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FarmAC model

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Training session 1

Schedule for day

09:00* – 10:00 Overview of the science behind FarmAC (Nick)

10:00 – 11:00 Using the model via the user interface (Ib).

11:00 – 12:00 The users use the two example farms implement their mitigation measures

13:30 – 14:00 Summing up of the experiences from the day
14:00 – 14:30 Preparation for next training session

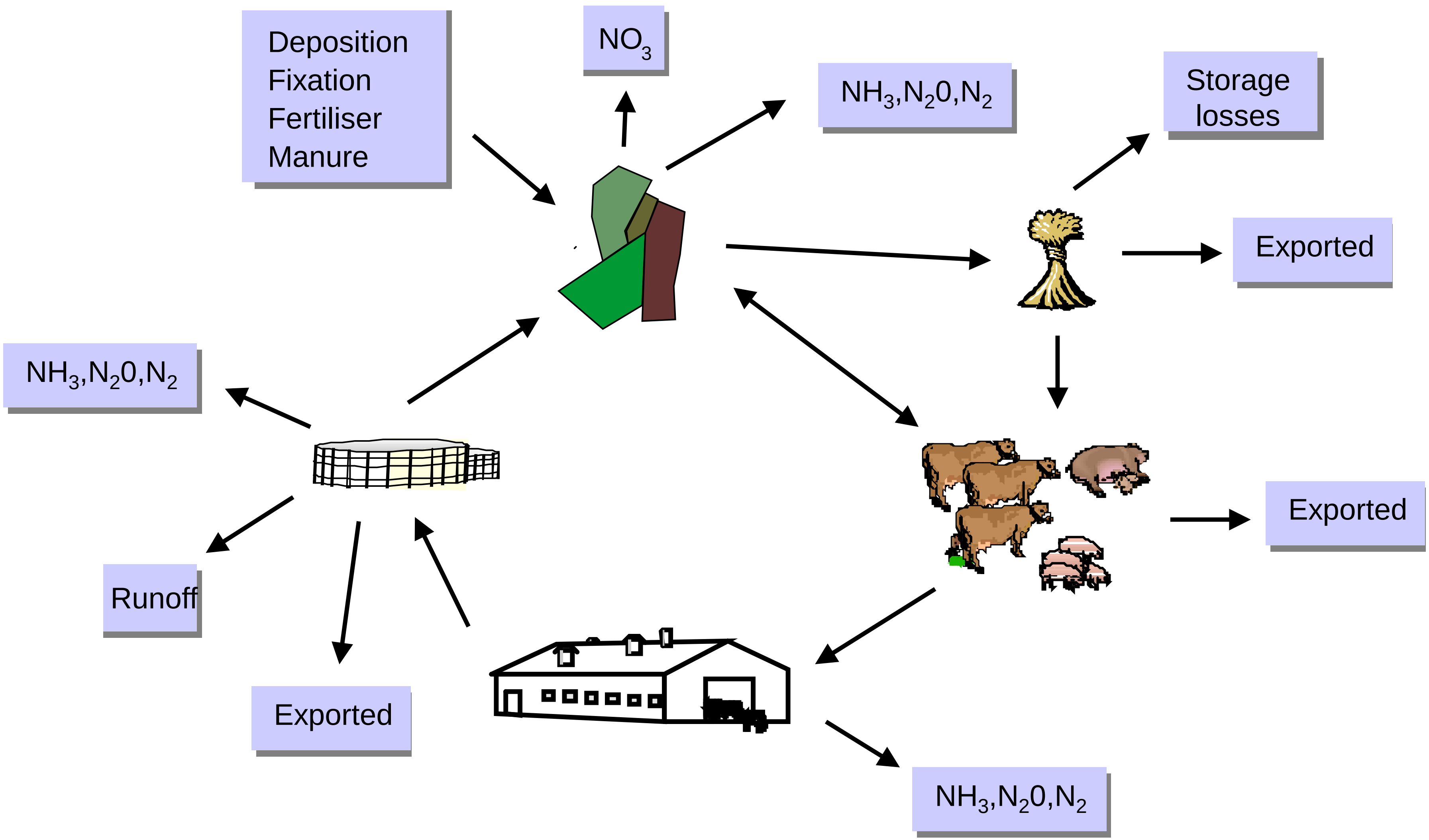
*Times are GMT

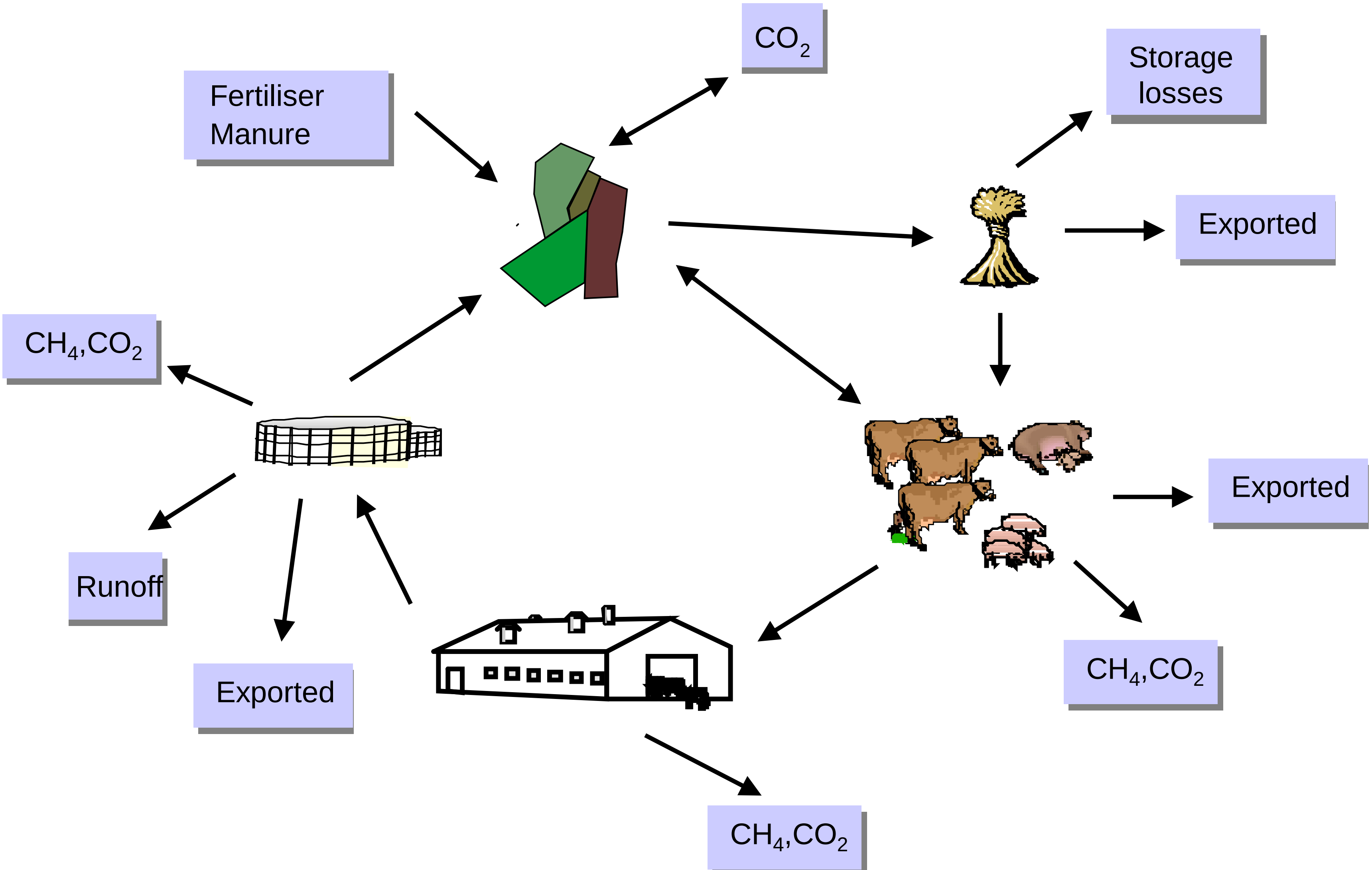
FarmAC model

- Focusses on livestock farming systems
  - Can be used for arable agriculture
- Intended to have wide applicability
- Simple enough that demand for inputs and parameters is manageable
- Complex enough to describe consequences of mitigation/adaptation measures
- Mass flow for C and N
  - Consistency between GHG and N emissions
  - Capture knock-on effects

Results from FarmAC

- N inputs, outputs and losses
- C inputs, outputs and losses
- Livestock and crop production
- Greenhouse gas (GHG) emissions
- Indicators


Deposition
Fixation
Fertiliser
Manure
NO_3
NH_3,N_20,N_2
Storage losses
Exported
NH_3,N_20,N_2
Exported
Runoff
Exported
NH_3,N_20,N_2

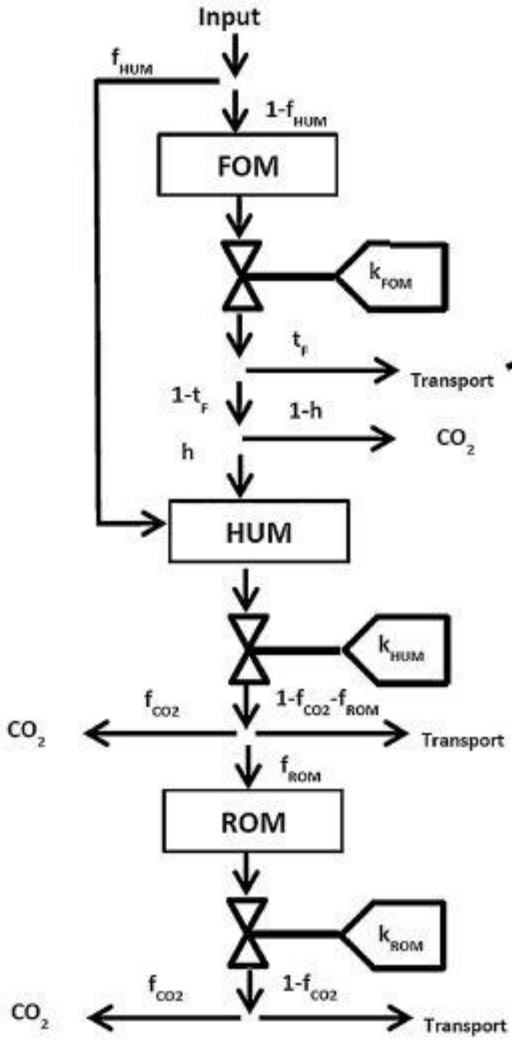

CO$_2$
Storage losses
Fertiliser
Manure
Exported
CH$_4$,CO$_2$
Exported
Runoff
CH$_4$,CO$_2$
Exported
CH$_4$,CO$_2$

Structure of presentation

- Soil organic matter dynamics
  - Complex – will consider briefly
- Arable farm (cereal cropping)
- Livestock
- Manure management
- Grazed grass

Soil organic matter

- Three types of soil carbon
- Fresh organic matter (FOM)
  - e.g. crop residues, decomposes in months
- Humus organic matter (HUM)
  - partially stabilised organic matter, decomposes in years
- Resistant organic matter (ROM)
  - very stable organic matter, decades/centuries
- Temperature and moisture effects


Input
f HUM
1-f HUM
FOM
k FOM
t F
Transport
1-t F
1-h
CO2
h
HUM
k HUM
f CO2
1-f CO2 -f ROM
CO2
Transport
f ROM
ROM
k ROM
f CO2
1-f CO2
CO2
Transport

Adaptation and Projection simulations

- Adaptation = simulate for many years to stablise soil model
- Projection = run model for 10-20 years to calculate results

Crop sequences

- Define for each crop
  - Crop products (e.g. grain, straw)
  - Start and end dates
  - rainfed or irrigated
- Bare soil is a ‘crop’
- No gaps in sequence
- Last day of last crop = first day of first crop -1

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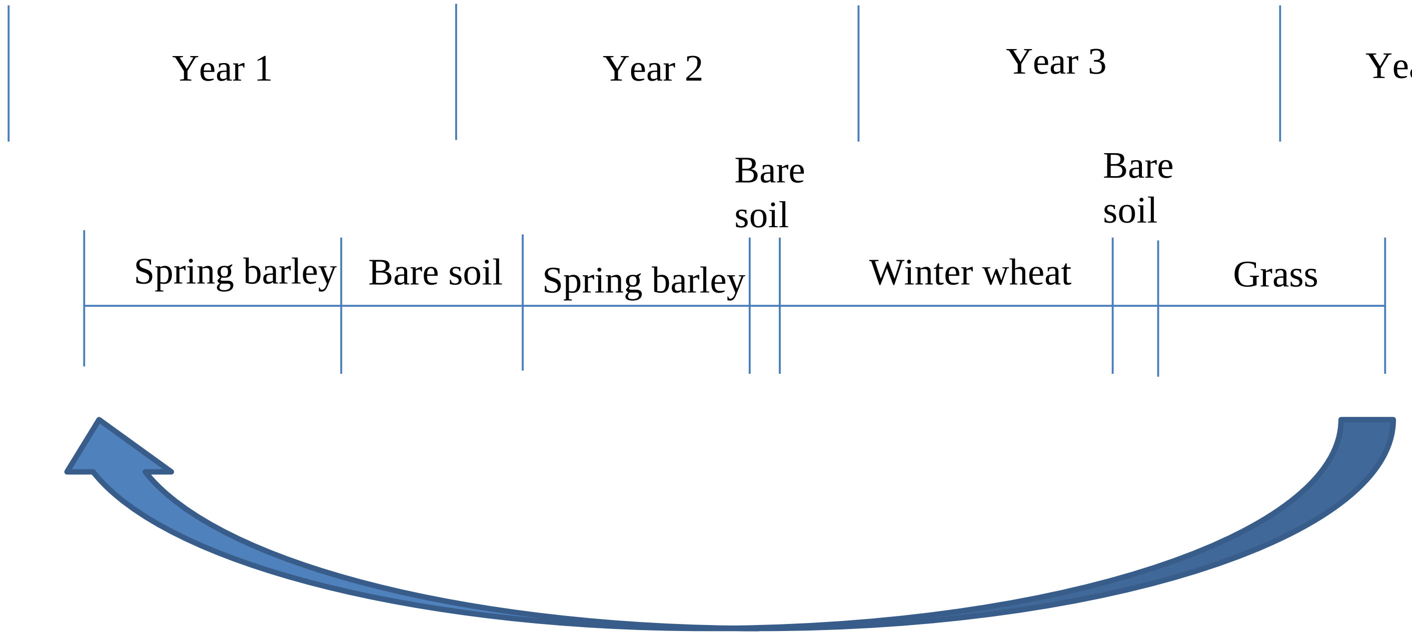
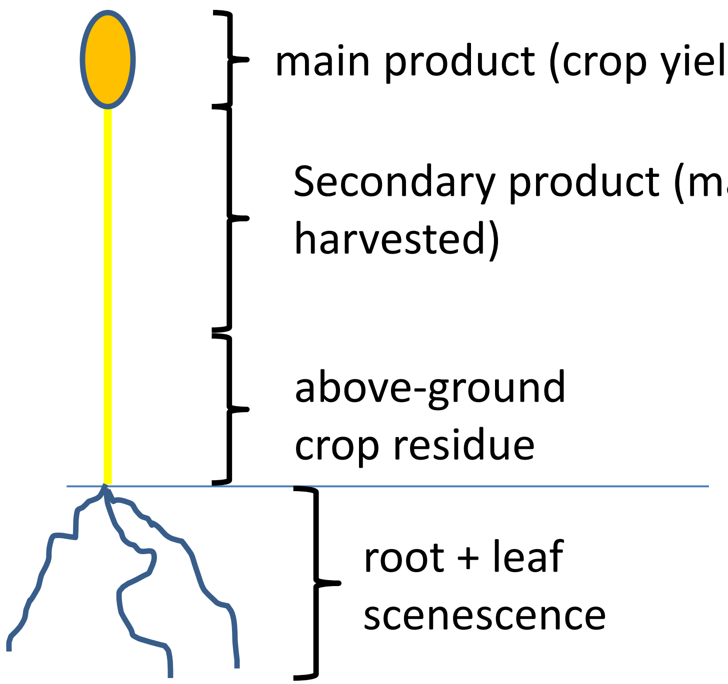


Crop products and residues



Yield modelling

- Potential yield (water and N unlimited)
  - for all crop products
  - input by users
- Calculate water-limited yield (soil water model)
- Calculate N uptake at water-limited yield
  - includes N in above and below-ground crop residues
- Calculate mineral N available
- Mineral N or maximum uptake determines yield
- Assume sufficient P and other nutrients

Calculating mineral N available (1)

- Mineral N available = mineral N input - losses
- N inputs
  - atmosphere
  - N fixation
  - fertiliser
  - manure
  - urine
  - mineralised soil, manure organic N, dung and crop residue N
- Does not distinguish between ammonium and nitrate

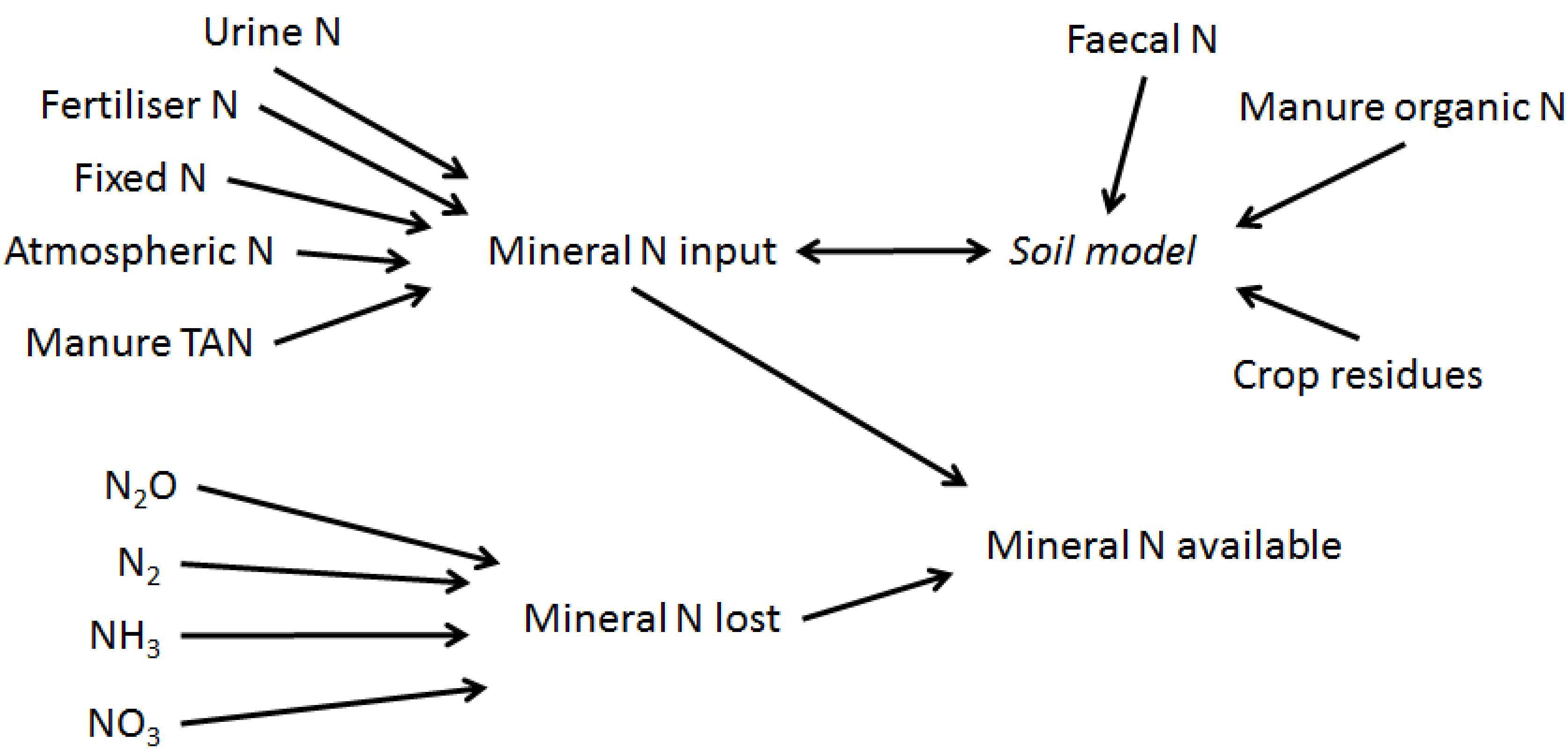
N fixation

- Calculate maximum N yield
- Calculate mineral N supply (fertiliser, manure, soil mineralisation etc)
- N fixation = NfixationFactor * (max N yield – mineral N supply)

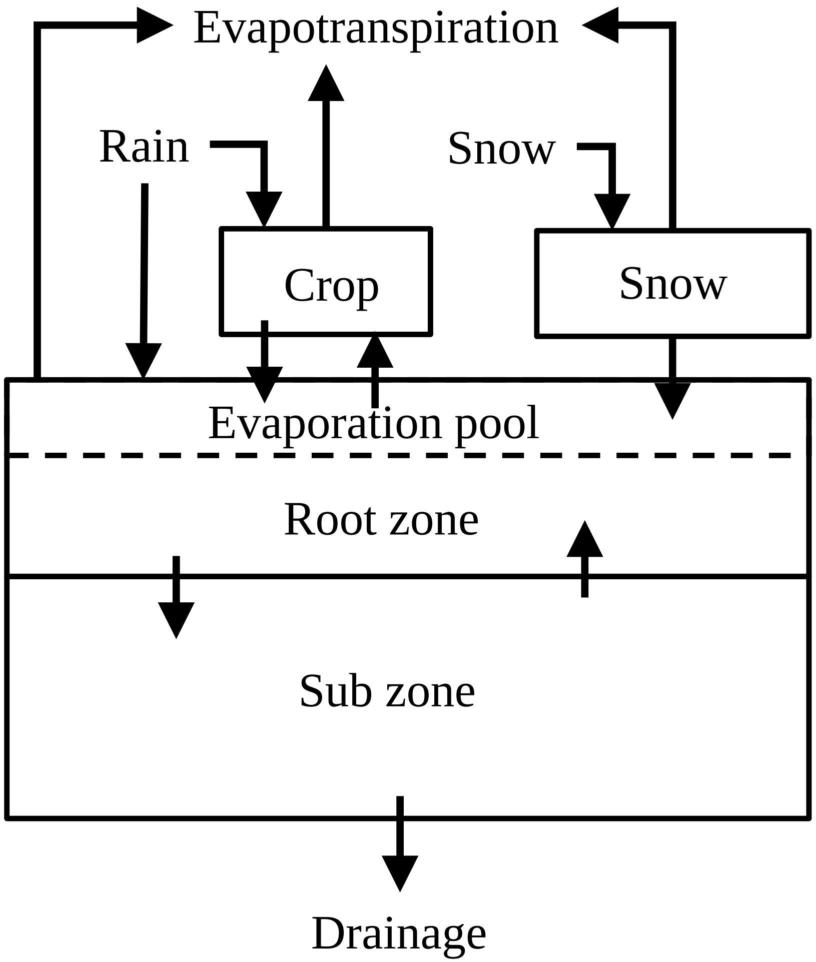
Calculating mineral N available (2)

- N outputs
  - Ammonia emission, which varies between
    - fertiliser, manure, urine
    - application method
  - N_2O and N_2 emission
    - N_2O via emission factor (varies between sources)
    - $N_2 = N_2O * \text{factor}$
  - N leaching is determined by soil water model

Mineral N available



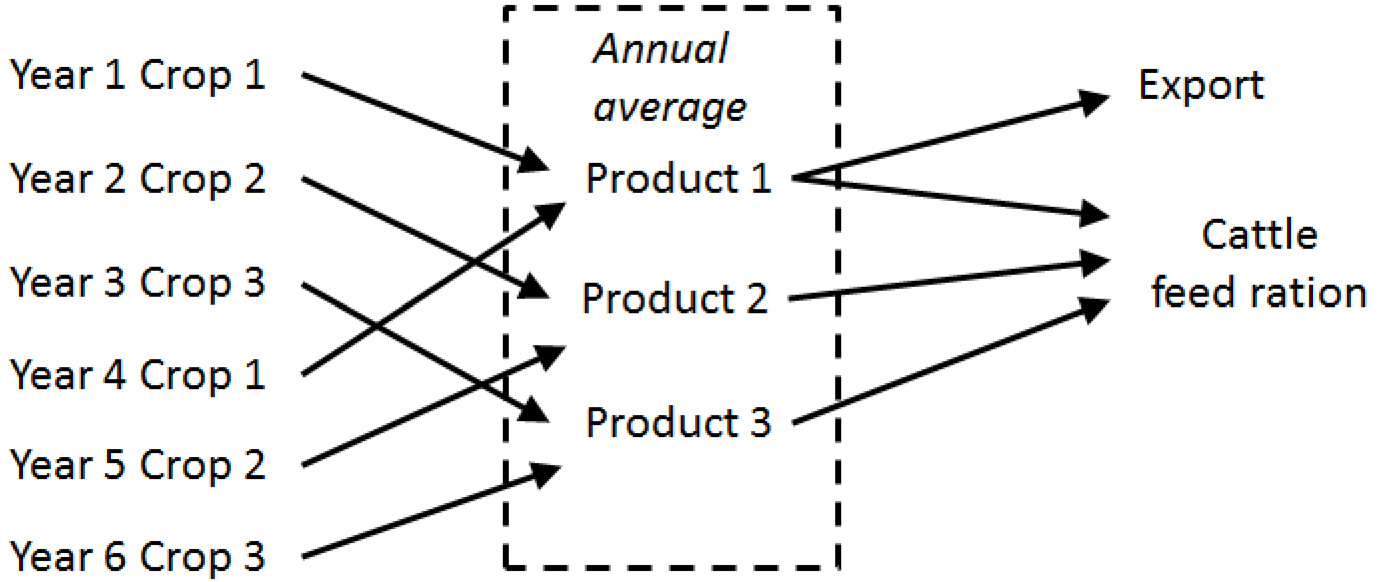
Soil water model



Processing/storage losses

- Losses will occur from crop products that are harvested and stored
  - cut but not collected
  - losses during processing (especially silage making)
- Losses are subtracted prior to becoming available for feeding or export

Crop production is averaged



Livestock (ruminants)

- Numbers are entered as average annual population
- Important to include seasonal diets
  - e.g. dairy cattle (crop growing season), dairy cattle (winter/drought)

Annual averaged population (AAP)

- AAP ≡ 365 feeding days ≡ results of a census
- Example 1:
  - Census finds an average of 1 beef calf, aged 6 months to 1 year (AAP = 1)
  - Feeding days = 183.25 = 0.5 year
  - Production = 2 beef calves per year

Annual averaged population (AAP)

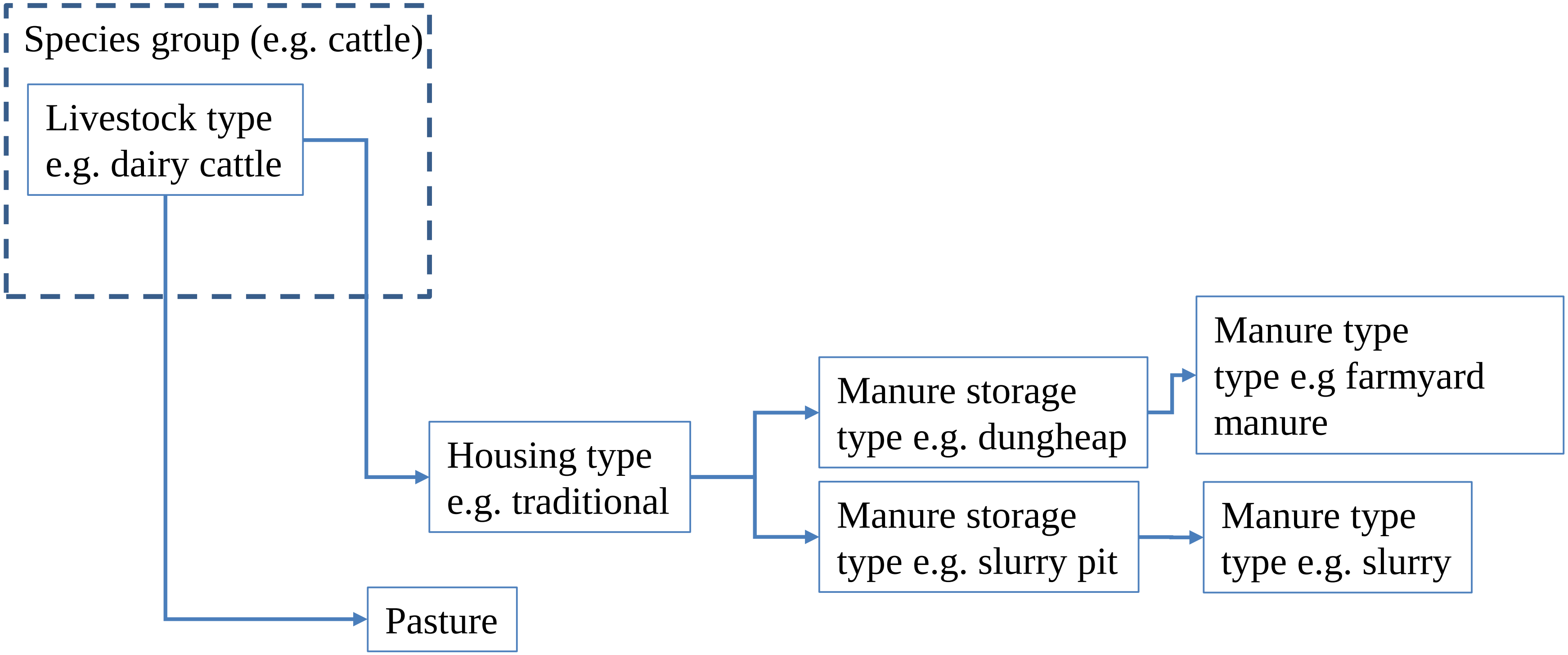
- Example 2:
  - 10 dairy cattle grazed for 6 months, housed for 6 months
  - Define 5 cattle with grazing diet
  - Define 5 cattle with housed diet

Feed ration and production

- Feed ration is input (feed items = crop products)
- Energy partitioning
  - Energy intake calculated
  - Energy partitioned between maintenance, growth and milk production
- Protein to faeces calculated using RedNex* equation
  - Remainder partitioned to production
  - Protein availability may limit production
- Does not currently account for walking/climbing

* RedNex - http://www.rednex-fp7.eu/

Manure management



Livestock housing

- Housing = any place livestock are kept when not grazing
  - includes corrals, stock yards
- NH_3 emission = emission factor * manure TAN
- CO_2 emission = urine C
- C and N is added in feed waste and bedding
- Remaining C and N passes to manure storage

Manure storage

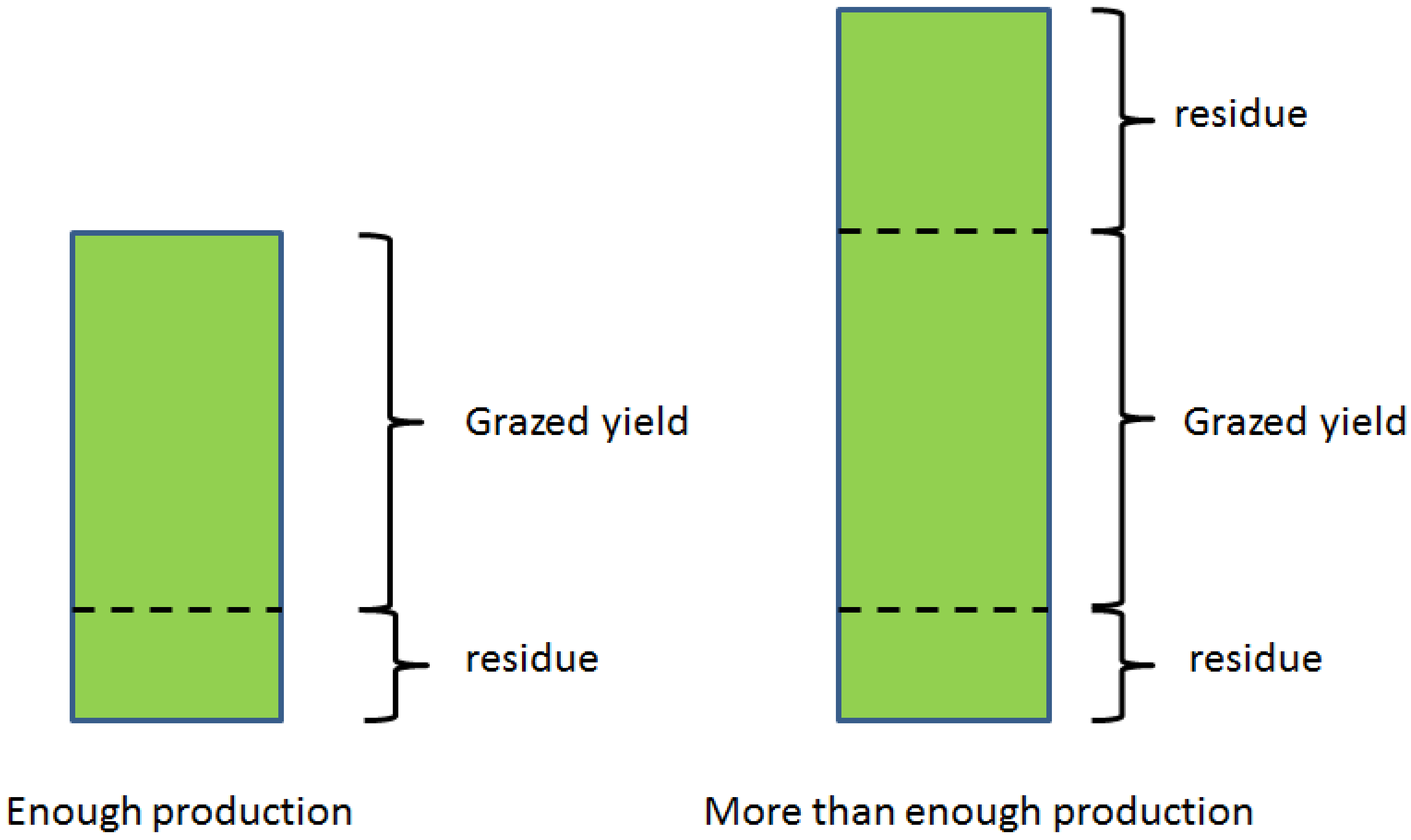
- NH_3 emission = emission factor * manure TAN
- N_2O emission = emission factor * total manure N
- N_2 emission = factor * N_2O emission
- Runoff/leakage TAN = factor * manure TAN
- Runoff/leakage organic N = factor * manure organic N
- Remaining C and N available for field application

Grazed crop products and excretion

- For crop products used as feed items for livestock
- Surplus = Production of crop product > livestock consumption
- Deficit = Production of crop product < livestock consumption
- For most crop products:
  - Surplus is exported from farm
  - Deficit is imported to farm
- Grazed crop products are an exception
  - Production must equal consumption

Grazed crop products

- Production of grazed products is specified at the scale of the crop
- If this production is not achieved, the model will report an error
- If this production is exceeded, the surplus production will be converted to crop residue


Grazed yield
residue
Enough production
residue
Grazed yield
residue
More than enough production