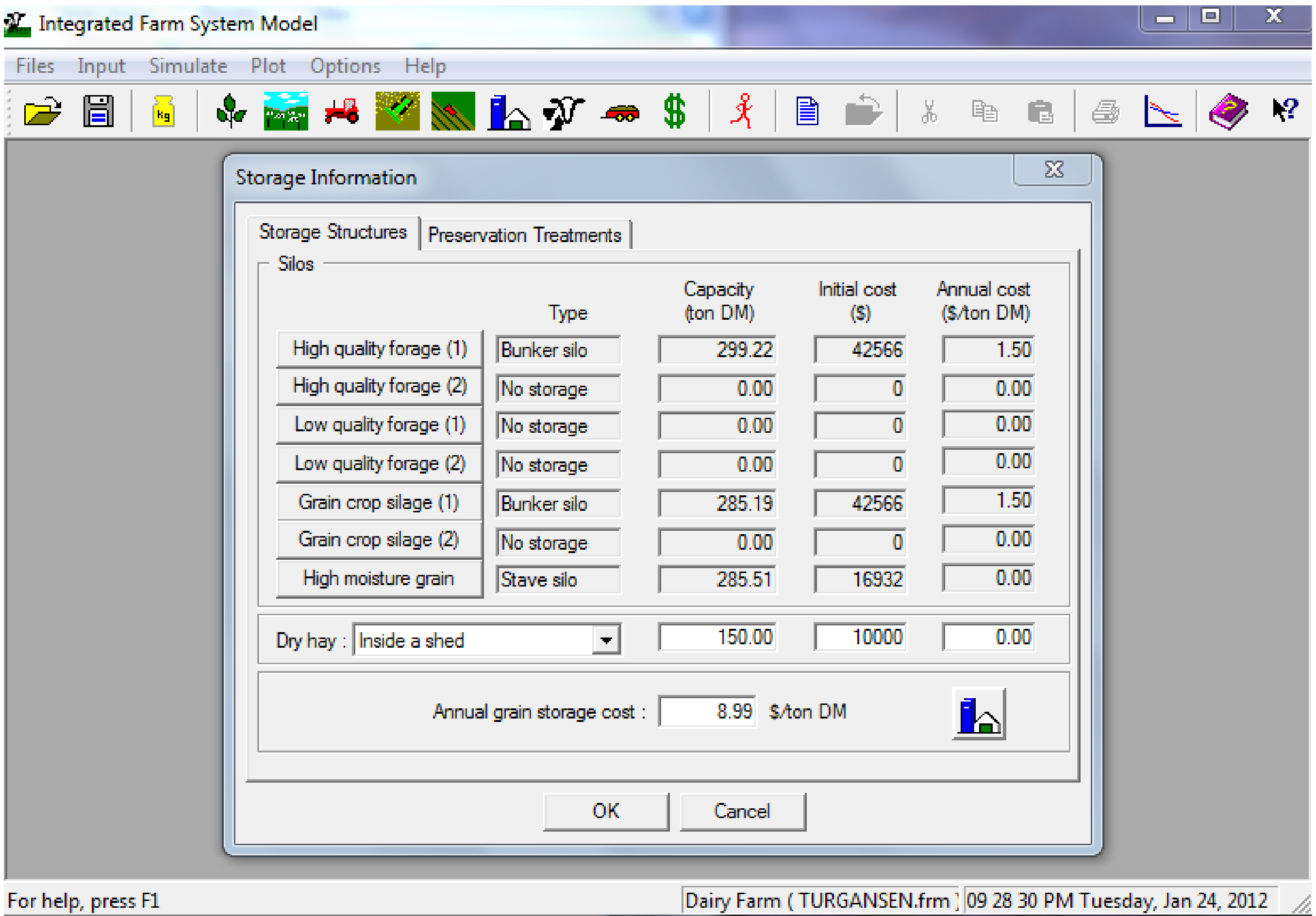
# CROP HARVEST (2/2)

- SMALL GRAINS:
  - Dates for harvesting as silage, high moisture grain or grain
  - Use on the farm
  - Use of straw for bedding

- SOYBEANS:
  - Starting date for harvesting
  - Use on the farm
  - Cost for roasting

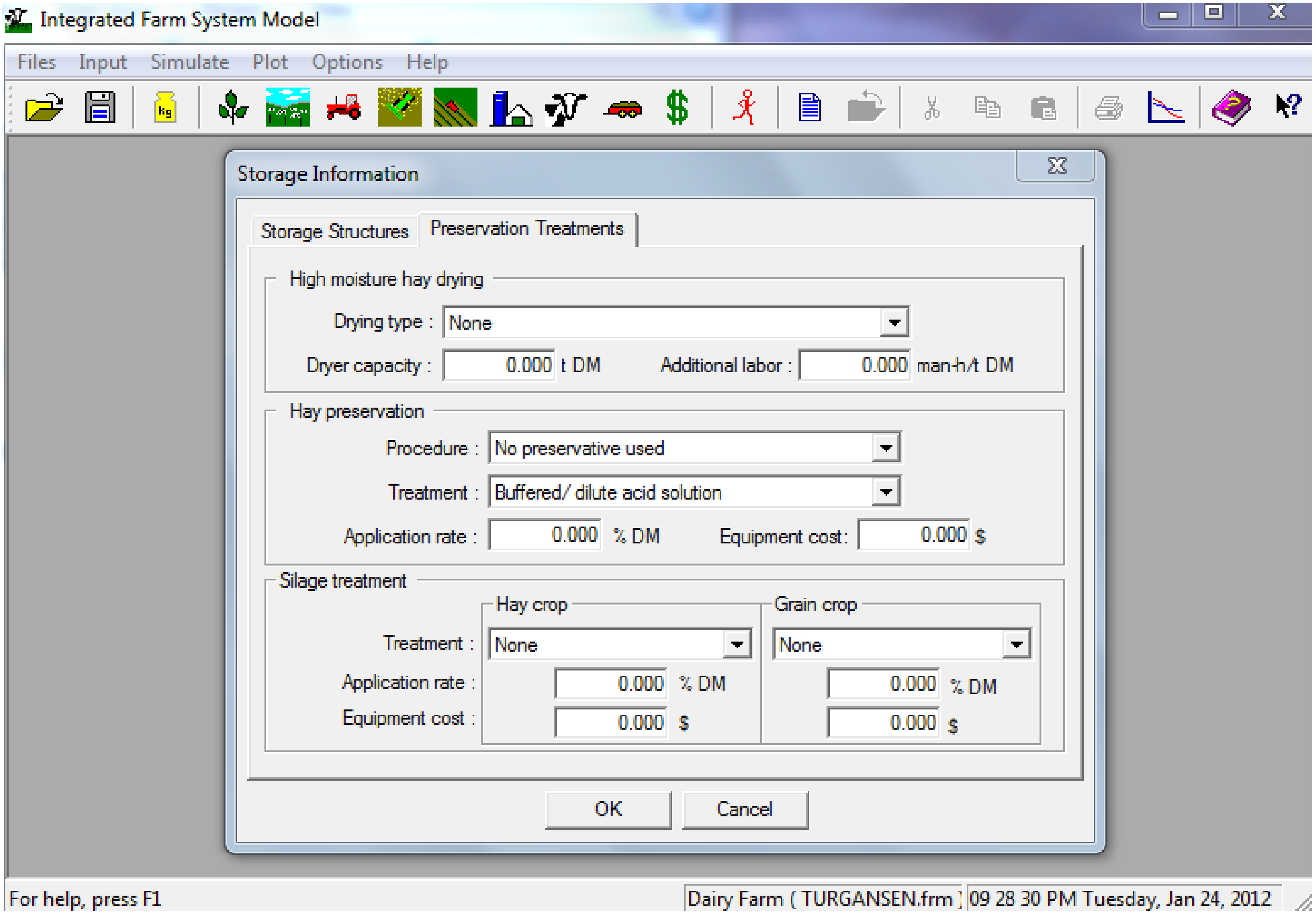
# FEED STORAGE (1/2)

- Storage structures:



# FEED STORAGE (2/2)

- Preservation treatments:

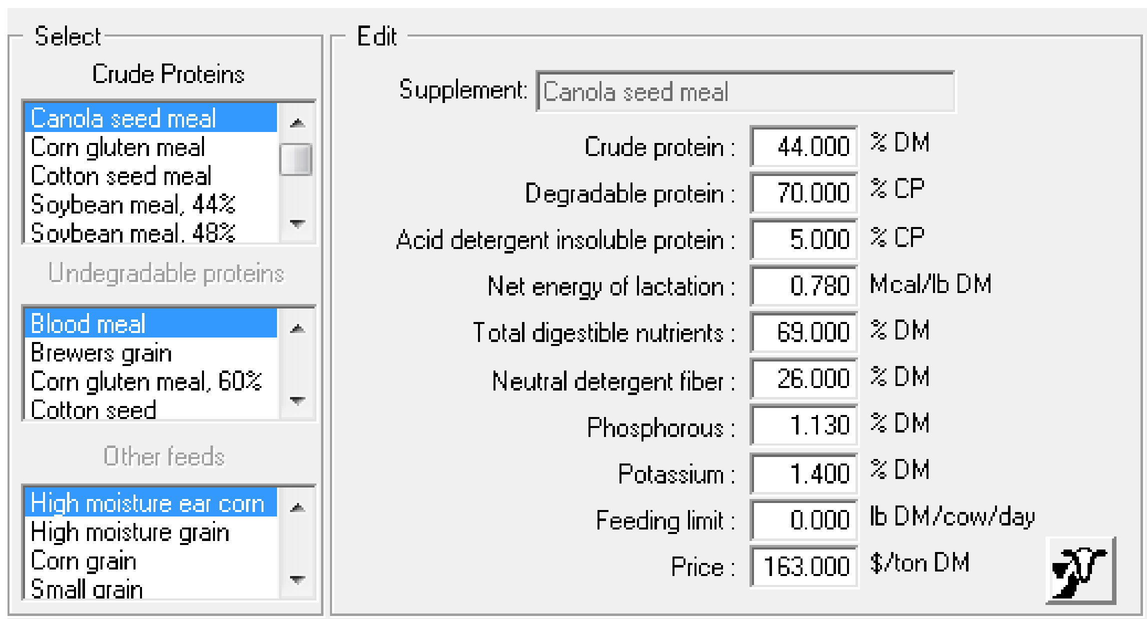


# HERD AND FEEDING (1/3)

- HERD AND FACILITIES:
  - Animal: breed, number of lactating cows, number of young stock over one year, number of young stock under one year, target milk production, proportion of first lactation animal in the herd, calving strategy.
  - Facilities: type of milking facilities, cow housing, heifer housing, feed facilities and their costs.
  - Time needed for milking and handling cows each day

# HERD AND FEEDING (2/3)

- FEEDING:
  - Feeding method for grain, silage and hay
  - Ration constituents: % hay, % phosphorus, % protein, forage to grain ratio, protein and energy supplement.
  - For each supplement, feed characteristics can be adjusted:



# HERD AND FEEDING (3/3)

- LIVESTOCK EXPENSES ($/cow):
  - Bovine somatotropin injection
  - Veterinary and medicine
  - Semen and breeding
  - Animal and milking supplies
  - Insurance of animals
  - Animal hauling
  - DHIA

# MANURE AND NUTRIENT

- Manure hauling on the farm:
  - Manure collection,
  - manure type,
  - incorporation into the soil,
  - average hauling distance.
- Storage:
  - Period of storage,
  - Type of storage
  - Capacity
  - Cost
- Import and export of manure:
  - Quantity and composition of manure imported to the farm or exported.

# ECONOMICS

- Prices for inputs: fuel, electricity, labor, land rental, taxes, crop treatments, seeds, chemicals, fertilizers, feed, bedding, milk hauling.
- Prices for outputs: grains, soybeans, hay, milk, culled cows, heifers, calves.
- Cost of custom operations: planting, tillage, mowing, tedding, raking, baling, chopping, harvesting and manure hauling.

# WEATHER

- Daily weather data for many years at a particular location.

- Data:
  - Date
  - Incident solar radiation
  - Maximum temperature
  - Minimum temperature
  - Precipitation

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# CROP GROWTH MODEL

- A model is used to predict the moisture and nitrogen content of the soil based on the weather data. E.g.:
  - Soil water balance (Jones and Kiniry, 1986)
  - Soil nitrogen balance (NLEAP; Shaffer et al., 1991)

- Based on the nitrogen and moisture content, a model is used to predict the yield and the nutritive value of each crop:
  - Alfalfa (ALSIM1. Fick, 1977)
  - Corn (CERES-Maize; Jones and Kiniry, 1986)
  - Grass (GRASIM. Mohtar et al., 1997)
  - Small grains (CERES-small grains, DSSAT; Tsuji et al., 1994)
  - Soybean (SOYGRO, DSSAT; Tsuji et al., 1994)

# GRAZING

- The grass or the alfalfa can be used for grazing.
- The timing and the amount of forage removed is the only difference with the growth model for harvested grass and alfalfa.
- Pasture is allocated to meet the nutrient needs of each animal group in the herd.
- The model does not allow the grass to be carried over from one month to the next.

# MACHINERY

- The machinery file is used to determine the labor requirement, the fuel consumption, the time needed for each operation, the need for custom work…

- Some operations can be parallel or sequential.

# TILLAGE AND PLANTING

- The model used for tillage and planting involves weather data and the machinery file.
- The first step for the model will be to determine a suitable day to start working the field based on the weather.
- Then, based on the machinery available on the farm, the time needed for tillage and planting will be determined.

# CROP HARVEST

- For crop harvest, the farm is divided into plots where each plot is the amount of crop that can be harvested by the machinery system in 3 hours.
- The start for harvesting depends on yield, calendar date define by the user, forage nutritive content and weather.
- The grass and alfalfa cannot be harvested is corn planting is not completed.
- The model also calculated losses during the drying time for grass and alfalfa in the field.

# FEED STORAGE

- Different storage options are provided for hay, silage and grain crops.
- Hay and silage can be separated into 2 levels of quality for storage and feed allocation.
- Losses and changes in quality are modeled during the storage for every crops.

# HERD AND FEEDING

- The model uses 6 animal groups:
  - Young stock under 1 year old
  - Heifers over one year old
  - Early lactation cows (16% of the herd)
  - Mid lactation cows (23% of the herd)
  - Late lactation cows (46% of the herd)
  - Non lactating cows (15% of the herd)
- The feeding is modeled so that it is making the best use of homegrown feed and uses NRC requirement for each of the 6 groups.
- Feed losses at feeding time are also modeled.

# MANURE AND NUTRIENT

- The quantity and composition of the manure produced by the animals is a function of the feed they received.
- The total quantity of manure handled depends on the manure produced by the animals, the type and amount of bedding used and the amount of water in the manure.
- The manure application depends on the weather and is not done if there is higher priority field operations to perform.
- An option for an anaerobic digester is also available

# ENVIRONMENTAL IMPACT

- The model includes:
  - volatile, leaching and denitrification losses of N
  - Volatile losses of $H_2S$
  - Runoff and leaching of P
  - Greenhouse gas emission of $CO_2$, $CH_4$ and $N_2O$

- Everything is modeled based on the inputs: animal housing, manure storage, manure application, crops, grazing animals…

# ECONOMIC ANALYSIS

- Whole farm budget where the total cost of production is compared to revenues = net return.
- Costs = facilities, machinery, land and crops, pasture management, livestock and custom work.
- Incomes = crops sales, milk sales, excess feeds and animal sales.

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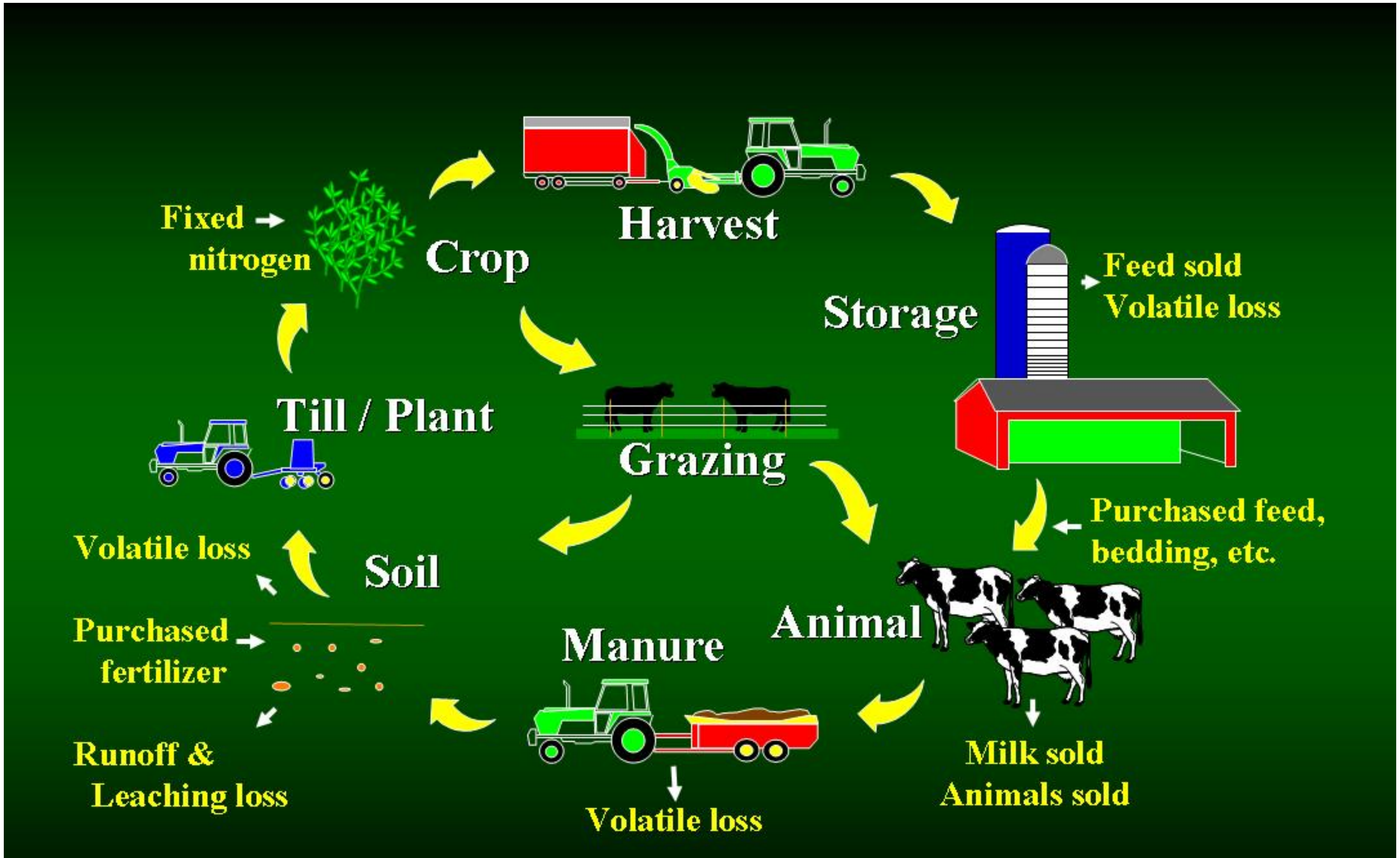
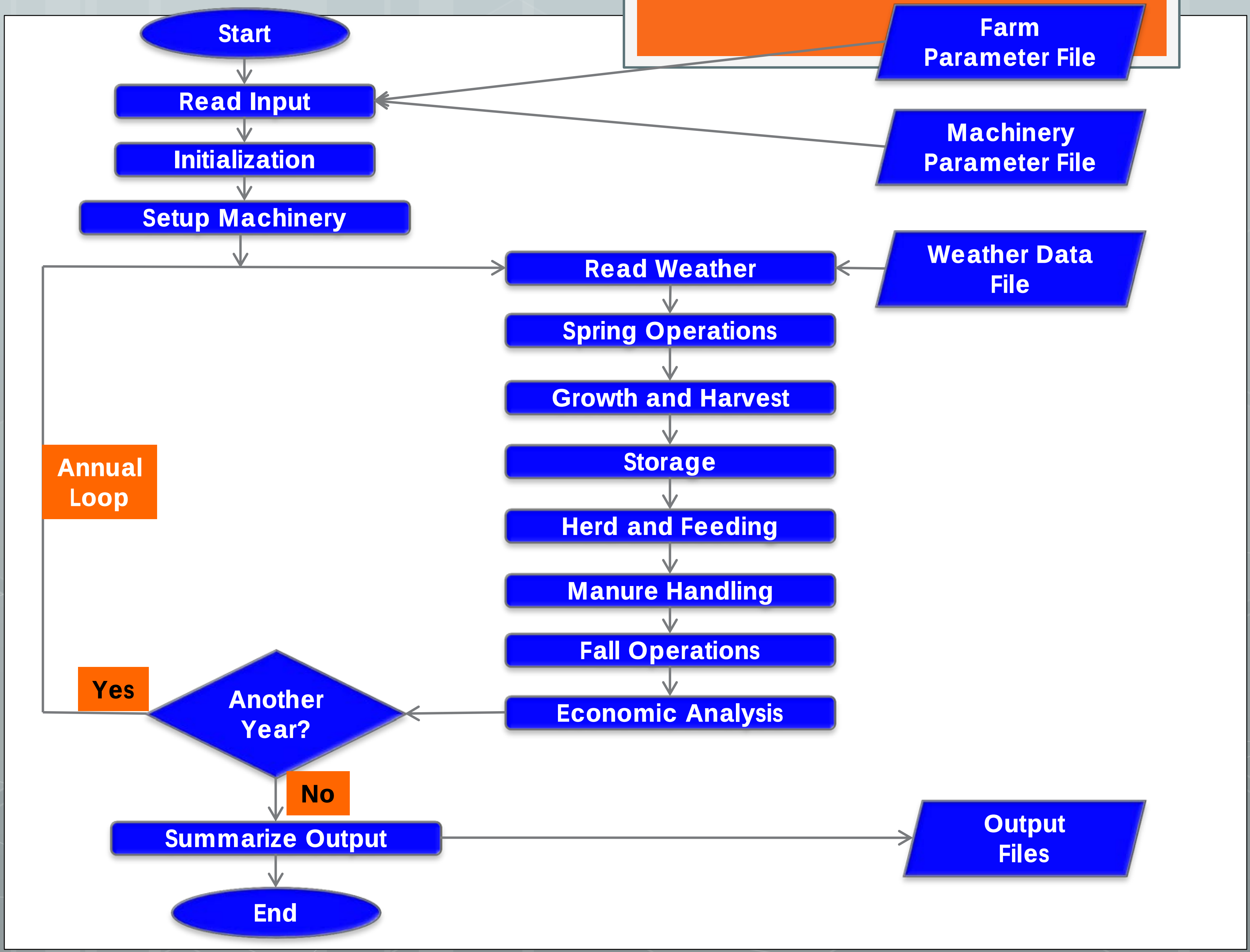
# SIMULATION




http://www.ars.usda.gov/main/docs.htm?docid=8519


Start
Read Input
Initialization
Setup Machinery
Farm Parameter File
Machinery Parameter File
Weather Data File
Read Weather
Spring Operations
Growth and Harvest
Storage
Herd and Feeding
Manure Handling
Fall Operations
Economic Analysis
Annual Loop
Another Year?
Yes
No
Summarize Output
Output Files
End

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# OUTPUTS

- Simulation of up to 26 years in one run

- 3 Files:
  1. Parameters file: summary of the inputs
  2. Results for each year simulated
  3. Average results for all years simulated

# RESULTS-PRODUCTION

- Yield and nutritive value of all the crops harvested on the farm
- The quantity and quality of homegrown and purchased feed used on the farm (hay, silage, grain, mineral, vitamin, protein…)

# RESULTS-ECONOMY

- The annual costs for machinery, all the inputs (fuel, electricity, seeds, chemical…), land rental, feed and bedding purchased, manure.
- The income from milk, feed and bedding sales, and animal sales.

# RESULTS-ENVIRONMENT

- The N, P, K and carbon imported, exported, available, lost or used by the crop
- Daily and annual emission of Ammonia, Hydrogen sulfide, Methane, Nitrous oxide, Biogenic Carbon Dioxide.
- Daily and annual greenhouse gas emission (CO2 equivalent).

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# DATA COLLECTION - SURVEY

## Feeding Strategies on Wisconsin Dairy Farms: Economic, Production, and Environmental Outcomes

THE UNIVERSITY of WISCONSIN MADISON — USDA United States Department of Agriculture National Institute of Food and Agriculture — NATIONAL SCIENCE FOUNDATION — UW Extension

Participation in the study is **voluntary**. All answers to questions in this survey will be kept ***strictly confidential***, and the results will only be used in statistical summaries. Individual farm information will not be identified in any publication. University of Wisconsin-Madison, Social and Behavioral Sciences, IRB Protocol Number SE-2009-0401.

**Consent forms need to be signed prior to the start of the interview**

We welcome your comments and suggestions
Contact: Victor E. Cabrera 608-265-8506 vcabrera@wisc.edu
Contact: Brad Barham 608-265-3090 barham@aae.wisc.edu

ENUMERATOR:

DATE OF SURVEY:

SURVEY STARTING TIME: SURVEY ENDING TIME:

FARMER ID#:

**A. FARM BUSINESS STRUCTURE AND DECISION MAKERS**

A.1. How is your farm business managed
(Check the one choice that applies best
☐ 1 = Individual
☐ 2 = Partnership;
☐ 3 = Hired management;
☐ 4 = Other (specify: ____

A.2. Are you an important decision maker
☐ 1 = YES, for how many years? ____
☐ 0 = NO

A.3. How many other people are important

A.4. Do you milk your dairy cattle at more than one location?
☐ 1 = YES
☐ 0 = NO, **SKIP TO A.5**

A.4.1. Do you consider the cows in the different location(s) part of the same herd?
☐ YES, for the rest of the survey we would like you to answer the questions for the whole herd. **SKIP TO A.5**
☐ NO, continue

A.4.2. Do you use the same land to feed those different herds?
☐ YES, for the rest of the survey we would like you to talk about the different herds as if they would be only one and tell us about all of the land used for the different herds.
☐ NO, for the rest of the survey we would like you to focus only on your main herd and the land you use to feed it.
How many cows you milk at the other location? __________
How far away is the other location? __________

A.5. Do you use grazing?
☐ 1 = YES, continue to A.6
☐ 0 = NO, **SKIP TO A.7** if they do not graze

A.6. How often are cows moved to a fresh pasture during the primary grazing season (May 1 to Oct 15)? ____
____________________

A.7. Are you or have you been certified organic?
☐ 0 = No, we have never been certified
☐ 1 = Yes, we are currently certified organic. What year did your farm become certified? __________
☐ 2 = We are transitioning into organic. What year did you start transitioning? __________
☐ 3 = We used to be certified, but are no longer certified as of (month and year) __________

2


446 ac
(70 rented)
Shallow Clay Loam
Alfalfa
141
Oats
28
Soybeans
17
Grass
70
Corn
190
75 Holstein
Manure
Scrapped
5 Tractors
66 Heifers
Tie Stall
Milk @ $15.88

# CASE STUDY (1/2)

- Conventional Wisconsin dairy farm:
  - 446 acres (70 rented)
  - Crops:
    - Alfalfa: 141 acres harvested as hay and silage and fertilized with 54 lbs. of N/acre and 138 lbs. of P/acre.
    - Grass: 70 acres used for hay and grazed by dry cows and older heifers.
    - Corn: 190 acres harvested as silage and grain and fertilized with 130 lbs. of N/acre, 13 lbs. of P/acre, 5 lbs. of K/acres and all the manure available on the farm.
    - Oats: 28 acres harvested as grain and bedding and fertilized with 100 lbs. of N/acre.
    - Soybeans: 17 acres harvested as grain with no fertilization.

# CASE STUDY (2/2)

- Animals:
  - 75 Holstein
  - 43% of first lactation animals
  - 66 young animals
- Grazing strategy: old heifers and dry cows
- Milking facilities:
  - Pipeline system in a tie stall barn.
- Milk price:
  - $15.88/cwt
- Simulation: 25 years form 1981 to 2005

| Alfalfa | |
|---|---|
| Stand life | 3 years |
| Yield adjust. | 87% |
| Irrigation | 0 in |
| N (lb/ac) | 54 |
| P (lb/ac) | 138 |
| K (lb/ac) | 0 |
| Manure | 0 % |

| Oats | |
|---|---|
| Stand life | 3 years |
| Grain yield adjust. | 100% |
| Silage yield adjust. | 100% |
| Irrigation | 0 in |
| Double cropped | No |
| N (lb/ac) | 100 |
| P, K, and Manure | 0 |

| Corn | |
|---|---|
| Plant population | 27,923/ac |
| Rel. maturity index | 110 d |
| Grain yield adjust. | 93% |
| Silage yield adjust. | 106% |
| Irrigation | 0 in |
| Pre-plant N (lb/ac) | 130 |
| Post-plan N (lb/ac) | 0 % |
| P | 13 |
| K | 5 |
| Manure | 100% |

| Grass | |
|---|---|
| Stand life | 16 years |
| Yield adjust. | 100% |
| Irrigation | 0 in |
| Initial sward DM | 418 lb/ac |
| Cool season | 100% |
| N, P, K, manure | 0 |

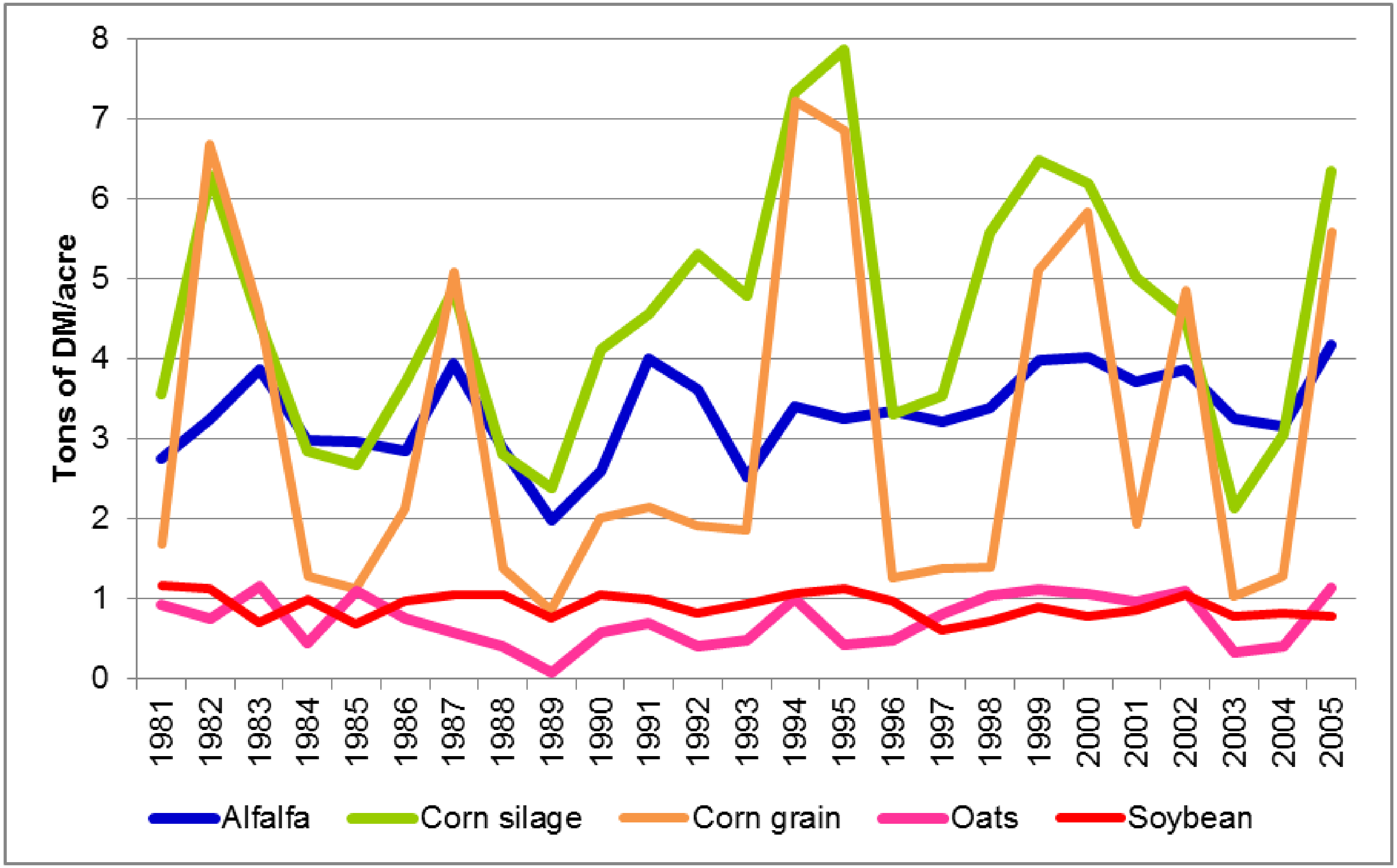
| Soybeans | |
|---|---|
| Plant population | 182,105/ac |
| Maturity group | MG III |
| Yield adjust. | 93% |
| Irrigation | 0 in |
| N, P, K, manure | 0 |

| Soil Characteristics | |
|---|---|
| Rotated cropland | Shallow Clay Loam |
| Grassland | Shallow loam |
| Topography | 3-8% slopping |
| P level | 30-50 ppm |
| Water holding | 2.362 in |
| Bare soil albedo | 0.11 |
| Soil evap. coeff. | 0.236 in |
| Moist bulk dens. | 74.921 $lb/ft^3$ |
| Organic carbon | 1.800% |
| Silt/Clay/Sand | 45/45/10 |
| Runoff curve # | 87.00 |
| Drainage coeff. | 0.350 |
| pH | 6.500 |

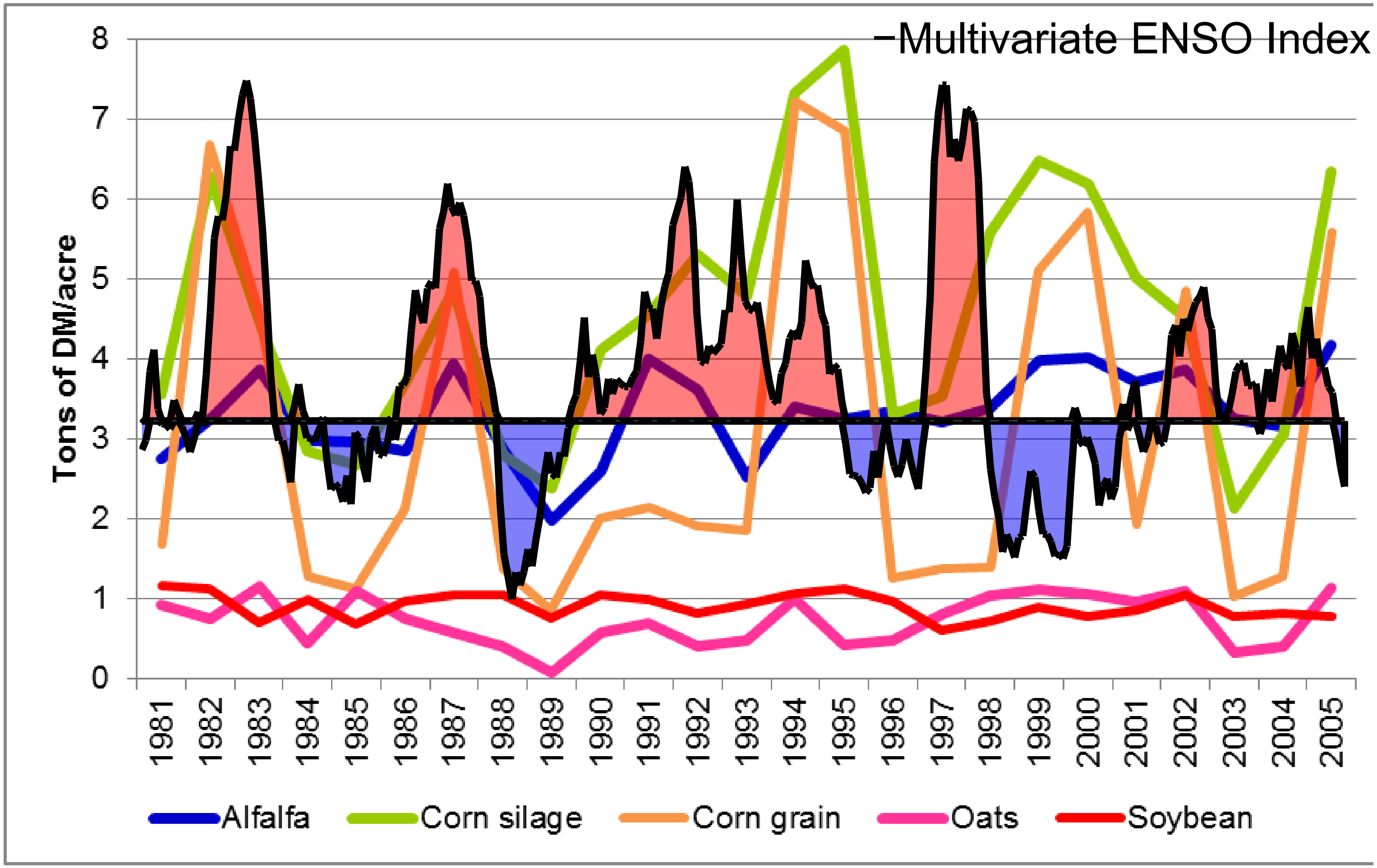
# AVERAGE RESULTS

- Crop yield:
  - Alfalfa: 3.32 Ton of DM/acre
  - Corn silage: 4.56 Ton of DM/acre
  - Corn grain: 4.88 Ton of DM/acre
  - Oats: 0.73 Ton of DM/acre
  - Soybeans: 0.92 Ton of DM/acre
- Milk production: 22,825 lbs./cow/year
- Net income over feed and manure cost:
  - $77,920/year
  - $1,039/cow
- Total green house gas emission:
  - 13,694 lbs. of $CO_2e$/cow/year

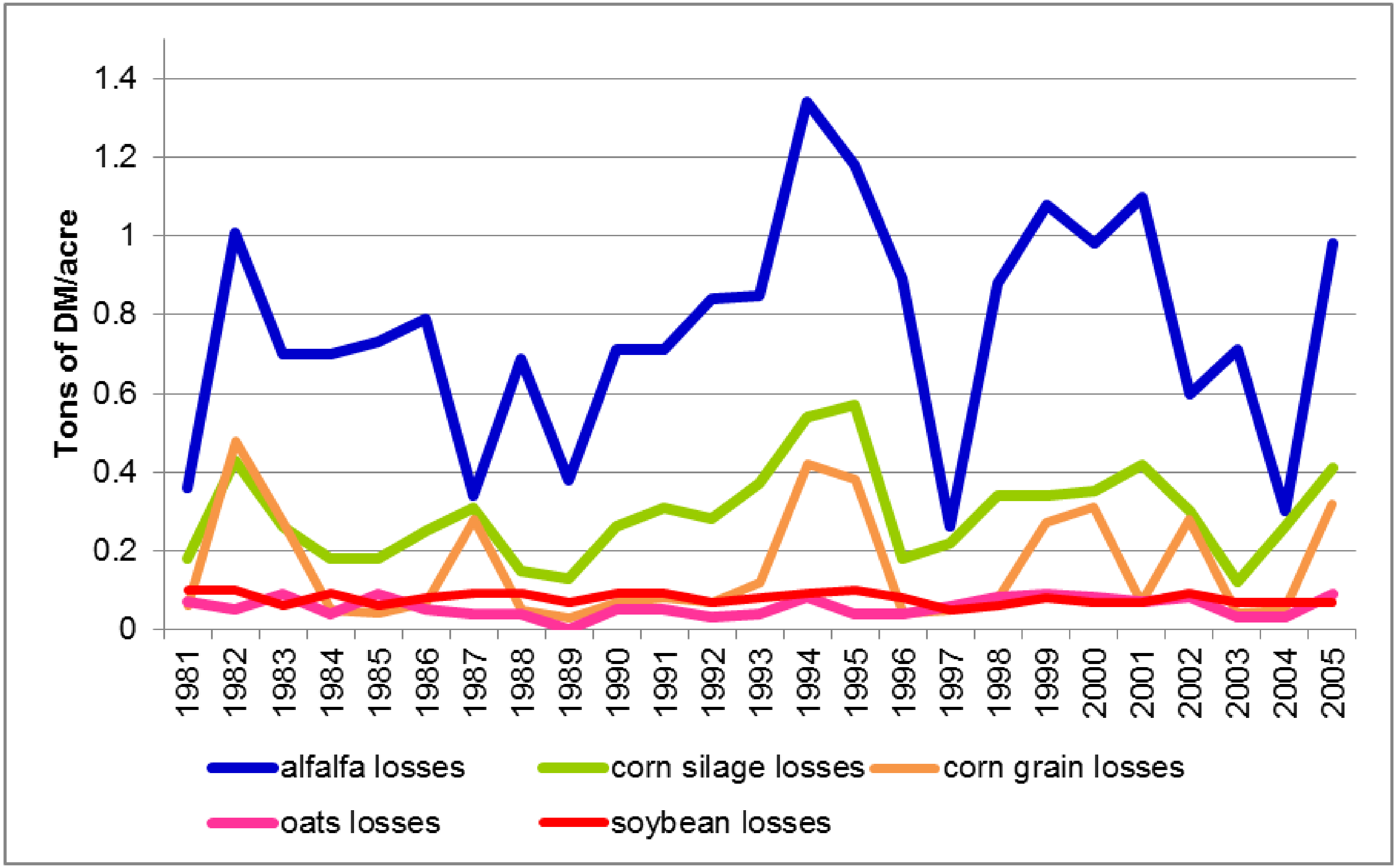
# CROP PRODUCTION



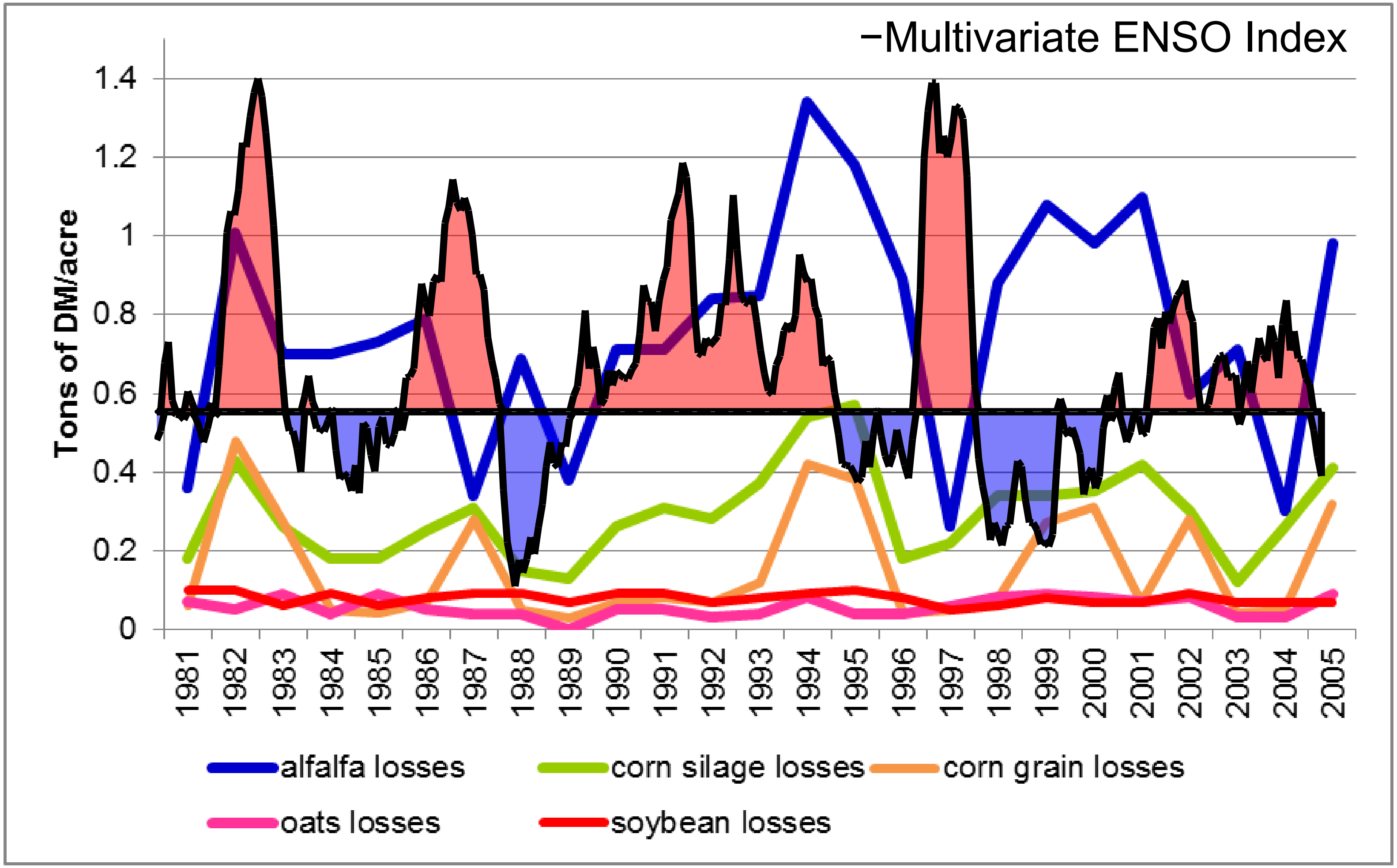
# CROP PRODUCTION & ENSO



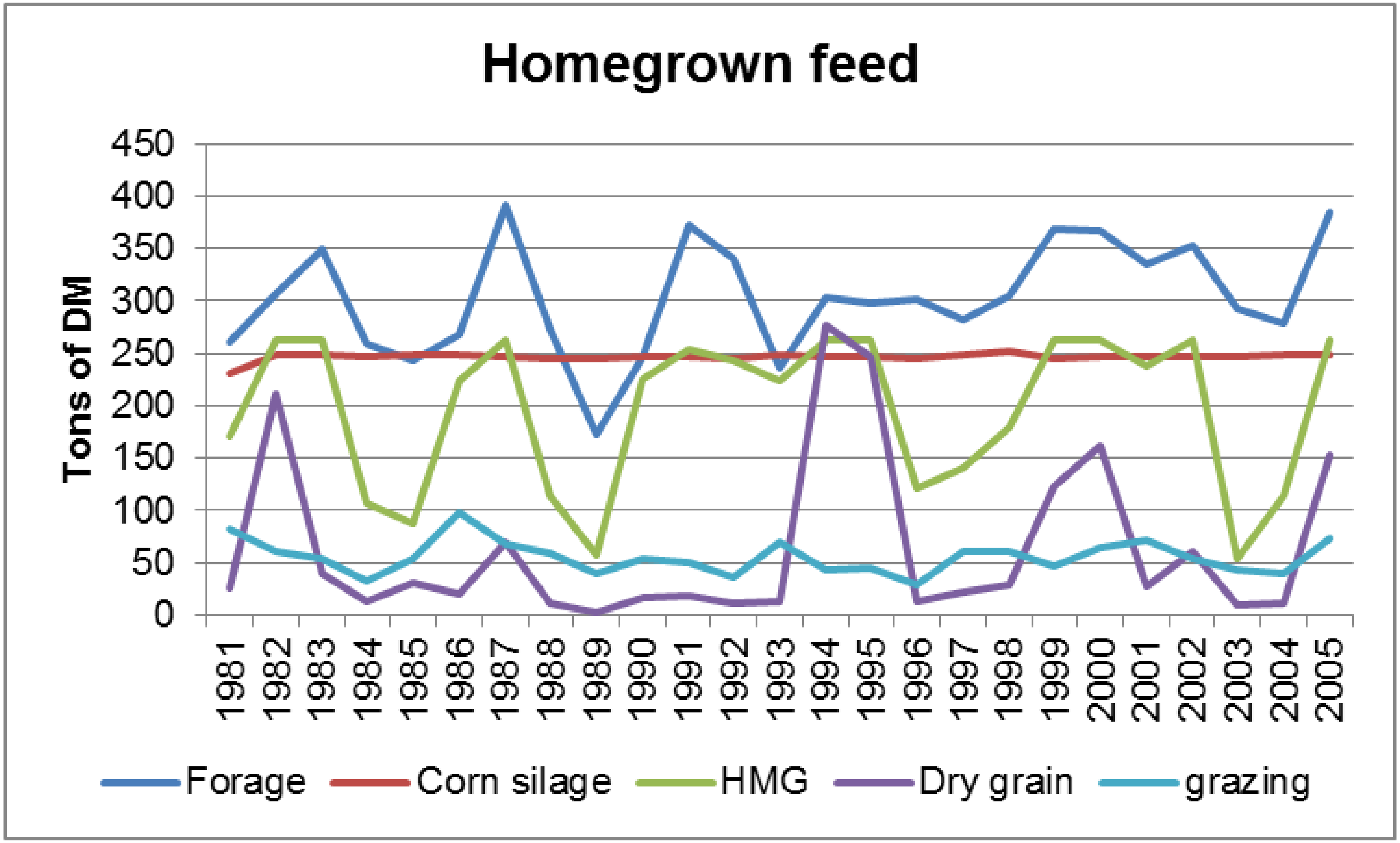
# LOSSES AFTER HARVEST



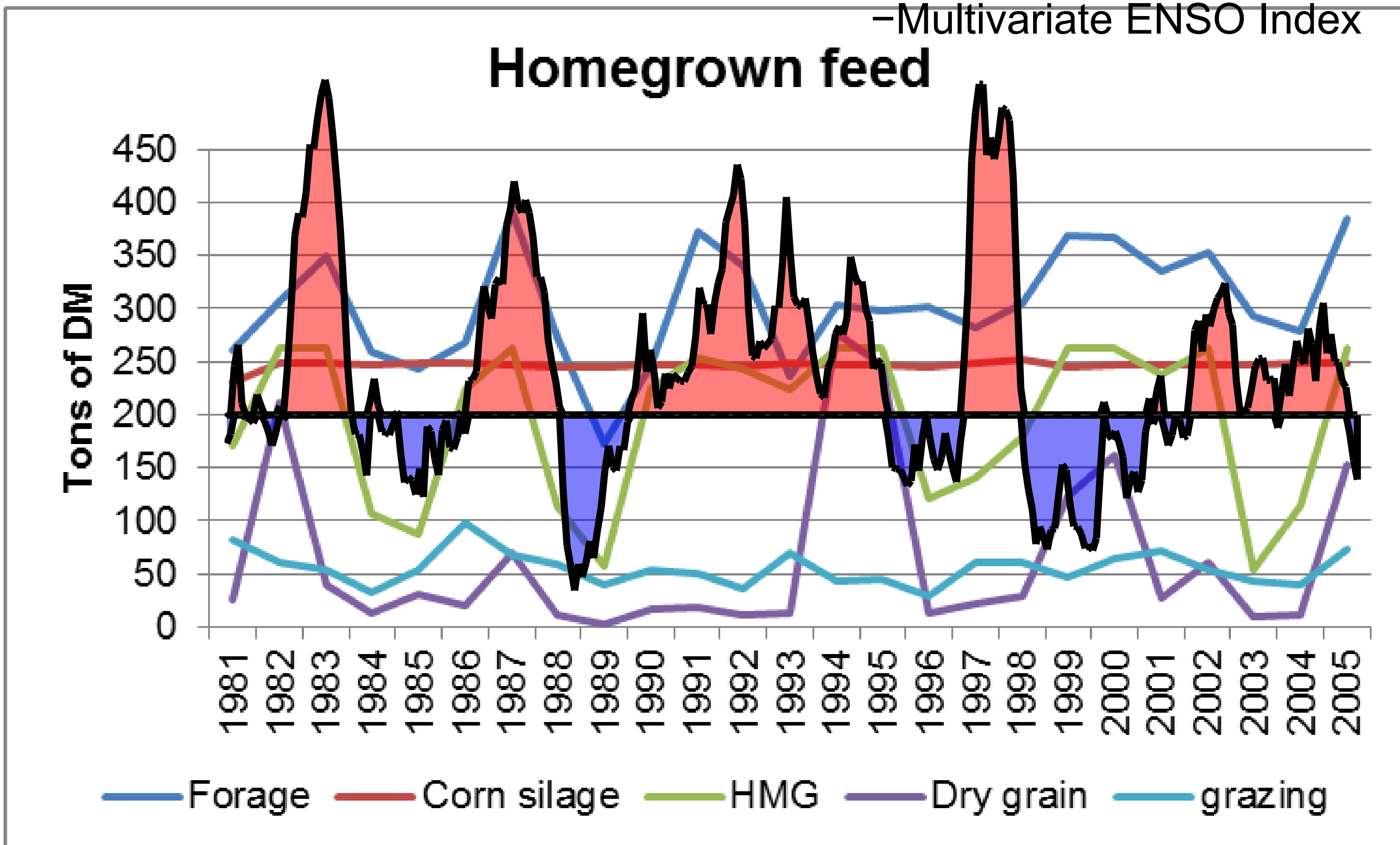
# HARVEST LOSSES & ENSO



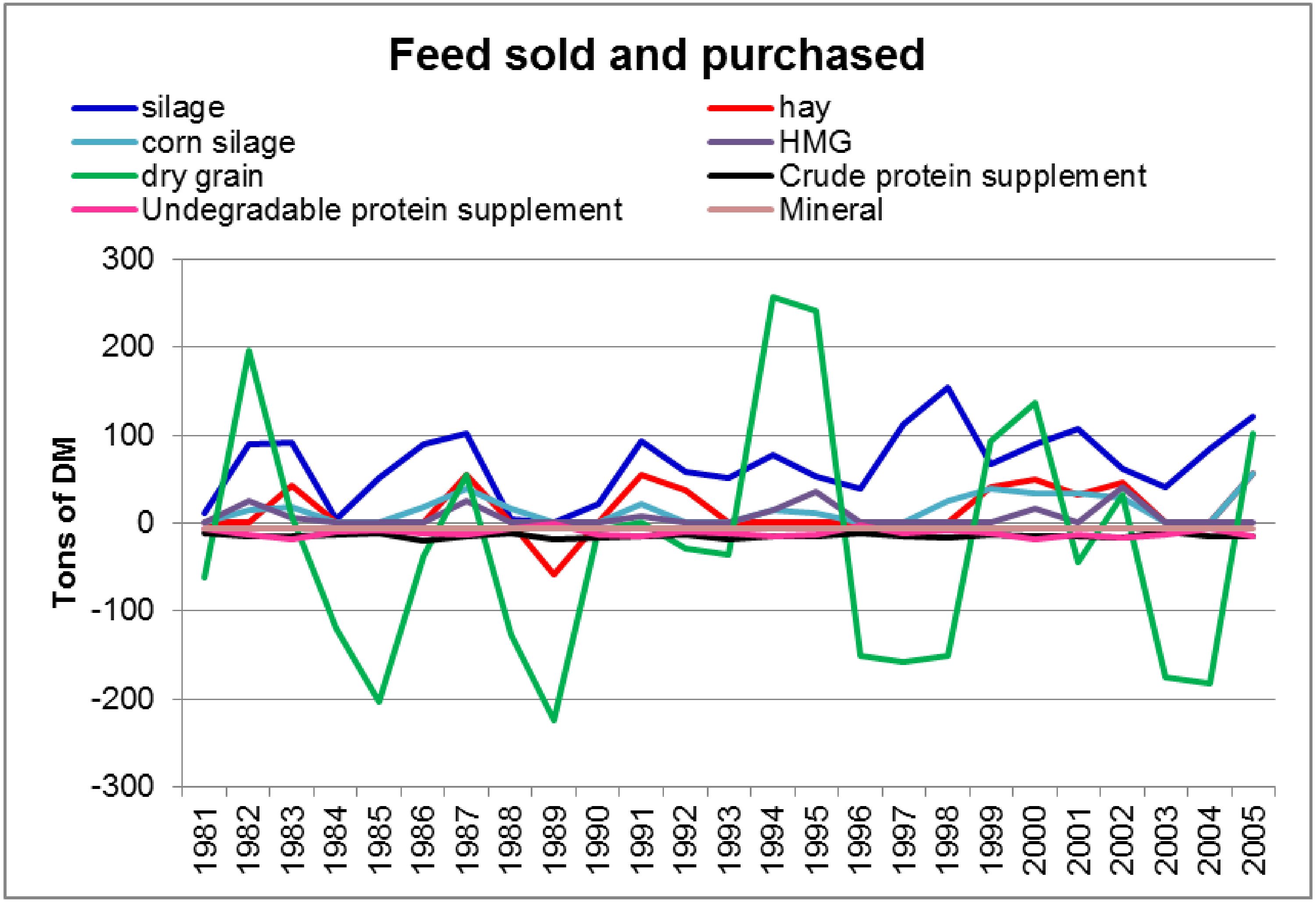
# DAIRY FEED PRODUCED



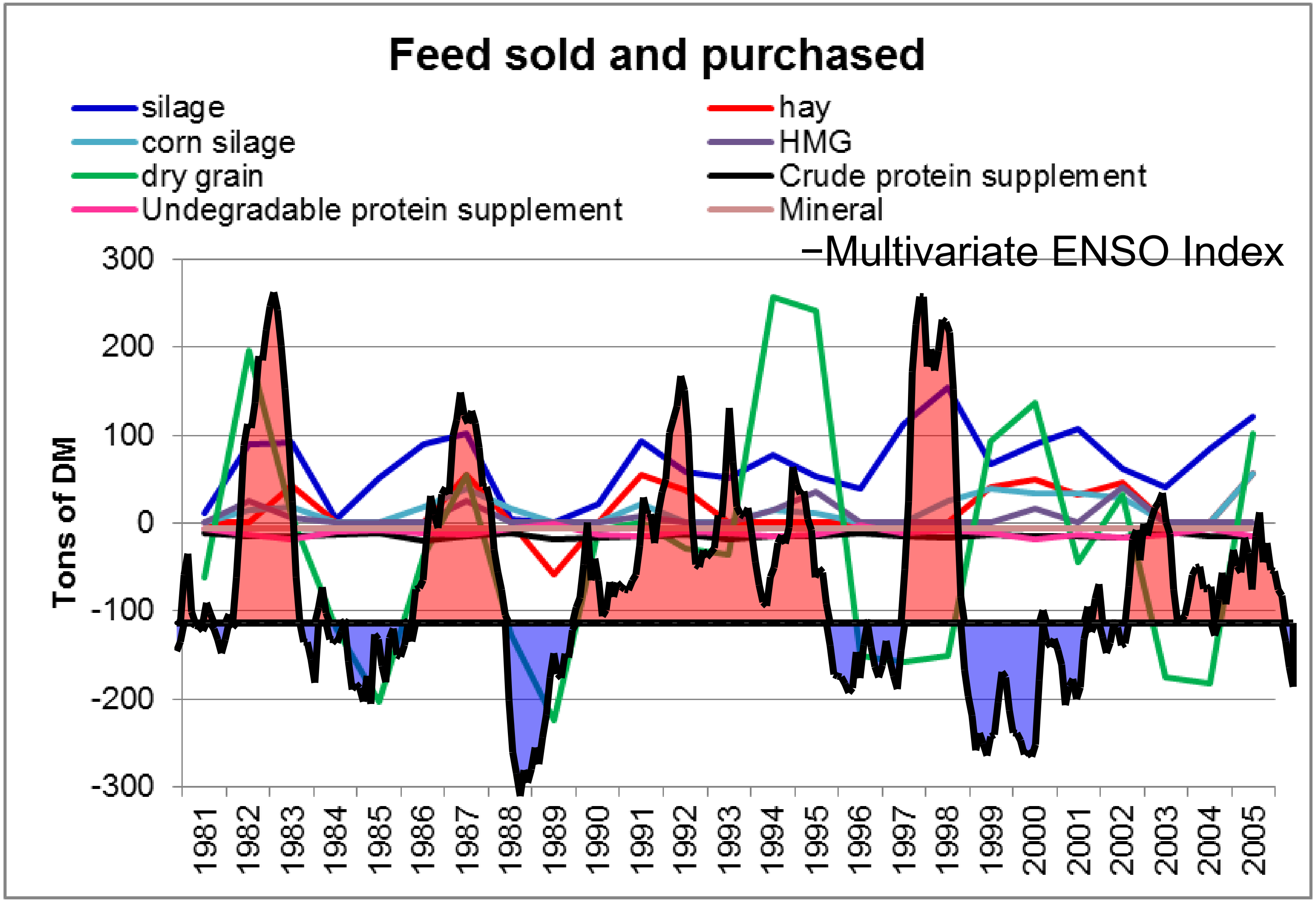
# DAIRY FEED & ENSO



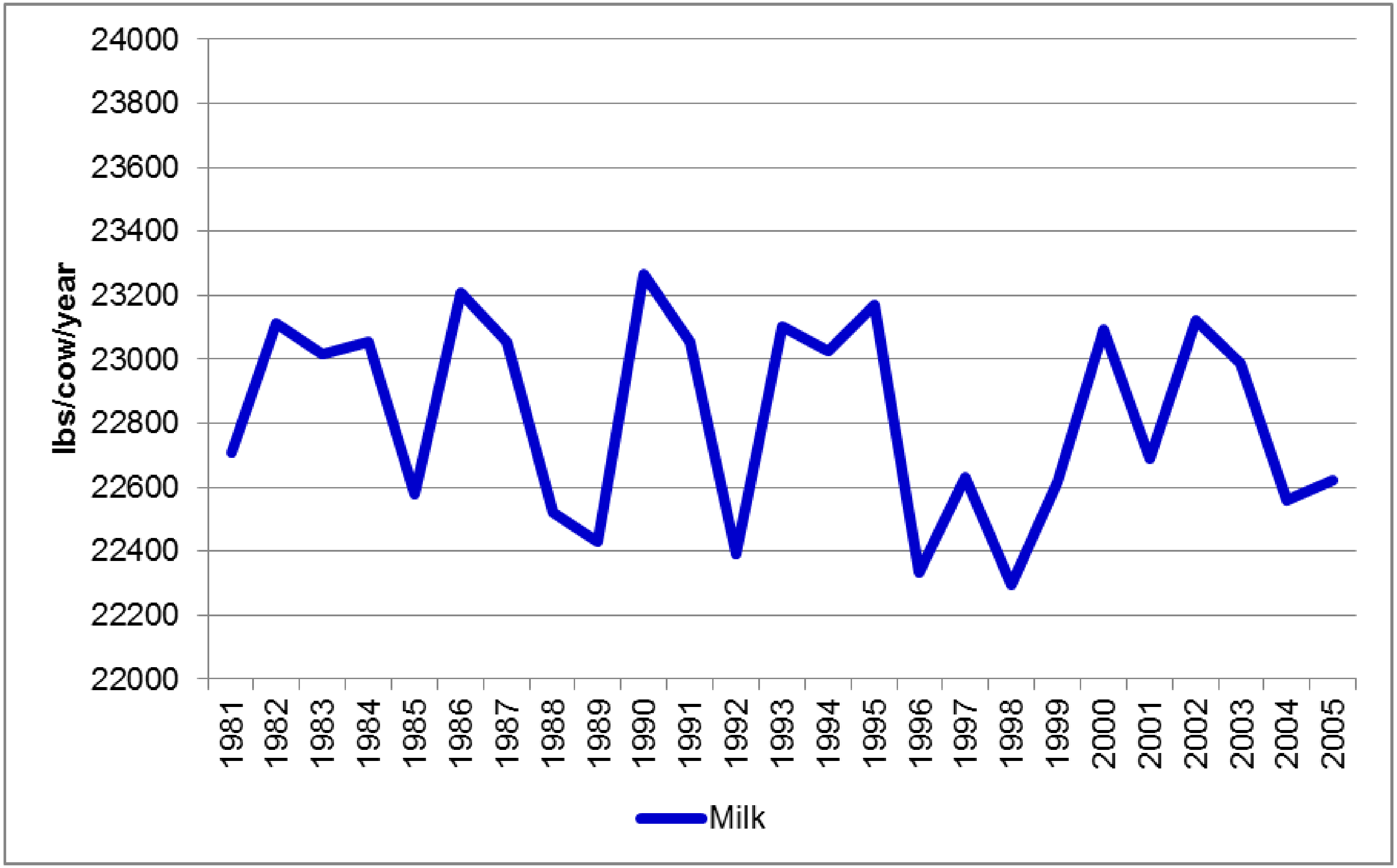
# FEED BALANCE



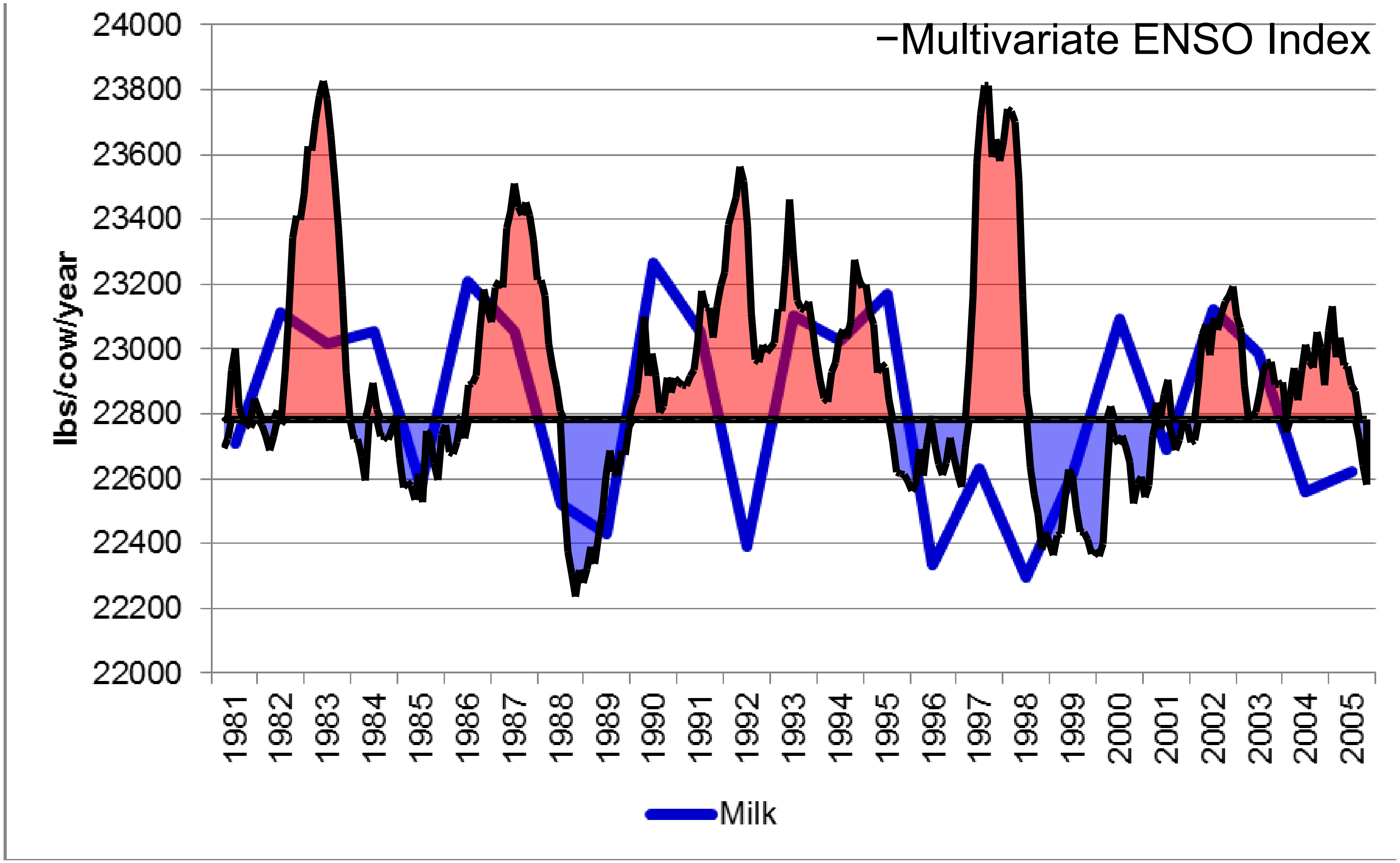
# FEED BALANCE & ENSO



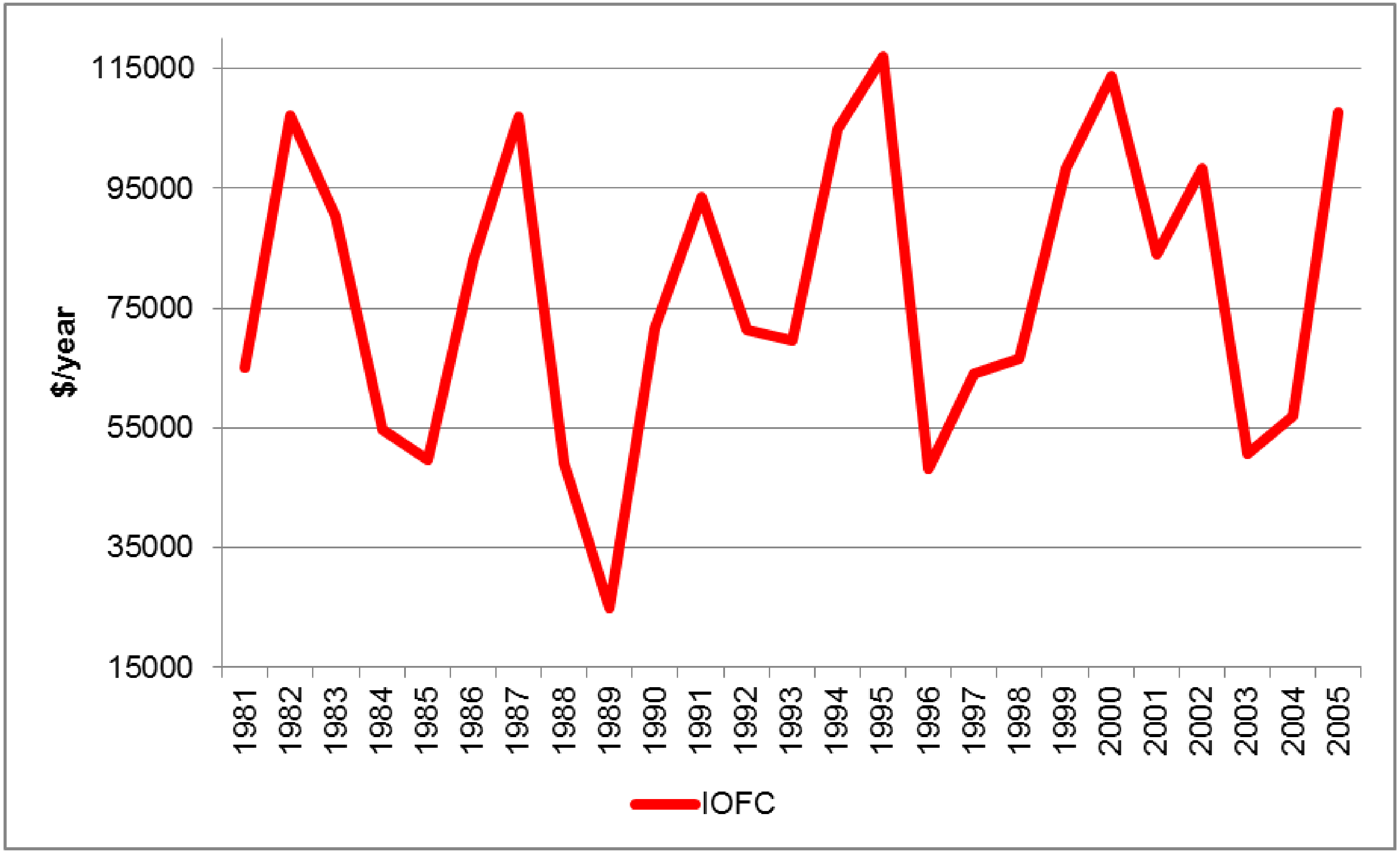
# MILK PODUCTION



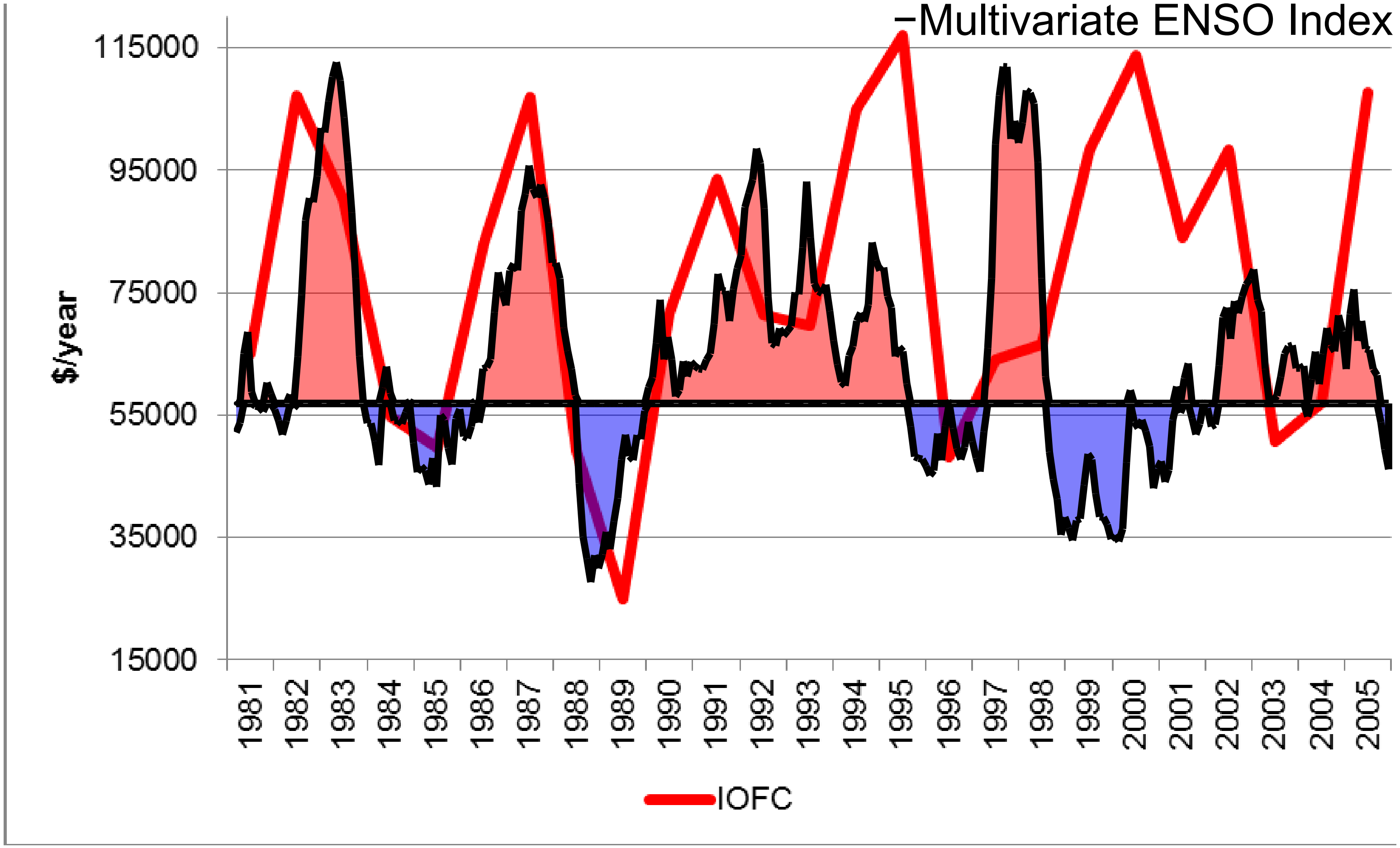
# MILK PRODUCTION & ENSO



# INCOME OVER FEED COST

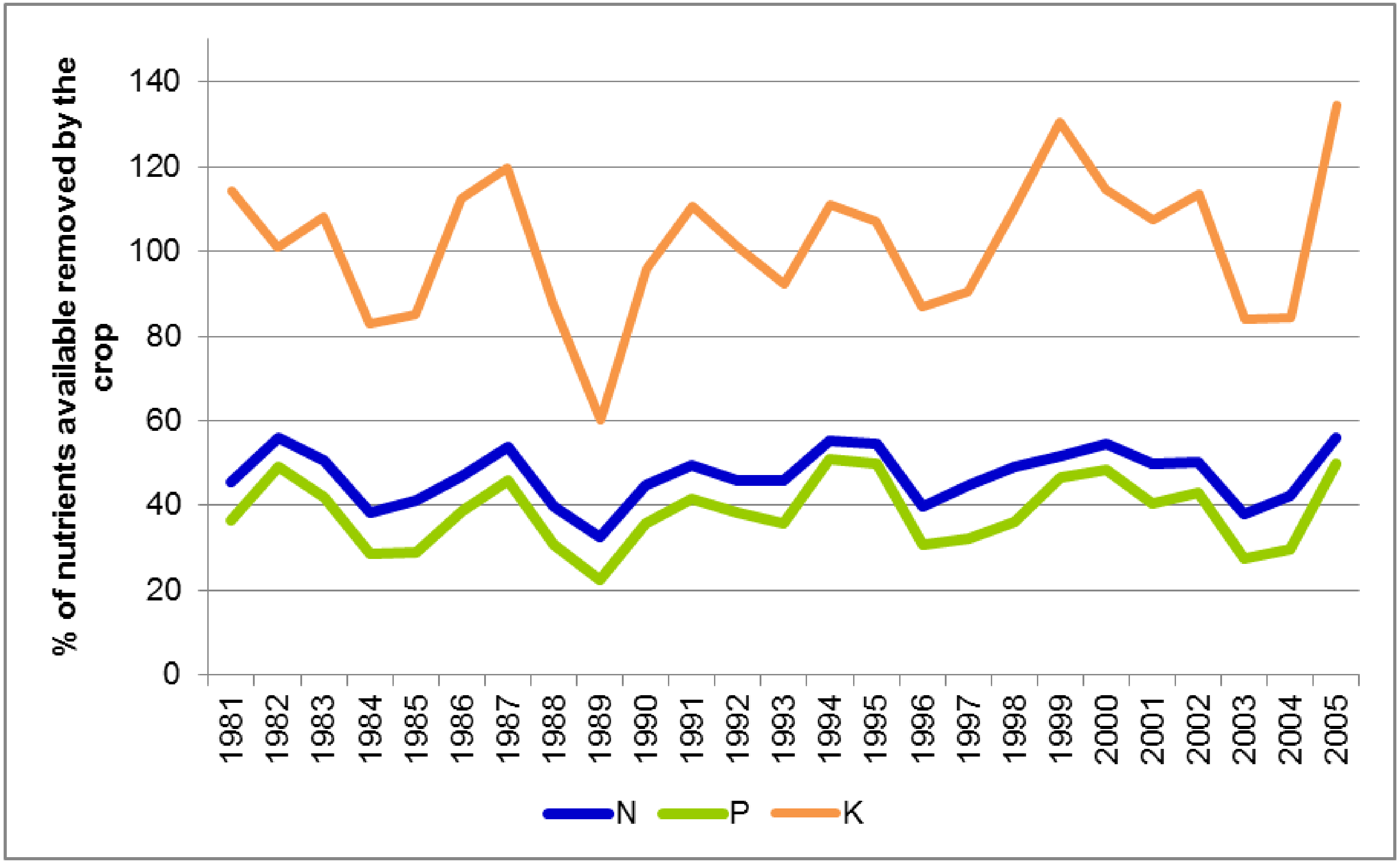


# IOFC & ENSO

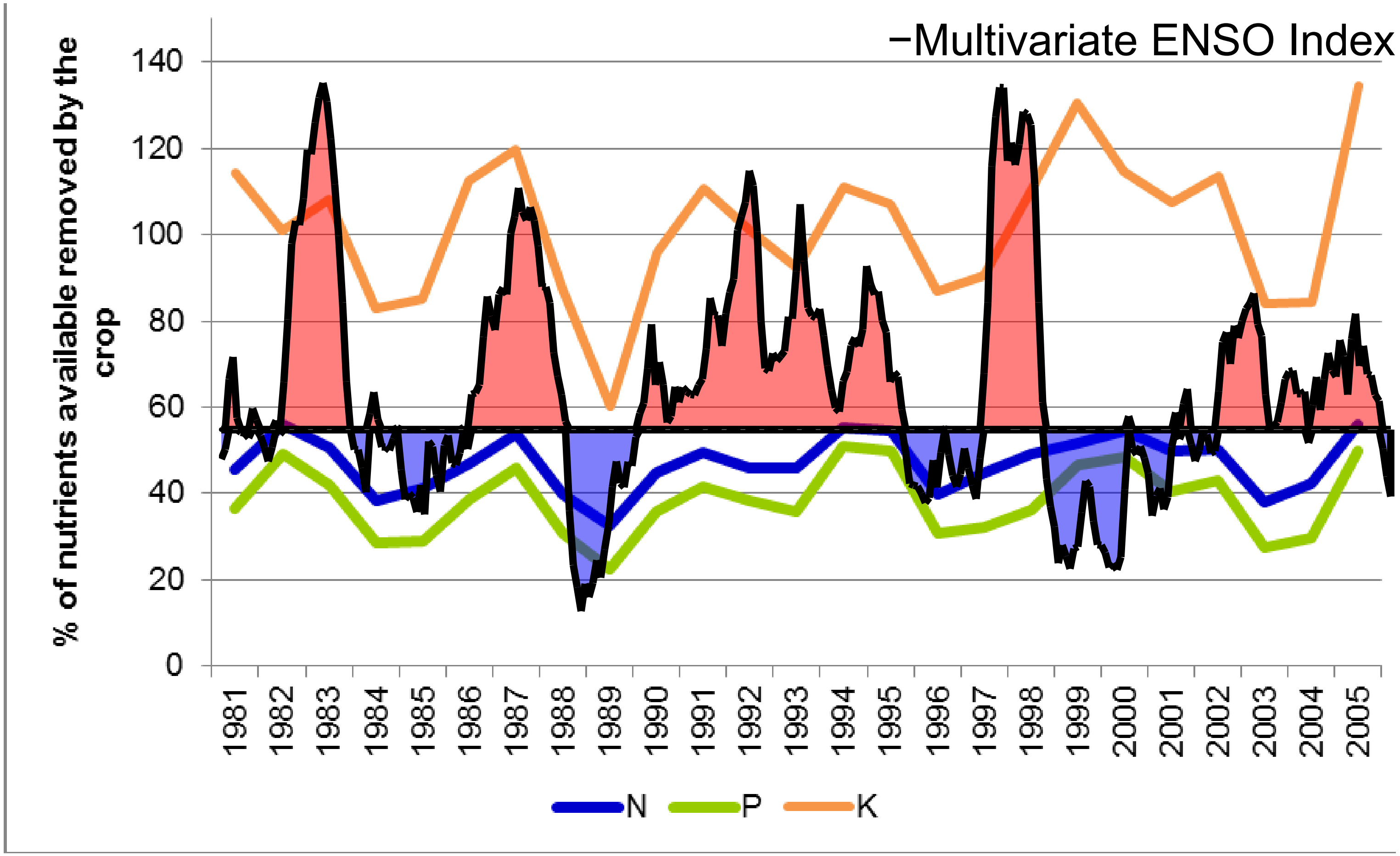


−Multivariate ENSO Index
115000
95000
75000
55000
35000
15000
$/year
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
IOFC

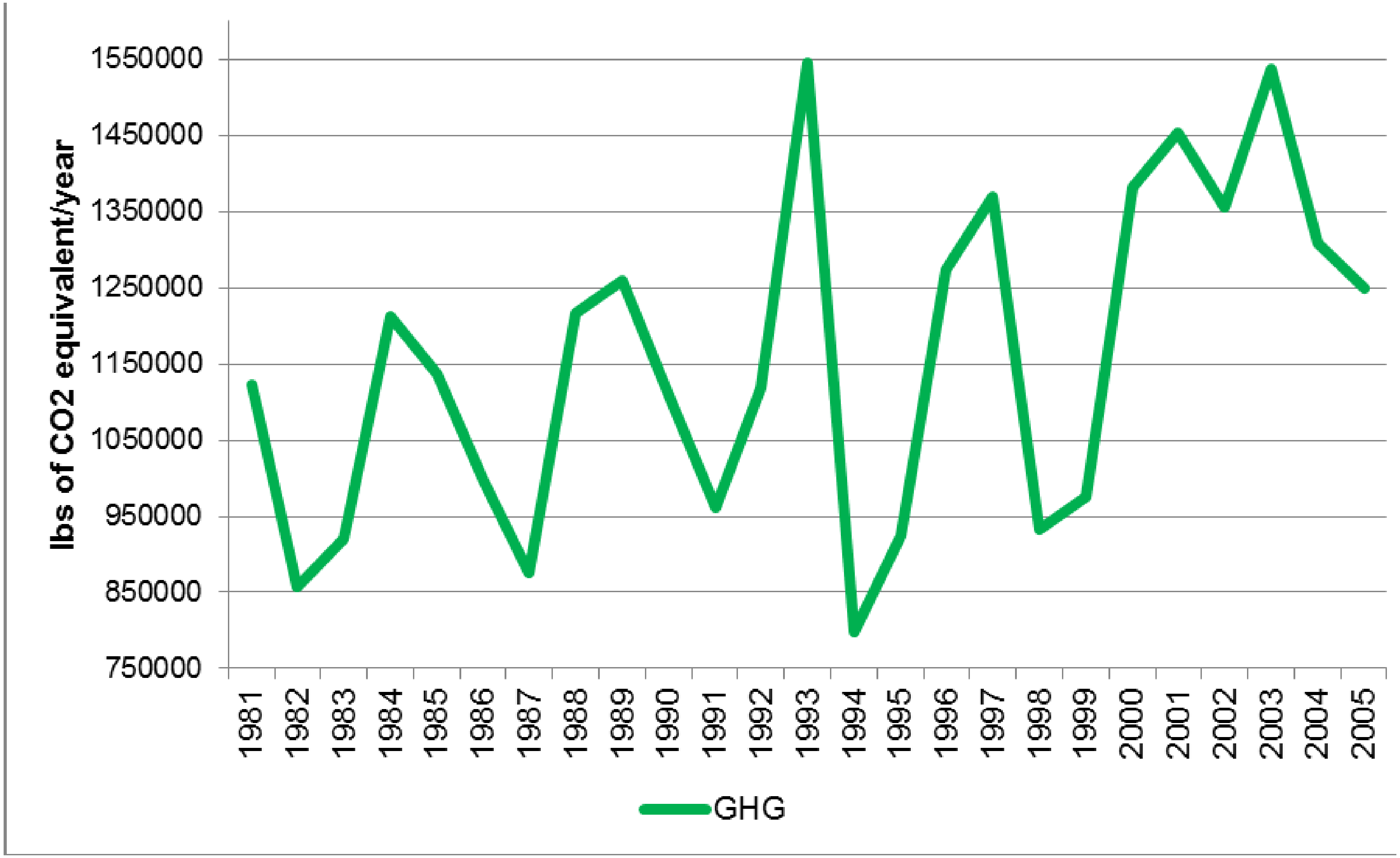
# NUTRIENT USE EFFICIENCY



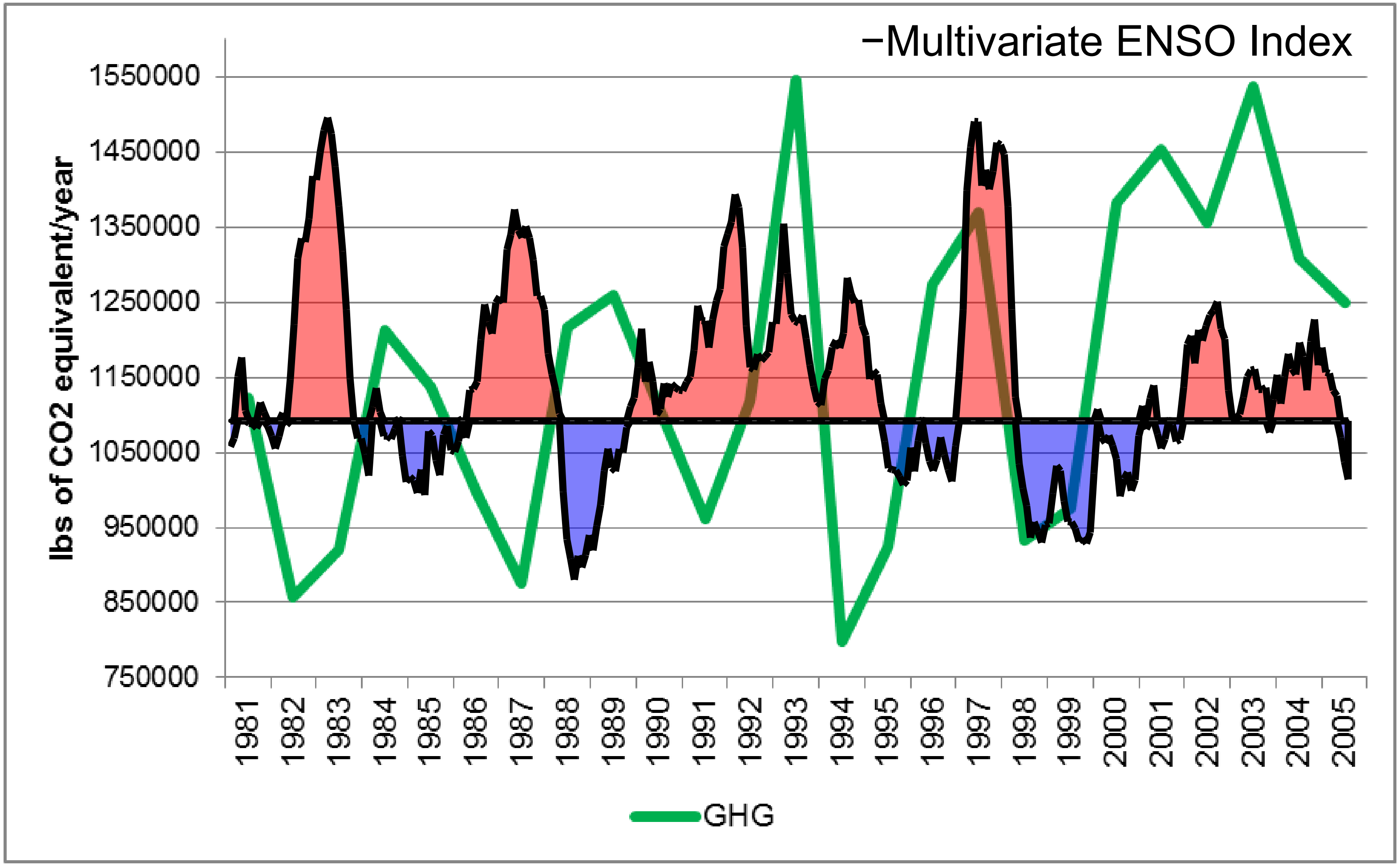
# NUTRIENT USE & ENSO



# GREEN HOUSE GAS



# GHG & ENSO



−Multivariate ENSO Index
lbs of CO2 equivalent/year
1550000
1450000
1350000
1250000
1150000
1050000
950000
850000
750000
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
GHG


Thanks
Victor E. Cabrera
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