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Modification and Configuration of Century 4.0 Model in Nutrient Simulation Studies: A Step by Step Process

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ABSTRACT

The use of environmental models requires a mathematical turn of mind. Amongst the models that have been tested in various ecosystem and cropping system namely: CENTURY 4.0, RothC, CERES, NCSOIL, SUNDAIL and STICS; the CENTURY 4.0 have been extensively modified and configured especially for carbon and nitrogen cycling. This work presents the step by step process especially in amending the FERT.100 file, weather and management information, parametisation and events scheduling and running to equilibrium. It will be relevant to beginners who would like to test the model in their region.

Introduction

Although mechanistic soil-crop models are increasingly accepted as valuable tools in analyzing agronomical or environmental issues potential users are faced with an equally increasing number of available models (Gabrielle *et al*, 2002; Plentinger and Penning de varies, 1995; Farage *et al*, 2005; Paul *et al*, 2003; Webb et al, 2003; Pumpanen et al, 2003); Qian *et al*, 2003; Parton, 1992; Smith *et al*, 1996, 1997). In addition, little information is given as to the validity, limits and potential application of these models, which would provide some guidance in the selection of the most appropriate package. As a result, models are chosen on the basis of practical criteria such as code accessibility or the existence of user-friendly interfaces rather than scientific assessment of their expected performance (Gabrielle, *et al*, 2002). Again, although testing the models over long time-scales may not be possible in all cases, the description of processes in the model can be validated (Bente *et al*, 2004). The most important data for such research are long term experiments with a duration of more than 20 years, with information available from SOM pool dynamics during the experimental period (Lyudmila *et al*, 2003). This work is an attempt to bridge the gap in first time users step by step modification and configuration of the CENTURY 4.0 Model based on input that was used in “Predicting carbon sequestration under land management for six periods of English agriculture (Igboji, 2015).

Materials and Methods

Getting Started (First step by step procedure)

Got to Start in your computer. Go to programs. Go to accessories. Go to MS-DOS prompt or command prompt. Click on the MS-DOS or command prompt. Type in cd|century. Press Enter. It automatically enters CENTURY program. There are three programs. Choose file.100 and press enter. Choose option 7 in the drop down menu and press enter. Choose option 2 in another drop down menu and press enter. Type in GS 75 (standing for grain with 75% straw removal) and press enter. Type in “d” to give definition and press enter. Enter response “d” again; choose 0.5 to 0.75 straw under the response. Choose ½ left standing or 0.25 left standing and press enter. Enter option 5. Shows difference options e.g GS, GS 75, GT. Press “0” to go back to menu after choosing one of the GS option.

Crop 100.file will not give definitions. He definition is in the manual under CENTURY. Enter No 12 (site 100) for temporal deciduous forest. Type in “tdecid”. Press enter. Type “writtle 1” and press enter. Choose CWT for coweeta, a tree spp. Leave it at that American spp. Press enter 2 to 3 times. Type –d for standard deviation definitions for Jan – Dec. Type –d for definition of skewness. Leave as “0”. It should remain same. Type d for definition to get ppt, max t°C. Avoid skewness and standard deviation (sd). Type 2 for site and control parameters. Leave as zero (0). 1 is for C and N, 2 for N and P, 3 for N and S. Type SitLNG for Latitude/Longitude. Enter writtle data on this. Type d for sand. Press enter. Fraction of silt and clay follows. Type d for bulk density (BD). Leave others as default values. Type d for drain. Press enter. Type d for BASEF. Press enter. Leave as default values. Leave wilt (AWILT). Enter d. Press enter. Enter pH values. Type d for definitions of slope. Leave as default value. Press enter. Leave others as default values till OM initial values. Do 1, 2 for main information. Type “0”. Press enter. Type “0” for quit.

Create a scenario with below file. Type Event100 or event 100.i for one already existing. Type event-i-spacetdecid. Press enter. Press enter to review tdecid.100 existing file. Press enter. Press enter for CO_2 concentration. Specify type of tree as defined in tree file. Leave CWT, the American spp. Press enter. Press enter again. Press 1st block and enter. The forest system has tree growing. To remove anything, type tree-x. Press enter. Type tfst. Press enter. To remove it. Type gomt (that is go to month). Enter 12 for December. Press enter to put the data in December. Type tlst for x to be deleted in Dec. Blank screen is got. To start crop in April. Type gomt4 and press enter. Type crop followed by desired crop. Press enter for crops if unknown. Type G3 Press enter. April has got crop, that is G3. Type pltm to fix x as planting month. Type gomtspace5 for May when it starts to grow. Type frst and press enter. Planted in April, start

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growing in May. Type gomtspace10. Press enter. Type harvspacegs75 to record harvest time in October and when it stops growing. Type gomt 2 for February. Type cult. Type p for ploughing. In February we have got cultivation (P). Type next. It moves to March. Type omad. Press enter. Type m for addition of straw manure. Type in (time). Press enter. Press 2 to alter block 2. Enter 299 – 300 years or 2 years, which is no of years in repeating sequence. Press enter. Type year output should begin. Enter where data comes from. Type m for mean values. Press enter. Press enter again. Type 13 for block 13. Type quit to save data. Press enter. Type n and press return or enter to avoid saving scraps. It will automatically go back to century. To save actual data type y and press enter. Y is for yeas and n is for No.

Running program.Type centuryspace-stdecidspace-nspacepaul1. Press enter. Model is running. Execution success. Remember Paul1 is Bin-file. Now type list100. Press enter. Type paul1 (binary input file). Press enter. Enter another name "pdat1". Press enter. Press enter again. Enter variables from list of appendix e.g totc for total soil carbon. Press enter. Press enter again to stop. Type exit to get out of DOS and check data. Press enter to go back to windows. Go to CENTURY directory (open pdata1). Double click on pdata1. Select excel. Click on excel. values of totc for yr 2013 to 2013 in g m^2. Change to ha by dividing by 100 to get t ha^{-1}. You can close excel. Go to open. Go to central directory under c-drive. Go to K. Select and click all files. Select pdat1. Click open. Select fixed width option. Click finish. Go to file and choose save as (as appropriate). Don't press return at end to avoid saving of alterations. Only type n for no and press enter. If you are happy with alterations type y for yes and press enter

Second step by step procedure

Create a scenario of land management which is a different program known as "event100". At start. Type event100 and press enter. Take file "writtle1" and press enter. Take option "0", no labeling. No microcosm. Type n for no. Type n again. Type no 2 for initial land management which is forest. Enter "cwt" for American tree spp. Starting yr of simulation for this block. Start with yr 1500. Last y is 2014. No of yrs in repeating sequence, put 1 y in repeated sequence. Enter yr to begin output. Leave at 1500. Enter month to begin output. Leave it at 1 – 12 months (Jan – Dec). For output interval, enter 1 for every year. Enter m for mean values entered. Enter Test1 under message. Enter gomt for go to month. Enter gomt4 for 4 or April. Current date; April of year. Enter tree as cwt.Enter tfst for commencing tree growth; tree first month, start to grow. Enter October for tree stops growing, that gomtspace10. Enter tlst, tree last month to get October as month of last growth. To save information. Quit the program first. Save as test1 as name of grid.To run it type: centuryspace-s(followed by (space)test1(followed by space)-n(followed by space)writ1. Model is running for 500 years. At end "Execution success". To look at data go to another programme called "list 100". Type in and press enter. Binary input file is writ1. Press enter. Type in paul1 under ASC11 output file and press enter. Type in 1500 as start time and press enter. Ending time, enter 2014. Enter variables one line. Enter totc. Press enter again. Done. Stop. Program terminated. Data has been put in file paul1. Go to window explorer. Click. Double click on paul1. Choose notepad. Double click to get data on paul1 (1500 – 2014) in g m^{-2}. Convert to t ha^{-1} by dividing values by 100

Third step by step procedure

To schedule understorey, grassland under pasture, arable land and woodland. Go to crop. Select no 1. UND for understorey abbreviation and undersorey for description. Enter UND_Geescroft. Type d for definition. Type in values for PRDX(1) etc as got from Rothamsted data archive. Return to main menu by typing zero. Quit is zero followed by enter.

Create a new scenario. Type event 100(followed by space)(dash)i(space)test1. Type -1000 as first y; that is 3000 yrs ago. Type y no 1 as last before adding new land management yr. Year in repeating sequence leave as 1. Yr to begin output is -1000. Beginning month. Leave as 1 or JAN. Output interval. Leave as 1 for 1 y. Leave as m; that is mean monthly values. Type cwt(space)forest as comment. Type CBLK for copy block. Type 1 for block no to copy. Leave as copies new block to the end. Type 1 for starting yr of simulation, since the other one stated year 0. Type 2 for last year of simulation. Leave 1 as no of years in repeating sequence. Leave 1 as yr to begin output. Type 1 as output interval. Type 1 for mean values. Type clear(space)cwt and enter. Type block 2 for block 2. Type gomt(space)4 and enter. Tree(space)x to clear the tree. Press enter. Type tfst and press enter, tree first month of growth. Type gomt(space)10 for October and press enter. Type tlst and press enter. Gomt(space)3 for march. Type trem and press enter for tree removal. Type cc for clear cut and press enter. Gomt(space)6 for month of June. Type fire since it has to be burnt and press enter. Type H for hot fire. Type CNPY for overstorey and canopy. Cwt, trees are there before growth it is burnt down, that is CC and CNPY. Go back to time to create new block. Type CBLK. Type 1 for copy block to where you want it to be. Block press. Leave as 3, year 3 as starting year of simulation. Type 2014 for last year of simulation for the block. Leave as 1 as no of years in repeating sequence. Leave 3 as year to begin output. Leave 1 as month to begin output. Leave 1 as output interval. Leave m as mean values. Type English woodland under comment. Type 3 to enter block 3. Type gomt(space)4. Type tree under user command. Type GEES and press enter, start to grow in April (4) and finishes in October(10). Type gomt(space)3 for month when it starts to grow. Type crop under user command. Type UND which stands for understorey_geescroft. Type frst for first month of growth and press enter. Type gomt(space)10 for last month of growth. Type last as user command for last month of growth. Type quit to save file.

Gblk(space) for go to block 2 and press enter. Type gomt(space)1. Type tfst for forest growth. Type gomt(space)3 for cutting. Type trem(space) to clear our moving it to next month (April).. Type tree trem(space). Type gomt(space)5 for month of May. Type trem(space)cc for clear cut. Type gomt(space)7 for July. Type fire and type H for hot. Type CNPY for canopy/understorey. Type gomt(space)10. Type tlst for last month of growth.

Go to quit to save document. Previous file name test1.sch. Type n for no when prompted on whether you want to save file or y for yes if you want to save with new name as "wwood". Has been saved.

To run file.Type century (space) dash(s) space (wwood) space(dash)n(space)w1.Running. Execution success. To look at data. Type list100 and press enter. Type w1 as name of binary file and press enter. Type wd1 for name of ASC11 output file. Type 0 as starting time. Type 2014 as ending time. Type totc for total soil OCand press enter. Until done. Stop. Program terminated is prompted. To look at file. Go to file manager. Click on explore. Click on century. Double click on wd1. Open file. See results on totc.

Table 1. Fert.100 file as amended using CENTURY file.100 updating utility

Symbol	Description
A	Automatic_maintain_production_at_minimum_concentrations
A90	Automatic_maintain_production_at_90%_of_maximum
A80	Automatic_maintain_production_at_80%_of_maximum
A75	Automatic_maintain_production_at_75%_of_maximum
MAX	Automatic_fertilizer_to_achieve_maximum_plant_nutrient_concentration
MED	Automatic_medium_nutrient_concentrations
N5	5 g N m^{-2}
N100	10 g N m^{-2}
N85	8.5 g N m^{-2}
N63	6.3 g N m^{-2}
N10	10 g N m^{-2} 7 g P m^{-2}
N5P25	5 g N_2.5 g P m^{-2}
N3P8	3.3 g N_8 g P m^{-2}
N0P35	0 g N_3.5 g Pm^{-2}
N12	12 g N m^{-2}
N45	4.5_g N m^{-2}
N3	3_g N m^{-2}
N1	1_g N m^{-2}
PS1	Superphosphate_125 kg ha^{-1}
PS2	Superphosphate_250_kg ha^{-1}
PS3	Superphosphate_188_kg ha^{-1}
P12	1.2 g P m^{-2}
P35	3.5 g P m^{-2}
PS4	Superphosphate_376 kg ha^{-1}
PS5	Superphosphate_564 kg ha^{-1}

Table 2. Geographical and soil information used in configuring weather and site.100 files through the CENTURY file.100 updating facility. SITLAT (Site Latitude), 51°C 44¹; SITLNG (Site longitude), 0°C 26¹; Sand, 0.35%; Clay, 0.27%; BD, 1.10 kg l^{-1}; pH, 6.33

Period	Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971 - 2011	Maximum air temp (°C)	7.1	7.4	10.2	12.7	16.6	19.5	22.2	22.3	18.9	14.7	10.1	7.9
2012		6.5	8.1	9.0	12.3	17.8	19.9	23.2	23.1	17.5	17.6	10.7	6.6
2013		8.9	11.0	11.7	14.6	16.6	20.1	21.9	23.0	19.7	14.5	11.8	8.2
2014		7.3	7.4	12.5	14.8	17.8	22.6	23.6	25.6	21.2	13.8	11.9	8.1
Mean		7.5	8.5	10.9	13.6	17.2	20.5	22.7	23.5	19.3	15.2	11.1	7.7
1971 - 2011	Minimum air temp. (°C)	1.3	0.9	2.5	3.6	6.3	9.3	11.5	11.3	9.4	6.6	3.5	2.2
2012		0.3	1.4	2.9	4.1	7.6	9.2	12.7	13.0	9.4	10.5	3.1	-0.1
2013		2.1	4.1	3.2	4.1	8.0	10.1	11.8	12.7	8.5	6.2	5.5	4.1
2014		1.6	0.3	1.7	3.6	6.7	11.1	12.6	12.7	6.3	4.9	5.3	1.9
Mean		1.3	1.7	2.6	3.9	7.2	9.9	12.2	12.4	8.4	7.1	4.4	2.0
1971 – 2011	Precipitation (mm)	54.4	35.2	42.5	42.3	45.4	52.8	39.3	49.4	51.3	58.2	54.4	52.8
2012		57.7	103.5	90.4	63.6	42.1	56.6	63.0	53.3	105.7	106.2	47.0	15.5
2013		50.8	67.5	34.5	42.0	67.4	44.9	49.8	38.0	29.9	63.4	125.6	101.8
2014		59.6	22.9	18.2	28.1	36.6	42.7	49.0	5.2	19.7	33.2	95.3	54.3
Mean		55.6	57.3	46.4	44.0	47.9	49.3	50.3	36.5	51.7	65.3	80.6	56.1

Table 3. Events schedule for arable land under barley using the CENTURY 4.0 Model. Rept. Is number of years, GWRS is Geescroft_wilderness_rothamsted_succession for woodland vegetation, m is mean values

Block	Start Year	End Year	Rept.	Output Year	Output Month	Output Interval	Weather Type	Field Comment
1	-6000	-5000	1	-6000	1	100	M	GWRS forest
2	-4999	-4999	1	-4999	1	1	M	GWRS forest
3	-4998	964	1	-4998	1	100	M	GWRS forest
4	965	1514	1	965	1	20	M	Pasture
5	1515	1734	1	1515	1	20	M	Wheat
6	1735	1954	1	1735	1	1	M	Wheat
7	1955	1964	10	1955	1	1	M	Barley
8	1965	1974	10	1965	1	1	M	Barley
9	1975	1984	10	1975	1	1	M	Wheat
10	1985	1994	10	1985	1	1	M	Wheat
11	1995	2004	10	1995	1	1	M	Barley
12	2005	2054	1	2005	1	1	M	Barley

Table 3. Details of scheduled scenarios in blocks 4 – 12 of arable land under barley

Scheduled block	Period	Month	Activities
Block 4	965 – 1514	April - October	Moderate rough grazing
Block 5 - 6	1515 – 1954	1. April 2. April 3. September	1. Spring wheat with OM (wheat straw) addition during seedbed preparation (1515 – 1734) 2. Spring wheat with 125 kg ha^{-1} superphosphate fertiliser top-dressing (1735 – 1954) 3. Harvesting of grain with 50% straw removal (1515 – 1954)
Block 7 - 8	1955 – 1974	1. April 2. September	1. Spring barley with 125 kg ha^{-1} superphosphate fertiliser top-dressing 2. Harvesting of grain with 50% straw removal
Block 9 - 10	1975 – 1994	1. April 2. September	1. Spring wheat with 125 kg ha^{-1} superphospahate fertiliser top-dressing 2. Harvesting of grain with 50% straw removal
Blocks 11 - 12	1995 – 2054	1. October 2. April 3. September	1. Winter barley with 125 kg ha^{-1} superphosphate seedbed fertiliser 2. Top-dressing with 3 g N m^{-2} fertiliser 3. Harvesting of grain with 50% straw removal

Table 4. Events schedule for grassland under permanent pasture sown with red clover a year before stocking using the CENTURY 4.0 Model

Block	Start Year	End Year	Rept.	Output Year	Output Month	Output Interval	Weather Type	Field Comment
1	-6000	-5000	1	-6000	1	100	M	GWRS forest
2	-4999	-4999	1	-4999	1	1	M	GWRS forest
3	-4998	964	1	-4998	1	20	M	GWRS forest
4	965	1514	1	965	1	20	M	Pasture
5	1515	1734	1	1515	1	20	M	Wheat
6	1735	1954	1	1735	1	20	M	Wheat
7	1955	1964	10	1955	1	1	M	Pasture
8	1965	1974	10	1965	1	1	M	Ley/pasture
9	1975	1984	10	1975	1	1	M	Ley/pasture
10	1985	1994	10	1985	1	1	M	Ley/pasture
11	1995	2004	10	1995	1	1	M	Clover/pasture
12	2005	2054	1	2005	1	1	M	Clover/pasture

Table 5. Details of scheduled scenarios in blocks 4 – 12 of grassland under permanent pasture sown with red clover a year before stocking

Scheduled block	Period	Month	Activities
Block 4	965-1514	April - October	Moderate rough grazing
Blocks 5 - 6	1515 - 1954	1. April 2. April 3. September	1. Spring wheat with OM (wheat straw) addition during seedbed preparation (1515 – 1734) 2. Spring wheat with 125 kg ha-1 superphospshate fertiliser top-dressing (1735 – 1954) 3. Harvesting of grain with 50% straw removal
Block 7	1955 - 1964	1.September (1st year) 2. April (2nd year) 3. June (2nd year) 4. April (3rd year) 5. March – October (4th to 5th year 6. March – October (6th yr) 7. March – October (7th – 8th yr)	1. Seeding of rye grass seeds 2. Top-dressing with 1.2 g m^{-2} of phosphorus 3. Harvesting of hay 4. Top-dressing of grass established last y with 1.2 g ^{m}-^{2} of phosphorus 5. Low grazing of grass 6. Rejuvenation of grass with rye-seeds 7. Low grazing of grass
Block 8	1965 - 1974	1. March – October (1st – 4th yr) 2. March – October (5th – 10 yr)	1. Rejuvenation of grass with rye-grass seeds, with fertiliser top-dressing at the rate of 0 g N_3.5 g Pm^{-2}; 3.5 g Pm^{-2}; 1.2 g P m^{-2}; 3.3 g N_8 g P m^{-2} in yr 5, 6, 7, and 9; as well as 3.5 g P m^{-2}; 0 g N_3.5 g P m^{-2}; 1.2 g P m^{-2} in yr 6, 7, and 8 respectively. 2. Low grazing of grass
Block 9 - 10	1975 - 1994	1. September (1st yr) 2. April (2nd yr) 3. March – October (3rd – 8th yr) 4. September (9th yr) 5. April (10th yr) 6. June (10th yr)	1. Seeding of rye-grass seeds 2. Top-dressing with 1.2 g P m^{-2} fertilizer 3. Low grazing of grass 4. Rejuvenation of grass with red clover 5. Top-dressing with 1.2 g P m^{-2} fertilizer 6. Harvesting of hay
Block 11	1995 - 2004	1. March – October (1st – 2nd yr) 2. March – October (3rd – 8th yr) 3. March – October (9th –10th yr)	1. Low grazing of grass 2. Rejuvenation of rye-grass with red clover. 3. Low grazing of grass
Block 12	2005 - 2054	March – October (1st – 10th yr)	Low grazed grassland under permanent pasture was assumed.

Block 9 - 10	1975 - 1994	1. September (1st yr) 2. April (2nd yr) 3. March – October (3rd – 8th yr) 4. September (9th yr) 5. April (10th yr) 6. June (10th yr)	1. Seeding of rye-grass seeds 2. Top-dressing with 1.2 g P m^{-2} fertilizer 3. Low grazing of grass 4. Rejuvenation of grass with red clover 5. Top-dressing with 1.2 g P m^{-2} fertilizer 6. Harvesting of hay
Block 11	1995 - 2004	1. March – October (1st – 2nd yr) 2. March – October (3rd – 8th yr) 3. March – October (9th –10th yr)	1. Low grazing of grass 2. Rejuvenation of rye-grass with red clover. 3. Low grazing of grass
Block 12	2005 - 2054	March – October (1st – 10th yr)	Low grazed grassland under permanent pasture was assumed.

Table 6. Events schedule for grassland under permanent pasture on 5 y ley before stocking using CENTURY 4.0 Model

Block	Start Year	End Year	Rept.	Output Year	Output Month	Output Interval	Weather Type	Field Comment
1	-6000	-5000	1	-6000	1	100	M	GWRS forest
2	-4999	-4999	1	-4999	1	1	M	GWRS forest
3	-4998	964	1	-4998	1	20	M	GWRS forest
4	965	1514	1	965	1	20	M	Pasture
5	1515	1734	1	1515	1	20	M	Wheat
6	1735	1954	1	1735	1	20	M	Wheat
7	1955	1964	10	1955	1	1	M	Pasture
8	1965	1974	10	1965	1	1	M	Ley/pasture
9	1975	1984	10	1975	1	1	M	Ley/pasture
10	1985	1994	10	1985	1	1	M	Ley/pasture
11	1995	2004	10	1995	1	1	M	Ley/pasture
12	2005	2054	1	2005	1	1	M	Ley/pasture

Table 7. Details of scheduled scenarios in blocks 4 – 12 of grassland under permanent pasture on 5 y ley before stocking

Scheduled block	Period	Month	Activities
Block 4	965 to 1514	April to October	Moderate rough grazing
Blocks 5 – 6	1515 – 1954	1. April 2. May 3. September	1. Spring wheat, with OM (wheat straw) addition during seedbed preparation (1515 – 1734) 2. Spring wheat, with 125 kg ha^{-1} superphosphate fertilizer top-dressing (1735 – 1954) 3. Harvesting of grain with 50% straw removal
Block 7	1955 to 1964	1.September (1st year) 2. April (2nd year) 3. June (2nd year) 4. April (3rd year) 5. March – October (4th to 5th year 6. March – October (6th yr) 7. March – October (7th – 8th yr)	1. Seeding of rye grass seeds 2. Top-dressing with 1.2 g m^{-2} of phosphorus 3. Harvesting of hay 4. Top-dressing of grass established last y with 1.2 g ^{m}-2 of phosphorus 5. Low grazing of grass 6. Rejuvenation of grass with rye-seeds 7. Low grazing of grass
Block 8	1965 - 1974	1. March – October (1st – 4th yr) 2. March – October (5th – 10 yr)	1. Rejuvenation of grass with rye-grass seeds, with fertiliser top-dressing at the rate of 0 g N_3.5 g Pm^{-2}; 3.5 g Pm^{-2}; 1.2 g P m^{-2}; 3.3 g N_8 g P m^{-2} in yr 5, 6, 7, and 9; as well as 3.5 g P m^{-2}; 0 g N_3.5 g P m^{-2}; 1.2 g P m^{-2} in yr 6, 7, and 8 respectively. 2. Low grazing of grass
Block 9	1975 - 1984	1. September (1st yr) 2. April (2nd yr) 3. March – October (3rd – 8th yr) 4. September (9th yr) 5. April (10th yr) 6. June (10th yr)	1. Seeding of rye-grass seeds 2. Top-dressing with 1.2 g P m^{-2} fertilizer 3. Low grazing of grass 4. Rejuvenation of grass with rye-grass seeds 5. Top-dressing with 1.2 g P m^{-2} fertilizer 6. Harvesting of hay

Block 11	1995 - 2004	1. March – October (1st – 2nd yr) 2. March – October (3rd – 8th yr) 3. March – October (9th – 10th yr)	1. Low grazing of grass 2. Rejuvenation of grass with various types and levels of seedbed and top-dressing fertilizers namely: 5 g N_2.5 g P m^{-2}; 0 g N_3.5 g P m^{-2}; 3.3 g N_8 g P m^{-2} seedbed fertilisers in yr 4, 5, and 7; and 3.5 g Pm^{-2}; 1.2 g P m^{-2}; 6.3 g N_2.3 g P m^{-2} and 5 g N_2.5 g P m^{-2} top-dressing fertilisers in yr 4 – 7. 3. Low grazing of grass
Block 12	2005 - 2054	March – October (1st – 10th yr)	Low grazed grassland under permanent pasture was assumed.

Table 8. Events schedule for deciduous woodland using the CENTURY 4.0 Model

Block	Start Year	End Year	Rept.	Output Year	Output Month	Output Interval	Weather Type	Field Comment
1	-6000	-5000	1	-6000	1	100	M	GWRS forest
2	-4999	-4999	1	-4999	1	1	M	GWRS forest
3	-4998	2054	1	-4998	1	1	M	GWRS forest

Table 9. Crop parameters values used in updating crop/tree file.100 century updating utility in line with writtle ecosystem. Adapted from farage et al (2005)

Crop parameter	Description	Wheat_medium_harvestindex	Potato	Standardmaize	Soybean
prdx(1)	Potential aboveground monthly production for crops – g C m^2	300	150.0	360.0	300
ppdf(1) ppdf(2)	Optimum temperature for production for parameterization of a Poisson Density Function curve to simulate temperature effect on growth Maximum temperature for production for parameterization of a Poisson Density Function curve to simulate temperature effect on growth	18 35	17.0 35.0	30.0 45.0	27
ppdf(3)	Left curve shape for parameterization of a Poisson Density Function curve to simulate temperature effect on growth	0.7	1.2	1.0	1.0
ppdf(4)	Right curve shape for parameterization of a Poisson Density Function curve to simulate temperature on growth	5.0	5.0	2.5	2.5

bioflg	Flag indicating whether production should be reduced by physical obstruction = 0 production should be reduced = 1 production should be reduced.	0	0.0	0.0	0.0
biok5	Level of aboveground standing dead + 10% struck(1) at which production is reduced to half maximum due to physical obstruction by dead material (g m^2)	1800	1800.0	1800.0	1800
pltmrf	Planting month reduction factor to limit seeding growth; set to 1.0 for grass	0.4	0.4	0.5	0.5
fulcan	Value of *aglivc* at full canopy cover, above which potential production is not reduced	150	150.0	150.0	150
frtc(1)	Initial fraction of C allocated to roots; for Great Plains equation based on precipitation, set to 0	0.6	0.6	0.5	0.5
frtc(2)	Final fraction of C allocated to roots	0.1	0.8	0.1	0.1
frtc(3)	Time after planting (months with soil temperature greater than *rtdtmp*) at which the final value is reached	3.0	2.0	3.0	3

biomax	Biomass level (g biomass m^{-2}) above which the minimum and maximum C/E ratios of new shoot increments equal pramn(*,2) and pramx(*,2) respectively	600	600.0	650.0	800
pramn(3,1)	Minimum C/E ratio with zero biomass; (1,1) = N; (2,1) = P and (3,1) = S	100	100.0	190.0	150
pramn(3,2)	Minimum C/E ratio with biomass greater than or equal to biomax; (1,2) = N; (2,2) = P and (3,2) = S	200	200.0	150.0	150
pramx(3,1)	Maximum C/E ratio with zero biomass; (1,1) = N; (2,1) = P; (3,1) = S	230	230.0	230.0	230
pramx(3,2)	Maximum C/E ratio with biomass greater than or equal to biomax; (1,2) = 1; (2,2) = P and (3,2) = S	270	270.0	230.0	230
prbmn(3,2)	Parameters for computing minimum C/N ratio for belowground matter as a linear function of annual precipitation; (1,1) = N, intercept; (2,1) = P, intercept; (3,1) = S, intercept; (1,2) = N, slope; (2,2) = P, slope; (3,2) = S, slope	0.0	0.0	0.0	0.0
prbmx(3,2)	Parameters for computing maximum C/N ratio for belowground matter as a linear of annual precipitation; (1,1) = N, intercept; (2,1) = P, intercept; (3,1) = S, slope; (1,2) = N, slope; (2,2) = P, slope; (3,2) = S, slope	0.0	0.0	0.0	0.0

fligni(1,1)	Intercept for equation to predict lignin content fraction based on annual rainfall for aboveground material	0.15	0.2	0.1	0.1
fligni(2,1)	Slope for equation to predict lignin content fraction based on annual rainfall for aboveground material. For crops, set to 0	0.0	0.0	0.0	0
fligni(1,2)	Intercept for equation to predict lignin content fraction based on annual rainfall for aboveground material	0.06	0.1	0.1	0.1
fligni(2,2)	Slope for equation to predict lignin content fraction based on annual rainfall for belowground material. For crops, set to 0	0.0	0.0	0.0	0
himax	Harvest index maximum (fraction of aboveground live C in grain)	0.35	0.4	0.38	0.3
hiwsf	Harvest index water stress factor = 0 no effect of water stress; = 1 no grain yield with maximum water stress	0.5	0.0	0.0	0.0

himon(1)	Number of months prior to harvest to which to begin accumulating water stress effect on harvest index	1	1.0	3.0	2
himon(2)	Number of months prior to harvest in which to stop accumulating water stress effect on harvest index	0	1.0	2.0	1
efrgrn(3)	Fraction of the aboveground E which goes to grain; (1) = N (2) = P (3) = S	0.6	0.6	0.6	0.6
vlossp	Fraction of aboveground plant N which is volatilised (occurs only at harvest)	0.04	0.1	0.1	0.1
fsdeth(1)	Maximum shoot death rate at very dry soil conditions (fraction/month); for getting the monthly shoot death rate, this fraction is multiplied times a reduction factor depending on the soil water status	0.0	0.0	0.0	0
fsdeth(2)	Fraction of shoots which die during senescence month; must be greater than or equal to 0.4	0.0	0.0	0.0	0
fsdeth(3)	Additional fraction of shoots which die when aboveground live C is greater than *fsdeth(4)*	0.0	0.0	0.0	0

fsdeth(4)	The level of aboveground C above which shading occurs and shoot senescence increases	200	200.0	500.0	500
fallrt	Fall rate (fraction of standing dead which falls each month)	0.12	0.1	0.1	0.1
rdr	Maximum root death rate at very dry soil conditions (fraction/month); for getting the monthly root death rate, this fraction is multiplied times a reduction factor depending on the soil water status	0.05	0.0	0.1	0.1
rtdtmp	Physiological shutdown temperature for root death and change in shoot/root ratio	2.0	2.0	2.0	2.0
crprtf(3)	Fraction of E translocated from grass/crop at death (1) = N (2) = P (3) = S	0.0	0.0	0.0	0
snfxmx(1)	Symbiotic N fixation maximum for grass/crop (Gn fixed/Gc new growth)	0.0	0.0	0.0	0
del ^{13}C	Delta ^{13}C value for stable isotope labelling	-27	-27.0	-15.0	-27.0
CO_2ipr(1)	In grass/crop system, the effect on plant production ratio of doubling the atmospheric CO_2 concentration from 350 ppm to 700 ppm	1.2	1.3	1.2	1.2

CO_2itr(1)	In grass/crop system, the effect on transpiration rate of doubling the atmospheric CO_2 concentration from 350 ppm to 700 ppm	0.8	0.8	0.8	0.8
CO_2ice(1,2,3)	In grass/crop system, the effect on C/E ratios of doubling the atmospheric CO_2 concentration from 350 ppm to 700 ppm; (1,1,1) = minimum C/N; (1,2,1) = maximum C/N; (1,1,2) = minimum C/P; (1,2,2) = maximum C/P; (1,1,3) = minimum C/S; (1,2,3) = maximum C/S	0	1.0	1.0	1.0
CO_2irs(1)	In grass/crop system, the effect on root-shoot ratio of doubling the atmospheric CO_2 concentration from 350 ppm to 700 ppm	1.0	1.0	1.0	1.0

Table 10. Other categories of crop and vegetation parameters whose values were used in updating crop/tree file by aid of the file 100 CENTURY updating utility in line with writtle agroecosystem. Details of parameter symbols are in Parton *et al*, 1993. Adapted from Farage *et al*, 2005

Crop/tree parameter	Geescroft_Wilderness_Rothamsted UK_Succession (Woodland vegetation	Successional_understory (Geescroft)	Grass_clover_pasture Geescroft	Rothamsted_grass	Barley (Brly_ V1).
DECID	1	PRDX (1) 200	350	270	300
PRDX(2)	800	PPDF (1) 27	22	18	17
PRDX(3)	500	PPDF (2) 45	35	35	35
PPDF(1)	25	PPDF (3) 1	0.8	1.2	0.5
PPDF(2)	45	PPDF (4) 3	3.5	3	5.0
PPDF(3)	1	BIOFLG 1	1	1	0
PPDF(4)	3	BIOK5 1800	200	60	1800
CERFOR(1,1,1)	25	PLTMRF 0.2	0.5	1	0.4
CERFOR(1,1,2)	150	FULCAN 100	150	100	150
CERFOR(1,1,3)	300	FRTC (1) 0.2	0.5	0	0.6
CERFOR(1,2,1)	40	FRTC (2) 0.1	0.5	0	0.1
CERFOR (1,2,2)	200	FRTC (3) 1	1	0	3.0
CERFOR (1,2,3)	250	BIOMAX 400	400	400	600
CERFOR (1,3,1)	100	PRAMN (1,1) 13	8.5	10	12.0
CERFOR (1,3,2)	400	PRAMN (2,1) 390	100	390	100
CERFOR (1,3,3)	1100	PRAMN (3,1) 340	125	340	100
CERFOR (1,4,1) CERFOR (1,4,2)	150 500	PRAMN (1,2) 15	8.5	15	57
CERFOR (1,4,3)	4000	PRAMN (2,2) 390	100	390	160
CERFOR (1,5,1)	150	PRAMN (3,2) 340	125	340	200
CERFOR (1,5,2)	500	PRAMX (1,1) 20	11	20	25
CERFOR (1,5,3)	4000	PRAMX (2,1) 440	133	440	200
CERFOR (2,1,1)	30	PRAMX (3,1) 440	160	440	230
CERFOR (2,1,2)	500	PRAMX (1,2) 25	11	40	125
CERFOR (2,1,3)	300	PRAMX (2,2) 440	133	440	260
CERFOR (2,2,1)	60	PRAMX (3,2) 440	160	440	270
CERFOR (2,2,2)	600	PRBMN (1,1) 20	17	30	45
CERFOR (2,2,3)	250	PRBMN (2,1) 390	100	390	390
CERFOR (2,3,1)	200	PRBMN (3,1) 340	125	340	340
CERFOR (2,3,2)	2000	PRBMN (1,2) 0	0	0	0
CERFOR (2,3,3)	1100	PRBMN (2,2) 0	0	0	0.0
CERFOR (2,4,1)	500	PRBMN (3,2) 0	0	0	0.0
CERFOR (2,4,2)	2500	PRBMX (1,1) 30	22	40	60.0
CERFOR (2,4,3)	4000	PRBMX (2,1) 420	133	420	420.0
CERFOR (2,5,1)	500	PRBMX (3,1) 420	160	420	420.0
CERFOR (2,5,2)	2000	PRBMX (1,2) 0	0	0	0.0
CERFOR (2,5,3)	4000	PRBMX (2,2) 0	0	0	0.0
CERFOR (3,1,1)	25	PRBMX (3,2) 0	0	0	0.0
CERFOR (3,1,2)	150	FLIGNI (1,1) 0.05	0.04	0.02	0.15
CERFOR (3,1,3)	300	FLIGNI (2,1) 0	0	0.01	0.0
CERFOR (3,2,1)	46.9	FLIGNI (1,2) 0.06	0.12	0.26	0.06
CERFOR (3,2,2)	250	FLIGNI (2,2) 0.1	0	-0.0015	0.0
CERFOR (3,2,3)	250	HIMAX 0	0	0	0.35
CERFOR (3,3,1)	130	HIWSF 0	0	0	0.25
CERFOR (3,3,2)	1100	HIMON (1) 2	2	2	1
CERFOR (3,3,3)	1100	HIMON (2) 1	1	1	1
CERFOR (3,4,1)	557	EFRGRN (1) 0	0	0	0.6
CERFOR (3,4,2)	4000	EFRGRN (2) 0	0	0	0.6
CERFOR (3,4,3)	4000	EFRGRN (3) 0	0	0	0.6
CERFOR (3,5,1)	450	VLOSSP 0.15	0.02	0.15	0.04
CERFOR (3,5,2)	4000	FSDETH (1) 0.2	0.3	0.2	0.0
CERFOR (3,5,3)	4000	FSDETH (2) 0.95	0.4	0.95	0.0
DECW(1)	0.2	FSDETH (3) 0.2	0.1	0.2	0.0
DECW(2)	0.01	FSDETH (4) 150	500	150	200
DECW(3)	0.04	FALLRT 0.18	0.5	0.15	0.12
FCFRAC (1,1)	0.23	RDR 0.05	0.6	0.25	0.05
FCFRAC (2,1)	0.27	RTDTMP 2	2	2	2.0
FCFRAC (3,1)	0.15	CRPRTF (1) 0	0	0	0.0
FCFRAC (4,1)	0.25	CRPRTF (2) 0	0	0	0.0
FCFRAC (5,1)	0.1	CRPRTF (3) 0	0	0	0.0
FCFRAC (1,2)	0.23	SNFXMX (1) 0	0.04	0	0.0

FCFRAC (2,2)	0.27	DEL^{13}C -18	-27	-24	-27
FCFRAC (3,2)	0.15	CO_2IPR 0.25	0	0	1.20
FCFRAC (4,2)	0.25	CO_2ITR 0.77	0	0	0.80
FCFRAC (5,2)	0.1	CO_2ICE (1,1,1) 1	0	0	1
LEAFDR (1)	0	CO_2ICE (1,1,2) 1	0	0	1
LEAFDR (2)	0	CO_2ICE (1,1,3) 1	0	0	1
LEAFDR (3)	0	CO_2ICE (1,2,1) 0.75	0	0	1.3
LEAFDR (4)	0	CO_2ICE (1,2,2) 1	0	0	1
LEAFDR (5)	0	CO_2ICE (1,2,3) 1	0	0	1
LEAFDR (6)	0	CO_2IRS 1	0	0	1.00
LEAFDR (7)	0				
LEAFDR (8)	0				
LEAFDR (9)	0.5				
LEAFDR (10)	0.8				
LEAFDR (11)	1				
LEAFDR (12)	0				
BTOLAI	0.01				
KLAI	1000				
LAITOP	-0.47				
MAXLAI	6				
MAXLDR	0				
FORRTF (1)	0.5				
FORTF (2)	0.5				
FORRTF (3)	0				
SAPK	1500				
SWOLD	6				
WDLIG (1)	0.15				
WDLIG (2)	0.2				
WDLIG (3)	0.22				
WDLIG (4)	0.22				
WDLIG (5)	0.22				
WOODDR (1)	0.95				
WOODDR (2)	0.4				
WOODDR (3)	0.07				
WOODDR (4)	0.01				
WOODDR (5)	0.01				
SNFXMX (2)	0				
DEL^{13}C	0				
CO_2IPR	0				
CO_2ITR	0				
CO_2ICE (1,1,1)	0				
CO_2ICE (1,1,2)	0				
CO_2ICE (1,1,3)	0				
CO_2ICE (1,2,1)	0				
CO_2ICE (1,2,2)	0				
CO_2ICE (1,2,3)	0				
CO_2IRS	0				
BASFC2	2				
BASFCT	100				
SITPOT	2600				

Table 11: Details of CENTURY environment files

Name of file	Description
Century.bat	Batch file used to run CENTURY and view
Centurym.exe	The Century executable model
Centurym.tab	Table file generated by the TIME-ZERO™ to handle I/O
Centurym.dat	Master list of all variables used in CENTURY, not to be modified by the user.
Temp.sav	File required by VIEW
Centuryx.exe	The stand-alone CENTURY executable model
Fix.100	File with fixed parameters primarily relating to organic matter decomposition and not normally adjusted between runs
<site>.100	Site-specific parameters such as precipitation, soil texture, and the initial conditions for soil organic matter, the name of the file is provided by the user.
Crop.100	Crop options file
Cult.100	Cultivation options file
Fert.100	Fertilization options file
Fire.100	Fire options file
Graz.100	Grazing options file
Harv.100	Harvest option file
Irrig.100	Irrigation options file
Omad.100	Organic matter addition options file
Tree.100	Tree options file
Trem.100	Tree removal options file
*Def	For each *.100 file, there is a corresponding ".def" file which contains the definitions of each parameter needed for each option; the format of these ASCII files should not be modified by the user
Sample.wth	Sample weather file
C14data	Sample ^{14}C data file

Enter CLOV for abbreviation for grassland under permanent pasture sown with red clover a y before stocking; Grass_clover_pasture abbreviation for second description; Grass for grassland under permanent pasture on 5 y ley before stocking; Rothamsted_grass as description; BRLY as barley abbreviation and arable land under barley as description.

Statistical and data analysis

This is as described in predicting carbon sequestration under land management practices for six periods of English agriculture by Igboji, P. O (2015)

Results and discussions

These are as described in predicting carbon sequestration under land management practices for six periods of English agriculture by Igboji P. O (2015)

Conclusion

A beginner can effectively and efficiently augment this step by step process in addition to Parton et al, 1993 tutorial to crack the mathematics and sciences surrounding modification and configuration of CENTURY 4.0 Model nutrient cycling to any ecosystem. In this work a model developed for grassland ecosystem in US Great Plains has been modified and configured to solve the problem in East Anglian temperate region of England.

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