

LRNS

The Large Ruminant Nutrition System to Predict Nutrient Requirements and Feed Utilization in Cattle

History, Science, and User Guide

Version 1.3.1, revision 3

Luis Orlindo Tedeschi

https://www.nutritionmodels.com

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About this document

Copyright. © 2009–2027 Luis Orlindo Tedeschi. All rights reserved. This document accompanies the Large Ruminant Nutrition System (LRNS) and may be copied and distributed with it. LRNS continues the Cornell Net Carbohydrate and Protein System (CNCPS) version 5 (Fox et al., 2004), developed at Cornell University, with the agreement of Danny G. Fox (letter of 2009). LRNS requires registration; an unregistered copy can be started 10 times.

Disclosure. This document was written with support from an artificial intelligence assistant (a chatbot) and from the papers and the book on which LRNS rests, the program and its lists of changes, its guide and tutorials of 2009 and 2010, and Dr. Tedeschi's files, and Dr. Tedeschi reviewed it and is responsible for its content.

Recollections. Where the text says that Luis Tedeschi remembers, the recollection is his only and his responsibility; it does not commit Danny G. Fox, the other authors of the CNCPS, or their institutions. Quotations are word for word.

Conflict of interest. LRNS is available at https://www.nutritionmodels.com. Its registration fees are kept to the minimum needed to maintain the program and to host the website. Dr. Tedeschi declares no other conflict of interest.

Funding and development. LRNS was developed by Dr. Tedeschi, beginning in 2009. He wrote its code and carried out the research and the writing behind it himself, on computers and with software he acquired for the purpose, and no external funds supported its programming. He held teaching and research positions in ruminant nutrition; he wrote the programs on his own time. Like all his models, this program's roots go back to his undergraduate years at ESALQ/USP, where courses in linear programming, operations research, animal nutrition, and statistics met his passion for computers, and some of the code he wrote then found its way into his programs. He also self-funded his studies.

Disclaimer. Neither Cornell University nor Texas A&M University funded the writing of the program's code. The author registered free copies of the program for students at both universities, and earlier versions carried the name of the university where he worked. This document does not represent the views or the policies of Cornell University or of Texas A&M University, and it is not an endorsement or an approval of the program by either of them.

What replaces what. This document replaces the LRNS quick guide of November 2009 (LRNS_help.pdf). The CNCPS 5.0 model documentation (Fox et al., 2003; CNCPS_manual.pdf) stays the reference for every equation. The windows are those of version 1.3.1.

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List of Acronyms

ADF = acid detergent fiber; ADG = average daily gain, lb/d; CHO = carbohydrate; CIAGRI = *Centro de Informática na Agricultura*; CNCPS = Cornell Net Carbohydrate and Protein System; CPM = Cornell-Penn-Miner; DMI = dry matter intake, lb/d; ESALQ = *Escola Superior de Agricultura "Luiz de Queiroz"*; HM = high-moisture; HTTPS = Hypertext Transfer Protocol Secure; LRNS = Large Ruminant Nutrition System; ME = metabolizable energy; MP = metabolizable protein; NASEM = National Academies of Sciences, Engineering, and Medicine; NDF = neutral detergent fiber; NEl = net energy for lactation; NRC = National Research Council; peNDF = physically effective NDF; RNMS = Ruminant Nutrition Management System; RNS = Ruminant Nutrition System; SBW = shrunk body weight, lb; SRNS = Small Ruminant Nutrition System; TDN = total digestible nutrients; USP = *Universidade de São Paulo* (University of São Paulo).

Abstract

This document is the history, science, and user guide of the Large Ruminant Nutrition System (LRNS), version 1.3.1, a Windows program that evaluates and formulates rations for beef and dairy cattle under the conditions of a particular farm: the animals, their environment and management, and the feeds at hand. LRNS implements the Cornell Net Carbohydrate and Protein System (CNCPS) version 5, as published by Fox et al. (2004), with a redesigned interface, corrections, and minor modifications. Texas A&M University released it in November 2009 to complement the Small Ruminant Nutrition System, and it preceded the Ruminant Nutrition System (RNS). The first chapter traces the CNCPS from its beginning at Cornell University in 1979, through its use in the Nutrient Requirements of Beef Cattle, to LRNS and the RNS. The second describes the model: its two levels of solution; the requirements for maintenance, growth, pregnancy, lactation, and body reserves; dry matter intake; the carbohydrate and protein fractions of feeds; ruminal fermentation and microbial growth; the supply of metabolizable energy, protein, and amino acids; and the linear and iterative ration optimizer. The third is a user guide to every window of the program, and the fourth works through a feedlot example step by step. Revision 2 (October 30, 2026) explains three points in more detail. First, the CNCPS changed what earlier systems did: earlier systems gave each feed one value for energy and one for protein, and the CNCPS divided

carbohydrate and protein into fractions digested at their own rates. The second is the difference between a mechanistic model and an empirical one. The third is how gains from metabolizable energy and metabolizable protein in a ration show which nutrient limits performance. The lineage of Figure 1 now runs to versions 6.1 and 6.5 of the CNCPS (Van Amburgh et al., 2010, 2015). Revision 2 also adds a List of Acronyms and units, cites its sources as live references, and makes every web address a link. The window pictures (Figures 3 to 12, 14, and 15) were taken again on November 9, 2026, with the license and registration numbers grayed out for privacy. Revision 3 (November 20, 2026) describes the new *Logs* submenu of the *Options* menu, which turns the error log and the start-up reports on or off, adds this abstract and a section on updates and problems, gives the release date of version 1.3.1 as December 1, 2026, and edits the text for clarity.

1. How the program began

The Large Ruminant Nutrition System (**LRNS**) evaluates and formulates rations for beef and dairy cattle under the conditions of a particular farm: the animals, their environment and management, and the feeds at hand. It does so with the Cornell Net Carbohydrate and Protein System (**CNCPS**) version 5, as published by Fox et al. (2004). The book that describes the family of models to which it belongs puts its origin in one sentence:

> **TEDESCHI AND FOX (2020), THE RUMINANT NUTRITION SYSTEM, 3RD ED., SECTION 2.2**
> *"The Large Ruminant Nutrition System (LRNS …) is based on the CNCPS version 5.x framework as published by Fox et al. (2004b) with a redesigned interface, several corrections, and minor modifications."*

1.1 The Cornell Net Carbohydrate and Protein System

The CNCPS was begun at Cornell University in 1979 by Danny G. Fox and Charles J. Sniffen (Tedeschi and Fox, 2020). Its structure was published in 1988 (Fox et al., 1988) and its first complete description, with a program written in Lotus 1-2-3, in 1990 (Fox et al., 1990). Four papers in the Journal of Animal Science then set out its parts: ruminal fermentation (Russell et al., 1992), carbohydrate and protein availability (Sniffen et al., 1992), cattle requirements and diet adequacy (Fox et al., 1992), and amino acid adequacy (O'Connor et al., 1993). Versions 2 and 3 ran in Excel. In 1992, Fox joined the National Research Council (**NRC**) committee that revised the Nutrient Requirements of Beef Cattle and used version 2 as the initial structure for its model, which the committee modified to meet its needs; the committee published that model in 1996 and updated it in 2000 (NRC, 1996, 2000). The exchange had gone the other way before: many of the requirements of the first CNCPS came from the earlier editions of the NRC; from 1996 the NRC adopted many concepts of the CNCPS, which carried on into the eighth revised edition of the Nutrient Requirements of Beef Cattle, by the National Academies of Sciences, Engineering, and Medicine (NASEM, 2016; Tedeschi, 2019; Tedeschi and Fox, 2020). Version 4.0, released in 2000, added herd nutrition and nutrient excretion (Fox et al., 2000); version 5.0 was documented in 2003 and published in 2004 (Fox et al., 2003, 2004), with Dr. Tedeschi among its authors. Luis Tedeschi came to Cornell as a graduate student in 1997; his 2001 doctoral thesis, under Fox, developed parts of the model: feed libraries, ruminal nitrogen deficiency, diet optimization, and the energy requirements for maintenance and growth (Tedeschi, 2001). The next version, 6.0, was published by Tylutki et al. (2008); Fox and Dr. Tedeschi are among its authors as well.

The name says what was new. Earlier systems, the NRC tables among them, gave each feed one value for its energy and one for its protein. The CNCPS divided the carbohydrate and protein of each feed into fractions, each with its own rate of digestion (Sniffen et al., 1992), and represented the rumen microbes that grow on them (Russell et al., 1992). What a feed supplies to the animal then depends on the animal: on how much it eats, which sets how fast the feed passes through the rumen, and on what the rest of the ration provides to the microbes. With analyses of a farm's own feeds, the model could therefore compare what each group of animals requires with what its ration supplies and identify which nutrient limits performance (Fox et al., 2004). Section 2 describes each of these parts.

This is the difference between a mechanistic model and an empirical one. An empirical model relates what is observed to the inputs as they were found together in experiments; a mechanistic model

represents the processes that produce the result, here the digestion of each fraction and the growth of the microbes, and so it can be applied to feeds and conditions other than those of the experiments, as long as the processes are described correctly (Tedeschi and Fox, 2020).

1.2 From Cornell to Texas A&M

Fox began a phased retirement from Cornell on January 1, 2004, and retired fully on September 15, 2005 (Fox, 2013). That same day Luis Tedeschi joined the faculty of Texas A&M University as an assistant professor, to teach and conduct research in ruminant nutrition. His programming and model development continued as they had begun in his student years: on his own time.

Luis Tedeschi remembers the reason as he and Danny Fox saw it then: the CNCPS version 5 still had much value for those who used it, and they decided to keep it available, under another name.

1.3 First the sheep, then the cattle

The small ruminants came first. The CNCPS for Sheep (Cannas et al., 2004), developed at Cornell with Antonello Cannas, of the University of Sassari, became the Small Ruminant Nutrition System (**SRNS**) between October 2005 and February 2006, soon after the move to Texas A&M. The same was then done for cattle. On November 1, 2009, Fox, by then professor emeritus, wrote to Dr. Tedeschi:

> **D. G. Fox, letter to L. O. Tedeschi, November 1, 2009**
> *"As part of our joint collaboration, I am providing you with the CNCPS version 5 source code at no charge and authorize you to use it to implement the CNCPS as published by Fox et al., Animal Feed Science Technology 112 (2004), 29-78. We have agreed that this will be used to develop a Large Ruminant Nutrition System (LRNS) to complement the Small Ruminant Nutrition System to be distributed at no charge to be used for teaching and workshops."*

LRNS 1.0.1 was released four days later, on November 5, 2009. It included CNCPS levels 1 and 2 for solution, animal groups, and the whole herd; four feed libraries; feed mixes; a linear and an iterative optimizer; the reports; and five sample simulations. The same letter named the next step, a model that would integrate both systems and be written anew, which the letter called the Ruminant Nutrition Management System (**RNMS**); it became the Ruminant Nutrition System (**RNS**), whose first version appeared in January 2011 and whose model is described in the book of the same name (Tedeschi and Fox, 2020).

1.4 The versions

Table 1 lists the versions that changed the most. In October 2026, the author revised the program throughout, with the help of an artificial intelligence assistant: a start-up screen that checks the program and the computer, files that read the same whatever the regional settings of Windows, corrections to the optimizer (the true dry matter cost of feeds, and the limits for physically effective **NDF** (neutral detergent fiber) and for NDF of the third edition of the book), a redesign of the reports, and a new registration. That release is version 1.3.1, dated January 1, 2027.

Table 1. The versions of LRNS that changed the most. The complete list is in the file of changes, lrns_changes.txt.

Version	Date	What changed
1.0.1	Nov 5, 2009	First release: CNCPS levels 1 and 2, animal groups and whole herd, four feed libraries, mixes, linear and iterative optimizer, reports, five sample simulations
1.0.2	Nov 28, 2009	The LRNS quick guide and the CNCPS 5.0 model documentation installed with the program
1.0.8, 1.0.10, 1.0.16	2010	The tutorials: beef feedlot, dual-purpose cow, small dairy farm, large dairy farm, beef cow herd
1.0.18	Oct 4, 2011	Option of the **TDN** (total digestible nutrients) equations of Detmann et al. (2008) for level 1
1.0.31	Jul 8, 2014	Batch processing of simulations; updated CNCPS feed library
1.0.32	Mar 29, 2015	The website moves to https://www.nutritionmodels.com
1.1.0	Aug 1, 2019	Secure (**HTTPS**, Hypertext Transfer Protocol Secure) update check and download
1.2.6	Nov 25, 2025	User files in Documents\NutritionModels\LRNS files; published by https://www.nutritionmodels.com
1.3.0	Oct 2, 2026	New start-up screen; update notes
1.3.1	Dec 1, 2026	The revision of October 2026 and new registration

Figure 1 draws the lineage of LRNS, from the CNCPS to the present version.

2. The science behind the model

LRNS sets what an animal requires against what its ration supplies (Figure 2). Requirements depend on the animal and its surroundings; supply depends on the feeds, how much is eaten, and what happens to the feeds in the rumen. The CNCPS combines mechanistic parts, where knowledge allows, with empirical ones, and is static: it describes the steady state of a group of animals on a ration. Every equation is in the model documentation (Fox et al., 2003) and the paper (Fox et al., 2004); this section says what each part does. A more thorough and deeper discussion of the biology behind these equations, which led to the development of the RNS model, is in Tedeschi and Fox (2020).

2.1 Two levels of solution

Level 1 values feeds from tabular total digestible nutrients (TDN) and undegraded intake protein, discounted for the level of intake; since version 1.0.18, it may compute TDN using the equations of Detmann et al. (2008). Level 2 values them mechanistically, based on the carbohydrate and protein fractions of each feed, their rates of digestion and passage, and the growth of rumen microbes. Level 2 requires more information about the feeds and more detail on the ration; level 1 is used when that information is lacking (Tedeschi et al., 2005, 2008).

2.2 Requirements

- Maintenance: metabolic body size, adjusted for breed, physiological state, previous plane of nutrition, activity, and the heat the animal gains or loses in its environment (temperature, humidity, wind, hair

coat, mud, and insulation by body condition), with the cost of excreting excess nitrogen as urea (Fox et al., 1988; Fox and Tylutki, 1998).

- Growth: the composition of the gain from the equivalent shrunk body weight, the expected mature size, and the rate of gain, with implants; target weights and rates of gain for replacement heifers (Tylutki et al., 1994; Fox et al., 1999).
- Pregnancy and lactation: the demand of the conceptus by day of gestation, and that of milk by yield and composition (Fox et al., 2003).
- Body reserves: energy and protein stored or mobilized, from body weight and condition score; in lactating cows, 1 Mcal of reserves replaces 0.82 Mcal of **NEl** (net energy for lactation) (Fox et al., 1999).
- Amino acids and minerals: the requirements of 10 essential amino acids (O'Connor et al., 1993) and of the macro and trace minerals.

2.3 Dry matter intake

Intake is predicted for each class of animal and adjusted for temperature, mud, breed, body fat, and implants. The model works best with the group's actual intake; the predicted intake then serves as a benchmark for diagnosis.

2.4 The feeds: carbohydrate and protein fractions

Each feed is described by the fractions of its carbohydrate and protein, measured with the detergent system of feed analysis and proximate analysis, and by a rate of digestion for each fraction (Table 2; Sniffen et al., 1992). Available fiber is NDF minus its protein and minus 2.4 times lignin.

Table 2. The carbohydrate (**CHO**) and protein fractions of a feed in the CNCPS (Sniffen et al., 1992).

Fraction	What it is	In the rumen
CHO A	Sugars	Fast
CHO B1	Starch and pectin	Intermediate; depends on the starch and its processing
CHO B2	Available NDF	Slow; competes with passage
CHO C	Unavailable NDF (2.4 × lignin)	Not digested
Protein A	Nonprotein nitrogen	Immediately
Protein B1	Soluble true protein	Fast
Protein B2	Insoluble protein, not in NDF	Partly in the rumen, partly in the intestines
Protein B3	Protein in NDF, not in **ADF** (acid detergent fiber)	Slow; mostly escapes
Protein C	Protein in ADF	Unavailable

2.5 The rumen

The rumen microbes are two pools: those that ferment fiber carbohydrates, which grow slowly and use ammonia, and those that ferment non-fiber carbohydrates (sugars, starch, pectin), which grow faster and

use ammonia and peptides (Russell et al., 1992). Each pool grows in proportion to the rate at which its carbohydrate is digested, as long as nitrogen is available; when ruminal nitrogen is short, fiber digestion and microbial yield fall with it (Tedeschi et al., 2000a). What is digested in the rumen and what escapes depends on the competition between the rate of digestion of each fraction and its rate of passage, which rises with intake and differs for forages and concentrates (Fox et al., 2004). Rumen pH is represented through physically effective NDF (**peNDF**): below 20% peNDF in the diet the yield of microbes falls 2.5% for each unit (Pitt et al., 1996).

2.6 Intestinal digestion, energy, and protein

The fractions that escape the rumen, and the microbes themselves, are digested in the intestines with fixed digestibilities. From the sum come the metabolizable energy (**ME**) and the metabolizable protein (**MP**) of the ration, its supply of essential amino acids, and the nitrogen and phosphorus excreted. Set against the requirements, they give what the ration allows: ME-allowable and MP-allowable gain or milk, the first limiting amino acid, and the balances of ruminal nitrogen, peptides, and peNDF.

2.7 The optimizer

The CNCPS is not linear, so a ration cannot be optimized on all its equations at once. The linear optimizer of LRNS uses the model to estimate, for each feed, how much energy, protein, and ruminal nitrogen it supplies in the ration at hand (its biological values), and then finds the least-cost ration that meets the constraints on ME, MP, peNDF, NDF, calcium, phosphorus, ruminal nitrogen and peptides, and methionine and lysine (Tedeschi et al., 2000b). In the iterative mode it recomputes the biological values on the new ration and runs again, until no feed changes by more than the sensitivity set (5% by default).

3. User guide

The names of windows, fields, and buttons are set in italics, as they appear on the screen.

3.1 Starting LRNS

An unregistered copy can be started 10 times; to keep using LRNS, register it with the license number at https://www.nutritionmodels.com. When LRNS starts, its start-up screen shows the version, the registration, and the computer, and runs nine checks, naming each one as it runs: the program and the computer, the data folders, the settings file, the last simulation, the four feed libraries, the program components, the help files, the printer, and whether a newer version exists (Figure 3). When they end, the line under the bar says how many items deserve a look; a click on it opens the report, which is also saved in *Documents\NutritionModels\LRNS files\Logs* while *Options > Logs > Save Start-up Reports* is on. The About window (*Help > About LRNS*; Figure 4) shows the version, the registration, and the notice of the program, and its buttons check for a newer version (*Update*), open the website (*Web*), describe the computer (*Sysinfo*), and open this document (*Help*).

3.2 Finding your way

The main window has a menu, a toolbar, and, on the left, a tree that summarizes the simulation (Figure 5). Table 3 lists the menus. The toolbar buttons, from left to right, are *New*, *Open*, *Save*, *Save as*, *Parameters*, *Feeds*, *Groups*, *Inputs*, *Reports*, *Optimizer*, *Options*, and *Help*. In the tree, a click on a group's *Description*, *Production*, *Mgt/Environment*, or *Ration* opens that page of the group, and a click on a feed opens it in the feeds window. Because the program can go from inputs to results at any moment, it always holds a simulation: the one you work on is saved as the default when you leave, unless *Auto-Save Simulation on Exit* is unchecked in the *File* menu.

Table 3. The menus of the main window.

Menu	Commands
File	New, Load, Save, and Save As a simulation; Auto-Save Simulation on Exit; Reports; recent files; Exit
View	Tree, Parameters, Feeds, Groups, Optimizer, All Inputs; Metric or English units; Dry Matter or As-Fed basis; Level 2 or Level 1 solution; Calorie or Joule units
Options	Summary Results, Reports, Feed Libraries, Miscellaneous; Regional Settings; Logs
Help	LRNS manual (this document); LRNS website; CNCPS 5.0 manual; Register; Check for update; About LRNS

3.3 The simulation and its parameters

A simulation has three parts: its parameters, its feeds collection, and its animal groups. The parameters window (Figure 6) sets the units (metric or English), the basis of the ration (dry matter or as fed), the level of solution, and the energy units (calories or joules). There, groups are created, copied, renamed, deleted, and ordered, and for the whole-herd results, each is given the number of animals and the days it is fed in a year. Comments about the simulation are kept there too.

3.4 Feeds, feed libraries, and mixes

The feeds collection holds every feed available on the farm; all the groups draw on it (Figure 7). *Add Feed(s)* opens the feed libraries, with the feeds by category; selected feeds are copied into the collection, where they can be edited without changing the library. A new feed is made most easily from a similar one; *Create Feed* offers reasonable values by type. Edited feeds are saved to the *User-Created Feeds Library*, and a whole collection can be saved and loaded into another simulation. LRNS ships with four libraries: the CNCPS feed library, the CNCPS-**CPM** (Cornell-Penn-Miner) feed library, the CNCPS tropical feed library (Tedeschi et al., 2002), and the user-created feeds library, with a template for libraries of your own (Microsoft Access, password protected so that the original values are not changed by mistake). Feeds can be combined into mixes; a mix fed to a group is decomposed into its feeds for the calculations.

3.5 Animal groups

The groups window (Figure 8) shows one group at a time, chosen in *Animal Group*, and describes it on four pages (Table 4): *Description* (Figure 9), *Production* (Figure 10), *Mgt/Environment* (Figure 11), and *Ration* (section 3.6). The inputs show their units, take numbers only where numbers are expected, and refuse impossible values. Body weight is shrunk body weight (96% of full weight); body condition is on the

dairy scale (1 to 5) or the beef scale (1 to 9). The 2009 guide gives advice that still holds: an accurate weight and condition score matter most; wind matters only near the animal's lower critical temperature; for the previous and current temperature, use the average of the past month, or 20 °C (68 °F) to leave maintenance unadjusted; and use a hair depth of 1.27 cm (0.5 in) in winter and 0.64 cm (0.25 in) in summer.

Table 4. The four pages of an animal group.

Page	Inputs
Description	Animal type, sex, age, breed type and breeds (up to three, with the breeding system), body weight (full or shrunk), condition score, expected weight at a body fat percentage
Production	Days pregnant and expected calf birth weight; days since calving, lactation number, calving interval, and age at first calving; milk production, fat and protein, and milk price
Mgt/Environment	Additive (implant, ionophore), added fat; time standing, position changes, distance walked; previous and current temperature and relative humidity, wind speed, minimum night temperature, hours in sunlight, storm exposure; hair depth and coat, hide, mud depth, panting
Ration	The amount of each feed and the summary results (section 3.6)

3.6 The ration and its results

On the *Ration* page the amount of each feed is entered, and the summary results are shown at once (Figure 12): for a growing animal, for example, the ME- and MP-allowable gain, the first limiting amino acid, and the balances of ruminal nitrogen, peptides, and peNDF. Up to nine summary results are shown, chosen from the options, by default those suited to the type of animal. *Intake Scalar* scales the whole ration, *Least Cost Optimizer* opens the optimizer for the group, and *Quick Report* shows a report of the group at once.

3.7 The optimizer

The optimizer (Figure 13) has two tabs: *Linear Optimization*, the least-cost linear program, and *Iterative Optimization*, a grid search, shown when *Show Iterative Optimizer (grid search)* is checked in the options. The linear optimizer has two pages. On *Ration Values* each feed gets its minimum and maximum (equal values fix a feed; mixes are held at their current amount). On *Constraints* each nutrient is used or not, with lower and upper factors applied to the requirement. *Dry Matter Intake* chooses the predicted or the current intake; *Initial Diet* chooses the ration on which the biological values are computed, the current one or a standard diet of 10 kg of alfalfa silage and 10 kg of orchardgrass hay; *Optimization Type* chooses a single run or the iterative mode with its *Sensitivity*. The 2009 guide's advice: give every feed a cost (the libraries have none, and feeds with no cost spoil the solution), keep at least one feed above zero, use the predicted intake unless you are sure of the current one, and use the standard diet unless the current ration is sound.

3.8 Reports

The reports window (Figure 14) lets you choose the groups and report components for each group, for several groups, or for the whole herd, and shows them in a print preview with zoom, page setup, and printing; you can also export a report. Level 1 offers 15 reports and level 2 offers 24 (Table 5).

Table 5. The reports of LRNS.

Level	Reports
Level 1 (15)	One Page Summary, Mix Feeds, Min/Vit Feed, Summary, Diet Summary, Feeds Summary, Maintenance, Growth, Target Weights, Lactation, Pregnancy, Body Reserves, Mineral Requirements, Predicted Dry Matter Intake, Biological Values
Level 2 (24)	The same, and Diet Evaluation, Mineral Balances, Amino Acid Supply and Requirements, Ration CHO and Protein Fractions, Ration Degradation and Passage, Bacterial Nitrogen, Ration Energy, Nitrogen Excretion, Carbohydrate Fermentability

3.9 Options

The options window (Figure 15) has four pages: the summary results shown on the ration page; the default report components, zoom, headers, footers, and fonts of the reports; the feed libraries the program uses (add, remove, update); and miscellaneous settings, among them whether the model runs again after each change of the ration, toolbar captions, the iterative optimizer, the decimal separator, and advanced options of the model. The advanced options change the calculations of the CNCPS; most are experimental and are to be used with care. The *Logs* submenu of the *Options* menu turns the error log (LRNS.LOG) and the start-up reports on or off (both are on unless turned off) and opens the Logs folder, the last start-up report, and the error log.

3.10 Files, batches, and the command line

Table 6 lists the files LRNS reads and writes. LRNS can be started with */f* and a simulation file to open it, or with */b* and a batch file (.bncps) that lists simulations and report codes: LRNS then writes each report as an RTF file in a folder named after the batch file, and closes.

Table 6. The files of LRNS.

Extension	Content
.ncps	A simulation: parameters, feeds collection, groups, and rations
.ncpg	One animal group, to reuse in another simulation
.ncpf	A feeds collection
.bncps	A batch: simulations and the report codes to write
.cns, .cng, .cnf	Files of the CNCPS, read by LRNS
.mdb	A feed library (Microsoft Access)

3.11 Updates and problems

Help > Check for update, or *Update* in the About window, compares the installed version with the one on the website and, when a newer one exists, shows what is new and offers the download window, where *Start* downloads the setup file to LRNS files\Update, *Stop* interrupts the download, and *Return* closes the window. A stopped or failed download leaves no incomplete file; when the download completes, the Update folder opens: close LRNS, open the zip file, and run the setup program. An unrecoverable error shows its number and description and closes LRNS, and the changes made since the simulation was last

saved are lost; while *Options > Logs > Save Error Log* is on, the error is written to LRNS.LOG. When reporting a problem, include the last start-up report and LRNS.LOG.

3.12 Files and folders

Where	What
Documents\NutritionModels\LRNS files\Simulations	The sample simulations of the tutorials, and your own
...\LRNS files\Feed Libraries	The feed libraries and the template
...\LRNS files\Feed Collections, Feed Mixes	Saved collections and mixes
...\LRNS files\Logs	The start-up reports (the newest 30) and the error log, LRNS.LOG (Options > Logs turns either off)
...\LRNS files\Update	The setup of a new version, when it is downloaded
The program folder	The program, this document (manual_en.pdf), the CNCPS 5.0 model documentation (CNCPS_manual.pdf), the tutorials

4. A worked example: a Holstein steer feedlot

The simulation *LRNS Beef Feedlot tutorial.ncps*, installed with LRNS, is the case of its beef feedlot tutorial (2010): a farm of 550 acres that feeds 950 Holstein steers a year, received at about 300 lb every seven weeks and fed in three weight groups on home-grown alfalfa silage and high-moisture corn, wet brewers' grains, and minerals. Table 7 gives the groups and their rations as the file holds them.

Table 7. The groups and rations of the feedlot tutorial, as the simulation file holds them (lb of dry matter per head per day; the file stores kg). All are Holstein steers, implanted and fed an ionophore, fed 365 days.

Group	Head	Age, mo	SBW (shrunk body weight), lb	Alfalfa silage	HM (high-moisture) corn	Dry corn	Brewers' grains	Minerals	Total
Light	425	6.5	550	4.40	7.40	—	2.50	0.21	14.51
Medium	200	10.5	900	4.50	11.90	—	3.20	0.30	19.90
Heavy	325	14.0	1175	4.80	10.00	6.50	2.40	0.37	24.07

Two of these results are the key to reading a ration. The ME-allowable gain is the gain that the metabolizable energy of the ration supports once maintenance is met, and the MP-allowable gain is the gain that its metabolizable protein supports. The animal can gain no more than the lower of the two, so the lower one names the nutrient that limits growth (Fox et al., 2004). When the two are close, the ration is balanced; when one is far above the other, part of that nutrient is not used, and protein in excess is excreted as nitrogen.

Opened in LRNS, with the units set to English and the solution level set to 2, the summary results for each group show what the ration allows. Table 8 and Figure 16 show them as the tutorial printed them; LRNS

1.3.1 gives the same values today (computed again on October 15, 2026 with the installed program; it prints them in kg/d, which agree with the table to the report's rounding). The model predicts intake well (within 5%) and slightly overpredicts gain: the ME-allowable gain is 2 to 4% above the gain the farm observed. Energy, not protein, limits growth in every group: the ruminal nitrogen balance is positive, and the MP-allowable gain is above the ME-allowable gain, by far in the two heavier groups. One value differs between the tutorial and LRNS 1.3.1: the balance of physically effective NDF, slightly positive in 2010 (0.6, 0.1, and 0.1 lb/d) and negative in 1.3.1 (−0.2, −0.9, and −1.1 lb/d). The supply of peNDF is the same; what changed is the requirement: since version 1.3.1 the peNDF required by growing and finishing cattle is 15% of the dry matter fed, as in The Ruminant Nutrition System (Tedeschi and Fox, 2020, Volume II, Equation 8.2), where it was 10% before. The requirement thus rises by 5% of the intake, about 0.7 lb/d for the lightweight steers and more for the heavier groups, which eat more; by today's standards, these rations fall short of providing effective fiber, especially in the two heavier groups. Peptides are short, but more microbial protein would not help while energy limits.

Table 8. Results of the feedlot tutorial, as printed in its Table 5 (LRNS, 2010) and reproduced by LRNS 1.3.1. Intake and gain in lb/d; balance of physically effective NDF (peNDF) in lb/d, as the tutorial printed it (2010) and as the Ration page of LRNS 1.3.1 shows it; every other value is the same in both.

Group	**DMI** (dry matter intake) **actual**	**DMI predicted**	**ADG** (average daily gain) **actual**	**ME-allowable ADG**	**MP-allowable ADG**	**Ruminal N, g/d**	**Peptides, g/d**	**peNDF, 2010**	**peNDF, 1.3.1**
Light	14.51	13.84	3.00	3.06	3.11	13	-7	0.6	-0.2
Medium	19.90	19.83	2.80	2.91	4.07	18	-15	0.1	-0.9
Heavy	24.07	24.89	2.71	2.80	4.35	22	-15	0.1	-1.1

The tutorial goes on from there, and its steps are a good way to learn the program: first make the predicted gain match the observed one, by checking the inputs and then the feeds (for the heavy group, a slower rate of digestion of the starch of dry corn); then use the excess of protein in the medium group to cut the supplement and the cost of gain; then see how cold, wind, and mud lower the gain of the light group; and finally compute the feed the whole herd needs in a year and the nitrogen, phosphorus, and potassium it excretes.

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Figures

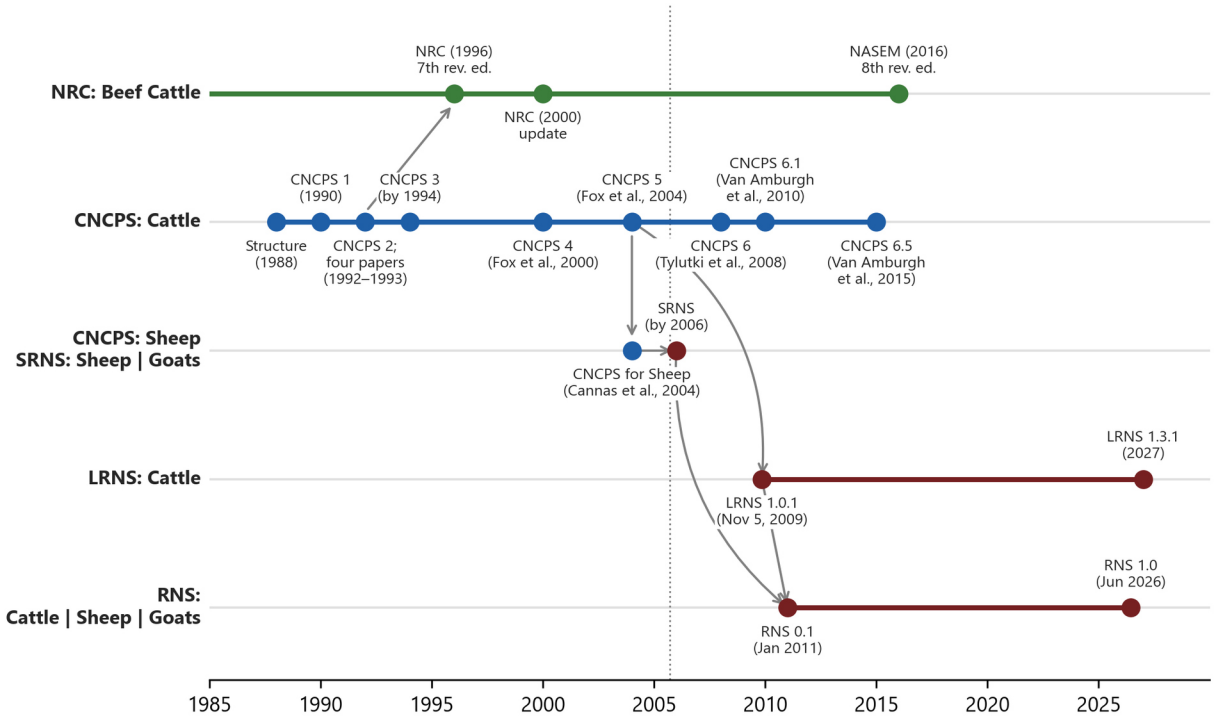

Figure 1. The lineage of LRNS: the CNCPS at Cornell University, its version for sheep and the SRNS, LRNS, and the Ruminant Nutrition System (RNS), with the Nutrient Requirements of Beef Cattle (NRC, 1996, 2000; NASEM, 2016), whose model of 1996 began from version 2 of the CNCPS. Blue marks are the versions of the CNCPS, up to 6.1 and 6.5 (Van Amburgh et al., 2010, 2015), green marks the editions of the beef NRC, and dark red marks the author's programs, distributed through https://www.nutritionmodels.com. The dotted line marks September 15, 2005, when Dr. Tedeschi moved to Texas A&M University and Fox retired from Cornell University. The structure of the CNCPS was published by Fox et al. (1988) and its first program, in Lotus 1-2-3, by Fox et al. (1990); versions 2 and 3, in Excel, followed within four years, and their marks are placed approximately (Tedeschi and Fox, 2020). Dates from the files and the lists of changes of the programs and from Tedeschi and Fox (2020).

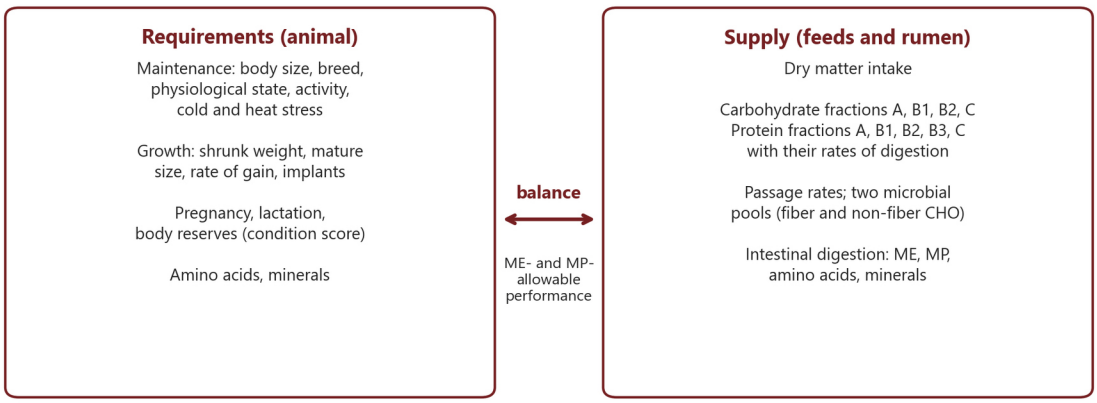

Figure 2. The structure of the CNCPS in LRNS: the requirements of the animal set against the supply from the feeds through the rumen and the intestines; their balance gives the performance the ration allows (after Fox et al., 2004).

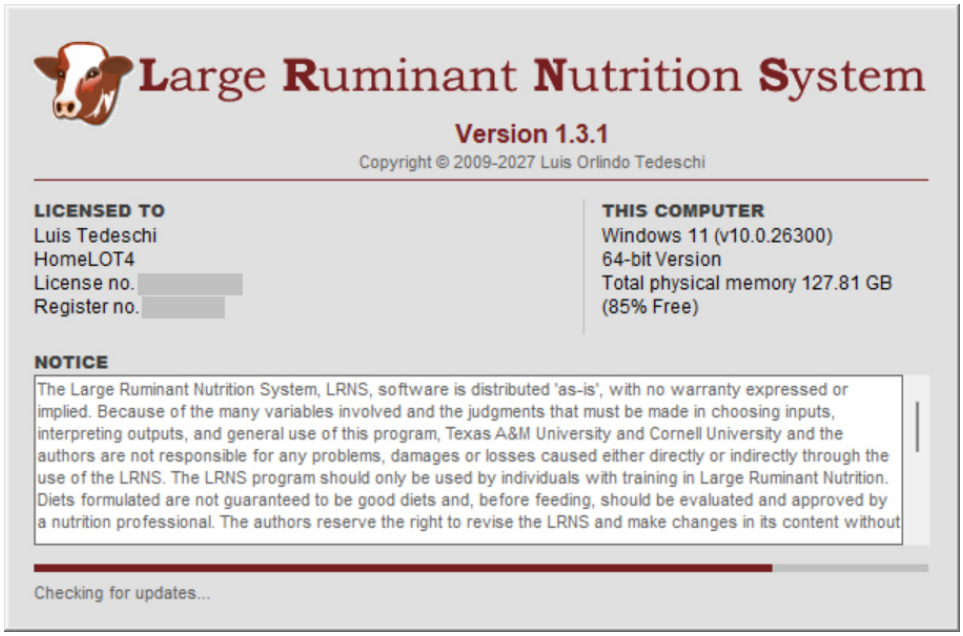

Figure 3. The start-up screen while it runs its checks; the line under the bar names each one and, at the end, how they went. The license and register numbers are grayed out for privacy.

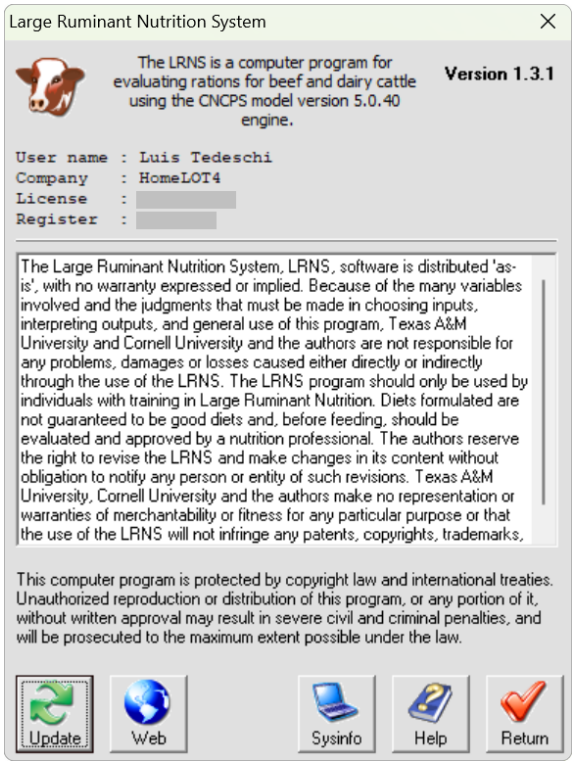

Figure 4. The About window. The license and register numbers are grayed out for privacy.

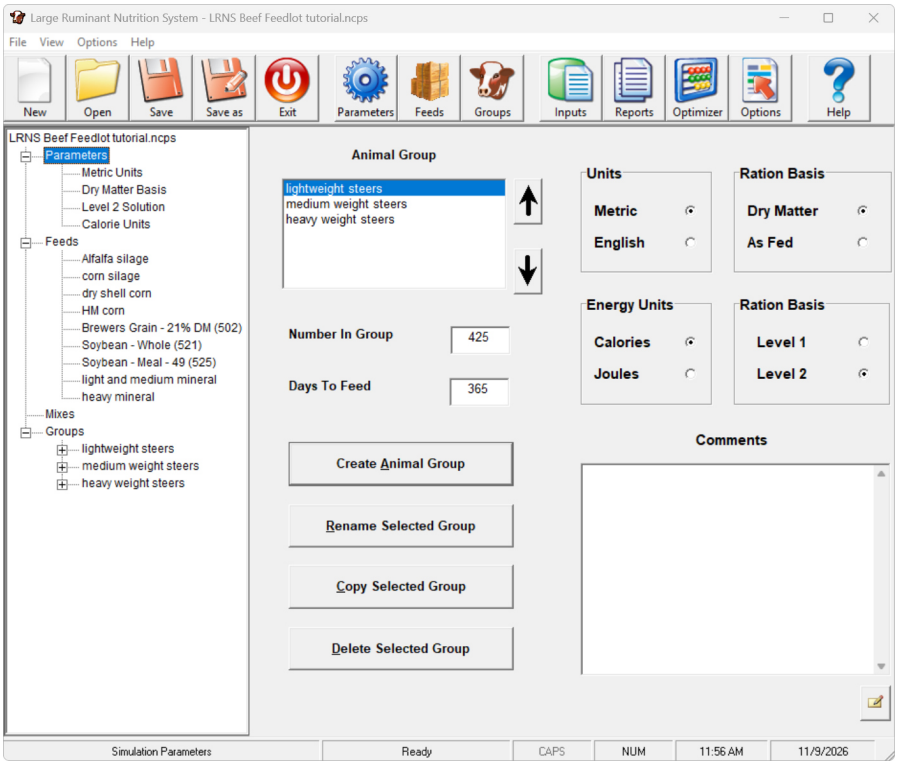

Figure 5. The main window: menu, toolbar, and the tree of the simulation.

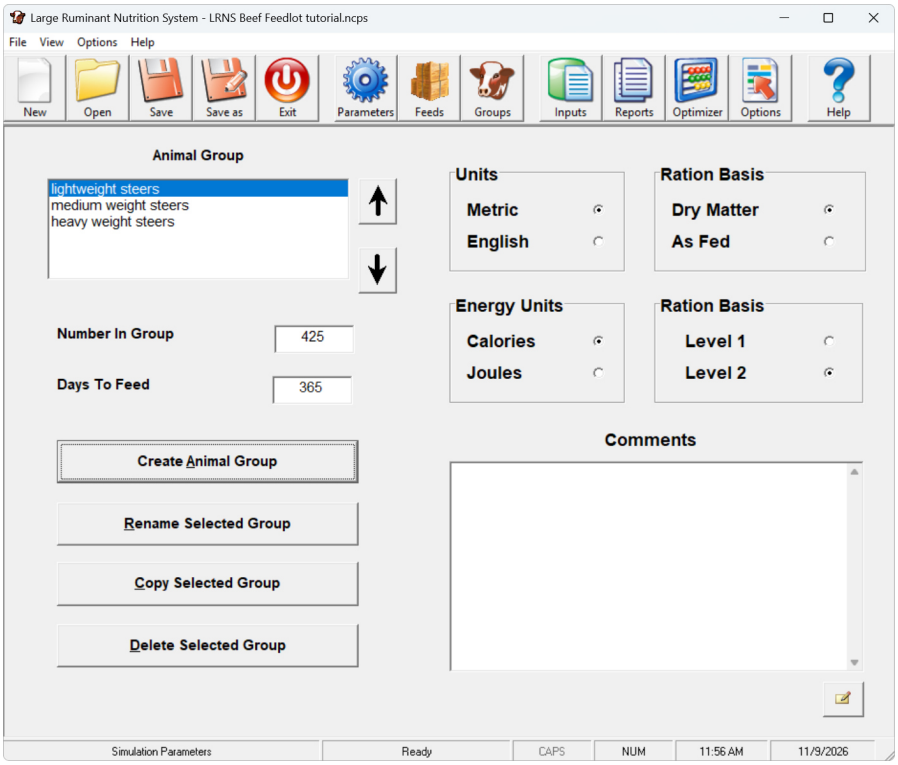

Figure 6. The simulation parameters.

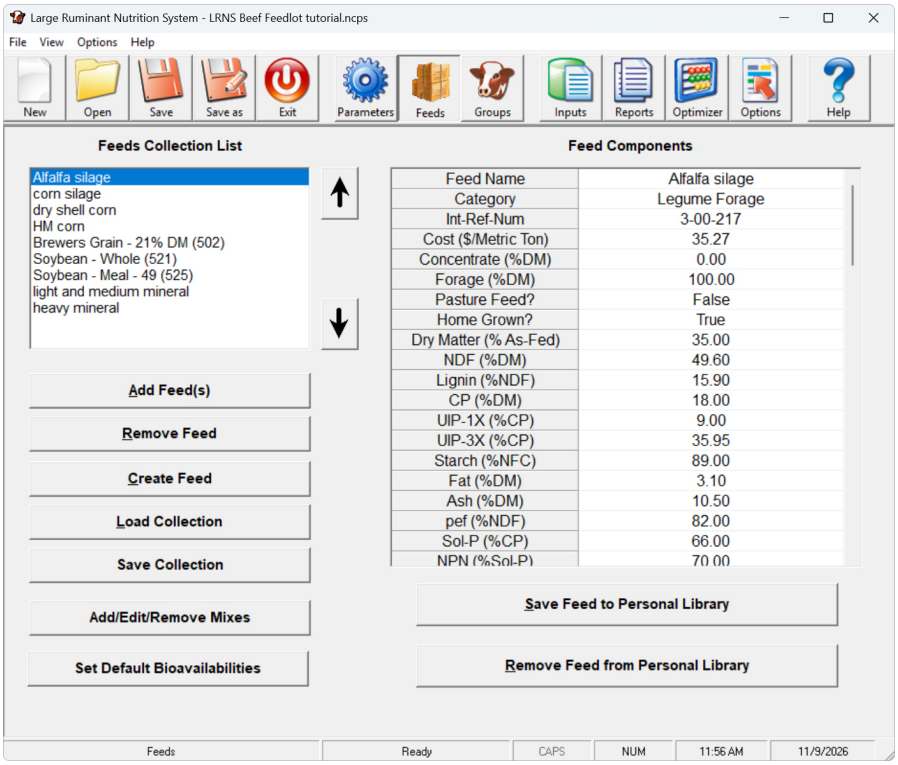

Figure 7. The feeds collection and the components of a feed.

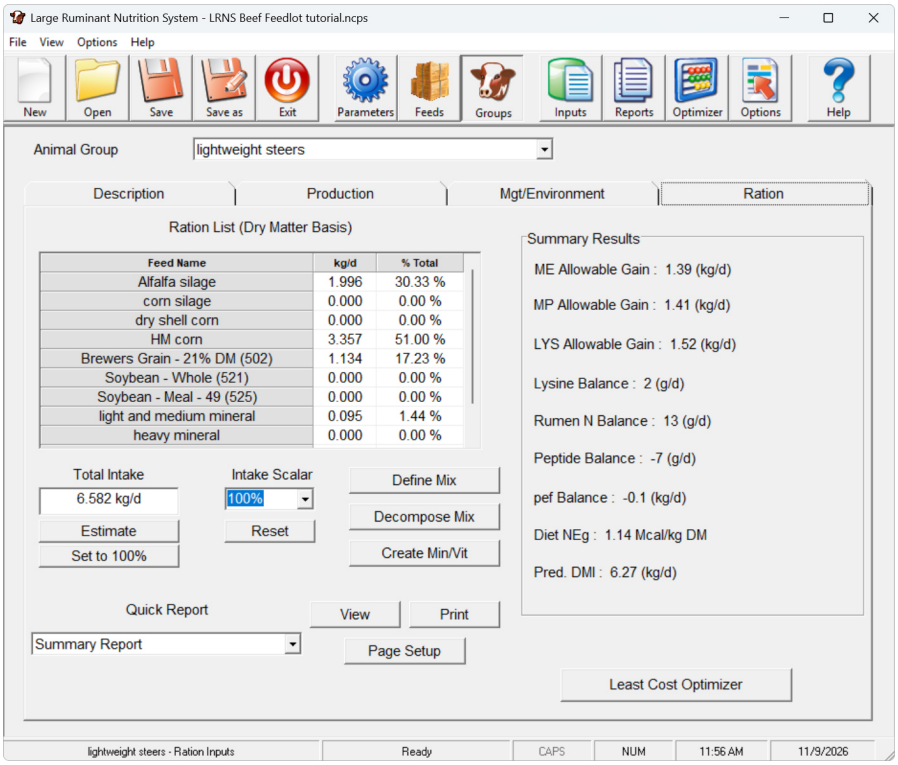

Figure 8. The groups window, here on the Ration page of the lightweight steers.

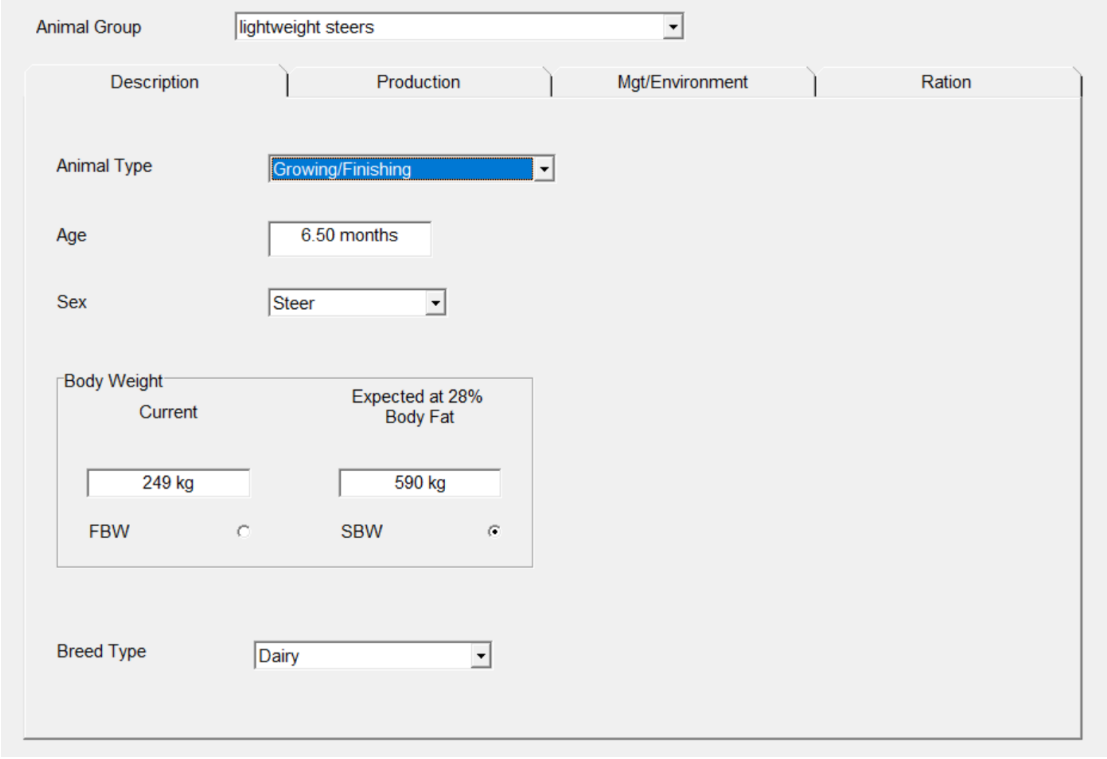

Figure 9. An animal group, Description page.

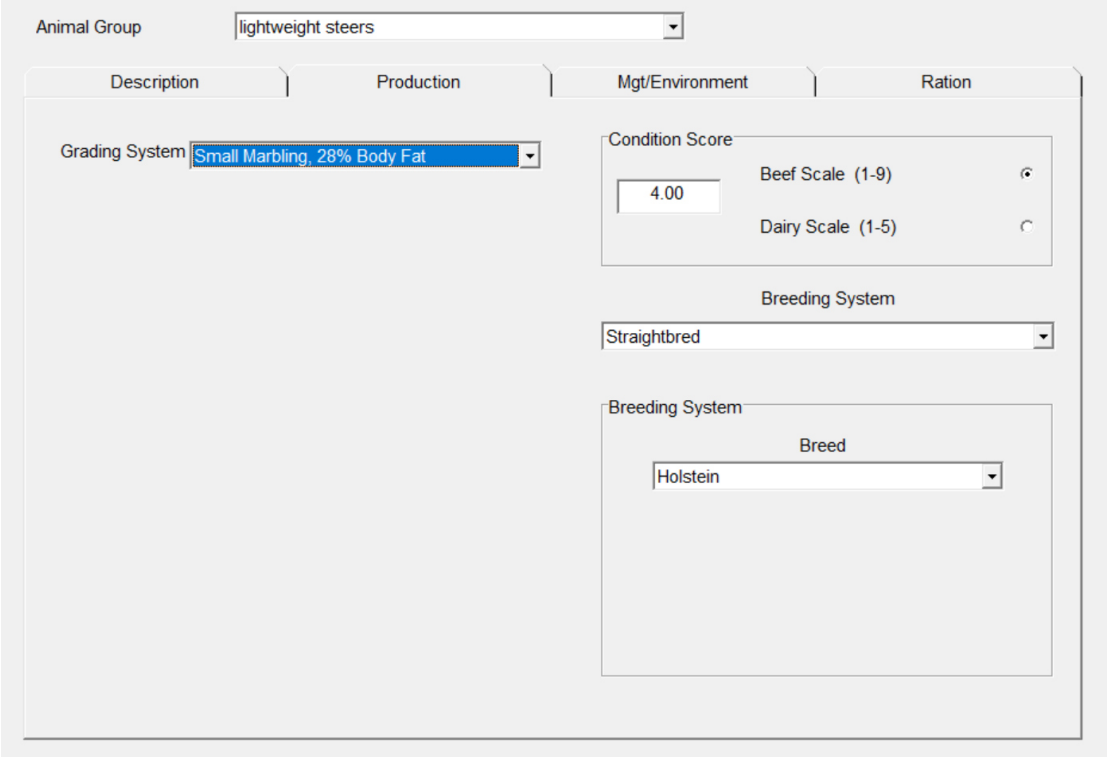

Figure 10. An animal group, Production page.

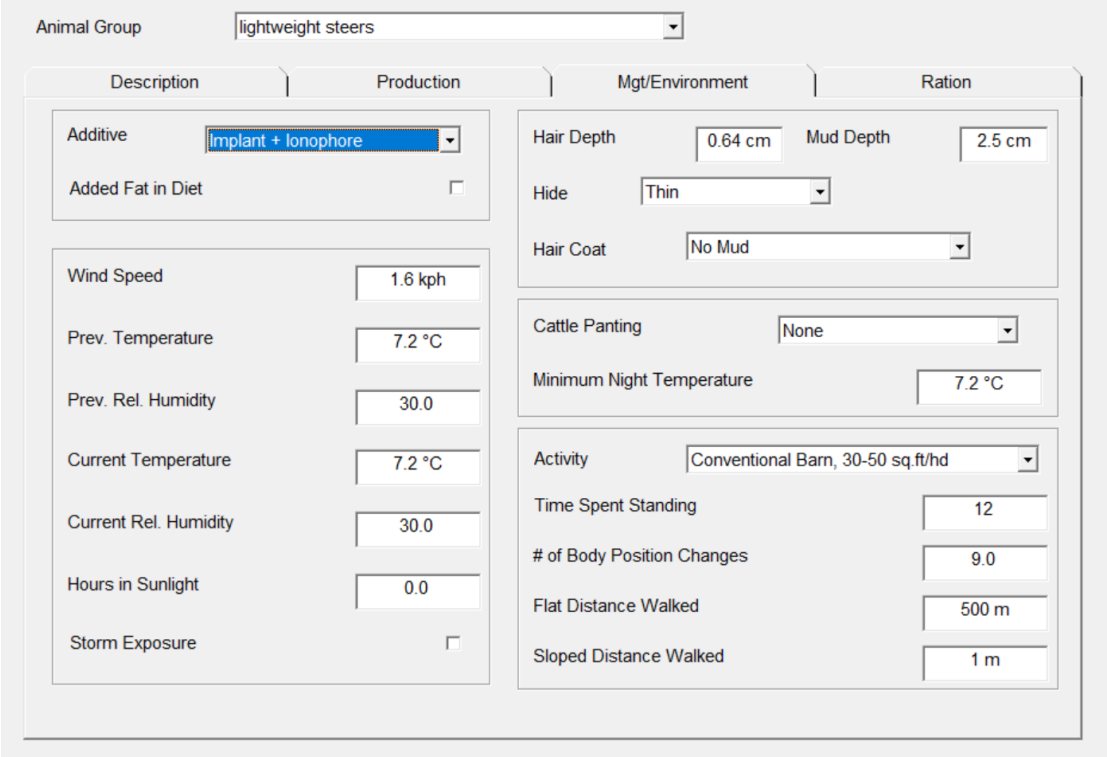

Figure 11. An animal group, Mgt/Environment page.

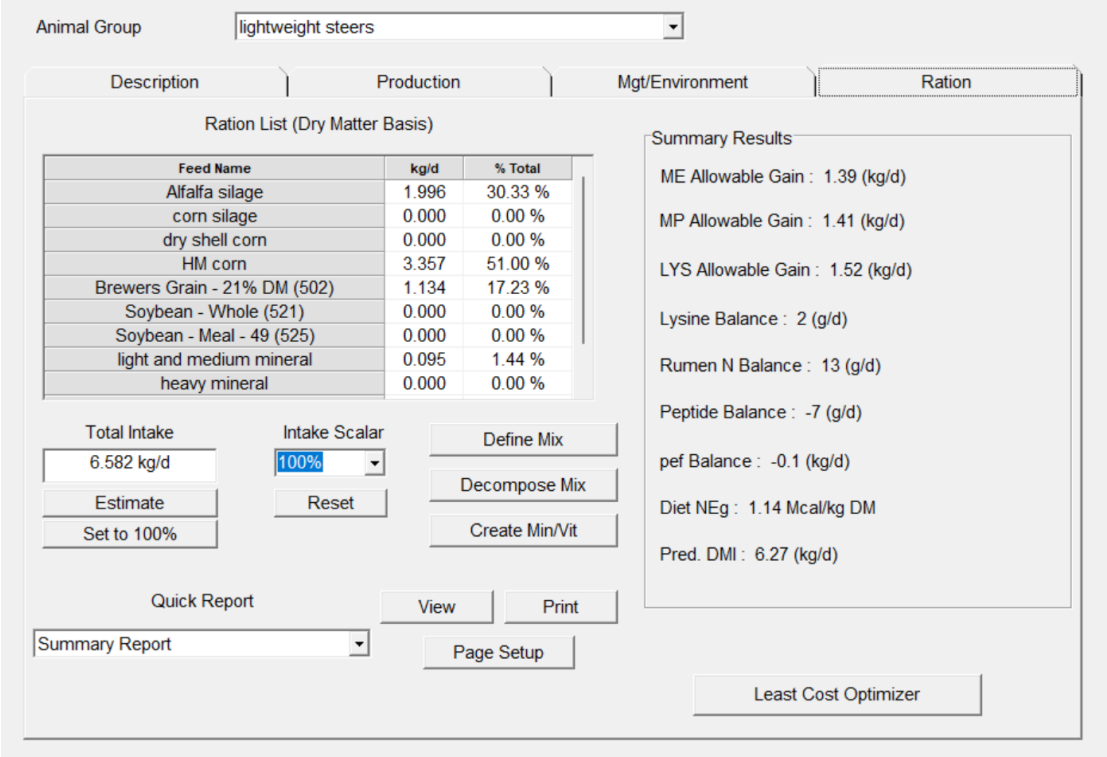

Figure 12. The Ration page with its summary results.

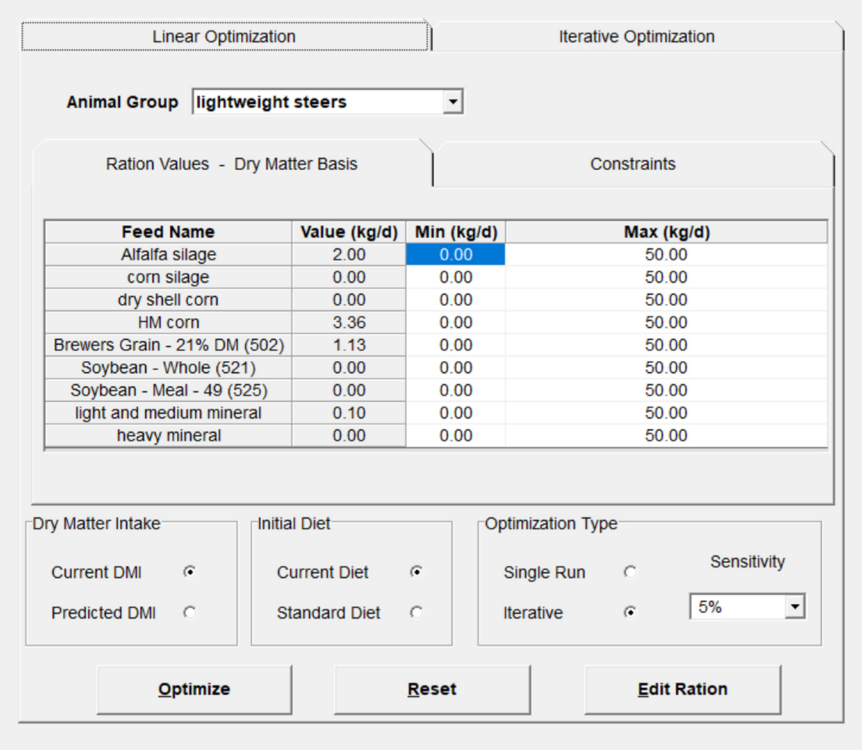

Figure 13. The optimizer: the Linear Optimization tab, Ration Values page, and beside it the Iterative Optimization tab.

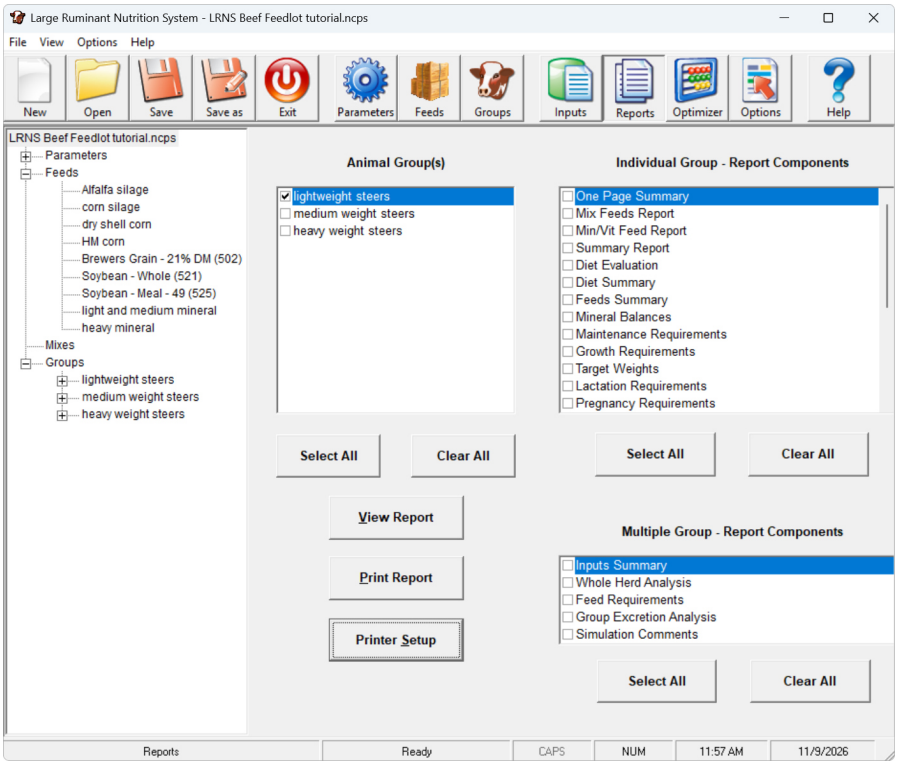

Figure 14. The Reports window: the groups and the components of the report are chosen before it is previewed.

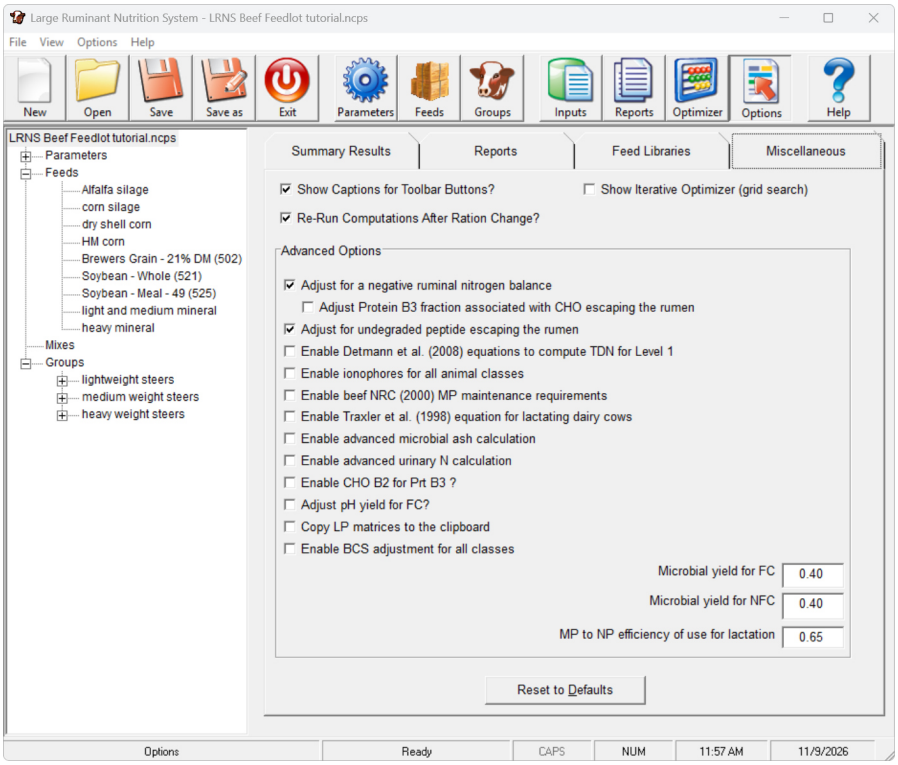

Figure 15. The options, Miscellaneous page.

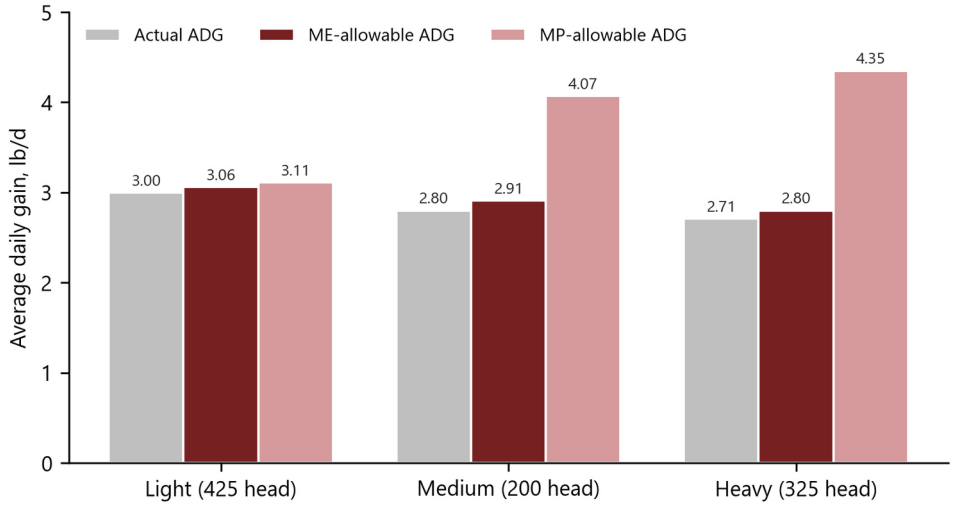

Figure 16. The worked example: actual gain of the three groups of steers and the gain allowed by the ME and the MP of their rations (Table 5 of the feedlot tutorial).