Parameterizing Century to model cultivated and noncultivated sites in the loess region of western Iowa

by Kristen L. Manies[1]
Jennifer W. Harden[1]
Larry Kramer[2]
William Parton[3]

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[1]U.S. Geological Survey, Menlo Park, California
[2]National Soils Tilth Laboratory, Deep Loess Research Station, Agricultural Research Service, U.S. Department of Agriculture, Council Bluff, Iowa
[3]Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado

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1.0 Introduction

One of the main questions remaining for global science involves the cycle of carbon among the atmosphere, oceans, and land. Scientists are trying to better determine the amount of carbon stored in and transferred between these three locations. This task has become more complex because in recent decades the amount of carbon released into the atmosphere has increased due to the burning of fossil fuels and land-use changes. The amount of this increase is greater than the amount of carbon accumulating in the atmosphere and oceans. Many scientists are studying different terrestrial ecosystems to find this 'missing' carbon. One such project is the Mississippi Basin Carbon Project (MBCP) of the U.S. Geological Survey (USGS). MBCP is studying the soils and sediments of the Mississippi River Basin, with an emphasis on understanding human influences on erosion and thus the movement of carbon within a landscape.[1]

One goal of the MBCP is to understand, at the field scale, the key processes of erosion and sedimentation, and thus the movement of carbon, in upland areas. Both field measurements and modeling efforts are being used for this purpose. On the modeling front, the Century Model is being used to describe the historical carbon dynamics for two field sites, an agricultural field and uncultivated prairie, located in the loess region of western Iowa. The objective of these modeling efforts is to recreate the carbon dynamics of the upper slope in each of these watersheds. The upper slope represents the area of a hillslope with the greatest potential erosion. This report describes how Century was parameterized to represent these two sites.

[1] For more information on MBCP see the project's web site at http://geochange.er.usgs.gov/pub/info/ccresearch.shtml.

2.0 Site Descriptions

The agricultural site used in this study is Watershed 1-1 at the National Soils Tilth Laboratory, Deep Loess Research Station. This research farm, run by the U.S. Department of Agriculture, Agriculture Research Service (USDA-ARS), is located near the town of Treynor, in Pottawattamie County, Iowa. (Hereafter this site will be referred to as the Treynor location.) The Treynor site was chosen because it has a deep loess cover and has been maintained since 1963 as a research area by the USDA-ARS to study the effects of agriculture on soils and hydrology in this region.

The uncultivated site is located at Dinesen Prairie, approximately thirty-three miles north-northeast of Treynor, in nearby Shelby County. Dinesen Prairie is a 20-acre tall-grass prairie that has never been plowed. Donated by Derald Dinesen in 1984, this preserve is managed by the Shelby County Conservation Board.

Both sites are located within a region characterized by gently sloping ridges and steep slopes (Bettis, 1990). Treynor soils belong to the Marshall and Monona series (ridges and some sideslopes), Ida series (sideslopes), and Napier series (lowlands). Dinesen is comprised entirely by the Marshall series (Branham, 1989, Jury et al., 1956). For both sites, the bedrock is overlain by glacial till. This in turn is covered by Peoria loess (Bettis, 1990), which was deposited over 20,000 years ago (Muhs and Bettis, 2000). The ridgetop profiles of Dinesen Prairie and Treynor are non-calcareous to 2 meters, although calcareous soils are found only three counties to the east, and to the west just across the Nebraska state line (Ruhe, 1984).

3.0 The Century model

Century was developed to model the movement of soil organic matter, nitrogen, phosphorus, and sulfur in the environment on a monthly time step. Century models these elements using plant-soil relationships based on a core ecosystem (a forest, cropland, grassland, or savanna). It contains the following submodels: soil organic matter, water budget/soil temperature, nitrogen, phosphorus, sulfur, and plant production. When modeling crops one is able to include agricultural influences such as cultivation, fertilization, grazing, irrigation, and different harvesting methods. A more detailed description of the model and its components is available from Metherell (1993), Parton et al. (1984), and Parton and Rasmussen (1984).

Century 4.0 was used for this project. The program was modified from the original version in two ways. First, a section of the water submodel (h2olos.f) was modified to include effects due to runoff. Previous modeling efforts using Century (Sharpe et al., 1998) determined that if the entire amount of monthly precipitation was available for use by plants, larger than expected Net Primary Production (NPP) values (*cproda*) would result. In reality, some of this water leaves the system as runoff or leachate before it has a chance to be used by the vegetation. Therefore, the amount of available water needed to be adjusted. Twenty years of Treynor's monthly precipitation (cm) were regressed against monthly runoff (cm) to determine this amount. The resulting equation was $y = 0.1246x - 0.4575$ ($r^2 = 0.4142$), where y is runoff and x is precipitation. Using this equation, the amount of precipitation needed to obtain runoff ($y \geq 0$) is 3.67 cm. Code was added[2] that reduces the amount of water available to vegetation, using the slope of the regression, when precipitation is greater than 3.67 cm.

[2] The added line of code is: runoff = MAX(0.0, 0.1246 * (inputs – 3.67)

The Century program was also adjusted to fix an inconsistency with nitrogen fixing plants. In previous versions of the model, nitrogen fixed by vegetation was not accounted for when computing the amount of nitrogen uptake needed. This in turn could reduce soil nitrogen levels more than necessary. The version of Century used on this project adjusts, if necessary, the amount of nitrogen taken up from the soil by the amount of nitrogen fixed by the plant.

4.0 Schedule files

4.1 Deep Loess Research Station at Treynor, Iowa

Three scenarios were run for Treynor: no erosion, minimum erosion, and maximum erosion. Minimum and maximum annual erosion rates for each crop grown were calculated using data from several published studies (Appendix A, Table 1). Values from these studies were summarized by calculating the mean, standard deviation, and 95% confidence interval (Appendix A, Table 2). The minimum annual erosion rate was obtained by subtracting the 95% confidence interval from the mean. The maximum annual erosion rate was calculated as the mean erosion rate plus the 95% confidence interval. The minimum and maximum erosion rates used in this study are not considered absolute values, but rather extremes, which bracket the actual erosion rates.

For two crops, wheat and alfalfa, only two studies containing erosion values were found. For these two crops the lower erosion rate represented the minimum annual erosion while the higher erosion rate was used for maximum annual erosion. Erosion rates for oats were not found. Therefore, the erosion rates calculated for wheat were also used for oats.

To obtain monthly erosion values, minimum and maximum annual erosion rates were multiplied by the percent of annual erosion received each month. These percentages represent the average monthly erosion received at Treynor Watersheds 1 through 4 from 1965 – 1992 (Table 1; Appendix A, Table 3). These monthly erosion values were placed into the schedule file, or list of events, used for modeling in Century.

In addition to varying between crops, erosion rates can also vary with farming practices. In fact, the purpose of certain farming practices is to reduce topsoil loss. Therefore, erosion rates for some crops were calculated twice; once using erosion rates from conventional farming practices and a second time using studies focused on the conservation practice known as contouring. Contour plowing was implemented at Treynor sometime before the USDA-ARS took over the site. Because widespread adoption of contour farming in neighboring counties was reported in 1939 (Iowa Dept. of Agriculture, 1939) and the West Pottawattamie County Soil Conservation District was created in 1944 (Branham, 1989), we assumed that contour farming would have likely been implemented on this watershed by block 6, which begins in 1950. Though narrow grass hedges, which could also be considered a conservation practice, were installed at Treynor in 1991, we did not adjust erosion rates at that time. Grass hedges provide a small scale, temporary blockade for sediment, so the eroded soil may be plowed back into the field at a later date. Because hedges do not affect the slope of the hill or farming techniques we felt that erosion values would not change significantly at the upper slope location being modeled. The start of the schedule file for Treynor (Appendix B) was based on estimates of permanent settlement in Pottawattamie County. Prior to 1838 "practically no agriculture carried

Month	Percent	Month	Percent
Jan	<1%	July	2%
Feb	<1%	Aug	3%
Mar	2%	Sept	2%
April	3%	Oct	<1%
May	30%	Nov	<1%
June	58%	Dec	<1%

Table 1. Percent of annual sheet rill erosion received each month. Data is from Watersheds 1 through 4 at Treynor from 1965-1992.

on in the county" (Whitney, 1914). Though Mormons stayed in the county on their travels to Utah, they usually only grew enough food for their own consumption (Whitney, 1914). It wasn't until 1856, when the railroad first passed through the county, that larger scale agriculture became feasible. Therefore, we begin to model the influence of agriculture in 1860.

One of the greatest uncertainties encountered during the creation of the Treynor schedule file was determining which crops were grown when and in what quantities. Two paths were taken to help discover the historical practices of the region from 1860 until 1963 (when the USDA-ARS began to manage the land). The first involved conversations with local farmers regarding their recollections of farming practices over time. The second method was based on agricultural statistics of Pottawattamie County (U.S. Dept. of Commerce, 1856, 1859, 1867, 1869, 1888, 1900, 1910, 1867, 1869, 1888, 1900, 1910; Iowa Dept. of Agriculture and Land Stewardship, 1919-1968). The six main crops of the region were modeled: corn, winter wheat, spring wheat, oats, alfalfa, and clover/timothy pasture.

Agricultural statistics were also used to determine the length of time each crop was placed in rotation. For this process we used a space for time substitution. In other words, the proportion of acres planted in each crop to the total amount of acres for all crops during a set time period determined the amount of time each crop was included in the rotation (Figure 1). For example, from 1860 to 1877 (block #1 in the schedule file), corn was planted in ~67% of the farming acres in Pottawattamie County. Therefore, corn was planted 67% of the time during block #1's nine-year cycle.

Decisions to create a new block were based on significant changes in crop use and/or the introduction of other factors that would influence how crops were being managed. Examples of these changes are the start of planting crops for hay (versus using the existing prairies), the

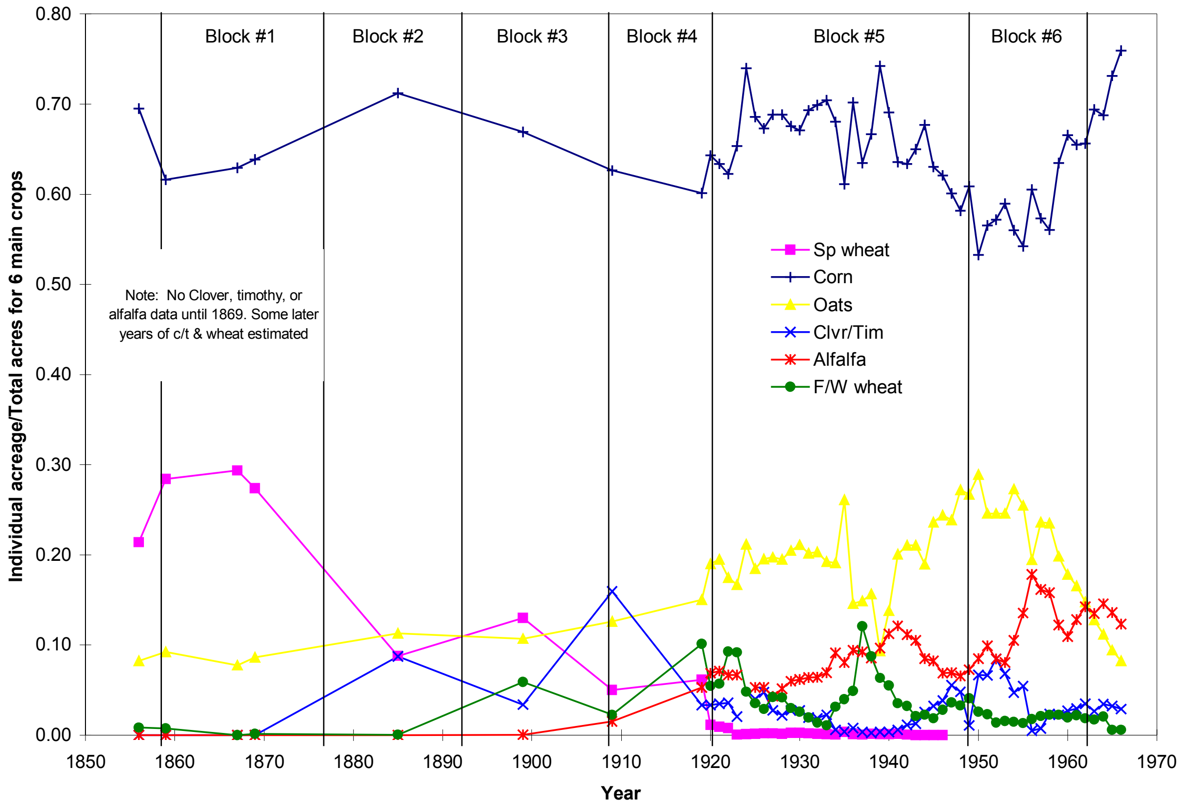

Figure 1. Proportion of each individual crop to the total number of acres planted for the six main crops.

introduction of mechanized equipment, and the use of commercial fertilizer (versus manure). Starting in 1963, official management records of the USDA-ARS were used to determine how the farm was managed.

Once the crops and management scheme within the schedule file were determined, we wanted to confirm the correct hybrid of each crop was being used, as each hybrid differs in terms of productivity. Model output (determined by the product of two parameters, *cgrain* and *hi*) was compared to historical yield data to check that Century was creating realistic productivity values. These yield values were obtained from the same agriculture statistics described above. Based on this information, cultivation began with the C5 version of corn (1860-1949), switched to C6 (1950-1962), and ended with C-HI (1963-1996). To better match historical yields we also adjusted the *himax* parameter (fraction of aboveground live carbon in the grain) for each hybrid; for C-HI it was changed to 0.65 (versus 0.50), for C6 it was changed to 0.60 (versus 0.50), and for C5 if was changed to 0.55 (versus 0.45). Three parameters for soybeans were modified: *prdx(1)* (potential aboveground monthly production) was changed from 300 to 450, *himax* was changed from 0.31 to 0.40, and *snfmx()* (maximum symbiotic nitrogen fixation) was changed from 0.0375 to 0.04. Values given in the Century manual were used for all other corn and soybean parameters and all parameters of winter wheat (W3 hybrid), and the grass/clover pasture (Metherell et al., 1993). Parameter values for spring wheat, oats, and alfalfa were developed by and obtained from Century personnel at Colorado State University and can be found in Appendix D.

Crop manipulations, such as fertilization and harvesting, varied historically. Because farmers were usually limited economically we did not apply nutrient enhancements to every crop. Of the six crops used only corn was fertilized, as it is the most draining on soil resources. Manure based fertilizer was used until commercial fertilizer became a popular alternative. In Iowa this occurred in the 1950s, at which time commercial fertilizers were used on almost half of Iowa's farms (Spomer and Piest, 1982). Therefore, commercial fertilizer replaced manure as the nutrient additive in block 6, which begins in 1950. (For more information on the rates of manure and commercial fertilizers added, see section 6.9, *omad.100*, and section 6.3, *fert.100*, respectively.)

Other management scenarios were included in the schedule file. Corn residue was grazed during the winter months (Vorthmann, 1998, Bogue, 1994) and clover was made to senese in November. Each crop was also harvested. Harvesting rates were determined by examining the historical methods used (e.g., horse-drawn machines, motor-driven combines) and estimating the amount of straw removed with each method.

4.2 Dinesen Prairie, Iowa

The carbon dynamics of Dinesen Prairie were modeled for the last 8,000 years, the estimated time that prairies have been present in the region (Collins and Wallace, 1990). Again, three scenarios were run: no erosion, minimum erosion, and maximum erosion. Erosion rates were calculated in the same manner as those for Treynor. The mean, standard deviation, and 95% confidence interval were calculated using erosion rates of grass (Appendix 1). Adding or subtracting the 95% confidence interval from the mean resulted in the annual maximum or minimum erosion rate. Monthly erosion rates were calculated by multiplying these annual values by the data found in Table 1.

For all blocks within the schedule file (Appendix C) the "crop" grown is Konza grass, in reference to the tall-grass prairie found at Konza Prairie, Kansas. Century personnel developed the parameter values for Konza grass (Appendix D) based on work done at the Long Term Ecological Research (LTER) site located there. The first block, which runs from 6002 BC to 1859 (7,862 years), consists of a ten-year cycle. Each year the grass is grown from January to December, with an episode of senesence in November, killing off 95% of the aboveground shoots. Bison grazing also occurs each year. The month during which this grazing takes place was determined using a random number generator, with each month having an equal probability of being chosen. In the final year of this ten-year block a "cold" fire occurs in June. Fire was included to approximate the natural fire cycle of the region (Ehrenreich and Aikman, 1963). In

Century fire removes vegetation and returns nutrients to the soil. The intensity of the fire (i.e., cold, medium, or hot) determines the magnitude of these changes.

The above 'natural' state began to change in the 1850s when large numbers of permanent settlers began moving into the area (Robinson, 1998) and the railroad arrived in the county (Whitney, 1914). The effects of these settlers (fire suppression and cattle grazing) are initiated in block two, which begins in 1860 (model year 7863). In block three, which runs from 1893 (model year 7895) through 1991 (model year 7993), grazing is discontinued as the settlers now grow their own hay for feed purposes (U.S. Department of Agriculture, 1924). In 1992 (model year 7994) the Shelby County Board of Conservation began actively managing Dinesen Prairie, including prescribed burns every other year. These burns are included as "cold" April fires.

5.0 Weather file

Historical records of monthly precipitation, minimum monthly temperature, and maximum monthly temperature were used from 1893 to 1998. From 1893 to 1973 these records were obtained from the Atlantic_1_NE,IA weather station, managed by the Midwestern Climate Center, Champaign, IL. Weather data from 1974-1998 were from a meteorological station located in or near Watershed 1 at Treynor. For simulation years prior to 1893, weather was generated by Century from the historical records. Monthly temperatures were averaged from the 105 years of observations. Monthly precipitation was determined stochastically using monthly mean, standard deviation, and skewness values calculated from the historical data.

6.0 .100 files

The following section describes the individual .100 files used to parameterize Century for the Dinesen and Treynor runs. Default values refer to those values listed for that parameter in the Century manual. Copies of the parameter files that cannot be found in Metherell et al. (1993) are in Appendix D.

6.1 Crop.100

For information on the origin of parameter values in this file, see the description of crops modeled in section 4.1 *Deep Loess Research Station at Treynor, Iowa*.

6.2 Cult.100

The *cult.100* file was modified in two ways. First, the plowing option was adjusted to increase its effect on decomposition (Six et al., 1998). All *clteff()* values (cultivation's effect on decomposition) for the plowing option were changed from 1.6 to 4.0. This change, based on conversations with Century personnel, also helped Century and historical yields match.

The second change was added to increase the length of time which plowing effects decomposition. Since Century runs on a monthly time-step each action only affects the carbon dynamics for that particular month. Studies have shown that plowing affects decomposition for several months (Metherell et al., 1995, Parton et al., 1994). Therefore, a new plowing option, called "Additional plowing effect (A)," was created. This option was used in the months following plowing to maintain these increased decomposition rates. This option was created by setting the *clteff()* values to 4.0, as they are with plowing. Because only decomposition rates were to be effected, all parameters other than those for *clteff()* were set to zero.

6.3 Fert.100

Rates of nitrogen additions were determined using Treynor records and values given in Spomer and Piest (1982). The average amount of nitrogen added was 10 g N m^{-2} yr^{-1} from 1950-1962, 12 g N m^{-2} yr^{-1} from 1963-1964, 30 g N m^{-2} yr^{-1} from 1965-1974, 15 g N m^{-2} yr^{-1} from 1975-1996, and 4.5 N m^{-2} yr^{-1} from 1997-1998. For each rate of application, the *feramt(1)* parameter was set to the appropriate value (e.g., 10, 12, 30, etc.). All other parameter values were set to zero.

6.4 Fire.100

Nothing in this file was changed from the default settings

6.5 Fix.100

Only two sets of values were changed from the default for the *fixed.100* file. First, *enrich* (the enrichment factor of soil organic material (SOM) losses) was changed from 2 to 1. This value was changed to simplify the way in which Century models the carbon dynamics, making additional modeling efforts of these sites using an user-created model easier.

The second change was to the *lhzf()* parameters. *Lhzf()*'s are used to compute the sizes of the lower horizon (> 20 cm) pools of carbon (e.g., active, slow, and passive). The values for these parameters were estimated using radiocarbon and carbon storage field data obtained from the ridgetop (our no erosion scenario field location) at Dinesen Prairie. The amount of carbon present in the 0-5 cm section of the soil profile was used to calculate the approximate amount of carbon in each of the first five centimeters. The value for the first centimeter was partitioned into three carbon pools, som1d (active/detrital carbon), som2 (slow carbon), and som3 (passive carbon), using the proportion each pool comprised out of the total amount of carbon in an initial run of Century (i.e., using early versions of schedule, fix, and parameter files). A depth profile of carbon, to one meter, was then created by adjusting the amount of carbon in the first centimeter for each additional centimeter using equations based on the model of Rosenbloom (1997):

$$\text{som}x\ C_y = \%C_{somx} * C_{1cm} * \text{Exp}(-cm_y/lhf)$$

where som$x$ C_y is the amount of carbon at depth y (cm) for pool som x, $\%C_{somx}$ is the percentage the som x pool represents out of the total carbon, C_{1cm} is the amount of carbon found at 1 centimeter, cm_y is the depth in centimeters, and lhf is the lower horizon factor.

Radiocarbon content, expressed as Fraction Modern (FM), at each centimeter was calculated for each pool using FM estimates of 1.1, 1.2, and 0.9388 for som1d, som2, and som3, respectively. Total ^{14}C (FM) and carbon (g/m^2) at each depth were then calculated by combining the values for all three pools. These modeled FM and carbon values were graphed against the field-based ^{14}C and carbon data. The lower horizon factors were adjusted until both graphs showed reasonable fits between the modeled and field data. The amount of carbon in each pool between 0-20 cm and 20-40 cm was then calculated. The ratio of the deep (20-40 cm) to the shallow (0-20 cm) carbon in each pool represents the *lhzf* parameter. Although there were not unique combinations of *lhzf*'s, the values chosen provided the best match between the field and modeled isotope data. These values were 0.2, 0.3, and 0.8 for *lhzf(1)*, *lhzf(2)*, and *lhzf(3)*, respectively.

6.6 Graz.100

An additional option was added to the graz.100 file, called bison grazing (GB). It contains the same parameters as low intensity grazing (GM), with the exception of *grzeff* (the grazing effect on production), which was set to zero. This option, created at the suggestion of

Century personnel, is thought to better represent the effects of free-ranging bison, versus GM which better represents light grazing from penned cattle.

6.7 Harv.100

Two options, G75 (75% straw removal) and G10 (10% straw removal), were added to the *harv.100* descriptions found in the Century manual to provide a variety of straw removal options. These options contain the same values for all parameters as 50% or 0% straw removal, with the exception of *rmvstr*, which was set to 0.75 or 0.10, respectively. To assist with nomenclature the name of the option that removed 50% of the straw was changed from GS to G50.

6.8 Irri.100

Nothing in this file was changed from the default settings.

6.9 Omad.100

BOMAH (Bovine manure at a high rate of application) was added to the *omad.100* file to provide an organic fertilizer (used pre-1950). This option was created by Century personnel to model manure additions to agricultural fields. BOMAH adds 200 g /m^2 of carbon (none of which is labeled), with 25% lignin content, and contains the following ratios: C/N = 25, C/P = 300, and C/S = 300. BOMAH was applied during the month of March because manure additions required up to four weeks to apply to the fields (Vorthmann, 1998). Commercial fertilizer, which has faster application rates, could be added just before plowing in April.

6.10 Tree.100

Nothing in this file was changed from the default settings.

6.11 Site.100

For both sites, default values were used for all parameters unless listed below:

Parameter	Site	How Obtained
precip(12)	Dinesen & Treynor	Historical weather data
prcstd(12)	Dinesen & Treynor	Historical weather data
prcskw(12)	Dinesen & Treynor	Historical weather data
tmn2m(12)	Dinesen & Treynor	Historical weather data
tmx2m(12)	Dinesen & Treynor	Historical weather data
ivauto	Dinesen & Treynor	Grass soil values were used for Dinesen. User-supplied values were used for Treynor. See below for information on how the user supplied values were obtained.
sitlat	Dinesen & Treynor	GPS measurement
sitlong	Dinesen & Treynor	GPS measurement
sand	Dinesen & Treynor	Field measurements
silt	Dinesen & Treynor	Field measurements
clay	Dinesen & Treynor	Field measurements
bulk density	Dinesen & Treynor	Field measurements
nlayer	Dinesen & Treynor	Field measurements and for Dinesen, figures in Joern (1995)
nlaypg	Dinesen & Treynor	Field measurements and for Dinesen, figures in Joern (1995)
epnfa(2)	Dinesen &Treynor	Calculated based on data in Tabatabia (1981)
som1ci(1,1)	Treynor	The final value of the Dinesen minimum erosion run was used to initialize the Treynor runs.
som1ci(2,1)	Treynor	The final value of the Dinesen minimum erosion run was used to initialize the Treynor runs.
som2ci(1)	Treynor	The final value of the Dinesen minimum erosion run was used to initialize the Treynor runs.
som3ci(1)	Treynor	The final value of the Dinesen minimum erosion run was used to initialize the Treynor runs.

7.0 Conclusion

This paper describes the characterization of two different sites in the loess region of Iowa for modeling using the Century program. The first site, Dinesen Prairie, has never been cultivated and represents the carbon dynamics of an undisturbed area. The second site, Treynor, has been farmed for over a hundred years. It was studied to determine the effects of regional agriculture practices. A combination of historical data, management records, and published studies were used to parameterize Century for each site. The results of these modeling efforts can be found in Manies et al. (in press). Copies of the Century program and the files described here can be obtained from the Century web site, which is located at http://nrel.colostate.edu/projects/century/.

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Appendix A. Erosion Rates

Table 1. Erosion rates from a variety of studies

Crop	Management	$kg/m^2/yr$	State	Reference
alfalfa	continuous	0.07	MO	(Miller, 1936)
alfalfa	not mentioned	0.00	IA	(Iowa Dept. of Agriculture, 1939)
corn	not mentioned	6.42	IA	(Iowa Dept. of Agriculture, 1939)
corn	not mentioned	4.39	MO	(Duley and Miller, 1923)
corn	continuous	2.95	MS	(McGregor et al., 1996b)
corn	"poor" planting	4.40	MS	(McGregor et al., 1996b)
corn	conventional for silage	2.77	MS	(McGregor et al., 1996b)
corn	conventional for grain	1.76	MS	(McGregor et al., 1996b)
corn	not mentioned	16.61	MO	(Miller, 1936)
corn	not mentioned	4.87	MO	(Miller, 1936, Miller and Krusekopf, 1932)
corn	not mentioned	5.11	MO	(Miller, 1936, Miller and Krusekopf, 1932)
corn	not mentioned	5.30	MO	(Miller, 1936, Miller and Krusekopf, 1932)
corn	"mismanaged"	4.94	IA	(Piest and Spomer, 1968)
corn	not mentioned	4.20	IA	(Piest and Ziemnicki, 1979)
corn	not mentioned	4.50	MO	(Woodruff, 1987)
corn	tilled	16.06	IA	(Spomer et al., 1985)
corn	tilled	9.81	IA	(Spomer et al., 1985)
corn	tilled	2.40	OH	(Spomer et al., 1976)
corn	intensive	2.10	IA, MN, WI	(Argabright et al., 1996)
corn	contour	1.11	MS	(McGregor et al., 1996b)
corn	contour #2, tilled	4.01	IA	(Spomer et al., 1976)
corn	contour #1, tilled	4.95	IA	(Spomer et al., 1976)
corn	contour, no-till	0.15	IA	(Spomer et al., 1976)
corn	contour #1	3.04	IA	(Spomer and Piest, 1982)
corn	contour #2	9.00	IA	(Spomer and Piest, 1982)
grass	none	0.25	IA	(Piest and Spomer, 1968)
grass	rotation grazed	0.07	IA	(Spomer et al., 1973)
grass	rotation grazed	0.20	IA	(Spomer et al., 1976)
grass	continuous	0.02	MO	(Duley and Miller, 1923)
grass	continuous	0.08	MO	(Miller, 1936)
grass	continuous	0.08	MO	(Miller, 1936, Miller and Krusekopf, 1932)
grass	continuous	0.01	IA	(Iowa Dept. of Agriculture, 1939)
soybeans	continuous, drilled	2.32	MO	(Miller, 1936, Miller and Krusekopf, 1932)
soybeans	continuous, in rows	4.82	MO	(Miller, 1936, Miller and Krusekopf, 1932)
soybeans	continuous, conventional	2.11	MS	(McGregor et al., 1996a)
soybeans	continuous, conventional	1.96	MS	(McGregor et al., 1996a)
wheat	continuous	1.41	MO	(Duley and Miller, 1923)
wheat	continuous	2.50	MO	(Miller, 1936, Miller and Krusekopf, 1932)
wheat	not mentioned	2.47	MO	(Woodruff, 1987)

Table 2. Statistical summary of annual erosion rates (g m^{-2} yr^{-1}). The mean minus the 95% confidence interval (CI) represents the minimum annual erosion rate. The mean plus the 95% confidence interval was used for the maximum annual erosion rate. Alfalfa and wheat erosion rates were calculated differently due to their small sample size (see section 4.1).

Management	*n*	Mean	Standard Deviation	95% CI	Mean – 95% CI	Mean + 95% CI
alfalfa	2	0.04	0.05			
corn (no conservation)	17	5.83	4.38	2.08	3.74	7.91
corn - contours	6	3.71	3.15	2.52	1.19	6.23
soybeans	4	2.80	1.36	1.33	1.47	4.13
wheat	2	1.95	0.77			
grass	7	0.10	0.09	0.07	0.04	0.17

Table 3. Monthly erosion rates for individual crops (g m^{-2} yr^{-1}). Minimum erosion is listed first, followed by maximum erosion. Values were obtained by multiplying the minimum or maximum annual erosion rate by the percent of annual erosion rate received each month (see section 4.1 and Table 1).

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
alfalfa	0.000/ 0.000	0.000/ 0.000	0.000/ 0.001	0.000/ 0.002	0.000/ 0.021	0.000/ 0.041	0.000/ 0.001	0.000/ 0.002	0.000/ 0.001	0.000/ 0.000	0.000/ 0.000	0.000/ 0.000
corn - w/o conservation	0.000/ 0.000	0.000/ 0.000	0.075/ 0.158	0.112/ 0.237	1.123/ 2.372	2.171/ 4.586	0.075/ 0.158	0.112/ 0.237	0.075/ 0.158	0.000/ 0.000	0.000/ 0.000	0.000/ 0.000
corn - contours	0.000/ 0.000	0.000/ 0.000	0.024/ 0.125	0.036/ 0.187	0.357/ 1.868	0.691/ 3.612	0.024/ 0.125	0.036/ 0.187	0.024/ 0.125	0.000/ 0.000	0.000/ 0.000	0.000/ 0.000
wheat	0.000/ 0.000	0.000/ 0.000	0.028/ 0.050	0.042/ 0.075	0.423/ 0.750	0.818/ 1.450	0.028/ 0.050	0.042/ 0.075	0.028/ 0.050	0.000/ 0.000	0.000/ 0.000	0.000/ 0.000
soybeans	0.000/ 0.000	0.000/ 0.000	0.029/ 0.083	0.044/ 0.124	0.442/ 1.239	0.855/ 2.396	0.029/ 0.083	0.044/ 0.124	0.029/ 0.083	0.000/ 0.000	0.000/ 0.000	0.000/ 0.000
grass	0.000/ 0.000	0.000/ 0.000	0.001/ 0.003	0.001/ 0.005	0.011/ 0.050	0.022/ 0.097	0.001/ 0.003	0.001/ 0.005	0.001/ 0.003	0.000/ 0.000	0.000/ 0.000	0.000/ 0.000

Appendix B. Treynor schedule file summary

Listed with each block is the percentage of time each crop is grown during that block. These values were calculated to compare with those calculated from the agricultural statistics (see section 4.2 and Figure 1). Abbreviations are as follows: C, corn; SW, spring wheat; WW, winter wheat; O, oats; A, alfalfa; and Cl, clover. The asterisk in the Year column indicates the year in which that block will conclude. A plus after the tillage option signifies that there are two additional months of cultivation effect included in the schedule file. See section 6.2 for more information. Under the harvest column, G signifies that the grain of the crop was harvested. The value that follows indicates the percentage of straw also removed with the grain. BOMAH stands for bovine manure at a high rate of application. W. graze under the grazing column indicates that winter grazing will occur.

Blk	Years	Yr	Tillage	Crop	Harvest	Fertilizer	Grazing	Other	Notes
1	1860-1877	1	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		Spring wheat up to 30% of the acreage. Oats ~10% of acreage. Prairie is hay source.
		2	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
	C=67%	3	plow+ (Mar)	Sp wheat (Apr)	G-75% (July)				
	SW=22%	4	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
	O=11%	5	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		6	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		7	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		8	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		9*	plow+ (Mar)	Sp wheat (Apr)	G-75% (July)		w. graze (Jan,Feb)		
2	1878-1893	1	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		Spring wheat decreasing (~10%), winter wheat increasing. Use spring wheat, though it was probably a combination of the two. Oats very slowly increasing. Pioneers start growing own hay ~1880.
		2	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
	C=75%	3	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
	SW=12.5%	4	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb,Dec)		
	O=12.5%	4/5		clover (Sept.)				senesce (Nov)	
		5	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		6	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		7	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		8*	plow+ (Mar)	Sp wheat (Apr)	G-75% (July)		w. graze (Jan,Feb)		

3	1894-1909 C=75% SW=12.5% O=12.5%	1	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		Start block #2 cycle again. Had to make two blocks to start using historical weather.
		2	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		3	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		4	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		4/5		clover (Sept.)			w. graze (Dec,Jan,Feb)	senesce (Nov)	
		5	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		6	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		7	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		8*	plow+ (Mar)	Sp wheat (Apr)	G-75% (July)		w. graze (Jan,Feb)		
4	1910-1921 C=66% O=17% WW=8% SW=8%	1	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		Oats still slightly increasing (~15%) Winter wheat slightly increasing, spring wheat slowly decreases until 1920 when not grown anymore.
		2	plow+ (Apr)	corn (May)	G-50% (Sept.)	BOMAH (Mar)	w. graze (Jan,Feb)		
		2/3	plow+ (Oct)	W wheat (Oct.)	G-75% (July)				
		4	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		5	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		6	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb,Dec)		
		6/7		clover (Sept.)				senesce (Nov)	
		7	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		8	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		9	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb,Dec)		
		9/10		clover (Sept.)				senesce (Nov)	
		10	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		11	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		12*	plow+ (Mar)	Sp wheat (Apr)	G-75% (July)		w. graze (Jan,Feb)		
5	1922-1949 C=64% O= 21% A=7% WW=7%	1	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		Oats now up around 20%. Alfalfa dependable & Pottawattamie Cty has the most (10% by 1940).
		2	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		3	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		4	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		5	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		6	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		7	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		8	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Jan,Feb,Dec)		
		9	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		10	plow+ (Apr)	corn (May)	G-50% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		11	plow+ (Apr)	corn (May)	G-50% (Sept.)	BOMAH (Mar)	w. graze (Jan,Feb)		
		11/12	plow+ (Oct)	W wheat (Oct.)	G-75% (July)				
		13	plow+ (Apr)	corn (May)	G-75% (Oct.)	BOMAH (Mar)	w. graze (Dec)		
		14*	plow+ (Mar)	alfalfa (Apr)	Hay (July & Oct.)				

6	1950-62	1	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Dec)		Tractors on 33% of farms in 1935 (R.V. got his in 1939). Assume most have them now, so can increase amount of residue left. Soil conservation in area (Adair Cty in 1939; Pottawattamie Cty in 1940). Decrease erosion due to contour farming, etc. Increase alfalfa.
		2	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Jan,Feb,Dec)		
	C=61%	3*	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
	O= 23%	4	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Dec)		
	A=15%	5	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Jan,Feb,Dec)		
		6	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		7	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Dec)		
		8	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Jan,Feb,Dec)		
		9	plow+ (Mar)	oats (Apr)	G-75% (Aug.)		w. graze (Jan,Feb)		
		10	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Dec)		
		11	plow+ (Apr)	corn (May)	G-50% (Oct.)	N-10 g/m^2 (Apr)	w. graze (Jan,Feb,Dec)		
		12	plow+ (Mar)	alfalfa (Apr)	Hay (July & Oct.)				
		13	plow+ (Mar)	alfalfa (Apr)	Hay (June,Aug,Oct.)				
7	1963-64	1	plow+ (Mar)	oats (Apr)	G-10% (Aug.)				
		1/2		clover (Sept.)				senesce (Nov)	
		2	plow+ (Apr)	corn (May)	G-10% (Oct.)	N-12 g/m^2 (Apr)	w. graze (Dec)		
8	1965-71	1	plow+ (Apr)	corn (May)	G-0% (Oct.)	N-30 g/m^2 (Apr)	w. graze (Dec-Feb)		
9	1972-74	1	plow+ (Apr)	corn (May)	G-0% (Oct.)	N-30 g/m^2 (Apr)			Stop winter grazing.
10	1975-96	1	plow+ (Apr)	corn (May)	G-0% (Oct.)	N-15 g/m^2 (Apr)			Decrease fertilizer.
11	1997-98	1	no-till drill (Apr)	soybean (May)	G-0% (Oct.)	N-4.5 g/m^2 (Apr)			To soybeans.

Appendix C. Dinesen Prairie schedule file summary

Schedule years indicates the years values used in the schedule file, while Roman years indicates the corresponding year on the Roman calendar.

Block	Schedule Years	Roman Years	Year	Crop	Fire	Grazing	Senesce
1	0-7862	6002 BC - 1859	1	Konza grass (Jan-Dec)		GB (Oct)	Nov
			2	Konza grass (Jan-Dec)		GB (Feb)	Nov
			3	Konza grass (Jan-Dec)		GB (Aug)	Nov
			4	Konza grass (Jan-Dec)		GB (June)	Nov
			5	Konza grass (Jan-Dec)		GB (Nov)	Nov
			6	Konza grass (Jan-Dec)		GB (July)	Nov
			7	Konza grass (Jan-Dec)		GB (Aug)	Nov
			8	Konza grass (Jan-Dec)		GB (May)	Nov
			9	Konza grass (Jan-Dec)		GB (Sept)	Nov
			10	Konza grass (Jan-Dec)	cold (June)	GB (Apr)	Nov
2	7863 - 7894	1860-1892	1	Konza grass (Jan-Dec)		medium (Apr-Sep)	Nov
3	7895 - 7993	1893-1991	1	Konza grass (Jan-Dec)			Nov
4	7994 - 8000	1992-1998	1	Konza grass (Jan-Dec)	cold (April)		Nov
			2	Konza grass (Jan-Dec)			Nov

Appendix D. Parameters for Other Crops

The following lists parameter values for those crops used in this modeling effort that are not found in the Century manual (Metherell et al., 1993). The values for these crops were created by Century personnel for their and others modeling efforts.

ALF N_fixing_alfalfa

300	'PRDX(1)'
22	'PPDF(1)'
35	'PPDF(2)'
0.8	'PPDF(3)'
3.5	'PPDF(4)'
1.0	'BIOFLG'
200	'BIOK5'
0.5	'PLTMRF'
150	'FULCAN'
0.4	'FRTC(1)'
0.4	'FRTC(2)'
1	'FRTC(3)'
400.0	'BIOMAX'
8.5	'PRAMN(1,1)'
100	'PRAMN(2,1)'
125	'PRAMN(3,1)'
8.5	'PRAMN(1,2)'
100	'PRAMN(2,2)'
125	'PRAMN(3,2)'
15	'PRAMX(1,1)'
133	'PRAMX(2,1)'
160	'PRAMX(3,1)'
15	'PRAMX(1,2)'
133	'PRAMX(2,2)'
160	'PRAMX(3,2)'
17	'PRBMN(1,1)'
100	'PRBMN(2,1)'
125	'PRBMN(3,1)'
0.0	'PRBMN(1,2)'
0.0	'PRBMN(2,2)'
0.0	'PRBMN(3,2)'
22	'PRBMX(1,1)'
133	'PRBMX(2,1)'
160	'PRBMX(3,1)'
0.0	'PRBMX(1,2)'
0.0	'PRBMX(2,2)'
0.0	'PRBMX(3,2)'
0.04	'FLIGNI(1,1)'
0	'FLIGNI(2,1)'
0.12	'FLIGNI(1,2)'
0	'FLIGNI(2,2)'
0.0	'HIMAX'
0.0	'HIWSF'
2	'HIMON(1)'
1	'HIMON(2)'
0	'EFRGRN(1)'
0.0	'EFRGRN(2)'
0.0	'EFRGRN(3)'
0.02	'VLOSSP'
0.3	'FSDETH(1)'
0.4	'FSDETH(2)'
0.1	'FSDETH(3)'
500	'FSDETH(4)'
0.5	'FALLRT'
0.2	'RDR'
2.0	'RTDTMP'
0	'CRPRTF(1)'
0.0	'CRPRTF(2)'
0.0	'CRPRTF(3)'
0.0335	'SNFXMX(1)'
-27	'DEL13C'
0.0	'CO2IPR'
0.0	'CO2ITR'
0.0	'CO2ICE(1,1,1)'
0.0	'CO2ICE(1,1,2)'
0.0	'CO2ICE(1,1,3)'
0.0	'CO2ICE(1,2,1)'
0.0	'CO2ICE(1,2,2)'
0.0	'CO2ICE(1,2,3)'
0.0	'CO2IRS'

KNZ Konza_tallgrass

250.0	'PRDX(1)'
30.0	'PPDF(1)'
45.0	'PPDF(2)'
1.0	'PPDF(3)'
2.5	'PPDF(4)'
1.0	'BIOFLG'
60.0	'BIOK5'
1.0	'PLTMRF'
100.0	'FULCAN'
0.0	'FRTC(1)'
0.0	'FRTC(2)'
0.0	'FRTC(3)'
400.0	'BIOMAX'
20.0	'PRAMN(1,1)'
390.0	'PRAMN(2,1)'
340.0	'PRAMN(3,1)'
30.0	'PRAMN(1,2)'
390.0	'PRAMN(2,2)'
340.0	'PRAMN(3,2)'
30.0	'PRAMX(1,1)'
440.0	'PRAMX(2,1)'
440.0	'PRAMX(3,1)'
80.0	'PRAMX(1,2)'
440.0	'PRAMX(2,2)'
440.0	'PRAMX(3,2)'
60.0	'PRBMN(1,1)'
390.0	'PRBMN(2,1)'
340.0	'PRBMN(3,1)'
0.0	'PRBMN(1,2)'
0.0	'PRBMN(2,2)'
0.0	'PRBMN(3,2)'
80.0	'PRBMX(1,1)'
420.0	'PRBMX(2,1)'
420.0	'PRBMX(3,1)'
0.0	'PRBMX(1,2)'
0.0	'PRBMX(2,2)'
0.0	'PRBMX(3,2)'
0.02	'FLIGNI(1,1)'
0.00120	'FLIGNI(2,1)'
0.26	'FLIGNI(1,2)'
-0.00150	'FLIGNI(2,2)'
0.0	'HIMAX'
0.0	'HIWSF'
0.0	'HIMON(1)'
0.0	'HIMON(2)'
0.50	'EFRGRN(1)'
0.50	'EFRGRN(2)'
0.50	'EFRGRN(3)'
0.04	'VLOSSP'
0.20	'FSDETH(1)'
0.95	'FSDETH(2)'
0.20	'FSDETH(3)'
150.0	'FSDETH(4)'
0.15	'FALLRT'
0.07	'RDR'

2.0 'RTDTMP'
0.50 'CRPRTF(1)'
0.0 'CRPRTF(2)'
0.0 'CRPRTF(3)'
0.0 'SNFXMX(1)'
27.0 'DEL13C'
0.00 'CO2IPR'
0.0 'CO2ITR'
0.0 'CO2ICE(1,1,1)'
0.0 'CO2ICE(1,1,2)'
0.0 'CO2ICE(1,1,3)'
0.0 'CO2ICE(1,2,1)'
0.0 'CO2ICE(1,2,2)'
0.0 'CO2ICE(1,2,3)'
0.0 'CO2IRS(1)'

SW3 Sp_Wheat_3
300.0 'PRDX(1)'
17.0 'PPDF(1)'
35.0 'PPDF(2)'
0.5 'PPDF(3)'
5.0 'PPDF(4)'
0.0 'BIOFLG'
1800.0 'BIOK5'
0.4 'PLTMRF'
150.0 'FULCAN'
0.6 'FRTC(1)'
0.1 'FRTC(2)'
3.0 'FRTC(3)'
600.0 'BIOMAX'
12.0 'PRAMN(1,1)'
100.0 'PRAMN(2,1)'
100.0 'PRAMN(3,1)'
57.0 'PRAMN(1,2)'
160.0 'PRAMN(2,2)'
200.0 'PRAMN(3,2)'
25.0 'PRAMX(1,1)'
200.0 'PRAMX(2,1)'
230.0 'PRAMX(3,1)'
125.0 'PRAMX(1,2)'
260.0 'PRAMX(2,2)'
270.0 'PRAMX(3,2)'
45.0 'PRBMN(1,1)'
390.0 'PRBMN(2,1)'
340.0 'PRBMN(3,1)'
0.0 'PRBMN(1,2)'
0.0 'PRBMN(2,2)'
0.0 'PRBMN(3,2)'
60.0 'PRBMX(1,1)'
420.0 'PRBMX(2,1)'
420.0 'PRBMX(3,1)'
0.0 'PRBMX(1,2)'
0.0 'PRBMX(2,2)'
0.0 'PRBMX(3,2)'
0.15 'FLIGNI(1,1)'
0.0 'FLIGNI(2,1)'
0.06 'FLIGNI(1,2)'
0.0 'FLIGNI(2,2)'
0.42 'HIMAX'
0.25 'HIWSF'
1.0 'HIMON(1)'
1.0 'HIMON(2)'
0.75 'EFRGRN(1)'
0.6 'EFRGRN(2)'
0.6 'EFRGRN(3)'
0.04 'VLOSSP'
0.0 'FSDETH(1)'
0.0 'FSDETH(2)'
0.0 'FSDETH(3)'
200.0 'FSDETH(4)'
0.12 'FALLRT'
0.05 'RDR'
2.0 'RTDTMP'
0.0 'CRPRTF(1)'
0.0 'CRPRTF(2)'
0.0 'CRPRTF(3)'
0.0 'SNFXMX(1)'
-27.0 'DEL13C'
0.0 'CO2IPR(1)'
0.0 'CO2ITR(1)'
0.0 'CO2ICE(1,1,1)'
0.0 'CO2ICE(1,1,2)'
0.0 'CO2ICE(1,1,3)'
0.0 'CO2ICE(1,2,1)'
0.0 'CO2ICE(1,2,2)'
0.0 'CO2ICE(1,2,3)'
0.0 'CO2IRS(1)'

OAT Oats
325.0 'PRDX(1)'
18.0 'PPDF(1)'
35.0 'PPDF(2)'
0.7 'PPDF(3)'
5.0 'PPDF(4)'
0.0 'BIOFLG'
1800.0 'BIOK5'
0.4 'PLTMRF'
150.0 'FULCAN'
0.7 'FRTC(1)'
0.1 'FRTC(2)'
3.0 'FRTC(3)'
600.0 'BIOMAX'
20.0 'PRAMN(1,1)'
100.0 'PRAMN(2,1)'
100.0 'PRAMN(3,1)'
40.0 'PRAMN(1,2)'
160.0 'PRAMN(2,2)'
200.0 'PRAMN(3,2)'
30.0 'PRAMX(1,1)'
200.0 'PRAMX(2,1)'
230.0 'PRAMX(3,1)'
60.00 'PRAMX(1,2)'
260.0 'PRAMX(2,2)'
270.0 'PRAMX(3,2)'
45.0 'PRBMN(1,1)'
390.0 'PRBMN(2,1)'
340.0 'PRBMN(3,1)'
0.0 'PRBMN(1,2)'
0.0 'PRBMN(2,2)'
0.0 'PRBMN(3,2)'
60.0 'PRBMX(1,1)'
420.0 'PRBMX(2,1)'
420.0 'PRBMX(3,1)'
0.0 'PRBMX(1,2)'
0.0 'PRBMX(2,2)'
0.0 'PRBMX(3,2)'
0.15 'FLIGNI(1,1)'
0.0 'FLIGNI(2,1)'
0.06 'FLIGNI(1,2)'
0.0 'FLIGNI(2,2)'
0.4 'HIMAX'
0.5 'HIWSF'
1.0 'HIMON(1)'
1.0 'HIMON(2)'
0.6 'EFRGRN(1)'
0.6 'EFRGRN(2)'
0.6 'EFRGRN(3)'
0.04 'VLOSSP'
0.0 'FSDETH(1)'
0.0 'FSDETH(2)'
0.0 'FSDETH(3)'
200.0 'FSDETH(4)'
0.12 'FALLRT'
0.05 'RDR'
2.0 'RTDTMP'
0.0 'CRPRTF(1)'
0.0 'CRPRTF(2)'
0.0 'CRPRTF(3)'
0.0 'SNFXMX(1)'
-27.0 'DEL13C'
0.0 'CO2IPR(1)'

0.0	'CO2ITR(1)'	0.0	'CO2ICE(1,1,3)'	0.0	'CO2ICE(1,2,3)'
0.0	'CO2ICE(1,1,1)'	0.0	'CO2ICE(1,2,1)'	0.0	'CO2IRS(1)'
0.0	'CO2ICE(1,1,2)'	0.0	'CO2ICE(1,2,2)'		