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1 APSIM Description

The Agricultural Production Systems sIMulator (APSIM) is a farming systems modelling framework that is being actively developed by the APSIM Initiative.

It is comprised of

1. a set of biophysical models that capture the science and management of the system being modelled,
2. a software framework that allows these models to be coupled together to facilitate data exchange between the models,
3. a set of input models that capture soil characteristics, climate variables, genotype information, field management etc,
4. a community of developers and users who work together, to share ideas, data and source code,
5. a data platform to enable this sharing and
6. a user interface to make it accessible to a broad range of users.

The literature contains numerous papers outlining the many uses of APSIM applied to diverse problem domains. In particular, Holzworth et al., 2014; Keating et al., 2003; McCown et al., 1996; McCown et al., 1995 have described earlier versions of APSIM in detail, outlining the key APSIM crop and soil process models and presented some examples of the capabilities of APSIM.

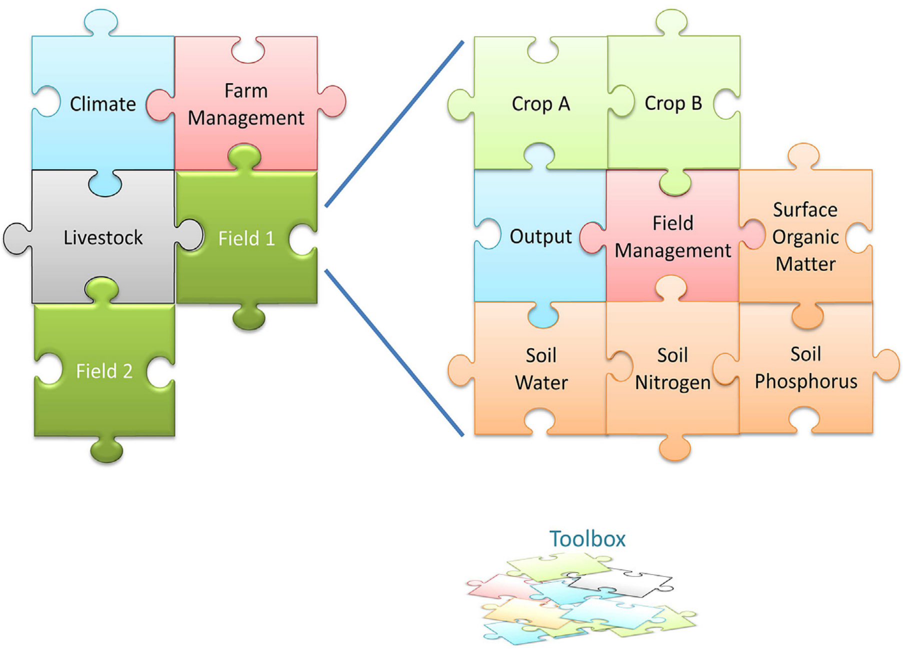


Figure 2: This conceptual representation of an APSIM simulation shows a “top level” farm (with climate, farm management and livestock) and two fields. The farm and each field are built from a combination of models found in the toolbox. The APSIM infrastructure connects all selected model pieces together to form a coherent simulation.*

The APSIM Initiative has begun developing a next generation of APSIM (APSIM Next Generation) that is written from scratch and designed to run natively on Windows, LINUX and MAC OSX. The new framework incorporates the best of the APSIM 7.x framework with an improved supporting framework. The Plant Modelling Framework (a generic collection of plant building blocks) was ported from the existing APSIM to bring a rapid development pathway for plant models. The user interface paradigm has been kept the same as the existing APSIM version, but completely rewritten to support new application domains and the newer Plant Modelling Framework. The ability to describe experiments has been added which can also be used for rapidly building factorials of simulations. The ability to write C# scripts to control farm and paddock management has been retained. Finally, all simulation outputs are written to an SQLite database to make it easier and quicker to query, filter and graph outputs.

The model described in this documentation is for APSIM Next Generation.

APSIM is freely available for non-commercial purposes. Non-commercial use of APSIM means public-good research & development and educational activities. It includes the support of policy development and/or implementation by, or on behalf of, government bodies and industry-good work where the research outcomes are to be made publicly available. For more information visit the licensing page on the APSIM web site

2 GrazPlan Stock

The STOCK component encapsulates the GRAZPLAN animal biology model, as described in [FREER1997].

The GrazPlan animal model technical description

Animals may be of different genotypes. In particular, sheep and cattle may be represented within a single STOCK instance.

Usually a single STOCK module is added to an AusFarm simulation, at the top level in the module hierarchy.

In a grazing system, however, there may be a variety of different classes of livestock. Animals may be of different genotypes (including both sheep and cattle); may be males, females or castrates; are likely to have a range of different ages; and females may be pregnant and/or lactating. The set of classes of livestock can change over time as animals enter or leave the system, are mated, give birth or are weaned. Further, animals that are otherwise similar may be placed in different paddocks, where their growth rates may differ.

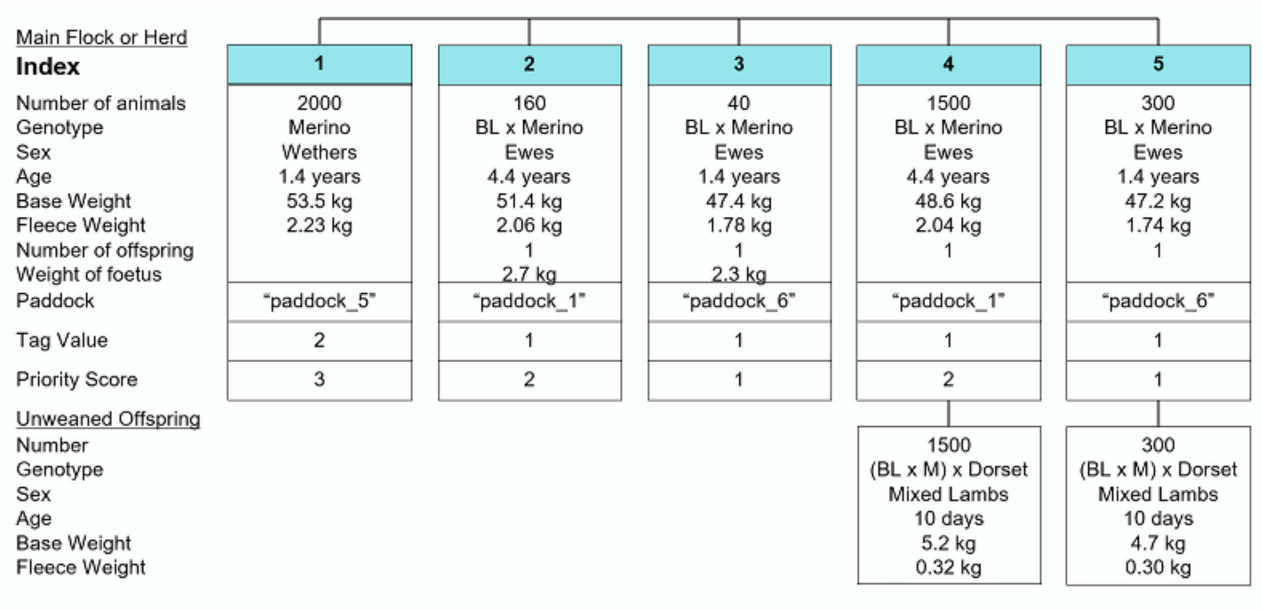


Figure 3: The list of animal groups at a particular time during a hypothetical simulation containing a STOCK module. Group 1 is distinct from the others because it has a different genotype and sex. Groups 2 and 3 are distinct because they are in different age classes (yearling vs mature). Groups 2 and 4 are distinct because they are in different reproductive states (pregnant vs lactating). Note how the unweaned lambs are associated with their mothers.

In the STOCK component, this complexity is handled by representing the set of animals in a simulated system as a list of animal groups (Figure 2.1). The members of each animal group have the same genotype and age class, but may have a range of ages (for example, an animal group containing mature animals may include four-year-old, five-year-old and six-year-old stock). The members of each animal group also have the same stage of pregnancy and/or lactation; the same number of suckling offspring; and occupy the same paddock.

The set of animal groups changes as animals enter and leave the simulation, and as physiological events such as maturation, mating, birth or weaning take place. Animal groups that become sufficiently similar are merged into a single group. The state of any unweaned lambs or calves is stored alongside that of their mothers; at weaning, the male and female weaners are transferred into two new animal groups within the main list.

In addition to the biological state variables that describe the animals, each animal group has four attributes that are of particular interest when writing management scripts.

Index

Each animal group has a unique, internally-assigned integer index, starting at 1. Because the set of groups present in a component instance is dynamic, the index number associated with a particular group of animals can – and usually does – change over time. This dynamic numbering scheme has consequences for the way that animals of a particular kind must be located when writing management scripts.

Paddock

Each animal group is also assigned a paddock. The forage and supplementary feed available to a group of animals are determined by the paddock it occupies. Paddocks are referred to by name in the STOCK component:

- To set the paddock occupied by an animal group, use the **Move** event.
- To determine the paddock occupied by an animal group, use the **Paddock** variable.

It is the user's responsibility to ensure that paddock names correspond to PADDOCK modules or other sources of necessary driving variables.

Tag Value

Each animal group also has a user-assigned tag value that takes an integer value. Tag values have two purposes:

- They can be used to manage distinct groups of animals in a common fashion. For example, all lactating ewes might be assigned the same tag value, and then all animals with this tag value might undergo the same supplementary feeding regime.
- If tag values are assigned sequentially (starting at 1), they can be used to generate summary variables. For example, **WeightTag[1]** gives the average live weight of all animals in groups with a tag value of 1.

Note that animal groups with different tag values are never merged, even if they are otherwise similar.

- To set the tag value of an animal group, use the **Tag** method.
- To determine the tag value of an animal group, use the **TagNo** variable.

Merging groups of similar animals

Animal groups that become sufficiently similar are merged into a single group. Animals are similar if all these are the same:

- Occupy the same paddock
- Reproduction status (Castrated, Male, Empty, Early Preg, Late Preg)
- Number of foetuses
- Mating cycle (day in the mating cycle)
- Days to mating (Days left in joining period)
- Pregnancy (Days since conception)
- Lactation status (Days since parturition (if lactating)) – within 7 days
- Has (not) young
- If young exist, their reproductive status must be the same
- Implants (hormone implants)
- Mean age (if the animals are less than one year old)

Encapsulates a parameter set for an animal.

3 Validation

This vignette describes the origins and development of the Stock Model validation dataset. A high-level overview of the Stock Model itself can be found in the memo under the Stock node.

The observed data set used for this validation simulation is based on publicly available data from New Zealand's Lincoln University Dairy Farm LUDF. The LUDF is a commercial demonstration dairy farm established in 2001 and operated by the South Island Dairying Development Centre (SIDDC) on behalf of Lincoln University to showcase sustainable and profitable dairy farming.

The LUDF is located at 1504 Shands Road, Lincoln (New Zealand; 43°38'S 172°26'E). The property is 186 ha of which 160 ha is the milking platform. The different soil types on the farm represent most of the common soil types in the surrounding Canterbury region. The farm operates in the top 2% of NZ dairy farms on profitability. The farm's targets and goals have varied over the years but in the 2019/20 season the target stocking rate was 3.5 cows/ha (peak milked), milk production of 1750 kg MS/ha (equivalent to 500kg MS/cow i.e. >100% liveweight in milk production), application of 160kg N/ha plus 300kg DM/cow imported supplement. Most cows are wintered off farm.

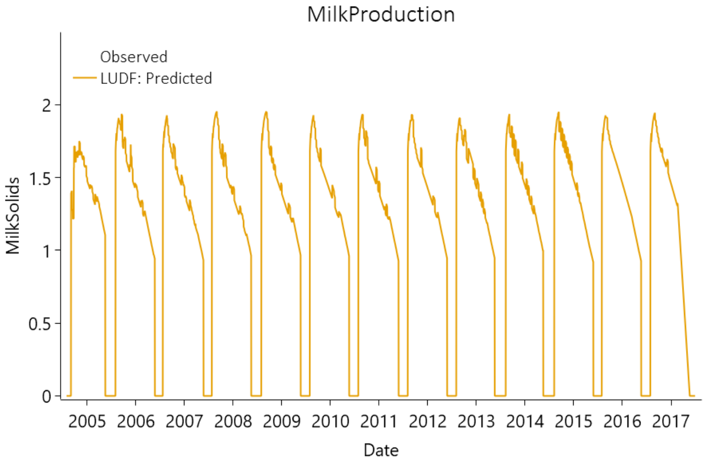
Average annual rainfall of 666 mm per annum is supplemented by an average irrigation input of 450 mm; average evapotranspiration for Lincoln is 870 mm/year. The milking platform was sown at conversion from a sheep operation (March 2001) in a mix of ryegrasses with white clovers, and a small amount of Timothy. The breed of cows at the LUDF are "KiwiCross" which was established as a separate breed in 2005 and is now New Zealand's most popular breed. In the 2019/20 season peak number of cows milked was 555 with the average days in milk of 282 days. The stocking rate of 3.5 cows/ha is equivalent to 1,665 kg liveweight/ha. In terms of feeding, in 2019/20 the cows ate 4.4 t DM/cow as pasture and 0.2 t DM/cow as supplement. Off-farm grazing was 0.7 t DM/cow giving a total feed intake of 5.4 t DM/cow.

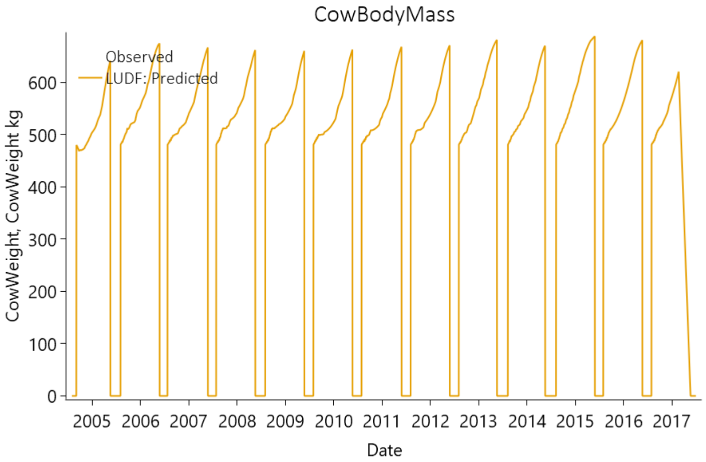
Weekly farm data from the LUDF is available at http://www.siddc.org.nz/lu-dairy-farm/weekly-data/ as PDF reports. The data for the years 2004 to 2017 was transcribed and collated to an Excel worksheet ("LUDFValidateData.xlsx"). There are two columns for pasture intake – that based on measured pasture disappearance i.e. the difference in pre- and post-grazing DM (column "CowPastureIntake") as well as that which takes into account the likely wastage of pasture during grazing ("CowPastureIntakeWaste"). Estimating this wastage event is difficult. In an investigation conducted at the LUDF, Pal et al., 2012 found that by direct measurement about 8% of the dry matter cows removed from the plants were not ingested (i.e. dropped to the ground). A similar wastage value was used in a DairyNZ feeding fact sheet for farmers: "The feed requirement figures are 'eaten' feed demand plus 6% to allow for feed wastage observed under good feeding conditions of pasture in farmlet trials." https://www.dairynz.co.nz/feed/nutrition/lactating-cows/; accessed June 2020. The DairyNZ value of 6% was obtained by farmlet measurements of pre- and post-grazing pasture mass and back calculations of live-weight and milk production (Chris Glassey, DairyNZ, June 2020, pers. comm.). Considering that the 6-8% wastage values are under ideal grazing conditions (which do not occur all the time), the "CowPastureIntakeWaste" column was calculated as 90% of "CowPastureIntake".

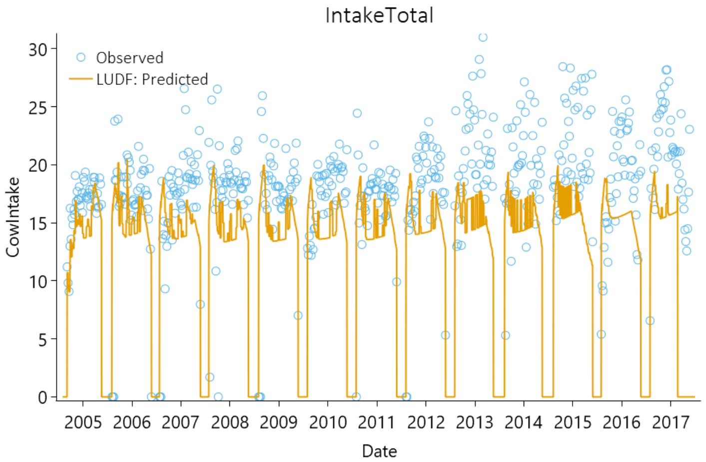
Acknowledgements

South Island Dairying Development Centre (SIDDC) and Lincoln University for making the dairy farm's production data available. Scott Rains, Samuel Dennis, Anna Taylor, Rogerio Cichota and Ronaldo Vibart for collating the LADF data when working at AgResearch. Ron Pellow (SIDDC) for comments on the collated data set. David Pacheco and Ronaldo Vibart (AgResearch) for further discussions about the data.

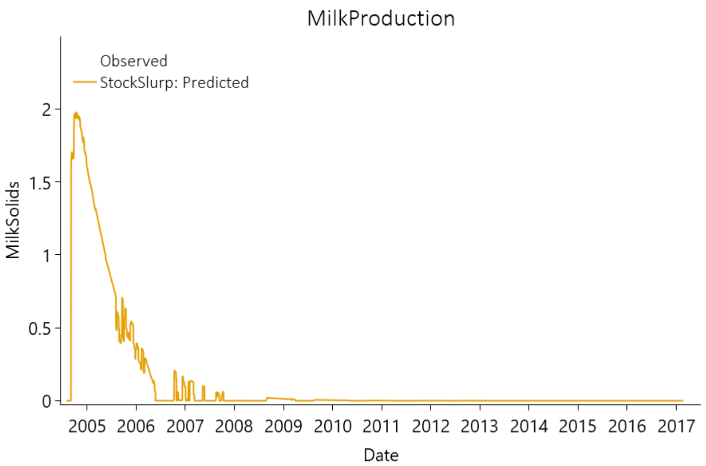
3.1 Validation Plots

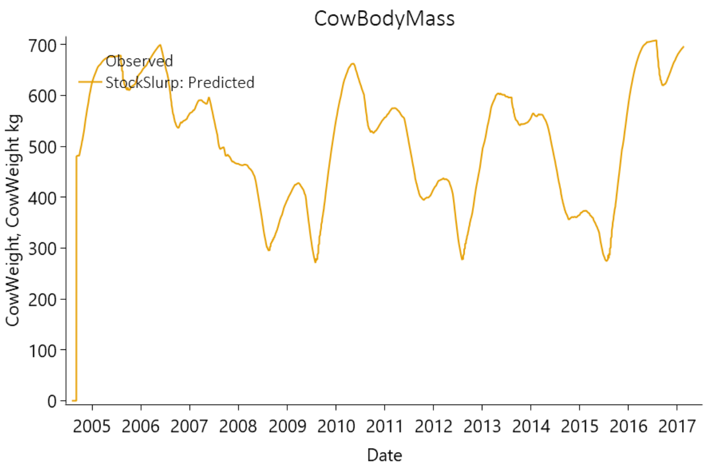


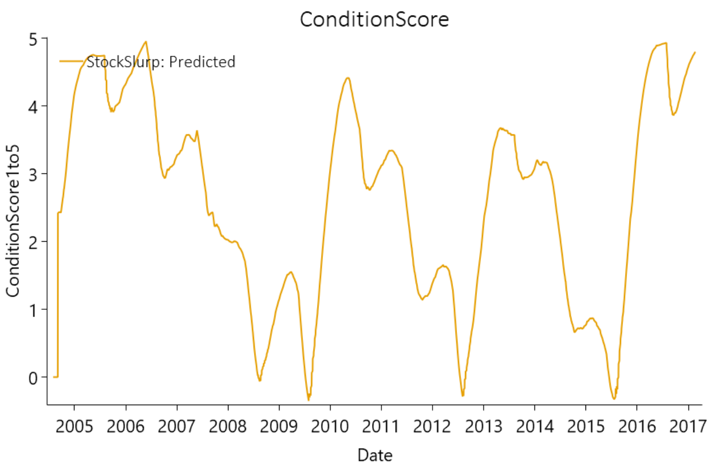


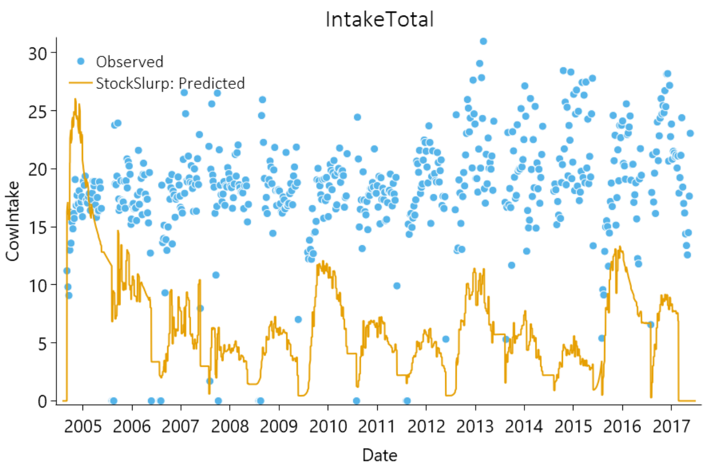


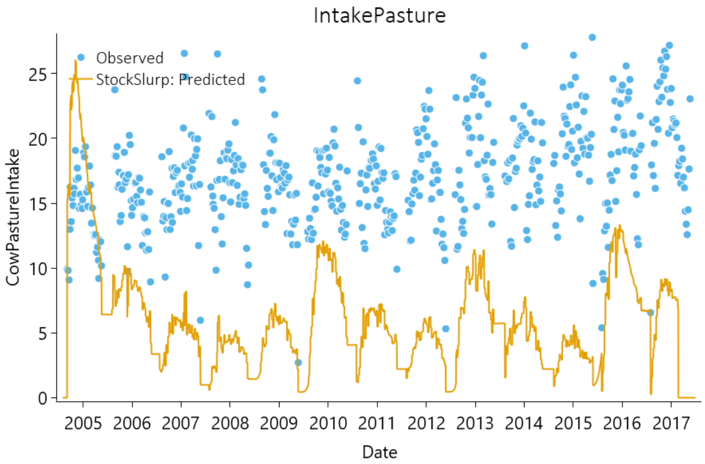
3.2 Validation Plots

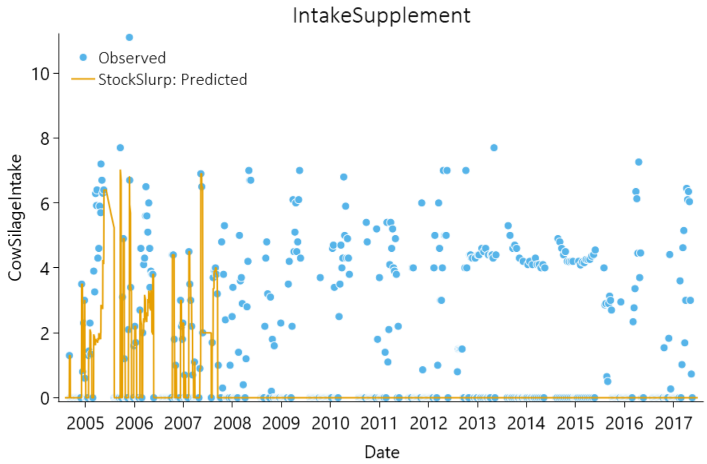












4 Sensibility

This sensibility test explores dual-purpose wheat in a high rainfall livestock system in south-eastern Australia.

It is based on:

Sprague SJ, Kirkegaard JA, Dove H, Graham JM, McDonald SE, Kelman WM (2015) ***Integrating dual-purpose wheat and canola into high-rainfall livestock systems in south-eastern Australia. 1. Crop forage and grain yield.*** *Crop and Pasture Science 66(4), 365-376.*

Sheep grazing wheat and fed in feedlot

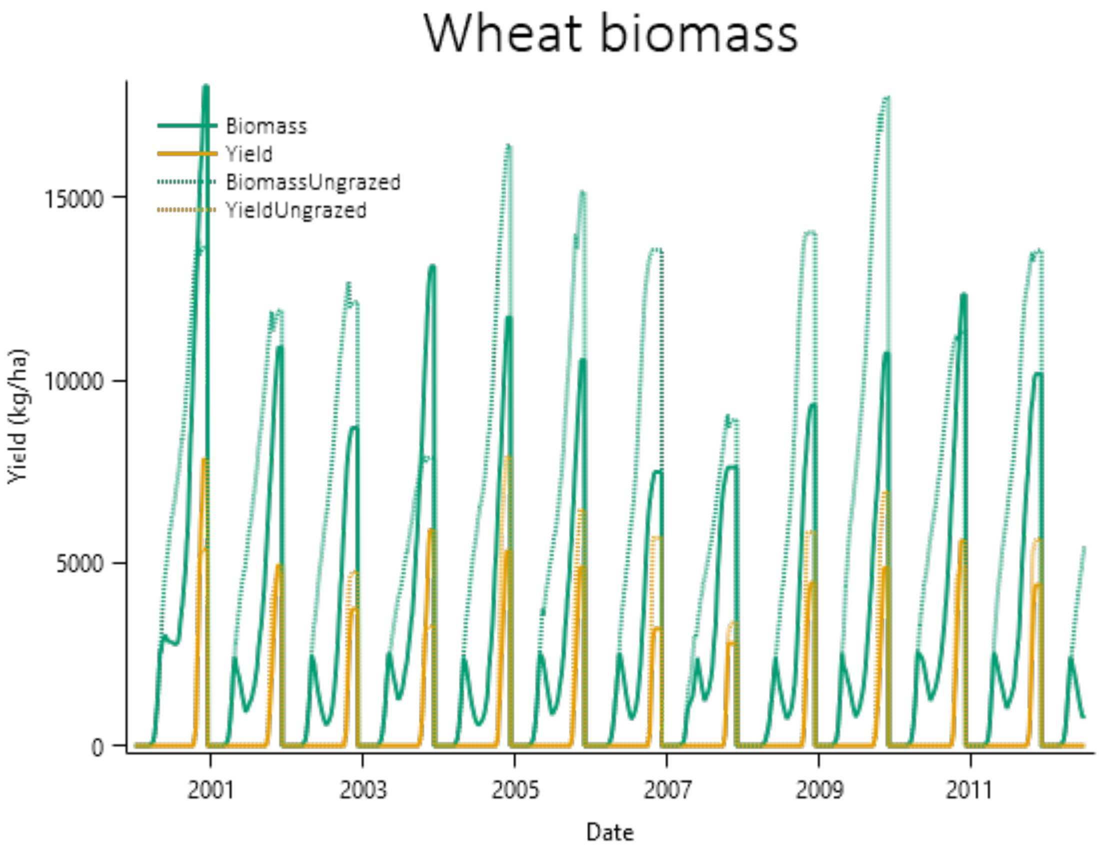
In this example simulation sheep are bought and sold on specified date. They are fed supplement in a feedlot at a set rate, but graze a wheat crop when crop biomass >= 2.4 t/ha. Sheep are moved from the wheat crop and back to feedlot when crop biomass reaches 0.5 t/ha or crop zadok = 31.

Activities in this manager:

1. Buy animals at start of year & put in feedlot
2. Move animals from feedlot to crop when ready to graze
3. Move animals from crop to feedlot
4. Shear all animals on specified date
5. Sell all animals at end of year

NOTES

1. When the animals are in the feedlot and an animal dies during the day, the supplement has already been fed into the feedlot based on the number of animals in the feedlot at the start of the day. This means the remaining animals have access to slightly more supplement and causes a spike in supp intake graph.
2. When sheep are culled for age + purchased to maintain stocking rate, several groups of sheep are created. This causes irregular amounts of supplement to be fed.



This graph shows the impact of grazing on the wheat crop.

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