



1 AGPRyegrass

Describes a pasture species.

AgPasture is a model developed to simulate pasture growth in the APSIM framework. It was initially based on the plant physiological model of [Thornley et al., 1990](#), as were the models SGS/DairyMod/EcoMod, presented by [Johnson et al., 2008](#). Today in AgPasture, the plant processes were adapted from EcoMod but all environmental factors and partition of resources is done by other models in the APSIM framework. The main purpose of AgPasture is to simulate mixed pastures but based on individual calculations for each species of photosynthesis, respiration, dry matter accumulation and partitioning and tissue turnover as presented by [Li et al., 2011](#). It simulates pastures composed by C3 and C4 grasses, legumes and forbs. Now AgPasture has the sward component that is responsible for integrating the outputs obtained for each species and controlling management aspects, such as grazing. The base species in AgPasture is a generic temperate C3 grass parameterised as a generic ryegrass. All simulations are based on an established pasture, so there is no development from seeds. The proportion of species in the sward varies according to environmental effects, water and nutrient extraction ability and effects of harvests (cutting or grazing) on each of the species in the sward. Each species is described as a set of organs (Figure 1) and these organs are described by tissue pools (Figure 2).

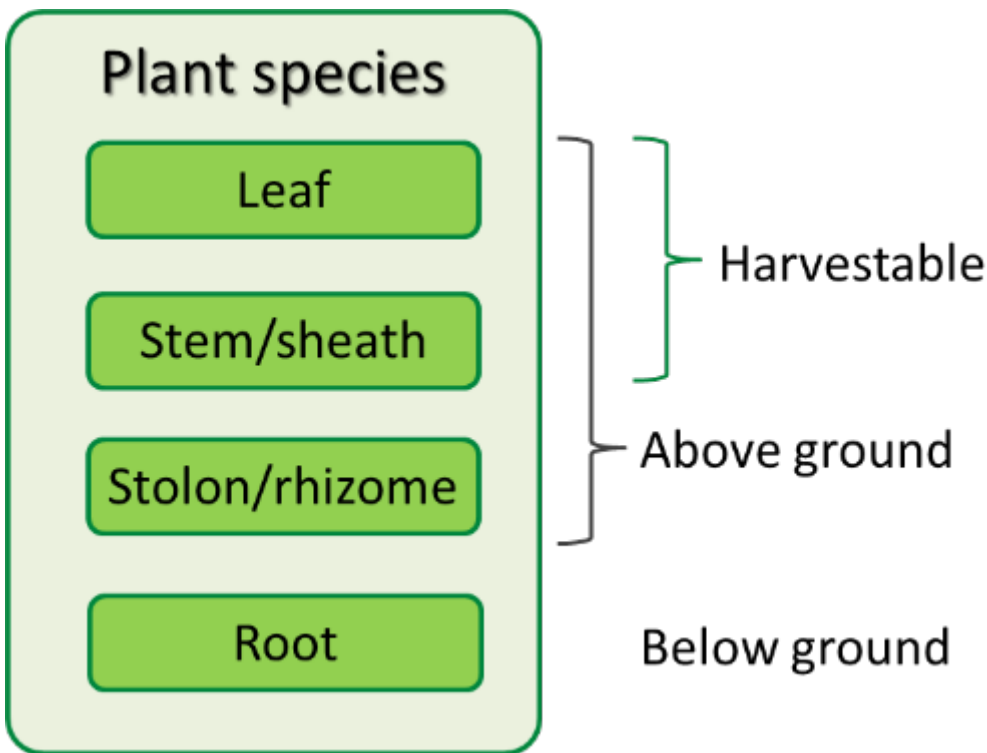


Figure 1: Description of plant species in AgPasture with the indication of a general class for plant parts.

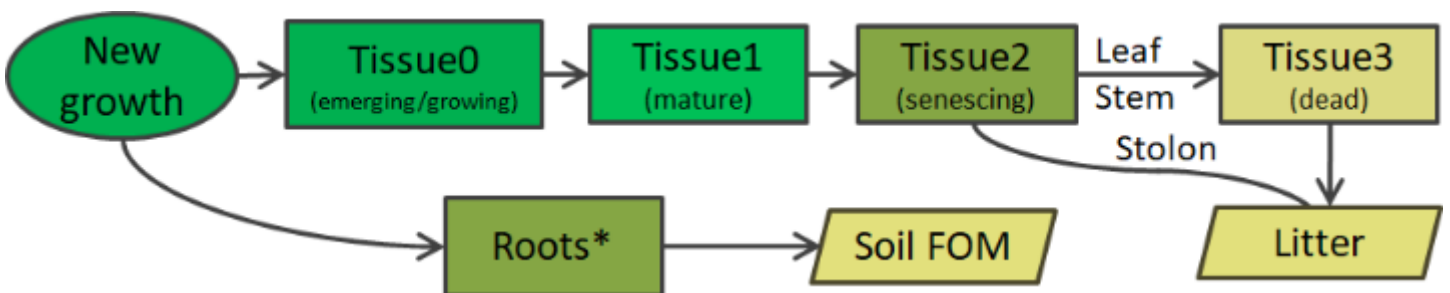


Figure 2: Tissue dynamics in AgPasture, from new growth until senescence.

Basically, water demand is calculated by micromet (Snow et al., 2004) and then its availability can be calculated according to different methods, that can be set up in the user interface. The same happens with nitrogen availability, that can be calculated through methods that can be set in the user interface. AgPasture receives this information and calculates plant potential growth through net photosynthesis and a series of growth limiting factors (GLF), related to water, nitrogen, temperature, fertility (to account for nutrient limitations, other than nitrogen) and a generic factor (to account for the effects of diseases, for example) are used to reach the actual plant growth. This actual plant growth is what is used for the further processes of tissue turnover and dry matter allocation presented in Figure 3. Dry matter transfer across tissues, how turnover rates act and nitrogen balance are presented in Figure 4. In general, AgPasture calculates the rates () for each tissue pool of all plant organs. The rates are then passed on to each organ and the amounts to be potentially turned over (dDM) are calculated for each tissue pool. For nitrogen, basically AgPasture uses the nitrogen taken up from the soil and fixed by legumes. This nitrogen amount will then be available for new growth. The process of nitrogen uptake aims for the maximum concentration of nitrogen in new growth (N_{max}^*). This is not always achieved and the current nitrogen concentration will be added to the pool of tissue 0, which actively contributes with dry matter and nitrogen transfer for older tissues. The same happens for tissues 1 and 2. One of the modifications done in AgPasture for APSIM X is the definition of an adequate nitrogen concentration in these pools. Now tissues have a target concentration of nitrogen and any extra nitrogen is put through the remobilisable nitrogen pool (Vogeler et al., 2016). The rate of nitrogen remobilisation is defined by k_L , which mainly shows that the priority is the first leaf. When the first leaf becomes deficient, the remobilisation of extra nitrogen aims to fulfill the nitrogen need for this pool. At the same time, a minimum concentration of nitrogen is always transferred to the pool of tissue 3, resulting in a constant nitrogen concentration of this pool. This is then added to the litter pool. where dry matter that comes from the shoot is added to the surface organic matter pool whereas dry matter from roots goes to the soil fresh organic matter pool. The amount of nitrogen remobilisable that was not used is then added to the litter pool.

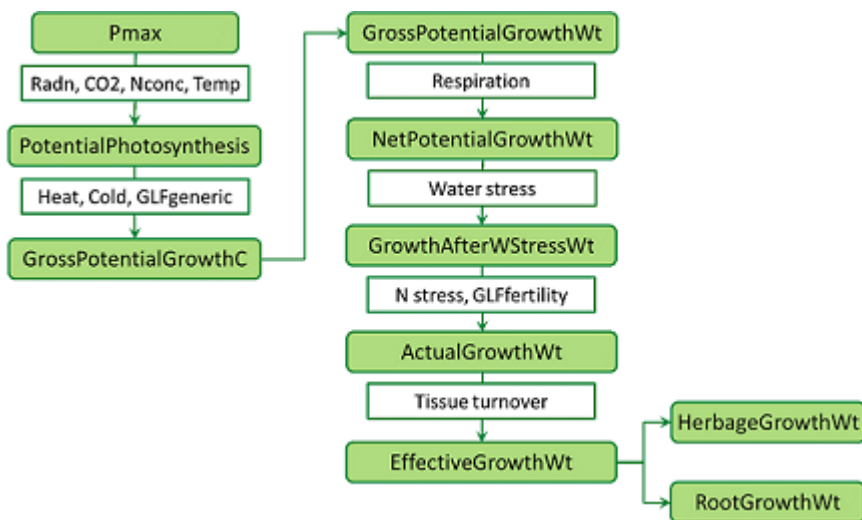


Figure 3: Description of growth calculations done by AgPasture, from photosynthesis up to the partitioning of growth between shoot and root.

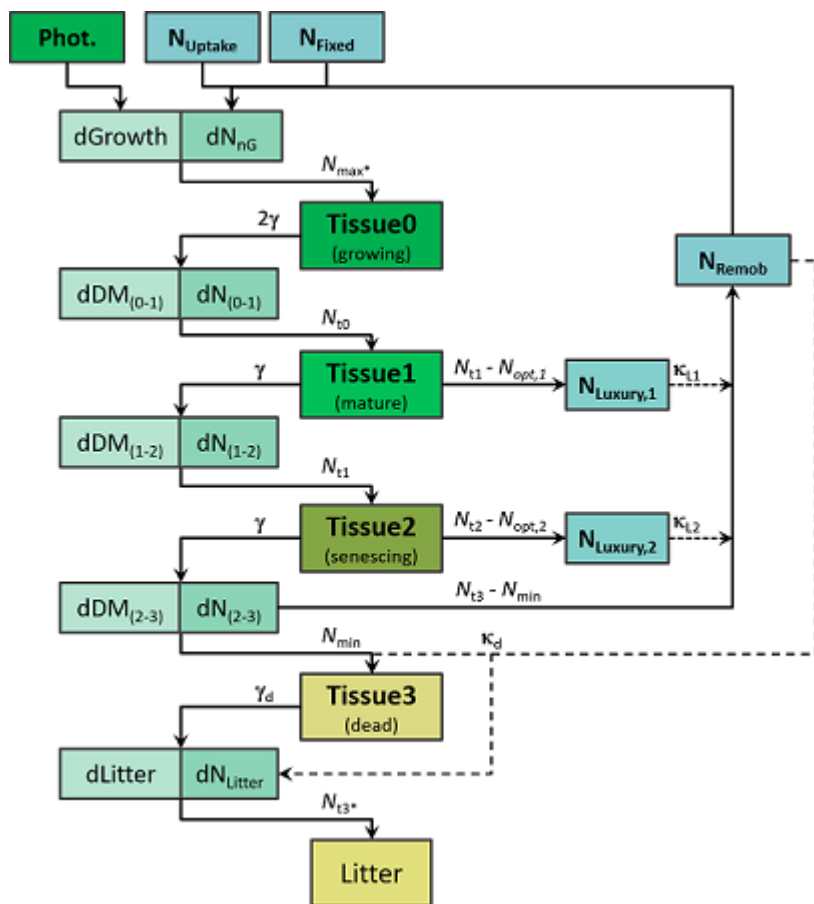


Figure 4: Nitrogen balance and dry matter transfer in AgPasture.

AgPasture does not simulate reproductive growth, therefore it does not simulate phenological development and seed production. Instead, the model mimics changes in growth rate and dry matter allocation by using a latitude reference that triggers changes in the shoot:root ratio of plants during this "reproductive period". Another limitation of the model is the lack of carbon remobilisation, which makes it difficult to simulate the proper remobilisation of reserves in the plant. More details are given in the supplementary documentation for AgPasture. Biomass removal can be simulated by the Graze (Figure 5) and RemoveBiomass (Figure 6) methods. The Graze method is a simple way to present the amount of biomass to be removed. It uses a parameter 'Amount', which sets up the amount of dry matter to be removed, and a parameter 'Type', which defines how the value of 'Amount' is interpreted. 'Type' can be set as 'ResidueAmount', where the target amount of dry matter is a value for the residual amount of biomass that will be left after harvest, or it can be set as 'RemoveAMount', where the target amount of dry matter is the value to be removed by the harvest. Both methods are dependent on a minimum above ground green dry matter that is set as a default of 100 kg DM/ha and can never be removed. Then a function 'RemoveDM' is responsible for the dry matter removal and partitions the amount to be removed among organs and pools. This is dependent on default preference values, which are currently set as 1. A series of checks is done to guarantee that mass balance is not affected by the removal of dry matter. The 'RemoveBiomass' method is more elaborate and allows to control the amount of each organ and pool that will be removed. The fractions to be removed can be set through a 'RemovalType' or a 'RemovalData' parameter. The 'RemovalType' is based on default fractions for organs (leaves, stems and stolons) with fractions for live and dead pools of dry matter to be removed and residual dry matter. The 'RemovalData' is optional and allows the fractions to be removed to be set up by the user.

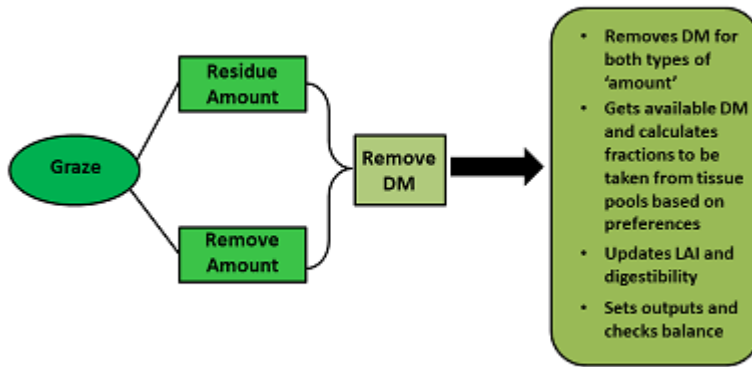


Figure 5: Graze method of biomass removal in AgPasture.

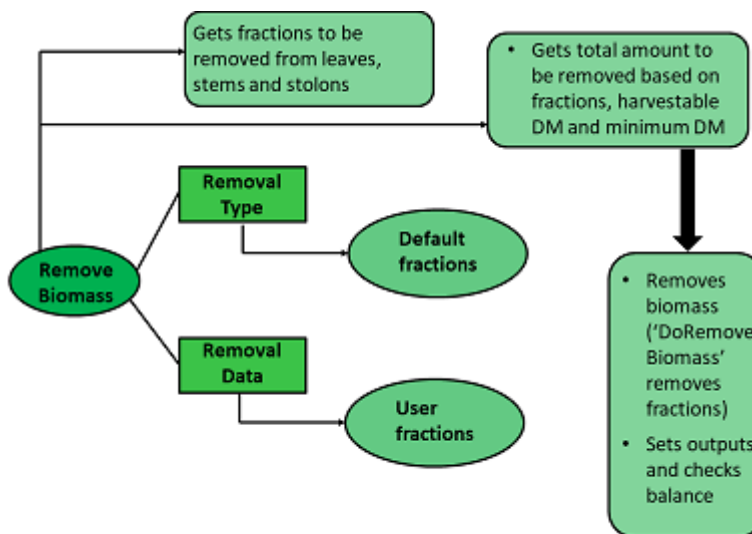


Figure 6: Description of the RemoveBiomass method in AgPasture

Figure 6. RemoveBiomass method of biomass removal in AgPasture.

Root distribution in AgPasture is mainly dependent on the root density information and follows a uniform distribution up to a certain depth, which can be set up by the user in the parameters list available in the sward component. From this depth on, the root decrease follows an exponential decline until no roots are present at a limit depth (Figure 7).

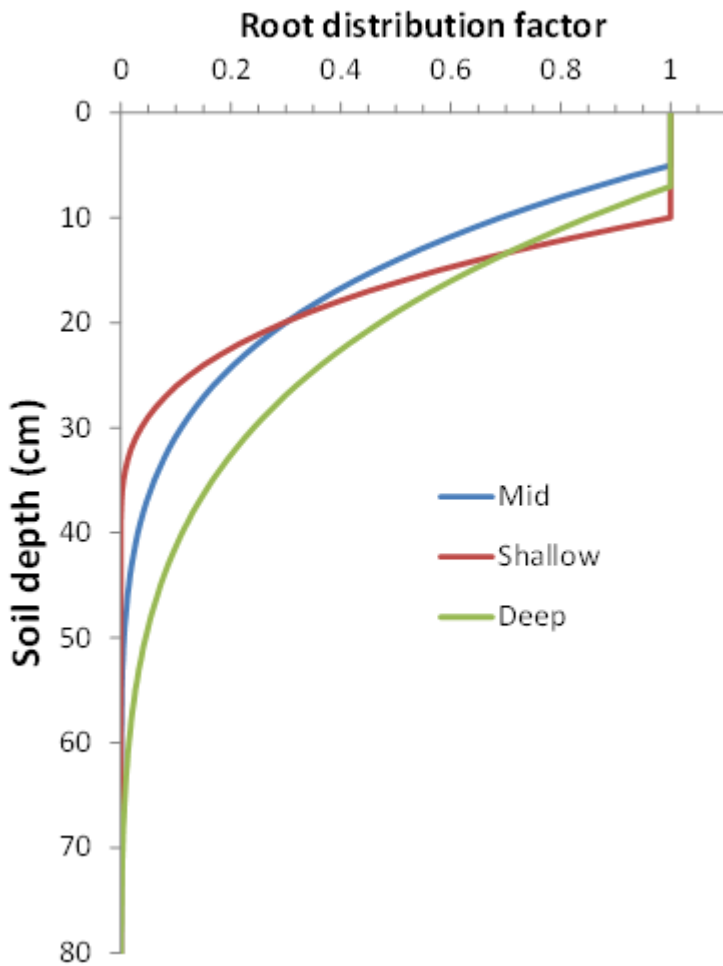


Figure 7: Example of a shallow, mid and deep distribution of roots in AgPasture.

AgPasture is a robust model for pasture production simulation and including it into APSIM X makes it easier to implement improvements that are still needed for a better performance of the model.

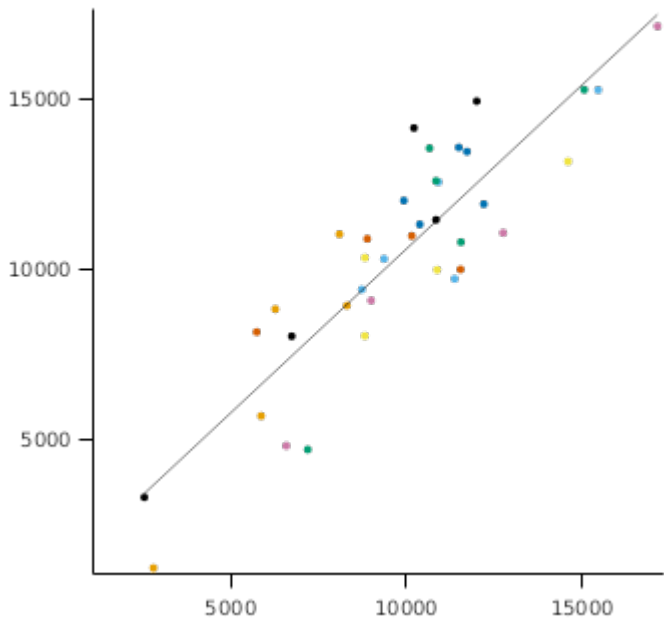
2 ValidationRadcliffe

The data set used for this simulation is called the 'Radcliffe trials' because it was obtained from experiments done based on the methodology described by [Radcliffe, 1974](#). It was a series of experiments on grass-clover pastures to evaluate pasture production using exclusion cages in areas across the north and south islands of New Zealand. The data presented is the average annual production of dry matter/ha. This validation set has experiments done in 33 places and some of those places are repeated due to irrigation or different periods of observation. Therefore, in total, there are 37 locations being used as a validation set for this simulation. Locations such as 'Arrowtown', 'Cromwell', 'Poolburn', 'Awamoko', 'LowerWaitakiPlains', 'WinchmoreRedcliff' and 'WinchmoreIrrig' are irrigated trials whereas the rest of locations are dryland sites. Two more data sets were added to the 'Radcliffe trials' with annual average production based on long term data of ryegrass-clover mixed pasture production trials in 'Ruakura' and two areas in Winchmore ('WinchmoreDland', which is a dryland trial, and 'WinchmoreIrrig', which is an irrigated trial). More information about the 'Ruakura' data set can be found in [McCall et al., 2003](#).

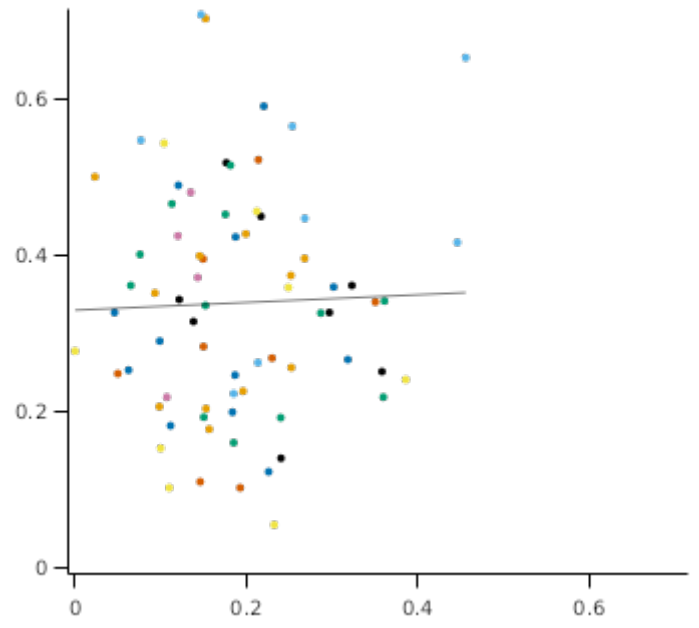
List of experiments.

| Experiment Name | Design (Number of Treatments) |
|-----------------|-------------------------------|
| Radcliffe | Location (37) |

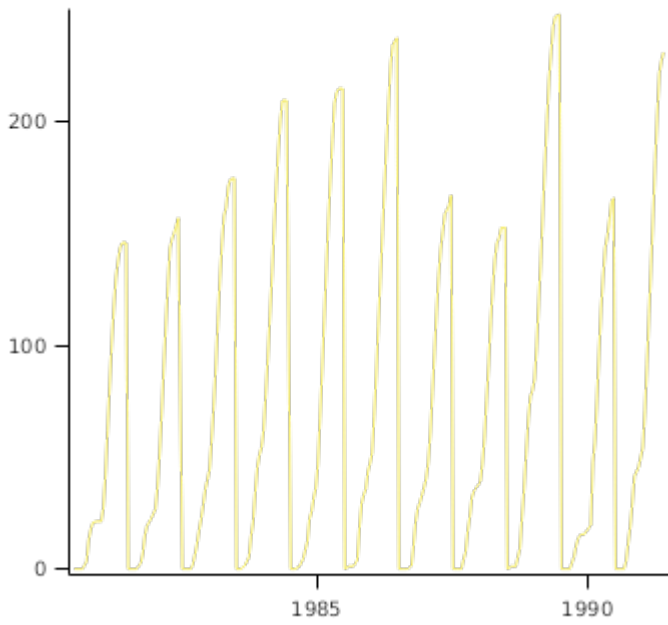
PxO_AveAnnualHarv



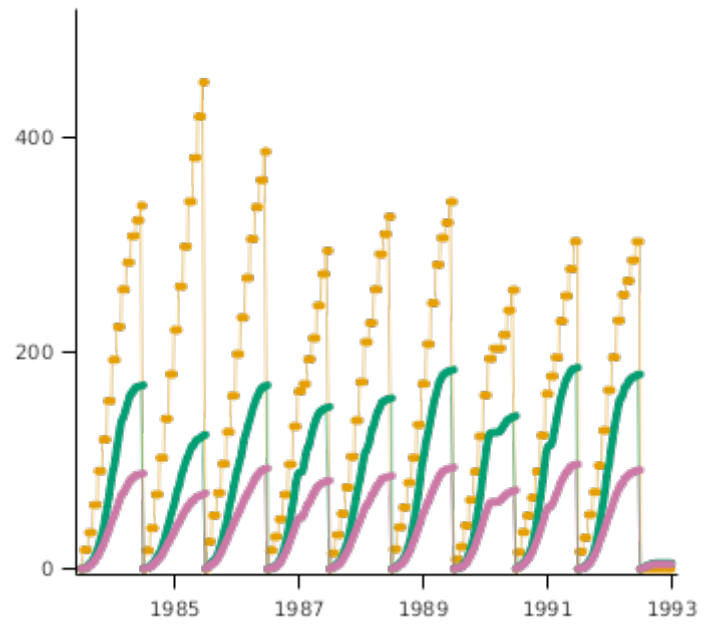
PxO_CloverDominance



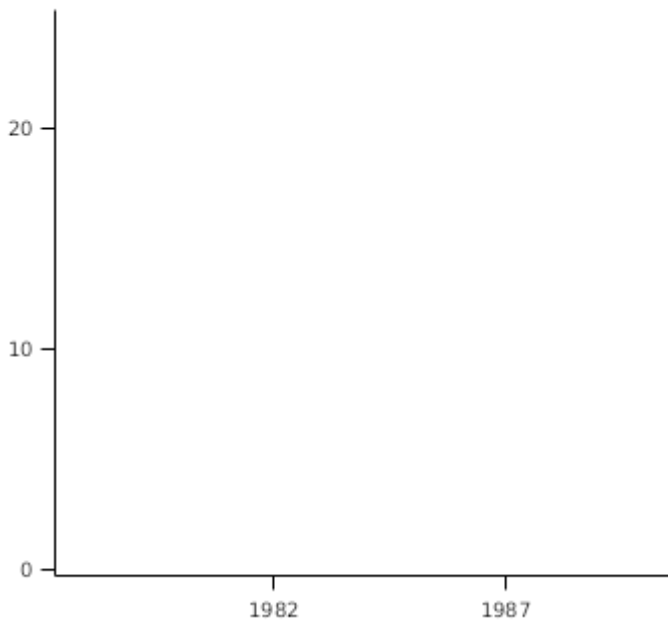
NRReturned



NUptake



Irrigation



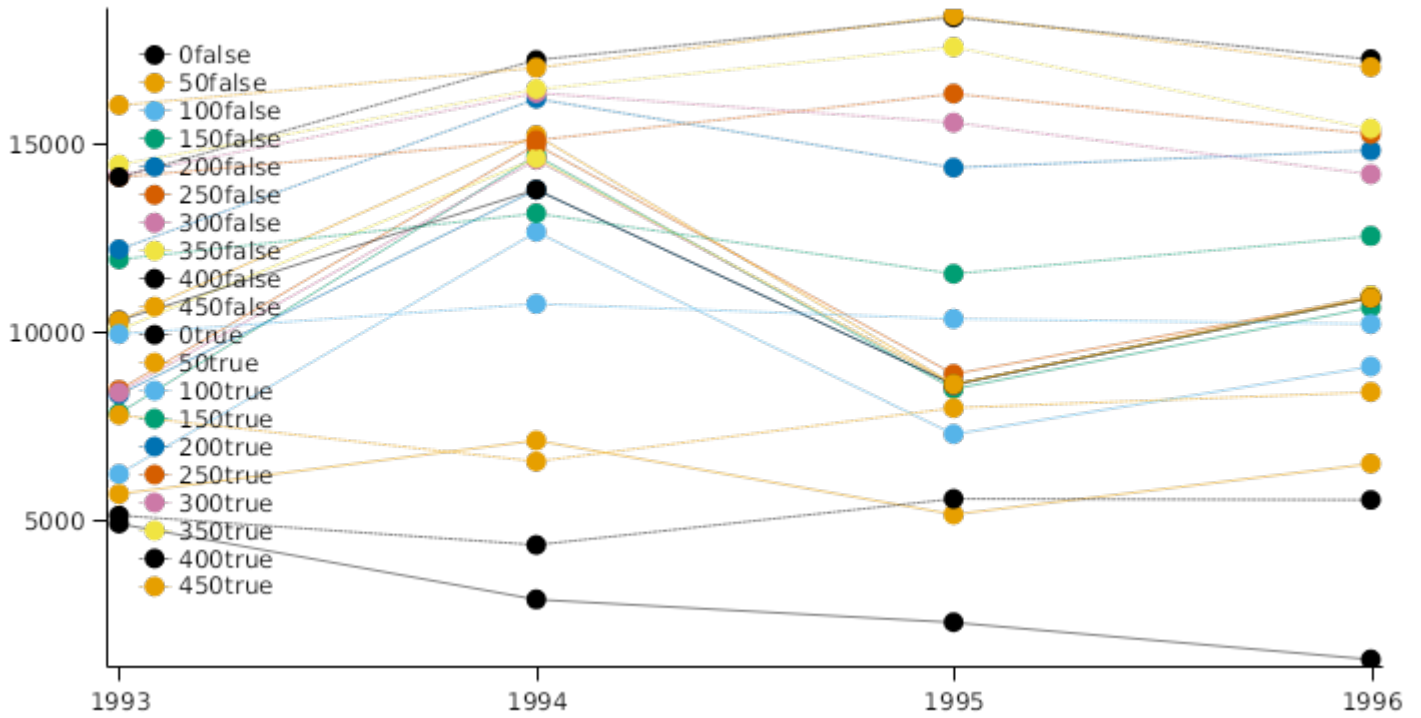
3 Sensibility

List of experiments.

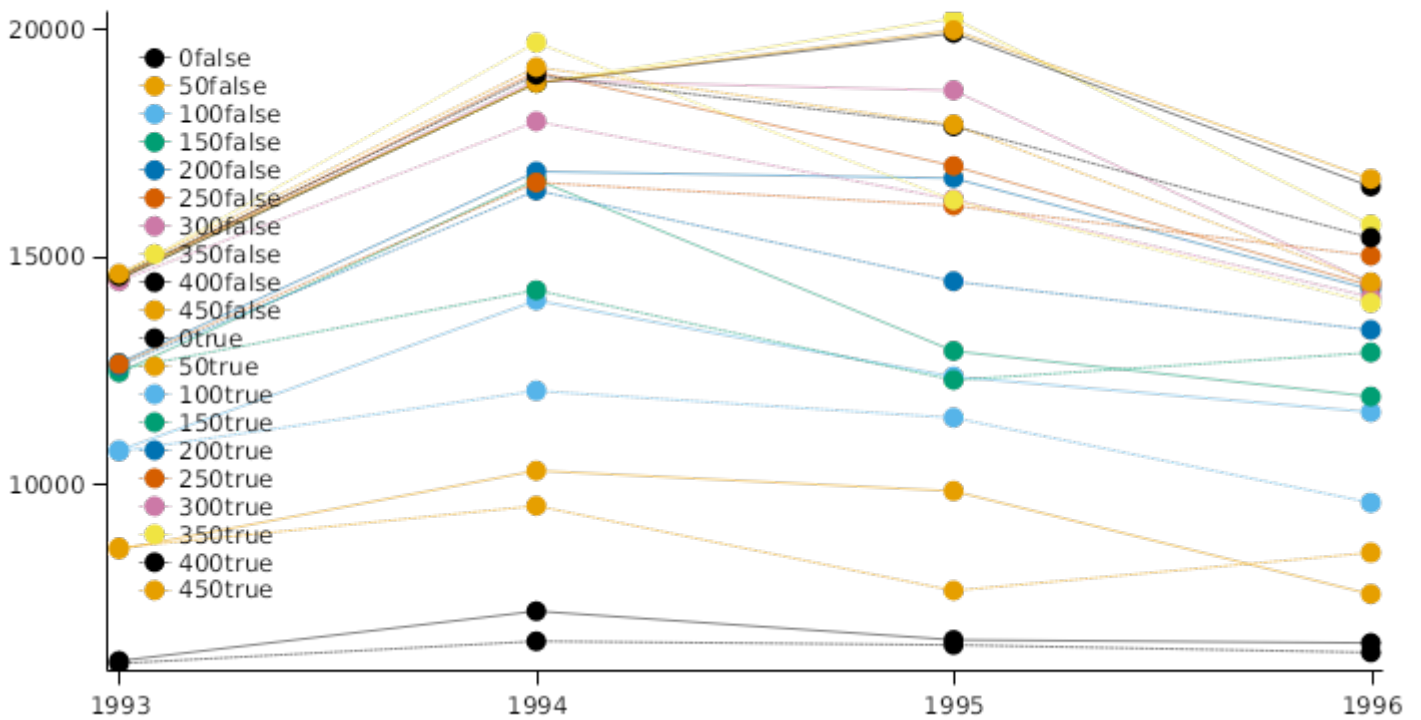
| Experiment Name | Design (Number of Treatments) |
|-----------------|----------------------------------|
| Sensibility | Location x Nitrogen x Water (80) |

3.1 Sensibility

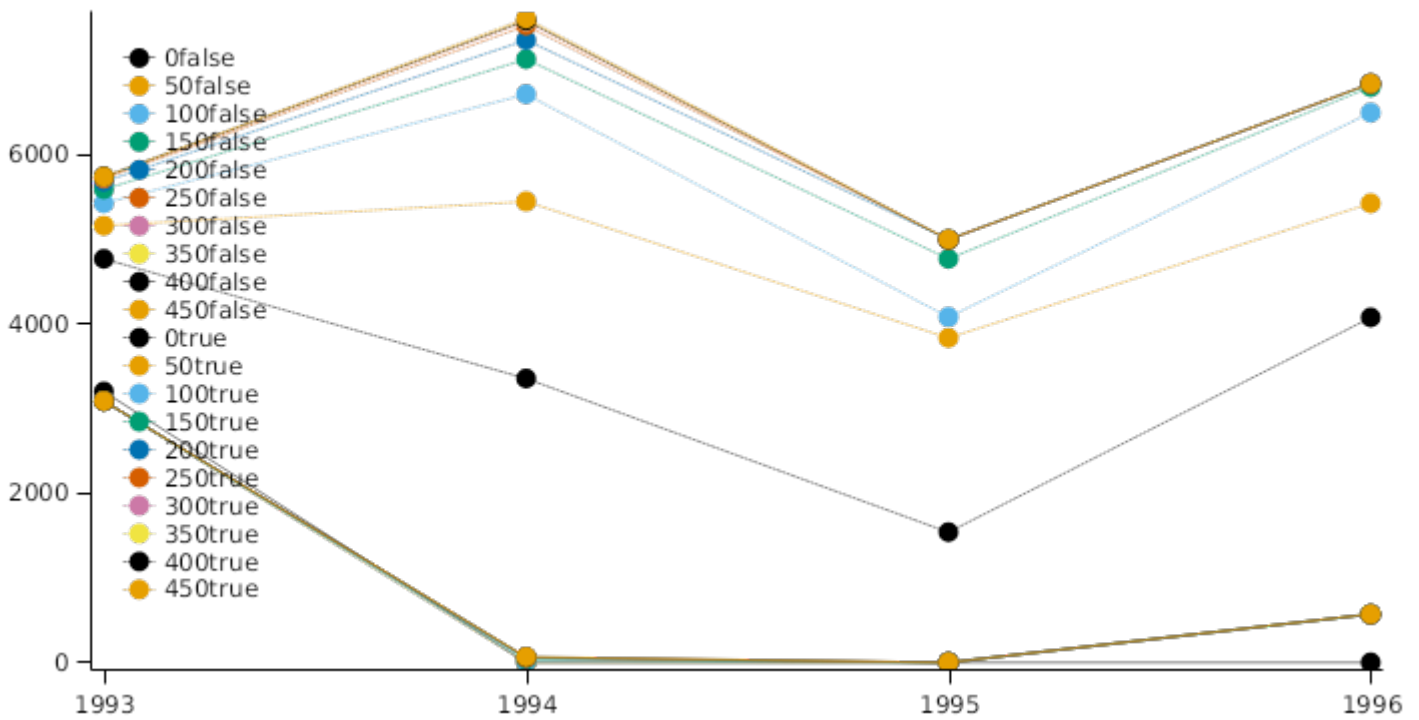
Lincoln



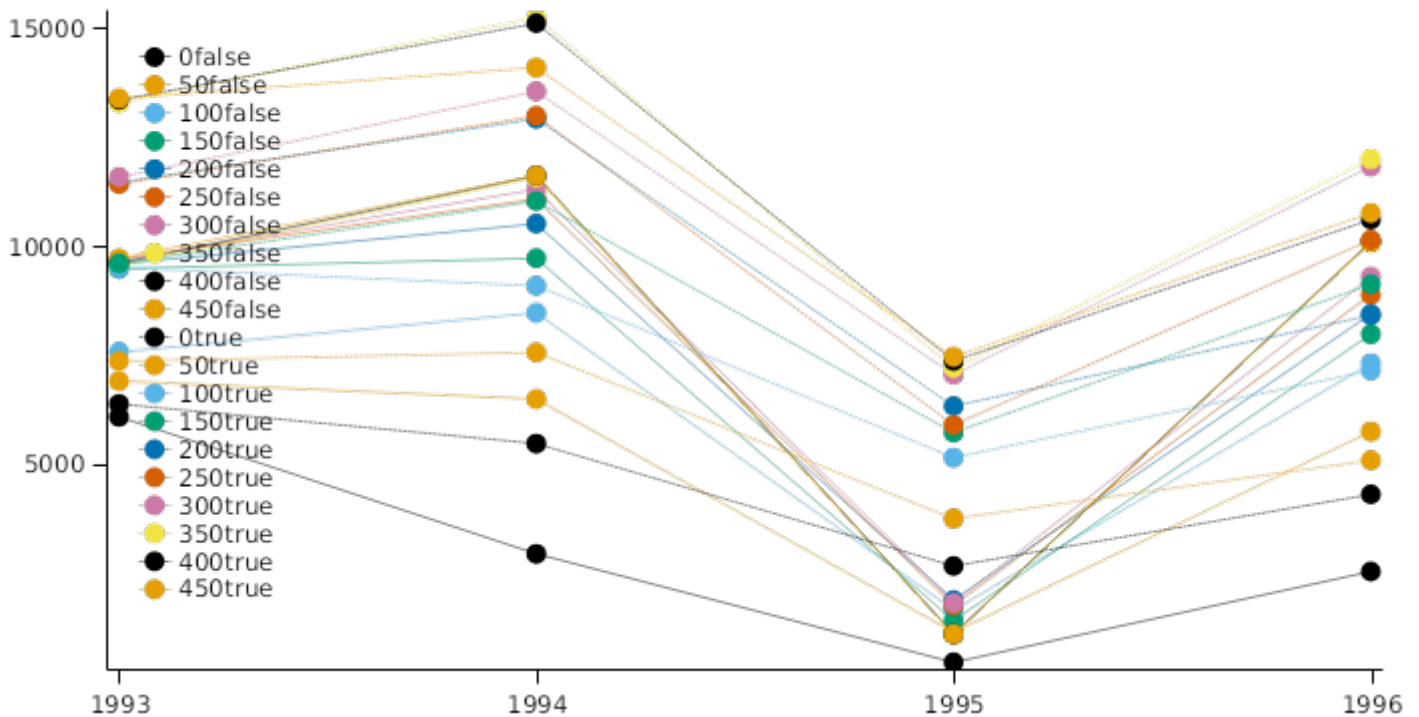
Ruakura



Dalby



WaggaWagga



4 References

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