Playing with Real-life numbers in Farming Simulator

By

ArmChairFarming

Preface

The most significant new feature in Farming Simulator 19 is the ability to design and build your own farm yard. A feature that more than any will facilitate and encourage individualization of the game, allowing players to build their farm either from pure fantasy or based on a real-life farm in their own neighborhood.

The present mod, **RealLifeNumbers by ArmChairFarming**, aims to allow further individualization of the game by providing easy access to key game parameters. The first objective of the model is to use real-life parameter values for various aspects of the game, including both arable farming and husbandry. Such real-life parameters are taken from official statistical services in the European Union (EU) and the United States Department of Agriculture (USDA). Over time, different versions will be published covering different member-countries in the EU and different USDA regions in the US.

This note aims to provide some background information on the series of scripts included in the mod, what parameters they alter, and what approach lies behind their new definition.

The mod differs from other mods in that the user must edit the mod frequently to fit the mod to the game style and farm plan the user attempts to implement. This editing is done in between game play, and, particularly during the initial phase of a new game, when the farm is being designed and necessary plans need to be made to create a harmonious balance between the size of the husbandry and the size of the farmland.

The mod consists of a series of scripts each covering different areas. The mod offers very little visual interaction with the player. The mod scripts redefine Game parameters during game start up, and a very large number of defined and derived values are printed to the log file.

Finally, a brief note on the author of the mod. My name is Kaj-Åge "Ki" Henneberg. I'm a professor of engineering and teach mathematical modeling to engineering students. My only real-life experience with farming is my childhood life on my parent's small farm in the western part of Denmark in the 1960-1970. We had lots of pigs, barley and potato, a David Brown 880, a Farmall D-320, and about 50 acres of very sandy fields. My brother and I had our daily chores, mugging out the pigs was one of them, ploughing and cultivating were some in the fun end of the scale.

This is the first ever mod made by this author. The features as well as the programming style certainly reflect this very clearly. Starting with no knowledge of the data structure of Farming Simulator and no knowledge about Lua programming, the progress was very slow in the beginning. Despite the beginners programming style, the mod has not yet shown any adverse effects. The mod uses scripts and will therefore not work on consoles. It has only been tested in Single player mode.

Who is **ArmChairFarming**? Just me. The expression "Armchair farming" was to my knowledge first used by George Saunders, a real-life British farmer and YouTube author, while comparing driving his much loved JCB 4220 in real-life and in FS17. Thank you, George, for letting me use it.

While enjoying immensely playing Farming Simulator, we all need external inspiration once in a while. This I get by watching YouTube videos from real-life farmers (George Saunders, MN Millenial Farmer, How Farms Work) as well as from game players and mod reviewers (Daggerwin, MrSealyP, Nick The Hick). Thank you all for teaching and inspiring me.

My final thank-you goes to all the hard core modders and mappers, who's complex codes make me feel like a newborn baby.

The redefined sell prices will only have their correct values when the economic difficulty level is set to HARD. Changing the economic difficulty level to Normal will scale the sell prices by a factor 1.8 and the Easy level will scale by a factor 3.

A second factor that can cause crop sell prices to deviate from the levels preset by the mod is if the map designer has implemented price-scaling at the sell points on the map. Some map designers do this systematically. To investigate if this is the case, you will need to unzip the map and inspect the xml files of each sell point in the placeables folder. Look out for the **pricescale** parameter. If different from one, the sell point is scaling the sell price. The same situation applies to user placeable sell points. It is a quickly mastered process of unzipping, editing and rezipping such maps and mods. I use the freeware program 7-ZIP to unzip and rezip files. Just remember, that the rezipped file should have the extension "zip", NOT "7z". I use the freeware editor Notepad++ to edit files. I recommend you do not edit mods while they are inside the FS19 mod folder. For this purpose, I have a series of folders: mods-unused, mods-edited, mods-conflicts, and so on.

A third factor to consider is the highly overexaggerated price variation built into FS19, causing price differences on the order of 100%. The mod does not attempt to rectify this game behavior. I simply ignore the outliers and use the sales points with prices within a realistic range.

Yours truely,

Kaj-Åge Henneberg
Mar. 20, 2019
Farum, Denmark

Figure 1. What lies ahead?

Content

List of Tables

1 Introduction

The mod **RealLifeNumbers** redefines the numerical values of a range of game parameters toward real-life values within a well-defined geographical region, either a country in the European Union (EU) or an agricultural region in the US as defined by the United States Department of Agriculture (USDA).

1.1 Objectives of the mod

The mod has three main objectives:

1. To define a game environment mimicking real-life farming in a well-defined area.
2. To enable players to individualize the game using a simple editor.
3. To provide a game planning tool for the player.

Ad 1) As time goes, maps will be available presenting farming in many different countries and within very different climatic environments. Farming thus is very different in different areas of the world, different crops are grown, different harvest yields are seen, and prices on crop, farm supplies, animals, milk, wool, farmland, etc. vary significantly. The first version of this mod will contain real-life numbers for Germany, as I'm presently playing on the maps Felsbrunn by Giants and Oberlausitz by RitchiF. However, other versions are planned for other countries within the EU and for different agricultural regions within the US. Their release awaits the evaluations by the mod users.

Ad 2) There is only one right way of playing Farming Simulator: Your way. Whether you play the career game, building up a farm from scratch while fighting economic hardship with a 2-furrow plough or play a real-life simulation game, there is a need to tweak the game toward your personal playing style. While the mod aims to setup a real-life framework, it can easily be made to meet other personal needs.

Ad 3) If your preferred style of playing is to do real-life simulation of farming in a specific geographical region, you need not only to redefine game parameters, you need also to do a pre-game setup, where you establish a good model of the farm you want to simulate. It is a real scoop for this game style, that FS19 now allows you to build your own farm yard. But many questions arise: How much land do I own? How many animals can I have if I have this much land? Can I afford buying more land or should I rent? What crop and how many hectares are needed to feed the animals? How many bales do I need of straw and grass? Do I have surplus crop for selling? What crop gives the highest income per hectare in my area? How much seed is needed? How do I calibrate my spreader/sprayer to spray the right amount? How much milk, wool, egg, manure and slurry do my animals produce? How much nutrient is in my organic fertilizer? How fast will my animal stock reproduce? What if I just want to rear fattening pigs? RealLifeNumbers provides the numbers and means you need to answer all these questions and more.

1.2 Who is this mod for?

A real-life simulation game is entirely different from a career game in how you measure success and how you judge the means to reach your objective. In a career game, the framework is a predefined set of conditions and the way you act to resolve all the different challenges are also governed by a set of implicit rules. In a real-life simulation game, the initial setup phase is a design phase, where you in a very direct way establish the farming environment, you want to create. Only when this is accomplished does the game begin. In the setup phase, you will need to add money to your bank account repeatedly using a money cheat mod to buy/rent fields, level grounds, build your farm, and acquire starting animals and equipment as well as feed and farm supplies. This is an established farm, not a new farm, so there is already plenty of slurry in the pit and bales in the hayloft.

Some will say that this style of play is too easy. But planning a farm requires lot of knowledge and information about farming. RealLifeNumbers will make it easier by providing lots of needed information.

Do not activate this mod, if you are in the middle of a serious career achievement game. The mod will change many economic parameters, and the economic achievements in your career game will take a different direction than what you started out with. If you want to use the mod, do it in a game, where your previous economic achievements are considered of minor relevance.

1.3 The components of the mod

RealLifeNumbers has a modular structure in the sense that several separate scripts are called in the order defined in modDESC.xml. The following scripts are activated by default:

- `RealNumbersInitialization.lua`
- `RealNumbersCropYield.lua`
- `RealNumbersGreenCropYield.lua`
- `RealNumbersSpraying.lua`
- `RealNumbersSeedUsage.lua`
- `RealNumbersCropPrices.lua`
- `RealNumbersCommodityPrices.lua`
- `RealNumbersAnimalProducts.lua`
- `RealNumbersAnimalCare.lua`
- `RealNumbersAnimalTradePrices.lua`
- `RealNumbersFieldInfo.lua (press leftAlt-rf)`
- `RealNumbersMissions.lua (press leftAlt-rm)`

The purpose of each script will be explained in the following sections.

1.4 How to use the mod

RealLifeNumbers does most of its job during game startup. Very little interaction with the mod user is implemented. One exception is the script `RealNumbersFieldInfo`. This mod prints information about ownership, crop type, and the size of farmlands and fields on the map. Farmland information is loaded into the game after the scripts in RealLifeNumbers are called. For this reason, this script requires the user to press `leftAlt-rf` (hold down left Alt and press r and f simultaneously) after the game has started. The price of each farmland is set automatically, hence it is only required to press `leftAlt-rf` if a printout to the log file of farmland information is needed.

User interaction with RealLifeNumbers is outside the game. If a mod user feels that the predefined numbers should be changed, this needs to be done using a simple editor. Notepad could be used, but Notepad++ is much better as it recognizes the lua syntax. To facilitate the recurrent interaction with the scripts, it is recommended to unzip a copy of the mod into a dedicated folder and keep this folder at all times. If a parameter value needs to be changed, open the specific script in Notepad++, make the change, save the script and make a new zip file with all the files in the folder. Then drag the new zip file to the folder with your mods and restart the game.

RealLifeNumbers prints all information to the log.txt file. The information is mixed with loading information from all other mods in the game. This seems a bit confusing, but as the user only needs this information occasionally, it is an easy task to edit out irrelevant loading information using a text editor and thereby create a map specific report. For use in the game planning phase, this report can be printed out on paper or converted to a pdf file and displayed on a tablet conveniently located next to your game computer.

This simplistic style of user-mod interaction may seem too complicated or annoying to many players. If this is the case, I believe your game style will not benefit much from the mod and you will be better off not using the mod. Players who play the game as a real-life simulator are used to making records of harvest yields and other information in a small note book. Hopefully, this group of players will find the simplistic approach manageable.

It may be of some convenience to see the log file on the screen while playing the game. This can be done by editing `game.xml` located in the folder `Documents\My Games\FarmingSimulator2019`. In this file,

```
<development>
        <controls>false</controls>
</development>
```

should be changed to:

```
<development>
        <controls>true</controls>
 </development>
```

When starting the game, you may then press the key just below the Esc key on your keyboard. Whatever is written to the log file will also be copied to the screen, but unfortunately not in fixed-width font. By using the Page Up/Down keys, you can browse through the output from the mod to get a quick look at something without leaving the game. Pressing the button just below the Esc key two times more will make the text disappear from the screen and you can continue playing the game.

To ensure that the mod gives you the expected results, **you must play the game with Economic Difficulty set to HARD**. At normal economic level, prices will be scaled by 1.8, and at EASY, they will be scaled by 3. This scaling is done by FS19, not by this mod.

1.5 What if I find a mistake?

It is very likely a user will disagree with one or more parameter values set by the mod. If the value in question is a factor 10 off from the value you think it should be, then it is likely, that I or the data source have made an error, and I would be glad to hear about it. If you disagree because you live in a part of the world with unusually high milk or oat yield, then simply refit the parameter values to match your situation. After all, individualization is one of the main aims of the mod.

In the derivation of game parameters, I have used a range of methods. Some take root in factual information published by universities or farming organizations and others are just rules of thumb found on the internet. In the latter case there might be better methods and I would like to hear about them.

1.6 Coexistence with other mods

A range of good mods change some of the same parameters as redefined in this mod, such as crop yield, seed usage and prices on crops and farm supply. If used simultaneously with RealLifeNumbers, conflicts will arise as to what value the parameters will end up having. Most other mods with this issue have entirely different objectives, hence it should be of no consequence to simply disable these mods when using RealLifeNumbers.

I use two mods, which supports RealLifeNumbers particularly well, **variableSprayUsage** by monteur1 an **GrowthControl** by apuehri/LS-Modcompany. **variableSprayUsage** by monteur1 adjusts the running output rate of spreaders and sprayers according to the current driving speed. This mechanism prevents over/under-application of spray material in areas of the field with varying driving speed, such as at headlands an on very hilly fields. The user can set the spray rate in Liters/hectare. It is easy to edit the mod and extend the range of possible settings, so the mod can be set to deliver the spray rates calculated by the script **RealNumbersSpraying.** To assist this adjustment, **pressing left Alt-rs** will cause the script **RealNumbersSpraying** to print the pre-set spray rates in the log file (and on the screen if development is set to true in game.xml and the log file is made visible by pressing the key below the ESC key once).

GrowthControl by apuehri/LS-Modcompany allows the user to define the duration of growth stages for each crop type. In the script **RealNumbersAnimalCare**, the concept of a Year is required to handle rearing cycles. As we do not yet have the **Seasons** mod by Realismus Modding, the concept of a Year in my script is purely fictional and has no effect on weather or crop growth. Nevertheless, GrowthControl allows the user to adjust the duration of growth stages, so that the time from seeding to harvest follows the same virtual year as animal reproduction. By default, RealLifeNumbers divides the year into 12 game days. Hence, a game day corresponds to one real-life month.

GrowthControl also adjust yield and seed rate, and this can cause conflicts regarding the resulting values of parameters defined in two mods. My initial test indicated that the crop/seed parameter values set by GrowthControl is overwritten by RealLifeNumbers, while the growth duration parameters remain as defined by GrowthControl. apuehri/LS-Modcompany encourages users to reassign the parameters in their mod to meet the user’s need, hence, to be on the safe side, I copied all my yield/seed parameter values into GrowthControl. I will not redistribute mod components of other people; hence I can’t include a copy of the specific file in GrowthControl into the zip file of RealLifeNumbers. However, a screen shot of my edited version is shown in Figure 2.

```xml
<growthcontrol>
    <fruit name="wheat" hours="24.000000" literPerSqm="0.518700" seedUsagePerSqm="0.012200"/>
    <fruit name="grass" hours="10.000000" literPerSqm="1.814500" seedUsagePerSqm="0.001100"/>
    <fruit name="canola" hours="18.000000" literPerSqm="0.293100" seedUsagePerSqm="0.000400"/>
    <fruit name="barley" hours="24.000000" literPerSqm="0.569400" seedUsagePerSqm="0.015100"/>
    <fruit name="maize" hours="36.000000" literPerSqm="0.686400" seedUsagePerSqm="0.002900"/>
    <fruit name="not used"/>
    <fruit name="potato" hours="30.000000" literPerSqm="3.017700" seedUsagePerSqm="0.240000"/>
    <fruit name="sugarBeet" hours="39.000000" literPerSqm="5.434800" seedUsagePerSqm="0.000700"/>
    <fruit name="sunflower" hours="18.000000" literPerSqm="0.263700" seedUsagePerSqm="0.002300"/>
    <fruit name="soybean" hours="30.000000" literPerSqm="0.191400" seedUsagePerSqm="0.006900"/>
    <fruit name="oilseedRadish" hours="12.000000" literPerSqm="0.243600" seedUsagePerSqm="0.004300"/>
    <fruit name="poplar" hours="72.000000" literPerSqm="0.813000" seedUsagePerSqm="0.150000"/>
    <fruit name="not used"/>
    <fruit name="oat" hours="24.000000" literPerSqm="0.568000" seedUsagePerSqm="0.023600"/>
    <fruit name="sugarCane" hours="30.000000" literPerSqm="4.285700" seedUsagePerSqm="1.200000"/>
    <fruit name="cotton" hours="30.000000" literPerSqm="0.108700" seedUsagePerSqm="0.050000"/>
    <setting showHelp="true" weedGrowthDelayFactor="1.300000"/>
</growthcontrol>
```


Figure 2. Screen shot of the file growthcontrol.xml by apuehri/LS-Modcompany. Here edited to cooperate with RealLifeNumbers.

2 Parameter definition

To facilitate easier location of the model parameters, far the majority of parameters are defined in the script **RealNumbersInitialization**. The parameters defined here are then passed on to the following scripts for processing. You can change the value of existing parameters, but you can't change the order or add additional numbers. If there is a comma separator or a brace "}" behind a number, it must not be removed. All parameters defined here are stored in a global table "RN". Elements in the global table then follow the naming convention RN.cropDensity, RN.soilType, RN.annualLoanInterest, and so on.

We all make mistakes. It is therefore strongly advised, that you keep backups of RealNumbersInitialization.lua.

3 Crop yield

The script **RealNumbersCropYield** sets the bulk material density and harvest yield of the in-game crops. For crop producing straw, the windrow yield is also set. A short excerpt is shown in Table 1.

The log file contains parameter values for all in-game crops.

Figure 3. Harvesting. What yield to expect?

Table 1. Printout to log.

Wheat fillTypeIndex	=	2	
Wheat fruitTypeIndex	=	1	
Wheat massPerLiter	=	0.7720	kg/L
Yield randomness scaling	=	1.0000	
Wheat base yield	=	5187	L/Ha
Wheat no plough loss	=	778	L/Ha
Wheat no weeding loss	=	1037	L/Ha
Wheat liming gain	=	778	L/Ha
Wheat 1x fertilizing gain	=	1297	L/Ha
Wheat max yield	=	10373	L/Ha
Wheat hectar per 30 sec	=	0.0633	Ha
Wheat windrowLiterPerHa	=	46816	L/Ha

Table 2. Mean and variations in crop yield. Germany, 2009 – 2018.

Crop	Mean yield (100 kg/ha)	Variation/mean 2 std/mean
Wheat	75.81	0.198
Barley	64.94	0.237
Oat	46.00	0.254
Maize	96.25	0.213
Potatoes	430.7	0.090
Sugarbeet	729.2	0.071
Oilseeds	36.54	0.363
Canola/rape	36.16	0.383
Sunflower	20.56	0.460
Soybeans	29.23	0.416

Values for bulk crop density vary depending on the crop variety and moisture content. In this mod, values have been obtained from the agricultural service of the province of Alberta, Canada. Values for crop yield depends very much on climate, geographical location and intensity of field preparation and fertilization. For maps within EU, crop yield values have been obtained from the statistical service of the European Union (EUROSTAT). In EU, annual yields are averaged from 2009 to 2018. Similar data is available from the USDA for the 12 agricultural regions in the US. Provided the mod is well received by mod users, mod versions will be released with data from other EU countries and from different agricultural regions in the US.

Crop yield varies from year to year. For some crops it varies more than for others (Table 2). Standard deviation is a statistical measure of how much a set of numbers deviates from their mean value. If the frequency of outcomes in a random process is bell-shaped it is called a normal distribution. About 96 percent of all outcomes with a normal distribution lies within +/-2 standard deviations. It has not been investigated whether variations in crop yield have a normal distribution. Nevertheless, this measure is used here to create reasonable variation in crop yield. The right most column in Table 2 shows the assumed maximum variation divided by the mean, hence presenting yield variation as a fraction of the mean yield. Root crops vary less than 10%, grain crops about 20%, and oilseeds, canola, sunflower and soybean between 36 and 42%.

The yield randomness factor is set for each crop each time the game is started. It is therefore the value of this factor at harvest that determines the yield. If the field is large and the harvest is divided between different game sessions, the randomness factor will be different in each game session, resulting in different yield in each game session. While this behavior is a result of the way the script works, its effect is yield variation across a large field, a real-life fact. Random variation in yield can be turned off by setting the variable `randomness = 0`.

In the Help menu of FS19 it is explained that the crop yield depends on the condition of the field. The intended protocol for adjusting yield based on completed field work is shown in Table 3, center column. Say we want the maximum yield (all field work completed) to match a national/regional average yield of 10000 L/ha. According to the intended protocol, the game parameter should be set to `literPerSqm = 6060.6/10000 = 0.60606`. If you have ploughed and weeded, you should expect 6060.6 L/ha. If you have not ploughed nor weeded, then the yield should be 3939.5 L/ha. If you have completed all field work, you should expect 10000 L/ha. But instead you get two times the specified yield. This means that the actual protocol adds a bonus for ploughing and weeding to the specified “base” yield. Therefore, the script specifies the minimum yield as illustrated in the right most column in Table 3.

Table 3. Intended and actual protocol for yield bonus.

	Intended protocol	Actual protocol
Minimum yield	3939.5 L/ha	5000 L/ha
No ploughing (-15%)	-909.1 L/ha	+750 L/ha
No weeding (-20%)	-1212 L/ha	+1000 L/ha
Base yield	6060.6 L/ha	6750 L/ha
Lime application (+15%)	+909.1 L/ha	+750 L/ha
1x fertilizing (+25%)	+1515 L/ha	+1250 L/ha
1x fertilizing (+25%)	+1515 L/ha	+1250 L/ha
Maximum yield	10000 L/ha	10000 L/ha

When you start harvesting a field, you would like to have an early indication of the yield. For this purpose, the script calculates the harvested area (in ha) for a 30 second run. In Table 1, this is printed in the log file to be 0.0633 ha. If in that 30 second run, 680 liters of crop is harvested, the yield estimate will be 680 L/0.063 ha = 10742 L/ha. To calculate how much land have been harvested in 30 seconds, the mod user must enter work speed (kph) and header width (m) into the script for each harvester.

The windrow yield by weight is defined as 80% of the grain yield by weight. The windrow yield by volume is calculated using the mass density of a straw bale here set to 0.13 kg/L ($8\ \mathrm{lb/ft^3}$). A windrow loss of 5% is incorporated.

The script has a feature to reward the farmer with an adjustable percentage yield increase compared to the statistically expected value for the country/agricultural region provided optimal field preparation, fertilization, liming and weeding has been done. It is set to 1.0 (no extra bonus) as default.

For some crops, statistical information is missing at EUROSTAT/USDA for a given country or agricultural region. In such cases, either the EU average is used, or the US average is used. For cotton, there is no data from EUROSTAT. In this case 50% of the US average has been used, simply from the perspective that cotton does not grow very well in Europe. Although possible, mod users should question the realism in growing cotton and sugarcane in Europe.

4 Green crop yield

Grass yield can be predicted based on kilogram dry matter growth per day per hectare. Such models are used to assess the effect of the number of days between cuts.

Table 4. Yield of grass and hay for two cuts per year.

```
GRASS massPerLiter                          =       0.4600  kg/L
GRASS TonnesPerHa                           =      10.0200  T/ha
GRASS literPerHa                            =    21783      L/ha
GRASS_WINDROW massPerLiter                  =       0.4600  kg/L
GRASS_WINDROW TonnesPerHa                   =       9.5190  T/ha
GRASS_WINDROW windrowLiterPerHa             =    20693      L/ha
GRASS_WINDROW Bale volume                   =     4000      L
GRASS_WINDROW Bale mass                     =     1840      kg
GRASS_WINDROW BalesPerHa                    =       5.1734  Bales/ha

DRYGRASS fillTypeIndex                      =       29
DRYGRASS fruitTypeIndex                     =       14
DRYGRASS massPerLiter                       =       0.1600  kg/L
DRYGRASS Fresh grass moisture               =       0.6693
DRYGRASS Dry grass moisture                 =       0.1500
DRYGRASS Drying mass reduction factor       =       0.3891
DRYGRASS TonnesPerHa                        =       3.7039  T/ha
DRYGRASS literPerHa                         =    23149      L/ha
DRYGRASS_WINDROW massPerLiter               =       0.1600  kg/L
DRYGRASS_WINDROW TonnesPerHa                =       3.5187  T/ha
DRYGRASS_WINDROW windrowLiterPerHa          =    21992      L/ha
DRYGRASS_WINDROW Bale volume                =     4000      L
DRYGRASS_WINDROW Bale mass                  =      640      kg
DRYGRASS_WINDROW BalesPerHa                 =       5.4980  Bales/ha
```

As the national/regional variation in crop yield is one of the main features of the mod, grass yield per hectare is here taken from statistical data sources. To better understand the approach, let us run through the specific situation with data for Germany. The average annual grass yield is 20040 kg/ha, and the statistical variation (spread/mean) is 0.153. Assuming two cuttings per year with equal yield, the yield per cut is 10020 kg/ha. To convert mass to volume we divide the mass yield by the mass density of a grass bale. The mass density of a bale is its weight divided by its volume.

In Farming Simulator, a round bale has a diameter of 1.3 m and a height of 1.12 m, giving it a volume of 1487 Liters. Square bales are 1.2 m x 0.9 m x 2.4 m giving it a volume of 2592 Liters. The density of round bales is set to 0.3 kg/L hence giving it a mass of 446.1 kg. The density of square bales is 0.2, giving it a mass of 518.4 kg. These numbers do not depend on the content of the bales. Regardless of the actual dimensions of the bales, Farming Simulator sets the standard bale volume at a very large 4000 L.

For the purpose of obtaining a content specific density of the bales, the script allows the mod user to define the mass of the bale. The script sets it to 1840 kg. This mass has no influence on how heavy the bale is to handle in the game. The sole purpose is to define a sensible mass density, here set to 1840 kg/4000L = 0.46 kg/L. The grass yield in volume then becomes 10020 (kg/ha) / 0.46 (kg/L) = 21783 L/ha. An adjustable windrow loss (default 5%) reduces the mass yield of windrowed grass to 9519 kg/ha and the volume to 20693 L/ha. The number of grass bales per hectare is 20693 (L/ha) / 4000 (L/bale) = 5.17 bales/ha. Five bales per hectare sounds like a very poor yield. Had we used a more reasonable 1487 L/ round bale, we would obtain 20693 (L/ha) / 1487 (L/bale) = 13.9 bales/ha.

When tedding freshly cut grass, the cut grass reduces its moisture content. A 5% loss is set for tedding. Hay is typically baled, when the moisture content is 15-16 %. The evaporation of water means that the mass of hay yield is less than the mass of fresh grass yield. How large this mass reduction is, depends on the moisture content of the freshly cut grass.

The mass of a bale is the sum of its water content (moisture) and its content of dry matter (DM). When grass dries to become hay, the dry matter content is the same. Hence, we can set up an equality:

$$Mass_{dry\ matter} = DM_{grass} \times Mass_{grass} = DM_{hay} \times Mass_{hay}$$

We want to obtain the dry matter content of grass; hence we can reorganize the above equation:

$$DM_{grass} = DM_{hay} \times \frac{Mass_{hay}}{Mass_{grass}}$$

If hay is assumed to have a moisture content of 15%, then the dry matter percentage is 85%. The mass ratio between hay and grass is here taken as the US average yield ratios.

$$\frac{Mass_{hay}}{Mass_{haylage}} = \frac{5170\ kg/ha}{13300\ kg/ha} = 0.389$$

We can now get an estimate of a reasonable dry mater content in fresh grass, or haylage.

$$DM_{grass} = 0.85 \times 0.389 = 0.33$$

We will then assume, that the moisture content in fresh grass is $1 - 0.33 = 0.67$, or 67%.

The yield of hay is than calculated as:

$$\frac{Mass_{hay}}{ha} = \frac{Mass_{grass}}{ha} \times \frac{DM_{grass}}{DM_{hay}}$$

Inserting numbers, we get:

$$Mass\ Yield_{hay} = 10020\frac{kg}{ha} \times \frac{0.33}{0.85} = 3890\frac{kg}{ha}$$

The script could have forced mass of the hay bale to be 38.9% of that of a grass bale. In this case, the mass of a hay bale would be $0.389 \times 1840\ kg = 716\ kg$. However, to allow the mod user some freedom, the mass of a hay bale is set independently. The default hay bale mass is set to 640 kg. This gives a mass density of the hay bale as $640kg/4000L = 0.16\ kg/L$

Dry grass (hay) mass is converted to volume by dividing the mass hay yield by the mass density of a hay bale (0.16 kg/L). The hay volume yield after tedding and before windrowing is then 23149 L/ha. A 5% loss is assumed for windrowing, hence the hay volume yield after windrowing is 21992 L/ha. This amounts to 5.5 Giant hay bales per hectare. Script printout is shown in Table 4. Random variation in grass/hay yield can be turned on or off as for other crops.

5 Spraying

The script **RealNumbersSpraying** defines the spray rate of sprayers and spreaders for the following types of spray material: solid fertilizer, liquid fertilizer, slurry, manure, digestate, lime, and herbicde. The purpose of applying fertilizers to a field is to add enough amounts of nutrients so that the field will hold enough nutrients to feed the next crop. Real-life farmers thus start by making soil tests to determine, how much nutrient is already present in the field. The applied amount should ideally only be the difference between how much nutrient, a crop need, and how much is already present. How much fertilizer to apply depends on the nutrient concentration of the fertilizer type used.

Figure 4. Spreading manure on top of lime.

5.1 Nutrient need in crops.

There is not yet a feature or a mod to manage the nutrient content in individual fields. Hence the present script only aims to replenish the amount removed from the field when the harvested crop is removed. The amount of nutrients removed by a certain crop can be looked up in tables. It depends on the moisture content in the crop. Typical values are listed in Table 5. The script aims to replenish the average amount of nutrients removed, i.e. the bottom row in Table 5. The removal of nutrients is calculated separately for grain and straw.

Table 5. Nutrient content removed from the field at harvest.

```
Wheat        : Moisture pct = 11.4, N = 191.8 kg/ha, P205 = 70.6 kg/ha, K20 =  35.2 kg/ha
Barley       : Moisture pct = 11.7, N = 131.1 kg/ha, P205 = 59.7 kg/ha, K20 =  40.4 kg/ha
Oat          : Moisture pct = 10.7, N =  82.3 kg/ha, P205 = 34.4 kg/ha, K20 =  22.1 kg/ha
Cotton       : Moisture pct =  9.0, N =  15.0 kg/ha, P205 =  4.3 kg/ha, K20 =   2.7 kg/ha
Canola       : Moisture pct =  8.9, N = 133.7 kg/ha, P205 = 48.8 kg/ha, K20 =  40.8 kg/ha
Sunflower    : Moisture pct =  7.4, N =  60.3 kg/ha, P205 = 28.9 kg/ha, K20 =  17.5 kg/ha
Soybean      : Moisture pct = 10.1, N = 174.5 kg/ha, P205 = 40.9 kg/ha, K20 =  49.6 kg/ha
Maize        : Moisture pct = 13.5, N = 140.1 kg/ha, P205 = 61.2 kg/ha, K20 =  35.7 kg/ha
Potato       : Moisture pct = 77.2, N = 166.0 kg/ha, P205 = 58.3 kg/ha, K20 = 249.5 kg/ha
Sugarbeet    : Moisture pct = 79.3, N = 165.9 kg/ha, P205 = 78.5 kg/ha, K20 = 294.4 kg/ha
Sugarcane    : Moisture pct = 73.8, N =  91.8 kg/ha, P205 = 57.1 kg/ha, K20 = 379.7 kg/ha
Grass        : Moisture pct = 85.0, N =  75.5 kg/ha, P205 = 26.1 kg/ha, K20 = 124.9 kg/ha
Wheat straw  : Moisture pct =  9.2, N =  62.3 kg/ha, P205 = 14.3 kg/ha, K20 = 138.4 kg/ha
Barley straw: Moisture pct = 11.3, N =  63.9 kg/ha, P205 = 20.4 kg/ha, K20 = 202.2 kg/ha
Oat straw    : Moisture pct =  9.7, N =  57.7 kg/ha, P205 = 15.9 kg/ha, K20 = 236.3 kg/ha
Mean values :                      N = 107.5 kg/ha, P205 = 41.3 kg/ha, K20 = 124.6 kg/ha
```

5.2 Nutrient content in fertilizer materials.

The script assumes that the amount of nutrients spread is divided between organic and nonorganic sources of fertilizers. The script assumes that 20 % is supplied via organic fertilizers (slurry, manure or digestate) and that the rest is supplied by artificial fertilizers. We will first determine the nutrient content in the organic fertilizers. This varies between slurry, manure and digestate and is also dependent on the animal producing the organic waste.

Table 6. Nutrient content in organic fertilizers.

```
pigSlurry                      : N =       3.6 kg/Tonne, P205 =       1.5 kg/Tonne, K20 =      2.2 kg/Tonne
pigSlurry crop available       : N =       2.0 kg/Tonne, P205 =       0.8 kg/Tonne, K20 =      2.0 kg/Tonne
pigSlurry liters needed        : N =  60299    L/Ha     , P205 =  61168    L/Ha     , K20 = 69931    L/Ha
cowSlurry                      : N =       2.6 kg/Tonne, P205 =       1.2 kg/Tonne, K20 =      2.5 kg/Tonne
cowSlurry crop available       : N =       1.0 kg/Tonne, P205 =       0.7 kg/Tonne, K20 =      2.3 kg/Tonne
cowSlurry liters needed        : N = 114801    L/Ha     , P205 =  63717    L/Ha     , K20 =   61540    L/Ha
Mixed slurry liters needed     : N =  87550    L/Ha     , P205 =  62443    L/Ha     , K20 = 65735    L/Ha
Reduced slurry liters needed   : N =  17510    L/Ha     , P205 =  12489    L/Ha     , K20 = 13147    L/Ha

pigManure                      : N =       7.0 kg/Tonne, P205 =       6.0 kg/Tonne, K20 =      8.0 kg/Tonne
pigManure crop available       : N =       1.1 kg/Tonne, P205 =       3.6 kg/Tonne, K20 =      7.2 kg/Tonne
pigManure liters needed        : N = 170561    L/Ha     , P205 =  19115    L/Ha     , K20 = 28847    L/Ha
cowManure                      : N =       6.0 kg/Tonne, P205 =       3.2 kg/Tonne, K20 =      9.4 kg/Tonne
cowManure crop available       : N =       0.6 kg/Tonne, P205 =       1.9 kg/Tonne, K20 =      8.5 kg/Tonne
cowManure liters needed        : N = 298482    L/Ha     , P205 =  35841    L/Ha     , K20 = 24550    L/Ha
Mixed manure liters needed     : N = 234522    L/Ha     , P205 =  27478    L/Ha     , K20 = 26699    L/Ha
Reduced manure liters needed   : N =  46904    L/Ha     , P205 =   5496    L/Ha     , K20 =  5340    L/Ha

digestate                      : N =       4.9 kg/Tonne, P205 =       1.1 kg/Tonne, K20 =      3.5 kg/Tonne
digestate crop available       : N =       2.7 kg/Tonne, P205 =       0.6 kg/Tonne, K20 =      3.1 kg/Tonne
digestate liters needed        : N =  44602    L/Ha     , P205 =  72819    L/Ha     , K20 = 44594    L/Ha
Reduced digestate liters needed: N =   8920    L/Ha     , P205 =  14564    L/Ha     , K20 =  8919    L/Ha
```

Farming Simulator does not distinguish between pig waste and cow waste. Hence the script allows the user to define how the total organic waste splits between pigs and cows. By default, the script assumes a 50-50 split.

```
RN.pigSlurryFraction =            0.5;
RN.pigManureFraction =            0.5;
```

Only a fraction of the applied nutrients become available for crop absorption. The worst case is the nitrogen content in cow manure. It contains about 5 kg per Tonne of manure, but only 10% is available for crop absorption. The majority evaporates to the atmosphere.

```
nutrient.pigSlurryNCropAvailability = 0.55;
nutrient.pigSlurryPCropAvailability = 0.50;
nutrient.pigSlurryKCropAvailability = 0.90;
nutrient.cowManureNCropAvailability = 0.10;
nutrient.cowManurePCropAvailability = 0.60;
nutrient.cowManureKCropAvailability = 0.90;
```

Using the mixing ratios and the crop-availability parameters, the script defines the NPK content in a representative slurry/manure.

5.3 Amounts of organic and inorganic fertilizer to be applied

The ratio of N, P, and K needed are different from the ratios in the fertilizer sources, hence the script calculates the organic fertilizer dose to meet the need of phosphate. Most countries have fertilizer acts regulating how much N, P, and K can be applied. Phosphate is typically the nutrient with the strictest limitation. The script then calculates how much N, P, and K is delivered per hectare, when the need to phosphate is met.

The amount of artificial fertilizer to apply is calculated as the gap between the needed potassium (K) and the average applied from slurry, manure and digestate.

The amount of liquid fertilizer needed is less than that for solid fertilizer, as the nutrients come in direct contact with the plants. This is included in the script using the parameter (`RN.liqfertLiquidReductionFactor`). Liquid fertilizers must be diluted with water for the sprayer to work effectively. The spray rate parameter must take this into account. The script provides a parameter (`RN.liqfertDilutionFactor`) to set the dilution factor. It is set so that 1 Liter of liquid fertilizer is diluted to a 20 Liter solution. The price for liquid fertilizer is then reduced by a factor 20 as only 5% of the tank is fertilizer, 95 % is water.

5.4 Lime application

Lime is spread to raise the pH of the soil. How much to spread depends on (1) how much the pH needs to be raised, (2) on the soil type, and (3) on the lime source. The script allows the user to define these parameters:

```
RN.soilType =          2;
RN.soilCurrentpH =     6;   -- determinant for lime application rate
RN.soilTargetpH =    6.7;   -- determinant for lime application rate
RN.limeNV =           50;   -- "Neutralizing Value, Ground limestone = 50
-- 1: Sands and loamy sands: 2: Sandy loams and silt loam; 3: Clay loams and clay
```

5.5 Herbicide application

Herbicides are sprayed to kill weeds. In this script, the default amount is 2 kg/ha, but this can be changed by the mod user. Herbicides are usually diluted with water and sprayed with a liquid fertilizer sprayer. In the script, the default dilution is set by the parameter:

```
RN.herbicideDilutionFactor = 200; -- 1 liter of herbicide to 200 liter of water
```

The price of herbicide is reduced accordingly.

5.6 Calibration of sprayers and spreaders

To set the spray rate, i.e. how much to be sprayed of a given spray type, Farming Simulator uses the parameter litersPerSecond. The name of this parameter suggests that we must specify how large a volume of spray material is output by the sprayer/spreader per second. This would not be convenient as the output rate should depend on width and working speed of the sprayer/spreader, values that vary from one brand/model to another.

If one looks into the function: Sprayer:getSprayerUsage(fillType, dt) in the scripting documentation, the last line says:

```
scale * litersPerSecond * self.speedLimit * workWidth * dt * 0.001
```

The purpose of this function is to calculate the volume output in a certain time interval. For this to be possible, `litersPerSecond` must be understood as `litersPerSqm`. We already have the application rate per hectare, hence it is simple to get the needed parameter value.

$$LitersPerSqm = LitersPerHa/10000$$

There is apparently an error in the line of code shown above. I assume speedLimit is given in kph, in which case this should have been divided by 3.6. As this is missing, the script divides the application rate by 3.6.

The line of code also includes a `scale` factor. This allows the sprayer/spreader mod maker to scale the output. In many mods, `scale = 1`, but you cannot be certain. It may therefore be necessary to calibrate the output rate of your sprayers and spreaders.

To facilitate the calibration, the script needs to know the *spray width* in meters, the *working speed* in kph, and the *load capacity* in liters. These values must be entered the script using a text editor. Using these parameters, the script will calculate and print out to the log file how many liters per second the spreader/sprayer must deliver. It will also print out how many liters to spray in 30 seconds, to meet the target dosage. This information is needed to determine the `RN.sprayCalibrationFactor`.

The calibration procedure is listed in Table 7.

If for example the 30 sec target volume is 2850 liters and the actual liters sprayed is 2550 liters, then the calibration factor is calculated as:

$$calibrationFactor = \frac{2850}{2550} = 1.118$$

In some cases, the calibration factor is smaller than one, in other cases equal to or larger than one. When the calibration factor has been determined, the game must be saved and terminated, so you can enter the correct value into the script. When the script has been edited, saved and rezipped, the zip file must be moved to the mod folder and the game restarted. To be certain, that the calibration is as accurate as you would like it to be, you will need to do a verification run. You simply repeat the procedure and see if the delivered amount is close to the target volume. If not, the calibration factor must be further adjusted. A 5 % accuracy seems a good goal.

Table 7. Calibration procedure.

Step	Action
1	Choose a field long enough that it takes more than 30 seconds to drive at working speed from one end to the other.
2	Write down how much spray material there is in the spreader/sprayer before the test run starts.
3	Place the tractor and sprayer in position and ready at one end of the field.
4	Set a countdown timer (e.g. smart phone app) to 30 sec.
5	Press the start button on the timer and the "Hire helper" button on the keyboard simultaneously.
6	When the timer alarm beeps, stop the helper.
7	Write down how much spray material is left in the sprayer.
8	Calculate the difference in amount to determine how many liters have actually been applied in 30 sec.

You need to calibrate every spreader and sprayer on your farm. If you use the same sprayer/ spreader for different spray material, you need to calibrate the sprayer/spreader for each spray type.

The script writes output to the log file. An excerpt is shown in Table 8.

Table 8. Sprayer information for a slurry spreader.

```
Spray width                        =      12       m
Working speed                      =      17       kph
Sprayer capacity                   =   15780       L
Work capacity                      =      20.4000  Ha/hour
Slurry liter per ha:               =   12024       L/Ha
Liters per square meter            =       1.2024  L/sqm
Square meters per sec              =      56.6667  sqm/s
Liters per sec                     =      68.1383  L/s
Ha per load                        =       1.3123  Ha
Calibration time                   =      30       sec
Calibration dose                   =    2044       L
Calibration area                   =    1700       sqm
Calibration factor                 =       1.0000
```

Other convenient information is the work capacity of the implement in Ha/hour and Ha/load. The first parameter tells you how much land you can cover if you never make turns at the headland or stop for refilling. In real life, the Ha/hour performance is much less for implements that need refilling. How many time-consuming refillings is needed, can be judged from the other parameter Ha/load. If you know the typical size of your fields, e.g. 4 ha, then it is very time saving to buy a spreader with a load capacity of slightly more than 4 ha/load. For a slurry spreader, like the one in Table 8, you would almost always need several loads to complete the field. Field sizes are printed out by another script in this mod.

6 Seed usage

The script **RealNumbersSeedUsage** defines how much seed needs to be applied per area for seeded and planted crops. This depends both on the crop type and the season for seeding and planting.

Seed resellers often provide an equation for calculating the seed rate:

$$seedUsagePerHa = \frac{TSM(gram) \times plantsPerSqm\ (m^{-2})}{Germination\ percentage}$$

TSM means “thousand seed mass” and is entered in grams. As an example, lets us look at spring barley. $TSM = 30\ g.\ plantsPerSqm = 300, Germinatin\ percentage = 90\%$. Entering these numbers in the equation we get:

$$seedUsagePerHa = \frac{30\ g \times 300\ (m^{-2})}{90} = 100\ kg/ha$$

The script only considers the crops for which I was able to find data: Wheat, Barley, Oat, Canola, Sunflower, Soybean, Maize, Potato, Sugarbeet, Oilseed Radish, Grass, and Sugar cane. I miss data for Cotton and Poplar. The volume of seed per hectare is obtained by dividing the mass by the density of the seed. Example data is shown in Table 9.

Figure 5. Planting potatoes stored in root crop bunker (modified silage bunker). Oberlausitz map by RitchiF.

The script provides the option of calibrating the seeder in a manner identical to that for sprayers and spreaders. However, as seen from Table 9, the volume output in 30 seconds is too small to be accurately measured by the seed tank content information given to the player. Hence, it is more accurate to seed a whole field, and divide the field area into the volume of used seed. An example: a 5.5 ha field required 794 L of wheat seed. The seed rate is then 144.4 L/ha. According to Table 9, the target seed usage is 122 L/ha. Hence the calibrationFactor = 122/144.4 = 0.845. The calibration factor may vary depending on the crop, the seeder, and perhaps the map.

Table 9. Seed usage data and seeder calibration data.

```
Wheat massPerLiter                        =        0.7720  kg/L
Wheat seedUsageRatePerHa                  =      122       L/Ha
Area per sec                              =       13.3333  sqm/s
Seeding rate                              =        0.1622  L/s
Calibration dosage                        =        4.8647  L
Calibration area                          =      400.0000  sqm
Calibration factor                        =        0.8450

Barley massPerLiter                       =        0.6180  kg/L
Barley seedUsageRatePerHa                 =      151       L/Ha
Area per sec                              =       13.3333  sqm/s
Seeding rate                              =        0.2014  L/s
Calibration dosage                        =        6.0410  L
Calibration area                          =      400.0000  sqm
Calibration factor                        =        1.0000
```

Seed usage depends on the germination percentage, a factor that varies considerably.

Table 10. Germination percentage.

	Seed bed preparation		
	Good	Average	Poor
Spring	95%	90%	80%
September	90%	85%	80%
October	85%	80%	75%

7 Crop sell prices

Mean crop sell-prices have been collected for a number of EU countries and USDA farming regions. Using the crop mass density these prices are converted to €/1000 L and used in the script **RealNumbersCropPrices** to overwrite the default values. If one multiplies the crop sell price with the crop yield, we obtain crop income per hectare.

Table 11. Crop sell prices and predicted income per hectare (Germany).

Wheat pricePer1000Liter	=	129	€/1000 L
Wheat pricePerHa	=	1337	€/Ha
Barley pricePer1000Liter	=	99	€/1000 L
Barley pricePerHa	=	1123	€/Ha
Oat pricePer1000Liter	=	69	€/1000 L
Oat pricePerHa	=	741	€/Ha
Canola pricePer1000Liter	=	192	€/1000 L
Canola pricePerHa	=	1127	€/Ha
Sunflower pricePer1000Liter	=	129	€/1000 L
Sunflower pricePerHa	=	724	€/Ha
Soybean pricePer1000Liter	=	298	€/1000 L
Soybean pricePerHa	=	1139	€/Ha
Maize pricePer1000Liter	=	121	€/1000 L
Maize pricePerHa	=	1663	€/Ha
Potato pricePer1000Liter	=	122	€/1000 L
Potato pricePerHa	=	7365	€/Ha
Sugarbeet pricePer1000Liter	=	22	€/1000 L
Sugarbeet pricePerHa	=	2435	€/Ha

Figure 6. Real-life crop sell-prices. The prices shown here are scaled by a factor 2 compared to Table 11 because the economic difficulty level was set to Normal at the time when the screen dump was made.

The biggest income source is potatoes. Despite the low selling price, sugarbeet is ranked second due to its high yield. This information must of course be compared with the cost of labor and equipment. You need to harvest 203 hectares of sugarbeet, before the 495,000 € Holmer Sugarbeet harvester is paid off. If you only have 2 hectares of sugarbeet, that would take 100 years. The table also suggest that growing Oat and Sunflower in Germany is a waste of good land, unless you have a couple of horses to feed. In other countries/USDA regions the picture is likely to be completely different.

The redefined sell prices will only have their correct values when the economic difficulty level is set to HARD. Changing the economic difficulty level to Normal will scale the sell prices by a factor 2 and the Easy level will scale by a factor 3. The in-game sell price variation between sell points makes it difficult to see, if the specified sell-price is in effect. If there seems to a tendency that the mean sell-prices are higher than they should be, it is very likely that you are playing on a contributor map, where the map maker has scaled sell prices for some of the map placeables.

Unfortunately, the in-game price variation between sell points is much too high, creating opportunities to sell at two times the national average.

8 Commodity prices

In Farming Simulator, the purchase price of farmland is very high. Much higher than in real life. The script **RealNumbersCommodityPrices** allows you to set the farmland price to a realistic value.

For some countries this information is confidential and therefore not include in EUROSTAT documents. The price per hectare varies considerably due to local differences in national laws (regulating foreign ownership), regional differences in climate and agricultural infrastructure as well as local variations in soil quality, drainage and terrain elevation.

It is very common that farmers rent farmland from other farmers. While this is not a standard feature in Farming Simulator, it is accomplished in this script by assigning lower prices to some fields. The price for renting farmland in EU and USDA farming regions are listed in Table 13 and Table 14. In EU, the ratio of rent-to-purchase varies from 0.01 to about 0.05, with an average of 0.025, or 2.5% of the purchase price. This would be a good second guess if playing a map in a country where farmland rent prices is confidential.

Table 12. Purchase price for farmland in EU. €/ha.

	2011	2012	2013	2014	2015	2016	2017
Belgium							
Bulgaria	2112	2843	3175	3620	3891	4131	4622
Czech Republic	1836	3264	3662	4282	4775	5463	6462
Denmark	17476	17562	15708	17209	18752	17584	17328
Germany							
Estonia	1062	1265	1865	2426	2567	2735	2890
Ireland			26366	23449	23594	18141	19903
Greece	15393	14968	13907	13276	12633	12528	12627
Spain		12005	11910	12192	12574	12522	12827
France	5390	5440	5770	5940	6000	6070	6030
Croatia					2726	2835	3005
Italy	34257	39342	32532	39247	40153	28985	33538
Cyprus							
Latvia	2336	4475	4980	2552	2654	2917	2975
Lithuania	1212	1527	2009	2330	3089	3516	3571
Luxemburg	23648	24230	26621	27438	27738	26030	35590
Hungary	2089	2380	2709	3042	3356	4182	4368
Malta							
Netherland	50801	52716	54134	56944	61400	62972	68197
Austria							
Poland	4855	6080	6275	7723	9220	9083	9699
Portugal							
Romania	1366	1666	1653	2423	2039	1958	2085
Slovenia			15545	16009	16071	17136	16876
Slovakia							
Finland	8210	8047	8461	8090	8138	8326	8718
Sweden	6811	7043	6797	7408	7751	7921	8708
United Kingdom	18885	21905	23283	26634	30464	25999	23450

Taking a loan is easy in Farming Simulator. With a default interest rate of 300% it might not be easy to pay back the loan. The script sets the interest rate at 4% and a max loan amount to 3 mill. €. Both can easily be changed.

Table 13. Rent price per year in EU. €/ha.

	2011	2012	2013	2014	2015	2016	2017
Belgium							
Bulgaria	153	174	194	210	215	225	240
Czech Republic	56	61	66	73	87	96	104
Denmark	534	562	555	535	518	536	539
Germany							
Estonia	26	35	40	48	52	52	58
Ireland			258	255	269	290	295
Greece	549	544	460	435			
Spain		134	136	138	140	144	148
France	139	145	155	167	184	202	215
Croatia			73	67	73	74	69
Italy							
Cyprus							
Latvia	57	67	71	38	43	46	57
Lithuania	56	66	78	80	80	81	99
Luxembourg				220	233	240	244
Hungary	107	126	129	131	139	151	160
Malta							
Netherlands	624	653	683	720	749	794	847
Austria	260	264	270	276	281	285	288
Poland							
Portugal							
Romania							
Slovenia							
Slovakia	37	37	39	44	44	50	
Finland	191	213	210	223	225	226	229
Sweden	168	176	180	174	160	160	
United Kingdom	214	238	212	237	245	224	

Table 14. Rent prices on farmland in USDA regions. $/ha. Averaged over 2016--2018.

USDA Regions	$/ACRE	$/ha
Delta Region	97	240
Eastern Mountain Region	87	214
Great Lakes Region	157	388
Heartland Region	156	386
Mountain Region	97	239
North Eastern Region	81	200
Northern Plains Region	96	238
Northwest Region	170	421
Pacific Region	267	659
Southern Plains Region	37	91
Southern Region	96	236
Upper Midwest Region	180	444
US average	**127**	**313**

The purchase price of a number of commodities are listed in Table 15. Herbicide and fertilizers are expensive. For herbicide and liquid fertilizer, the purchase price of pure substance has been reduced by typical sprayer dilution factors as mentioned in the section on spraying.

A small random day-by-day variation is installed in commodity prices:

```
RN.commodityPriceVariation = 10;    -- price fluctuation in percentage
```

Table 15. Commodity prices (Germany).

Annual interest rate	=	4	%
Max loan	=	3000000	€
Farmland purchase price Per Ha	=	25000	€/ha
Farmland rent price Per Ha	=	625	€/ha
FUEL massPerLiter	=	0.7500	kg/L
FUEL	=	1074	€/1000 L
WATER massPerLiter	=	1.0000	kg/L
WATER	=	100	€/1000 L
SEEDS massPerLiter	=	0.3200	kg/L
SEEDS	=	157	€/1000 L
DIESEL massPerLiter	=	0.8400	kg/L
DIESEL	=	916	€/1000 L
FERTILIZER massPerLiter	=	0.8000	kg/L
FERTILIZER	=	378	€/1000 L
LIQUIDFERTILIZER massPerLiter	=	0.9000	kg/L
LIQUIDFERTILIZER (diluted)	=	60	€/1000 L
PIGFOOD massPerLiter	=	0.6500	kg/L
PIGFOOD	=	189	€/1000 L
FORAGE_MIXING massPerLiter	=	0.2200	kg/L
FORAGE_MIXING	=	54	€/1000 L
LIME massPerLiter	=	1.2000	kg/L
LIME	=	64	€/1000 L
HERBICIDE massPerLiter	=	1.0000	kg/L
HERBICIDE (diluted)	=	51	€/1000 L

The purchase price of store commodities, such as bales, bigbags and pallets are reduced to values typical for the country/USDA region, and the prices are made to fluctuate randomly. For this reason, there will be small differences in the prices of round and square bales.

Figure 7. Modified store prices on pallets.

Figure 8. Not everything costs money. Sometimes you are lucky. Oberlausitz map by RitchiF.

The cost of leasing equipment is very high in Farming Simulator. The in-game default cost is divided into three components, all percentages of the purchase price: a 2% lease initiation fee, 1 % daily fee, and an hourly fee of 2.1%. Let us consider as an example that we have 4 ha of sugar beet to harvest. According to Table 11, the crop income will be about 10,000 €. Let us assume that we can harvest the field within 2 hours if we use the big Holmer self-propelled sugar beet harvester. It costs about 500,000 €, hence the cost of leasing for two hours will be (2+2.1+2.1+1= 7.2%) 36,000 €.

As I have no knowledge of farm economy, I will assume that an equipment cost of more than 10% of the crop income would be considered unacceptable. In this scenario, lease costs should not exceed 250€/ha.

Attempts have been made to reduce the cost of leasing equipment. I've tried the following lines of code:

```
if g_storeManager.items ~= nil then
   for k,items in pairs(g_storeManager.items) do
        if items.allowLeasing then
           items.runningLeasingFactor  = RN.DEFAULT_RUNNING_LEASING_FACTOR;
        end;
   end;
end;
g_currentMission.economyManager.DEFAULT_RUNNING_LEASING_FACTOR =
                                                      RN.DEFAULT_RUNNING_LEASING_FACTOR;
g_currentMission.economyManager.PER_DAY_LEASING_FACTOR = RN.PER_DAY_LEASING_FACTOR;
g_currentMission.economyManager.DEFAULT_LEASING_DEPOSIT_FACTOR =
                                                      RN.DEFAULT_LEASING_DEPOSIT_FACTOR;
```

Although the new values are stored in their variables, they have no effect in the store menu. If anybody knows how to fix this, please let me know.

9 Animal products

Sell prices for animal products (milk, wool and egg) have been obtained for EU countries and USDA agricultural regions. These prices are defined in the script **RealNumbersAnimalProducts**. Output to the log file is shown in Table 16.

Wool density is based on wool bales of 480 L and 180 kg yielding 0.375 kg/L. Egg density is based on 60 gram per egg and bulk volume of 50 ml/egg, yielding 1.2 kg/L.

Table 16. Sell prices for animal products (Germany).

MILK massPerLiter	=	1.0250	kg/L
MILK pricePer1000Liter	=	322	€/1000 L
WOOL massPerLiter	=	0.3750	kg/L
WOOL pricePer1000Liter	=	2531	€/1000 L
EGG massPerLiter	=	1.2000	kg/L
EGG pricePer1000Liter	=	1908	€/1000 L

Figure 9. Off to the spinnery. Felsbrunn.

10 Animal care

The script **RealNumbersAnimalCare** redefines a large number of parameters associated with husbandry farming. These parameters can be divided into three main groups:

- Reproduction rate
- Animal input (food consumption)
- Animal output

In addition, the script makes predictions on:

- Total amount of feed required per animal type for one year
- Amount of bedding straw bales required per animal type for one year
- Amount of water consumed in a year
- Amount of feed components required (grain, protein, root crop, grass, hay, silage)
- Number of bales (straw, hay, and silage) needed for feed
- Field areas required to produce the feed and bales
- Amount of milk, manure and slurry produced in a year.

Table 17. Average number of animals on EU farms in 2015.

Country	Farms	Total animals	Dairy cows	Other cattle	Sheep and goats	Pigs	Poultry
(BEL) Belgium	29140,00	128,79	18,42	46,35	0,74	51,43	11,51
(BGR) Bulgaria	114420,00	11,79	2,64	2,60	2,55	2,00	1,92
(CYP) Cyprus	10470,00	8,55	1,81	0,86	3,62	0,58	1,68
(CZE) Czech Republic	17210,00	91,51	21,96	38,63	1,04	19,41	9,97
(DAN) Denmark	28330,00	144,96	20,83	21,38	0,51	95,28	6,42
(DEU) Germany	187460,00	89,55	23,19	26,12	0,68	36,17	2,71
(ELL) Greece	346580,00	6,01	0,13	1,06	4,48	0,08	0,24
(ESP) Spain	417830,00	32,22	2,26	6,77	5,13	14,27	3,64
(EST) Estonia	7620,00	39,62	13,63	15,33	1,24	7,48	1,63
(FRA) France	298110,00	72,51	12,78	32,22	3,24	10,76	13,24
(HRV) Croatia	81460,00	9,11	1,91	1,99	1,83	1,82	1,35
(HUN) Hungary	102100,00	20,81	2,63	3,28	1,40	8,08	5,26
(IRE) Ireland	86380,00	58,67	13,96	38,95	5,31	0,09	0,03
(ITA) Italy	532660,00	19,88	3,10	5,34	1,56	6,25	3,49
(LTU) Lithuania	61710,00	11,98	4,69	5,02	0,24	1,60	0,36
(LUX) Luxembourg	1600,00	112,70	29,12	65,16	0,54	17,36	0,23
(LVA) Latvia	24680,00	21,54	6,84	7,17	0,30	6,93	0,23
(MLT) Malta	2830,00	16,24	2,52	2,04	0,56	6,75	4,27
(NED) Netherlands	49520,00	135,16	33,04	25,30	2,78	50,52	22,87
(OST) Austria	91290,00	24,45	6,12	8,64	0,54	7,32	1,58
(POL) Poland	735170,00	12,09	3,07	3,37	0,08	3,78	1,67
(POR) Portugal	97690,00	15,08	2,01	6,75	3,14	0,51	2,57
(ROU) Romania	1133230,00	4,57	1,37	0,56	1,65	0,57	0,31
(SUO) Finland	36630,00	30,03	8,00	9,84	0,25	8,96	2,80
(SVE) Sweden	27990,00	76,04	13,77	27,64	0,97	23,76	9,56
(SVK) Slovakia	3650,00	143,09	38,08	57,43	10,39	20,15	16,74
(SVN) Slovenia	43930,00	9,96	2,28	5,09	0,41	1,37	0,58
(UKI) United Kingdom	97580,00	135,50	18,41	51,27	30,78	17,55	16,79
Average		52,94	11,02	18,43	3,07	15,03	5,13

These predictions are made for small pens and for large-scale specialized pens. The predictions can help the mod user to determine, how many animals can be fed by a certain amount of farmland. If you want to aim for an average farm hold in a specific EU country, Table 17 lists the average number of farm animals.

10.1 Animal reproduction rate

Farming Simulator uses the same type of reproduction model for all animal types. This model ignores that pigs typically gets 13-14 pigs in a litter and sheep produce on average 1.25 lambs (can be set by the user). The in-game model also ignores that it takes a considerable time before an animal is mature enough to reproduce. We cannot side-step the in-game model used, but we can set up birth rates such that we will see a realistic increase in the number of animals within a breeding cycle. Examples of small-scale pens are shown in Table 18. The number of breeders can easily be changed.

Table 18. Breeding model parameters

Parameter	Symbol	Pig	Cows	Sheep	Chicken
Game days per year		12	12	12	12
Breeding cycles per year		2	1	1	4
Breeding days	N_{days}	6	12	12	3
Litter size per breeder		13	1	1.25	7
Number of breeders	n_0	6	20	30	10
Offspring		78	20	37.5	70
Animals after one cycle	n_{end}	84	40	67.5	80
Pen capacity	n_{max}	100	50	80	100
Birth rate parameter	k	0.7350	0.1493	0.1831	1.1945
Mean number of animals	n_{mean}	40.15	30.66	50.47	41.97
Time to first birth		5:22:58	13:17:29	6:56:45	2:08:22

Figure 10. Two pig pens, 2 cow pens, 3 sheep pens, 1 chicken pen and 1 horse pen on Felsbrunn.

For this scheme to work, we must operate with the concept of a year, and number of game days per year. Without the Seasons mod by Realismus Modding, this is all completely fictional, and only serves the purpose of generating real-life animal reproduction.

Target numbers for animal reproduction is listed in Table 18. Horses do not breed in FS19. It requires a bit of mathematics to calculate the birth rates that will produce the target numbers. If not interested, skip this part.

$$\frac{dn}{dt} = k\frac{n_{max} - n(t)}{n_{max}} \times \, n(t)$$

The rate of increase in animal numbers (dn/dt) is proportional to the current number of animals ($k \times n(t)$), and k is the birth rate parameter we want to determine. As a new feature in FS19, birthrate will decrease as the number of animals in the pen approaches the pen capacity (n_{max}). As $n(t) \rightarrow n_{max}$, the fraction on the right-hand side approaches zero. To avoid severe effects of this growth stagnation, pen capacity should be much larger than the number of animals intended to hold.

The solution to the differential equation is:

$$n(t) = \frac{e^{k\,t}\, n_0\, n_{max}}{n_{max} + n_0(e^{k\,t} - 1)}$$

where n_0 is the starting number of animals. Solving for the birth rate k, we get:

$$k = \frac{1}{t}\ln\left(\frac{n(t)}{n_0} \times \frac{n_{max} - n_0}{n_{max} - n(t)}\right)$$

To make this result useful, we will define time t as the number of game days in the breeding cycle (N_{days}). The target number of animals we will denote n_{end}. Inserting this notation, we get:

$$k = \frac{1}{N_{days}}\ln\left(\frac{n_{end}}{n_0} \times \frac{n_{max} - n_0}{n_{max} - n_{end}}\right)$$

Using this equation, the birth rate has been calculated for the parameters listed in Table 18. For calculating feed consumption, we also need to know the average number of animals within the breeding cycle:

$$n_{mean} = \frac{n_{max}}{k\, N_{days}}\ln\left(1 - \frac{n_0}{n_{max}}\left(1 - e^{k\, N_{days}}\right)\right)$$

The script also calculates the time to the first birth.

Figure 11 shows the growth in the number of animals over time (months). For pigs and chickens, the growth-limiting effect of the pen capacity causes the growth rate to approach stagnation. For sheep and cows, the pen capacity is not limiting.

To make it clear whether a potential capacity limitation can slow down animal production by an unforeseen amount, the script prints out the pen capacities found on the map.

If the preset number of birth-giving animals is too big for the pen capacity, the number of birth-giving animals are reduced sufficiently for the pen to hold all animals at the end of the rearing cycle.

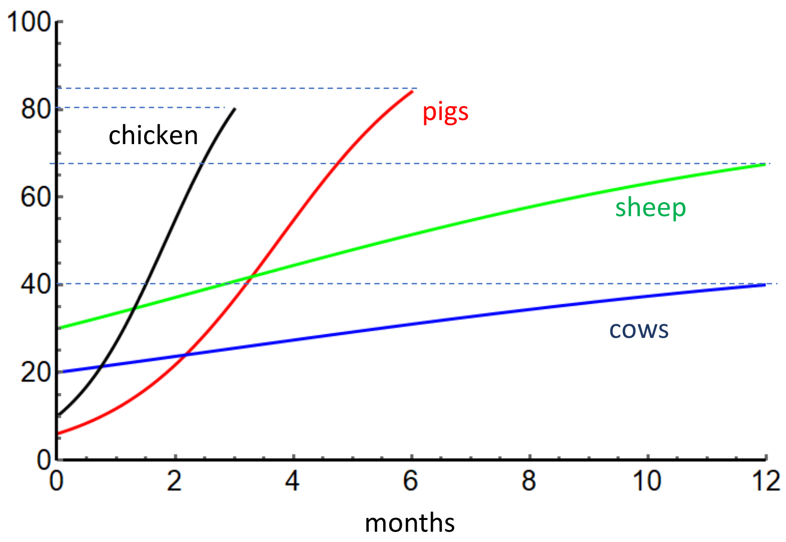

Figure 11. Growth rate of animals.

Table 19. Animal pen capacities on the map.

Pig shed number 1 has a capacity of	=	300	animals
Pig shed number 2 has a capacity of	=	500	animals
Cow shed number 1 has a capacity of	=	200	animals
Cow shed number 2 has a capacity of	=	500	animals
Sheep shed number 1 has a capacity of	=	80	animals
Sheep shed number 2 has a capacity of	=	250	animals
Sheep shed number 3 has a capacity of	=	250	animals
Chicken shed number 1 has a capacity of	=	100	animals
Horse shed number 1 has a capacity of	=	16	animals

To allow the user to follow the progress in animal reproduction, Table 20 shows the development in number of animals, game day by game day for different size pens. If you filled the pen with the starting animals at 11:00, then your daily check up on progress should be at 11:00.

Notice that the numbers listed in Table 20 depend on the pen size. If your pen size is different, the numbers will not agree. Notice that the birthrate (k) is sometimes identical. This happens, if one pen is a complete upscale of another.

We don’t know for sure, if the proposed approach to determine the birth rate actually agrees with Farming Simulator. To investigate this, a test run was made with 6 sows in a pen with capacity for 300 pigs. The “Time to next animal” was recorded for the first six births and entered into Table 21 together with times predicted by RealNumbersAnimalCare.

Figure 12. Thirsty pigs. Oberlausitz map by RitchiF.

Table 20. Evolution in animal numbers as game days progress.

	Pigs	Pigs	Pigs	Cows	Cows	Cows	Sheep	Sheep	Sheep
Start number	6	12	24	20	40	100	30	100	200
Litter size	13	13	13	1	1	1	1.25	1.25	1.25
End number	84	168	336	40	80	200	67.5	225	450
Pen size	100	300	500	50	200	500	80	250	500
Grow days	6	6	6	12	12	12	12	12	12
k	0.7350	0.5699	0.6174	0.1493	0.0817	0.0817	0.1831	0.2169	0.2169
Game day									
1	11.7	20.6	42.7	21.8	42.7	106.7	33.5	113.2	226.5
2	21.7	34.6	73.9	23.7	45.5	113.7	37.1	126.8	253.5
3	36.7	56.2	121.6	25.5	48.4	121.1	40.8	140.2	280.5
4	54.7	86.8	186.7	27.4	51.5	128.7	44.4	153.4	306.8
5	71.6	125.6	262.5	29.2	54.7	136.7	48.0	165.9	331.8
6	84.0	168.0	336.0	31.0	58.0	144.9	51.4	177.5	355.1
7				32.7	61.4	153.5	54.7	188.2	376.3
8				34.4	64.9	162.3	57.8	197.7	395.4
9				35.9	68.6	171.4	60.6	206.1	412.2
10				37.4	72.3	180.7	63.1	213.4	426.8
11				38.8	76.1	190.3	65.4	219.7	439.4
12				40.0	80.0	200.0	67.5	225.0	450.0

The numbers are the minutes between consecutive births. The RN column is predicted times and FS19 are observed times. It is noted, that FS19 rounds off “Time to next animal” to the nearest quarter. Over a long season, such rounding can lead to a significant deviation between expected and actual animals at the end of the rearing season.

Table 21. Comparison of predicted "Time to next animal" with that observed in FS19.

	Pigs	
Start number	6	
Litter size	13	
End number	84	
Pen size	300	
Grow days	6	
k	0.4912	
Minutes to next animal		
	RN	FS19
1	498.54	495
2	428.78	420
3	376.47	375
4	335.79	330
5	303.25	300
6	276.64	270

10.2 Small scale versus large scale husbandry

Farming Simulator 19 has introduced animal subtypes. There are 4 types of pigs, sheep, and chickens and 8 types of cows and horses. Each animal subtype can be assigned different parameters for feed consumption, reproduction, and production of milk, wool and egg. This allows the mod to set up specialized pen types for each animal and use the animal subtypes to define different features of each pen. This is only the second-best option. It would have been better if the features of the animals were inherited from the pen they are living in, so you could define breeding pen, grower's pen, finisher's pen, etc. As this is not the case, the approach taken is to use the subtypes of animals to define breeders, growers, finishers etc.

Table 22. Standard animal pens.

	Pigs	Cows	Sheep	Chicken
Animal color	Red	Brown	White	Black
Animal color		Brahman Brown		
Mature	6	20	24	42
Littersize	13	1	1.25	7
Offspring per breeding cycle	78	20	30	294
Breeding cycle (months)	6	12	12	12

The mod offers standard pens and specialized pens. The standard pens operate as we are used to. Standard pen animals breed and produce milk, egg or wool. Offspring becomes immediately mature and start breeding themselves. As far as the standard pens are concerned, the mod only adjusts the feed consumption, birthrates and production rates so to compensate for the fact that offspring do not eat as much as mature animals, and they do not breed, or produce milk, egg or wool. After a set time, the pen has produced a realistic number of offspring, produced realistic amounts of milk, egg, and wool and consumed a realistic amount of feed, water and bedding straw (Table 22). Standard pens are best suited for small scale animal farming.

10.3 Large-scale pig farming

In this mod, large-scale pig farming requires three specialized pens to be used (Table 23).

Table 23. Large-scale pig farming

	Breeder's pen	Grower's pen	Finisher's pen
Animal color	White	Black-White	Black
Breeding cycle (months)	6	6	6
Offspring months in pen	2	1	1
Mature animals (breeding)	48	0	0
Litters per month	8	0	0
Offspring (non-breeding) per month	104	0	0
Added offspring per month	0	104	104
Removed offspring per month	104	104	104
Starting weight (kg)	1	21	47
End weight (kg)	21	47	81

Figure 13. Large-scale pig farming at Fenton Forest by Stevie.

With two litters per year, 48 sows will have 96 litters. Spread out evenly, this corresponds to 8 litters of 13 piglets per month. Each litter of piglets stays in the breeder's pen for 2 months, but each month 8 litters are moved to the grower's pen. The growers only stay in the grower's pen for one month, then 104 growers are "moved" to the finisher's pen. The finishers stay in the finisher's pen for one month and are then sold for slaughter. Hence 104 finishers are sold for slaughter each month. You can change the number of pigs as you desire.

Because the features of the growers are defined by the animal color and not by the pen, we cannot actually move the growers from the grower's pen to the finisher's pen. Instead we must sell the black-white growers at the grower's pen and buy the black finishers at the finisher's pen. The growers are sold at the same price as the finishers are bought, hence the "move" is economically neutral. For this reason, the transport fee is set to zero for animals in specialized pens.

The reason we cannot mix growers and finishers in the same pen is that their feed consumption and waste production differ.

10.4 Large-scale dairy farming.

For large-scale dairy farming there are three specialized pens.

Table 24. Large-scale dairy farming.

	Milker's pen	1st year pen	2nd year pen
Animal color	White	Black	Black-White
Animal color (Brahman)	White	Light brown	Grey
Breeding cycle (months)	12	12	12
Offspring months in pen	0	12	12
Mature animals (breeding)	96	1	0
Offspring (non-breeding) per year	0	96	0
Added offspring per year	0	96	16
Removed offspring per month	0	96	16
Starting weight (kg)	0	20	290
End weight (kg)	0	290	545

Newborn calves are removed from the cow about 48 hours after birth. For this reason, it does not make sense to let the offspring live with the mature cows. Instead a "dummy" breeder needs to be put in the 1st year pen. This dummy breeder produces one calf per year for each cow in the milker's pen. In the mod, the milkers only produce milk, they do not breed. After one year, the growers in the 1st year pen are either sold or "moved" to the 2nd year pen. A milker is usually slaughtered after six years. Hence, each year one sixth of the dairy herd need to be replaced by 2nd year heifers. As for the pigs, the growers are not moved physically. Instead they are sold at the 1st year pen and new animals are bought at the 2nd year pen at the same price.

10.5 Large-scale sheep farming

For "large-scale" sheep farming, three specialized pens are needed. Lambs are staying with the ewe the first 4 months. Although lambing is usually limited to a few months in the spring, lambing is here taken to occur all year round. Hence 120 ewes produce 150 lambs, or 50 lambs per 4 months. Every 4 months, 50 lambs are "moved" to the grower's pen, where they stay for 4 months and are either sold for slaughter or moved to the replacer pen. In this case only one fifth is moved to the replacer's pen. The rest is sold for slaughter.

Figure 14. Two cow pens back-to-back at Fenton Forest by Stevie.

Figure 15. Two back-to-back sheep pens at Fenton Forest by Stevie.

Like pigs and cows, sheep are not moved physically. Instead 50 sheep are sold at the lambing pen and 50 are bought at the grower's pen for the same price. Likewise, 50 growers are sold at the grower's pen, and 10 are bought at the replacer's pen.

Table 25. Large-scale sheep farming.

	Lambing pen	Grower's pen	Replacer's pen
Animal color	Brown	Black-White	Black
Breeding cycle (months)	12	12	12
Litter size	1.25	0	0
Offspring months in pen	4	4	4
Mature animals (breeding)	120	0	0
Offspring (non-breeding) per pen stay	50	0	0
Added offspring per pen stay	0	50	10
Removed offspring per pen stay	0	50	10
Starting weight (kg)	0	21	44
End weight (kg)	21	44	66

10.6 Large-scale chicken farming

Chicken farming is either egg production or meat production. The same type of chicken is not used for both. Here, we facilitate both, but in separate pens and with separate chicken subtypes.

Figure 16. Two of three chicken pens at Fenton Forest by Stevie.

Two pens are used in the egg production line. Forty 1-day old chicks are bought every month. When 4 months old, all 40 are "moved" to the layers pen, where they stay for one year. After a phasing-in period of 4 months there will be 160 chickens in the chick pen, and after one year, 480 in the layer's pen. After one year and 4 months, 40 layers are sold for slaughter every month.

In the broiler pen, chickens are bought in as 1-day old and sold for slaughter when 4 months old. If you add and remove 100 every month, you will be replacing 25% of the flock.

Table 26. Large-scale egg and chicken farming.

	Chick pen	Layer's pen	Broiler's pen
Animal color	White	Brown	Rooster
Breeding cycle (months)	12	12	12
Litter size	0	0	0
Offspring months in pen	4	12	4
Mature animals (breeding)	0	0	0
Offspring (non-breeding) per pen stay	0	0	0
Added offspring per month	40	40	400
Removed offspring per month	40	40	400
Starting weight (kg)	0.05	1.4	0.05
End weight (kg)	1.4	2.6	2.6

It is likely to be a time-consuming job to do large scale farming of more than one type of animal. Nevertheless, large scale farming of both pigs, cows, sheep and chicken will require 12 pens, in addition to perhaps a horse pen. The game limit on husbandries is by default 10. The mod increases this to 20 to give room for ambitious farming plans.

10.7 Animal input

For all animals, water, straw and feed consumption as well as waste production are separate for mature and growing animals. For growing animals, the feed amount consumed, or waste produced is based on the range of weight according to weight charts.

Table 27. Weight chart for pigs.

	weeks	Weight kg	Water L/day	Accum L/pig	Feed kg/day	Accum kg/pig	Gain kg/day	Manure kg/day	Manure kg/week	Accum kg/pig
	1	2.27						0.13	0.92	0.9
Creep	2	3.63						0.22	1.53	2.5
	3	6						0.37	2.61	5.1
	4	7.5	0.90	6	0.25	1.8	0.25	0.47	3.30	8.4
	5	9.5	1.40	16	0.41	4.6	0.35	0.60	4.21	12.6
	6	13	1.90	29	0.58	8.7	0.45	0.83	5.80	18.4
	7	17	2.20	45	0.74	13.8	0.57	1.09	7.62	26.0
	8	21	2.50	62	0.9	20.1	0.69	1.35	9.44	35.4
Growers	9	28	2.75	82	1.1	27.8	0.73	1.80	12.63	48.1
	10	34	3.00	103	1.2	36.2	0.77	2.19	15.36	63.4
	11	41	3.30	126	1.5	46.7	0.80	2.65	18.55	82.0
	12	47	3.60	151	1.5	57.2	0.84	3.04	21.28	103.2
Finishers	13	54	3.90	178	1.7	69.1	0.87	3.50	24.47	127.7
	14	61	4.20	208	1.9	82.4	0.90	3.95	27.65	155.4
	15	67	4.50	239	2.1	97.1	0.93	4.34	30.38	185.8
	16	74	4.80	273	2.2	112.5	0.96	4.80	33.57	219.3
Slaughter	17	81	5.15	309	2.4	129.3	0.98	5.25	36.76	256.1
	18	88	5.50	347	2.6	147.5	1.01	5.71	39.94	296.0
	19	94	5.75	387	2.8	167.1	1.03	6.10	42.68	338.7
	20	101	6.00	429	3.1	188.8	1.05	6.55	45.86	384.6
	21	108	6.30	474	3.3	211.9	1.07	7.01	49.05	433.6
	22	115	6.60	520	3.5	236.4	1.08	7.46	52.24	485.8
	23	122	6.90	568	3.7	262.3	1.09	7.92	55.42	541.3
	24	129	7.20	618	3.9	289.6	1.10	8.37	58.61	599.9
	25	137	7.73	673	4.09	318.2	1.10	8.89	62.25	662.1
	26	145	8.11	729	4.31	348.4	1.10	9.41	65.89	728.0
Sows		180	17.50	3150.0	3.3	592.0		11.69	81.83	2104.0

Bedding straw for pigs are set to 2 kg per real-life day per mature pig and 0.9 kg for growers.

Water and feed intake are calculated separately for mature animals and offspring and added together. The total feed is subdivided into 50% maize, 25% grain, 20% protein, and 5% root crop. Dividing the volumes of individual foods by their yield per hectare, we get how much field area is needed to produce the different types of feed ingredients.

Water intake by pigs and cows is very large. To avoid having to spend too much time driving a water bowser to the water trough, it is assumed that a major fraction of all water intake is obtained from an automatic system, and only a smaller portion from a bowser.

```
RN.pigs.bowserWaterFraction =           0.1;
```

Table 28. Weight chart for cows.

Month	Holstein lb	Weight kg	Water L/day	Accum L/animal	Gain kg/day	Energy need MJ/day	Feed DM kg/kg BW	Feed DM kg/day	Manure kg/day	Accum kg/animal
0	90	41		0	0.4	7.9	Milk + Milk replacer and grain starter mix		3.0	91.0
1	119	54	6	180	0.44	19.6			4.1	214.6
2	161	73	7.5	405	0.64	24.6			5.7	385.1
3	211	96	9.25	683	0.76	30.1			7.6	611.7
4	258	117	12.3	1052	0.71	35.0			9.3	890.9
5	311	141	14.4	1484	0.80	40.3			11.3	1229.5
6	369	167	15.8	1958	0.88	45.8		0.00	13.5	1633.0
7	422	192	17.1	2472	0.80	50.7	0.033	6.32	15.4	2095.9
8	468	212	18.3	3020	0.70	54.8	0.033	7.01	17.1	2610.3
9	530	241	19.8	3614	0.94	60.1	0.033	7.94	19.5	3194.2
10	575	261	20.9	4241	0.68	63.9	0.033	8.61	21.1	3828.4
11	638	290	22.5	4915	0.95	69.1	0.033	9.56	23.5	4533.2
12	682	310	23.5	5621	0.67	72.6	0.033	10.22	25.1	5287.4
13	728	330	24.7	6361	0.70	76.3	0.033	10.91	26.9	6093.0
14	776	352	25.9	7137	0.73	80.0	0.033	11.62	28.6	6952.4
15	843	383	27.5	7962	1.01	85.1	0.033	12.63	31.1	7886.8
16	913	414	29.2	8839	1.06	90.4	0.033	13.68	33.8	8899.6
17	931	423	29.7	9729	0.27	91.7	0.033	13.95	34.4	9932.6
18	969	440	30.6	10648	0.57	94.5	0.033	14.52	35.9	11008.2
19	1007	457	31.5	11594	0.57	97.3	0.033	15.08	37.3	12126.3
20	1050	477	32.6	12572	0.65	100.4	0.033	15.73	38.9	13292.6
21	1100	499	33.8	13587	0.76	103.9	0.033	16.48	40.7	14514.9
22	1150	522	35.1	14639	0.76	107.5	0.033	17.23	42.6	15793.2
23	1200	545	36.3	15728	0.76	111.0	0.033	17.98	44.5	17127.5
Cows	Annual	640	102	37156			0.026	16.90	52.3	18833.0

For cows, bedding straw is set to 1.4 kg per real-life day per cow. Using the straw bale volume and number of cows we get the total volume of bedding straw per year. The script then calculates how large a wheat, barley or oat field is needed to produce the bedding straw for cows.

Cows drink 4-5 times their milk production, amounting to almost 40000 liters per year, or 100-110 L/real-life day. Calves drinks much less, here set to 4915 liters per year, or 14 L/real-life day averaged over the year. This adds up to a lot of water. Therefore only 10% is to be delivered by a water bowser. The total feed intake of mature cows and offspring are added up to obtain the total cow feed per year. This is a very large amount; hence it is assumed that a fraction is obtained by grazing, and that the rest is given in the trough. The mod user can adjust the trough fraction. Of trough feed, 50% is assumed to be hay, 25% silage and 25% straw (a valid TMR mixing ratio). From the consumed volume of hay, silage and straw, the corresponding number of bales and field areas are calculated.

Table 29. Sheep weight chart.

Months	Weight kg	Feed DM kg/day	Feed DM accum, kg
1	5.0	0.2	6
2	10.5	0.42	18.6
3	16.0	0.64	37.9
4	21.6	0.86	63.7
5	27.1	1.08	96.2
6	32.6	1.30	135.4
7	38.1	1.52	181.1
8	43.6	1.75	233.5
9	49.2	1.97	292.5
10	54.7	2.19	358.1
11	60.2	2.41	430.3
12	65.7	2.63	509.2

For sheep, water intake is calculated separately for mature animals and for offspring. Mature sheep drink about 7 liters of water per day, when lactating and 4 liters per day when dry. Averaged out, this amounts to about 4.75 liters per real-life day. For lambs, growers and finishers, the water intake is set to 0.75, 3.0, and 4.0 L per real-life day (averaged over time). The fresh matter feed intake of mature sheep is set to 10.5 kg and correspondingly less for offspring in accord with their weight chart.

As in Table 29, animal feed intake is often given in dry matter content, as the nutrients are stored in the dry matter part of the feed, not the water content. To get the fresh matter mass you use the equation:

$$Fresh\,matter\ (kg) = \frac{Dry\ matter\ (kg)}{drymatter\ fraction}$$

$$drymatter\ fraction = 1 - moisture\ content$$

An example of the use of these equations is shown in Table 30.

Table 30. Calculation of feed intake for sheep.

Mature sheep weight	120	kg
Dry matter intake per body mass	0.013	
Dry matter intake per day	1.56	kg DM per day
Grass dry matter fraction	0.15	
Grass fresh matter intake	10.40	kg/day
Grass bale density	0.46	kg/L
Grass volume intake	22.61	L/day
Hay dry matter fraction	0.85	
Hay mass intake	1.84	kg/day
Hay bale density	0.16	kg/L
Hay volume intake	11.47	L/day

Here the dry matter intake is set to 1.3% of the sheep's body mass. The water content in pasture grass is set to 85% hence the dry matter fraction is 0.15. To cover the dry matter intake, the sheep will have to eat 22.6 liters of fresh grass, or 11.5 liters of hay. The dry matter concentration in hay is 85%, hence less hay is needed.

The mod user can set how large a fraction of the annual feed should be given in the trough. The mod sets it to 50%. The required number of bales and grassland is calculated.

In FS19, chicken do not take water or straw, only feed. Mature chicken eat about 0.11 kg/day (see Table 31 and Table 32).

Table 31. Weight chart for chicken (layers).

AGE (WEEK)	AVERAGE BODY WEIGHT	AVERAGE FEED INTAKE	CUMULATIVE FEED INTAKE	AVERAGE WATER INTAKE
	(kg/bird)	(g/bird/day)	(kg to date)	(ml/bird/day)
1	0.065	14.5	0.1015	25.5
2	0.125	19	0.2345	38
3	0.19	24	0.4025	46.5
4	0.265	28	0.5985	56.5
5	0.36	35	0.8435	65.5
6	0.46	39	1.1165	71.5
7	0.56	42	1.4105	78
8	0.67	47	1.7395	87
9	0.78	56	2.1315	93
10	0.89	54	2.5095	101
11	0.99	60	2.9295	109.5
12	1.08	64	3.3775	117.5
13	1.165	69	3.8605	124.5
14	1.23	72	4.3645	128.5
15	1.3	74	4.8825	133
16	1.37	77	5.4215	138.5
17 egg laying	1.44	80	5.9815	146.5
18	1.52	85	6.5765	152.5
19	1.62	88	7.1925	161
20	1.68	94	7.8505	169.5
21	1.72	98	8.5365	176.5
22	1.77	102	9.2505	183.5
23	1.8	106	9.9925	188.5
24	1.84	108	10.7485	191
25	1.85	109	11.5115	192.5
26	1.86	110	12.2815	193.5
27	1.88	110	13.0515	193.5
28	1.89	110	13.8215	193.5
29	1.9	110	14.5915	193.5
30	1.9	110	15.3615	193.5
31	1.9	111	16.1385	195
32	1.91	111	16.9155	195
33	1.91	111	17.6925	195
34	1.91	111	18.4695	195
35	1.91	111	19.2465	195
36	1.92	111	20.0235	195
37	1.92	111	20.8005	195
38	1.92	111	21.5775	195
39	1.93	111	22.3545	195
40	1.93	111	23.1315	195
41	1.93	111	23.9085	195
42	1.94	111	24.6855	195
43	1.94	111	25.4625	195
44	1.94	110.5	26.236	195
45	1.95	110	27.006	193.5
46	1.95	110	27.776	193.5
47	1.95	110	28.546	193.5
48	1.95	110	29.316	193.5
49	1.95	110	30.086	193.5
50	1.95	109.5	30.8525	193.5
51	1.95	109	31.6155	191.5
52	1.95	109	32.3785	191.5
53	1.95	109	33.1415	191.5
54	1.95	109	33.9045	191.5
55	1.96	109	34.6675	191.5
56	1.96	109	35.4305	191.5
57	1.96	109	36.1935	191.5
58	1.96	109	36.9565	191.5
59	1.96	109	37.7195	191.5

60	1.96	109	38.4825	191.5
61	1.96	109	39.2455	191.5
62	1.96	109	40.0085	191.5
63	1.96	109	40.7715	191.5
64	1.96	109	41.5345	191.5
65	1.96	109	42.2975	191.5
66	1.96	109	43.0605	191.5
67	1.96	109	43.8235	191.5
68	1.96	109	44.5865	191.5
69	1.96	109	45.3495	191.5
70	1.97	109	46.1125	191.5
71	1.97	109	46.8755	191.5
72	1.97	109	47.6385	191.5
73	1.97	109	48.4015	191.5
74	1.97	109	49.1645	191.5
75	1.97	109	49.9275	191.5
76	1.97	109	50.6905	191.5
77	1.97	109	51.4535	191.5

Table 32. Broiler weight chart.

AGE (DAYS)	FEED CONSUMED PER BIRD (KG)	CUMULATIVE FEED CONSUMED PER BIRD (KG)	AVERAGE BODY WEIGHT (KG)	AVERAGE BODY WEIGHT GAIN PER BIRD (KG)
0	0	0	0.042	0
1	0.013	0.013	0.056	0.014
2	0.016	0.029	0.07	0.014
3	0.02	0.049	0.087	0.017
4	0.023	0.072	0.106	0.019
5	0.026	0.098	0.128	0.022
6	0.03	0.128	0.152	0.024
7	0.035	0.163	0.179	0.027
8	0.038	0.201	0.208	0.029
9	0.042	0.243	0.241	0.033
10	0.047	0.29	0.276	0.035
11	0.052	0.342	0.315	0.039
12	0.057	0.399	0.357	0.042
13	0.062	0.461	0.402	0.045
14	0.067	0.528	0.45	0.048
15	0.073	0.601	0.501	0.051
16	0.078	0.679	0.555	0.054
17	0.084	0.763	0.612	0.057
18	0.09	0.853	0.672	0.06
19	0.096	0.949	0.734	0.062
20	0.102	1.051	0.8	0.066
21	0.108	1.159	0.868	0.068
22	0.114	1.273	0.938	0.07
23	0.12	1.393	1.011	0.073
24	0.126	1.519	1.086	0.075
25	0.132	1.651	1.164	0.078
26	0.137	1.788	1.243	0.079
27	0.144	1.932	1.323	0.08
28	0.148	2.08	1.406	0.083
29	0.155	2.235	1.49	0.084
30	0.159	2.394	1.575	0.085
31	0.165	2.559	1.661	0.086
32	0.17	2.729	1.748	0.087
33	0.175	2.904	1.836	0.088
34	0.179	3.083	1.924	0.088
35	0.183	3.266	2.013	0.089
36	0.188	3.454	2.102	0.089
37	0.191	3.645	2.192	0.09
38	0.196	3.841	2.281	0.089
39	0.198	4.039	2.37	0.089
40	0.203	4.242	2.459	0.089
41	0.205	4.447	2.548	0.089
42	0.208	4.655	2.637	0.089

In real-life the amount of straw bedding for horses varies from nothing to one big bale per month depending on the believes of the owner. The concern of straw use regards both the dust from straw and hay and the unevenness of the floor in deep layers of bedding. The script specifies an amount per game day corresponding to 10% of a straw bale per game day per horse.

Water intake per real-life day is set to 0.084 liters per kg body weight. Feed intake per real-life day is set to 0.025 kg per kg body weight. The feed intake is split into 75% oat and 25% hay.

10.8 Animal output

A mature sow produces about 12 kg manure per real-life day and the offspring about 4 kg. Liquid manure is set to 85% of the water intake for lactating sows and 90% for offspring.

A cow's manure production per year is set to 52 kg per real-life day and for the offspring 13 kg. For lactating cows, the liquid manure production is set to 75% of the water intake. Milk yield is set to 8715 liters/year (Germany).

Table 33. Script output sample for Animal care.

```
cow start number                           =       20
cow end number                             =       40
cow pen capacity                           =      500
cow BirthRatePerDay                        =        0.0613
cow mean number                            =       28.9243
cow time to first birth                    =  19:54:56

Total cow bedding straw per year           =    121846      Liter
Total cow bedding straw bales per year     =       31       bales
Wheat field for cow bedding straw          =        2.8140  Ha
Barley field for cow bedding straw         =        3.4208  Ha
Oat field for cow bedding straw            =        3.9064  Ha

Total cow water per year                   =    889920      Liter
Bowser fraction of drinking water          =        0.1000
Total cow bowser water per year            =     88992      Liter

Trough food per year                       =    957273      Liter
Straw fraction of total mixed ration       =        0.2500
Hay fraction of total mixed ration         =        0.5000
Silage fraction of total mixed ration      =        0.2500
Total cow straw feed per year              =    239318      Liter
Total cow hay feed per year                =    478636      Liter
Total cow silage feed per year             =    239318      Liter
Total cow straw bale feed per year         =       60       bales
Total cow hay bale feed per year           =      120       bales
Total cow silage bale feed per year        =       60       bales

Wheat field for cow straw feed             =        5.5270  Ha or
Barley field for cow straw feed            =        6.7189  Ha or
Oat field for cow straw feed               =        7.6726  Ha
Hay field for cow hay feed                 =       11.0019  Ha
Grass field for cow silage feed            =        5.5009  Ha

Total milk per year                        =    170049      Liter
Total cow manure per year                  =    778800      Liter
Total cow liquid manure per year           =    682128      Liter
cow food spillage per game day             =      137.8991  Liter

cow straw per cow per game day             =      351.0489  Liter
cow water per cow per game day             =      256.3934  Liter
cow feed per cow per game day              =     2757.9826  Liter
```

A sheep's wool production is set to 8.2 kg/year. With a bale density of 0.375 kg/L this amounts to 21.8 liters of a 1000 liter wool pallet. Hence it requires 50 sheep to produce one wool pallet per year; much less than in the standard game. Let me know if this is way off.

Chickens are set to lay 275 eggs per year. One egg is assumed to be 0.05 liters. Hence one layer produces 13.75 liters of egg per year. In FS19 an egg pallet/box is set to contain 75 liters of eggs, corresponding to 1500 eggs.

Horses do not produce output. Food spillage is controllable in the script. It is set to 5%.

```
RN.feedSpillageFraction = 0.05;-- fraction of feed spilled in front of trough
```

11 Animal trade prices

The script **RealNumbersAnimalTradesPrices** sets purchase and sell-prices for animals based on collected data from EUROSTAT and USDA. Such prices are based on the body weight of the animal.

Table 34. Purchase and sell prices for pigs (Germany).

```
Standard

RED fillType                          =       73
RED animalMatureWeight                =      180       kg
RED animalBuyWeight                   =      180.0000  kg
RED animalSellWeight                  =       81.0000  kg
RED buyprice                          =      239.4000 €/head
RED sellprice                         =      107.7300 €/head
RED transportFee                      =       10.0000 €/head


Sows+Piglets

WHITE fillType                        =       74
WHITE animalMatureWeight              =      180       kg
WHITE animalBuyWeight                 =        1.0000  kg
WHITE animalSellWeight                =       21.0000  kg
WHITE buyprice                        =        1.3300 €/head
WHITE sellprice                       =       27.9300 €/head
WHITE transportFee                    =        0.0000 €/head


Growers

BLACK_WHITE fillType                  =       75
BLACK_WHITE animalMatureWeight        =      180       kg
BLACK_WHITE animalBuyWeight           =       21.0000  kg
BLACK_WHITE animalSellWeight          =       47.0000  kg
BLACK_WHITE buyprice                  =       27.9300 €/head
BLACK_WHITE sellprice                 =       62.5100 €/head
BLACK_WHITE transportFee              =        0.0000 €/head


Finishers

BLACK fillType                        =       76
BLACK animalMatureWeight              =      180       kg
BLACK animalBuyWeight                 =       47.0000  kg
BLACK animalSellWeight                =       81.0000  kg
BLACK buyprice                        =       62.5100 €/head
BLACK sellprice                       =      107.7300 €/head
BLACK transportFee                    =        0.0000 €/head
```

Although animal transfer from one pen type to the next is orchestrated by selling and buying animals, no actual expense is associated with this. Table 34 illustrates this as the sell price of piglets equals the buy price of growers and the sell price of growers equals the buy price of finishers. To keep the expense of animal transfer neutral, the transport fee is set to zero for these animal subtypes.

12 Field information

Different countries do different types of farming. In Table 35 it is seen that 98.5% of all farmland is arable land in Finland, whereas 79% of all farmland is grassland in Ireland.

Table 35. Farmland type distribution in percentage in EU.

	Arable land	Permanent grassland and meadow	Permanent crops	Other
EU-28	59.8	34.2	5.9	0.2
Finland	**98.5**	1.4	0.2	0.0
Denmark	91.5	7.5	1.0	0.0
Sweden	85.1	14.8	0.2	0.0
Hungary	81.6	15.1	3.0	0.3
Lithuania	79.6	19.6	0.8	0.0
Malta	78.8	0.0	11.6	9.7
Poland	74.7	22.3	2.9	0.2
Cyprus	73.3	1.7	**25.0**	0.0
Slovakia	71.7	27.3	1.0	0.0
Czech Republic	71.4	27.5	1.1	0.0
Germany	71.1	27.7	1.2	0.0
Bulgaria	70.5	27.3	2.0	0.1
France	66.6	29.7	3.7	0.0
Estonia	65.6	33.9	0.4	0.1
Latvia	64.1	34.8	0.4	0.7
Romania	62.8	33.7	2.3	1.2
Belgium	61.1	37.2	1.7	0.0
Netherlands	56.2	41.8	2.0	0.0
Croatia	55.9	39.3	4.6	0.1
Italy	55.6	27.4	16.8	0.2
Austria	50.0	47.5	2.4	0.1
Spain	48.5	34.2	17.3	0.0
Luxembourg	47.8	51.1	1.2	0.0
Greece	37.4	43.3	19.1	0.2
United Kingdom	36.7	63.1	0.2	0.0
Slovenia	35.6	58.6	5.6	0.2
Portugal	30.2	49.9	19.5	0.4
Ireland	21.0	**79.0**	0.0	0.0

The average farmland area of farms in EU is shown in Figure 17.

Having obtained information about how much field area is required for a certain number of animals, the script **RealNumbersFieldInfo** provides information about farmlands and fields, their size and price, their crop, their ownership status and if the field can be bought or rented (Table 36).

The purchase or rent price is determined by the hectares of farmland, not the hectares of the field. When a fruit type is undefined, no crop is growing on the field at this moment. The column showing ownership status has four possibilities: for sale, for rent, owned or rented. The concept of renting is here much simpler than the principle of renting equipment in the game. There is no option for returning usage privilege of the field to its owner. It is simply a field at a reduced cost of use.

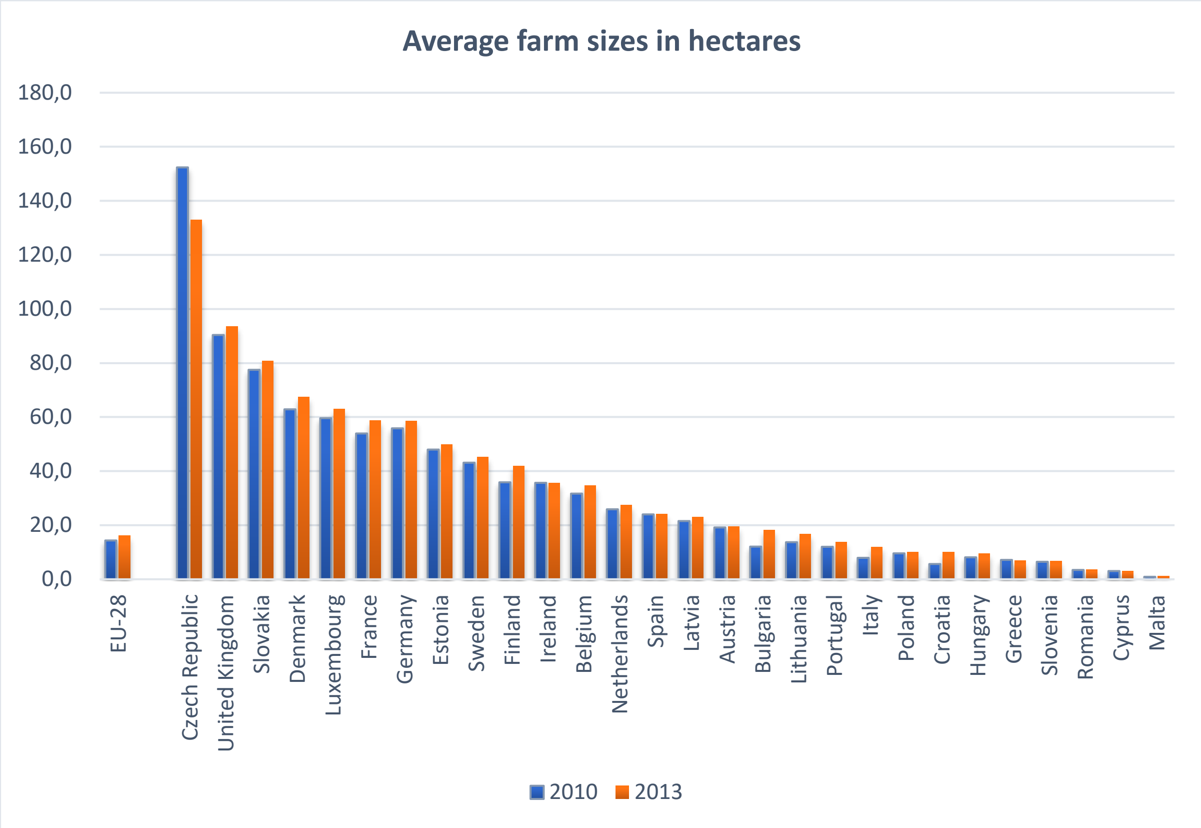

Figure 17. Average land area on farms in EU.

Table 36. Field information for a map. You pay for land area, not field area.

```
Mean land purchase price = 25000 €/ha
Mean land rent price = 625 €/ha
Field  1: Landarea =  6.3 ha, Fieldarea =  2.3 ha, Price =  157859 €,  For sale, Fruittype: Soybean
Field  2: Landarea =  4.8 ha, Fieldarea =  2.2 ha, Price =  116876 €,  For sale, Fruittype: Barley
Field  3: Landarea =  5.1 ha, Fieldarea =  1.6 ha, Price =  126710 €,  For sale, Fruittype: Grass
Field  4: Landarea =  7.9 ha, Fieldarea =  1.6 ha, Price =  188180 €,  For sale, Fruittype: Barley
Field  5: Landarea =  4.6 ha, Fieldarea =  1.0 ha, Price =    2931 €,  For rent, Fruittype: Undefined
Field  6: Landarea = 14.2 ha, Fieldarea =  5.2 ha, Price =  364945 €,  Owned   , Fruittype: Wheat
Field  7: Landarea =  8.4 ha, Fieldarea =  3.8 ha, Price =  216774 €,  Owned   , Fruittype: Barley
Field  8: Landarea =  5.5 ha, Fieldarea =  2.6 ha, Price =  136271 €,  For sale, Fruittype: Sugarbeet
Field  9: Landarea =  4.9 ha, Fieldarea =  3.0 ha, Price =    2998 €,  Rented  , Fruittype: Barley
Field 10: Landarea =  8.8 ha, Fieldarea =  5.2 ha, Price =  226029 €,  Owned   , Fruittype: Sunflower
Field 11: Landarea =  3.2 ha, Fieldarea =  2.1 ha, Price =   81448 €,  Owned   , Fruittype: Wheat
Field 12: Landarea =  7.6 ha, Fieldarea =  5.6 ha, Price =  197587 €,  For sale, Fruittype: Undefined
Field 13: Landarea =  5.1 ha, Fieldarea =  4.1 ha, Price =  132828 €,  For sale, Fruittype: Undefined
Field 14: Landarea =  6.7 ha, Fieldarea =  3.9 ha, Price =    4268 €,  Rented  , Fruittype: Oat
Field 15: Landarea =  3.8 ha, Fieldarea =  1.3 ha, Price =   96010 €,  For sale, Fruittype: Wheat
Field 16: Landarea = 10.1 ha, Fieldarea =  4.8 ha, Price =    6202 €,  For rent, Fruittype: Barley
Field 17: Landarea =  4.4 ha, Fieldarea =  3.0 ha, Price =  106361 €,  Owned   , Fruittype: Wheat
Field 18: Landarea =  3.0 ha, Fieldarea =  2.0 ha, Price =   73283 €,  For sale, Fruittype: Undefined
Field 19: Landarea =  2.9 ha, Fieldarea =  1.6 ha, Price =   72262 €,  For sale, Fruittype: Undefined
Field 20: Landarea =  3.0 ha, Fieldarea =  0.7 ha, Price =    1887 €,  For rent, Fruittype: Undefined
Field 21: Landarea =  4.7 ha, Fieldarea =  2.4 ha, Price =  111652 €,  Owned   , Fruittype: Grass
Field 22: Landarea =  6.7 ha, Fieldarea =  3.8 ha, Price =  161355 €,  Owned   , Fruittype: Grass
Field 23: Landarea =  7.4 ha, Fieldarea =  2.2 ha, Price =    4439 €,  For rent, Fruittype: Undefined
Field 24: Landarea =  4.9 ha, Fieldarea =  1.3 ha, Price =  121884 €,  For sale, Fruittype: Undefined
Field 25: Landarea =  2.6 ha, Fieldarea =  0.7 ha, Price =   62971 €,  For sale, Fruittype: Canola
Field 26: Landarea =  2.1 ha, Fieldarea =  1.2 ha, Price =   52968 €,  Owned   , Fruittype: Grass
Field 27: Landarea =  3.4 ha, Fieldarea =  1.7 ha, Price =   86656 €,  Owned   , Fruittype: Barley
Field 28: Landarea =  1.8 ha, Fieldarea =  0.6 ha, Price =    1070 €,  Rented  , Fruittype: Potato
Field 29: Landarea =  2.1 ha, Fieldarea =  0.5 ha, Price =   53019 €,  For sale, Fruittype: Undefined
Field 30: Landarea =  3.0 ha, Fieldarea =  1.6 ha, Price =   75270 €,  Owned   , Fruittype: Grass
Field 31: Landarea =  3.7 ha, Fieldarea =  1.6 ha, Price =   93322 €,  For sale, Fruittype: Undefined
Field 32: Landarea =  3.4 ha, Fieldarea =  1.0 ha, Price =    2044 €,  For rent, Fruittype: Undefined
Field 33: Landarea =  4.5 ha, Fieldarea =  1.2 ha, Price =  115395 €,  For sale, Fruittype: Sunflower
```

To have an idea about how much field work lies ahead, Table 37 sums up the hectares of different crop groups. This helps deciding the size of headers for your harvester and width of implements such as ploughs, cultivators and seeders.

People playing the game for the money challenge might consider renting fields at a lower cost cheating. But this mod is not intended to be of any service to such a game style, so if a player feels uneasy using such options, it is easy to disable the mod.

The present script needs to delay its execution until the map loading has completed. For this reason, this script is **only run when the user presses leftAlt-rf**, i.e. the left Alt key is held down while pressing r and f.

Table 37. Summary of crop area on farm.

Total farmland area owned/rented	=	97.7	Ha
Total field area owned/rented	=	53.1	Ha
Grain crop area	=	22.7	Ha
Row grain crop area	=	5.2	Ha
Potato area	=	0.6	Ha
Sugarbeet area	=	0.0	Ha
Grass area	=	9.0	Ha
Cotton area	=	0.0	Ha
Sugarcane area	=	0.0	Ha

Figure 18. Another day on the farm. Fenton Forest by Stevie.

Figure 19. Before the error causing an excessive production of wool was fixed.

13 Missions

The final script **RealNumbersMissions** changes the reward paid for field and transport missions. The wage is set to 10 €/hour. The mod user can change this and the work capacity (hectares/hour) for different jobs. Default rewards are listed in Table 38. The mod user should time the work capacity of plowing, cultivating, etc. and set the number of hectares per hour to values that fit the field on the map they play. Such numbers depend on the size of the equipment and the shape of the fields.

Table 38. Rewards and reimbursements for missions.

mow-bale hay	=	10.0000 €/Ha
mow-bale silage	=	10.0000 €/Ha
plow	=	2.5000 €/Ha
cultivate	=	1.6667 €/Ha
sow	=	5.0000 €/Ha
harvest small	=	2.0000 €/Ha
harvest wide	=	2.0000 €/Ha
weed	=	1.2500 €/Ha
spray reward	=	0.4167 €/Ha
spray reimbursement	=	92.9324 €/Ha
fertilize reward	=	0.4167 €/Ha
fertilize reimbursement	=	318.5183 €/Ha
transport reward	=	0.3333 €/km
transport reimbursement	=	3.5000 €/object

This script does not alter the cost of hired helpers. However, there is an excellent mod HelperAdmin by apuehri/LS-Modcompany, in which the wage can be changed to real-life wages.

14 Planning a large pig farm

The log file is full of useful numbers. Let us first use it to make predictions on farmland need for a large-scale pig farm (Table 39).

Table 39. Field sizes required to feed a large pig herd.

	Sow+Piglets	Growers	Finishers	Total	
Pig start number	14	0	0		
Pig end number	196	104	104		
Pig mean number	118	104	104	326	
Bedding	83	54	108	245	Bales
Bedding straw land	7.6	5.8	11.5	24.9	Hectares
Grain feed	16477	25920	53280	95677	Liters
Maize feed	32954	51840	106560	191354	Liters
Protein feed	13182	20736	42624	76542	Liters
Root crop feed	3295	5184	10656	19135	Liters
Grain feed land	2	3.1	6.4	11.5	Hectares
Maize feed land	2.2	3.4	7	12.6	Hectares
Protein feed land	2.1	3.3	6.9	12.3	Hectares
Root crop feed land	0.03	0.05	0.1	0.18	Hectares
Manure	163800	230880	492960	887640	Liters
Slurry	133938	134784	235872	504594	Liters

There are about 325 pigs on the farm, and they use 245 straw bales for bedding in one year. It takes about 25 hectares of grain crop to produce this number of straw bales. About 50 hectares of field area is required. There will be plenty of organic fertilizer.

15 Planning a large dairy farm

As another example of use of all the information printed in the log file, let use predict the feed consumption and field sizes required to feed the cows on a large-scale dairy farm (Table 40).

Table 40. Field sizes required to feed a large dairy herd.

	Milkers	1st year	2nd year	Total	
cow start number	96	1	0		
cow end number	96	97	16	209	
cow mean number	96	22	16	134	
Bedding	94	52	16	162	Bales
Bedding straw land	8.6	4.8	1.5	14.9	Hectares
Straw feed	216	72	26	314	Bales
Hay feed	432	143	52	627	Bales
Silage feed	216	72	26	314	Bales
Straw feed land	20	6.6	2.4	29	Hectares
Hay feed land	40	13	4.7	57.7	Hectares
Silage feed land	20	6.6	2.4	29	Hectares
Milk yield	816234	0	0	816234	Liters
Manure	3012480	725760	336000	4074240	Liters
Slurry	2851200	423014	155520	3429734	Liters

Table 40 shows the number of bales and hectares of fields needed to feed close to 100 dairy cows and an equal number of calves for one year. It has been assumed that grass fields can be cut two times in a year. The totals are very large because the mod assumes that 50% of all cow feed is given in the trough. The user can adjust the trough fraction as seen fit. It takes about 45 hectares of grain fields and 90 hectares of grass land to provide 50% of the feed to 208 cows. This is about 1-hectare grass land to 1.2 cows.

In a well-managed pasture rotation system, 1 hectare of pasture can feed 2 – 2.5 dairy cows (a stocking rate of 2 – 2.5) during the grazing season. A stocking rate of 1 equals one livestock unit per hectare. A livestock unit is the amount of feed energy consumed by a mature Holstein dairy cow. The livestock unit of all other grazing animals are then relative to that of a Holstein dairy cow (Table 41).

Table 41. Livestock units and stocking rate for cattle[1].

Cattle	Livestock unit	Stocking rate
Holstein dairy cow	1.00	2
Beef cow	0.75	2.66
Beef bull	0.65	3.1
Heifer in calf	0.80	2.5
Other cattle 0 – 12 months	0.34	5.8
Other cattle 12-24 months	0.65	3.1
Barley beef	0.47	4.2

The grass land to cow rate we calculated (to be 1 ha : 1.2 cows) is not directly comparable to the stocking rate, as the former include all year feed intake and the latter just feed intake during the grazing season.

16 Planning a large sheep farm

For a large-scale sheep farm the amount of grass land amounts to 1-hectare grass land for each 3.4 sheep. The numbers given in Table 42, are calculated based on the assumption that 100% of the feed is given in the trough.

Table 42. Bales and field size requirements for a large sheep farm with 100% trough feed.

	Lambing	Growers	Replacers	Total	
Sheep start number	120	0	0		
Sheep end number	170	50	10		
Sheep mean number	144	50	10	204	
Grass bales	270	32	11	313	Bales
Hay bales	270	32	11	313	Bales
Grass feed land	25.5	3.2	1	29.7	Hectares
Hay feed land	24	3.0	0.93	27.9	Hectares

If all feed is given in the trough, 200 sheep requires about 60 hectares of grass land.

[1] http://beefandlamb.ahdb.org.uk/wp/wp-content/uploads/2016/07/BRP-Planning-grazing-strategies-manual-8-150716.pdf

Table 43. Livestock units and stocking rate for sheep[2].

Sheep	Livestock unit	Stocking rate
Holstein dairy cow	1.00	2
Lowland ewes	0.11	18.2
Upland ewes	0.08	25
Hill ewes	0.06	33
Rams	0.08	25
Store lambs 0 – 12 months	0.04	50
Breeding ewe hoggs 6 – 12 months	0.06	33
Other sheep more than 1 year old	0.08	25

The high stocking rate seen in Table 43 suggests that trough feed should be significantly smaller than 100%. If sheep feed is 100% grazing for 8 months and 50% for 4 months, trough feed would be $0.5 \times 0.33 = 0.167$ or 16.7% of the annual feed intake (see Table 44).

Table 44. Bales and field size requirements for a large sheep farm with 17% trough feed.

	Lambing	Growers	Replacers	Total	
Sheep start number	120	0	0		
Sheep end number	170	50	10		
Sheep mean number	144	50	10	204	
Grass bales	46	6	2	54	Bales
Hay bales	46	6	2	54	Bales
Grass feed land	4.9	0.57	0.19	5.66	Hectares
Hay feed land	4.6	0.54	0.18	5.32	Hectares

With 17% trough feed, 11 hectares of grass and is needed. The grass land to sheep rate for trough feed is about 1 ha: 10 sheep.

[2] http://beefandlamb.ahdb.org.uk/wp/wp-content/uploads/2016/07/BRP-Planning-grazing-strategies-manual-8-150716.pdf

17 Matching feed requirements to land ownership

Having obtained an idea about the land area needed to feed the herds, the next step is to investigate, if you have enough land or if more should be purchased or rented.

By pressing leftAlt-rf after game start, the mod will print out an overview of land ownership to the log file. An example is shown in Table 45. Obviously, this tycoon has taken it all.

Table 45. Overview of land ownership.

```
Map                    : Fenton Forest By Stevie. Savegame 8
Money                  : 2761248
Economic difficulty    : 3
Sell price multiplier  : 1
Buy price multiplier   : 1
Current game day       : 2
Time of day            : 15:53

Mean land purchase price = 25000 €/ha
Mean land rent price = 625 €/ha
Field  1: Landarea = 43.1 ha, Fieldarea =  9.0 ha, Price = 1086658 €,  Owned   , Fruittype: Undefined
Field  2: Landarea = 43.1 ha, Fieldarea =  5.7 ha, Price = 1086658 €,  Owned   , Fruittype: Undefined
Field  3: Landarea =  7.8 ha, Fieldarea =  4.3 ha, Price =  185361 €,  Owned   , Fruittype: WHEAT
Field  4: Landarea =  9.9 ha, Fieldarea =  7.6 ha, Price =  254733 €,  Owned   , Fruittype: BARLEY
Field  5: Landarea = 12.9 ha, Fieldarea =  5.6 ha, Price =    8405 €,  Rented  , Fruittype: Undefined
Field  6: Landarea = 14.9 ha, Fieldarea = 12.1 ha, Price =  391847 €,  Owned   , Fruittype: Undefined
Field  7: Landarea = 10.1 ha, Fieldarea =  8.4 ha, Price =  253189 €,  Owned   , Fruittype: CANOLA
Field  8: Landarea = 10.0 ha, Fieldarea =  3.6 ha, Price =  241451 €,  Owned   , Fruittype: GRASS
Field  9: Landarea = 14.2 ha, Fieldarea = 11.9 ha, Price =    8499 €,  Rented  , Fruittype: SOYBEAN
Field 10: Landarea =  4.7 ha, Fieldarea =  3.5 ha, Price =  114706 €,  Owned   , Fruittype: MAIZE
Field 11: Landarea = 17.3 ha, Fieldarea = 11.6 ha, Price =  446407 €,  Owned   , Fruittype: POTATO
Field 12: Landarea = 16.7 ha, Fieldarea =  6.5 ha, Price =  437579 €,  Owned   , Fruittype: Undefined
Field 13: Landarea = 22.2 ha, Fieldarea = 11.8 ha, Price =  569906 €,  Owned   , Fruittype: WHEAT
Field 14: Landarea = 11.2 ha, Fieldarea =  4.4 ha, Price =    6680 €,  Rented  , Fruittype: BARLEY
Field 15: Landarea = 27.8 ha, Fieldarea = 15.0 ha, Price =  695708 €,  Owned   , Fruittype: OAT
Field 16: Landarea = 15.0 ha, Fieldarea =  8.8 ha, Price =    9659 €,  Rented  , Fruittype: COTTON

---Owned land and crop area---

Total farmland area owned/rented        =     281.0  Ha
Total field area owned/rented           =     129.7  Ha
Grain crop area                         =      63.4  Ha
Row grain crop area                     =       3.5  Ha
Potato area                             =      11.6  Ha
Sugarbeet area                          =       0.0  Ha
Grass area                              =       3.6  Ha
Cotton area                             =       8.8  Ha
Sugarcane area                          =       0.0  Ha

Field  1: Usability ratio =   0.2082
Field  2: Usability ratio =   0.1334
Field  3: Usability ratio =   0.5475
Field  4: Usability ratio =   0.7755
Field  5: Usability ratio =   0.4328
Field  6: Usability ratio =   0.8068
Field  7: Usability ratio =   0.8287
Field  8: Usability ratio =   0.3578
Field  9: Usability ratio =   0.8375
Field 10: Usability ratio =   0.7379
Field 11: Usability ratio =   0.6715
Field 12: Usability ratio =   0.3918
Field 13: Usability ratio =   0.5331
Field 14: Usability ratio =   0.3874
Field 15: Usability ratio =   0.5388
Field 16: Usability ratio =   0.5851
```

While this farmer has plenty of land, we observe that out of 281 ha owned, only 130 ha is usable field area. We also see from the middle part of the table, that the farmer has 3.6 ha grass land, not sufficient to feed cows or sheep in a large-scale farming setup. In FS19 the large amount of grass around fields seems to suggest that such wild grass is suitable feed for animals. It might be for sheep, but in many countries, farmers are very particular about the type of grass they feed their dairy herd, and wild grass is not on the menu.

Before going out and buying more expensive land, it is wise to look at how good use you make of the land you already own. The usability ratio listed at the bottom of Table 45 is simply the field area divided by the land area. For field 1 this is about 20% while for field 9 it is almost 84%. If you want to convert owned land to field area, bringing the plough to field 1 would give you the largest increase in total field area.

If on the other hand, you were looking at buying more farmland and do not want to spend time ploughing the unused part of the land, buying field 9 would give you the most field area for your money.

If helper friendly fields are top priority, then land conversion is often not an attractive option, and you should buy/rent fields with a high usability ratio.

18 End notes

A lot more could have been done, and things could have been more streamlined. But better stop at 80%, as the remaining 20% takes 80% of the time. I hope you will enjoy simulating real-life farming, and not the least, tweaking the mod to your game.

19 Appendix

Table 46. Pig terminology[3].

Term	Description
Barrow	Male pig castrated before reaching sexual maturity.
Boar	Male hog or pig with intact testicles.
Colostrum	First milk produced by the sow; it provides immunity to the baby pigs for the first few weeks.
Creep Feed	Creep feed is a starter ration for piglets. It is high in protein, usually from sugar and milk proteins for high energy.
Cull sow	Full-grown female sold for slaughter. Usually showing poor physical characteristics that make her undesirable for breeding.
Culling	This is the process of removing any undesirable animals from the herd normally for health or performance issues.
Dam	Mother sow
Estrus	Also known as “going into heat” or “in heat”, is the period when the sow or gilt is sexually receptive. Usually every 21 days, with gilts starting their first estrus between 5 and 8 months depending on the breed of pig.
Farrow	To give birth to piglets. Farrow (as a noun) is a litter.
Farrow to Finish	This means you raise the pig from birth to butchering size.
Feeder Pig	These are young pigs, usually 6 – 10 weeks old that are produced by one farm then purchased and finished on another farm. It also refers to any piglet that is being raised for pork.
Finish Hog	A pig that has been raised to market weight and is ready for butchering.
Finishing	Feeding a pig out to reach market weight.
Gestation	Pregnancy, lasting about 114 days in swine. Also known to some as 3 months, 3 weeks, and 3 days.
Gilt	A gilt or gilts are young females that have not yet produced a litter.
Grower Pig	(Finishing pig)- animal weighing between 40 and 220 lbs. that is being fed for slaughter
Hog	A pig that weighs at least 120 pounds
In Pig	When a sow is pregnant, she is in pig.
Lactation	The time when a sow is producing milk and feeding piglets.
Litter	All the offspring from a single farrowing.
Mummy	A piglet that is born dead but hasn't fully developed. The piglet died too late in the pregnancy for the sow’s body to reabsorb it.
Open	A gilt or sow that did not conceive at breeding or may have absorbed the pregnancy.
Runt	Small or weak pig in a litter. Runts should be culled out of the herd.
Scours	Diarrhea. Severe scours can cause death.
Service	The introduction of semen into the uterus of a sow or gilt. This can be natural (done by a boar) or by artificial insemination.
Shoat	A young pig that has not yet reached 120 pounds.
Sow	Female which has farrowed at least once.
Swine	General term used for all pigs
Wallow	Water-filled depression or container large enough for pigs to lay in to cool off during warm weather
Weaning	Removing young from their mother. Weaning can take place anywhere from 3 to 8 weeks depending on the farmers growing system. Little Pig Farm recommends leaving the piglets to nurse for a minimum of 6 weeks.
Weanling	A piglet recently removed from the sow and typically weighing between 25 and 40 pounds.

[3] http://littlepigfarm.com/swine-terminology/

Table 47. Dairy cow terminology.

Term	Description
Abomasum	True stomach of the ruminant animal.
Beast	General descriptive term for an adult bovine.
Baby beef	Slaughter cattle weighing 700 to 1000lbs (approximately 315 to 450kgs) at 9 to 15 months of age grading good or better for quality.
Beefling	A fat young cattle beast weighing 500kg (approx. 1100lbs) at one and a half to two years of age.
Bobby calf	Calf slaughtered whilst only a few days old.
Bob veal calf	One to three weeks old, sold for baby veal, often the male calves from dairy farms, average weight 150lbs (68kgs).
Body condition score	(BCS) A way for producers to classify their animals, useful in managing feeding of classes of animals.
Bull calf	Male young animal up to stage of yearling.
Bull	Male bovine animal of breeding age, usually over one year old.
Bullock	Mature castrated male cattle destined for meat production.
Bull beef	From entire animals instead of the fatter steer or bullock.
Calf	Bovine animal less than a year old. (In some legislation six months old or even less.
Calving	The act of giving birth in cattle.
Colostrum	First milk following calving. High in fat, protein, and immunoglobulins that may be directly absorbed by the newborn calf in its first 24 hours of life.
Concentrates	The generic term for all non-forage feeds. High energy or high protein feeds consisting primarily of the seed of the plant, but without stems and leaves.
Cow	A female that has had one or more calves.
Cull	To remove a cow from the herd. Culling reasons include voluntary culling of cows for low milk production, or involuntary culling of cows for reasons of health or injury.
Cull cow	A cow that has been removed from the dairy herd or beef breeding herd to be sent to slaughter.
Dairy calf	Calf of a mating between a bull and a cow both of dairy breeds.
Veal calf	Specially reared, grown quickly and fed on special food aged up to three months.
Dairy cow	Cow of a breed specifically defined as being for milk production, as distinct from beef or dual-purpose breeds.
Dam	Mother of a calf.
Dry cow	A cow in the two - three month period between the end of lactation and the subsequent calving. Cows in which calving is imminent are close-up dry cows or are freshening. Also refers to a mature cow that is not lactating whatever the reason.
Fat stock	(Finished Stock) Beef animals that are ready for slaughter.
Flush system	A manure removal system in which an area is cleaned by high volumes of fresh water, or gray water that is recycled from a manure pit or lagoon.
Forage	Feedstuffs composed primarily of the whole plant, including stems and leaves.
Free-Marten	A female born with a male twin, usually infertile.
Fresh (Cow)	A cow who has recently given birth (or “calved”); the act of giving birth (“calving”) is sometimes described as “freshening”
Freestall barn	A type of housing system where cows are housed in large group pens, with free choice access to feed, water, and comfortable stalls to lay in. Stalls in freestall barns are typically bedded with sand, straw, or some type of mattress.
Gray water	Water that is considered waste and not to be used for cleaning milking systems. Usually including recycled water from a lagoon or milk house waste. Even water only used to cool milk in a plate cooler is considered gray water, though it is often fed to cows to reduce total usage.
Hay	Dried feed consisting of the entire plant. Alfalfa, clover, grass, and oat hay are used in dairy rations.

Heifer	Young female bovine animal up to birth of first calf or in lactation following the first calving. May be qualified as replacement (to enter herd as a replacement for a culled cow), pregnant, maiden or spayed heifer. A springing heifer is in the last one or two weeks of pregnancy. After second calving known as a cow (also second calver).
Heifer calf	A baby female cattle.
In Heat	A cow's fertile period when she may become pregnant, indicated by increased activity and other hallmark signs. Most cows cycling normally come into heat every 21 days. This period is also referred to as "estrus."
Lactation	The stage of a cow's life where she is producing milk after having calved. Most cows lactate for between 300 to 365 days before going into a dry period.
Multiparous	Female animal that has had two or more pregnancies resulting in viable offspring.
Maiden heifer	(Bulling Heifer) - heifer before going the bull.
Maiden	A female, e.g. ewe, gilt, heifer, bitch, mare, of breeding age but not yet mated.
Milk solids	What is left when all water is removed from milk. As it comes from the cow, the solids portion of milk contains approximately 3.7 percent fat and 9 percent solids-not-fat. Milk has typically about 4 % fat and 3.5 % protein. This varies between species.
Omasum	Third stomach compartment of ruminant, responsible for removing water and reducing particle size.
Pasture	Plants, such as grass, grown for feeding or grazing animals. Also serves as a place to feed cattle and other livestock.
Protein concentrates	These are intended for further mixing before feeding with planned proportions of cereals and other feedstuffs either on the farm or in a compound mill. They contain blended high-protein ingredients such as MBM, fishmeal and soybean meal. When mixed with appropriate straights (see below), they can be equivalent in nutritional terms to compounds.
Primiparous	General term for any female animal that has had one pregnancy that resulted in viable offspring.
Replacements	Cattle bred on farm to replace culled breeding stock.
Reticulum	First compartment of the ruminant stomach, also called the hardware compartment and honeycomb.
Rotational grazing	Grazing herd rotates between sectioned-off areas of the pasture to allow pasture to regrow. Also called high density grazing, short duration grazing, block and strip grazing, planned grazing and cell grazing. Perennial grass is best.
Ruminant	An animal with a four chambered stomach.
Set stocking	Cows graze continuously in the same pasture over an extended time. Annual grass species, including clovers are favored.
Silage	A feed prepared by chopping green forage (e.g. grass, legumes, field corn) and placing the material in a structure or container designed to exclude air. The material then undergoes fermentation, retarding spoilage. Silage has a water content of between 60 and 80%.
Sire	The father of an animal.
Suckler cow	The mother of a calf raised for beef production.
Stirk	Regional term for a half-grown animal, heifer or bullock, six to 12 months of age.
Steer	Castrated male animal over one year of age.
Stanchion	A method of restraint of dairy cows where their head is restrained.
Stocking ratio	The number of cows per hectare of grazing area open to the cows at any given time.
Store cattle	Animals for beef which have been reared on one or more farms, and then are sold, either to dealers or other farmers. They are brought for finishing, normally well-grown animals of up to two years of age.
Tie-stall barn	A type of housing system where cows remain in an assigned stall for most of the time, with free choice access to food and water. Cows in tie-stalls (also called "stanchion barns") are milked in their stalls (rather than walking to a milking parlor), and typically turned out to exercise for a portion of the day.
Total Mixed Ration (TMR)	Ration formulated to meet requirements of the cow in which all of the ingredients are blended together in a mixer.
Udder	The organ responsible for milk production.
Yearling	An animal in its second year of age, eg yearling cattle, yearling filly, yearling colt.
Young bulls	Male calves that have not been castrated.

Table 48. Milestones in the life of a cow.

Age	Milestone
1-6 hr	Intake of colostrum, the first cow milk rich in antibodies. Ability to absorb these antibodies declines rapidly and is much reduced after 10 hr. Antibodies must reach intestinal walls before bacteria for the calf to survive.
Day 2	Start of milk replacer feeding, removed from dam. Surplus and frozen colostrum may still be used as calf feed.
Day 11	Initial serving of grain starter mix. Solid feed stimulates development of the rumen. Small amounts of long hay (unchopped hay). No silage.
Day 17	Intake of water starts
Day 36	Initial feed of forage
Week 3-5	Goes from two to one daily milk replacer feed.
Week 6-8	Weaning from milk replacer when a minimum grain starter mix of about 1.5 kg is consumed 3 days in a row.
Month 3	Gradual change from starter to grower grain mix.
Month 4	Pasture grazing starts
Month 6	Transition from weaner to grower. Half the hay (dry matter) can be replaced by equivalent amount of silage
Month 12	Transition from grower to finisher
Month 15	Start of first pregnancy
Year 2	First calving
Year 6	Sold for slaughter and replaced by two-year old heifer

A.J. Heinrichs and C.M. Jones have written a very informative paper on feeding the newborn calf[4]. Additional good readings are listed in the footnotes[5,6,7].

[4] https://extension.psu.edu/feeding-the-newborn-dairy-calf
[5] https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/bamn/BAMN17_GuideFeeding.pdf
[6] https://www.dairynz.co.nz/media/5787669/dairynz-facts-and-figures.pdf
[7] http://www.aces.edu/pubs/docs/A/ANR-0609/ANR-0609.pdf