Project Gigaton Soil-Health Greenhouse-Gas Accounting Methodology

Version 1.01

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[1]External advisory committee was comprised of Doria Gordon and Joseph Rudek from Environmental Defense Fund, and Lesley Atwood, Joseph Fargione, and Stephen Wood from The Nature Conservancy.

[2]Internal advisory committee was comprised of Johannes Lehmann and Andrew McDonald from Cornell University, with additional feedback received from Cornell faculty Rebecca Nelson, Matt Ryan, and Harold Van Es.

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1 General methods applicable to all emissions

The greenhouse gas (GHG) accounting methodology described here covers impacts of cover cropping, reduced tillage, and nitrogen (N) fertilizer management on agricultural GHG emissions for major commodity grain crops in the continental USA. Two major GHGs are considered—carbon dioxide (CO_2) and nitrous oxide (N_2O). These are the most important GHGs in the systems considered here. Extension of a future version of the methodology to also include livestock, manure management and wetlands (such as paddy-rice cultivation or peatland restoration) would need to additionally consider methane (CH_4) emissions, but this is not required for the scope of the current method.

Net emissions of different greenhouse gases are aggregated into a single metric of tonnes CO2-equivalent (Mg CO_2e), as shown in Eq.1. Note that Metric (SI) units are used throughout this document. If the final user interface is to be provided in alternative units (e.g. US Imperial units), appropriate conversion factors will need to be used in construction of the web-interface.

Equation 1: Net Greenhouse Gas reduction from soil health practices

$$\Delta GHG = \sum_{r,m,z,s} \left[A_{r,m,z,s} \cdot \left(\Delta \mathrm{CO2}_{r,m,z,s} + \Delta \mathrm{N2O}_{r,m,z,s} \cdot \mathrm{GWP}_{N2O}\right)\right]$$

Where:

$\Delta GHG =$ Net avoided GHG emissions (Mg CO_2e yr^{-1}),

$r =$ Crop rotation,

$m =$ Management intervention,

$z =$ Climate zone,

$s =$ Soil class,

$A_{r,m,z,s} =$ Area of land being reported, for each combination of climate, management, soil, and crop rotation,

$\Delta \mathrm{CO2} =$ Net avoided CO_2 emissions, Mg CO_2 ha^{-1} yr^{-1}, (see Eq. 2),

$\Delta \mathrm{N2O} =$ Net avoided N_2O emissions, Mg N_2O ha^{-1} yr^{-1}(see Eq. 6),

$\mathrm{GWP}_{N2O} =$ Global warming potential of N_2O (see Table 1).

Table 1: *Values of constants.*

Constant	Description	Value	Unit
GWP_{N_2O}	Global warming potential of N_2O	298	Mg CO_2e Mg^{-1} N_2O
α	Conversion factor from carbon to CO_2	3.67	Mg CO_2 Mg^{-1}C

1.1 Supporting Information

Note that this document provides a summary of the equations and parameter values required to calculate the net avoided GHG emissions. A detailed account of the published literature and method derivation underlying this methodology is shown in the Technical Appendices C (Tillage), D (cover crops, non-soil carbon aspects), E (soil carbon in cover crops), and F (nitrogen fertilizer and nitrous oxide emissions), accompanying this document.

1.2 Sign convention

The sign convention adopted in this methodology is that positive values indicate a removal of GHGs from the atmosphere or a reduction in emissions. Conversely, increased emissions are negative. Thus, the method measures the net avoided emissions, with positive values indicating an improvement relative to current practices.

1.3 Area of practice

Each unique combination of management, crop-rotation, climate, and soil-type should be reported as a separate entry in the calculator. Total GHG mitigation impact across the whole reported supply chain is then calculated as the arithmetic sum of the GHG impact in each of these areas. Total area under cover crops and/or improved tillage within these areas should be reported. This includes early-adopter farms that had begun implementation of the soil-health practice prior to the project baseline year of 2015, because 1) continuation of the practice is an ongoing annual decision; and 2) even though a fraction of the net SOC sequestration potential will have occurred prior to the baseline year, continuation of practice is required to prevent those early gains from being reversed.

1.4 Climate zones

The climate zones defined for this method comprise a factorial combination of dry/moist and warm/cool, resulting in four zones: warm–dry, warm–moist, cool–dry, and cool–

moist. Warm locations are defined as having a mean annual temperature greater than or equal to 10 °C. Moist regions are defined as having mean annual precipitation (MAP) greater than or equal to potential evapo-transpiration (PET). Default emission factors for each US State and County are based on the climate zone that covers the largest fraction of the area within that jurisdiction. Default climate zones by State (Fig. 1) and County (Fig. 2) are listed in appendices A and B, respectively.

1.5 Soil classes

The method uses three soil classes: sandy, loamy and clayey, defined using the USDA soil-texture classification. Sand, loamy-sand, sandy-loam, sandy-clay loam and sandy-clay soils are classed together as "sandy" soils in this methodology. Clay and clay-loam soils are classed as "clayey". All other soil textures are classed as "silty". Figure 3 shows the USDA soil texture triangle with examples of average soil texture class by county. For specific soil classification, by state and county see Appendices A and B, respectively.

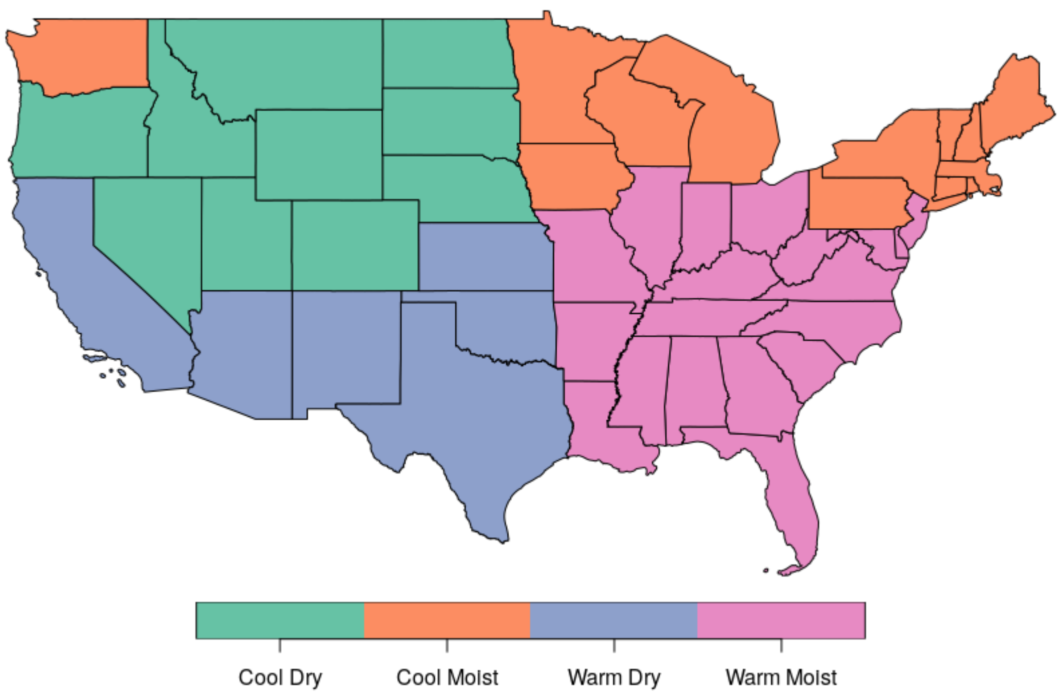

Figure 1: *Default climate zones in the coterminous USA, by State.*

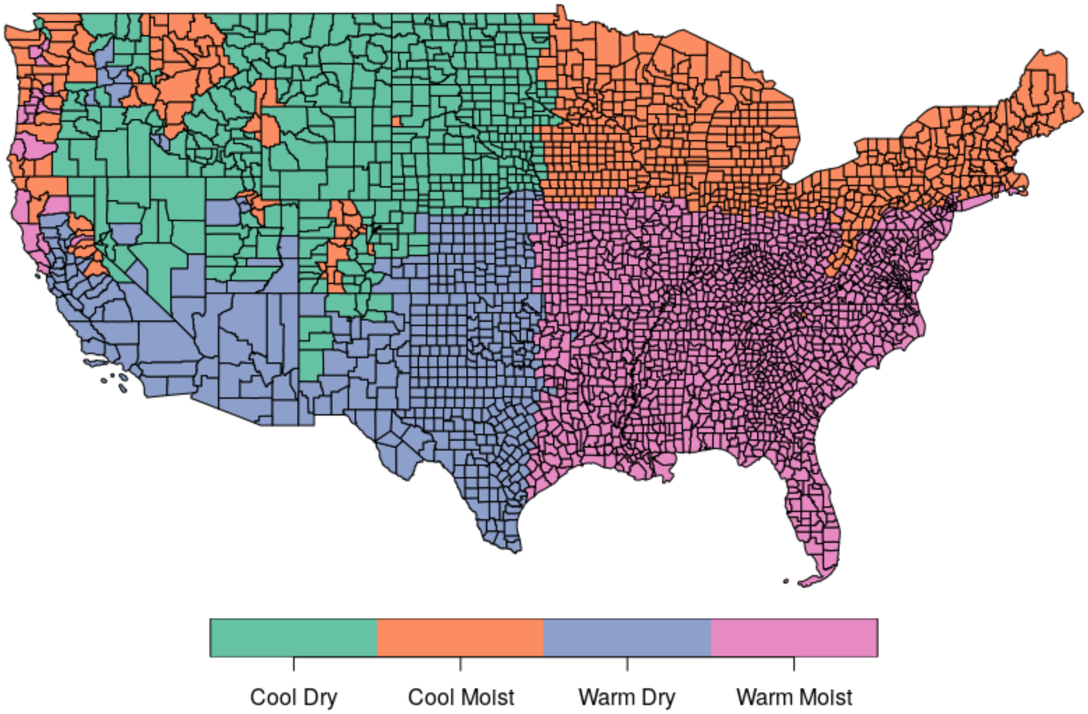

Figure 2: *Default climate zones in the coterminous USA, by County.*

2 Tillage

The classifications of tillage practices are defined in Table 2. These definitions are based on the percentage of the soil surface covered by residues between crop harvest and planting of the subsequent crop, in order to allow verification by visual inspection or remote sensing.

Table 2: *Definitions of tillage classes, based on surface coverage of crop residues.*

Tillage class	Definition for corn (Surface residue cover)	Definition for other crops (Surface residue cover)
Conventional	0-15%	0-15%
Reduced tillage	16-50%	16-30%
No-till	51-100%	31-100%

Source: Applied Geosolutions. 2019. Mapping Conservation Practices and Outcomes in the Corn Belt - Final Report, a collaborative project between Applied Geosolutions LLC, Dagan, Inc., The Nature Conservancy, and the Conservation Technology Information Center, 10 September 2019.: 24 p.

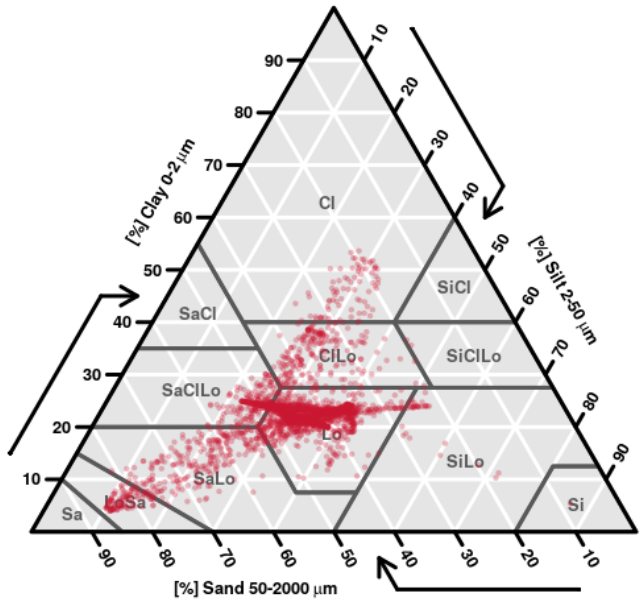

Figure 3: *Default texture classes (USDA classification), by county, for soils in the coterminous USA. Sand, loamy-sand, sandy-loam, sandy-clay loam and sandy-clay soils are classed together as "sandy" soils in this methodology. Clay and clay-loam soils are classed as "clayey". All other soil textures are classed as "silty". For specific soil classification, by state and county see Appendices A and B, respectively.*

3 Cover crops

Cover crops are defined here as the addition of a winter cover crop into the annual crop rotation, where previously there was a bare fallow period. Note that this includes early adopters, as described in Section 1.3. Also note that this methodology does not account for "double cropping" systems in which a harvested cash crop is introduced to replace a bare fallow season. Emission factors for the GHG impacts of cover crops are shown in Sections 4–6 for each GHG source and sink, including any changes to nitrogen-fertilizer inputs (Section 6.4).

Cover crops in dry climates are not supported in this methodology, due to potential for adverse impacts on yield and competition for available water (see Appendix D).

4 Carbon dioxide emissions

The net avoided CO_2 emissions (ΔCO_2) are calculated according to Eq. 2. Avoided CO_2 emissions must be calculated separately for each management intervention (reduced tillage and/or introduction of cover crops) in each climate zone.

Equation 2: Net carbon dioxide reduction from soil health practices

$$\Delta CO2 = \alpha \cdot (1 - R) \cdot \Delta SOC + \Delta CO2_F + \Delta CO2_I + \Delta CO2_N + \Delta CO2_L$$

Where:

$\Delta CO2 =$ Net avoided CO_2 emissions, Mg CO_2 ha^{-1} yr^{-1},

$\Delta SOC =$ Sequestered soil organic carbon, Mg C ha^{-1} yr^{-1}),

$R =$ Risk of reversal of SOC sequestration,

$\alpha =$ Conversion factor from carbon to CO_2 (see table 1),

$\Delta CO2_F =$ Change in CO_2 emissions from machinery use in field operations (Mg CO_2 ha^{-1} yr^{-1}),

$\Delta CO2_I =$ Change in CO_2 emissions from agricultural inputs, excluding nitrogen fertilizer (Mg CO_2 ha^{-1} yr^{-1}),

$\Delta CO2_N =$ Change in CO_2 emissions from nitrogen fertilizer production (Mg CO_2 ha^{-1} yr^{-1}),

$\Delta CO2_L =$ Change in CO_2 emissions from leakage (Mg CO_2 ha^{-1} yr^{-1}),

4.1 Soil organic carbon

Soil organic carbon sequestration rate is assumed to be the arithmetic sum of SOC sequestration due to cover crops and due to reduced tillage (Equation 3). That is, there is assumed to be no interaction between tillage and cover crops.

4.1.1 SOC reversal risk

If the cover-crop or improved-tillage practice is discontinued at any time, the accumulated SOC will be lost again as the SOC levels return to the same amount as they would under conventional practice. The default value for the discontinuation risk (R) is 0.5. The risk value R is intended to represent the fraction of area reported as conducting a soil health practice that will cease to do so within 100 years—a time frame that is consistent with the treatment of “permanent removals” in the Intergovernmental Panel on Climate Change (IPCC) and United Nations Framework Convention on Climate Change (UNFCCC) reporting frameworks.

Equation 3: Soil organic carbon sequestration

$$\Delta SOC = \left(f_{100_{CC}} \cdot \Delta SOC_{CC}\right) + \left(f_{100_T} \cdot \Delta SOC_T\right)$$

Where:

ΔSOC_{CC} = Sequestered soil organic carbon from cover crops, Mg C ha^{-1} yr^{-1},

ΔSOC_T = Sequestered soil organic carbon from tillage, Mg C ha^{-1} yr^{-1}.

f_{100} = SOC adjustment factor to account for the fact that annual sequestration rates diminish over time. $f_{100_{CC}}$ and f_{100_T} apply to cover crops and tillage, respectively.

Users may be given the option to enter a risk assessment value other than the default if they self-certify that a risk assessment has been conducted. A lower value will typically be justified only if there are demonstrable factors in place that mitigate the risk. If users wish to enter their own value to over-ride the default they will be required to click a checkbox to certify that a risk appraisal has been conducted. If they check this box they will also be required to identify the method used and to upload supporting documentation which will form part of the public annotations to their report. The tool will only allow modification of the default value if these steps are followed.

4.1.2 SOC sequestration in cover crops

SOC sequestration rate under cover crops is a factor of the moisture regime (i.e., dry or moist climate), as shown in Table 3

Table 3: *Default SOC accumulation rates for cover crops (Mg C ha^{-1} yr^{-1}).*

Moisture	ΔSOC_{CC}
Dry	0.00
Moist	0.19

4.1.3 SOC sequestration in reduced tillage

SOC sequestration rate for tillage is a factor of the tillage practice (Table 2), climate (Section 1.4), and soil texture (whether the soil is classed as sandy or not). Tillage-related SOC sequestration rates are given in Table 4

Table 4: *Default SOC accumulation rates for tillage practices (Mg C ha^{-1} yr^{-1}), relative to a baseline of SOC in conventional tillage. Soil texture is classed as either "Sandy" or "Other", the latter including both silty and clayey soils.*

Tillage Practice	Temperature	Moisture	Soil	ΔSOC_T
Conventional	All	All	All	0.00
Reduced-till	Cool	Dry	Other	0.02
Reduced-till	Cool	Dry	Sandy	0.07
Reduced-till	Cool	Moist	Other	0.07
Reduced-till	Cool	Moist	Sandy	0.17
Reduced-till	Warm	Dry	Other	0.19
Reduced-till	Warm	Dry	Sandy	0.09
Reduced-till	Warm	Moist	Other	0.30
Reduced-till	Warm	Moist	Sandy	0.18
No-till	Cool	Dry	Other	0.02
No-till	Cool	Dry	Sandy	0.08
No-till	Cool	Moist	Other	0.08
No-till	Cool	Moist	Sandy	0.18
No-till	Warm	Dry	Other	0.21
No-till	Warm	Dry	Sandy	0.10
No-till	Warm	Moist	Other	0.33
No-till	Warm	Moist	Sandy	0.21

4.1.4 SOC adjustment factors

The SOC adjustment factors to account for the fact that annual sequestration rates diminish over time ($f_{100_{CC}}$ and f_{100_T}) are given in Table 5. See Technical Appendix C (tillage) and Technical Appendix E (soil organic carbon in cover crops) for the derivation of f_{100_T} and $f_{100_{CC}}$, respectively.

Table 5: *SOC adjustment factor to account for the fact that annual sequestration rates diminish over time. $f_{100_{CC}}$ and f_{100_T} apply to cover crops and tillage, respectively.*

Temperature	Moisture	$f_{100_{CC}}$	f_{100_T}
Warm	Moist	0.26	0.25
Warm	Dry	0.26	0.25
Cool	Moist	0.28	0.25
Cool	Dry	0.29	0.25

4.2 Energy use in field operations

Emission factors for the impact of cover crops on farm fuel use ($\Delta CO2_F$) are given in Table 6. Emission factors for the impact of tillage practices on farm fuel use ($\Delta CO2_F$) are given in Table 7. If both cover crops and improved tillage are implemented together then the net impact is the arithmetic sum of the fuel-use emissions from both.

Table 6: *Cover-crop emission-factors for agricultural inputs, excluding fertilizer ($\Delta CO2_I$), and farm fuel use ($\Delta CO2_F$) (Mg CO_2e ha^{-1} yr^{-1}). Agricultural inputs include seed production (all systems) and herbicide production (no-till systems, chemical cover crop termination). Fertilizer production is accounted for separately in the fertilizer optimization section. Farm energy use includes field operations for sowing, mechanical termination of cover crop (conventional tillage systems) and herbicide application (no-till systems).*

Cover crop	Tillage Practice	$\Delta CO2_I$	$\Delta CO2_F$
Non-legume	Conventional	-0.037	-0.040
Non-legume	Reduced-till	-0.059	-0.029
Non-legume	No-till	-0.059	-0.029
Legume	Conventional	-0.017	-0.040
Legume	Reduced-till	-0.039	-0.029
Legume	No-till	-0.039	-0.029

Table 7: *Tillage emission factors for agricultural inputs ($\Delta CO2_I$), and farm fuel use ($\Delta CO2_F$) (Mg CO_2e ha^{-1} yr^{-1}). Agricultural inputs include only herbicide production. Fertilizer is accounted for separately in the fertilizer optimization section. On-farm fuel use ($\Delta CO2_F$) is lowered by the reduction in tillage operations.*

Tillage Practice	Crop	$\Delta CO2_I$	$\Delta CO2_F$
Reduced-till	Maize	0.00	0.08
Reduced-till	Wheat	-0.01	0.08
Reduced-till	Soybean	0.00	0.08
No-till	Maize	-0.01	0.10
No-till	Wheat	-0.02	0.10
No-till	Soybean	-0.01	0.10

4.3 Production of agricultural inputs

Agricultural inputs accounted for in this section include seed, herbicide, and pesticide. Note that nitrogen fertilizer inputs are accounted for separately according to the methods described in Section 6. It is assumed that application rates of phosphorus, potassium or other plant nutrients and of agricultural lime are unchanged by the practices in this methodology.

Emission factors for the impact of cover crops and tillage practices on agricultural inputs ($\Delta CO2_I$) are given in Tables 6 and 7, respectively. If both cover crops and improved tillage are implemented together then the net impact is the arithmetic sum of the fuel-use emissions from both.

4.4 Leakage

Leakage refers to indirect impacts on GHG emissions that occur outside of the project area itself. Any changes to crop yield caused by introduction of soil health practices will cause an indirect response in the overall food commodity supply chain to accommodate the change in local production levels. A reduction in yield in the soil-health program area will tend to cause an increase in demand from elsewhere. Conversely, an increase in yield within the soil health program area will reduce demand from elsewhere. The impact of this leakage on GHGs will be comprised of several factors. Firstly there are the emissions associated with crop production itself. The direct emissions from any increase or decrease in production outside the program should be accounted for. Secondly, the change in demand outside the program area may drive either a conversion of unused marginal lands into agricultural production (if yield decreases), or, conversely, abandonment of marginal agricultural lands elsewhere if yield increases. Such indirect land use change (ILUC) has associated impacts on GHG fluxes due to the difference in carbon stocks sequestered in cropland compared to other land uses. The extent to which a change in demand outside the program area drives ILUC depends on both 1) the price elasticity of demand and 2) on the extent to which change in production will be accomplished by changing production-intensity versus through land-use change.

GHG emissions due to change in yield in the soil health program are calculated according to Equation 4 below. The same sign convention is applied here that positive values indicate a net reduction in emissions. The reversibility risk factor (R; see Section 4.1.1) is applied to indirect land-use change emissions which are reversible, but not to the indirect production emissions, which are permanent and not reversible.

4.4.1 Change in yield

Change in crop yield due to introduction of soil health practices is calculated according to Equation 5. Default yields (Y_0) under conventional practice for each state, county and crop are shown in Appendices A and B. Grain yield is reported and used in the methodology for standard moisture contents as follows: maize = 15.5%, soybean = 13% and wheat =13.5%.

Equation 4: Carbon dioxide emissions from yield changes due to soil health practices

$$\Delta CO2_L = \sum_c \left[f_c \cdot \Delta Y_c \cdot \left(F_p + (1 - f_i) \cdot (1 - \frac{R}{100}) \cdot F_i \right) \right]$$

Where:

$c =$ Each crop in the rotation,

$f_c =$ Fraction of the rotation for which crop c is grown,

$\Delta Y_c =$ Change in yield of crop c, kg grain ha^{-1} yr^{-1},

$F_p =$ Production emission factor, Mg CO_{2e} kg^{-1} grain,

$f_i =$ intensification factor, i.e., the fraction of leakage that is accommodated by a change in intensification rather than extensification,

$f_i =$ reversal probability (see Section 4.1.1),

$F_i =$ Indirect land use change emission factor, Mg CO_{2e} kg^{-1} grain.

Equation 5: Yield change due to soil health practices

$$\Delta Y = Y_0 \cdot \left(F_{Y_{CC}} + F_{Y_T} \right)$$

Where:

$\Delta Y =$ Change in yield, kg grain ha^{-1} yr^{-1},

$Y_0 =$ Baseline yield, without soil health practices

$F_{Y_{CC}} =$ Relative change in yield due to cover crop practice (%). Defined as zero for conventional rotations without cover crops.

$F_{Y_T} =$ Relative change in yield due to tillage practice (%). Defined as zero for conventional tillage.

Values of $F_{Y_{CC}}$ (relative change in yield due to introduction of cover crops) are shown in Table 8. Values of F_{Y_T} (relative change in yield due to tillage practice) are shown in Table 9, below.

Table 8: *Default change in cash crop yield due to introduction of cover crops (%).*

Crop	Moisture	$F_{Y_{CC}}$
Maize	All	0.0
Wheat	Moist	0.0
Wheat	Dry	NA
Soybean	All	3.8

Table 9: *Default change in crop yield due to tillage management (F_{Y_T}, expressed in units of % of initial yield).*

Practice	Crop	Climate	Rotation	F_{Y_T}
No-till	Maize	All	Maize-Soybean	0.0
No-till	Maize	All	Continuous Maize	0.0
No-till	Soybean	All	All	0.0
No-till	Wheat	Moist	All	-4.0
No-till	Wheat	Dry	All	4.3
Reduced-till	Maize	All	Maize-Soybean	0.0
Reduced-till	Maize	All	Continuous Maize	0.0
Reduced-till	Soybean	All	All	0.0
Reduced-till	Wheat	Moist	All	-2.0
Reduced-till	Wheat	Dry	All	2.2

5 Indirect land use change

The indirect land use change emission factor (F_i), expressed as Mg CO_{2e} kg^{-1} grain, is shown in Table 10 as a function of crop type. The intensification factor (f_i), i.e., the fraction of leakage that is accommodated by a change in intensification rather than extensification, is 0.49 for all crop types.

6 Nitrogen fertilizer

Nitrogen (N) is an essential plant nutrient, and all agriculture requires N inputs, whether from an exogenous source (such as N-fertilizer, or manure), and/or from N-fixation in

Table 10: *Indirect land use change emission factors for the net GHG emissions on new cropland (outside of the program area) that is brought into production in response to a decline in yield within the program area. The indirect emissions are comprised of both the carbon opportunity cost from land conversion (F_i), and the production emissions on the new cropland (F_p). Both F_p and F_i are expressed in units of Mg CO_2e kg^{-1} grain (fresh weight).*

Crop	F_i	F_p
Maize	2.21e-03	4.6e-04
Wheat	2.22e-03	6.9e-04
Soybean	5.58e-03	2.6e-04

leguminous crops or cover crops. A small fraction of any N added to soil is inevitably volatilized as the potent GHG nitrous oxide (N_2O). Methods aimed at reducing N_2O emissions typically work by increasing the nitrogen-use efficiency (NUE) of the crop production, thereby allowing farmers to reduce N inputs while maintaining yield. Reducing excess reactive nitrogen is the key management pathway for reducing N loss from agricultural systems. Optimal N application rates should provide N to maintain crop yield as well as N to maintain SOM stocks. To achieve optimal N rates, a farmer manages system N balance, the difference between system N inputs and N harvested in crop biomass. The modeling approach applied here is based on quantifying the change in N inputs and using published formulae that estimate N_2O emissions per unit N input. The choice of models is explained in more detail in the Nitrogen Technical Appendix.

N_2O emissions can be classified as either direct emissions (emitted from the field where the N is applied) or indirect (downstream emissions from N that is exported from the field either by leaching or by volatilization). The total change in N_2O emissions is calculated as the sum of the change in direct and indirect N_2O emissions (Equation 6).

Equation 6: Change in total nitrous oxide emissions (ΔN2O), Mg N_2O ha^{-1} yr^{-1}.

$$\Delta N2O = (\Delta N2O_d + \Delta N2O_i)\ /1000$$

Where:

ΔN2O = Net avoided N_2O emissions, Mg N_2O ha^{-1} yr^{-1}

$\Delta N2O_d$ = Change in direct N_2O emissions, kg N_2O ha^{-1} yr^{-1},

$\Delta N2O_i$ = Change in indirect N_2O emissions, kg N_2O ha^{-1} yr^{-1}.

Furthermore, GHG emissions are also associated with the production of N fertilizer ($\Delta CO2_N$). These are calculated as described in Section 6.3.

6.1 Direct nitrous oxide emissions

The change in direct N_2O emissions ($\Delta N2O_d$) is calculated using Equation 7.

Equation 7: Change in direct nitrous oxide emissions ($\Delta N2O_d$, kg N_2O ha^{-1} yr^{-1}).

$$\Delta N2O_d = f_{Nd} \cdot \Delta N + f_{ONd} \cdot \Delta N_O$$

Where:

f_{Nd} = Emission factor for direct N_2O emissions due to mineral N-fertilizer application (kg N_2O kg N^{-1}).

f_{ONd} = Emission factor for direct N_2O emissions due to organic-N application (kg N_2O kg N^{-1}).

ΔN = Change in mineral nitrogen-fertilizer application rate (kg N ha^{-1} yr^{-1}).

ΔN_O = Change in organic-nitrogen application rate (kg N ha^{-1} yr^{-1}).

Values for the emission factor for direct N_2O emissions due to N-fertilizer application (f_{Nd}) are provided in Table 11. Emission factors for direct N_2O emissions due to organic N application (f_{ONd}) are provided in Table 12.

Table 11: *Emission factors for direct N_2O emissions due to N-fertilizer application (f_{Nd}), kg N_2O kg^{-1} N. Default values for clay (the clay fraction of the soil), as required for moist-climate corn production, are provided in Appendices A and B for each State and County in the coterminous USA, respectively.*

Crop	Moisture class	f_{Nd}
Corn	Moist	$0.085 \cdot clay$
Corn	Dry	0.0079
Wheat	Moist	0.0251
Wheat	Dry	0.0079
Soybean	Moist	0.0251
Soybean	Dry	0.0079

6.2 Indirect nitrous oxide emissions

The change in indirect N_2O emissions ($\Delta N2O_i$) is calculated using Equation 8.

Emission factors for indirect N_2O emissions due to N-fertilizer application (f_{Nv} and f_{Nl}) or organic N (f_{ONv} and f_{ONl}) are provided in Tables 13 and 12. Factors for the relative reduction in N leaching due to soil health practices (f_{up}) are provided in Table 14.

Table 12: *Emission factor for direct (f_{ONd}) and indirect (f_{ONv}, f_{ONl}) N_2O emissions due to organic nitrogen additions, kg N_2O kg^{-1} N.*

Moisture	f_{ONd}	f_{ONv}	f_{ONl}
Dry	0.0079	0	0.00000
Moist	0.0094	0	0.00415

Equation 8: Change in indirect nitrous oxide emissions ($\Delta N2O_i$, kg N_2O ha^{-1} yr^{-1}).

$$\Delta N2O_i = f_{Nv} \cdot \Delta N + f_{Nl} \cdot (1 - f_{up}) \cdot \Delta N + f_{ONv} \cdot \Delta N_O + f_{ONl} \cdot (1 - f_{up}) \cdot \Delta N_O$$

Where:

f_{Nv} = Emission factor for indirect N_2O emissions from volatilization due to mineral N-fertilizer application (kg N_2O kg N^{-1}),

f_{Nl} = Emission factor for indirect N_2O emissions from leaching due to mineral N-fertilizer application (kg N_2O kg N^{-1}),

f_{ONv} = Emission factor for indirect N_2O emissions from volatilization due to organic N inputs (kg N_2O kg N^{-1}),

f_{ONl} = Emission factor for indirect N_2O emissions from leaching due to organic N inputs (kg N_2O kg N^{-1}),

f_{up} = Reduction in leaching due to soil health practices (proportion),

ΔN = Change in mineral nitrogen-fertilizer application rate (kg N ha^{-1} yr^{-1}),

ΔN_O = Change in organic-nitrogen inputs (kg N ha^{-1} yr^{-1}).

6.3 Emissions from fertilizer production

The change in CO_2-equivalent GHG emissions from nitrogen fertilizer production ($\Delta CO2_N$) is calculated using Equation 9.

The default value for f_{Np} is 0.00441 Mg CO_2e kg^{-1} N.

6.4 Nitrogen fertilizer application rate

In this section we provide default methods for calculating the change in mineral-nitrogen fertilizer inputs (ΔN). For fertilizer N-optimization practices, the method assumes that farmer goals are to maintain optimal cash-crop yield. This assumption is in line with

Table 13: *Emission factors for indirect N_2O emissions due to N-fertilizer application from volatilisation (f_{Nv}) and leaching (f_{Nl}), kg N_2O kg^{-1} N.*

Crop	Moisture	f_{Nv}	f_{Nl}
Maize	Moist	0.00242	0.00415
Maize	Dry	0.00086	0.00000
Wheat	Moist	0.00242	0.00415
Wheat	Dry	0.00086	0.00000
Soybean	Moist	0.00242	0.00415
Soybean	Dry	0.00086	0.00000

Table 14: *Relative reduction in nitrogen leaching due to soil health practices (f_{up}), expressed as a fraction.*

Cover Crop	Tillage	f_{up}
Non-legume	All	0.540
Legume	All	0.400
None	Conventional	0.000
None	No-till	0.250
None	Reduced till	0.125

application of N-optimization methods in which N optimization led to neutral or positive impact on yield (see N technical appendix for N optimization references). For cover crops and tillage, yield changes are described in Section 4.4.1. Default methods for calculating change in mineral-nitrogen fertilizer inputs (ΔN) are provided in Table 15. These values measure the reduction in N input (i.e. a positive value indicates that N fertilizer was reduced).

The basis of these values is summarized below for each practice. For more details see the

Equation 9: Change in CO_2-equivalent GHG emissions from nitrogen fertilizer production ($\Delta CO2_N$).

$$\Delta CO2_N = f_{Np} \cdot \Delta N$$

Where:

f_{Np} = Emission factor for N-fertilizer production (Mg CO_2e kg^{-1} N).

ΔN = Net reduction in nitrogen fertilizer application rate (Mg N ha^{-1}), from both soil-health and fertilizer-management practices (Eq. 10).

nitrogen technical appendix.

Legume cover crops: It is assumed that fixed nitrogen in the cover crop can substitute for mineral-N fertilizer. It is also assumed that legume cover crops will adjust their N-fixation rate based on the amount of residual N (and ultimately by the amount of N leaching they prevent, ΔL). The average amount of fixed-N is assumed to be 52 kg N ha^{-1} yr^{-1}. It is assumed that organic-N in the cover crop can substitute only a fraction (f_{NUE}) of the equivalent mineral-N fertilizer, due to the lower N use efficiency of organic-N. The default value of f_{NUE} is 0.87. The amount of N sequestered in soil organic matter is then subtracted to provide the plant-available N from the cover crop. N sequestered in soil is calculated by multiplying the SOC sequestration rate by the average N/C content of soil (0.072 Mg N Mg^{-1} C). Finally, in calculating ΔN for leguminous cover crops, any change in crop yield is multiplied by the grain N fraction (f_{Ng}; see Table 16) to estimate the change in crop N uptake.

Non-legume cover crops: These do not provide fixed nitrogen. It is assumed that nitrogen loss by leaching is reduced by an amount ΔL (see Section 6.5). The average non-legume cover crop biomass is set as 22 kg N ha^{-1} yr^{-1}. Non-legume cover-crop biomass N is assumed to be the source of ΔSON, non-legume biomass N is not counted as a source of N for cash crop growth. Non-legume cover crop biomass N is achieved from residual N following prior-season cash-crop harvest, calculated as the amount of avoided leaching due to cover crop management. If uptake of residual N is insufficient for this assumed average cover-crop biomass accumulation, it is assumed a farmer adds N fertilizer to achieve this average biomass N. If there is a surplus from residual N uptake after cover crop biomass N accounting, it is assumed that organic-N from the non-legume cover crop can substitute only a fraction (f_{NUE}) of the equivalent mineral-N fertilizer, due to the lower N use efficiency of organic-N. The default value of f_{NUE} is 0.87. For non-legume cover crops, it is assumed that the amount of N sequestered in soil organic matter is acquired from the average non-legume biomass N accumulated in the system. As for legumes, in calculating ΔN for non-leguminous cover crops, any change in cash crop yield is multiplied by the grain N fraction (f_{Ng}; see Table 16) to estimate the change in crop N uptake.

Tillage: It is assumed that the amount of N sequestered in soil organic matter is an additional N requirement in the system. It is also assumed that nitrogen loss by leaching is reduced by an amount ΔL (see Section 6.5). Sequestered N in soil organic matter and the change in cash crop yield resulting from tillage management are implemented as in legume cover crop management. N sequestered in soil is calculated by multiplying the SOC sequestration rate by the average N/C content of soil (0.072 Mg N Mg^{-1} C). Any change in crop yield is multiplied by the grain N fraction (f_{Ng}; see Table 16) to estimate the change in crop N uptake. No-till or reduced tillage do not provide an N credit for the following cash crop.

Cover crop and tillage interaction: It is assumed that if both cover crop and no-till or reduced till management occur concurrently, that the reduction in leaching, ΔL, is limited to the largest reduction calculated, namely the ΔL calculated due to cover crop management (see Section 6.5).

Model-based N optimization: Use of models (such as, for example, Adapt-N) to optimize fertilizer rates and timing is assumed to reduce N inputs, on average, by 13%.

Sensor / Variable Rate Technology (VRT) N optimization: Use of various techniques to optimize fertilizer rates (precision agriculture, optical sensors, in-field N rate tests) is assumed to reduce N inputs, on average, by 13% in maize and 26% in wheat.

Timing: Improved N fertilizer timing, such as switching from fall to spring application or from pre-plant to side-dress application, is assumed to reduce N fertilizer rate by 9%.

Other N-optimization practices: No default value for ΔN is provided for other N management practices. If users wish to report reduced N inputs that have been achieved through other methods than listed above, they must collect data on the actual change in N rate and crop yield that was achieved, and enter the average ΔN value explicitly. The tool should require user input of both the practice employed and the claimed value of ΔN for that practice.

6.4.1 Combined impact of several practices

The ΔN values in Table 15 are classified into separate "Combination groups". These combination groups are used for calculating the overall impact when more than one practice is employed simultaneously. Only one ΔN value from each group may be used and the combined impact of these practices is calculated according to the following method shown in Equation 10.

In Equation 10, only the largest applicable ΔN from combination group C is used. For example if both "Model-based N-rate optimization" and "Timing optimization" are used simultaneously, the ΔN value for group C will be the larger of these, which is "Model-based N-rate optimization".

Equation 10: Method to calculate combined change in N fertilizer application rate (ΔN) when more than one practice is employed simultaneously.

If any N-optimization practice in group D is reported then

$$\Delta N = \Delta N_D,$$

otherwise,

$$\Delta N = \Delta N_A + \Delta N_B + \Delta N_C$$

Where:

ΔN_A = Change in nitrogen fertilizer rate from practices in group A,

ΔN_B = Change in nitrogen fertilizer rate from practices in group B,

ΔN_C = Change in nitrogen fertilizer rate from practices in group C,

ΔN_D = Change in nitrogen fertilizer rate from practices in group D,

The following procedure is used to apply this formula:

1. If a practice from group D is reported, the net change in nitrogen-fertilization rate (ΔN_{tot}) is equal to ΔN_D. Do not proceed to step 2.
2. If leguminous or non-leguminous cover crops are used, ΔN_A is the corresponding ΔN value from group A.
3. If a mixed leguminous/non-leguminous cover crop is used, ΔN_A is the average of these two ΔN values from group A.
4. If reduced tillage or no-till is used, ΔN_B is the corresponding ΔN value from group B.
5. If any practices from group C are employed, ΔN_C is equal to the largest ΔN from these. f_O is the corresponding coefficient in Table 15.
6. If no N-optimization practices from Group C are applied, then ΔN_C is equal to zero.
7. The net change in nitrogen-fertilization rate (ΔN_{tot}) is then calculated using Equation 10.

6.5 Reduced nitrogen leaching

In humid systems it is assumed that 24% of added N is leached under normal practice (the IPCC default value). It is assumed that non-leguminous cover crops reduce leaching

Table 15: *Default change in nitrogen fertilizer rate (ΔN) resulting from soil-health or fertilizer-optimization practices. ΔN represents the amount by which N fertilizer inputs are reduced in kg N ha^{-1} yr^{-1} (positive values indicate an improvement (reduction) in N fertilizer rates; negative values indicate an increase in fertilizer application). The availability of organic N from cover crop biomass is reduced by factor fNUE= 0.87. Note that group C values are expressed as a proportion (f_O) of applied N, provided in the final column. Default N inputs by crop and State are provided in appendix A. The N rate used in group C equations is adjusted from the default value by the change in N rate due to cover cropping, tillage practice or change in yield before the f_O factor is applied. ΔY is the change in crop yield (Equation 5). f_{Ng} is the nitrogen content of the crop (Table 16).*

Practice	Group	ΔN	f_O
Leguminous Cover Crops	A	$52 \cdot f_{NUE} - 72 \cdot \Delta SOC_c - \Delta Y \cdot f_{Ng}$	
Non-legume cover crops	A	$(\Delta L - 22 - \Delta Y \cdot f_{Ng}) \cdot f_{NUE}$	
Reduced Tillage or No-till (no cover crop)	B	$\Delta L - 72 \cdot \Delta SOC_t - \Delta Y \cdot f_{Ng}$	
Reduced Tillage or No-till (combined with cover crop)	B	$-72 \cdot \Delta SOC_t$	
Model-based optimization	C	$f_O \cdot (N - \Delta N_A - \Delta N_B)$	0.13
VRT (maize)	C	$f_O \cdot (N - \Delta N_A - \Delta N_B)$	0.13
VRT (wheat)	C	$f_O \cdot (N - \Delta N_A - \Delta N_B)$	0.26
Timing optimization	C	$f_O \cdot (N - \Delta N_A - \Delta N_B)$	0.09
Other N-optimization practices	D	Provided by user	

Table 16: *Nitrogen content of crops (f_{Ng}), kg N kg^{-1} grain.*

Crop	f_{Ng}
Maize	0.012
Wheat	0.021
Soybean	0.059

by 54%. It is assumed that legume cover crops reduce leaching by 40%. For humid no-till systems it is assumed that leaching is reduced by 25%. Reduced tillage is assumed to reduce leaching by only half this amount (12.5%). In dry systems we use the default IPCC approximation that no N is leached. Changes in leached nitrogen due to introduction of a practice(s) are summarized in Table 17.

6.6 Organic nitrogen application rate

Default methods for calculating change in organic-nitrogen inputs are shown in Table 18.

Table 17: *Change in leached nitrogen (ΔL, kg N ha^{-1} yr^{-1}), due to introduction of a practice, calculated as a fraction of applied fertilizer-N (N). Note that ΔL is calculated differently for Soybean to other crops, as N is adjusted to also include the organic nitrogen in soybean residues, assumed to be 60 kg N ha^{-1}. Equations for soybean and other crops are shown in separate columns in the table.*

Cover Crop	Tillage Practice	Climate	ΔL (Soybean)	ΔL (Maize or wheat)
Non-legume	Any	Moist	$0.13 \cdot (N + 60)$	$0.13 \cdot N$
Legume	Any	Moist	$0.1 \cdot (N + 60)$	$0.1 \cdot N$
None	Reduced tillage	Moist	$0.03 \cdot (N + 60)$	$0.03 \cdot N$
None	No-till	Moist	$0.06 \cdot (N + 60)$	$0.06 \cdot N$
None	Conventional	Any	0.0	0.0
Any	Any	Dry	0.0	0.0

Table 18: *Default change in organic nitrogen inputs (ΔON) resulting from soil-health practices. Note that ΔON represents the amount by which N inputs are reduced (in kg N ha^{-1} yr^{-1}), thus negative values indicate an increase in ON inputs.*

Practice	Crop	Moisture	Soil	ΔON
Legume Cover Crops	All	Moist	All	-52
Non-legume cover crops	All	Moist	All	-22
Reduced Tillage or No-till	All	All	All	0.0

7 Mixed cover crops and crop rotations

If cover crops are a mixture of leguminous and non-leguminous plants, then the above methods should be applied for each type and the overall impact is calculated as the average (mean) GHG reduction from leguminous and non-leguminous cover crops.

If more than one main crop is grown in the rotation, then the above methods should be applied for each crop and the overall impact is calculated as the average (mean) of their GHG reductions.

Appendices

A State level factors

State- and county-level default values for N-fertilizer application rate and grain yield are derived from USDA National Agricultural Statistical Service (NASS) survey data for corn, soybean, and wheat. Available data from 2015-2019 were used to establish Phase 1 default values, though NASS does not report all parameters in all years. For N fertilizer rate, state-level values are used when available. For grain yield, both state-level and county-level data are used when available. NASS data are reported in English units, and were converted to kg N per hectare or kg grain per hectare.

Yield data: State-level yield data were downloaded from NASS when available and units were converted to kg grain/ha. Yield data are available for states where the crop is commonly grown, but not for all states. When state yield data are not available, default yield data are not available in the tool and must be supplied by the user.

County-level yield data were extracted from NASS ,when available, and units were converted to kg grain/ha. The mean yield for a county was calculated using values provided during the period 2015-2019. Some counties have only some years reported. Many counties have no years reported. For each state, an unweighted state-level mean yield is estimated as the average of the county-level data. If a county does not have any data, the calculated state-level mean is used for that county. For a few states lacking county-level data, a state-level yield reported by NASS is used instead, when available. For a few states where each crop is not commonly grown, no yield data are available from NASS and thus are not available in the tool.

County and state-level data were available between 2015-2019 for corn and soybean crops. For wheat, at the county level we used data for winter wheat because the general wheat category did not report data from 2015-2019. At the state level, we used the general wheat category from the NASS survey data.

The final county data table contains yield data for each crop. If county data are available, they are used. If county data are not available, but state data are available, the state data are used for each county in the state. If state data are not available, no default yield value is provided by the tool.

N fertilizer rate: N rate data are only provided for states and counties for which yield data are available. State-level average N fertilizer rate for each crop are used to calculate a N/yield ratio (NYR) = N rate / grain yield. Because NASS does not report average N fertilizer rate data for all states that report grain yield, we also determined a national-scale NYR = national average N rate / national grain yield for each crop. To estimate a county-level average N rate the NYR for a given state was multiplied by county-level yield (when available). For counties lacking yield data, average NYR and yield data were used to calculate a N rate.

Table 19: *Default parameter values for each State in the continental USA. Clay fraction is in N application rates are in kg N ha^{-1} yr^{-1}, and yields are in kg grain ha^{-1} yr^{-1}. Yield and N rate data are not available (NA) for some crops in some states. Users wishing to report emission reductions in locations without default values must provide their own N rate and/or yield values.*

				Corn		Soybean		Wheat	
State	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Alabama	0.27	Sandy	Warm Moist	136	9252	5	2623	106	4829
Arizona	0.17	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arkansas	0.28	Clayey	Warm Moist	164	11185	4	3315	80	3618
California	0.22	Silty	Warm Dry	157	10670	NA	NA	109	4948
Colorado	0.21	Silty	Cool Dry	141	8474	NA	NA	30	2873
Connecticut	0.13	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Delaware	0.19	Silty	Warm Moist	158	10758	5	2972	103	4681
Florida	0.10	Sandy	Warm Moist	141	9603	4	2438	54	2455
Georgia	0.22	Sandy	Warm Moist	203	10645	4	2468	73	3309
Idaho	0.20	Silty	Cool Dry	187	12754	NA	NA	133	5788
Illinois	0.23	Silty	Warm Moist	185	12102	6	3907	101	4681
Indiana	0.22	Silty	Warm Moist	174	10809	8	3632	106	4788
Iowa	0.22	Silty	Cool Moist	156	12441	2	3827	89	4052
Kansas	0.23	Silty	Warm Dry	158	8587	7	2804	62	3120
Kentucky	0.23	Silty	Warm Moist	169	10708	10	3349	110	5003
Louisiana	0.30	Clayey	Warm Moist	158	10771	4	3268	72	3278
Maine	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maryland	0.21	Silty	Warm Moist	147	9980	5	3013	100	4533
Massachusetts	0.09	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Michigan	0.12	Sandy	Cool Moist	144	9767	7	3094	110	5326
Minnesota	0.23	Silty	Cool Moist	149	11675	4	3262	126	4059
Mississippi	0.33	Clayey	Warm Moist	164	11160	1	3376	74	3363
Missouri	0.23	Silty	Warm Moist	186	9666	4	3087	100	4210
Montana	0.21	Silty	Cool Dry	85	5775	NA	NA	72	2495
Nebraska	0.17	Silty	Cool Dry	169	11524	6	3941	49	3282
Nevada	0.20	Silty	Cool Dry	NA	NA	NA	NA	138	6251
New Hampshire	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Jersey	0.19	Sandy	Warm Moist	139	9478	4	2549	91	4116
New Mexico	0.20	Silty	Warm Dry	145	9867	NA	NA	36	1641
New York	0.17	Sandy	Cool Moist	92	9415	5	3080	100	4519
North Carolina	0.23	Silty	Warm Moist	148	7633	13	2354	69	3524
North Dakota	0.24	Silty	Cool Dry	148	8900	6	2354	100	3036

Table 19: *Default parameter values for each State in the continental USA. Clay fraction is in (continued)*

				Corn		Soybean		Wheat	
State	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Ohio	0.23	Silty	Warm Moist	183	10545	6	3484	92	4734
Oklahoma	0.22	Silty	Warm Dry	119	8122	3	1964	63	2246
Oregon	0.21	Silty	Cool Dry	196	13332	NA	NA	68	3973
Pennsylvania	0.21	Silty	Cool Moist	112	9164	5	3087	102	4613
Rhode Island	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
South Carolina	0.22	Silty	Warm Moist	109	7394	3	2024	71	3228
South Dakota	0.31	Clayey	Cool Dry	139	9654	5	3040	84	3026
Tennessee	0.26	Sandy	Warm Moist	153	10382	16	3141	102	4613
Texas	0.28	Clayey	Warm Dry	144	8072	4	2065	40	2112
Utah	0.20	Silty	Cool Dry	157	10658	NA	NA	79	3583
Vermont	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Virginia	0.23	Silty	Warm Moist	136	9277	14	2562	91	4129
Washington	0.19	Silty	Cool Moist	209	14211	NA	NA	89	4357
West Virginia	0.20	Silty	Warm Moist	141	9566	6	3463	88	3968
Wisconsin	0.18	Sandy	Cool Moist	118	10721	8	3322	106	4788
Wyoming	0.23	Silty	Cool Dry	138	9390	NA	NA	51	2300

B County level factors

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in N application rates are in kg N ha^{-1} yr^{-1}, and yields are in kg grain ha^{-1} yr^{-1}. Yield and N rate data are not available (NA) for some crops in some states. Users wishing to report emission reductions in locations without default values must provide their own N rate and/or yield values*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Alabama	Autauga	0.35	Clayey	Warm Moist	154	10503	4	2510	106	4829
Alabama	Baldwin	0.25	Silty	Warm Moist	141	9603	5	2902	106	4829
Alabama	Barbour	0.26	Sandy	Warm Moist	172	11720	6	3504	106	4829
Alabama	Bibb	0.30	Clayey	Warm Moist	126	8576	4	2510	106	4829
Alabama	Blount	0.24	Sandy	Warm Moist	118	8059	4	2582	106	4829
Alabama	Bullock	0.28	Sandy	Warm Moist	125	8474	4	2510	106	4829
Alabama	Butler	0.28	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Calhoun	0.24	Sandy	Warm Moist	135	9208	4	2510	106	4829
Alabama	Chambers	0.26	Silty	Warm Moist	126	8576	4	2510	106	4829
Alabama	Cherokee	0.24	Sandy	Warm Moist	108	7320	4	2268	106	4829
Alabama	Chilton	0.32	Clayey	Warm Moist	126	8576	5	2804	106	4829
Alabama	Choctaw	0.27	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Clarke	0.26	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Clay	0.25	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Cleburne	0.24	Sandy	Warm Moist	109	7410	4	2510	106	4829
Alabama	Coffee	0.25	Sandy	Warm Moist	104	7052	5	2932	106	4829
Alabama	Colbert	0.26	Sandy	Warm Moist	147	9995	5	2667	106	4829
Alabama	Conecuh	0.25	Sandy	Warm Moist	102	6913	4	2273	106	4829
Alabama	Coosa	0.30	Clayey	Warm Moist	126	8576	4	2510	106	4829
Alabama	Covington	0.24	Sandy	Warm Moist	106	7241	4	2387	106	4829
Alabama	Crenshaw	0.28	Sandy	Warm Moist	119	8091	4	2510	106	4829
Alabama	Cullman	0.24	Sandy	Warm Moist	150	10187	5	3048	106	4829
Alabama	Dale	0.25	Sandy	Warm Moist	120	8164	4	2510	106	4829
Alabama	Dallas	0.34	Clayey	Warm Moist	124	8458	4	2332	106	4829
Alabama	DeKalb	0.24	Sandy	Warm Moist	131	8918	5	2709	106	4829
Alabama	Elmore	0.34	Clayey	Warm Moist	143	9757	4	2309	106	4829
Alabama	Escambia	0.24	Sandy	Warm Moist	135	9178	4	2468	106	4829
Alabama	Etowah	0.24	Sandy	Warm Moist	106	7185	4	2448	106	4829
Alabama	Fayette	0.25	Sandy	Warm Moist	101	6906	3	1714	106	4829
Alabama	Franklin	0.25	Sandy	Warm Moist	112	7628	5	2630	106	4829
Alabama	Geneva	0.24	Sandy	Warm Moist	114	7789	5	2665	106	4829
Alabama	Greene	0.30	Clayey	Warm Moist	126	8576	4	2510	106	4829
Alabama	Hale	0.32	Clayey	Warm Moist	126	8576	3	1957	106	4829
Alabama	Henry	0.25	Sandy	Warm Moist	138	9415	4	2510	106	4829
Alabama	Houston	0.25	Sandy	Warm Moist	123	8375	4	2311	106	4829
Alabama	Jackson	0.24	Sandy	Warm Moist	121	8246	4	2218	106	4829
Alabama	Jefferson	0.25	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Lamar	0.25	Sandy	Warm Moist	73	4934	3	1819	106	4829
Alabama	Lauderdale	0.26	Sandy	Warm Moist	145	9848	5	2646	106	4829
Alabama	Lawrence	0.24	Sandy	Warm Moist	149	10171	5	2806	106	4829

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Alabama	Lee	0.27	Silty	Warm Moist	126	8576	4	2510	106	4829
Alabama	Limestone	0.24	Sandy	Warm Moist	152	10375	5	2869	106	4829
Alabama	Lowndes	0.33	Clayey	Warm Moist	126	8576	3	1927	106	4829
Alabama	Macon	0.29	Clayey	Warm Moist	131	8888	4	2159	106	4829
Alabama	Madison	0.24	Sandy	Warm Moist	155	10547	5	2737	106	4829
Alabama	Marengo	0.31	Clayey	Warm Moist	127	8612	4	2071	106	4829
Alabama	Marion	0.25	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Marshall	0.24	Sandy	Warm Moist	141	9585	4	2473	106	4829
Alabama	Mobile	0.25	Silty	Warm Moist	126	8576	4	2510	106	4829
Alabama	Monroe	0.26	Sandy	Warm Moist	137	9316	4	2327	106	4829
Alabama	Montgomery	0.33	Clayey	Warm Moist	126	8576	4	2510	106	4829
Alabama	Morgan	0.24	Sandy	Warm Moist	140	9517	5	2769	106	4829
Alabama	Perry	0.33	Clayey	Warm Moist	116	7897	4	2382	106	4829
Alabama	Pickens	0.26	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Pike	0.27	Sandy	Warm Moist	106	7197	5	2728	106	4829
Alabama	Randolph	0.25	Sandy	Warm Moist	86	5836	4	2510	106	4829
Alabama	Russell	0.25	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	St. Clair	0.24	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Shelby	0.27	Sandy	Warm Moist	86	5875	5	2670	106	4829
Alabama	Sumter	0.27	Sandy	Warm Moist	126	8576	4	2449	106	4829
Alabama	Talladega	0.25	Sandy	Warm Moist	127	8614	5	2699	106	4829
Alabama	Tallapoosa	0.29	Clayey	Warm Moist	169	11515	4	2510	106	4829
Alabama	Tuscaloosa	0.26	Sandy	Warm Moist	135	9172	5	2853	106	4829
Alabama	Walker	0.24	Sandy	Warm Moist	112	7641	4	2384	106	4829
Alabama	Washington	0.25	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Wilcox	0.30	Sandy	Warm Moist	126	8576	4	2510	106	4829
Alabama	Winston	0.24	Sandy	Warm Moist	126	8576	4	2510	106	4829
Arizona	Apache	0.21	Silty	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Cochise	0.17	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Coconino	0.21	Silty	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Gila	0.19	Silty	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Graham	0.19	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Greenlee	0.21	Silty	Warm Dry	198	13445	NA	NA	265	6808
Arizona	La Paz	0.11	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Maricopa	0.12	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Mohave	0.16	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Navajo	0.21	Silty	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Pima	0.14	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Pinal	0.14	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Santa Cruz	0.17	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Yavapai	0.17	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arizona	Yuma	0.10	Sandy	Warm Dry	198	13445	NA	NA	265	6808
Arkansas	Arkansas	0.37	Clayey	Warm Moist	174	11840	5	3762	92	4170
Arkansas	Ashley	0.32	Clayey	Warm Moist	173	11758	5	3720	76	3463
Arkansas	Baxter	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Arkansas	Benton	0.25	Sandy	Warm Moist	161	10950	3	2508	81	3664
Arkansas	Boone	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Bradley	0.29	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Calhoun	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Carroll	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Chicot	0.37	Clayey	Warm Moist	168	11449	5	3537	81	3664
Arkansas	Clark	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Clay	0.23	Silty	Warm Moist	171	11609	5	3367	70	3174
Arkansas	Cleburne	0.28	Clayey	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Cleveland	0.29	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Columbia	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Conway	0.24	Sandy	Warm Moist	161	10950	3	2569	77	3510
Arkansas	Craighead	0.32	Clayey	Warm Moist	173	11773	4	3365	81	3688
Arkansas	Crawford	0.24	Silty	Warm Moist	101	6904	4	3094	81	3664
Arkansas	Crittenden	0.49	Clayey	Warm Moist	154	10476	4	3132	93	4217
Arkansas	Cross	0.44	Clayey	Warm Moist	178	12086	5	3393	99	4501
Arkansas	Dallas	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Desha	0.38	Clayey	Warm Moist	175	11906	5	3938	75	3379
Arkansas	Drew	0.33	Clayey	Warm Moist	173	11789	5	3758	81	3664
Arkansas	Faulkner	0.26	Sandy	Warm Moist	161	10950	4	2744	81	3664
Arkansas	Franklin	0.24	Silty	Warm Moist	161	10950	3	2387	81	3664
Arkansas	Fulton	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Garland	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Grant	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Greene	0.26	Silty	Warm Moist	164	11156	4	3056	66	2999
Arkansas	Hempstead	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Hot Spring	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Howard	0.24	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Independence	0.30	Clayey	Warm Moist	148	10064	4	2751	81	3664
Arkansas	Izard	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Jackson	0.37	Clayey	Warm Moist	156	10616	4	2721	79	3560
Arkansas	Jefferson	0.32	Clayey	Warm Moist	176	11943	5	3722	76	3457
Arkansas	Johnson	0.24	Silty	Warm Moist	136	9261	4	3094	81	3664
Arkansas	Lafayette	0.24	Sandy	Warm Moist	145	9864	4	3094	81	3664
Arkansas	Lawrence	0.30	Clayey	Warm Moist	157	10696	4	2635	93	4230
Arkansas	Lee	0.41	Clayey	Warm Moist	154	10460	4	3094	68	3100
Arkansas	Lincoln	0.33	Clayey	Warm Moist	174	11862	5	3832	64	2902
Arkansas	Little River	0.24	Silty	Warm Moist	161	10950	3	2031	81	3664
Arkansas	Logan	0.24	Silty	Warm Moist	156	10645	4	3094	81	3664
Arkansas	Lonoke	0.32	Clayey	Warm Moist	169	11489	4	3083	73	3299
Arkansas	Madison	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Marion	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Miller	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Mississippi	0.39	Clayey	Warm Moist	157	10688	5	3453	90	4069
Arkansas	Monroe	0.39	Clayey	Warm Moist	160	10904	4	3119	90	4098

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Arkansas	Montgomery	0.24	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Nevada	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Newton	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Ouachita	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Perry	0.24	Sandy	Warm Moist	161	10950	2	1708	81	3664
Arkansas	Phillips	0.39	Clayey	Warm Moist	158	10727	4	3352	82	3709
Arkansas	Pike	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Poinsett	0.41	Clayey	Warm Moist	175	11902	5	3574	92	4165
Arkansas	Polk	0.24	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Pope	0.24	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Prairie	0.36	Clayey	Warm Moist	169	11516	4	3314	87	3924
Arkansas	Pulaski	0.28	Sandy	Warm Moist	161	10950	4	3060	63	2872
Arkansas	Randolph	0.24	Silty	Warm Moist	162	11006	4	2922	81	3664
Arkansas	St. Francis	0.42	Clayey	Warm Moist	162	11019	4	3149	75	3389
Arkansas	Saline	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Scott	0.24	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Searcy	0.24	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Sebastian	0.24	Silty	Warm Dry	161	10950	4	3094	81	3664
Arkansas	Sevier	0.24	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Sharp	0.26	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Stone	0.26	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Union	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Van Buren	0.25	Sandy	Warm Moist	161	10950	4	3094	81	3664
Arkansas	Washington	0.25	Silty	Warm Moist	161	10950	4	3094	81	3664
Arkansas	White	0.33	Clayey	Warm Moist	169	11526	4	2746	81	3664
Arkansas	Woodruff	0.41	Clayey	Warm Moist	157	10691	4	2833	97	4403
Arkansas	Yell	0.24	Silty	Warm Moist	145	9836	4	2865	81	3664
California	Alameda	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Alpine	0.23	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Amador	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Butte	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Calaveras	0.24	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Colusa	0.23	Silty	Warm Dry	155	10518	NA	NA	98	4465
California	Contra Costa	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Del Norte	0.24	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	El Dorado	0.22	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Fresno	0.28	Clayey	Warm Dry	153	10419	NA	NA	79	3564
California	Glenn	0.24	Silty	Warm Dry	176	11984	NA	NA	84	3809
California	Humboldt	0.24	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Imperial	0.13	Sandy	Warm Dry	155	10518	NA	NA	108	4897
California	Inyo	0.22	Sandy	Warm Dry	155	10518	NA	NA	108	4897
California	Kern	0.30	Clayey	Warm Dry	129	8756	NA	NA	107	4845
California	Kings	0.34	Clayey	Warm Dry	155	10518	NA	NA	114	5167
California	Lake	0.24	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Lassen	0.24	Silty	Cool Dry	155	10518	NA	NA	133	6053

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
California	Los Angeles	0.21	Sandy	Warm Dry	155	10518	NA	NA	108	4897
California	Madera	0.25	Silty	Warm Dry	155	10518	NA	NA	124	5604
California	Marin	0.23	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Mariposa	0.24	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Mendocino	0.24	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Merced	0.24	Silty	Warm Dry	120	8150	NA	NA	109	4951
California	Modoc	0.23	Silty	Cool Dry	155	10518	NA	NA	108	4897
California	Mono	0.23	Silty	Cool Dry	155	10518	NA	NA	108	4897
California	Monterey	0.25	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Napa	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Nevada	0.22	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Orange	0.21	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Placer	0.22	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Plumas	0.23	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Riverside	0.14	Sandy	Warm Dry	155	10518	NA	NA	108	4897
California	Sacramento	0.23	Silty	Warm Dry	160	10887	NA	NA	138	6248
California	San Benito	0.25	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	San Bernardino	0.13	Sandy	Warm Dry	155	10518	NA	NA	108	4897
California	San Diego	0.19	Sandy	Warm Dry	155	10518	NA	NA	108	4897
California	San Francisco	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	San Joaquin	0.23	Silty	Warm Dry	149	10170	NA	NA	122	5536
California	San Luis Obispo	0.30	Clayey	Warm Dry	155	10518	NA	NA	108	4897
California	San Mateo	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Santa Barbara	0.28	Clayey	Warm Dry	155	10518	NA	NA	108	4897
California	Santa Clara	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Santa Cruz	0.23	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Shasta	0.24	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Sierra	0.22	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Siskiyou	0.24	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Solano	0.23	Silty	Warm Dry	158	10758	NA	NA	99	4490
California	Sonoma	0.23	Silty	Warm Moist	155	10518	NA	NA	108	4897
California	Stanislaus	0.24	Silty	Warm Dry	138	9415	NA	NA	119	5402
California	Sutter	0.22	Silty	Warm Dry	191	12997	NA	NA	106	4798
California	Tehama	0.24	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Trinity	0.24	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Tulare	0.33	Clayey	Warm Dry	155	10518	NA	NA	91	4122
California	Tuolumne	0.24	Silty	Cool Moist	155	10518	NA	NA	108	4897
California	Ventura	0.27	Silty	Warm Dry	155	10518	NA	NA	108	4897
California	Yolo	0.23	Silty	Warm Dry	171	11647	NA	NA	97	4397
California	Yuba	0.22	Silty	Warm Dry	155	10518	NA	NA	108	4897
Colorado	Adams	0.22	Silty	Cool Dry	82	4908	NA	NA	27	2597
Colorado	Alamosa	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Arapahoe	0.21	Silty	Cool Dry	139	8313	NA	NA	20	1958
Colorado	Archuleta	0.19	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Baca	0.23	Sandy	Warm Dry	134	8047	NA	NA	16	1574

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Colorado	Bent	0.23	Sandy	Warm Dry	178	10649	NA	NA	47	4587
Colorado	Boulder	0.21	Silty	Cool Dry	153	9183	NA	NA	30	2926
Colorado	Broomfield	0.21	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Chaffee	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Cheyenne	0.23	Silty	Warm Dry	100	6004	NA	NA	26	2511
Colorado	Clear Creek	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Conejos	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Costilla	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Crowley	0.21	Silty	Warm Dry	139	8313	NA	NA	30	2926
Colorado	Custer	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Delta	0.21	Silty	Cool Dry	201	12076	NA	NA	30	2926
Colorado	Denver	0.21	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Dolores	0.21	Silty	Cool Dry	139	8313	NA	NA	10	1009
Colorado	Douglas	0.20	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Eagle	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Elbert	0.21	Silty	Cool Dry	65	3908	NA	NA	27	2603
Colorado	El Paso	0.20	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Fremont	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Garfield	0.21	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Gilpin	0.21	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Grand	0.21	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Gunnison	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Hinsdale	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Huerfano	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Jackson	0.21	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Jefferson	0.20	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Kiowa	0.23	Sandy	Warm Dry	68	4080	NA	NA	26	2557
Colorado	Kit Carson	0.23	Silty	Cool Dry	125	7468	NA	NA	35	3392
Colorado	Lake	0.19	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	La Plata	0.19	Silty	Cool Dry	139	8313	NA	NA	18	1752
Colorado	Larimer	0.21	Silty	Cool Dry	132	7944	NA	NA	28	2717
Colorado	Las Animas	0.20	Silty	Warm Dry	139	8313	NA	NA	20	1964
Colorado	Lincoln	0.22	Silty	Cool Dry	67	3992	NA	NA	27	2576
Colorado	Logan	0.23	Silty	Cool Dry	150	9001	NA	NA	30	2882
Colorado	Mesa	0.22	Silty	Cool Dry	139	8313	NA	NA	86	8327
Colorado	Mineral	0.19	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Moffat	0.23	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Montezuma	0.20	Silty	Cool Dry	157	9415	NA	NA	21	2014
Colorado	Montrose	0.22	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Morgan	0.23	Silty	Cool Dry	177	10604	NA	NA	25	2445
Colorado	Otero	0.21	Silty	Warm Dry	170	10204	NA	NA	44	4277
Colorado	Ouray	0.21	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Park	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Phillips	0.23	Silty	Cool Dry	147	8799	NA	NA	38	3648
Colorado	Pitkin	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Colorado	Prowers	0.24	Sandy	Warm Dry	174	10463	NA	NA	33	3216
Colorado	Pueblo	0.20	Silty	Warm Dry	185	11108	NA	NA	30	2926
Colorado	Rio Blanco	0.22	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Rio Grande	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Routt	0.22	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Saguache	0.19	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	San Juan	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	San Miguel	0.22	Silty	Cool Dry	139	8313	NA	NA	30	2926
Colorado	Sedgwick	0.22	Silty	Cool Dry	141	8432	NA	NA	30	2872
Colorado	Summit	0.20	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Teller	0.19	Silty	Cool Moist	139	8313	NA	NA	30	2926
Colorado	Washington	0.23	Silty	Cool Dry	74	4440	NA	NA	28	2757
Colorado	Weld	0.22	Silty	Cool Dry	172	10318	NA	NA	26	2549
Colorado	Yuma	0.23	Silty	Warm Dry	198	11849	NA	NA	36	3437
Connecticut	Fairfield	0.19	Silty	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	Hartford	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	Litchfield	0.12	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	Middlesex	0.11	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	New Haven	0.16	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	New London	0.12	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	Tolland	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Connecticut	Windham	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Delaware	Kent	0.17	Sandy	Warm Moist	161	10962	5	2952	103	4681
Delaware	New Castle	0.19	Sandy	Warm Moist	154	10456	5	3041	103	4681
Delaware	Sussex	0.19	Silty	Warm Moist	157	10707	5	2847	103	4681
Florida	Alachua	0.09	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Baker	0.12	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Bay	0.17	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Bradford	0.09	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Brevard	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Broward	0.10	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Calhoun	0.20	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Charlotte	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Citrus	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Clay	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Collier	0.09	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Columbia	0.13	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	DeSoto	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Dixie	0.09	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Duval	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Escambia	0.25	Silty	Warm Moist	141	9603	4	2438	54	2455
Florida	Flagler	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Franklin	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Gadsden	0.23	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Gilchrist	0.10	Sandy	Warm Moist	141	9603	4	2438	54	2455

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Florida	Glades	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Gulf	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Hamilton	0.17	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Hardee	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Hendry	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Hernando	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Highlands	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Hillsborough	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Holmes	0.24	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Indian River	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Jackson	0.25	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Jefferson	0.20	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Lafayette	0.13	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Lake	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Lee	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Leon	0.20	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Levy	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Liberty	0.17	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Madison	0.19	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Manatee	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Marion	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Martin	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Miami-Dade	0.10	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Monroe	0.10	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Nassau	0.08	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Okaloosa	0.23	Silty	Warm Moist	141	9603	4	2438	54	2455
Florida	Okeechobee	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Orange	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Osceola	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Palm Beach	0.09	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Pasco	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Pinellas	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Polk	0.04	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Putnam	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	St. Johns	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	St. Lucie	0.07	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Santa Rosa	0.23	Silty	Warm Moist	141	9603	4	2438	54	2455
Florida	Sarasota	0.05	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Seminole	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Sumter	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Suwannee	0.13	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Taylor	0.13	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Union	0.10	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Volusia	0.06	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Wakulla	0.14	Sandy	Warm Moist	141	9603	4	2438	54	2455

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Florida	Walton	0.21	Sandy	Warm Moist	141	9603	4	2438	54	2455
Florida	Washington	0.23	Sandy	Warm Moist	141	9603	4	2438	54	2455
Georgia	Appling	0.18	Sandy	Warm Moist	179	9384	4	2580	68	3083
Georgia	Atkinson	0.19	Sandy	Warm Moist	186	9721	4	2458	68	3083
Georgia	Bacon	0.15	Sandy	Warm Moist	154	8066	4	2458	68	3083
Georgia	Baker	0.25	Sandy	Warm Moist	228	11930	4	2458	68	3083
Georgia	Baldwin	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Banks	0.24	Sandy	Warm Moist	117	6107	4	2458	68	3083
Georgia	Barrow	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Bartow	0.24	Sandy	Warm Moist	183	9564	3	1836	68	3083
Georgia	Ben Hill	0.22	Sandy	Warm Moist	203	10620	4	2458	68	3083
Georgia	Berrien	0.21	Sandy	Warm Moist	199	10415	5	2972	68	3083
Georgia	Bibb	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Bleckley	0.24	Sandy	Warm Moist	222	11614	5	2878	79	3578
Georgia	Brantley	0.13	Sandy	Warm Moist	88	4601	4	2458	68	3083
Georgia	Brooks	0.24	Sandy	Warm Moist	177	9290	5	3174	68	3083
Georgia	Bryan	0.17	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Bulloch	0.18	Sandy	Warm Moist	143	7476	3	1732	54	2448
Georgia	Burke	0.22	Sandy	Warm Moist	232	12158	4	2329	71	3208
Georgia	Butts	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Calhoun	0.25	Sandy	Warm Moist	259	13565	4	2458	68	3083
Georgia	Camden	0.08	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Candler	0.20	Sandy	Warm Moist	99	5172	2	1453	68	3083
Georgia	Carroll	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Catoosa	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Charlton	0.12	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Chatham	0.13	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Chattahoochee	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Chattooga	0.24	Sandy	Warm Moist	183	9575	4	2414	68	3083
Georgia	Cherokee	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Clarke	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Clay	0.25	Sandy	Warm Moist	217	11361	4	2458	68	3083
Georgia	Clayton	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Clinch	0.17	Sandy	Warm Moist	50	2592	4	2458	68	3083
Georgia	Cobb	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Coffee	0.19	Sandy	Warm Moist	188	9853	4	2340	68	3083
Georgia	Colquitt	0.24	Sandy	Warm Moist	219	11480	5	2927	68	3083
Georgia	Columbia	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Cook	0.22	Sandy	Warm Moist	190	9972	4	2458	68	3083
Georgia	Coweta	0.24	Sandy	Warm Moist	186	9717	4	2458	75	3403
Georgia	Crawford	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Crisp	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Dade	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Dawson	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Decatur	0.25	Sandy	Warm Moist	232	12166	6	3312	68	3083

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Georgia	DeKalb	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Dodge	0.23	Sandy	Warm Moist	199	10419	4	2155	68	3083
Georgia	Dooly	0.24	Sandy	Warm Moist	254	13282	5	2845	66	2986
Georgia	Dougherty	0.24	Sandy	Warm Moist	247	12958	4	2458	68	3083
Georgia	Douglas	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Early	0.25	Sandy	Warm Moist	222	11625	4	2266	60	2714
Georgia	Echols	0.19	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Effingham	0.16	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Elbert	0.24	Sandy	Warm Moist	186	9717	4	2459	77	3497
Georgia	Emanuel	0.23	Sandy	Warm Moist	165	8629	4	2337	63	2858
Georgia	Evans	0.19	Sandy	Warm Moist	156	8185	4	2387	68	3083
Georgia	Fannin	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Fayette	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Floyd	0.24	Sandy	Warm Moist	182	9553	4	2297	68	3083
Georgia	Forsyth	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Franklin	0.24	Sandy	Warm Moist	165	8634	3	1584	68	3083
Georgia	Fulton	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Gilmer	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Glascock	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Glynn	0.10	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Gordon	0.24	Sandy	Warm Moist	133	6956	5	2677	68	3083
Georgia	Grady	0.25	Sandy	Warm Moist	184	9619	5	2804	68	3083
Georgia	Greene	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Gwinnett	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Habersham	0.24	Sandy	Warm Moist	133	6961	4	2458	68	3083
Georgia	Hall	0.24	Sandy	Warm Moist	137	7173	4	2458	68	3083
Georgia	Hancock	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Haralson	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Harris	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Hart	0.24	Sandy	Warm Moist	187	9788	4	2147	80	3642
Georgia	Heard	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Henry	0.24	Sandy	Warm Moist	186	9717	5	2831	68	3083
Georgia	Houston	0.24	Sandy	Warm Moist	184	9635	4	2508	68	3083
Georgia	Irwin	0.21	Sandy	Warm Moist	210	11012	4	2458	68	3083
Georgia	Jackson	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Jasper	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Jeff Davis	0.18	Sandy	Warm Moist	167	8739	5	3120	68	3083
Georgia	Jefferson	0.24	Sandy	Warm Moist	239	12531	4	2337	57	2593
Georgia	Jenkins	0.22	Sandy	Warm Moist	239	12528	5	2714	72	3275
Georgia	Johnson	0.24	Sandy	Warm Moist	200	10471	2	1432	68	3083
Georgia	Jones	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Lamar	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Lanier	0.20	Sandy	Warm Moist	159	8351	4	2458	68	3083
Georgia	Laurens	0.23	Sandy	Warm Moist	186	9717	6	3289	74	3376
Georgia	Lee	0.24	Sandy	Warm Moist	176	9233	4	2394	50	2280

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Georgia	Liberty	0.13	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Lincoln	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Long	0.13	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Lowndes	0.21	Sandy	Warm Moist	186	9717	4	2599	68	3083
Georgia	Lumpkin	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	McDuffie	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	McIntosh	0.10	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Macon	0.24	Sandy	Warm Moist	211	11022	4	2335	61	2764
Georgia	Madison	0.24	Sandy	Warm Moist	186	9717	2	1083	73	3295
Georgia	Marion	0.24	Sandy	Warm Moist	146	7650	3	1941	68	3083
Georgia	Meriwether	0.24	Sandy	Warm Moist	153	7997	4	2458	68	3083
Georgia	Miller	0.25	Sandy	Warm Moist	235	12297	4	2458	45	2031
Georgia	Mitchell	0.25	Sandy	Warm Moist	231	12081	5	3174	68	3083
Georgia	Monroe	0.24	Sandy	Warm Moist	186	9717	4	2458	84	3793
Georgia	Montgomery	0.21	Sandy	Warm Moist	173	9064	5	2714	68	3083
Georgia	Morgan	0.24	Sandy	Warm Moist	186	9717	4	2441	73	3305
Georgia	Murray	0.24	Sandy	Warm Moist	186	9717	3	1560	68	3083
Georgia	Muscogee	0.25	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Newton	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Oconee	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Oglethorpe	0.24	Sandy	Warm Moist	186	9717	4	2374	56	2535
Georgia	Paulding	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Peach	0.24	Sandy	Warm Moist	210	11016	5	2663	77	3474
Georgia	Pickens	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Pierce	0.14	Sandy	Warm Moist	171	8980	4	2303	68	3083
Georgia	Pike	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Polk	0.24	Sandy	Warm Moist	171	8963	3	1466	68	3083
Georgia	Pulaski	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Putnam	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Quitman	0.25	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Rabun	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Randolph	0.25	Sandy	Warm Moist	241	12639	5	3064	82	3732
Georgia	Richmond	0.23	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Rockdale	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Schley	0.24	Sandy	Warm Moist	97	5065	4	2458	68	3083
Georgia	Screven	0.20	Sandy	Warm Moist	205	10731	4	2434	64	2909
Georgia	Seminole	0.25	Sandy	Warm Moist	246	12875	5	3075	64	2899
Georgia	Spalding	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Stephens	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Stewart	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Sumter	0.24	Sandy	Warm Moist	238	12469	4	2458	66	3013
Georgia	Talbot	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Taliaferro	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Tattnall	0.18	Sandy	Warm Moist	197	10298	4	2085	70	3194
Georgia	Taylor	0.24	Sandy	Warm Moist	125	6528	4	2552	68	3083

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Georgia	Telfair	0.21	Sandy	Warm Moist	186	9717	4	2434	68	3083
Georgia	Terrell	0.25	Sandy	Warm Moist	211	11024	3	1762	71	3208
Georgia	Thomas	0.25	Sandy	Warm Moist	141	7407	5	3156	68	3083
Georgia	Tift	0.23	Sandy	Warm Moist	233	12183	5	3141	67	3016
Georgia	Toombs	0.20	Sandy	Warm Moist	224	11741	5	2751	68	3083
Georgia	Towns	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Treutlen	0.23	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Troup	0.25	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Turner	0.23	Sandy	Warm Moist	233	12177	4	2458	68	3083
Georgia	Twiggs	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Union	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Upson	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Walker	0.24	Sandy	Warm Moist	168	8787	6	3285	68	3083
Georgia	Walton	0.24	Sandy	Warm Moist	186	9717	4	2458	74	3349
Georgia	Ware	0.15	Sandy	Warm Moist	154	8072	4	2287	68	3083
Georgia	Warren	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Washington	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Wayne	0.13	Sandy	Warm Moist	148	7758	4	2458	68	3083
Georgia	Webster	0.24	Sandy	Warm Moist	144	7529	4	2458	68	3083
Georgia	Wheeler	0.22	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	White	0.24	Sandy	Warm Moist	186	9717	4	2458	68	3083
Georgia	Whitfield	0.24	Sandy	Warm Moist	121	6346	4	2458	68	3083
Georgia	Wilcox	0.23	Sandy	Warm Moist	235	12312	4	2458	76	3457
Georgia	Wilkes	0.24	Sandy	Warm Moist	186	9717	4	2458	67	3026
Georgia	Wilkinson	0.24	Sandy	Warm Moist	186	9717	4	2458	60	2710
Georgia	Worth	0.24	Sandy	Warm Moist	228	11942	4	2458	68	3083
Idaho	Ada	0.24	Silty	Warm Dry	203	13838	NA	NA	199	8627
Idaho	Adams	0.24	Silty	Cool Moist	188	12778	NA	NA	149	6445
Idaho	Bannock	0.22	Silty	Cool Dry	188	12778	NA	NA	110	4761
Idaho	Bear Lake	0.21	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Benewah	0.20	Silty	Cool Moist	188	12778	NA	NA	114	4929
Idaho	Bingham	0.22	Silty	Cool Dry	188	12778	NA	NA	184	7976
Idaho	Blaine	0.24	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Boise	0.23	Silty	Cool Moist	188	12778	NA	NA	149	6445
Idaho	Bonner	0.13	Silty	Cool Moist	188	12778	NA	NA	149	6445
Idaho	Bonneville	0.22	Silty	Cool Dry	188	12778	NA	NA	117	5083
Idaho	Boundary	0.11	Silty	Cool Moist	188	12778	NA	NA	134	5829
Idaho	Butte	0.23	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Camas	0.24	Sandy	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Canyon	0.23	Silty	Warm Dry	184	12522	NA	NA	195	8468
Idaho	Caribou	0.21	Silty	Cool Dry	188	12778	NA	NA	107	4660
Idaho	Cassia	0.23	Silty	Cool Dry	151	10266	NA	NA	142	6159
Idaho	Clark	0.22	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Clearwater	0.15	Silty	Cool Moist	188	12778	NA	NA	149	6445
Idaho	Custer	0.21	Silty	Cool Dry	188	12778	NA	NA	149	6445

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Idaho	Elmore	0.24	Sandy	Cool Dry	193	13131	NA	NA	153	6640
Idaho	Franklin	0.21	Silty	Cool Dry	130	8819	NA	NA	149	6445
Idaho	Fremont	0.22	Silty	Cool Moist	188	12778	NA	NA	203	8810
Idaho	Gem	0.23	Silty	Cool Dry	195	13288	NA	NA	166	7216
Idaho	Gooding	0.24	Sandy	Cool Dry	204	13893	NA	NA	149	6445
Idaho	Idaho	0.18	Silty	Cool Moist	188	12778	NA	NA	117	5067
Idaho	Jefferson	0.23	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Jerome	0.24	Sandy	Cool Dry	195	13300	NA	NA	213	9250
Idaho	Kootenai	0.19	Silty	Cool Moist	188	12778	NA	NA	101	4391
Idaho	Latah	0.19	Silty	Cool Moist	188	12778	NA	NA	123	5323
Idaho	Lemhi	0.16	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Lewis	0.20	Silty	Cool Moist	188	12778	NA	NA	110	4763
Idaho	Lincoln	0.24	Sandy	Cool Dry	185	12615	NA	NA	205	8897
Idaho	Madison	0.22	Silty	Cool Dry	188	12778	NA	NA	149	6445
Idaho	Minidoka	0.23	Silty	Cool Dry	188	12778	NA	NA	183	7936
Idaho	Nez Perce	0.21	Silty	Cool Dry	188	12778	NA	NA	120	5209
Idaho	Oneida	0.22	Silty	Cool Dry	188	12778	NA	NA	64	2784
Idaho	Owyhee	0.23	Silty	Cool Dry	205	13955	NA	NA	173	7513
Idaho	Payette	0.23	Silty	Cool Dry	209	14222	NA	NA	196	8499
Idaho	Power	0.22	Silty	Cool Dry	188	12778	NA	NA	123	5328
Idaho	Shoshone	0.15	Silty	Cool Moist	188	12778	NA	NA	149	6445
Idaho	Teton	0.22	Silty	Cool Moist	188	12778	NA	NA	90	3901
Idaho	Twin Falls	0.23	Silty	Cool Dry	198	13489	NA	NA	211	9146
Idaho	Valley	0.21	Silty	Cool Moist	188	12778	NA	NA	149	6445
Idaho	Washington	0.23	Silty	Cool Dry	188	12778	NA	NA	158	6862
Illinois	Adams	0.21	Silty	Warm Moist	175	11415	6	3684	93	4307
Illinois	Alexander	0.24	Silty	Warm Moist	150	9784	4	2714	72	3319
Illinois	Bond	0.22	Silty	Warm Moist	165	10763	6	3727	101	4689
Illinois	Boone	0.23	Silty	Cool Moist	185	12071	6	3740	123	5696
Illinois	Brown	0.21	Silty	Warm Moist	172	11237	6	3693	98	4539
Illinois	Bureau	0.23	Silty	Cool Moist	194	12680	7	4161	109	5035
Illinois	Calhoun	0.21	Silty	Warm Moist	154	10080	6	3603	85	3907
Illinois	Carroll	0.23	Silty	Cool Moist	211	13775	7	4445	113	5204
Illinois	Cass	0.22	Silty	Warm Moist	194	12658	7	4324	88	4079
Illinois	Champaign	0.24	Silty	Warm Moist	194	12660	7	4260	115	5332
Illinois	Christian	0.22	Silty	Warm Moist	201	13112	7	4410	104	4820
Illinois	Clark	0.21	Silty	Warm Moist	177	11593	7	4051	110	5065
Illinois	Clay	0.21	Silty	Warm Moist	141	9224	5	3254	100	4624
Illinois	Clinton	0.22	Silty	Warm Moist	162	10561	6	3563	103	4751
Illinois	Coles	0.22	Silty	Warm Moist	196	12790	7	4409	98	4546
Illinois	Cook	0.24	Silty	Cool Moist	165	10796	6	3804	101	4689
Illinois	Crawford	0.20	Silty	Warm Moist	158	10313	6	3667	94	4347
Illinois	Cumberland	0.21	Silty	Warm Moist	164	10747	6	3894	114	5247
Illinois	DeKalb	0.24	Silty	Cool Moist	189	12324	7	4022	119	5484
Illinois	De Witt	0.24	Silty	Warm Moist	204	13313	7	4479	101	4689

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Illinois	Douglas	0.23	Silty	Warm Moist	205	13422	7	4554	102	4717
Illinois	DuPage	0.24	Silty	Cool Moist	177	11549	6	3804	101	4689
Illinois	Edgar	0.23	Silty	Warm Moist	190	12444	7	4262	104	4805
Illinois	Edwards	0.22	Silty	Warm Moist	154	10076	5	3304	95	4408
Illinois	Effingham	0.21	Silty	Warm Moist	174	11392	6	3899	102	4726
Illinois	Fayette	0.21	Silty	Warm Moist	157	10261	6	3603	97	4470
Illinois	Ford	0.24	Silty	Warm Moist	182	11894	6	3965	102	4734
Illinois	Franklin	0.23	Silty	Warm Moist	137	8952	5	3011	100	4619
Illinois	Fulton	0.22	Silty	Warm Moist	184	12026	6	3884	89	4096
Illinois	Gallatin	0.23	Silty	Warm Moist	164	10713	5	3389	110	5089
Illinois	Greene	0.21	Silty	Warm Moist	180	11759	7	4211	98	4514
Illinois	Grundy	0.24	Silty	Cool Moist	182	11928	6	3712	88	4069
Illinois	Hamilton	0.23	Silty	Warm Moist	148	9652	5	3331	104	4808
Illinois	Hancock	0.21	Silty	Warm Moist	203	13253	7	4301	94	4362
Illinois	Hardin	0.24	Silty	Warm Moist	177	11549	5	2878	101	4689
Illinois	Henderson	0.21	Silty	Warm Moist	198	12921	6	3983	109	5030
Illinois	Henry	0.22	Silty	Cool Moist	197	12870	6	3975	111	5145
Illinois	Iroquois	0.24	Silty	Cool Moist	166	10853	6	3617	104	4798
Illinois	Jackson	0.24	Silty	Warm Moist	148	9671	5	3107	90	4170
Illinois	Jasper	0.21	Silty	Warm Moist	169	11041	6	3771	99	4580
Illinois	Jefferson	0.22	Silty	Warm Moist	128	8356	5	2962	84	3880
Illinois	Jersey	0.21	Silty	Warm Moist	166	10829	6	3800	103	4758
Illinois	Jo Daviess	0.22	Silty	Cool Moist	188	12270	6	3781	97	4472
Illinois	Johnson	0.24	Silty	Warm Moist	118	7714	5	3003	101	4689
Illinois	Kane	0.24	Silty	Cool Moist	180	11755	6	3829	108	4998
Illinois	Kankakee	0.24	Silty	Cool Moist	160	10445	6	3498	119	5498
Illinois	Kendall	0.24	Silty	Cool Moist	196	12812	6	3970	120	5568
Illinois	Knox	0.22	Silty	Warm Moist	208	13575	7	4176	118	5477
Illinois	Lake	0.27	Silty	Cool Moist	140	9164	5	3127	92	4270
Illinois	LaSalle	0.24	Silty	Cool Moist	189	12364	7	4070	122	5619
Illinois	Lawrence	0.21	Silty	Warm Moist	155	10143	6	3425	97	4482
Illinois	Lee	0.23	Silty	Cool Moist	189	12373	7	4090	101	4687
Illinois	Livingston	0.24	Silty	Warm Moist	191	12513	6	3992	105	4849
Illinois	Logan	0.23	Silty	Warm Moist	199	13000	7	4338	94	4365
Illinois	McDonough	0.22	Silty	Warm Moist	197	12899	7	4256	94	4331
Illinois	McHenry	0.24	Silty	Cool Moist	181	11851	6	3717	114	5275
Illinois	McLean	0.24	Silty	Warm Moist	205	13423	7	4354	115	5318
Illinois	Macon	0.23	Silty	Warm Moist	208	13598	7	4584	105	4873
Illinois	Macoupin	0.21	Silty	Warm Moist	181	11808	7	4139	90	4159
Illinois	Madison	0.22	Silty	Warm Moist	176	11496	6	3841	100	4604
Illinois	Marion	0.22	Silty	Warm Moist	151	9901	6	3420	99	4562
Illinois	Marshall	0.23	Silty	Warm Moist	200	13100	7	4073	89	4122
Illinois	Mason	0.23	Silty	Warm Moist	175	11469	6	3835	106	4897
Illinois	Massac	0.24	Silty	Warm Moist	155	10113	5	3165	94	4340
Illinois	Menard	0.22	Silty	Warm Moist	198	12934	7	4279	118	5437

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Illinois	Mercer	0.22	Silty	Warm Moist	207	13524	6	3958	101	4689
Illinois	Monroe	0.24	Silty	Warm Moist	150	9792	5	3198	98	4531
Illinois	Montgomery	0.21	Silty	Warm Moist	187	12230	7	4230	102	4717
Illinois	Morgan	0.22	Silty	Warm Moist	195	12764	7	4339	110	5079
Illinois	Moultrie	0.23	Silty	Warm Moist	202	13219	7	4504	94	4358
Illinois	Ogle	0.23	Silty	Cool Moist	194	12665	7	4102	122	5619
Illinois	Peoria	0.23	Silty	Warm Moist	202	13187	7	4124	89	4098
Illinois	Perry	0.24	Silty	Warm Moist	127	8284	5	2982	82	3793
Illinois	Piatt	0.24	Silty	Warm Moist	211	13776	8	4896	97	4496
Illinois	Pike	0.21	Silty	Warm Moist	165	10815	6	3778	98	4518
Illinois	Pope	0.24	Silty	Warm Moist	140	9145	5	2867	101	4689
Illinois	Pulaski	0.24	Silty	Warm Moist	160	10462	5	3045	103	4764
Illinois	Putnam	0.23	Silty	Cool Moist	197	12881	7	4046	118	5447
Illinois	Randolph	0.24	Silty	Warm Moist	138	8996	5	3091	110	5102
Illinois	Richland	0.21	Silty	Warm Moist	145	9509	6	3445	102	4712
Illinois	Rock Island	0.22	Silty	Cool Moist	205	13387	6	3956	77	3558
Illinois	St. Clair	0.23	Silty	Warm Moist	164	10717	6	3474	104	4804
Illinois	Saline	0.23	Silty	Warm Moist	154	10048	5	3275	94	4348
Illinois	Sangamon	0.22	Silty	Warm Moist	206	13466	7	4615	95	4405
Illinois	Schuyler	0.22	Silty	Warm Moist	174	11372	6	3843	86	3978
Illinois	Scott	0.22	Silty	Warm Moist	175	11449	6	3845	80	3706
Illinois	Shelby	0.21	Silty	Warm Moist	184	12054	7	4098	104	4785
Illinois	Stark	0.23	Silty	Cool Moist	212	13858	7	4223	135	6241
Illinois	Stephenson	0.23	Silty	Cool Moist	195	12734	7	4104	123	5700
Illinois	Tazewell	0.23	Silty	Warm Moist	209	13651	7	4413	109	5033
Illinois	Union	0.24	Silty	Warm Moist	129	8425	5	2901	96	4418
Illinois	Vermilion	0.24	Silty	Warm Moist	188	12317	7	4412	112	5185
Illinois	Wabash	0.22	Silty	Warm Moist	156	10173	6	3558	102	4701
Illinois	Warren	0.22	Silty	Warm Moist	214	13981	7	4202	74	3416
Illinois	Washington	0.23	Silty	Warm Moist	149	9736	5	3254	106	4903
Illinois	Wayne	0.22	Silty	Warm Moist	161	10507	5	3177	93	4277
Illinois	White	0.23	Silty	Warm Moist	160	10463	5	3324	101	4660
Illinois	Whiteside	0.23	Silty	Cool Moist	192	12557	7	4084	86	3964
Illinois	Will	0.24	Silty	Cool Moist	174	11384	6	3517	106	4879
Illinois	Williamson	0.23	Silty	Warm Moist	144	9409	5	3048	101	4689
Illinois	Winnebago	0.23	Silty	Cool Moist	180	11786	6	3672	106	4893
Illinois	Woodford	0.23	Silty	Warm Moist	203	13248	7	4262	101	4676
Indiana	Adams	0.21	Silty	Cool Moist	161	10010	8	3521	101	4560
Indiana	Allen	0.21	Silty	Cool Moist	164	10160	8	3469	109	4943
Indiana	Bartholomew	0.22	Silty	Warm Moist	176	10911	8	3648	118	5328
Indiana	Benton	0.24	Silty	Cool Moist	193	11994	9	4028	101	4584
Indiana	Blackford	0.21	Silty	Cool Moist	170	10539	8	3692	97	4383
Indiana	Boone	0.23	Silty	Warm Moist	178	11013	8	3769	127	5743
Indiana	Brown	0.22	Silty	Warm Moist	171	10588	7	3413	101	4584
Indiana	Carroll	0.23	Silty	Warm Moist	189	11748	9	4040	117	5286

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Indiana	Cass	0.23	Silty	Cool Moist	176	10915	8	3806	109	4955
Indiana	Clark	0.24	Silty	Warm Moist	156	9699	7	3064	94	4241
Indiana	Clay	0.22	Silty	Warm Moist	181	11227	8	3484	87	3939
Indiana	Clinton	0.23	Silty	Warm Moist	186	11552	9	4069	64	2899
Indiana	Crawford	0.24	Silty	Warm Moist	128	7934	7	3168	101	4584
Indiana	Daviess	0.22	Silty	Warm Moist	183	11360	8	3697	91	4134
Indiana	Dearborn	0.22	Silty	Warm Moist	160	9897	7	3045	95	4328
Indiana	Decatur	0.22	Silty	Warm Moist	189	11722	9	3965	108	4919
Indiana	DeKalb	0.21	Silty	Cool Moist	163	10109	7	3270	111	5044
Indiana	Delaware	0.22	Silty	Warm Moist	165	10241	8	3551	89	4035
Indiana	Dubois	0.23	Silty	Warm Moist	174	10770	8	3788	100	4549
Indiana	Elkhart	0.22	Silty	Cool Moist	165	10224	8	3579	101	4578
Indiana	Fayette	0.22	Silty	Warm Moist	183	11343	8	3693	112	5069
Indiana	Floyd	0.24	Silty	Warm Moist	146	9062	6	2822	47	2152
Indiana	Fountain	0.24	Silty	Warm Moist	184	11401	8	3795	106	4798
Indiana	Franklin	0.22	Silty	Warm Moist	177	10965	8	3584	94	4241
Indiana	Fulton	0.22	Silty	Cool Moist	178	11030	8	3580	96	4347
Indiana	Gibson	0.22	Silty	Warm Moist	181	11253	8	3770	112	5090
Indiana	Grant	0.22	Silty	Cool Moist	172	10652	8	3638	109	4950
Indiana	Greene	0.21	Silty	Warm Moist	159	9886	7	3344	101	4580
Indiana	Hamilton	0.22	Silty	Warm Moist	164	10191	8	3769	105	4741
Indiana	Hancock	0.22	Silty	Warm Moist	163	10119	7	3402	111	5045
Indiana	Harrison	0.24	Silty	Warm Moist	164	10150	7	3267	89	4051
Indiana	Hendricks	0.22	Silty	Warm Moist	181	11233	8	3775	112	5088
Indiana	Henry	0.22	Silty	Warm Moist	179	11091	8	3578	107	4873
Indiana	Howard	0.22	Silty	Cool Moist	190	11794	8	3866	116	5246
Indiana	Huntington	0.22	Silty	Cool Moist	166	10267	8	3609	103	4687
Indiana	Jackson	0.22	Silty	Warm Moist	165	10241	7	3410	102	4602
Indiana	Jasper	0.23	Silty	Cool Moist	158	9822	8	3440	101	4584
Indiana	Jay	0.21	Silty	Cool Moist	160	9897	8	3516	104	4737
Indiana	Jefferson	0.23	Silty	Warm Moist	157	9754	6	2827	92	4170
Indiana	Jennings	0.22	Silty	Warm Moist	163	10109	7	3411	109	4938
Indiana	Johnson	0.22	Silty	Warm Moist	166	10317	8	3714	117	5291
Indiana	Knox	0.21	Silty	Warm Moist	177	10958	8	3590	93	4225
Indiana	Kosciusko	0.22	Silty	Cool Moist	174	10802	8	3571	107	4842
Indiana	LaGrange	0.22	Silty	Cool Moist	142	8808	8	3458	107	4860
Indiana	Lake	0.24	Silty	Cool Moist	174	10802	8	3455	104	4721
Indiana	LaPorte	0.23	Silty	Cool Moist	154	9551	8	3609	110	4985
Indiana	Lawrence	0.23	Silty	Warm Moist	166	10309	7	3292	105	4761
Indiana	Madison	0.22	Silty	Warm Moist	171	10630	8	3623	92	4190
Indiana	Marion	0.22	Silty	Warm Moist	158	9792	7	3241	101	4584
Indiana	Marshall	0.22	Silty	Cool Moist	169	10477	8	3480	104	4718
Indiana	Martin	0.22	Silty	Warm Moist	166	10315	7	3332	75	3396
Indiana	Miami	0.22	Silty	Cool Moist	169	10487	8	3461	108	4907
Indiana	Monroe	0.22	Silty	Warm Moist	160	9939	7	3216	101	4584

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Indiana	Montgomery	0.23	Silty	Warm Moist	194	12026	9	4065	122	5528
Indiana	Morgan	0.22	Silty	Warm Moist	174	10783	8	3531	96	4354
Indiana	Newton	0.24	Silty	Cool Moist	182	11308	8	3727	93	4230
Indiana	Noble	0.22	Silty	Cool Moist	171	10619	8	3494	107	4845
Indiana	Ohio	0.23	Silty	Warm Moist	162	10037	7	3185	94	4250
Indiana	Orange	0.23	Silty	Warm Moist	184	11427	8	3819	101	4584
Indiana	Owen	0.21	Silty	Warm Moist	165	10253	7	3111	115	5212
Indiana	Parke	0.23	Silty	Warm Moist	181	11219	8	3716	115	5203
Indiana	Perry	0.24	Silty	Warm Moist	182	11273	7	3100	76	3450
Indiana	Pike	0.22	Silty	Warm Moist	148	9195	8	3457	85	3836
Indiana	Porter	0.23	Silty	Cool Moist	177	10976	8	3718	112	5060
Indiana	Posey	0.23	Silty	Warm Moist	179	11086	8	3746	109	4950
Indiana	Pulaski	0.23	Silty	Cool Moist	159	9852	7	3278	101	4584
Indiana	Putnam	0.22	Silty	Warm Moist	179	11071	8	3841	82	3699
Indiana	Randolph	0.21	Silty	Cool Moist	169	10488	8	3609	99	4503
Indiana	Ripley	0.22	Silty	Warm Moist	173	10755	7	3338	91	4120
Indiana	Rush	0.22	Silty	Warm Moist	188	11647	9	3892	114	5182
Indiana	St. Joseph	0.22	Silty	Cool Moist	160	9926	7	3368	100	4535
Indiana	Scott	0.23	Silty	Warm Moist	166	10311	7	3228	101	4584
Indiana	Shelby	0.22	Silty	Warm Moist	174	10780	8	3773	112	5092
Indiana	Spencer	0.23	Silty	Warm Moist	169	10473	8	3618	116	5266
Indiana	Starke	0.23	Silty	Cool Moist	141	8762	7	3363	66	2972
Indiana	Steuben	0.21	Silty	Cool Moist	154	9574	7	3268	108	4876
Indiana	Sullivan	0.21	Silty	Warm Moist	174	10785	8	3520	99	4472
Indiana	Switzerland	0.23	Silty	Warm Moist	160	9902	7	3373	73	3329
Indiana	Tippecanoe	0.23	Silty	Warm Moist	180	11133	8	3768	108	4880
Indiana	Tipton	0.22	Silty	Warm Moist	189	11706	9	4025	115	5214
Indiana	Union	0.21	Silty	Warm Moist	185	11486	8	3845	95	4304
Indiana	Vanderburgh	0.23	Silty	Warm Moist	174	10817	9	3910	100	4555
Indiana	Vermillion	0.23	Silty	Warm Moist	184	11380	8	3809	101	4584
Indiana	Vigo	0.22	Silty	Warm Moist	177	10967	8	3450	95	4315
Indiana	Wabash	0.22	Silty	Cool Moist	177	10954	8	3599	109	4943
Indiana	Warren	0.24	Silty	Warm Moist	202	12501	9	4238	105	4768
Indiana	Warrick	0.23	Silty	Warm Moist	159	9875	8	3562	105	4757
Indiana	Washington	0.23	Silty	Warm Moist	161	9978	7	3321	82	3722
Indiana	Wayne	0.21	Silty	Warm Moist	174	10790	8	3739	96	4346
Indiana	Wells	0.21	Silty	Cool Moist	169	10497	8	3618	104	4717
Indiana	White	0.23	Silty	Cool Moist	178	11011	8	3825	120	5425
Indiana	Whitley	0.22	Silty	Cool Moist	168	10416	8	3516	105	4775
Iowa	Adair	0.23	Silty	Cool Moist	137	10898	2	3609	89	4052
Iowa	Adams	0.23	Silty	Cool Moist	139	11118	2	3574	89	4052
Iowa	Allamakee	0.22	Silty	Cool Moist	150	12009	2	3637	89	4052
Iowa	Appanoose	0.23	Silty	Warm Moist	133	10630	2	3361	89	4052
Iowa	Audubon	0.23	Silty	Cool Moist	158	12592	2	3876	89	4052
Iowa	Benton	0.23	Silty	Cool Moist	160	12741	3	3956	89	4052

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Iowa	Black Hawk	0.23	Silty	Cool Moist	160	12802	2	3868	89	4052
Iowa	Boone	0.23	Silty	Cool Moist	154	12323	2	3745	89	4052
Iowa	Bremer	0.23	Silty	Cool Moist	165	13197	2	3875	89	4052
Iowa	Buchanan	0.23	Silty	Cool Moist	164	13112	2	3849	89	4052
Iowa	Buena Vista	0.18	Sandy	Cool Moist	153	12247	2	3837	89	4052
Iowa	Butler	0.23	Silty	Cool Moist	162	12965	2	3828	89	4052
Iowa	Calhoun	0.21	Silty	Cool Moist	156	12418	2	3809	89	4052
Iowa	Carroll	0.23	Silty	Cool Moist	163	13029	3	3966	89	4052
Iowa	Cass	0.23	Silty	Cool Moist	150	12011	2	3809	89	4052
Iowa	Cedar	0.22	Silty	Cool Moist	164	13086	3	4040	89	4052
Iowa	Cerro Gordo	0.23	Silty	Cool Moist	153	12247	2	3727	89	4052
Iowa	Cherokee	0.18	Sandy	Cool Moist	166	13246	3	4274	89	4052
Iowa	Chickasaw	0.23	Silty	Cool Moist	159	12664	2	3628	89	4052
Iowa	Clarke	0.23	Silty	Cool Moist	125	10003	2	3118	89	4052
Iowa	Clay	0.19	Silty	Cool Moist	149	11877	2	3816	89	4052
Iowa	Clayton	0.22	Silty	Cool Moist	160	12756	3	3957	89	4052
Iowa	Clinton	0.22	Silty	Cool Moist	161	12833	3	3988	89	4052
Iowa	Crawford	0.23	Silty	Cool Moist	170	13598	3	4139	89	4052
Iowa	Dallas	0.23	Silty	Cool Moist	148	11833	2	3707	89	4052
Iowa	Davis	0.22	Silty	Warm Moist	118	9390	2	3345	89	4052
Iowa	Decatur	0.24	Silty	Cool Moist	135	10802	2	3398	89	4052
Iowa	Delaware	0.22	Silty	Cool Moist	164	13125	3	4161	89	4052
Iowa	Des Moines	0.21	Silty	Warm Moist	151	12031	3	3946	89	4052
Iowa	Dickinson	0.21	Silty	Cool Moist	143	11412	2	3649	89	4052
Iowa	Dubuque	0.22	Silty	Cool Moist	165	13204	3	4018	89	4052
Iowa	Emmet	0.22	Silty	Cool Moist	151	12047	2	3736	89	4052
Iowa	Fayette	0.23	Silty	Cool Moist	158	12585	2	3859	89	4052
Iowa	Floyd	0.23	Silty	Cool Moist	155	12346	2	3681	89	4052
Iowa	Franklin	0.23	Silty	Cool Moist	160	12781	2	3872	89	4052
Iowa	Fremont	0.24	Silty	Warm Moist	149	11931	2	3670	89	4052
Iowa	Greene	0.23	Silty	Cool Moist	157	12546	2	3813	89	4052
Iowa	Grundy	0.23	Silty	Cool Moist	165	13190	3	4131	89	4052
Iowa	Guthrie	0.23	Silty	Cool Moist	152	12100	2	3742	89	4052
Iowa	Hamilton	0.23	Silty	Cool Moist	156	12413	2	3683	89	4052
Iowa	Hancock	0.23	Silty	Cool Moist	153	12198	2	3796	89	4052
Iowa	Hardin	0.23	Silty	Cool Moist	163	13028	2	3879	89	4052
Iowa	Harrison	0.24	Silty	Cool Moist	150	11978	2	3642	89	4052
Iowa	Henry	0.21	Silty	Warm Moist	146	11650	3	3937	89	4052
Iowa	Howard	0.23	Silty	Cool Moist	155	12374	2	3681	89	4052
Iowa	Humboldt	0.21	Silty	Cool Moist	151	12087	2	3778	89	4052
Iowa	Ida	0.20	Silty	Cool Moist	168	13448	3	4265	89	4052
Iowa	Iowa	0.23	Silty	Cool Moist	162	12916	2	3747	89	4052
Iowa	Jackson	0.22	Silty	Cool Moist	155	12336	3	3980	89	4052
Iowa	Jasper	0.23	Silty	Cool Moist	165	13132	3	3980	89	4052
Iowa	Jefferson	0.22	Silty	Warm Moist	140	11200	2	3586	89	4052

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Iowa	Johnson	0.22	Silty	Cool Moist	155	12338	2	3810	89	4052
Iowa	Jones	0.22	Silty	Cool Moist	160	12764	2	3871	89	4052
Iowa	Keokuk	0.23	Silty	Cool Moist	149	11866	2	3707	89	4052
Iowa	Kossuth	0.22	Silty	Cool Moist	155	12405	3	3987	89	4052
Iowa	Lee	0.21	Silty	Warm Moist	140	11191	2	3785	89	4052
Iowa	Linn	0.23	Silty	Cool Moist	165	13131	2	3852	89	4052
Iowa	Louisa	0.22	Silty	Warm Moist	153	12172	2	3837	89	4052
Iowa	Lucas	0.23	Silty	Cool Moist	130	10338	2	3134	89	4052
Iowa	Lyon	0.21	Silty	Cool Dry	158	12571	3	4121	89	4052
Iowa	Madison	0.23	Silty	Cool Moist	137	10943	2	3587	89	4052
Iowa	Mahaska	0.23	Silty	Cool Moist	153	12174	2	3800	89	4052
Iowa	Marion	0.23	Silty	Cool Moist	145	11583	2	3736	89	4052
Iowa	Marshall	0.23	Silty	Cool Moist	169	13514	3	4143	89	4052
Iowa	Mills	0.24	Silty	Cool Moist	152	12164	2	3766	89	4052
Iowa	Mitchell	0.23	Silty	Cool Moist	158	12584	2	3773	89	4052
Iowa	Monona	0.23	Silty	Cool Dry	147	11735	2	3722	89	4052
Iowa	Monroe	0.23	Silty	Warm Moist	134	10658	2	3574	89	4052
Iowa	Montgomery	0.24	Silty	Cool Moist	152	12128	2	3700	89	4052
Iowa	Muscatine	0.22	Silty	Cool Moist	153	12181	3	3957	89	4052
Iowa	O'Brien	0.19	Silty	Cool Moist	163	13008	3	4098	89	4052
Iowa	Osceola	0.21	Silty	Cool Moist	155	12336	2	3810	89	4052
Iowa	Page	0.24	Silty	Warm Moist	145	11602	2	3619	89	4052
Iowa	Palo Alto	0.20	Silty	Cool Moist	149	11864	2	3785	89	4052
Iowa	Plymouth	0.18	Silty	Cool Dry	163	13023	3	4154	89	4052
Iowa	Pocahontas	0.19	Silty	Cool Moist	154	12277	2	3808	89	4052
Iowa	Polk	0.23	Silty	Cool Moist	153	12177	2	3619	89	4052
Iowa	Pottawattamie	0.24	Silty	Cool Moist	161	12839	3	3944	89	4052
Iowa	Poweshiek	0.23	Silty	Cool Moist	164	13120	2	3793	89	4052
Iowa	Ringgold	0.24	Silty	Warm Moist	127	10175	2	3210	89	4052
Iowa	Sac	0.20	Silty	Cool Moist	165	13152	3	4059	89	4052
Iowa	Scott	0.22	Silty	Cool Moist	163	12995	3	4211	89	4052
Iowa	Shelby	0.24	Silty	Cool Moist	161	12856	3	3933	89	4052
Iowa	Sioux	0.19	Silty	Cool Dry	163	13042	3	4327	89	4052
Iowa	Story	0.23	Silty	Cool Moist	154	12325	2	3633	89	4052
Iowa	Tama	0.23	Silty	Cool Moist	165	13151	3	3960	89	4052
Iowa	Taylor	0.24	Silty	Warm Moist	128	10215	2	3459	89	4052
Iowa	Union	0.23	Silty	Cool Moist	129	10288	2	3356	89	4052
Iowa	Van Buren	0.22	Silty	Warm Moist	130	10387	2	3328	89	4052
Iowa	Wapello	0.22	Silty	Warm Moist	135	10760	2	3595	89	4052
Iowa	Warren	0.23	Silty	Cool Moist	138	11011	2	3525	89	4052
Iowa	Washington	0.22	Silty	Warm Moist	160	12764	3	3936	89	4052
Iowa	Wayne	0.23	Silty	Cool Moist	129	10288	2	3374	89	4052
Iowa	Webster	0.22	Silty	Cool Moist	156	12437	2	3650	89	4052
Iowa	Winnebago	0.23	Silty	Cool Moist	156	12451	2	3871	89	4052
Iowa	Winneshiek	0.23	Silty	Cool Moist	156	12484	2	3711	89	4052

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Iowa	Woodbury	0.20	Silty	Cool Dry	164	13106	3	3927	89	4052
Iowa	Worth	0.23	Silty	Cool Moist	152	12159	2	3727	89	4052
Iowa	Wright	0.23	Silty	Cool Moist	155	12340	2	3798	89	4052
Kansas	Allen	0.23	Silty	Warm Moist	143	7748	7	2791	57	2878
Kansas	Anderson	0.23	Silty	Warm Moist	140	7584	7	2920	58	2924
Kansas	Atchison	0.24	Silty	Warm Moist	167	9068	8	3299	54	2729
Kansas	Barber	0.22	Silty	Warm Dry	163	8853	4	1796	62	3096
Kansas	Barton	0.23	Silty	Warm Dry	172	9327	5	2076	64	3201
Kansas	Bourbon	0.23	Silty	Warm Moist	138	7479	6	2446	66	3329
Kansas	Brown	0.24	Silty	Warm Moist	179	9745	9	3544	72	3627
Kansas	Butler	0.23	Silty	Warm Dry	142	7741	7	2794	59	2961
Kansas	Chase	0.23	Silty	Warm Dry	151	8208	7	3080	61	3073
Kansas	Chautauqua	0.23	Silty	Warm Moist	114	6195	6	2358	59	2981
Kansas	Cherokee	0.24	Silty	Warm Moist	157	8549	7	2697	73	3663
Kansas	Cheyenne	0.23	Silty	Warm Dry	168	9108	9	3840	67	3378
Kansas	Clark	0.23	Silty	Warm Dry	155	8417	7	2917	61	3067
Kansas	Clay	0.23	Silty	Warm Dry	162	8794	7	3022	69	3439
Kansas	Cloud	0.23	Silty	Warm Dry	194	10557	7	3013	68	3430
Kansas	Coffey	0.23	Silty	Warm Moist	138	7507	6	2665	61	3070
Kansas	Comanche	0.22	Silty	Warm Dry	159	8618	7	2917	52	2607
Kansas	Cowley	0.22	Silty	Warm Dry	114	6216	6	2453	48	2399
Kansas	Crawford	0.24	Silty	Warm Moist	134	7278	6	2619	69	3445
Kansas	Decatur	0.23	Silty	Warm Dry	112	6082	7	2777	70	3517
Kansas	Dickinson	0.23	Silty	Warm Dry	149	8094	6	2681	65	3257
Kansas	Doniphan	0.24	Silty	Warm Moist	203	11030	9	3903	62	3096
Kansas	Douglas	0.24	Silty	Warm Moist	142	7740	7	2799	53	2670
Kansas	Edwards	0.23	Silty	Warm Dry	198	10771	9	3591	60	3026
Kansas	Elk	0.23	Silty	Warm Moist	137	7444	6	2521	62	3098
Kansas	Ellis	0.23	Silty	Warm Dry	79	4268	7	2917	55	2751
Kansas	Ellsworth	0.23	Silty	Warm Dry	93	5063	8	3235	60	3015
Kansas	Finney	0.23	Silty	Warm Dry	180	9785	10	4183	55	2757
Kansas	Ford	0.23	Silty	Warm Dry	214	11612	7	2917	66	3290
Kansas	Franklin	0.24	Silty	Warm Moist	140	7585	7	2914	61	3083
Kansas	Geary	0.23	Silty	Warm Dry	178	9658	8	3143	63	3151
Kansas	Gove	0.23	Silty	Warm Dry	126	6831	8	3285	62	3110
Kansas	Graham	0.23	Silty	Warm Dry	151	8208	9	3521	62	3096
Kansas	Grant	0.23	Sandy	Warm Dry	210	11434	7	2917	60	3020
Kansas	Gray	0.23	Silty	Warm Dry	203	11012	10	4131	78	3901
Kansas	Greeley	0.24	Sandy	Warm Dry	120	6534	7	2917	58	2932
Kansas	Greenwood	0.23	Silty	Warm Moist	112	6063	6	2320	65	3246
Kansas	Hamilton	0.24	Sandy	Warm Dry	127	6902	7	2917	56	2830
Kansas	Harper	0.21	Silty	Warm Dry	94	5128	5	1871	47	2339
Kansas	Harvey	0.23	Silty	Warm Dry	138	7489	7	2734	60	3009
Kansas	Haskell	0.23	Silty	Warm Dry	203	11026	10	4265	62	3096
Kansas	Hodgeman	0.23	Silty	Warm Dry	208	11317	10	3997	62	3096

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Kansas	Jackson	0.24	Silty	Warm Moist	147	7990	7	2835	53	2673
Kansas	Jefferson	0.24	Silty	Warm Moist	169	9183	8	3272	54	2707
Kansas	Jewell	0.23	Silty	Warm Dry	155	8405	8	3099	56	2801
Kansas	Johnson	0.24	Silty	Warm Moist	79	4281	6	2293	78	3925
Kansas	Kearny	0.23	Sandy	Warm Dry	188	10231	7	2917	71	3578
Kansas	Kingman	0.22	Silty	Warm Dry	172	9332	6	2443	57	2865
Kansas	Kiowa	0.23	Silty	Warm Dry	151	8208	10	4072	69	3453
Kansas	Labette	0.23	Silty	Warm Moist	118	6398	6	2466	51	2576
Kansas	Lane	0.23	Silty	Warm Dry	205	11166	7	2917	75	3755
Kansas	Leavenworth	0.24	Silty	Warm Moist	145	7901	6	2680	63	3149
Kansas	Lincoln	0.23	Silty	Warm Dry	121	6569	7	2917	70	3537
Kansas	Linn	0.23	Silty	Warm Moist	151	8208	6	2502	58	2893
Kansas	Logan	0.23	Silty	Warm Dry	151	8208	7	2917	61	3063
Kansas	Lyon	0.23	Silty	Warm Moist	121	6578	6	2480	57	2840
Kansas	McPherson	0.23	Silty	Warm Dry	151	8216	6	2546	68	3412
Kansas	Marion	0.23	Silty	Warm Dry	121	6562	6	2546	63	3150
Kansas	Marshall	0.23	Silty	Warm Dry	148	8035	6	2634	71	3564
Kansas	Meade	0.23	Silty	Warm Dry	235	12754	11	4556	69	3480
Kansas	Miami	0.24	Silty	Warm Moist	156	8500	7	3032	73	3682
Kansas	Mitchell	0.23	Silty	Warm Dry	141	7647	8	3132	68	3407
Kansas	Montgomery	0.23	Silty	Warm Moist	125	6769	6	2476	58	2888
Kansas	Morris	0.23	Silty	Warm Dry	115	6249	6	2624	59	2944
Kansas	Morton	0.23	Sandy	Warm Dry	176	9546	7	2917	50	2502
Kansas	Nemaha	0.24	Silty	Warm Moist	139	7579	7	2729	76	3811
Kansas	Neosho	0.23	Silty	Warm Moist	135	7345	6	2596	58	2890
Kansas	Ness	0.23	Silty	Warm Dry	110	6003	7	2917	60	3024
Kansas	Norton	0.23	Silty	Warm Dry	151	8208	8	3215	48	2404
Kansas	Osage	0.23	Silty	Warm Moist	131	7112	7	2726	63	3155
Kansas	Osborne	0.23	Silty	Warm Dry	122	6656	6	2434	52	2625
Kansas	Ottawa	0.23	Silty	Warm Dry	150	8164	6	2381	60	3010
Kansas	Pawnee	0.23	Silty	Warm Dry	173	9421	8	3114	66	3318
Kansas	Phillips	0.23	Silty	Warm Dry	139	7532	7	2724	58	2927
Kansas	Pottawatomie	0.24	Silty	Warm Moist	157	8540	8	3143	61	3084
Kansas	Pratt	0.23	Silty	Warm Dry	194	10567	9	3658	61	3055
Kansas	Rawlins	0.23	Silty	Warm Dry	134	7261	7	2917	74	3712
Kansas	Reno	0.23	Silty	Warm Dry	159	8637	6	2310	59	2966
Kansas	Republic	0.23	Silty	Warm Dry	186	10097	8	3260	60	3006
Kansas	Rice	0.23	Silty	Warm Dry	148	8053	6	2381	74	3739
Kansas	Riley	0.23	Silty	Warm Dry	178	9701	7	2904	66	3302
Kansas	Rooks	0.23	Silty	Warm Dry	118	6401	4	1715	62	3119
Kansas	Rush	0.23	Silty	Warm Dry	149	8084	6	2663	47	2361
Kansas	Russell	0.23	Silty	Warm Dry	151	8208	5	2179	60	3011
Kansas	Saline	0.23	Silty	Warm Dry	113	6147	6	2408	59	2938
Kansas	Scott	0.23	Silty	Warm Dry	151	8227	9	3833	60	2993
Kansas	Sedgwick	0.22	Silty	Warm Dry	144	7815	7	2710	56	2822

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Kansas	Seward	0.23	Silty	Warm Dry	213	11595	11	4405	65	3270
Kansas	Shawnee	0.24	Silty	Warm Moist	157	8509	7	2816	62	3090
Kansas	Sheridan	0.23	Silty	Warm Dry	154	8382	7	2917	85	4270
Kansas	Sherman	0.23	Silty	Warm Dry	159	8659	9	3517	71	3568
Kansas	Smith	0.23	Silty	Warm Dry	168	9108	7	2703	62	3134
Kansas	Stafford	0.23	Silty	Warm Dry	164	8907	8	3275	62	3111
Kansas	Stanton	0.23	Sandy	Warm Dry	180	9764	7	2917	63	3161
Kansas	Stevens	0.23	Sandy	Warm Dry	203	11009	10	4015	60	3002
Kansas	Sumner	0.21	Silty	Warm Dry	118	6393	5	2204	51	2565
Kansas	Thomas	0.23	Silty	Warm Dry	135	7344	7	2917	54	2717
Kansas	Trego	0.23	Silty	Warm Dry	151	8208	6	2340	42	2118
Kansas	Wabaunsee	0.23	Silty	Warm Moist	126	6873	6	2280	66	3305
Kansas	Wallace	0.23	Silty	Warm Dry	157	8543	7	2917	58	2920
Kansas	Washington	0.23	Silty	Warm Dry	139	7576	6	2582	41	2051
Kansas	Wichita	0.23	Silty	Warm Dry	153	8320	9	3531	66	3313
Kansas	Wilson	0.23	Silty	Warm Moist	137	7425	7	2717	69	3479
Kansas	Woodson	0.23	Silty	Warm Moist	116	6289	6	2421	61	3073
Kansas	Wyandotte	0.24	Silty	Warm Moist	151	8208	7	2917	62	3096
Kentucky	Adair	0.24	Sandy	Warm Moist	165	10463	11	3712	83	3773
Kentucky	Allen	0.24	Sandy	Warm Moist	160	10132	9	3114	87	3961
Kentucky	Anderson	0.24	Silty	Warm Moist	139	8800	10	3268	97	4388
Kentucky	Ballard	0.24	Silty	Warm Moist	169	10685	10	3384	102	4608
Kentucky	Barren	0.24	Sandy	Warm Moist	174	11031	10	3405	96	4367
Kentucky	Bath	0.24	Silty	Warm Moist	141	8895	9	3087	67	3046
Kentucky	Bell	0.23	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Boone	0.23	Silty	Warm Moist	151	9557	11	3665	97	4388
Kentucky	Bourbon	0.24	Silty	Warm Moist	167	10575	10	3252	74	3371
Kentucky	Boyd	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Boyle	0.24	Silty	Warm Moist	175	11082	11	3488	97	4388
Kentucky	Bracken	0.22	Silty	Warm Moist	150	9464	10	3245	97	4388
Kentucky	Breathitt	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Breckinridge	0.24	Silty	Warm Moist	158	9999	10	3305	100	4538
Kentucky	Bullitt	0.24	Silty	Warm Moist	141	8919	9	2995	97	4388
Kentucky	Butler	0.24	Silty	Warm Moist	167	10589	10	3326	97	4388
Kentucky	Caldwell	0.24	Silty	Warm Moist	162	10242	10	3270	114	5180
Kentucky	Calloway	0.23	Silty	Warm Moist	146	9227	9	2907	95	4327
Kentucky	Campbell	0.22	Silty	Warm Moist	163	10338	10	3268	97	4388
Kentucky	Carlisle	0.23	Silty	Warm Moist	168	10598	10	3401	99	4474
Kentucky	Carroll	0.23	Silty	Warm Moist	152	9610	8	2663	97	4388
Kentucky	Carter	0.23	Silty	Warm Moist	125	7884	10	3268	97	4388
Kentucky	Casey	0.24	Silty	Warm Moist	151	9558	10	3461	97	4388
Kentucky	Christian	0.24	Silty	Warm Moist	183	11561	10	3303	119	5388
Kentucky	Clark	0.24	Silty	Warm Moist	166	10504	11	3544	72	3252
Kentucky	Clay	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Clinton	0.24	Silty	Warm Moist	156	9869	10	3322	97	4388

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Kentucky	Crittenden	0.24	Silty	Warm Moist	162	10231	10	3310	120	5441
Kentucky	Cumberland	0.24	Sandy	Warm Moist	183	11562	11	3555	97	4388
Kentucky	Daviess	0.24	Silty	Warm Moist	176	11145	11	3736	115	5204
Kentucky	Edmonson	0.24	Sandy	Warm Moist	161	10206	10	3201	97	4388
Kentucky	Elliott	0.23	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Estill	0.23	Silty	Warm Moist	131	8298	8	2616	97	4388
Kentucky	Fayette	0.24	Silty	Warm Moist	171	10832	10	3447	88	4006
Kentucky	Fleming	0.23	Silty	Warm Moist	147	9267	9	2952	86	3918
Kentucky	Floyd	0.21	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Franklin	0.24	Silty	Warm Moist	160	10095	11	3652	97	4388
Kentucky	Fulton	0.22	Silty	Warm Moist	179	11331	10	3381	101	4592
Kentucky	Gallatin	0.23	Silty	Warm Moist	162	10275	10	3161	82	3726
Kentucky	Garrard	0.24	Silty	Warm Moist	136	8618	10	3295	97	4388
Kentucky	Grant	0.23	Silty	Warm Moist	147	9323	10	3373	97	4388
Kentucky	Graves	0.23	Silty	Warm Moist	161	10154	10	3336	105	4741
Kentucky	Grayson	0.24	Silty	Warm Moist	155	9784	10	3405	78	3544
Kentucky	Green	0.24	Sandy	Warm Moist	163	10327	11	3568	72	3282
Kentucky	Greenup	0.22	Silty	Warm Moist	122	7697	9	3094	97	4388
Kentucky	Hancock	0.24	Silty	Warm Moist	182	11507	11	3579	97	4388
Kentucky	Hardin	0.24	Silty	Warm Moist	166	10493	10	3345	101	4565
Kentucky	Harlan	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Harrison	0.23	Silty	Warm Moist	169	10689	10	3154	89	4035
Kentucky	Hart	0.24	Silty	Warm Moist	155	9779	11	3474	97	4388
Kentucky	Henderson	0.23	Silty	Warm Moist	177	11206	11	3658	97	4394
Kentucky	Henry	0.23	Silty	Warm Moist	156	9839	9	2931	72	3268
Kentucky	Hickman	0.22	Silty	Warm Moist	173	10935	10	3383	104	4702
Kentucky	Hopkins	0.24	Silty	Warm Moist	152	9603	10	3268	97	4388
Kentucky	Jackson	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Jefferson	0.24	Silty	Warm Moist	168	10617	5	1681	97	4388
Kentucky	Jessamine	0.24	Silty	Warm Moist	144	9076	9	2881	97	4388
Kentucky	Johnson	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Kenton	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Knott	0.21	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Knox	0.23	Silty	Warm Moist	124	7846	10	3268	97	4388
Kentucky	Larue	0.24	Silty	Warm Moist	160	10095	11	3486	108	4882
Kentucky	Laurel	0.23	Silty	Warm Moist	135	8561	10	3268	97	4388
Kentucky	Lawrence	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Lee	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Leslie	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Letcher	0.21	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Lewis	0.23	Silty	Warm Moist	157	9935	10	3170	97	4388
Kentucky	Lincoln	0.24	Silty	Warm Moist	167	10532	10	3216	87	3932
Kentucky	Livingston	0.24	Silty	Warm Moist	151	9555	10	3170	97	4388
Kentucky	Logan	0.24	Silty	Warm Moist	182	11484	9	3108	115	5209
Kentucky	Lyon	0.24	Silty	Warm Moist	170	10733	9	2930	97	4388

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Kentucky	McCracken	0.24	Silty	Warm Moist	151	9572	10	3268	106	4787
Kentucky	McCreary	0.24	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	McLean	0.24	Silty	Warm Moist	178	11256	11	3672	102	4623
Kentucky	Madison	0.23	Silty	Warm Moist	149	9395	9	3123	97	4388
Kentucky	Magoffin	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Marion	0.24	Silty	Warm Moist	164	10355	11	3482	108	4896
Kentucky	Marshall	0.23	Silty	Warm Moist	144	9133	8	2773	98	4465
Kentucky	Martin	0.21	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Mason	0.23	Silty	Warm Moist	156	9836	11	3519	78	3540
Kentucky	Meade	0.24	Silty	Warm Moist	166	10523	11	3568	107	4853
Kentucky	Menifee	0.23	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Mercer	0.24	Silty	Warm Moist	173	10950	10	3334	119	5380
Kentucky	Metcalfe	0.24	Sandy	Warm Moist	179	11317	10	3439	97	4388
Kentucky	Monroe	0.24	Silty	Warm Moist	163	10290	10	3359	83	3746
Kentucky	Montgomery	0.24	Silty	Warm Moist	141	8944	10	3268	97	4388
Kentucky	Morgan	0.23	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Muhlenberg	0.24	Silty	Warm Moist	171	10827	10	3181	97	4385
Kentucky	Nelson	0.24	Silty	Warm Moist	176	11116	9	3082	109	4936
Kentucky	Nicholas	0.24	Silty	Warm Moist	156	9855	9	2984	97	4388
Kentucky	Ohio	0.24	Silty	Warm Moist	175	11065	11	3700	80	3638
Kentucky	Oldham	0.24	Silty	Warm Moist	154	9719	9	3046	93	4207
Kentucky	Owen	0.23	Silty	Warm Moist	139	8764	9	2808	97	4388
Kentucky	Owsley	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Pendleton	0.23	Silty	Warm Moist	154	9750	11	3489	97	4388
Kentucky	Perry	0.22	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Pike	0.20	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Powell	0.23	Silty	Warm Moist	148	9330	10	3268	97	4388
Kentucky	Pulaski	0.23	Silty	Warm Moist	174	11031	10	3427	80	3625
Kentucky	Robertson	0.23	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Rockcastle	0.23	Silty	Warm Moist	132	8339	9	3006	97	4388
Kentucky	Rowan	0.23	Silty	Warm Moist	131	8294	8	2569	97	4388
Kentucky	Russell	0.24	Sandy	Warm Moist	157	9944	10	3360	86	3901
Kentucky	Scott	0.24	Silty	Warm Moist	164	10380	10	3366	95	4297
Kentucky	Shelby	0.24	Silty	Warm Moist	165	10463	10	3365	93	4217
Kentucky	Simpson	0.24	Silty	Warm Moist	181	11426	10	3176	116	5246
Kentucky	Spencer	0.24	Silty	Warm Moist	159	10058	10	3391	84	3806
Kentucky	Taylor	0.24	Sandy	Warm Moist	172	10849	10	3348	97	4388
Kentucky	Todd	0.24	Silty	Warm Moist	178	11266	10	3270	115	5220
Kentucky	Trigg	0.24	Silty	Warm Moist	170	10741	10	3166	113	5141
Kentucky	Trimble	0.23	Silty	Warm Moist	152	9643	9	2862	74	3363
Kentucky	Union	0.24	Silty	Warm Moist	176	11127	11	3754	119	5406
Kentucky	Warren	0.24	Silty	Warm Moist	189	11933	10	3352	117	5317
Kentucky	Washington	0.24	Silty	Warm Moist	164	10363	9	3110	99	4506
Kentucky	Wayne	0.24	Silty	Warm Moist	193	12212	11	3476	121	5485
Kentucky	Webster	0.24	Silty	Warm Moist	169	10713	11	3548	107	4849

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Kentucky	Whitley	0.23	Silty	Warm Moist	113	7162	10	3268	97	4388
Kentucky	Wolfe	0.23	Silty	Warm Moist	160	10095	10	3268	97	4388
Kentucky	Woodford	0.24	Silty	Warm Moist	156	9860	11	3570	92	4176
Louisiana	Acadia	0.20	Silty	Warm Moist	154	10505	3	2299	72	3278
Louisiana	Allen	0.22	Silty	Warm Moist	154	10505	2	1601	72	3278
Louisiana	Ascension	0.36	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Assumption	0.34	Clayey	Warm Moist	154	10505	3	2780	72	3278
Louisiana	Avoyelles	0.28	Clayey	Warm Moist	151	10271	3	2925	72	3278
Louisiana	Beauregard	0.23	Silty	Warm Moist	154	10505	3	2495	72	3278
Louisiana	Bienville	0.24	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Bossier	0.24	Sandy	Warm Moist	154	10505	3	2396	72	3278
Louisiana	Caddo	0.24	Sandy	Warm Moist	122	8323	3	2794	72	3278
Louisiana	Calcasieu	0.25	Silty	Warm Moist	154	10505	2	2098	72	3278
Louisiana	Caldwell	0.29	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Cameron	0.24	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Catahoula	0.33	Clayey	Warm Moist	158	10731	3	2993	72	3278
Louisiana	Claiborne	0.24	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Concordia	0.34	Clayey	Warm Moist	161	10954	4	3521	72	3278
Louisiana	De Soto	0.24	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	East Baton Rouge	0.36	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	East Carroll	0.37	Clayey	Warm Moist	166	11323	5	4050	72	3278
Louisiana	East Feliciana	0.37	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Evangeline	0.24	Silty	Warm Moist	154	10505	2	2083	72	3278
Louisiana	Franklin	0.33	Clayey	Warm Moist	168	11424	4	3797	72	3278
Louisiana	Grant	0.24	Silty	Warm Moist	152	10363	3	2418	72	3278
Louisiana	Iberia	0.26	Sandy	Warm Moist	154	10505	3	2547	72	3278
Louisiana	Iberville	0.34	Clayey	Warm Moist	154	10505	4	3548	72	3278
Louisiana	Jackson	0.25	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Jefferson	0.42	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Jefferson Davis	0.21	Sandy	Warm Moist	154	10505	2	1888	72	3278
Louisiana	Lafayette	0.24	Silty	Warm Moist	154	10505	3	2394	72	3278
Louisiana	Lafourche	0.40	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	LaSalle	0.28	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Lincoln	0.24	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Livingston	0.36	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Madison	0.37	Clayey	Warm Moist	154	10473	4	3537	72	3278
Louisiana	Morehouse	0.32	Clayey	Warm Moist	166	11289	4	3697	72	3278
Louisiana	Natchitoches	0.24	Sandy	Warm Moist	127	8647	3	2572	72	3278
Louisiana	Orleans	0.41	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Ouachita	0.28	Clayey	Warm Moist	163	11078	4	3201	72	3278
Louisiana	Plaquemines	0.42	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Pointe Coupee	0.32	Clayey	Warm Moist	166	11318	4	3325	72	3278
Louisiana	Rapides	0.24	Silty	Warm Moist	140	9547	3	2947	72	3278
Louisiana	Red River	0.24	Sandy	Warm Moist	145	9859	3	2448	72	3278
Louisiana	Richland	0.33	Clayey	Warm Moist	171	11643	4	3403	72	3278

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
Louisiana	Sabine	0.24	Silty	Warm Moist	154	10505	3	2864	72	3278
Louisiana	St. Bernard	0.39	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	St. Charles	0.40	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	St. Helena	0.37	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	St. James	0.37	Clayey	Warm Moist	154	10505	3	2508	72	3278
Louisiana	St. John the Baptist	0.38	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	St. Landry	0.25	Silty	Warm Moist	150	10220	3	2522	72	3278
Louisiana	St. Martin	0.28	Clayey	Warm Moist	154	10505	3	2395	72	3278
Louisiana	St. Mary	0.29	Sandy	Warm Moist	154	10505	3	2941	72	3278
Louisiana	St. Tammany	0.38	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Tangipahoa	0.37	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Tensas	0.36	Clayey	Warm Moist	158	10719	4	3724	72	3278
Louisiana	Terrebonne	0.38	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Union	0.25	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Vermilion	0.18	Sandy	Warm Moist	154	10505	3	2223	72	3278
Louisiana	Vernon	0.23	Silty	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Washington	0.36	Clayey	Warm Moist	154	10505	3	2511	72	3278
Louisiana	Webster	0.24	Sandy	Warm Moist	154	10505	3	2864	72	3278
Louisiana	West Baton Rouge	0.34	Clayey	Warm Moist	154	10505	4	3860	72	3278
Louisiana	West Carroll	0.36	Clayey	Warm Moist	160	10910	4	3788	72	3278
Louisiana	West Feliciana	0.35	Clayey	Warm Moist	154	10505	3	2864	72	3278
Louisiana	Winn	0.25	Sandy	Warm Moist	154	10505	3	2864	72	3278
Maine	Androscoggin	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Aroostook	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Cumberland	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Franklin	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Hancock	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Kennebec	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Knox	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Lincoln	0.09	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Oxford	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Penobscot	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Piscataquis	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Sagadahoc	0.09	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Somerset	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Waldo	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	Washington	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maine	York	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Maryland	Allegany	0.21	Silty	Warm Moist	112	7597	5	2884	102	4632
Maryland	Anne Arundel	0.18	Sandy	Warm Moist	137	9352	4	2504	102	4632
Maryland	Baltimore	0.19	Sandy	Warm Moist	150	10198	6	3327	102	4632
Maryland	Calvert	0.21	Silty	Warm Moist	108	7380	3	1984	102	4632
Maryland	Caroline	0.18	Sandy	Warm Moist	149	10142	5	2776	93	4198
Maryland	Carroll	0.20	Silty	Warm Moist	156	10645	5	3180	109	4925
Maryland	Cecil	0.19	Sandy	Warm Moist	153	10394	6	3278	119	5380

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Maryland	Charles	0.22	Silty	Warm Moist	107	7312	3	1913	102	4632
Maryland	Dorchester	0.21	Silty	Warm Moist	166	11282	5	3032	98	4442
Maryland	Frederick	0.21	Silty	Warm Moist	148	10057	6	3344	94	4241
Maryland	Garrett	0.21	Silty	Cool Moist	127	8654	5	2884	102	4632
Maryland	Harford	0.19	Sandy	Warm Moist	159	10805	6	3348	104	4712
Maryland	Howard	0.20	Silty	Warm Moist	163	11072	6	3450	115	5219
Maryland	Kent	0.17	Sandy	Warm Moist	152	10313	6	3406	111	5037
Maryland	Montgomery	0.21	Silty	Warm Moist	151	10306	4	2186	102	4632
Maryland	Prince George's	0.21	Sandy	Warm Moist	104	7077	5	2710	102	4632
Maryland	Queen Anne's	0.17	Sandy	Warm Moist	151	10270	5	3090	101	4563
Maryland	St. Mary's	0.23	Silty	Warm Moist	134	9085	4	2598	102	4632
Maryland	Somerset	0.23	Silty	Warm Moist	130	8856	5	3001	107	4864
Maryland	Talbot	0.20	Sandy	Warm Moist	137	9330	5	2793	100	4556
Maryland	Washington	0.21	Silty	Warm Moist	139	9478	5	3174	110	4974
Maryland	Wicomico	0.22	Silty	Warm Moist	125	8511	4	2608	78	3517
Maryland	Worcester	0.23	Silty	Warm Moist	138	9381	5	2873	93	4227
Maryland	Baltimore	0.19	Sandy	Warm Moist	139	9456	5	2884	102	4632
Massachusetts	Barnstable	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Berkshire	0.12	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Bristol	0.09	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Dukes	0.09	Sandy	Warm Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Essex	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Franklin	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Hampden	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Hampshire	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Middlesex	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Nantucket	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Norfolk	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Plymouth	0.09	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Suffolk	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Massachusetts	Worcester	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Michigan	Alcona	0.09	Sandy	Cool Moist	116	7846	6	2367	100	4847
Michigan	Alger	0.05	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Allegan	0.25	Sandy	Cool Moist	149	10047	8	3173	93	4506
Michigan	Alpena	0.08	Sandy	Cool Moist	104	7054	5	2145	85	4099
Michigan	Antrim	0.08	Sandy	Cool Moist	105	7109	7	2952	100	4847
Michigan	Arenac	0.12	Sandy	Cool Moist	138	9363	7	3028	103	4968
Michigan	Baraga	0.04	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Barry	0.17	Sandy	Cool Moist	141	9533	8	3152	97	4696
Michigan	Bay	0.12	Sandy	Cool Moist	151	10190	8	3534	116	5594
Michigan	Benzie	0.24	Sandy	Cool Moist	104	7044	7	2952	100	4847
Michigan	Berrien	0.23	Silty	Cool Moist	158	10664	7	3070	106	5100
Michigan	Branch	0.21	Silty	Cool Moist	148	10007	7	3145	90	4362
Michigan	Calhoun	0.18	Sandy	Cool Moist	128	8677	7	2834	92	4459
Michigan	Cass	0.22	Silty	Cool Moist	142	9577	8	3272	81	3912

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Michigan	Charlevoix	0.07	Sandy	Cool Moist	95	6453	7	2952	100	4847
Michigan	Cheboygan	0.05	Sandy	Cool Moist	101	6848	7	2952	111	5353
Michigan	Chippewa	0.04	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Clare	0.05	Sandy	Cool Moist	114	7676	7	2754	90	4349
Michigan	Clinton	0.15	Sandy	Cool Moist	149	10106	7	3059	115	5551
Michigan	Crawford	0.04	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Delta	0.06	Sandy	Cool Moist	116	7852	7	2952	100	4847
Michigan	Dickinson	0.04	Sandy	Cool Moist	105	7112	7	2952	100	4847
Michigan	Eaton	0.15	Sandy	Cool Moist	144	9732	7	2977	96	4616
Michigan	Emmet	0.06	Sandy	Cool Moist	93	6277	7	2952	100	4847
Michigan	Genesee	0.20	Silty	Cool Moist	139	9395	6	2656	98	4751
Michigan	Gladwin	0.08	Sandy	Cool Moist	140	9461	7	3044	73	3517
Michigan	Gogebic	0.08	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Grand Traverse	0.13	Sandy	Cool Moist	111	7488	7	2784	100	4847
Michigan	Gratiot	0.12	Sandy	Cool Moist	152	10291	8	3376	113	5453
Michigan	Hillsdale	0.21	Silty	Cool Moist	147	9944	7	3042	106	5094
Michigan	Houghton	0.05	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Huron	0.19	Silty	Cool Moist	171	11561	8	3467	135	6538
Michigan	Ingham	0.18	Sandy	Cool Moist	144	9738	7	3139	111	5373
Michigan	Ionia	0.13	Sandy	Cool Moist	157	10625	8	3322	116	5587
Michigan	Iosco	0.13	Sandy	Cool Moist	123	8282	7	2811	100	4847
Michigan	Iron	0.04	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Isabella	0.07	Sandy	Cool Moist	138	9354	7	2981	103	4993
Michigan	Jackson	0.20	Silty	Cool Moist	126	8526	6	2709	102	4913
Michigan	Kalamazoo	0.20	Silty	Cool Moist	137	9271	8	3400	97	4696
Michigan	Kalkaska	0.07	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Kent	0.18	Sandy	Cool Moist	149	10073	8	3376	99	4798
Michigan	Keweenaw	0.06	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Lake	0.17	Sandy	Cool Moist	110	7425	7	2952	108	5232
Michigan	Lapeer	0.24	Silty	Cool Moist	158	10707	7	2925	104	5042
Michigan	Leelanau	0.16	Sandy	Cool Moist	88	5943	7	2952	100	4847
Michigan	Lenawee	0.21	Silty	Cool Moist	158	10663	8	3240	112	5428
Michigan	Livingston	0.20	Silty	Cool Moist	143	9647	8	3179	98	4747
Michigan	Luce	0.05	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Mackinac	0.06	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Macomb	0.32	Clayey	Cool Moist	153	10370	7	2940	103	4977
Michigan	Manistee	0.24	Sandy	Cool Moist	96	6503	7	2952	100	4847
Michigan	Marquette	0.04	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Mason	0.26	Sandy	Cool Moist	135	9104	7	3107	85	4125
Michigan	Mecosta	0.11	Sandy	Cool Moist	123	8298	6	2527	92	4434
Michigan	Menominee	0.08	Sandy	Cool Moist	107	7239	7	2952	100	4847
Michigan	Midland	0.10	Sandy	Cool Moist	153	10369	7	3126	111	5375
Michigan	Missaukee	0.07	Sandy	Cool Moist	131	8872	7	2952	100	4847
Michigan	Monroe	0.25	Silty	Cool Moist	156	10532	8	3204	102	4946
Michigan	Montcalm	0.11	Sandy	Cool Moist	139	9419	6	2724	102	4943

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Michigan	Montmorency	0.04	Sandy	Cool Moist	100	6732	6	2434	81	3907
Michigan	Muskegon	0.27	Sandy	Cool Moist	134	9034	7	3008	104	5007
Michigan	Newaygo	0.18	Sandy	Cool Moist	127	8554	6	2582	100	4810
Michigan	Oakland	0.25	Silty	Cool Moist	135	9134	7	2736	100	4847
Michigan	Oceana	0.26	Sandy	Cool Moist	126	8506	7	2939	80	3843
Michigan	Ogemaw	0.07	Sandy	Cool Moist	137	9234	7	3094	106	5099
Michigan	Ontonagon	0.06	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Osceola	0.09	Sandy	Cool Moist	112	7597	7	2739	92	4435
Michigan	Oscoda	0.05	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Otsego	0.04	Sandy	Cool Moist	91	6185	4	1849	73	3547
Michigan	Ottawa	0.27	Sandy	Cool Moist	144	9752	8	3294	99	4771
Michigan	Presque Isle	0.06	Sandy	Cool Moist	112	7587	4	1829	60	2878
Michigan	Roscommon	0.05	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Saginaw	0.15	Sandy	Cool Moist	154	10406	8	3221	115	5556
Michigan	St. Clair	0.33	Clayey	Cool Moist	151	10211	7	2893	108	5238
Michigan	St. Joseph	0.21	Silty	Cool Moist	119	8036	8	3386	105	5055
Michigan	Sanilac	0.27	Silty	Cool Moist	165	11124	8	3294	125	6018
Michigan	Schoolcraft	0.07	Sandy	Cool Moist	131	8870	7	2952	100	4847
Michigan	Shiawassee	0.17	Sandy	Cool Moist	145	9831	7	2963	102	4908
Michigan	Tuscola	0.18	Sandy	Cool Moist	163	10996	8	3349	119	5742
Michigan	Van Buren	0.24	Silty	Cool Moist	131	8870	7	2952	100	4847
Michigan	Washtenaw	0.22	Silty	Cool Moist	136	9169	7	2917	104	5010
Michigan	Wayne	0.28	Clayey	Cool Moist	117	7906	6	2330	100	4847
Michigan	Wexford	0.14	Sandy	Cool Moist	106	7177	7	2952	100	4847
Minnesota	Aitkin	0.15	Sandy	Cool Moist	82	6399	3	2042	126	4059
Minnesota	Anoka	0.21	Silty	Cool Moist	120	9365	3	2683	126	4059
Minnesota	Becker	0.36	Clayey	Cool Moist	136	10606	3	2732	126	4059
Minnesota	Beltrami	0.30	Clayey	Cool Moist	121	9434	3	2206	126	4059
Minnesota	Benton	0.21	Silty	Cool Moist	133	10396	4	3075	126	4059
Minnesota	Big Stone	0.24	Silty	Cool Dry	145	11338	4	3192	126	4059
Minnesota	Blue Earth	0.23	Silty	Cool Moist	154	12083	5	3773	126	4059
Minnesota	Brown	0.23	Silty	Cool Moist	147	11484	4	3544	126	4059
Minnesota	Carlton	0.16	Silty	Cool Moist	109	8515	4	3227	126	4059
Minnesota	Carver	0.22	Silty	Cool Moist	154	12012	5	3716	126	4059
Minnesota	Cass	0.21	Silty	Cool Moist	121	9434	4	3227	126	4059
Minnesota	Chippewa	0.24	Silty	Cool Dry	155	12139	4	3402	126	4059
Minnesota	Chisago	0.21	Silty	Cool Moist	124	9715	3	2703	126	4059
Minnesota	Clay	0.36	Silty	Cool Dry	137	10726	4	2826	126	4059
Minnesota	Clearwater	0.34	Clayey	Cool Moist	140	10915	3	2601	126	4059
Minnesota	Cook	0.08	Sandy	Cool Moist	141	11021	4	3227	126	4059
Minnesota	Cottonwood	0.24	Silty	Cool Moist	150	11763	5	3654	126	4059
Minnesota	Crow Wing	0.18	Sandy	Cool Moist	105	8202	3	2751	126	4059
Minnesota	Dakota	0.22	Silty	Cool Moist	158	12344	5	3640	126	4059
Minnesota	Dodge	0.23	Silty	Cool Moist	162	12641	5	3770	126	4059
Minnesota	Douglas	0.25	Silty	Cool Moist	144	11252	4	3045	126	4059

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Minnesota	Faribault	0.23	Silty	Cool Moist	157	12295	5	3897	126	4059
Minnesota	Fillmore	0.23	Silty	Cool Moist	159	12417	5	3677	126	4059
Minnesota	Freeborn	0.23	Silty	Cool Moist	155	12156	5	3706	126	4059
Minnesota	Goodhue	0.22	Silty	Cool Moist	159	12477	5	3832	126	4059
Minnesota	Grant	0.27	Silty	Cool Dry	148	11563	4	3156	126	4059
Minnesota	Hennepin	0.22	Silty	Cool Moist	142	11115	4	3294	126	4059
Minnesota	Houston	0.23	Silty	Cool Moist	152	11881	5	3625	126	4059
Minnesota	Hubbard	0.31	Clayey	Cool Moist	134	10517	4	3227	126	4059
Minnesota	Isanti	0.21	Silty	Cool Moist	125	9743	3	2576	126	4059
Minnesota	Itasca	0.15	Silty	Cool Moist	141	11021	4	3227	126	4059
Minnesota	Jackson	0.23	Silty	Cool Moist	148	11604	4	3571	126	4059
Minnesota	Kanabec	0.19	Silty	Cool Moist	133	10382	4	2936	126	4059
Minnesota	Kandiyohi	0.23	Silty	Cool Moist	156	12232	4	3499	126	4059
Minnesota	Kittson	0.27	Silty	Cool Dry	105	8213	3	2186	126	4059
Minnesota	Koochiching	0.28	Silty	Cool Moist	141	11021	3	2172	126	4059
Minnesota	Lac qui Parle	0.24	Silty	Cool Dry	151	11798	4	3515	126	4059
Minnesota	Lake	0.11	Silty	Cool Moist	141	11021	4	3227	126	4059
Minnesota	Lake of the Woods	0.33	Clayey	Cool Moist	141	11021	3	2340	126	4059
Minnesota	Le Sueur	0.22	Silty	Cool Moist	159	12441	5	3682	126	4059
Minnesota	Lincoln	0.24	Silty	Cool Dry	142	11075	4	3309	126	4059
Minnesota	Lyon	0.24	Silty	Cool Dry	150	11699	4	3572	126	4059
Minnesota	McLeod	0.22	Silty	Cool Moist	154	12017	4	3376	126	4059
Minnesota	Mahnomen	0.37	Clayey	Cool Moist	124	9737	3	2670	126	4059
Minnesota	Marshall	0.27	Silty	Cool Dry	108	8474	3	2231	126	4059
Minnesota	Martin	0.23	Silty	Cool Moist	154	12029	5	3844	126	4059
Minnesota	Meeker	0.23	Silty	Cool Moist	145	11317	4	3268	126	4059
Minnesota	Mille Lacs	0.20	Silty	Cool Moist	130	10146	4	2819	126	4059
Minnesota	Morrison	0.21	Silty	Cool Moist	132	10333	4	3051	126	4059
Minnesota	Mower	0.23	Silty	Cool Moist	159	12478	5	3742	126	4059
Minnesota	Murray	0.24	Silty	Cool Moist	147	11509	4	3486	126	4059
Minnesota	Nicollet	0.23	Silty	Cool Moist	161	12620	5	3828	126	4059
Minnesota	Nobles	0.23	Silty	Cool Moist	143	11215	4	3476	126	4059
Minnesota	Norman	0.37	Silty	Cool Dry	130	10152	3	2574	126	4059
Minnesota	Olmsted	0.23	Silty	Cool Moist	155	12162	5	3808	126	4059
Minnesota	Otter Tail	0.32	Clayey	Cool Moist	145	11380	4	2948	126	4059
Minnesota	Pennington	0.31	Clayey	Cool Dry	100	7849	3	2257	126	4059
Minnesota	Pine	0.18	Silty	Cool Moist	122	9583	4	2841	126	4059
Minnesota	Pipestone	0.24	Silty	Cool Moist	143	11174	4	3502	126	4059
Minnesota	Polk	0.33	Clayey	Cool Dry	131	10259	3	2631	126	4059
Minnesota	Pope	0.23	Silty	Cool Dry	150	11761	4	3331	126	4059
Minnesota	Ramsey	0.21	Silty	Cool Moist	141	11021	4	3227	126	4059
Minnesota	Red Lake	0.33	Clayey	Cool Dry	125	9770	3	2600	126	4059
Minnesota	Redwood	0.24	Silty	Cool Dry	152	11928	4	3579	126	4059
Minnesota	Renville	0.23	Silty	Cool Moist	155	12122	4	3583	126	4059
Minnesota	Rice	0.22	Silty	Cool Moist	156	12219	5	3766	126	4059

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Minnesota	Rock	0.23	Silty	Cool Dry	150	11771	5	3801	126	4059
Minnesota	Roseau	0.30	Clayey	Cool Moist	105	8177	3	2207	126	4059
Minnesota	St. Louis	0.15	Silty	Cool Moist	108	8474	4	3227	126	4059
Minnesota	Scott	0.22	Silty	Cool Moist	157	12277	5	3795	126	4059
Minnesota	Sherburne	0.21	Silty	Cool Moist	122	9583	4	3227	126	4059
Minnesota	Sibley	0.23	Silty	Cool Moist	154	12051	5	3660	126	4059
Minnesota	Stearns	0.22	Silty	Cool Moist	143	11165	4	3380	126	4059
Minnesota	Steele	0.23	Silty	Cool Moist	158	12353	5	3677	126	4059
Minnesota	Stevens	0.24	Silty	Cool Dry	153	11986	4	3231	126	4059
Minnesota	Swift	0.24	Silty	Cool Dry	152	11925	4	3336	126	4059
Minnesota	Todd	0.25	Silty	Cool Moist	126	9837	4	2888	126	4059
Minnesota	Traverse	0.25	Silty	Cool Dry	145	11323	4	3129	126	4059
Minnesota	Wabasha	0.22	Silty	Cool Moist	157	12255	5	3874	126	4059
Minnesota	Wadena	0.29	Sandy	Cool Moist	126	9841	4	2872	126	4059
Minnesota	Waseca	0.23	Silty	Cool Moist	160	12554	5	3891	126	4059
Minnesota	Washington	0.21	Silty	Cool Moist	155	12120	4	3502	126	4059
Minnesota	Watonwan	0.23	Silty	Cool Moist	150	11736	5	3753	126	4059
Minnesota	Wilkin	0.33	Clayey	Cool Dry	143	11185	4	2851	126	4059
Minnesota	Winona	0.23	Silty	Cool Moist	155	12158	5	3727	126	4059
Minnesota	Wright	0.22	Silty	Cool Moist	147	11491	4	3569	126	4059
Minnesota	Yellow Medicine	0.24	Silty	Cool Dry	151	11810	4	3480	126	4059
Mississippi	Adams	0.36	Clayey	Warm Moist	178	12133	1	3632	74	3343
Mississippi	Alcorn	0.32	Clayey	Warm Moist	137	9350	1	2499	74	3343
Mississippi	Amite	0.37	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Attala	0.33	Clayey	Warm Moist	145	9855	1	2423	74	3343
Mississippi	Benton	0.37	Clayey	Warm Moist	140	9559	1	2909	74	3343
Mississippi	Bolivar	0.38	Clayey	Warm Moist	167	11392	1	3711	80	3625
Mississippi	Calhoun	0.30	Sandy	Warm Moist	149	10121	1	2589	74	3343
Mississippi	Carroll	0.37	Clayey	Warm Moist	167	11330	1	3537	74	3343
Mississippi	Chickasaw	0.27	Sandy	Warm Moist	130	8850	1	2323	74	3343
Mississippi	Choctaw	0.30	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Claiborne	0.38	Clayey	Warm Moist	160	10918	1	3363	74	3343
Mississippi	Clarke	0.25	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Clay	0.26	Sandy	Warm Moist	132	8951	1	2922	74	3343
Mississippi	Coahoma	0.38	Clayey	Warm Moist	169	11485	1	3528	90	4066
Mississippi	Copiah	0.38	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Covington	0.33	Clayey	Warm Moist	145	9855	1	2589	74	3343
Mississippi	DeSoto	0.46	Clayey	Warm Moist	146	9936	1	2901	73	3305
Mississippi	Forrest	0.29	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Franklin	0.38	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	George	0.24	Sandy	Warm Moist	145	9855	1	2165	74	3343
Mississippi	Greene	0.24	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Grenada	0.35	Clayey	Warm Moist	139	9481	1	2350	74	3343
Mississippi	Hancock	0.34	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Harrison	0.30	Clayey	Warm Moist	145	9855	1	2892	74	3343

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
Mississippi	Hinds	0.37	Clayey	Warm Moist	141	9607	1	3112	74	3343
Mississippi	Holmes	0.37	Clayey	Warm Moist	171	11662	1	3423	74	3343
Mississippi	Humphreys	0.38	Clayey	Warm Moist	175	11925	1	3418	84	3818
Mississippi	Issaquena	0.38	Clayey	Warm Moist	171	11611	1	3334	81	3685
Mississippi	Itawamba	0.25	Sandy	Warm Moist	76	5194	1	2387	51	2327
Mississippi	Jackson	0.27	Silty	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Jasper	0.29	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Jefferson	0.38	Clayey	Warm Moist	145	9855	1	3699	74	3343
Mississippi	Jefferson Davis	0.37	Clayey	Warm Moist	127	8649	1	2892	74	3343
Mississippi	Jones	0.30	Sandy	Warm Moist	120	8191	1	2892	74	3343
Mississippi	Kemper	0.25	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Lafayette	0.34	Clayey	Warm Moist	133	9055	1	2443	74	3343
Mississippi	Lamar	0.33	Clayey	Warm Moist	145	9855	1	3026	74	3343
Mississippi	Lauderdale	0.25	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Lawrence	0.38	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Leake	0.32	Clayey	Warm Moist	117	7990	1	2892	74	3343
Mississippi	Lee	0.25	Sandy	Warm Moist	120	8141	1	2403	36	1614
Mississippi	Leflore	0.38	Clayey	Warm Moist	179	12177	1	3875	62	2811
Mississippi	Lincoln	0.38	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Lowndes	0.25	Sandy	Warm Moist	150	10177	1	2323	80	3621
Mississippi	Madison	0.36	Clayey	Warm Moist	143	9707	1	2931	74	3343
Mississippi	Marion	0.36	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Marshall	0.41	Clayey	Warm Moist	122	8285	1	2494	114	5172
Mississippi	Monroe	0.25	Sandy	Warm Moist	129	8799	1	2307	73	3302
Mississippi	Montgomery	0.33	Clayey	Warm Moist	142	9635	1	2405	74	3343
Mississippi	Neshoba	0.29	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Newton	0.28	Clayey	Warm Moist	123	8367	1	3410	74	3343
Mississippi	Noxubee	0.25	Sandy	Warm Moist	149	10172	1	2981	74	3343
Mississippi	Oktibbeha	0.26	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Panola	0.39	Clayey	Warm Moist	147	10023	1	2796	68	3087
Mississippi	Pearl River	0.32	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Perry	0.26	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Pike	0.38	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Pontotoc	0.28	Sandy	Warm Moist	113	7710	1	2274	74	3343
Mississippi	Prentiss	0.28	Sandy	Warm Moist	101	6904	1	2153	60	2724
Mississippi	Quitman	0.39	Clayey	Warm Moist	161	10928	1	2991	74	3343
Mississippi	Rankin	0.36	Clayey	Warm Moist	123	8396	1	3040	74	3343
Mississippi	Scott	0.32	Clayey	Warm Moist	115	7846	1	2614	74	3343
Mississippi	Sharkey	0.38	Clayey	Warm Moist	182	12376	1	3910	93	4230
Mississippi	Simpson	0.37	Clayey	Warm Moist	145	9855	1	2656	74	3343
Mississippi	Smith	0.32	Clayey	Warm Moist	145	9855	1	2011	74	3343
Mississippi	Stone	0.27	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Sunflower	0.38	Clayey	Warm Moist	175	11874	1	3788	55	2502
Mississippi	Tallahatchie	0.38	Clayey	Warm Moist	168	11434	1	3411	74	3343
Mississippi	Tate	0.43	Clayey	Warm Moist	154	10452	1	2982	85	3843

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Mississippi	Tippah	0.34	Clayey	Warm Moist	136	9228	1	2515	74	3343
Mississippi	Tishomingo	0.28	Sandy	Warm Moist	145	9855	1	2596	74	3343
Mississippi	Tunica	0.40	Clayey	Warm Moist	156	10616	1	3028	63	2872
Mississippi	Union	0.30	Sandy	Warm Moist	142	9629	1	2608	74	3343
Mississippi	Walthall	0.38	Clayey	Warm Moist	120	8191	1	2290	74	3343
Mississippi	Warren	0.38	Clayey	Warm Moist	158	10749	1	3271	74	3343
Mississippi	Washington	0.38	Clayey	Warm Moist	177	12056	1	4101	69	3132
Mississippi	Wayne	0.26	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Webster	0.30	Sandy	Warm Moist	134	9104	1	1984	74	3343
Mississippi	Wilkinson	0.36	Clayey	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Winston	0.28	Sandy	Warm Moist	145	9855	1	2892	74	3343
Mississippi	Yalobusha	0.35	Clayey	Warm Moist	169	11505	1	2414	74	3343
Mississippi	Yazoo	0.37	Clayey	Warm Moist	162	10999	1	3315	83	3776
Missouri	Adair	0.23	Silty	Warm Moist	174	9016	4	3067	110	4631
Missouri	Andrew	0.24	Silty	Warm Moist	190	9829	4	3339	110	4647
Missouri	Atchison	0.24	Silty	Warm Moist	211	10953	5	3472	93	3911
Missouri	Audrain	0.22	Silty	Warm Moist	184	9539	4	3176	117	4929
Missouri	Barry	0.25	Sandy	Warm Moist	155	8030	4	2845	108	4582
Missouri	Barton	0.24	Silty	Warm Moist	174	9022	4	2733	110	4644
Missouri	Bates	0.23	Silty	Warm Moist	196	10177	4	2979	93	3911
Missouri	Benton	0.22	Silty	Warm Moist	204	10583	4	3030	74	3141
Missouri	Bollinger	0.24	Sandy	Warm Moist	189	9808	3	2670	95	3997
Missouri	Boone	0.22	Silty	Warm Moist	187	9708	4	2912	99	4199
Missouri	Buchanan	0.24	Silty	Warm Moist	193	10011	4	3259	82	3486
Missouri	Butler	0.23	Silty	Warm Moist	196	10156	4	3024	50	2132
Missouri	Caldwell	0.24	Silty	Warm Moist	192	9936	4	2999	73	3076
Missouri	Callaway	0.22	Silty	Warm Moist	219	11342	4	3030	102	4311
Missouri	Camden	0.22	Silty	Warm Moist	179	9287	4	3030	93	3911
Missouri	Cape Girardeau	0.24	Silty	Warm Moist	177	9177	4	3078	91	3831
Missouri	Carroll	0.23	Silty	Warm Moist	187	9688	4	2881	87	3660
Missouri	Carter	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Cass	0.23	Silty	Warm Moist	186	9647	4	2878	79	3319
Missouri	Cedar	0.23	Silty	Warm Moist	155	8037	3	2623	92	3897
Missouri	Chariton	0.23	Silty	Warm Moist	193	9989	4	3048	99	4196
Missouri	Christian	0.25	Sandy	Warm Moist	119	6148	3	2623	93	3911
Missouri	Clark	0.22	Silty	Warm Moist	179	9287	4	3030	77	3248
Missouri	Clay	0.24	Silty	Warm Moist	185	9601	4	3258	69	2937
Missouri	Clinton	0.24	Silty	Warm Moist	172	8890	4	3090	93	3911
Missouri	Cole	0.22	Silty	Warm Moist	185	9596	4	3100	71	2985
Missouri	Cooper	0.22	Silty	Warm Moist	217	11245	5	3638	109	4617
Missouri	Crawford	0.24	Sandy	Warm Moist	179	9287	3	2508	93	3911
Missouri	Dade	0.24	Silty	Warm Moist	144	7488	4	2703	104	4404
Missouri	Dallas	0.23	Silty	Warm Moist	124	6402	3	2660	80	3363
Missouri	Daviess	0.24	Silty	Warm Moist	160	8298	4	2863	83	3512
Missouri	DeKalb	0.24	Silty	Warm Moist	154	7969	4	3030	93	3911

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Missouri	Dent	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Douglas	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Dunklin	0.26	Silty	Warm Moist	212	11006	4	2989	92	3875
Missouri	Franklin	0.23	Silty	Warm Moist	174	9018	4	3080	84	3537
Missouri	Gasconade	0.23	Silty	Warm Moist	157	8118	4	2956	98	4148
Missouri	Gentry	0.24	Silty	Warm Moist	168	8690	4	3033	84	3564
Missouri	Greene	0.24	Silty	Warm Moist	152	7866	4	2771	74	3131
Missouri	Grundy	0.24	Silty	Warm Moist	133	6898	4	2919	53	2219
Missouri	Harrison	0.24	Silty	Warm Moist	178	9239	4	3030	88	3699
Missouri	Henry	0.22	Silty	Warm Moist	190	9836	4	3085	105	4439
Missouri	Hickory	0.23	Silty	Warm Moist	151	7849	4	2791	93	3911
Missouri	Holt	0.24	Silty	Warm Moist	226	11734	5	3632	93	3911
Missouri	Howard	0.22	Silty	Warm Moist	179	9287	4	3030	99	4163
Missouri	Howell	0.24	Sandy	Warm Moist	179	9287	4	3030	59	2475
Missouri	Iron	0.24	Silty	Warm Moist	179	9287	4	3030	93	3911
Missouri	Jackson	0.24	Silty	Warm Moist	199	10319	4	3011	105	4430
Missouri	Jasper	0.24	Silty	Warm Moist	172	8897	3	2608	105	4452
Missouri	Jefferson	0.24	Silty	Warm Moist	154	7994	4	2920	77	3248
Missouri	Johnson	0.23	Silty	Warm Moist	194	10074	4	2814	94	3952
Missouri	Knox	0.22	Silty	Warm Moist	185	9570	4	3105	107	4507
Missouri	Laclede	0.23	Silty	Warm Moist	160	8295	3	2289	93	3911
Missouri	Lafayette	0.23	Silty	Warm Moist	220	11392	5	3575	100	4212
Missouri	Lawrence	0.24	Silty	Warm Moist	155	8020	3	2634	84	3558
Missouri	Lewis	0.22	Silty	Warm Moist	169	8748	4	3171	78	3277
Missouri	Lincoln	0.21	Silty	Warm Moist	180	9352	4	3015	99	4180
Missouri	Linn	0.23	Silty	Warm Moist	194	10055	4	2986	93	3911
Missouri	Livingston	0.24	Silty	Warm Moist	185	9575	4	2784	83	3512
Missouri	McDonald	0.24	Silty	Warm Moist	179	9287	4	3383	93	3911
Missouri	Macon	0.22	Silty	Warm Moist	179	9287	4	3030	123	5185
Missouri	Madison	0.24	Silty	Warm Moist	127	6591	4	3262	93	3911
Missouri	Maries	0.23	Silty	Warm Moist	161	8344	3	2596	67	2841
Missouri	Marion	0.21	Silty	Warm Moist	207	10744	5	3544	102	4299
Missouri	Mercer	0.24	Silty	Warm Moist	181	9384	4	3030	93	3911
Missouri	Miller	0.22	Silty	Warm Moist	158	8195	4	3182	113	4775
Missouri	Mississippi	0.23	Silty	Warm Moist	207	10716	4	3354	108	4558
Missouri	Moniteau	0.22	Silty	Warm Moist	180	9313	4	3003	102	4294
Missouri	Monroe	0.22	Silty	Warm Moist	174	8999	4	3354	100	4214
Missouri	Montgomery	0.21	Silty	Warm Moist	178	9208	4	3259	108	4544
Missouri	Morgan	0.22	Silty	Warm Moist	178	9216	4	3020	104	4400
Missouri	New Madrid	0.23	Silty	Warm Moist	216	11210	4	3108	105	4432
Missouri	Newton	0.24	Silty	Warm Moist	160	8282	4	3320	108	4570
Missouri	Nodaway	0.24	Silty	Warm Moist	185	9564	4	3152	109	4600
Missouri	Oregon	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Osage	0.23	Silty	Warm Moist	188	9768	4	3197	75	3171
Missouri	Ozark	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Missouri	Pemiscot	0.26	Silty	Warm Moist	203	10526	4	3091	102	4299
Missouri	Perry	0.24	Silty	Warm Moist	182	9419	4	3349	97	4097
Missouri	Pettis	0.23	Silty	Warm Moist	186	9663	4	3081	99	4188
Missouri	Phelps	0.23	Silty	Warm Moist	179	9287	4	3030	93	3911
Missouri	Pike	0.21	Silty	Warm Moist	173	8948	4	3383	102	4322
Missouri	Platte	0.24	Silty	Warm Moist	187	9706	4	3154	49	2092
Missouri	Polk	0.23	Silty	Warm Moist	164	8476	4	2783	83	3488
Missouri	Pulaski	0.23	Silty	Warm Moist	179	9287	4	3030	93	3911
Missouri	Putnam	0.23	Silty	Warm Moist	171	8875	3	2535	93	3911
Missouri	Ralls	0.21	Silty	Warm Moist	182	9435	4	3013	103	4371
Missouri	Randolph	0.22	Silty	Warm Moist	188	9733	4	3141	90	3793
Missouri	Ray	0.24	Silty	Warm Moist	200	10344	4	3094	70	2968
Missouri	Reynolds	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Ripley	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	St. Charles	0.22	Silty	Warm Moist	194	10062	4	3353	107	4537
Missouri	St. Clair	0.22	Silty	Warm Moist	166	8612	4	3050	92	3880
Missouri	Ste. Genevieve	0.24	Silty	Warm Moist	183	9490	4	3176	103	4351
Missouri	St. Francois	0.24	Silty	Warm Moist	177	9158	4	3347	93	3927
Missouri	St. Louis	0.23	Silty	Warm Moist	182	9453	4	3220	101	4257
Missouri	Saline	0.23	Silty	Warm Moist	215	11148	5	3582	93	3911
Missouri	Schuyler	0.23	Silty	Warm Moist	179	9287	3	2562	93	3911
Missouri	Scotland	0.22	Silty	Warm Moist	179	9258	4	3030	91	3855
Missouri	Scott	0.24	Silty	Warm Moist	217	11240	4	3050	105	4439
Missouri	Shannon	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Shelby	0.22	Silty	Warm Moist	212	10984	4	3203	109	4627
Missouri	Stoddard	0.23	Silty	Warm Moist	199	10339	4	3349	113	4790
Missouri	Stone	0.25	Silty	Warm Moist	179	9287	4	3030	93	3911
Missouri	Sullivan	0.23	Silty	Warm Moist	147	7617	3	2519	93	3911
Missouri	Taney	0.25	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	Texas	0.24	Sandy	Warm Moist	153	7953	4	3030	93	3911
Missouri	Vernon	0.23	Silty	Warm Moist	163	8474	3	2640	124	5259
Missouri	Warren	0.22	Silty	Warm Moist	187	9708	4	3231	87	3684
Missouri	Washington	0.24	Silty	Warm Moist	179	9287	4	3030	93	3911
Missouri	Wayne	0.24	Sandy	Warm Moist	153	7950	3	2417	53	2239
Missouri	Webster	0.24	Sandy	Warm Moist	150	7767	4	3070	78	3315
Missouri	Worth	0.24	Silty	Warm Moist	162	8397	4	2866	93	3911
Missouri	Wright	0.24	Sandy	Warm Moist	179	9287	4	3030	93	3911
Missouri	St. Louis	0.23	Silty	Warm Moist	179	9287	4	3030	93	3911
Montana	Beaverhead	0.18	Silty	Cool Dry	88	6010	NA	NA	84	2916
Montana	Big Horn	0.21	Silty	Cool Dry	88	6010	NA	NA	91	3156
Montana	Blaine	0.23	Silty	Cool Dry	99	6748	NA	NA	78	2700
Montana	Broadwater	0.20	Silty	Cool Dry	88	6010	NA	NA	86	2966
Montana	Carbon	0.21	Silty	Cool Dry	154	10476	NA	NA	88	3033
Montana	Carter	0.24	Silty	Cool Dry	43	2931	NA	NA	61	2123
Montana	Cascade	0.22	Silty	Cool Dry	88	6010	NA	NA	108	3734

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Montana	Chouteau	0.24	Silty	Cool Dry	88	6010	NA	NA	106	3652
Montana	Custer	0.23	Silty	Cool Dry	88	6010	NA	NA	57	1957
Montana	Daniels	0.22	Silty	Cool Dry	70	4789	NA	NA	76	2643
Montana	Dawson	0.22	Silty	Cool Dry	57	3873	NA	NA	84	2916
Montana	Deer Lodge	0.15	Silty	Cool Dry	88	6010	NA	NA	84	2916
Montana	Fallon	0.23	Silty	Cool Dry	48	3233	NA	NA	79	2717
Montana	Fergus	0.24	Silty	Cool Dry	88	6010	NA	NA	89	3071
Montana	Flathead	0.17	Silty	Cool Moist	88	6010	NA	NA	134	4640
Montana	Gallatin	0.22	Silty	Cool Moist	88	6010	NA	NA	113	3924
Montana	Garfield	0.23	Silty	Cool Dry	65	4394	NA	NA	66	2271
Montana	Glacier	0.22	Silty	Cool Dry	88	6010	NA	NA	91	3137
Montana	Golden Valley	0.24	Silty	Cool Dry	88	6010	NA	NA	104	3593
Montana	Granite	0.15	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	Hill	0.23	Silty	Cool Dry	88	6010	NA	NA	78	2694
Montana	Jefferson	0.19	Silty	Cool Dry	88	6010	NA	NA	84	2916
Montana	Judith Basin	0.23	Silty	Cool Dry	88	6010	NA	NA	95	3280
Montana	Lake	0.15	Silty	Cool Moist	88	6010	NA	NA	127	4385
Montana	Lewis and Clark	0.20	Silty	Cool Dry	88	6010	NA	NA	93	3205
Montana	Liberty	0.23	Silty	Cool Dry	88	6010	NA	NA	80	2769
Montana	Lincoln	0.14	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	McCone	0.22	Silty	Cool Dry	88	6010	NA	NA	72	2479
Montana	Madison	0.20	Silty	Cool Dry	88	6010	NA	NA	115	3971
Montana	Meagher	0.21	Silty	Cool Dry	88	6010	NA	NA	74	2549
Montana	Mineral	0.12	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	Missoula	0.14	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	Musselshell	0.24	Silty	Cool Dry	88	6010	NA	NA	63	2177
Montana	Park	0.22	Silty	Cool Moist	88	6010	NA	NA	84	2900
Montana	Petroleum	0.24	Silty	Cool Dry	88	6010	NA	NA	58	2015
Montana	Phillips	0.23	Silty	Cool Dry	88	6010	NA	NA	80	2764
Montana	Pondera	0.22	Silty	Cool Dry	88	6010	NA	NA	101	3504
Montana	Powder River	0.22	Sandy	Cool Dry	88	6010	NA	NA	61	2108
Montana	Powell	0.18	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	Prairie	0.16	Silty	Cool Dry	88	6010	NA	NA	71	2446
Montana	Ravalli	0.13	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	Richland	0.23	Silty	Cool Dry	113	7673	NA	NA	67	2320
Montana	Roosevelt	0.23	Silty	Cool Dry	88	6010	NA	NA	67	2334
Montana	Rosebud	0.22	Silty	Cool Dry	88	6010	NA	NA	61	2125
Montana	Sanders	0.13	Silty	Cool Moist	88	6010	NA	NA	84	2916
Montana	Sheridan	0.23	Silty	Cool Dry	92	6277	NA	NA	63	2165
Montana	Silver Bow	0.16	Silty	Cool Dry	88	6010	NA	NA	84	2916
Montana	Stillwater	0.23	Silty	Cool Dry	88	6010	NA	NA	74	2545
Montana	Sweet Grass	0.23	Silty	Cool Dry	88	6010	NA	NA	110	3813
Montana	Teton	0.21	Silty	Cool Dry	88	6010	NA	NA	105	3623
Montana	Toole	0.23	Silty	Cool Dry	88	6010	NA	NA	68	2363
Montana	Treasure	0.23	Silty	Cool Dry	88	6010	NA	NA	94	3250

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Montana	Valley	0.23	Silty	Cool Dry	100	6810	NA	NA	82	2825
Montana	Wheatland	0.23	Silty	Cool Dry	88	6010	NA	NA	77	2651
Montana	Wibaux	0.23	Silty	Cool Dry	88	6010	NA	NA	76	2636
Montana	Yellowstone	0.23	Silty	Cool Dry	131	8910	NA	NA	89	3072
Nebraska	Adams	0.23	Silty	Warm Dry	185	12634	7	4382	47	3120
Nebraska	Antelope	0.13	Sandy	Cool Dry	189	12881	7	4121	51	3438
Nebraska	Arthur	0.12	Sandy	Cool Dry	163	11109	6	3972	51	3438
Nebraska	Banner	0.22	Silty	Cool Dry	75	5141	6	3972	39	2638
Nebraska	Blaine	0.07	Sandy	Cool Dry	148	10074	6	3972	51	3438
Nebraska	Boone	0.13	Sandy	Cool Dry	180	12319	7	4210	51	3438
Nebraska	Box Butte	0.19	Silty	Cool Dry	141	9631	6	3972	47	3173
Nebraska	Boyd	0.18	Silty	Cool Dry	141	9614	6	3768	74	4950
Nebraska	Brown	0.08	Sandy	Cool Dry	196	13390	6	3979	51	3438
Nebraska	Buffalo	0.21	Silty	Cool Dry	189	12882	7	4524	62	4155
Nebraska	Burt	0.23	Silty	Cool Dry	174	11858	6	3780	51	3438
Nebraska	Butler	0.22	Silty	Warm Dry	177	12051	6	3887	51	3438
Nebraska	Cass	0.23	Silty	Warm Moist	170	11621	6	3654	60	3988
Nebraska	Cedar	0.20	Silty	Cool Dry	178	12137	6	3949	51	3438
Nebraska	Chase	0.20	Silty	Cool Dry	165	11279	7	4284	64	4306
Nebraska	Cherry	0.13	Sandy	Cool Dry	175	11932	6	3972	51	3438
Nebraska	Cheyenne	0.21	Silty	Cool Dry	163	11109	4	2751	38	2567
Nebraska	Clay	0.23	Silty	Warm Dry	177	12099	7	4385	46	3092
Nebraska	Colfax	0.20	Silty	Cool Dry	180	12260	6	3972	36	2381
Nebraska	Cuming	0.20	Silty	Cool Dry	185	12634	7	4079	51	3438
Nebraska	Custer	0.13	Sandy	Cool Dry	172	11758	6	3953	52	3445
Nebraska	Dakota	0.20	Silty	Cool Dry	168	11449	6	3954	51	3438
Nebraska	Dawes	0.23	Silty	Cool Dry	130	8891	6	3972	40	2656
Nebraska	Dawson	0.17	Sandy	Cool Dry	195	13327	7	4690	57	3800
Nebraska	Deuel	0.21	Silty	Cool Dry	102	6983	6	3972	38	2510
Nebraska	Dixon	0.20	Silty	Cool Dry	172	11745	6	3921	51	3438
Nebraska	Dodge	0.21	Silty	Cool Dry	177	12107	6	4054	51	3438
Nebraska	Douglas	0.23	Silty	Warm Dry	172	11725	6	3827	37	2482
Nebraska	Dundy	0.22	Silty	Warm Dry	147	10015	7	4163	65	4330
Nebraska	Fillmore	0.23	Silty	Warm Dry	184	12536	7	4264	55	3682
Nebraska	Franklin	0.23	Silty	Warm Dry	170	11622	6	3958	46	3099
Nebraska	Frontier	0.19	Silty	Cool Dry	133	9051	6	3914	55	3643
Nebraska	Furnas	0.22	Silty	Warm Dry	134	9160	6	3717	56	3710
Nebraska	Gage	0.23	Silty	Warm Dry	142	9713	5	3424	51	3375
Nebraska	Garden	0.16	Sandy	Cool Dry	101	6873	6	3972	38	2532
Nebraska	Garfield	0.07	Sandy	Cool Dry	174	11891	6	4062	51	3438
Nebraska	Gosper	0.19	Silty	Cool Dry	174	11905	7	4422	54	3613
Nebraska	Grant	0.11	Sandy	Cool Dry	163	11109	6	3972	51	3438
Nebraska	Greeley	0.13	Sandy	Cool Dry	174	11872	6	4023	51	3438
Nebraska	Hall	0.23	Silty	Cool Dry	181	12358	7	4292	51	3438
Nebraska	Hamilton	0.23	Silty	Warm Dry	197	13418	7	4445	54	3623

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Nebraska	Harlan	0.22	Silty	Warm Dry	163	11122	7	4318	53	3568
Nebraska	Hayes	0.19	Silty	Cool Dry	137	9318	6	3972	52	3506
Nebraska	Hitchcock	0.22	Silty	Warm Dry	120	8225	6	3972	60	3987
Nebraska	Holt	0.12	Sandy	Cool Dry	190	12938	7	4231	63	4217
Nebraska	Hooker	0.08	Sandy	Cool Dry	163	11109	6	3972	51	3438
Nebraska	Howard	0.19	Silty	Cool Dry	169	11547	6	3991	64	4264
Nebraska	Jefferson	0.23	Silty	Warm Dry	152	10389	6	3687	53	3510
Nebraska	Johnson	0.24	Silty	Warm Moist	135	9203	5	3263	45	3021
Nebraska	Kearney	0.22	Silty	Warm Dry	193	13184	7	4381	53	3548
Nebraska	Keith	0.15	Sandy	Cool Dry	149	10168	7	4166	53	3563
Nebraska	Keya Paha	0.12	Sandy	Cool Dry	178	12153	6	3874	51	3438
Nebraska	Kimball	0.23	Silty	Cool Dry	86	5886	6	3972	30	2011
Nebraska	Knox	0.18	Silty	Cool Dry	170	11579	6	3774	66	4412
Nebraska	Lancaster	0.23	Silty	Warm Dry	152	10342	5	3399	50	3307
Nebraska	Lincoln	0.13	Sandy	Cool Dry	162	11067	6	4065	52	3497
Nebraska	Logan	0.09	Sandy	Cool Dry	169	11558	6	4008	51	3438
Nebraska	Loup	0.07	Sandy	Cool Dry	149	10168	7	4149	51	3438
Nebraska	McPherson	0.10	Sandy	Cool Dry	145	9924	6	3972	51	3438
Nebraska	Madison	0.15	Sandy	Cool Dry	179	12202	6	3856	51	3438
Nebraska	Merrick	0.21	Silty	Warm Dry	168	11446	7	4166	51	3438
Nebraska	Morrill	0.19	Silty	Cool Dry	155	10566	6	3972	50	3353
Nebraska	Nance	0.19	Silty	Cool Dry	170	11596	7	4106	51	3438
Nebraska	Nemaha	0.24	Silty	Warm Moist	155	10598	6	3500	49	3276
Nebraska	Nuckolls	0.23	Silty	Warm Dry	161	10957	6	3979	49	3289
Nebraska	Otoe	0.24	Silty	Warm Moist	149	10180	5	3422	40	2668
Nebraska	Pawnee	0.24	Silty	Warm Moist	130	8895	5	2929	48	3220
Nebraska	Perkins	0.18	Silty	Cool Dry	128	8740	7	4163	56	3763
Nebraska	Phelps	0.21	Silty	Warm Dry	201	13707	7	4601	60	3997
Nebraska	Pierce	0.17	Sandy	Cool Dry	176	12012	6	3805	51	3438
Nebraska	Platte	0.18	Silty	Cool Dry	183	12500	7	4140	62	4116
Nebraska	Polk	0.22	Silty	Warm Dry	184	12550	7	4391	51	3438
Nebraska	Red Willow	0.22	Silty	Warm Dry	136	9273	7	4311	60	4010
Nebraska	Richardson	0.24	Silty	Warm Moist	148	10087	5	3438	48	3194
Nebraska	Rock	0.09	Sandy	Cool Dry	183	12478	6	3706	51	3438
Nebraska	Saline	0.23	Silty	Warm Dry	161	10974	6	3657	44	2936
Nebraska	Sarpy	0.24	Silty	Warm Dry	178	12160	6	3917	51	3438
Nebraska	Saunders	0.23	Silty	Warm Dry	173	11805	6	3809	53	3534
Nebraska	Scotts Bluff	0.22	Silty	Cool Dry	157	10747	6	3972	49	3295
Nebraska	Seward	0.23	Silty	Warm Dry	171	11697	7	4101	58	3847
Nebraska	Sheridan	0.19	Silty	Cool Dry	139	9484	6	3972	44	2936
Nebraska	Sherman	0.18	Silty	Cool Dry	169	11505	7	4193	51	3438
Nebraska	Sioux	0.23	Silty	Cool Dry	164	11163	6	3972	64	4296
Nebraska	Stanton	0.17	Sandy	Cool Dry	182	12395	6	3927	51	3438
Nebraska	Thayer	0.23	Silty	Warm Dry	168	11445	6	3884	51	3430
Nebraska	Thomas	0.07	Sandy	Cool Dry	169	11537	6	3972	51	3438

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Nebraska	Thurston	0.22	Silty	Cool Dry	178	12133	6	3783	51	3438
Nebraska	Valley	0.12	Sandy	Cool Dry	174	11863	7	4375	46	3104
Nebraska	Washington	0.23	Silty	Cool Dry	170	11617	6	3744	51	3438
Nebraska	Wayne	0.19	Silty	Cool Dry	182	12397	6	3954	51	3438
Nebraska	Webster	0.23	Silty	Warm Dry	149	10168	6	3548	45	2979
Nebraska	Wheeler	0.09	Sandy	Cool Dry	163	11109	6	3972	51	3438
Nebraska	York	0.23	Silty	Warm Dry	193	13151	7	4406	51	3438
Nevada	Churchill	0.21	Silty	Warm Dry	NA	NA	NA	NA	138	6251
Nevada	Clark	0.13	Sandy	Warm Dry	NA	NA	NA	NA	138	6251
Nevada	Douglas	0.22	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Elko	0.21	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Esmeralda	0.22	Silty	Warm Dry	NA	NA	NA	NA	138	6251
Nevada	Eureka	0.20	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Humboldt	0.19	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Lander	0.20	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Lincoln	0.20	Silty	Warm Dry	NA	NA	NA	NA	138	6251
Nevada	Lyon	0.22	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Mineral	0.22	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Nye	0.20	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Pershing	0.21	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Storey	0.22	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Washoe	0.22	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	White Pine	0.21	Silty	Cool Dry	NA	NA	NA	NA	138	6251
Nevada	Carson City	0.22	Silty	Cool Dry	NA	NA	NA	NA	138	6251
New Hampshire	Belknap	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Carroll	0.04	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Cheshire	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Coos	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Grafton	0.04	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Hillsborough	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Merrimack	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Rockingham	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Strafford	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Hampshire	Sullivan	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
New Jersey	Atlantic	0.18	Sandy	Warm Moist	71	4802	4	2504	71	3206
New Jersey	Bergen	0.21	Silty	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Burlington	0.17	Sandy	Warm Moist	131	8935	4	2394	81	3652
New Jersey	Camden	0.17	Sandy	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Cape May	0.18	Sandy	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Cumberland	0.17	Sandy	Warm Moist	152	10316	4	2529	71	3206
New Jersey	Essex	0.21	Silty	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Gloucester	0.17	Sandy	Warm Moist	96	6544	4	2471	71	3206
New Jersey	Hudson	0.21	Silty	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Hunterdon	0.19	Sandy	Warm Moist	141	9566	5	2915	68	3100
New Jersey	Mercer	0.18	Sandy	Warm Moist	128	8725	5	2754	71	3206

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
New Jersey	Middlesex	0.19	Sandy	Warm Moist	129	8778	4	2273	71	3206
New Jersey	Monmouth	0.18	Sandy	Warm Moist	126	8542	4	2404	83	3773
New Jersey	Morris	0.21	Silty	Cool Moist	126	8561	4	2504	71	3206
New Jersey	Ocean	0.18	Sandy	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Passaic	0.21	Silty	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Salem	0.18	Sandy	Warm Moist	137	9352	4	2490	71	3206
New Jersey	Somerset	0.20	Silty	Warm Moist	126	8542	3	1506	51	2300
New Jersey	Sussex	0.22	Silty	Cool Moist	126	8542	4	2354	71	3206
New Jersey	Union	0.20	Silty	Warm Moist	126	8542	4	2504	71	3206
New Jersey	Warren	0.21	Silty	Cool Moist	145	9845	6	3459	71	3206
New Mexico	Bernalillo	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Catron	0.22	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Chaves	0.20	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Cibola	0.21	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Colfax	0.19	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Curry	0.21	Silty	Warm Dry	125	8483	NA	NA	31	1426
New Mexico	De Baca	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Dona Ana	0.20	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Eddy	0.19	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Grant	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Guadalupe	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Harding	0.20	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Hidalgo	0.20	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Lea	0.16	Sandy	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Lincoln	0.22	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Los Alamos	0.21	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Luna	0.19	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	McKinley	0.21	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Mora	0.20	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Otero	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Quay	0.21	Silty	Warm Dry	139	9490	NA	NA	27	1217
New Mexico	Rio Arriba	0.20	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Roosevelt	0.19	Silty	Warm Dry	151	10264	NA	NA	28	1271
New Mexico	Sandoval	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	San Juan	0.20	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	San Miguel	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Santa Fe	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Sierra	0.22	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Socorro	0.22	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Taos	0.19	Silty	Cool Dry	151	10264	NA	NA	29	1305
New Mexico	Torrance	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New Mexico	Union	0.20	Silty	Warm Dry	188	12817	NA	NA	29	1305
New Mexico	Valencia	0.21	Silty	Warm Dry	151	10264	NA	NA	29	1305
New York	Albany	0.18	Silty	Cool Moist	79	8100	5	3078	99	4491
New York	Allegany	0.19	Silty	Cool Moist	80	8246	5	2858	84	3813

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
New York	Bronx	0.21	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	Broome	0.20	Silty	Cool Moist	95	9785	5	3078	99	4491
New York	Cattaraugus	0.18	Silty	Cool Moist	93	9580	5	2930	99	4491
New York	Cayuga	0.20	Silty	Cool Moist	94	9670	5	3115	105	4765
New York	Chautauqua	0.16	Sandy	Cool Moist	99	10154	5	2865	100	4546
New York	Chemung	0.20	Silty	Cool Moist	104	10670	5	3058	99	4491
New York	Chenango	0.20	Silty	Cool Moist	85	8697	6	3309	99	4491
New York	Clinton	0.13	Sandy	Cool Moist	107	10984	5	3078	99	4491
New York	Columbia	0.13	Sandy	Cool Moist	89	9156	6	3437	99	4491
New York	Cortland	0.21	Silty	Cool Moist	89	9089	5	2882	99	4491
New York	Delaware	0.19	Silty	Cool Moist	75	7742	5	3078	99	4491
New York	Dutchess	0.15	Sandy	Cool Moist	94	9639	6	3383	99	4491
New York	Erie	0.14	Sandy	Cool Moist	83	8569	5	2855	63	2845
New York	Essex	0.08	Sandy	Cool Moist	90	9258	5	3078	99	4491
New York	Franklin	0.13	Sandy	Cool Moist	90	9258	5	3078	99	4491
New York	Fulton	0.18	Silty	Cool Moist	90	9258	5	3078	99	4491
New York	Genesee	0.16	Sandy	Cool Moist	94	9654	6	3209	105	4741
New York	Greene	0.17	Silty	Cool Moist	90	9258	5	3078	99	4491
New York	Hamilton	0.12	Sandy	Cool Moist	90	9258	5	3078	99	4491
New York	Herkimer	0.16	Sandy	Cool Moist	84	8666	5	3056	99	4491
New York	Jefferson	0.17	Silty	Cool Moist	80	8220	4	2398	99	4491
New York	Kings	0.20	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	Lewis	0.15	Sandy	Cool Moist	79	8095	5	2858	99	4491
New York	Livingston	0.19	Silty	Cool Moist	93	9571	5	3172	100	4526
New York	Madison	0.21	Silty	Cool Moist	89	9172	5	2725	99	4491
New York	Monroe	0.17	Sandy	Cool Moist	95	9764	6	3334	107	4832
New York	Montgomery	0.19	Silty	Cool Moist	96	9887	4	2213	99	4491
New York	Nassau	0.21	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	New York	0.21	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	Niagara	0.13	Sandy	Cool Moist	97	9982	5	3094	107	4839
New York	Oneida	0.18	Silty	Cool Moist	91	9327	5	3038	101	4573
New York	Onondaga	0.21	Silty	Cool Moist	91	9291	5	3133	88	3975
New York	Ontario	0.20	Silty	Cool Moist	91	9351	5	3045	100	4539
New York	Orange	0.19	Silty	Cool Moist	94	9631	7	4237	99	4491
New York	Orleans	0.14	Sandy	Cool Moist	90	9258	5	3123	98	4425
New York	Oswego	0.20	Silty	Cool Moist	84	8583	5	3143	99	4491
New York	Otsego	0.20	Silty	Cool Moist	85	8679	5	3151	99	4491
New York	Putnam	0.19	Silty	Cool Moist	90	9258	5	3078	99	4491
New York	Queens	0.20	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	Rensselaer	0.17	Silty	Cool Moist	93	9495	5	3120	99	4491
New York	Richmond	0.19	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	Rockland	0.21	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	St. Lawrence	0.12	Sandy	Cool Moist	85	8744	4	2532	99	4491
New York	Saratoga	0.16	Silty	Cool Moist	96	9884	5	3078	99	4491
New York	Schenectady	0.20	Silty	Cool Moist	90	9258	5	3078	99	4491

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
New York	Schoharie	0.20	Silty	Cool Moist	89	9111	3	1681	99	4491
New York	Schuyler	0.20	Silty	Cool Moist	98	10032	6	3241	99	4491
New York	Seneca	0.20	Silty	Cool Moist	95	9710	5	3138	100	4536
New York	Steuben	0.20	Silty	Cool Moist	86	8784	5	2669	99	4472
New York	Suffolk	0.19	Silty	Warm Moist	74	7554	5	3078	99	4491
New York	Sullivan	0.19	Silty	Cool Moist	90	9258	5	3078	99	4491
New York	Tioga	0.20	Silty	Cool Moist	100	10291	6	3291	99	4491
New York	Tompkins	0.21	Silty	Cool Moist	79	8132	5	2808	99	4491
New York	Ulster	0.17	Silty	Cool Moist	85	8691	7	4365	99	4491
New York	Warren	0.08	Sandy	Cool Moist	90	9258	5	3078	99	4491
New York	Washington	0.13	Sandy	Cool Moist	82	8455	7	3820	99	4491
New York	Wayne	0.18	Silty	Cool Moist	97	10005	5	3157	106	4802
New York	Westchester	0.18	Silty	Warm Moist	90	9258	5	3078	99	4491
New York	Wyoming	0.17	Silty	Cool Moist	98	10048	5	3194	121	5467
New York	Yates	0.21	Silty	Cool Moist	102	10457	6	3392	103	4657
North Carolina	Alamance	0.24	Sandy	Warm Moist	145	7481	13	2335	74	3767
North Carolina	Alexander	0.24	Sandy	Warm Moist	153	7894	12	2223	67	3437
North Carolina	Alleghany	0.23	Silty	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Anson	0.24	Sandy	Warm Moist	122	6289	10	1927	67	3437
North Carolina	Ashe	0.24	Silty	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Avery	0.24	Sandy	Cool Moist	146	7496	13	2310	69	3517
North Carolina	Beaufort	0.23	Silty	Warm Moist	170	8725	15	2682	68	3457
North Carolina	Bertie	0.23	Silty	Warm Moist	151	7746	13	2463	69	3506
North Carolina	Bladen	0.22	Silty	Warm Moist	136	6991	11	2012	46	2337
North Carolina	Brunswick	0.18	Silty	Warm Moist	147	7556	11	2038	69	3517
North Carolina	Buncombe	0.24	Sandy	Warm Moist	163	8398	13	2310	69	3517
North Carolina	Burke	0.24	Sandy	Warm Moist	125	6420	13	2369	69	3517
North Carolina	Cabarrus	0.24	Sandy	Warm Moist	142	7282	10	1925	72	3672
North Carolina	Caldwell	0.24	Sandy	Warm Moist	170	8769	13	2310	69	3517
North Carolina	Camden	0.23	Silty	Warm Moist	205	10550	16	2881	82	4176
North Carolina	Carteret	0.18	Silty	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Caswell	0.24	Sandy	Warm Moist	115	5909	11	2109	72	3684
North Carolina	Catawba	0.24	Sandy	Warm Moist	150	7697	11	2078	78	4003
North Carolina	Chatham	0.24	Sandy	Warm Moist	146	7513	14	2586	69	3546
North Carolina	Cherokee	0.24	Sandy	Warm Moist	217	11173	19	3564	69	3517
North Carolina	Chowan	0.23	Silty	Warm Moist	174	8941	15	2838	83	4238
North Carolina	Clay	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Cleveland	0.24	Sandy	Warm Moist	132	6810	11	2056	72	3685
North Carolina	Columbus	0.22	Silty	Warm Moist	157	8062	11	1944	52	2670
North Carolina	Craven	0.21	Silty	Warm Moist	143	7341	12	2284	54	2747
North Carolina	Cumberland	0.24	Silty	Warm Moist	141	7281	11	2011	78	3992
North Carolina	Currituck	0.23	Silty	Warm Moist	184	9454	14	2668	71	3622
North Carolina	Dare	0.23	Silty	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Davidson	0.24	Sandy	Warm Moist	132	6786	12	2168	74	3789
North Carolina	Davie	0.24	Sandy	Warm Moist	140	7211	14	2494	70	3579

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
North Carolina	Duplin	0.20	Silty	Warm Moist	140	7221	12	2258	55	2801
North Carolina	Durham	0.24	Sandy	Warm Moist	146	7496	11	2031	56	2851
North Carolina	Edgecombe	0.24	Silty	Warm Moist	130	6669	12	2260	61	3120
North Carolina	Forsyth	0.24	Sandy	Warm Moist	128	6609	10	1836	65	3339
North Carolina	Franklin	0.24	Silty	Warm Moist	129	6614	10	1765	61	3119
North Carolina	Gaston	0.24	Sandy	Warm Moist	107	5517	13	2390	72	3667
North Carolina	Gates	0.23	Silty	Warm Moist	169	8718	15	2712	85	4335
North Carolina	Graham	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Granville	0.24	Sandy	Warm Moist	120	6170	10	1883	62	3142
North Carolina	Greene	0.24	Silty	Warm Moist	130	6694	14	2515	63	3205
North Carolina	Guilford	0.24	Sandy	Warm Moist	130	6715	12	2216	71	3648
North Carolina	Halifax	0.24	Silty	Warm Moist	131	6755	14	2564	65	3326
North Carolina	Harnett	0.24	Sandy	Warm Moist	117	6007	11	2008	71	3648
North Carolina	Haywood	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Henderson	0.24	Sandy	Warm Moist	176	9054	19	3514	69	3517
North Carolina	Hertford	0.23	Silty	Warm Moist	162	8326	12	2229	88	4469
North Carolina	Hoke	0.24	Silty	Warm Moist	146	7496	13	2310	48	2458
North Carolina	Hyde	0.23	Silty	Warm Moist	180	9249	16	3023	68	3459
North Carolina	Iredell	0.24	Sandy	Warm Moist	140	7217	14	2529	85	4329
North Carolina	Jackson	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Johnston	0.24	Sandy	Warm Moist	117	6010	11	2000	65	3320
North Carolina	Jones	0.20	Silty	Warm Moist	137	7075	13	2377	78	4005
North Carolina	Lee	0.24	Sandy	Warm Moist	105	5379	8	1459	67	3413
North Carolina	Lenoir	0.22	Silty	Warm Moist	138	7105	13	2361	62	3161
North Carolina	Lincoln	0.24	Sandy	Warm Moist	117	6042	11	1972	75	3811
North Carolina	McDowell	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Macon	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Madison	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Martin	0.23	Silty	Warm Moist	125	6442	13	2428	64	3282
North Carolina	Mecklenburg	0.24	Sandy	Warm Moist	146	7496	13	2310	77	3951
North Carolina	Mitchell	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Montgomery	0.24	Sandy	Warm Moist	146	7496	12	2145	61	3094
North Carolina	Moore	0.24	Sandy	Warm Moist	107	5527	9	1737	65	3321
North Carolina	Nash	0.24	Silty	Warm Moist	143	7353	11	1989	61	3131
North Carolina	New Hanover	0.17	Silty	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Northampton	0.23	Silty	Warm Moist	157	8098	13	2386	77	3943
North Carolina	Onslow	0.17	Sandy	Warm Moist	122	6257	11	1977	60	3041
North Carolina	Orange	0.24	Sandy	Warm Moist	166	8556	13	2354	78	3993
North Carolina	Pamlico	0.21	Silty	Warm Moist	175	9031	14	2591	72	3652
North Carolina	Pasquotank	0.23	Silty	Warm Moist	204	10507	16	3026	82	4160
North Carolina	Pender	0.16	Sandy	Warm Moist	151	7789	13	2354	69	3517
North Carolina	Perquimans	0.23	Silty	Warm Moist	181	9329	15	2780	87	4440
North Carolina	Person	0.24	Sandy	Warm Moist	139	7129	10	1910	60	3053
North Carolina	Pitt	0.23	Silty	Warm Moist	133	6867	12	2226	61	3118
North Carolina	Polk	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
North Carolina	Randolph	0.24	Sandy	Warm Moist	134	6876	12	2284	70	3584
North Carolina	Richmond	0.24	Silty	Warm Moist	146	7496	8	1533	69	3517
North Carolina	Robeson	0.23	Silty	Warm Moist	144	7408	11	2001	58	2938
North Carolina	Rockingham	0.24	Silty	Warm Moist	141	7255	12	2244	68	3490
North Carolina	Rowan	0.24	Sandy	Warm Moist	145	7461	13	2313	86	4394
North Carolina	Rutherford	0.24	Sandy	Warm Moist	116	5990	10	1876	59	3020
North Carolina	Sampson	0.23	Silty	Warm Moist	138	7117	13	2469	65	3297
North Carolina	Scotland	0.24	Silty	Warm Moist	151	7746	10	1789	51	2626
North Carolina	Stanly	0.24	Sandy	Warm Moist	143	7361	12	2269	79	4020
North Carolina	Stokes	0.24	Silty	Warm Moist	133	6832	12	2150	59	3024
North Carolina	Surry	0.24	Silty	Warm Moist	186	9597	15	2761	80	4082
North Carolina	Swain	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Transylvania	0.24	Sandy	Warm Moist	209	10746	19	3470	69	3517
North Carolina	Tyrrell	0.23	Silty	Warm Moist	186	9548	15	2806	65	3307
North Carolina	Union	0.24	Sandy	Warm Moist	120	6180	13	2482	78	3960
North Carolina	Vance	0.24	Sandy	Warm Moist	146	7496	10	1883	73	3732
North Carolina	Wake	0.24	Sandy	Warm Moist	88	4513	9	1623	58	2948
North Carolina	Warren	0.24	Silty	Warm Moist	87	4475	10	1856	76	3866
North Carolina	Washington	0.23	Silty	Warm Moist	186	9596	16	2863	71	3645
North Carolina	Watauga	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Carolina	Wayne	0.23	Silty	Warm Moist	124	6368	12	2291	63	3230
North Carolina	Wilkes	0.24	Sandy	Warm Moist	178	9169	16	2878	69	3517
North Carolina	Wilson	0.24	Silty	Warm Moist	135	6943	13	2406	76	3875
North Carolina	Yadkin	0.24	Sandy	Warm Moist	159	8189	14	2502	79	4042
North Carolina	Yancey	0.24	Sandy	Warm Moist	146	7496	13	2310	69	3517
North Dakota	Adams	0.23	Silty	Cool Dry	83	4952	5	1671	98	2958
North Dakota	Barnes	0.24	Silty	Cool Dry	162	9716	7	2469	98	2958
North Dakota	Benson	0.24	Silty	Cool Dry	139	8315	6	2125	98	2958
North Dakota	Billings	0.22	Silty	Cool Dry	107	6427	6	2261	98	2958
North Dakota	Bottineau	0.24	Silty	Cool Dry	117	6997	6	2144	119	3591
North Dakota	Bowman	0.23	Silty	Cool Dry	74	4425	6	2261	56	1705
North Dakota	Burke	0.23	Silty	Cool Dry	113	6773	5	1789	98	2958
North Dakota	Burleigh	0.23	Silty	Cool Dry	119	7146	6	2118	98	2958
North Dakota	Cass	0.27	Silty	Cool Dry	178	10645	7	2708	98	2958
North Dakota	Cavalier	0.25	Silty	Cool Dry	120	7199	6	2077	98	2958
North Dakota	Dickey	0.24	Silty	Cool Dry	167	10030	7	2673	98	2958
North Dakota	Divide	0.23	Silty	Cool Dry	88	5279	6	2261	87	2636
North Dakota	Dunn	0.23	Silty	Cool Dry	91	5436	6	2261	99	2997
North Dakota	Eddy	0.24	Silty	Cool Dry	132	7939	5	1986	98	2958
North Dakota	Emmons	0.23	Silty	Cool Dry	125	7466	7	2441	97	2929
North Dakota	Foster	0.24	Silty	Cool Dry	149	8955	6	2256	98	2958
North Dakota	Golden Valley	0.25	Silty	Cool Dry	61	3649	6	2261	98	2958
North Dakota	Grand Forks	0.25	Silty	Cool Dry	157	9390	6	2390	98	2958
North Dakota	Grant	0.23	Silty	Cool Dry	80	4811	5	1809	87	2623
North Dakota	Griggs	0.24	Silty	Cool Dry	156	9365	7	2508	98	2958

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
North Dakota	Hettinger	0.23	Silty	Cool Dry	83	4986	4	1429	96	2912
North Dakota	Kidder	0.23	Silty	Cool Dry	136	8174	6	2083	98	2958
North Dakota	LaMoure	0.24	Silty	Cool Dry	164	9855	7	2678	98	2958
North Dakota	Logan	0.23	Silty	Cool Dry	137	8191	6	2152	98	2958
North Dakota	McHenry	0.24	Silty	Cool Dry	126	7526	5	1992	98	2958
North Dakota	McIntosh	0.23	Silty	Cool Dry	153	9164	6	2283	98	2958
North Dakota	McKenzie	0.23	Silty	Cool Dry	99	5922	6	2098	98	2958
North Dakota	McLean	0.23	Silty	Cool Dry	127	7595	6	2177	107	3241
North Dakota	Mercer	0.23	Silty	Cool Dry	113	6773	6	2226	98	2958
North Dakota	Morton	0.23	Silty	Cool Dry	115	6908	8	2919	98	2958
North Dakota	Mountrail	0.23	Silty	Cool Dry	110	6578	5	1940	98	2958
North Dakota	Nelson	0.24	Silty	Cool Dry	133	7971	6	2131	98	2958
North Dakota	Oliver	0.23	Silty	Cool Dry	120	7221	6	2392	98	2958
North Dakota	Pembina	0.26	Silty	Cool Dry	141	8433	6	2186	157	4734
North Dakota	Pierce	0.24	Silty	Cool Dry	105	6289	6	2104	98	2958
North Dakota	Ramsey	0.24	Silty	Cool Dry	133	7975	6	2041	98	2958
North Dakota	Ransom	0.25	Silty	Cool Dry	191	11443	8	2939	98	2958
North Dakota	Renville	0.23	Silty	Cool Dry	113	6762	6	2059	98	2958
North Dakota	Richland	0.28	Clayey	Cool Dry	187	11190	8	2823	98	2958
North Dakota	Rolette	0.24	Silty	Cool Dry	99	5938	6	2051	98	2958
North Dakota	Sargent	0.25	Silty	Cool Dry	185	11082	8	2900	98	2958
North Dakota	Sheridan	0.23	Silty	Cool Dry	132	7940	5	2024	98	2958
North Dakota	Sioux	0.23	Silty	Cool Dry	126	7534	8	2777	98	2958
North Dakota	Slope	0.23	Silty	Cool Dry	70	4171	6	2261	98	2958
North Dakota	Stark	0.23	Silty	Cool Dry	78	4655	6	2261	76	2287
North Dakota	Steele	0.24	Silty	Cool Dry	170	10219	7	2542	98	2958
North Dakota	Stutsman	0.24	Silty	Cool Dry	148	8886	6	2331	100	3006
North Dakota	Towner	0.24	Silty	Cool Dry	123	7381	6	2102	102	3094
North Dakota	Traill	0.28	Clayey	Cool Dry	162	9729	7	2691	98	2958
North Dakota	Walsh	0.24	Silty	Cool Dry	145	8709	6	2255	98	2958
North Dakota	Ward	0.23	Silty	Cool Dry	108	6450	5	2023	118	3554
North Dakota	Wells	0.24	Silty	Cool Dry	137	8204	6	2210	98	2958
North Dakota	Williams	0.23	Silty	Cool Dry	75	4507	6	2290	69	2098
Ohio	Adams	0.22	Silty	Warm Moist	176	10153	5	3252	79	4055
Ohio	Allen	0.21	Silty	Cool Moist	171	9864	6	3550	100	5138
Ohio	Ashland	0.21	Silty	Cool Moist	152	8769	5	3076	79	4067
Ohio	Ashtabula	0.29	Clayey	Cool Moist	169	9713	5	3053	76	3884
Ohio	Athens	0.20	Silty	Warm Moist	175	10097	6	3408	81	4174
Ohio	Auglaize	0.21	Silty	Cool Moist	176	10104	6	3614	95	4868
Ohio	Belmont	0.21	Silty	Warm Moist	115	6591	5	3341	88	4533
Ohio	Brown	0.21	Silty	Warm Moist	195	11248	5	3293	83	4248
Ohio	Butler	0.22	Silty	Warm Moist	183	10515	5	3352	79	4061
Ohio	Carroll	0.21	Silty	Cool Moist	124	7118	4	2543	53	2737
Ohio	Champaign	0.21	Silty	Warm Moist	190	10913	6	3653	95	4884
Ohio	Clark	0.21	Silty	Warm Moist	196	11299	6	3679	109	5578

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Ohio	Clermont	0.22	Silty	Warm Moist	193	11096	5	3320	98	5037
Ohio	Clinton	0.21	Silty	Warm Moist	213	12265	6	3781	87	4467
Ohio	Columbiana	0.21	Silty	Cool Moist	158	9106	5	3162	82	4186
Ohio	Coshocton	0.21	Silty	Warm Moist	169	9720	5	3276	79	4081
Ohio	Crawford	0.21	Silty	Cool Moist	196	11292	6	3701	96	4935
Ohio	Cuyahoga	0.32	Clayey	Cool Moist	175	10088	5	3341	88	4533
Ohio	Darke	0.21	Silty	Warm Moist	191	11019	6	3664	94	4826
Ohio	Defiance	0.21	Silty	Cool Moist	170	9779	5	3144	84	4289
Ohio	Delaware	0.21	Silty	Warm Moist	172	9908	5	3340	94	4803
Ohio	Erie	0.29	Clayey	Cool Moist	186	10712	6	3445	105	5399
Ohio	Fairfield	0.21	Silty	Warm Moist	194	11163	6	3746	93	4779
Ohio	Fayette	0.21	Silty	Warm Moist	197	11343	6	3806	101	5166
Ohio	Franklin	0.21	Silty	Warm Moist	177	10202	5	3378	92	4724
Ohio	Fulton	0.21	Silty	Cool Moist	192	11055	6	3533	104	5342
Ohio	Gallia	0.21	Silty	Warm Moist	172	9920	5	3257	88	4533
Ohio	Geauga	0.28	Clayey	Cool Moist	140	8041	5	2777	56	2851
Ohio	Greene	0.21	Silty	Warm Moist	209	12014	6	3848	100	5125
Ohio	Guernsey	0.21	Silty	Warm Moist	160	9190	6	3383	88	4533
Ohio	Hamilton	0.22	Silty	Warm Moist	198	11403	6	3764	88	4533
Ohio	Hancock	0.21	Silty	Cool Moist	174	10037	6	3388	98	5044
Ohio	Hardin	0.21	Silty	Cool Moist	165	9487	5	3361	87	4480
Ohio	Harrison	0.21	Silty	Warm Moist	154	8862	5	3224	88	4533
Ohio	Henry	0.21	Silty	Cool Moist	188	10804	6	3618	97	4982
Ohio	Highland	0.21	Silty	Warm Moist	190	10943	6	3481	90	4639
Ohio	Hocking	0.21	Silty	Warm Moist	177	10168	5	3089	88	4533
Ohio	Holmes	0.21	Silty	Cool Moist	161	9253	5	3231	82	4230
Ohio	Huron	0.23	Silty	Cool Moist	180	10333	6	3445	87	4491
Ohio	Jackson	0.21	Silty	Warm Moist	172	9880	5	3357	72	3679
Ohio	Jefferson	0.21	Silty	Warm Moist	155	8926	6	3463	88	4533
Ohio	Knox	0.21	Silty	Cool Moist	176	10107	6	3404	84	4316
Ohio	Lake	0.35	Clayey	Cool Moist	175	10088	4	2616	88	4533
Ohio	Lawrence	0.21	Silty	Warm Moist	151	8673	4	2381	88	4533
Ohio	Licking	0.21	Silty	Warm Moist	182	10445	5	3337	98	5029
Ohio	Logan	0.21	Silty	Cool Moist	171	9843	6	3457	95	4853
Ohio	Lorain	0.31	Clayey	Cool Moist	166	9559	5	3133	59	3006
Ohio	Lucas	0.27	Silty	Cool Moist	189	10901	6	3431	99	5092
Ohio	Madison	0.21	Silty	Warm Moist	195	11193	6	3731	98	5016
Ohio	Mahoning	0.23	Silty	Cool Moist	158	9095	5	3017	84	4304
Ohio	Marion	0.21	Silty	Cool Moist	194	11146	6	3630	95	4858
Ohio	Medina	0.23	Silty	Cool Moist	168	9639	5	2954	80	4133
Ohio	Meigs	0.20	Silty	Warm Moist	158	9119	5	3366	88	4533
Ohio	Mercer	0.21	Silty	Warm Moist	182	10488	6	3749	106	5425
Ohio	Miami	0.21	Silty	Warm Moist	188	10800	6	3621	88	4515
Ohio	Monroe	0.20	Silty	Warm Moist	136	7846	5	3341	88	4533
Ohio	Montgomery	0.21	Silty	Warm Moist	184	10616	6	3572	97	4972

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Ohio	Morgan	0.20	Silty	Warm Moist	151	8711	5	2902	99	5098
Ohio	Morrow	0.21	Silty	Cool Moist	168	9658	5	3115	85	4352
Ohio	Muskingum	0.21	Silty	Warm Moist	184	10584	6	3722	75	3836
Ohio	Noble	0.20	Silty	Warm Moist	151	8683	5	3341	88	4533
Ohio	Ottawa	0.27	Silty	Cool Moist	171	9867	5	3104	80	4107
Ohio	Paulding	0.21	Silty	Cool Moist	166	9578	5	3216	89	4557
Ohio	Perry	0.21	Silty	Warm Moist	194	11166	6	3638	82	4203
Ohio	Pickaway	0.21	Silty	Warm Moist	191	11006	6	3628	102	5240
Ohio	Pike	0.21	Silty	Warm Moist	183	10550	5	3289	96	4919
Ohio	Portage	0.23	Silty	Cool Moist	153	8782	5	2855	82	4215
Ohio	Preble	0.21	Silty	Warm Moist	194	11173	6	3845	96	4948
Ohio	Putnam	0.21	Silty	Cool Moist	180	10386	6	3420	87	4467
Ohio	Richland	0.21	Silty	Cool Moist	174	10019	5	3255	90	4603
Ohio	Ross	0.21	Silty	Warm Moist	192	11048	6	3551	92	4728
Ohio	Sandusky	0.24	Silty	Cool Moist	189	10885	6	3515	96	4938
Ohio	Scioto	0.21	Silty	Warm Moist	181	10442	5	3333	73	3764
Ohio	Seneca	0.22	Silty	Cool Moist	183	10559	6	3446	90	4627
Ohio	Shelby	0.21	Silty	Warm Moist	178	10266	6	3532	93	4771
Ohio	Stark	0.21	Silty	Cool Moist	156	8948	5	3081	84	4328
Ohio	Summit	0.25	Silty	Cool Moist	175	10088	3	1816	68	3484
Ohio	Trumbull	0.25	Silty	Cool Moist	177	10206	5	3071	93	4768
Ohio	Tuscarawas	0.21	Silty	Cool Moist	163	9355	6	3416	88	4500
Ohio	Union	0.21	Silty	Warm Moist	191	10988	6	3556	90	4620
Ohio	Van Wert	0.21	Silty	Cool Moist	177	10165	6	3615	97	4981
Ohio	Vinton	0.21	Silty	Warm Moist	157	9026	4	2340	88	4533
Ohio	Warren	0.21	Silty	Warm Moist	195	11229	6	3501	86	4414
Ohio	Washington	0.20	Silty	Warm Moist	171	9823	5	3333	65	3363
Ohio	Wayne	0.21	Silty	Cool Moist	165	9517	5	3275	85	4365
Ohio	Williams	0.21	Silty	Cool Moist	183	10552	6	3457	93	4779
Ohio	Wood	0.22	Silty	Cool Moist	179	10316	6	3442	99	5083
Ohio	Wyandot	0.21	Silty	Cool Moist	178	10249	6	3515	90	4608
Oklahoma	Adair	0.24	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Alfalfa	0.19	Silty	Warm Dry	64	4340	3	1918	66	2362
Oklahoma	Atoka	0.23	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Beaver	0.23	Silty	Warm Dry	90	6106	4	2064	65	2303
Oklahoma	Beckham	0.23	Silty	Warm Dry	90	6106	4	2064	55	1949
Oklahoma	Blaine	0.20	Silty	Warm Dry	90	6106	4	2064	61	2191
Oklahoma	Bryan	0.23	Silty	Warm Dry	122	8310	4	2064	72	2571
Oklahoma	Caddo	0.23	Silty	Warm Dry	90	6106	3	1506	63	2231
Oklahoma	Canadian	0.22	Silty	Warm Dry	89	6070	3	1584	64	2292
Oklahoma	Carter	0.23	Silty	Warm Dry	90	6106	4	2064	62	2222
Oklahoma	Cherokee	0.24	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Choctaw	0.23	Silty	Warm Moist	90	6106	5	3050	66	2360
Oklahoma	Cimarron	0.22	Sandy	Warm Dry	173	11769	4	2064	67	2401
Oklahoma	Cleveland	0.23	Silty	Warm Dry	92	6277	4	2064	65	2313

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Oklahoma	Coal	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Comanche	0.23	Silty	Warm Dry	90	6106	4	2064	52	1858
Oklahoma	Cotton	0.23	Silty	Warm Dry	90	6106	4	2064	54	1918
Oklahoma	Craig	0.24	Silty	Warm Moist	76	5159	4	2464	87	3106
Oklahoma	Creek	0.23	Silty	Warm Dry	77	5272	3	1624	75	2656
Oklahoma	Custer	0.22	Silty	Warm Dry	105	7162	4	2114	66	2350
Oklahoma	Delaware	0.24	Silty	Warm Moist	89	6061	4	2514	88	3151
Oklahoma	Dewey	0.21	Silty	Warm Dry	90	6106	5	3087	61	2175
Oklahoma	Ellis	0.23	Silty	Warm Dry	101	6854	4	2064	51	1831
Oklahoma	Garfield	0.17	Silty	Warm Dry	71	4811	3	1918	71	2518
Oklahoma	Garvin	0.23	Silty	Warm Dry	72	4890	3	1991	90	3212
Oklahoma	Grady	0.23	Silty	Warm Dry	94	6380	3	1886	60	2129
Oklahoma	Grant	0.19	Silty	Warm Dry	55	3758	3	1728	64	2268
Oklahoma	Greer	0.23	Silty	Warm Dry	90	6106	4	2064	51	1806
Oklahoma	Harmon	0.23	Silty	Warm Dry	90	6106	4	2064	43	1522
Oklahoma	Harper	0.23	Silty	Warm Dry	90	6106	4	2064	54	1937
Oklahoma	Haskell	0.23	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Hughes	0.23	Silty	Warm Dry	80	5472	4	2064	56	1997
Oklahoma	Jackson	0.23	Silty	Warm Dry	90	6106	4	2064	57	2031
Oklahoma	Jefferson	0.23	Silty	Warm Dry	90	6106	4	2064	73	2587
Oklahoma	Johnston	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Kay	0.20	Silty	Warm Dry	66	4508	3	1761	59	2110
Oklahoma	Kingfisher	0.19	Silty	Warm Dry	130	8878	4	2448	65	2330
Oklahoma	Kiowa	0.23	Silty	Warm Dry	90	6106	4	2064	51	1828
Oklahoma	Latimer	0.23	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Le Flore	0.23	Silty	Warm Moist	90	6106	3	1540	111	3961
Oklahoma	Lincoln	0.21	Silty	Warm Dry	88	6016	3	2021	69	2475
Oklahoma	Logan	0.19	Silty	Warm Dry	90	6106	4	2502	65	2319
Oklahoma	Love	0.23	Silty	Warm Dry	90	6106	4	2064	42	1513
Oklahoma	McClain	0.23	Silty	Warm Dry	102	6971	3	1870	79	2800
Oklahoma	McCurtain	0.24	Silty	Warm Moist	81	5539	4	2371	66	2360
Oklahoma	McIntosh	0.23	Silty	Warm Moist	90	6106	2	1315	66	2360
Oklahoma	Major	0.18	Silty	Warm Dry	164	11131	4	2064	78	2779
Oklahoma	Marshall	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Mayes	0.24	Silty	Warm Moist	75	5070	3	1798	72	2549
Oklahoma	Murray	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Muskogee	0.23	Silty	Warm Moist	112	7606	4	2429	98	3494
Oklahoma	Noble	0.18	Silty	Warm Dry	57	3878	3	1547	61	2164
Oklahoma	Nowata	0.24	Silty	Warm Moist	95	6478	4	2077	51	1821
Oklahoma	Okfuskee	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Oklahoma	0.22	Silty	Warm Dry	77	5241	4	2056	70	2483
Oklahoma	Okmulgee	0.23	Silty	Warm Moist	98	6678	4	2139	95	3398
Oklahoma	Osage	0.22	Silty	Warm Dry	75	5109	3	1656	65	2325
Oklahoma	Ottawa	0.24	Silty	Warm Moist	102	6963	4	2527	79	2825
Oklahoma	Pawnee	0.21	Silty	Warm Dry	90	6106	2	1439	62	2202

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Oklahoma	Payne	0.20	Silty	Warm Dry	70	4758	3	1833	57	2042
Oklahoma	Pittsburg	0.23	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Pontotoc	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Pottawatomie	0.23	Silty	Warm Dry	99	6729	4	2191	86	3070
Oklahoma	Pushmataha	0.23	Silty	Warm Moist	90	6106	4	2064	66	2360
Oklahoma	Roger Mills	0.23	Silty	Warm Dry	90	6106	4	2064	61	2183
Oklahoma	Rogers	0.24	Silty	Warm Moist	88	5963	3	1937	50	1772
Oklahoma	Seminole	0.23	Silty	Warm Dry	90	6106	4	2064	66	2360
Oklahoma	Sequoyah	0.23	Silty	Warm Moist	100	6783	4	2390	107	3818
Oklahoma	Stephens	0.23	Silty	Warm Dry	90	6106	4	2064	59	2093
Oklahoma	Texas	0.22	Silty	Warm Dry	90	6106	6	3342	68	2434
Oklahoma	Tillman	0.23	Silty	Warm Dry	48	3270	4	2064	55	1948
Oklahoma	Tulsa	0.23	Silty	Warm Dry	90	6106	4	2078	39	1379
Oklahoma	Wagoner	0.24	Silty	Warm Moist	66	4510	3	1852	77	2754
Oklahoma	Washington	0.23	Silty	Warm Dry	76	5153	3	1801	70	2493
Oklahoma	Washita	0.23	Silty	Warm Dry	90	6106	4	2179	54	1918
Oklahoma	Woods	0.20	Silty	Warm Dry	90	6106	4	2064	64	2291
Oklahoma	Woodward	0.21	Silty	Warm Dry	90	6106	4	2064	60	2141
Oregon	Baker	0.23	Silty	Cool Dry	196	13332	NA	NA	115	6762
Oregon	Benton	0.24	Silty	Warm Moist	196	13332	NA	NA	99	5826
Oregon	Clackamas	0.21	Silty	Cool Moist	196	13332	NA	NA	110	6434
Oregon	Clatsop	0.23	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Columbia	0.23	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Coos	0.24	Silty	Warm Moist	196	13332	NA	NA	99	5826
Oregon	Crook	0.21	Silty	Cool Dry	196	13332	NA	NA	99	5826
Oregon	Curry	0.24	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Deschutes	0.22	Silty	Cool Dry	196	13332	NA	NA	99	5826
Oregon	Douglas	0.24	Silty	Warm Moist	196	13332	NA	NA	99	5826
Oregon	Gilliam	0.16	Silty	Warm Dry	196	13332	NA	NA	44	2580
Oregon	Grant	0.22	Silty	Cool Dry	196	13332	NA	NA	99	5826
Oregon	Harney	0.21	Silty	Cool Dry	196	13332	NA	NA	99	5826
Oregon	Hood River	0.20	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Jackson	0.24	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Jefferson	0.18	Sandy	Cool Dry	196	13332	NA	NA	148	8665
Oregon	Josephine	0.24	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Klamath	0.21	Sandy	Cool Dry	196	13332	NA	NA	108	6310
Oregon	Lake	0.19	Silty	Cool Dry	196	13332	NA	NA	99	5826
Oregon	Lane	0.23	Silty	Cool Moist	196	13332	NA	NA	115	6770
Oregon	Lincoln	0.24	Silty	Warm Moist	196	13332	NA	NA	99	5826
Oregon	Linn	0.23	Silty	Cool Moist	196	13332	NA	NA	129	7550
Oregon	Malheur	0.22	Silty	Cool Dry	196	13332	NA	NA	118	6947
Oregon	Marion	0.22	Silty	Warm Moist	196	13332	NA	NA	129	7557
Oregon	Morrow	0.18	Silty	Cool Dry	196	13332	NA	NA	45	2621
Oregon	Multnomah	0.22	Silty	Warm Moist	196	13332	NA	NA	99	5826
Oregon	Polk	0.23	Silty	Warm Moist	196	13332	NA	NA	124	7274

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Oregon	Sherman	0.17	Silty	Cool Dry	196	13332	NA	NA	57	3353
Oregon	Tillamook	0.23	Silty	Cool Moist	196	13332	NA	NA	99	5826
Oregon	Umatilla	0.22	Silty	Warm Dry	196	13332	NA	NA	80	4675
Oregon	Union	0.23	Silty	Cool Moist	196	13332	NA	NA	93	5427
Oregon	Wallowa	0.24	Silty	Cool Moist	196	13332	NA	NA	52	3060
Oregon	Wasco	0.17	Sandy	Cool Dry	196	13332	NA	NA	57	3372
Oregon	Washington	0.23	Silty	Warm Moist	196	13332	NA	NA	133	7781
Oregon	Wheeler	0.17	Sandy	Cool Dry	196	13332	NA	NA	99	5826
Oregon	Yamhill	0.23	Silty	Warm Moist	196	13332	NA	NA	132	7736
Pennsylvania	Adams	0.21	Silty	Warm Moist	102	8371	5	2993	101	4587
Pennsylvania	Allegheny	0.22	Silty	Warm Moist	90	7405	5	2950	93	4227
Pennsylvania	Armstrong	0.22	Silty	Cool Moist	88	7262	4	2564	75	3406
Pennsylvania	Beaver	0.22	Silty	Cool Moist	105	8579	5	2947	93	4227
Pennsylvania	Bedford	0.21	Silty	Cool Moist	94	7730	5	3163	86	3917
Pennsylvania	Berks	0.21	Silty	Warm Moist	118	9666	6	3520	91	4146
Pennsylvania	Blair	0.21	Silty	Cool Moist	121	9928	6	3388	120	5454
Pennsylvania	Bradford	0.20	Silty	Cool Moist	97	7975	4	2475	84	3786
Pennsylvania	Bucks	0.18	Sandy	Warm Moist	105	8609	5	2850	78	3524
Pennsylvania	Butler	0.22	Silty	Cool Moist	100	8233	4	2466	79	3564
Pennsylvania	Cambria	0.22	Silty	Cool Moist	87	7130	5	2927	94	4267
Pennsylvania	Cameron	0.20	Silty	Cool Moist	102	8365	5	2950	93	4227
Pennsylvania	Carbon	0.21	Silty	Cool Moist	91	7488	6	3248	93	4227
Pennsylvania	Centre	0.20	Silty	Cool Moist	114	9346	5	3168	104	4694
Pennsylvania	Chester	0.20	Silty	Warm Moist	141	11545	6	3665	103	4691
Pennsylvania	Clarion	0.22	Silty	Cool Moist	107	8767	5	2730	64	2905
Pennsylvania	Clearfield	0.21	Silty	Cool Moist	85	7011	5	2950	96	4344
Pennsylvania	Clinton	0.20	Silty	Cool Moist	97	7950	6	3349	114	5185
Pennsylvania	Columbia	0.20	Silty	Cool Moist	110	9005	5	2811	98	4432
Pennsylvania	Crawford	0.23	Silty	Cool Moist	95	7761	4	2493	74	3363
Pennsylvania	Cumberland	0.20	Silty	Warm Moist	115	9467	5	3124	92	4170
Pennsylvania	Dauphin	0.21	Silty	Warm Moist	109	8944	5	2848	103	4677
Pennsylvania	Delaware	0.19	Sandy	Warm Moist	102	8365	5	2950	93	4227
Pennsylvania	Elk	0.21	Silty	Cool Moist	94	7750	5	2950	93	4227
Pennsylvania	Erie	0.20	Silty	Cool Moist	109	8914	4	2607	79	3584
Pennsylvania	Fayette	0.22	Silty	Cool Moist	93	7619	4	2464	93	4227
Pennsylvania	Forest	0.21	Silty	Cool Moist	91	7460	5	2950	93	4227
Pennsylvania	Franklin	0.20	Silty	Warm Moist	117	9635	5	3138	100	4550
Pennsylvania	Fulton	0.21	Silty	Warm Moist	81	6619	4	2456	88	3975
Pennsylvania	Greene	0.21	Silty	Warm Moist	95	7777	5	2950	93	4227
Pennsylvania	Huntingdon	0.21	Silty	Cool Moist	100	8202	6	3372	96	4358
Pennsylvania	Indiana	0.22	Silty	Cool Moist	100	8230	5	2658	87	3961
Pennsylvania	Jefferson	0.22	Silty	Cool Moist	94	7698	3	2019	89	4032
Pennsylvania	Juniata	0.20	Silty	Warm Moist	96	7846	5	2827	86	3894
Pennsylvania	Lackawanna	0.21	Silty	Cool Moist	83	6782	5	2950	93	4227
Pennsylvania	Lancaster	0.21	Silty	Warm Moist	141	11539	7	3987	124	5605

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Pennsylvania	Lawrence	0.22	Silty	Cool Moist	106	8718	5	2882	86	3877
Pennsylvania	Lebanon	0.21	Silty	Warm Moist	130	10689	6	3708	126	5700
Pennsylvania	Lehigh	0.20	Silty	Warm Moist	122	10032	6	3237	95	4301
Pennsylvania	Luzerne	0.20	Silty	Cool Moist	87	7163	5	3015	88	3995
Pennsylvania	Lycoming	0.20	Silty	Cool Moist	100	8190	5	2999	88	3995
Pennsylvania	McKean	0.20	Silty	Cool Moist	81	6678	5	2950	93	4227
Pennsylvania	Mercer	0.23	Silty	Cool Moist	103	8459	5	2888	89	4015
Pennsylvania	Mifflin	0.20	Silty	Cool Moist	107	8803	6	3364	87	3958
Pennsylvania	Monroe	0.21	Silty	Cool Moist	102	8365	5	2821	93	4227
Pennsylvania	Montgomery	0.19	Sandy	Warm Moist	102	8365	5	2950	93	4227
Pennsylvania	Montour	0.20	Silty	Cool Moist	101	8263	5	2986	72	3285
Pennsylvania	Northampton	0.21	Silty	Cool Moist	117	9613	6	3215	96	4338
Pennsylvania	Northumberland	0.20	Silty	Cool Moist	118	9660	6	3327	105	4751
Pennsylvania	Perry	0.20	Silty	Warm Moist	102	8344	5	2967	95	4297
Pennsylvania	Philadelphia	0.17	Sandy	Warm Moist	102	8365	5	2950	93	4227
Pennsylvania	Pike	0.21	Silty	Cool Moist	102	8365	5	2950	93	4227
Pennsylvania	Potter	0.20	Silty	Cool Moist	95	7762	4	2152	108	4879
Pennsylvania	Schuylkill	0.21	Silty	Cool Moist	104	8551	5	3033	87	3954
Pennsylvania	Snyder	0.20	Silty	Cool Moist	101	8323	5	2865	89	4032
Pennsylvania	Somerset	0.22	Silty	Cool Moist	101	8301	5	2858	93	4227
Pennsylvania	Sullivan	0.20	Silty	Cool Moist	87	7099	5	2950	93	4227
Pennsylvania	Susquehanna	0.20	Silty	Cool Moist	76	6220	5	2950	93	4227
Pennsylvania	Tioga	0.20	Silty	Cool Moist	102	8374	4	2569	89	4055
Pennsylvania	Union	0.20	Silty	Cool Moist	116	9498	6	3279	97	4391
Pennsylvania	Venango	0.21	Silty	Cool Moist	95	7775	4	2313	93	4227
Pennsylvania	Warren	0.20	Silty	Cool Moist	102	8365	5	2950	93	4227
Pennsylvania	Washington	0.22	Silty	Cool Moist	94	7714	5	2831	93	4227
Pennsylvania	Wayne	0.20	Silty	Cool Moist	105	8649	5	2950	93	4227
Pennsylvania	Westmoreland	0.22	Silty	Cool Moist	96	7889	5	2757	93	4227
Pennsylvania	Wyoming	0.20	Silty	Cool Moist	81	6628	5	2950	93	4227
Pennsylvania	York	0.21	Silty	Warm Moist	125	10247	5	3182	107	4859
Rhode Island	Bristol	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Rhode Island	Kent	0.10	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Rhode Island	Newport	0.12	Sandy	Warm Moist	NA	NA	NA	NA	NA	NA
Rhode Island	Providence	0.09	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Rhode Island	Washington	0.11	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
South Carolina	Abbeville	0.24	Sandy	Warm Moist	104	7066	3	1988	60	2710
South Carolina	Aiken	0.23	Silty	Warm Moist	100	6796	3	1648	51	2320
South Carolina	Allendale	0.20	Sandy	Warm Moist	96	6563	3	1840	55	2495
South Carolina	Anderson	0.24	Sandy	Warm Moist	61	4134	3	1468	56	2529
South Carolina	Bamberg	0.22	Silty	Warm Moist	127	8618	4	2198	51	2300
South Carolina	Barnwell	0.23	Silty	Warm Moist	129	8778	4	2170	66	3006
South Carolina	Beaufort	0.16	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Berkeley	0.22	Silty	Warm Moist	58	3954	3	1749	65	2930
South Carolina	Calhoun	0.23	Silty	Warm Moist	139	9484	3	1831	67	3020

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
South Carolina	Charleston	0.19	Silty	Warm Moist	107	7282	3	1988	65	2930
South Carolina	Cherokee	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Chester	0.24	Sandy	Warm Moist	80	5417	3	1988	65	2930
South Carolina	Chesterfield	0.24	Silty	Warm Moist	76	5188	3	1977	86	3880
South Carolina	Clarendon	0.23	Silty	Warm Moist	116	7925	4	2248	71	3238
South Carolina	Colleton	0.19	Sandy	Warm Moist	76	5177	4	2282	65	2930
South Carolina	Darlington	0.23	Silty	Warm Moist	98	6671	3	1817	72	3268
South Carolina	Dillon	0.23	Silty	Warm Moist	107	7301	4	2199	64	2922
South Carolina	Dorchester	0.20	Silty	Warm Moist	95	6486	4	2122	65	2930
South Carolina	Edgefield	0.24	Sandy	Warm Moist	112	7639	3	1740	65	2930
South Carolina	Fairfield	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Florence	0.23	Silty	Warm Moist	93	6298	3	1887	46	2078
South Carolina	Georgetown	0.23	Silty	Warm Moist	98	6685	4	2098	65	2930
South Carolina	Greenville	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Greenwood	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Hampton	0.19	Sandy	Warm Moist	128	8682	4	2345	70	3154
South Carolina	Horry	0.23	Silty	Warm Moist	97	6609	3	1742	53	2414
South Carolina	Jasper	0.16	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Kershaw	0.24	Silty	Warm Moist	148	10043	4	2401	65	2930
South Carolina	Lancaster	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Laurens	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Lee	0.23	Silty	Warm Moist	119	8131	3	1977	71	3208
South Carolina	Lexington	0.24	Silty	Warm Moist	120	8146	3	1488	64	2912
South Carolina	McCormick	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Marion	0.23	Silty	Warm Moist	112	7606	4	2222	70	3194
South Carolina	Marlboro	0.24	Silty	Warm Moist	106	7218	4	2174	71	3238
South Carolina	Newberry	0.24	Sandy	Warm Moist	76	5185	4	2238	76	3437
South Carolina	Oconee	0.24	Sandy	Warm Moist	89	6049	3	1993	65	2930
South Carolina	Orangeburg	0.23	Silty	Warm Moist	118	8008	4	2165	76	3463
South Carolina	Pickens	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Richland	0.24	Silty	Warm Moist	161	10928	4	2055	43	1967
South Carolina	Saluda	0.24	Sandy	Warm Moist	79	5382	4	2334	65	2930
South Carolina	Spartanburg	0.24	Sandy	Warm Moist	85	5762	3	1681	74	3349
South Carolina	Sumter	0.23	Silty	Warm Moist	125	8472	4	2362	66	2972
South Carolina	Union	0.24	Sandy	Warm Moist	104	7066	3	1988	65	2930
South Carolina	Williamsburg	0.23	Silty	Warm Moist	97	6574	3	1997	65	2930
South Carolina	York	0.24	Sandy	Warm Moist	104	7066	2	1184	71	3241
South Dakota	Aurora	0.32	Clayey	Cool Dry	120	8348	5	3004	121	4349
South Dakota	Beadle	0.26	Silty	Cool Dry	138	9610	5	3065	113	4071
South Dakota	Bennett	0.24	Silty	Cool Dry	116	8078	5	3034	80	2865
South Dakota	Bon Homme	0.22	Silty	Cool Dry	141	9818	6	3275	127	4566
South Dakota	Brookings	0.24	Silty	Cool Dry	177	12331	6	3591	122	4365
South Dakota	Brown	0.24	Silty	Cool Dry	147	10206	5	2827	105	3769
South Dakota	Brule	0.36	Clayey	Cool Dry	126	8776	6	3220	107	3839
South Dakota	Buffalo	0.38	Clayey	Cool Dry	121	8379	5	2892	105	3769

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
South Dakota	Butte	0.36	Clayey	Cool Dry	126	8769	5	2593	105	3769
South Dakota	Campbell	0.23	Silty	Cool Dry	112	7786	4	2526	105	3769
South Dakota	Charles Mix	0.26	Silty	Cool Dry	133	9271	6	3256	122	4395
South Dakota	Clark	0.24	Silty	Cool Dry	160	11104	5	3068	105	3769
South Dakota	Clay	0.21	Silty	Cool Dry	166	11508	6	3576	105	3769
South Dakota	Codington	0.24	Silty	Cool Dry	154	10733	5	3048	126	4517
South Dakota	Corson	0.24	Silty	Cool Dry	79	5498	3	1722	105	3769
South Dakota	Custer	0.25	Silty	Cool Dry	90	6277	5	3034	105	3769
South Dakota	Davison	0.28	Clayey	Cool Dry	117	8122	6	3171	112	4004
South Dakota	Day	0.24	Silty	Cool Dry	140	9732	5	2690	105	3769
South Dakota	Deuel	0.24	Silty	Cool Dry	160	11131	6	3295	105	3769
South Dakota	Dewey	0.36	Clayey	Cool Dry	82	5724	5	3034	105	3769
South Dakota	Douglas	0.27	Silty	Cool Dry	125	8682	6	3394	125	4471
South Dakota	Edmunds	0.25	Silty	Cool Dry	113	7868	4	2213	105	3769
South Dakota	Fall River	0.24	Silty	Cool Dry	128	8862	5	3034	105	3769
South Dakota	Faulk	0.26	Silty	Cool Dry	112	7767	4	2406	105	3769
South Dakota	Grant	0.24	Silty	Cool Dry	156	10839	6	3151	129	4617
South Dakota	Gregory	0.26	Silty	Cool Dry	116	8066	5	3053	105	3769
South Dakota	Haakon	0.47	Clayey	Cool Dry	128	8862	5	3034	69	2482
South Dakota	Hamlin	0.24	Silty	Cool Dry	173	12034	6	3527	139	4973
South Dakota	Hand	0.28	Clayey	Cool Dry	122	8501	5	2753	117	4212
South Dakota	Hanson	0.24	Silty	Cool Dry	132	9186	6	3241	152	5464
South Dakota	Harding	0.26	Silty	Cool Dry	77	5323	5	3034	105	3769
South Dakota	Hughes	0.41	Clayey	Cool Dry	95	6597	5	2569	102	3650
South Dakota	Hutchinson	0.24	Silty	Cool Dry	145	10087	6	3342	127	4558
South Dakota	Hyde	0.33	Clayey	Cool Dry	114	7890	5	3034	105	3769
South Dakota	Jackson	0.40	Clayey	Cool Dry	128	8862	5	3034	65	2337
South Dakota	Jerauld	0.33	Clayey	Cool Dry	132	9208	5	3016	105	3769
South Dakota	Jones	0.48	Clayey	Cool Dry	86	6007	3	1829	80	2858
South Dakota	Kingsbury	0.24	Silty	Cool Dry	160	11132	6	3416	106	3810
South Dakota	Lake	0.23	Silty	Cool Dry	161	11180	6	3510	105	3769
South Dakota	Lawrence	0.29	Clayey	Cool Moist	128	8862	5	3034	105	3769
South Dakota	Lincoln	0.21	Silty	Cool Dry	155	10801	6	3465	138	4940
South Dakota	Lyman	0.44	Clayey	Cool Dry	99	6897	5	2883	95	3400
South Dakota	McCook	0.23	Silty	Cool Dry	150	10408	6	3424	105	3769
South Dakota	McPherson	0.24	Silty	Cool Dry	116	8028	4	2206	105	3769
South Dakota	Marshall	0.25	Silty	Cool Dry	162	11231	5	2978	105	3769
South Dakota	Meade	0.42	Clayey	Cool Dry	79	5511	5	3034	74	2666
South Dakota	Mellette	0.40	Clayey	Cool Dry	64	4431	5	3034	71	2556
South Dakota	Miner	0.24	Silty	Cool Dry	149	10323	6	3412	99	3544
South Dakota	Minnehaha	0.23	Silty	Cool Dry	167	11591	7	3790	105	3769
South Dakota	Moody	0.23	Silty	Cool Dry	180	12497	7	3932	105	3769
South Dakota	Oglala Lakota	0.28	Clayey	Cool Dry	128	8862	5	3034	88	3154
South Dakota	Pennington	0.35	Clayey	Cool Dry	128	8862	5	3034	84	2999
South Dakota	Perkins	0.31	Clayey	Cool Dry	40	2768	5	3034	105	3769

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
South Dakota	Potter	0.31	Clayey	Cool Dry	106	7339	4	2342	86	3100
South Dakota	Roberts	0.25	Silty	Cool Dry	163	11356	5	3052	109	3901
South Dakota	Sanborn	0.28	Clayey	Cool Dry	141	9809	6	3342	103	3706
South Dakota	Sanborn	0.28	Clayey	Cool Dry	141	9809	6	3342	103	3706
South Dakota	Stanley	0.46	Clayey	Cool Dry	128	8862	5	3034	75	2697
South Dakota	Sully	0.37	Clayey	Cool Dry	103	7128	5	2591	96	3439
South Dakota	Todd	0.26	Sandy	Cool Dry	103	7155	5	3034	74	2650
South Dakota	Tripp	0.29	Sandy	Cool Dry	99	6864	5	2838	88	3168
South Dakota	Turner	0.22	Silty	Cool Dry	156	10865	6	3478	139	4991
South Dakota	Union	0.20	Silty	Cool Dry	167	11594	6	3665	105	3769
South Dakota	Walworth	0.26	Silty	Cool Dry	127	8852	5	2598	138	4956
South Dakota	Yankton	0.22	Silty	Cool Dry	158	10976	6	3598	119	4265
South Dakota	Ziebach	0.42	Clayey	Cool Dry	74	5121	5	3034	78	2809
Tennessee	Anderson	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Bedford	0.24	Sandy	Warm Moist	150	10203	15	3041	98	4443
Tennessee	Benton	0.24	Silty	Warm Moist	149	10145	15	2934	97	4398
Tennessee	Bledsoe	0.24	Sandy	Warm Moist	125	8519	14	2863	96	4344
Tennessee	Blount	0.24	Sandy	Warm Moist	128	8731	14	2798	66	2999
Tennessee	Bradley	0.24	Sandy	Warm Moist	117	7986	15	2951	80	3645
Tennessee	Campbell	0.24	Silty	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Cannon	0.24	Sandy	Warm Moist	155	10564	19	3715	94	4254
Tennessee	Carroll	0.26	Silty	Warm Moist	140	9516	16	3116	110	4993
Tennessee	Carter	0.24	Silty	Warm Moist	135	9160	16	3104	97	4398
Tennessee	Cheatham	0.23	Silty	Warm Moist	155	10545	13	2673	75	3416
Tennessee	Chester	0.35	Clayey	Warm Moist	142	9651	15	3085	97	4398
Tennessee	Claiborne	0.24	Silty	Warm Moist	105	7137	16	3104	97	4398
Tennessee	Clay	0.24	Silty	Warm Moist	139	9475	17	3412	97	4398
Tennessee	Cocke	0.24	Sandy	Warm Moist	96	6547	14	2825	97	4398
Tennessee	Coffee	0.24	Sandy	Warm Moist	164	11148	18	3610	108	4908
Tennessee	Crockett	0.30	Clayey	Warm Moist	151	10247	17	3418	107	4845
Tennessee	Cumberland	0.24	Sandy	Warm Moist	110	7453	16	3104	97	4398
Tennessee	Davidson	0.24	Silty	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Decatur	0.28	Clayey	Warm Moist	154	10505	14	2752	97	4398
Tennessee	DeKalb	0.24	Sandy	Warm Moist	143	9761	16	3273	97	4398
Tennessee	Dickson	0.23	Silty	Warm Moist	158	10765	13	2623	97	4398
Tennessee	Dyer	0.25	Silty	Warm Moist	157	10714	15	3040	96	4341
Tennessee	Fayette	0.44	Clayey	Warm Moist	151	10260	15	3034	88	3997
Tennessee	Fentress	0.24	Silty	Warm Moist	119	8111	15	3005	97	4398
Tennessee	Franklin	0.24	Sandy	Warm Moist	166	11301	18	3649	116	5240
Tennessee	Gibson	0.26	Silty	Warm Moist	148	10047	16	3098	105	4759
Tennessee	Giles	0.24	Sandy	Warm Moist	166	11319	17	3354	99	4479
Tennessee	Grainger	0.24	Sandy	Warm Moist	125	8489	16	3104	97	4398
Tennessee	Greene	0.24	Sandy	Warm Moist	133	9042	16	3172	76	3450
Tennessee	Grundy	0.24	Sandy	Warm Moist	114	7727	15	2929	97	4398
Tennessee	Hamblen	0.24	Sandy	Warm Moist	148	10043	13	2502	97	4398

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Tennessee	Hamilton	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Hancock	0.24	Silty	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Hardeman	0.39	Clayey	Warm Moist	145	9842	15	2966	98	4459
Tennessee	Hardin	0.32	Clayey	Warm Moist	143	9763	14	2803	100	4553
Tennessee	Hawkins	0.24	Silty	Warm Moist	115	7806	16	3225	97	4398
Tennessee	Haywood	0.38	Clayey	Warm Moist	167	11394	16	3137	101	4584
Tennessee	Henderson	0.31	Clayey	Warm Moist	139	9492	15	2964	94	4240
Tennessee	Henry	0.22	Silty	Warm Moist	154	10447	16	3223	102	4634
Tennessee	Hickman	0.24	Sandy	Warm Moist	159	10812	14	2757	102	4634
Tennessee	Houston	0.23	Silty	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Humphreys	0.23	Silty	Warm Moist	147	10034	15	3083	97	4398
Tennessee	Jackson	0.24	Silty	Warm Moist	133	9055	15	2986	97	4398
Tennessee	Jefferson	0.24	Sandy	Warm Moist	123	8379	17	3426	97	4398
Tennessee	Johnson	0.23	Silty	Warm Moist	138	9415	16	3104	97	4398
Tennessee	Knox	0.24	Sandy	Warm Moist	107	7256	14	2858	97	4398
Tennessee	Lake	0.24	Silty	Warm Moist	154	10482	18	3544	107	4847
Tennessee	Lauderdale	0.37	Clayey	Warm Moist	152	10350	16	3127	106	4802
Tennessee	Lawrence	0.24	Sandy	Warm Moist	160	10905	16	3255	116	5275
Tennessee	Lewis	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Lincoln	0.24	Sandy	Warm Moist	162	11027	16	3276	103	4671
Tennessee	Loudon	0.24	Sandy	Warm Moist	143	9761	18	3692	65	2939
Tennessee	McMinn	0.24	Sandy	Warm Moist	160	10887	14	2851	101	4593
Tennessee	McNairy	0.35	Clayey	Warm Moist	128	8738	14	2845	97	4398
Tennessee	Macon	0.24	Silty	Warm Moist	156	10625	17	3455	97	4398
Tennessee	Madison	0.36	Clayey	Warm Moist	155	10578	15	3026	106	4799
Tennessee	Marion	0.24	Sandy	Warm Moist	151	10299	16	3162	97	4398
Tennessee	Marshall	0.24	Sandy	Warm Moist	148	10062	16	3166	90	4080
Tennessee	Maury	0.24	Sandy	Warm Moist	154	10482	16	3116	97	4401
Tennessee	Meigs	0.24	Sandy	Warm Moist	111	7543	17	3386	97	4398
Tennessee	Monroe	0.24	Sandy	Warm Moist	142	9687	11	2222	93	4211
Tennessee	Montgomery	0.23	Silty	Warm Moist	153	10443	16	3166	106	4794
Tennessee	Moore	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Morgan	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Obion	0.22	Silty	Warm Moist	160	10895	17	3325	100	4548
Tennessee	Overton	0.24	Silty	Warm Moist	140	9512	19	3773	97	4398
Tennessee	Perry	0.28	Sandy	Warm Moist	117	7978	11	2280	97	4398
Tennessee	Pickett	0.24	Silty	Warm Moist	158	10768	16	3104	97	4398
Tennessee	Polk	0.24	Sandy	Warm Moist	134	9101	16	3104	97	4398
Tennessee	Putnam	0.24	Silty	Warm Moist	157	10670	18	3512	97	4398
Tennessee	Rhea	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Roane	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Robertson	0.24	Silty	Warm Moist	163	11086	15	3053	104	4695
Tennessee	Rutherford	0.24	Sandy	Warm Moist	164	11170	16	3280	97	4390
Tennessee	Scott	0.24	Silty	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Sequatchie	0.24	Sandy	Warm Moist	116	7877	14	2845	97	4398

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Tennessee	Sevier	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Shelby	0.50	Clayey	Warm Moist	142	9666	16	3104	97	4398
Tennessee	Smith	0.24	Silty	Warm Moist	158	10733	17	3319	116	5259
Tennessee	Stewart	0.23	Silty	Warm Moist	145	9852	15	2959	97	4398
Tennessee	Sullivan	0.24	Silty	Warm Moist	132	9004	16	3104	97	4398
Tennessee	Sumner	0.24	Silty	Warm Moist	164	11173	16	3263	95	4322
Tennessee	Tipton	0.46	Clayey	Warm Moist	146	9944	15	2971	86	3899
Tennessee	Trousdale	0.24	Silty	Warm Moist	143	9761	15	2999	97	4398
Tennessee	Unicoi	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Union	0.24	Sandy	Warm Moist	143	9761	16	3104	97	4398
Tennessee	Van Buren	0.24	Sandy	Warm Moist	143	9761	15	2972	97	4398
Tennessee	Warren	0.24	Sandy	Warm Moist	163	11078	17	3311	91	4134
Tennessee	Washington	0.24	Silty	Warm Moist	131	8895	14	2888	85	3833
Tennessee	Wayne	0.27	Sandy	Warm Moist	131	8907	14	2739	97	4398
Tennessee	Weakley	0.22	Silty	Warm Moist	147	10028	16	3228	96	4369
Tennessee	White	0.24	Sandy	Warm Moist	164	11169	18	3609	97	4398
Tennessee	Williamson	0.24	Sandy	Warm Moist	172	11700	17	3394	103	4654
Tennessee	Wilson	0.24	Silty	Warm Moist	139	9490	15	3038	97	4398
Texas	Anderson	0.29	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Andrews	0.15	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Angelina	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Aransas	0.48	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Archer	0.23	Silty	Warm Dry	125	7036	3	1998	31	1645
Texas	Armstrong	0.23	Silty	Warm Dry	194	10888	3	1998	34	1813
Texas	Atascosa	0.49	Clayey	Warm Dry	85	4758	3	1998	36	1903
Texas	Austin	0.48	Clayey	Warm Moist	110	6145	3	1998	38	2044
Texas	Bailey	0.19	Silty	Warm Dry	64	3584	3	1998	38	2026
Texas	Bandera	0.46	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Bastrop	0.51	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Baylor	0.23	Silty	Warm Dry	125	7036	3	1998	29	1538
Texas	Bee	0.45	Clayey	Warm Dry	94	5298	3	1998	38	2044
Texas	Bell	0.44	Clayey	Warm Dry	87	4890	3	1998	50	2666
Texas	Bexar	0.49	Clayey	Warm Dry	103	5766	3	1998	44	2344
Texas	Blanco	0.50	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Borden	0.15	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Bosque	0.30	Clayey	Warm Dry	125	7036	3	1998	36	1892
Texas	Bowie	0.24	Silty	Warm Moist	125	7036	3	1998	33	1749
Texas	Brazoria	0.46	Clayey	Warm Moist	94	5279	3	1982	38	2044
Texas	Brazos	0.41	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Brewster	0.21	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Briscoe	0.23	Silty	Warm Dry	141	7919	3	1998	22	1194
Texas	Brooks	0.19	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Brown	0.23	Silty	Warm Dry	125	7036	3	1998	29	1518
Texas	Burleson	0.44	Clayey	Warm Dry	113	6318	3	1998	38	2044
Texas	Burnet	0.46	Clayey	Warm Dry	125	7036	3	1998	38	2044

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Texas	Caldwell	0.52	Clayey	Warm Dry	109	6116	3	1998	38	2018
Texas	Calhoun	0.53	Clayey	Warm Moist	114	6405	2	1137	38	2044
Texas	Callahan	0.22	Silty	Warm Dry	125	7036	3	1998	35	1847
Texas	Cameron	0.28	Sandy	Warm Dry	102	5718	3	1998	38	2044
Texas	Camp	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Carson	0.24	Silty	Warm Dry	207	11584	3	1998	36	1894
Texas	Cass	0.24	Sandy	Warm Moist	125	7036	3	1998	38	2044
Texas	Castro	0.22	Silty	Warm Dry	231	12965	3	1998	45	2397
Texas	Chambers	0.45	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Cherokee	0.25	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Childress	0.23	Silty	Warm Dry	125	7036	3	1998	23	1226
Texas	Clay	0.23	Silty	Warm Dry	125	7036	3	1998	31	1668
Texas	Cochran	0.15	Sandy	Warm Dry	121	6804	3	1998	28	1501
Texas	Coke	0.22	Silty	Warm Dry	125	7036	3	1998	28	1514
Texas	Coleman	0.23	Silty	Warm Dry	92	5138	3	1998	26	1408
Texas	Collin	0.24	Silty	Warm Dry	84	4734	3	1998	57	3052
Texas	Collingsworth	0.23	Silty	Warm Dry	125	7036	3	1998	36	1902
Texas	Colorado	0.51	Clayey	Warm Moist	126	7086	3	1998	38	2044
Texas	Comal	0.50	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Comanche	0.24	Silty	Warm Dry	125	7036	3	1998	38	2038
Texas	Concho	0.27	Silty	Warm Dry	117	6559	3	1998	37	1961
Texas	Cooke	0.23	Silty	Warm Dry	102	5740	3	1998	44	2335
Texas	Coryell	0.37	Clayey	Warm Dry	125	7036	3	1998	36	1901
Texas	Cottle	0.22	Silty	Warm Dry	125	7036	3	1998	23	1204
Texas	Crane	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Crockett	0.23	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Crosby	0.18	Sandy	Warm Dry	117	6572	3	1998	23	1240
Texas	Culberson	0.22	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Dallam	0.21	Silty	Warm Dry	223	12500	3	1998	63	3354
Texas	Dallas	0.24	Silty	Warm Dry	125	7036	3	1998	47	2508
Texas	Dawson	0.14	Sandy	Warm Dry	125	7036	3	1998	51	2695
Texas	Deaf Smith	0.22	Silty	Warm Dry	196	11011	3	1998	42	2211
Texas	Delta	0.24	Silty	Warm Moist	79	4444	3	1533	64	3386
Texas	Denton	0.24	Silty	Warm Dry	48	2680	1	773	38	2015
Texas	DeWitt	0.52	Clayey	Warm Dry	65	3656	3	1998	38	2044
Texas	Dickens	0.19	Silty	Warm Dry	125	7036	3	1998	29	1520
Texas	Dimmit	0.41	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Donley	0.23	Silty	Warm Dry	125	7036	3	1998	30	1601
Texas	Duval	0.24	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Eastland	0.23	Silty	Warm Dry	125	7036	3	1998	19	1009
Texas	Ector	0.21	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Edwards	0.38	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Ellis	0.26	Silty	Warm Dry	91	5114	5	3080	55	2920
Texas	El Paso	0.17	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Erath	0.25	Silty	Warm Dry	125	7036	3	1998	38	2044

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Texas	Falls	0.40	Clayey	Warm Dry	91	5078	3	1998	59	3119
Texas	Fannin	0.24	Silty	Warm Moist	100	5593	3	1811	53	2806
Texas	Fayette	0.50	Clayey	Warm Dry	96	5358	3	1998	38	2044
Texas	Fisher	0.20	Sandy	Warm Dry	125	7036	3	1998	28	1490
Texas	Floyd	0.21	Silty	Warm Dry	170	9532	3	1998	29	1553
Texas	Foard	0.23	Silty	Warm Dry	125	7036	3	1998	33	1738
Texas	Fort Bend	0.50	Clayey	Warm Moist	118	6628	4	2136	38	2044
Texas	Franklin	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Freestone	0.33	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Frio	0.48	Clayey	Warm Dry	154	8641	3	1998	63	3354
Texas	Gaines	0.12	Sandy	Warm Dry	125	7036	3	1998	53	2842
Texas	Galveston	0.44	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Garza	0.16	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Gillespie	0.48	Clayey	Warm Dry	84	4737	3	1998	40	2116
Texas	Glasscock	0.22	Silty	Warm Dry	125	7036	3	1998	35	1840
Texas	Goliad	0.50	Clayey	Warm Dry	90	5043	3	1998	38	2044
Texas	Gonzales	0.52	Clayey	Warm Dry	111	6211	3	1998	37	1970
Texas	Gray	0.24	Silty	Warm Dry	194	10879	3	1998	31	1670
Texas	Grayson	0.24	Silty	Warm Dry	85	4752	5	2885	60	3197
Texas	Gregg	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Grimes	0.39	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Guadalupe	0.50	Clayey	Warm Dry	96	5382	3	1998	40	2137
Texas	Hale	0.20	Silty	Warm Dry	169	9475	3	1998	32	1695
Texas	Hall	0.23	Silty	Warm Dry	125	7036	3	1998	28	1506
Texas	Hamilton	0.29	Clayey	Warm Dry	125	7036	3	1998	36	1915
Texas	Hansford	0.22	Silty	Warm Dry	221	12417	3	1998	48	2535
Texas	Hardeman	0.23	Silty	Warm Dry	125	7036	3	1998	30	1578
Texas	Hardin	0.28	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Harris	0.46	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Harrison	0.24	Sandy	Warm Moist	125	7036	3	1998	38	2044
Texas	Hartley	0.22	Silty	Warm Dry	239	13426	3	1998	59	3154
Texas	Haskell	0.22	Silty	Warm Dry	125	7036	3	1998	29	1523
Texas	Hays	0.51	Clayey	Warm Dry	100	5605	3	1998	33	1749
Texas	Hemphill	0.24	Silty	Warm Dry	125	7036	3	1998	34	1807
Texas	Henderson	0.28	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Hidalgo	0.19	Sandy	Warm Dry	114	6398	3	1998	38	2044
Texas	Hill	0.30	Clayey	Warm Dry	94	5293	3	1998	60	3165
Texas	Hockley	0.14	Sandy	Warm Dry	112	6279	3	1998	34	1796
Texas	Hood	0.25	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Hopkins	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Houston	0.28	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Howard	0.18	Sandy	Warm Dry	125	7036	3	1998	35	1876
Texas	Hudspeth	0.19	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Hunt	0.24	Silty	Warm Dry	100	5601	4	2324	53	2828
Texas	Hutchinson	0.23	Silty	Warm Dry	218	12251	3	1998	38	2008

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Texas	Irion	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Jack	0.23	Silty	Warm Dry	125	7036	3	1998	36	1921
Texas	Jackson	0.54	Clayey	Warm Moist	112	6283	4	2071	38	2044
Texas	Jasper	0.25	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Jeff Davis	0.21	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Jefferson	0.37	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Jim Hogg	0.18	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Jim Wells	0.32	Clayey	Warm Dry	83	4667	3	1998	38	2044
Texas	Johnson	0.26	Silty	Warm Dry	74	4138	3	1998	54	2862
Texas	Jones	0.21	Silty	Warm Dry	125	7036	3	1998	27	1410
Texas	Karnes	0.51	Clayey	Warm Dry	95	5304	3	1998	60	3174
Texas	Kaufman	0.25	Silty	Warm Dry	125	7036	3	1863	41	2165
Texas	Kendall	0.49	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Kenedy	0.20	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Kent	0.18	Sandy	Warm Dry	125	7036	3	1998	27	1459
Texas	Kerr	0.44	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Kimble	0.40	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	King	0.21	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Kinney	0.40	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Kleberg	0.29	Sandy	Warm Dry	84	4730	3	1998	28	1480
Texas	Knox	0.22	Silty	Warm Dry	125	7036	3	1998	34	1825
Texas	Lamar	0.24	Silty	Warm Moist	102	5699	2	1446	52	2775
Texas	Lamb	0.20	Silty	Warm Dry	156	8761	3	1998	50	2665
Texas	Lampasas	0.36	Clayey	Warm Dry	125	7036	3	1998	38	2000
Texas	La Salle	0.38	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Lavaca	0.52	Clayey	Warm Dry	92	5174	3	1998	38	2044
Texas	Lee	0.48	Clayey	Warm Dry	97	5425	3	1998	38	2044
Texas	Leon	0.34	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Liberty	0.37	Clayey	Warm Moist	125	7036	3	1598	38	2044
Texas	Limestone	0.36	Clayey	Warm Dry	85	4780	3	1998	60	3211
Texas	Lipscomb	0.23	Silty	Warm Dry	125	7036	3	1998	40	2107
Texas	Live Oak	0.41	Clayey	Warm Dry	86	4833	3	1998	38	2044
Texas	Llano	0.47	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Loving	0.22	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Lubbock	0.16	Sandy	Warm Dry	154	8612	3	1998	33	1735
Texas	Lynn	0.14	Sandy	Warm Dry	131	7369	3	1998	36	1932
Texas	McCulloch	0.30	Clayey	Warm Dry	125	7036	3	1998	36	1940
Texas	McLennan	0.36	Clayey	Warm Dry	98	5495	3	1998	56	2985
Texas	McMullen	0.38	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Madison	0.35	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Marion	0.24	Sandy	Warm Moist	125	7036	3	1998	38	2044
Texas	Martin	0.16	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Mason	0.43	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Matagorda	0.50	Clayey	Warm Moist	110	6168	4	2280	38	2044
Texas	Maverick	0.40	Clayey	Warm Dry	125	7036	3	1998	38	2044

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Texas	Medina	0.48	Clayey	Warm Dry	136	7604	3	1998	52	2788
Texas	Menard	0.36	Clayey	Warm Dry	125	7036	3	1998	35	1836
Texas	Midland	0.21	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Milam	0.44	Clayey	Warm Dry	86	4812	3	1998	46	2450
Texas	Mills	0.26	Silty	Warm Dry	125	7036	3	1998	37	1973
Texas	Mitchell	0.19	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Montague	0.23	Silty	Warm Dry	125	7036	3	1998	36	1910
Texas	Montgomery	0.38	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Moore	0.22	Silty	Warm Dry	229	12855	3	1998	44	2336
Texas	Morris	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Motley	0.22	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Nacogdoches	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Navarro	0.30	Clayey	Warm Dry	94	5244	3	1998	49	2593
Texas	Newton	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Nolan	0.21	Silty	Warm Dry	125	7036	3	1998	31	1641
Texas	Nueces	0.37	Clayey	Warm Dry	96	5370	3	1998	38	2044
Texas	Ochiltree	0.23	Silty	Warm Dry	213	11966	3	1998	45	2389
Texas	Oldham	0.23	Silty	Warm Dry	209	11744	3	1998	25	1354
Texas	Orange	0.31	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Palo Pinto	0.23	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Panola	0.24	Sandy	Warm Moist	125	7036	3	1998	38	2044
Texas	Parker	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Parmer	0.22	Silty	Warm Dry	169	9450	3	1998	34	1792
Texas	Pecos	0.23	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Polk	0.25	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Potter	0.23	Silty	Warm Dry	125	7036	3	1998	37	1940
Texas	Presidio	0.17	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Rains	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Randall	0.23	Silty	Warm Dry	183	10278	3	1998	32	1720
Texas	Reagan	0.24	Silty	Warm Dry	125	7036	3	1998	27	1419
Texas	Real	0.43	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Red River	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Reeves	0.23	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Refugio	0.48	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Roberts	0.23	Silty	Warm Dry	243	13646	3	1998	26	1406
Texas	Robertson	0.40	Clayey	Warm Dry	131	7344	3	1998	57	3046
Texas	Rockwall	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Runnels	0.23	Silty	Warm Dry	125	7036	3	1998	38	2020
Texas	Rusk	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Sabine	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	San Augustine	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	San Jacinto	0.28	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	San Patricio	0.41	Clayey	Warm Dry	97	5428	3	1998	38	2044
Texas	San Saba	0.36	Clayey	Warm Dry	125	7036	3	1998	40	2130
Texas	Schleicher	0.29	Clayey	Warm Dry	125	7036	3	1998	21	1116

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
Texas	Scurry	0.17	Sandy	Warm Dry	125	7036	3	1998	29	1536
Texas	Shackelford	0.22	Silty	Warm Dry	125	7036	3	1998	28	1513
Texas	Shelby	0.24	Sandy	Warm Moist	125	7036	3	1998	38	2044
Texas	Sherman	0.22	Silty	Warm Dry	233	13043	3	1998	56	2993
Texas	Smith	0.25	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Somervell	0.26	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Starr	0.16	Sandy	Warm Dry	112	6258	3	1998	38	2044
Texas	Stephens	0.23	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Sterling	0.22	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Stonewall	0.20	Silty	Warm Dry	125	7036	3	1998	24	1284
Texas	Sutton	0.32	Clayey	Warm Dry	125	7036	3	1998	38	2044
Texas	Swisher	0.23	Silty	Warm Dry	150	8430	3	1998	28	1501
Texas	Tarrant	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Taylor	0.22	Silty	Warm Dry	125	7036	3	1998	31	1672
Texas	Terrell	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Terry	0.12	Sandy	Warm Dry	111	6220	3	1998	30	1601
Texas	Throckmorton	0.22	Silty	Warm Dry	125	7036	3	1998	32	1695
Texas	Titus	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Tom Green	0.25	Silty	Warm Dry	139	7789	3	1998	44	2340
Texas	Travis	0.51	Clayey	Warm Dry	77	4306	3	1998	36	1937
Texas	Trinity	0.26	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Tyler	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Upshur	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Upton	0.24	Silty	Warm Dry	125	7036	3	1998	28	1504
Texas	Uvalde	0.46	Clayey	Warm Dry	153	8563	3	1998	51	2695
Texas	Val Verde	0.29	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Van Zandt	0.24	Silty	Warm Moist	125	7036	3	1998	38	2044
Texas	Victoria	0.52	Clayey	Warm Dry	113	6326	5	2650	38	2044
Texas	Walker	0.31	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Waller	0.46	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Ward	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Washington	0.44	Clayey	Warm Moist	125	7036	3	1998	38	2044
Texas	Webb	0.25	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Wharton	0.52	Clayey	Warm Moist	125	7037	4	2405	38	2044
Texas	Wheeler	0.24	Silty	Warm Dry	125	7036	3	1998	29	1518
Texas	Wichita	0.23	Silty	Warm Dry	125	7036	3	1998	34	1822
Texas	Wilbarger	0.23	Silty	Warm Dry	125	7036	3	1998	38	2001
Texas	Willacy	0.21	Sandy	Warm Dry	111	6233	3	1998	38	2044
Texas	Williamson	0.50	Clayey	Warm Dry	88	4941	3	1998	52	2779
Texas	Wilson	0.50	Clayey	Warm Dry	119	6701	3	1998	53	2811
Texas	Winkler	0.21	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Wise	0.24	Silty	Warm Dry	125	7036	3	1998	36	1913
Texas	Wood	0.24	Silty	Warm Dry	125	7036	3	1998	38	2044
Texas	Yoakum	0.12	Sandy	Warm Dry	125	7036	3	1998	26	1375
Texas	Young	0.23	Silty	Warm Dry	125	7036	3	1998	33	1753

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Texas	Zapata	0.16	Sandy	Warm Dry	125	7036	3	1998	38	2044
Texas	Zavala	0.46	Clayey	Warm Dry	124	6930	3	1998	38	2022
Utah	Beaver	0.22	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Box Elder	0.15	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Cache	0.18	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Carbon	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Daggett	0.24	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Davis	0.05	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Duchesne	0.22	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Emery	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Garfield	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Grand	0.23	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Iron	0.21	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Juab	0.22	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Kane	0.22	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Millard	0.21	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Morgan	0.11	Silty	Cool Moist	157	10658	NA	NA	79	3583
Utah	Piute	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Rich	0.18	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Salt Lake	0.10	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	San Juan	0.22	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Sanpete	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Sevier	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Summit	0.17	Silty	Cool Moist	157	10658	NA	NA	79	3583
Utah	Tooele	0.15	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Uintah	0.23	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Utah	0.21	Silty	Cool Dry	157	10658	NA	NA	79	3583
Utah	Wasatch	0.19	Silty	Cool Moist	157	10658	NA	NA	79	3583
Utah	Washington	0.21	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Wayne	0.23	Silty	Warm Dry	157	10658	NA	NA	79	3583
Utah	Weber	0.13	Silty	Cool Moist	157	10658	NA	NA	79	3583
Vermont	Addison	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Bennington	0.13	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Caledonia	0.04	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Chittenden	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Essex	0.04	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Franklin	0.08	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Grand Isle	0.11	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Lamoille	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Orange	0.04	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Orleans	0.05	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Rutland	0.06	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Washington	0.04	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Windham	0.13	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA
Vermont	Windsor	0.07	Sandy	Cool Moist	NA	NA	NA	NA	NA	NA

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Virginia	Accomack	0.23	Silty	Warm Moist	147	9969	14	2611	100	4515
Virginia	Albemarle	0.23	Silty	Warm Moist	113	7689	14	2567	89	4020
Virginia	Alleghany	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Amelia	0.24	Silty	Warm Moist	124	8418	13	2422	94	4270
Virginia	Amherst	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Appomattox	0.24	Silty	Warm Moist	102	6932	13	2361	75	3418
Virginia	Arlington	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Augusta	0.21	Silty	Warm Moist	148	10093	14	2567	93	4237
Virginia	Bath	0.21	Silty	Warm Moist	111	7545	14	2567	89	4020
Virginia	Bedford	0.23	Silty	Warm Moist	116	7871	12	2143	84	3820
Virginia	Bland	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Botetourt	0.22	Silty	Warm Moist	139	9444	14	2567	89	4020
Virginia	Brunswick	0.24	Silty	Warm Moist	130	8838	10	1851	72	3268
Virginia	Buchanan	0.20	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Buckingham	0.23	Silty	Warm Moist	117	7978	14	2567	89	4020
Virginia	Campbell	0.24	Silty	Warm Moist	113	7720	11	1974	77	3470
Virginia	Caroline	0.24	Silty	Warm Moist	141	9573	15	2749	99	4468
Virginia	Carroll	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Charles City	0.23	Silty	Warm Moist	134	9123	14	2630	93	4233
Virginia	Charlotte	0.24	Sandy	Warm Moist	99	6736	12	2140	70	3183
Virginia	Chesterfield	0.24	Silty	Warm Moist	147	9980	11	2093	89	4020
Virginia	Clarke	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Craig	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Culpeper	0.22	Silty	Warm Moist	148	10055	19	3387	91	4140
Virginia	Cumberland	0.24	Silty	Warm Moist	123	8367	13	2434	84	3806
Virginia	Dickenson	0.20	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Dinwiddie	0.24	Silty	Warm Moist	129	8750	13	2298	84	3831
Virginia	Essex	0.24	Silty	Warm Moist	131	8931	15	2790	94	4261
Virginia	Fairfax	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Fauquier	0.22	Silty	Warm Moist	144	9808	16	2931	91	4109
Virginia	Floyd	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Fluvanna	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Franklin	0.23	Silty	Warm Moist	124	8449	12	2112	83	3778
Virginia	Frederick	0.21	Silty	Warm Moist	132	8998	16	2991	121	5501
Virginia	Giles	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Gloucester	0.23	Silty	Warm Moist	140	9511	14	2613	101	4587
Virginia	Goochland	0.24	Silty	Warm Moist	130	8838	16	2899	77	3510
Virginia	Grayson	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Greene	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Greensville	0.24	Silty	Warm Moist	115	7793	12	2157	76	3447
Virginia	Halifax	0.24	Sandy	Warm Moist	91	6187	9	1690	64	2908
Virginia	Hanover	0.24	Silty	Warm Moist	149	10112	14	2633	86	3892
Virginia	Henrico	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Henry	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Highland	0.21	Silty	Cool Moist	130	8838	14	2567	89	4020

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

State	County	Clay	Soil	Climate	Corn N rate	Corn Yield	Soybean N rate	Soybean Yield	Wheat N rate	Wheat Yield
Virginia	Isle of Wight	0.23	Silty	Warm Moist	131	8917	14	2638	97	4402
Virginia	James City	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	King and Queen	0.24	Silty	Warm Moist	129	8745	14	2635	93	4214
Virginia	King George	0.23	Silty	Warm Moist	126	8587	16	2993	95	4301
Virginia	King William	0.24	Silty	Warm Moist	142	9687	16	2925	92	4152
Virginia	Lancaster	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Lee	0.23	Silty	Warm Moist	111	7534	14	2567	89	4020
Virginia	Loudoun	0.22	Silty	Warm Moist	128	8722	16	2919	96	4366
Virginia	Louisa	0.23	Silty	Warm Moist	153	10405	13	2420	89	4020
Virginia	Lunenburg	0.24	Silty	Warm Moist	115	7796	12	2128	84	3786
Virginia	Madison	0.22	Silty	Warm Moist	141	9592	19	3395	92	4163
Virginia	Mathews	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Mecklenburg	0.24	Sandy	Warm Moist	99	6722	11	2007	76	3426
Virginia	Middlesex	0.23	Silty	Warm Moist	136	9252	14	2594	102	4625
Virginia	Montgomery	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Nelson	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	New Kent	0.24	Silty	Warm Moist	129	8797	12	2186	87	3954
Virginia	Northampton	0.23	Silty	Warm Moist	143	9724	13	2367	99	4482
Virginia	Northumberland	0.23	Silty	Warm Moist	137	9345	15	2802	99	4467
Virginia	Nottoway	0.24	Silty	Warm Moist	120	8175	13	2309	86	3880
Virginia	Orange	0.23	Silty	Warm Moist	143	9705	19	3388	85	3833
Virginia	Page	0.22	Silty	Warm Moist	118	8020	14	2517	89	4020
Virginia	Patrick	0.23	Silty	Warm Moist	130	8838	15	2703	89	4020
Virginia	Pittsylvania	0.23	Silty	Warm Moist	92	6293	12	2209	67	3049
Virginia	Powhatan	0.24	Silty	Warm Moist	141	9578	15	2744	79	3602
Virginia	Prince Edward	0.24	Silty	Warm Moist	116	7871	12	2147	89	4020
Virginia	Prince George	0.23	Silty	Warm Moist	127	8643	13	2288	86	3896
Virginia	Prince William	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Pulaski	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Rappahannock	0.22	Silty	Warm Moist	130	8838	17	3030	89	4020
Virginia	Richmond	0.24	Silty	Warm Moist	132	8951	15	2739	91	4136
Virginia	Roanoke	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Rockbridge	0.22	Silty	Warm Moist	135	9209	14	2567	89	4020
Virginia	Rockingham	0.21	Silty	Warm Moist	152	10369	19	3412	99	4507
Virginia	Russell	0.22	Silty	Warm Moist	139	9472	14	2567	89	4020
Virginia	Scott	0.23	Silty	Warm Moist	127	8646	14	2567	89	4020
Virginia	Shenandoah	0.21	Silty	Warm Moist	144	9803	17	3085	100	4530
Virginia	Smyth	0.22	Silty	Warm Moist	156	10595	14	2567	89	4020
Virginia	Southampton	0.23	Silty	Warm Moist	136	9277	14	2533	94	4273
Virginia	Spotsylvania	0.24	Silty	Warm Moist	130	8842	16	2866	81	3685
Virginia	Stafford	0.24	Silty	Warm Moist	124	8423	13	2367	89	4020
Virginia	Surry	0.23	Silty	Warm Moist	132	8958	12	2170	83	3755
Virginia	Sussex	0.23	Silty	Warm Moist	130	8838	14	2567	88	3993
Virginia	Tazewell	0.20	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Warren	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Virginia	Washington	0.22	Silty	Warm Moist	117	7939	14	2567	89	4020
Virginia	Westmoreland	0.24	Silty	Warm Moist	139	9440	15	2662	99	4469
Virginia	Wise	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Wythe	0.22	Silty	Warm Moist	137	9315	14	2567	89	4020
Virginia	York	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Alexandria	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
		NA			130	8838	14	2567	89	4020
Virginia	Bristol	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Buena Vista	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Charlottesville	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Chesapeake	0.23	Silty	Warm Moist	157	10669	15	2729	82	3737
Virginia	Colonial Heights	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Covington	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Danville	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Emporia	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Fairfax	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Falls Church	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Franklin	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Fredericksburg	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Galax	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Hampton	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Harrisonburg	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Hopewell	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Lexington	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Lynchburg	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Manassas	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Manassas Park	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Martinsville	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Newport News	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Norfolk	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Norton	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Petersburg	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Poquoson	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Portsmouth	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Radford	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Richmond	0.24	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Roanoke	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Salem	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Staunton	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Suffolk	0.23	Silty	Warm Moist	129	8805	15	2715	87	3941
Virginia	Virginia Beach	0.23	Silty	Warm Moist	146	9917	14	2636	104	4734
Virginia	Waynesboro	0.22	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Williamsburg	0.23	Silty	Warm Moist	130	8838	14	2567	89	4020
Virginia	Winchester	0.21	Silty	Warm Moist	130	8838	14	2567	89	4020
Washington	Adams	0.21	Silty	Cool Dry	198	13445	NA	NA	82	3995

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Washington	Asotin	0.23	Silty	Cool Dry	204	13852	NA	NA	89	4338
Washington	Benton	0.18	Silty	Warm Dry	249	16960	NA	NA	97	4743
Washington	Chelan	0.16	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Clallam	0.17	Sandy	Cool Moist	204	13852	NA	NA	93	4528
Washington	Clark	0.23	Silty	Warm Moist	204	13852	NA	NA	93	4528
Washington	Columbia	0.23	Silty	Cool Moist	204	13852	NA	NA	116	5680
Washington	Cowlitz	0.23	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Douglas	0.16	Silty	Cool Dry	204	13852	NA	NA	67	3271
Washington	Ferry	0.14	Silty	Cool Dry	204	13852	NA	NA	93	4528
Washington	Franklin	0.20	Silty	Warm Dry	204	13852	NA	NA	74	3620
Washington	Garfield	0.22	Silty	Cool Dry	204	13852	NA	NA	108	5278
Washington	Grant	0.18	Silty	Warm Dry	183	12453	NA	NA	85	4151
Washington	Grays Harbor	0.23	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Island	0.22	Silty	Cool Dry	204	13852	NA	NA	93	4528
Washington	Jefferson	0.22	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	King	0.20	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Kitsap	0.23	Silty	Warm Moist	204	13852	NA	NA	93	4528
Washington	Kittitas	0.17	Silty	Cool Moist	204	13852	NA	NA	110	5380
Washington	Klickitat	0.17	Silty	Cool Dry	204	13852	NA	NA	56	2730
Washington	Lewis	0.22	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Lincoln	0.21	Silty	Cool Dry	204	13852	NA	NA	97	4753
Washington	Mason	0.23	Silty	Warm Moist	204	13852	NA	NA	93	4528
Washington	Okanogan	0.13	Silty	Cool Dry	204	13852	NA	NA	62	3042
Washington	Pacific	0.23	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Pend Oreille	0.12	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Pierce	0.22	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	San Juan	0.17	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Skagit	0.18	Silty	Cool Moist	204	13852	NA	NA	136	6665
Washington	Skamania	0.20	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Snohomish	0.19	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Spokane	0.21	Silty	Cool Dry	204	13852	NA	NA	95	4666
Washington	Stevens	0.14	Silty	Cool Dry	204	13852	NA	NA	76	3744
Washington	Thurston	0.23	Silty	Warm Moist	204	13852	NA	NA	93	4528
Washington	Wahkiakum	0.23	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Walla Walla	0.22	Silty	Warm Dry	202	13715	NA	NA	116	5687
Washington	Whatcom	0.15	Silty	Cool Moist	204	13852	NA	NA	93	4528
Washington	Whitman	0.22	Silty	Cool Dry	204	13852	NA	NA	117	5716
Washington	Yakima	0.17	Silty	Cool Moist	186	12685	NA	NA	83	4054
West Virginia	Barbour	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Berkeley	0.21	Silty	Warm Moist	118	8000	5	2872	83	3753
West Virginia	Boone	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Braxton	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Brooke	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Cabell	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Calhoun	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
West Virginia	Clay	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Doddridge	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Fayette	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Gilmer	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Grant	0.20	Silty	Cool Moist	126	8555	5	2822	90	4082
West Virginia	Greenbrier	0.20	Silty	Cool Moist	154	10495	5	2822	90	4082
West Virginia	Hampshire	0.20	Silty	Warm Moist	110	7491	5	2822	90	4082
West Virginia	Hancock	0.22	Silty	Cool Moist	133	9047	5	2822	90	4082
West Virginia	Hardy	0.20	Silty	Warm Moist	133	9070	5	2822	90	4082
West Virginia	Harrison	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Jackson	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Jefferson	0.21	Silty	Warm Moist	155	10554	5	3134	97	4412
West Virginia	Kanawha	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Lewis	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Lincoln	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Logan	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	McDowell	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Marion	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Marshall	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Mason	0.21	Silty	Warm Moist	142	9685	5	2822	90	4082
West Virginia	Mercer	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Mineral	0.21	Silty	Warm Moist	139	9456	5	2822	90	4082
West Virginia	Mingo	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Monongalia	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Monroe	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Morgan	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Nicholas	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Ohio	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Pendleton	0.21	Silty	Cool Moist	131	8919	5	2822	90	4082
West Virginia	Pleasants	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Pocahontas	0.20	Silty	Cool Moist	140	9525	5	2822	90	4082
West Virginia	Preston	0.21	Silty	Cool Moist	117	7928	4	2461	90	4082
West Virginia	Putnam	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Raleigh	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Randolph	0.20	Silty	Cool Moist	133	9047	5	2822	90	4082
West Virginia	Ritchie	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Roane	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Summers	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Taylor	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Tucker	0.20	Silty	Cool Moist	133	9047	5	2822	90	4082
West Virginia	Tyler	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Upshur	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Wayne	0.22	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Webster	0.20	Silty	Cool Moist	133	9047	5	2822	90	4082
West Virginia	Wetzel	0.21	Silty	Warm Moist	133	9047	5	2822	90	4082

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
West Virginia	Wirt	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
West Virginia	Wood	0.20	Silty	Warm Moist	131	8885	5	2822	90	4082
West Virginia	Wyoming	0.20	Silty	Warm Moist	133	9047	5	2822	90	4082
Wisconsin	Adams	0.15	Sandy	Cool Moist	87	7833	8	3184	92	4156
Wisconsin	Ashland	0.10	Silty	Cool Moist	57	5185	8	3167	100	4516
Wisconsin	Barron	0.21	Silty	Cool Moist	106	9597	7	3025	98	4445
Wisconsin	Bayfield	0.12	Silty	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Brown	0.22	Sandy	Cool Moist	115	10372	8	3230	94	4247
Wisconsin	Buffalo	0.22	Silty	Cool Moist	115	10362	8	3202	100	4516
Wisconsin	Burnett	0.20	Silty	Cool Moist	95	8559	7	2714	100	4516
Wisconsin	Calumet	0.20	Sandy	Cool Moist	115	10392	8	3350	118	5335
Wisconsin	Chippewa	0.21	Silty	Cool Moist	107	9667	7	2977	80	3645
Wisconsin	Clark	0.21	Silty	Cool Moist	94	8480	7	3025	85	3833
Wisconsin	Columbia	0.17	Sandy	Cool Moist	129	11661	9	3558	113	5102
Wisconsin	Crawford	0.22	Silty	Cool Moist	112	10167	8	3063	93	4201
Wisconsin	Dane	0.20	Silty	Cool Moist	130	11768	9	3731	118	5360
Wisconsin	Dodge	0.19	Silty	Cool Moist	128	11563	9	3623	112	5064
Wisconsin	Door	0.19	Sandy	Cool Moist	97	8816	7	2949	92	4194
Wisconsin	Douglas	0.15	Silty	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Dunn	0.21	Silty	Cool Moist	120	10832	8	3142	100	4516
Wisconsin	Eau Claire	0.21	Silty	Cool Moist	112	10114	7	2977	100	4516
Wisconsin	Florence	0.04	Sandy	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Fond du Lac	0.19	Sandy	Cool Moist	127	11510	9	3539	115	5215
Wisconsin	Forest	0.05	Sandy	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Grant	0.22	Silty	Cool Moist	135	12222	10	3934	100	4533
Wisconsin	Green	0.23	Silty	Cool Moist	130	11792	9	3706	109	4961
Wisconsin	Green Lake	0.14	Sandy	Cool Moist	125	11321	9	3769	103	4690
Wisconsin	Iowa	0.21	Silty	Cool Moist	125	11294	9	3723	113	5114
Wisconsin	Iron	0.11	Sandy	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Jackson	0.20	Silty	Cool Moist	111	10060	8	3157	100	4516
Wisconsin	Jefferson	0.22	Silty	Cool Moist	124	11228	9	3451	109	4924
Wisconsin	Juneau	0.16	Sandy	Cool Moist	113	10185	7	2939	78	3526
Wisconsin	Kenosha	0.28	Clayey	Cool Moist	117	10570	8	3145	112	5060
Wisconsin	Kewaunee	0.26	Sandy	Cool Moist	114	10291	8	3285	109	4931
Wisconsin	La Crosse	0.21	Silty	Cool Moist	117	10574	8	3309	100	4516
Wisconsin	Lafayette	0.22	Silty	Cool Moist	138	12517	10	4035	108	4889
Wisconsin	Langlade	0.10	Sandy	Cool Moist	87	7868	6	2347	99	4486
Wisconsin	Lincoln	0.14	Sandy	Cool Moist	92	8342	6	2287	100	4516
Wisconsin	Manitowoc	0.28	Sandy	Cool Moist	119	10785	8	3349	109	4940
Wisconsin	Marathon	0.18	Sandy	Cool Moist	103	9294	7	2923	91	4145
Wisconsin	Marinette	0.09	Sandy	Cool Moist	91	8250	7	2827	84	3800
Wisconsin	Marquette	0.14	Sandy	Cool Moist	98	8863	6	2589	81	3654
Wisconsin	Menominee	0.13	Sandy	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Milwaukee	0.31	Clayey	Cool Moist	101	9101	7	2686	100	4516
Wisconsin	Monroe	0.18	Silty	Cool Moist	110	9921	8	3119	100	4516

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Wisconsin	Oconto	0.13	Sandy	Cool Moist	97	8752	7	2950	89	4037
Wisconsin	Oneida	0.10	Sandy	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Outagamie	0.17	Sandy	Cool Moist	113	10210	8	3226	102	4630
Wisconsin	Ozaukee	0.31	Clayey	Cool Moist	115	10391	8	3403	111	5049
Wisconsin	Pepin	0.21	Silty	Cool Moist	119	10783	9	3793	100	4516
Wisconsin	Pierce	0.21	Silty	Cool Moist	129	11647	9	3461	100	4516
Wisconsin	Polk	0.21	Silty	Cool Moist	111	10023	7	2948	100	4516
Wisconsin	Portage	0.18	Sandy	Cool Moist	113	10237	7	2896	62	2825
Wisconsin	Price	0.15	Sandy	Cool Moist	88	7971	6	2374	100	4516
Wisconsin	Racine	0.29	Clayey	Cool Moist	121	10993	8	3295	115	5205
Wisconsin	Richland	0.20	Silty	Cool Moist	108	9779	7	2917	88	3991
Wisconsin	Rock	0.23	Silty	Cool Moist	133	12019	9	3703	116	5259
Wisconsin	Rusk	0.20	Silty	Cool Moist	90	8108	6	2593	100	4516
Wisconsin	St. Croix	0.21	Silty	Cool Moist	120	10899	8	3235	100	4516
Wisconsin	Sauk	0.18	Silty	Cool Moist	117	10595	8	3312	103	4675
Wisconsin	Sawyer	0.18	Silty	Cool Moist	93	8379	6	2313	100	4516
Wisconsin	Shawano	0.15	Sandy	Cool Moist	106	9600	8	3134	93	4210
Wisconsin	Sheboygan	0.30	Clayey	Cool Moist	116	10517	8	3395	110	5001
Wisconsin	Taylor	0.18	Sandy	Cool Moist	92	8308	7	2923	100	4516
Wisconsin	Trempealeau	0.22	Silty	Cool Moist	112	10137	8	3132	100	4516
Wisconsin	Vernon	0.20	Silty	Cool Moist	112	10155	8	3109	89	4019
Wisconsin	Vilas	0.08	Sandy	Cool Moist	111	10050	8	3167	100	4516
Wisconsin	Walworth	0.24	Silty	Cool Moist	126	11416	9	3537	114	5183
Wisconsin	Washburn	0.19	Silty	Cool Moist	110	9945	7	2893	100	4516
Wisconsin	Washington	0.24	Silty	Cool Moist	119	10804	8	3315	110	4989
Wisconsin	Waukesha	0.26	Silty	Cool Moist	122	11036	8	3266	100	4516
Wisconsin	Waupaca	0.14	Sandy	Cool Moist	107	9716	8	3257	90	4074
Wisconsin	Waushara	0.14	Sandy	Cool Moist	115	10378	8	3080	80	3630
Wisconsin	Winnebago	0.16	Sandy	Cool Moist	108	9768	8	3256	105	4758
Wisconsin	Wood	0.19	Silty	Cool Moist	102	9264	7	2958	93	4217
Wyoming	Albany	0.23	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Big Horn	0.21	Silty	Cool Dry	141	9566	NA	NA	49	2210
Wyoming	Campbell	0.23	Sandy	Cool Dry	139	9425	NA	NA	47	2112
Wyoming	Carbon	0.23	Sandy	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Converse	0.24	Sandy	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Crook	0.27	Sandy	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Fremont	0.23	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Goshen	0.23	Silty	Cool Dry	143	9745	NA	NA	45	2058
Wyoming	Hot Springs	0.22	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Johnson	0.23	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Laramie	0.22	Silty	Cool Dry	119	8119	NA	NA	49	2233
Wyoming	Lincoln	0.21	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Natrona	0.24	Sandy	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Niobrara	0.24	Sandy	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Park	0.20	Silty	Cool Dry	151	10269	NA	NA	49	2210

Table 20: *Default parameter values for each county in the continental USA. Clay fraction is in (continued)*

					Corn		Soybean		Wheat	
State	County	Clay	Soil	Climate	N rate	Yield	N rate	Yield	N rate	Yield
Wyoming	Platte	0.24	Sandy	Cool Dry	139	9425	NA	NA	43	1937
Wyoming	Sheridan	0.21	Silty	Cool Dry	139	9425	NA	NA	60	2710
Wyoming	Sublette	0.22	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Sweetwater	0.24	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Teton	0.21	Silty	Cool Moist	139	9425	NA	NA	49	2210
Wyoming	Uinta	0.20	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Washakie	0.22	Silty	Cool Dry	139	9425	NA	NA	49	2210
Wyoming	Weston	0.24	Sandy	Cool Dry	139	9425	NA	NA	49	2210

Appendix C: Tillage Methods

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1. Overview: Tillage

The overall scope is for US crops of corn, wheat, and soybean production, and crops commonly grown in rotation with these crops, and crops grown as cover crops with these crops. For "tillage", the focus is on tillage alone, we examine other practices such as cover cropping separately. There are many types of conservation tillage. We include in our analysis both a strict no-till as well as a reduced-till (defined below).

2. Soil carbon stock change due to reduced-till and no-till

Two recent meta-analyses found small increases in SOC with the use of no-till or reduced-till. Ogle et al. (2019), find an average for strict no-till of 0.94 Mg CO_2e ha^{-1} y^{-1} while Meurer et al. (2018) find an average value of 0.25 Mg CO_2e ha^{-1} y^{-1}. The average length of the experiments in these studies is 20 years (Ogle et al. 2019) and 16-18 years (Meurer et al. 2018). The Ogle et al (2019) estimate is for a depth of between 0–30 and 0–70 cm, depending on whether there was a significant difference below 30 cm (see their Table 1). In contrast, Meurer et al. (2018) report to an average depth of 60 cm. Importantly, Meurer et al. (2018) found that strict no-till to 30 cm depth averaged 0.86 Mg CO_2e ha^{-1} y^{-1}, which is close to the Ogle et al. (2019) value of 0.94 for variable depths. Because Ogle et al. (2019) calculated values for different soil textural classes and climatic conditions; we will use Ogle's values, but adjust them to 60 cm depth using the ratio of Meurer values for 60 versus 30 cm, with the adjustment depending on the depth to which Ogle et al. (2018) calculated the change in SOC. For reduced-till, we used the results of Meurer et al. (2018), who examined both no-till and reduced-till. Based on their results, reduced-till had 90%

of the increase in SOC found with no-till, so we multiplied our results for no-till by that factor to estimate the effects of reduced-till. It should be noted, however, that significant uncertainty remains even in these average values. Ogle et al. (2019) note that there is still insufficient information to "make precise estimates of the ΔSOC, particularly deeper in the soil profile", and that "there is also a chance that ΔSOC may be negative according to our confidence intervals". Therefore, GHG abatement programs need to consider the risk associated with the uncertainty in ΔSOC from no-till adoption.

Even if reduced tillage is practiced indefinitely, it is anticipated that a new steady state SOC level will be reached in a few decades, with no further increase in SOC (Chung et al. 2008, Stewart et al. 2007, Stewart et al. 2008). The steady-state level within a specific soil may increase with no-till compared to conventional tillage, but is still expected to approach a quasi-steady-state (Stewart et al. 2007). Based on a review by West & Six (2007), the effect of reducing tillage will reach a quasi-steady-state after 21 years, on average. Based on a review by Meurer et al. (2018, Figure 3), there is very little additional SOC sequestration after 25 to 30 years. Based on these two results, we selected a value of 25 years as the average time by which a new quasi-steady-state of SOC will be reached after reduction in tillage.

3. Effects of occasional tillage on SOC

Continuous no-till (NT) may not be practiced indefinitely on commercial farms due to problems such as weed control, stratification of SOC and nutrients, or compaction. We therefore reviewed the literature to determine the effect of occasional tillage (circa every 10 years) on SOC accumulation in no-till cropping. This topic was recently reviewed Blanco-Canqui & Wortmann (2020), but we found 70% more studies that were not included in their review. We also extracted additional information from each study and the results are summarized in Table [OT]. In sum, there was no effect of occasional tillage on SOC (no change in 11 studies, increase in 2 studies, decrease in 2 studies). The median time in no-till prior to occasional tillage was 13.5 years (range 6-20) and the median time after occasional tillage before soil sampling was 1.5 years (range 1-8). There was also no clear effect on yield (no change in 5 studies, increase in 2 studies, decrease in 2 studies, not reported in the others). We conclude that occasional tillage (circa every 10 to 15 years) does not decrease SOC on average compared to strict no-till, nor does it change yield.

Table [OT]. Effects of occasional tillage after many years of continuous no-till on soil organic carbon and yield[1].

Country	Region, State, location	Soil Description	Years under NT (yr)	Tillage Method (depth, cm)	Maximum time after OT (y)	Depth of Sampling (cm)	SOC units	Effect of Occasional Tillage on Soil Organic C	Effect of Occasional Tillage on yield	Notes	Citation
Australia	Northeast	5 Vertisols, 1 Sodosol, 1 Dermosol	9 to 43	Chisel, disk, scarifier, and cultivator	2.0	10	Equivalent soil mass	None	*None*	7 on-farm experiments. Soil sampled to 30 cm, but SOC reported to 10 cm. Overlap with Crawford et al. 2015?	Dang et al. 2018
Australia	New South Wales	Vertisol (sandy clay loam)	15	Chisel (10 cm) or disk (15 cm)	1.0	30	$g\ kg^{-1}$	None	*None*		Liu et al. 2016
Australia	Northern grain regions	Five soils	7-44	Primarily chisel	1.0	30	Equivalent soil mass	None	*None in 9 site-years, Increase in 1 site-year*	5 experiments, apparently on-farm. Overlap with Dang et al. 2018?	Crawford et al. 2015
Brazil	Pato Branco, Paraná	Oxisol, Clayey	17	Disk plow and harrow	1.7	20	$g\ kg^{-1}$	Increase	*None*	Statistically significant only for 10-20 cm.	Fidalski et al., 2015
Canada	La Pocatiere, Quebec	Gleysol (clay)	24	MP	1.0	20	Equivalent soil mass	None	*Increase*		Malhi et al. 2018
Canada	Saskatchewan	Brown Chernozem (loam), Black Chernozem (fine loam), Gray Luvisol (silty clay loam/clay loam)	10-12	Cultivator, disk	0.0	10	Equivalent soil mass	n/a	*Increase, but under herbicide-free management*	Soil sampling occurred immediately after the last tillage treatement.	Baan et al. 2009
Canada	Ontario, Southern	sandy loam, sandy clay loam, silty clay loam, well- and poorly drained (Mollic Aqualf, Typic Hapludalf	22	MP (20 cm)	1.5	Circa 40	Equivalent soil mass	None in 3 soils, Decrease in 1 soil	*Not reported*	Only the low carbon sandy loam soil had a significant change in SOC.	VandenBygaart & Kay 2004
Canada	Ontario, Woodslee	Clay (Typic Argiaquoll)	13	MP (17-20 cm)	n/a, see notes	20-60 cm	Equivalent soil mass	None, despite 8 years of MP.	*Not reported*	NOT a one-time plowing, but rather 8 years of MP after 13 years of NT, and still no significant change in SOC. Soils were sampled to 60 cm, but reported on the basis of 3000 Mg ha-1, which was circa 20 cm in the NT treatment.	Yang et al. 2008
Germany	Lower Saxony	Silt loam (Typic Hapludalf)	20	Moldboard plow (MP)	1.5	50	$g\ kg^{-1}$	Decrease, but CT and MT not significantly different prior to OT	*Not reported*	Minimum till = 6-8 cm rotary harrow or rototiller	Stockfisch et al., 1999
Spain	Alange-Badajoz	Loam (Eutric Leptosol)	11	MP (30 cm) and disc harrow (15 cm)	3.0	25	$kg\ C\ ha^{-1}$	Decrease to 25 cm, not clear if statistically significant (see text p. 184)	*Possible decrease (may not be signficant)*	On-farm, pseudo-replication within one treatment strip. SOC reported data shallower than MP depth.	López-Garrido et al. 2011
Spain	Jerez de la Frontera (Cadiz)	Clay loam (Leptic Typic Xerorthent)	8	MP (25 cm) and for reduced-till chisel (15 cm)	1.3	25	$g\ kg^{-1}$	None	*Not reported*	See Table 2.	Melero et al., 2011
Turkey	Adana (southern)	Clay (Haplic Vertisol)	9	MP	1.0	30	$g\ kg^{-1}$	Increase	*Decrease for wheat, none for soybean*	Statistically significant for 10-20 and 20-30 cm.	Celik et al., 2019
USA	NE, Eastern (Sidney)	Silt loam (Aridic Argiustoll)	20	MP (15 cm)	5.0	30	$Mg\ ha^{-1}$	None	*Increase 30% year 1 and 9% year 3*		Kettler et al., 2000
USA	NE, 2 sites, Eastern	2 silty clay loams	7, 12	MP, miniMP, and chisel or disk (20 cm)	5.0	30	Equivalent soil mass	None	*None*	Wortmann results presented herein because they were longer term.	Quincke et al., 2007b; Wortmann et al., 2010
USA	MI, East Lansing	Loam	6, 7		5.0	20	$kg\ m^{-3}$	None	*Not reported*	I summed SOC from all depths (from Table 6).	Pierce et al. 1994
USA	IN, West Lafayette	Silty clay loam (Typic Endoaquoll)	6-18	MP	n/a, see notes	100	Equivalent soil mass	None,despite 6 years of tillage.	*Not reported*	Treatments were long-term NT vs CP converted to NT for 6 years.	Omonode et al. 2006
USA	KY, Princeton	Silt loam (Fluventic Hapludoll)	20	Chisel, disc	8.0	20	$g\ kg^{-1}$	None, despite 4 tillage events over 8 years	*Out of 20 crop/seasons, none in 13, decrease in 5, increase in 2*	Tillage occurred 4 times in 8 years, not just once.	Diaz-Zorita 2004
SUMMARY	**From USA and Canada**	**56%**	**Median years of NT = 13.5 (range 6-20)**		**Median years after OT = 1.5 (range 1-8)**	**Mostly 20 to 30 cm**		**None = 12 Increase = 2 Decrease = 2**	**None = 5 Increase = 2 Decrease = 2**		

[1] After Table 3 of Blanco-Canqui 2020 but with all values derived from original literature and additional information added to the table such as yield as well as 70% more studies included.

4. Machinery use

No-till and reduced-till reduce GHG emissions in comparison to conventional tillage due to reducing emissions from combustion of fuel from machinery such as tractors. We used results from the USDA based on national farm survey data from thousands of farms to estimate this reduction. The value for no-till was 0.10 Mg $CO2_{eq}$ ha^{-1} yr^{-1}, and for reduced-till was 0.08 Mg CO_2eq ha^{-1} yr^{-1} (USDA-NRCS (2016). These values occur each year indefinitely as long as the practice is continued. These values do not include embedded energy in equipment, which are expected to be a small fraction of that associated with fuel use, especially amortized over many decades. These values are slightly lower than older values from the literature (Marland et al. 2003, Dyer & Desjardins 2005), probably because they reflect more recent and more detailed data on the different types of equipment used in both conventional and reduced tillage.

5. Herbicide use

It is commonly expected that no-till requires more herbicide than conventional tillage because reducing tillage also reduces weed control, thus requiring additional herbicide use for weed management. We therefore used data on the change in herbicide application rates for different crops as follows. For maize, we used USDA-NASS (2019a) and for soybean, we used USDA-NASS (2019b). For wheat, we used Camargo et al. (2013). For changes in herbicide use with no-till, we used West & Marland (2002).

To estimate the change in GHG emissions for a given amount of herbicide, we used the average of three of four values from the FEAT model (Camargo et al. 2013). One value was not used because it was from Europe and was much lower. Total changes in GHG emissions for no-till were -0.01 Mg $CO2_{eq}$ ha^{-1} yr^{-1} for maize and soybean and -0.02 Mg $CO2_{eq}$ ha^{-1} yr^{-1} for wheat (negative values are GHG emission). Total changes for reduced-till were zero for maize and soybean and -0.01 Mg $CO2_{eq}$ ha^{-1} yr^{-1} for wheat.

6. Crop yield

Several meta-analyses suggest that there are, on average, decreases in yield from no-till experiments for some crops and regions (Pittelkow et al. 2015, Huang et al. 2018, Toliver et al. 2012). This conclusion is important because decreases in yield are expected to increase GHG emissions due to displacing crop production to other locations (i.e., indirect land use change, see subsequent section). It is unlikely that users of the Gigaton Soil Health Tool would have site-specific data about the effect of no-till or reduced-till on yields, because it would require controlled trials to compare yields with and without no-till or reduced-till. Therefore, we provide default estimates of yield impacts for use when site-specific data are not available.

The effects of tillage on crop yield vary substantially with crop type, climate, moisture regime, and the number of years since conventional tillage (e.g. Pittelkow et al. 2015). In a global study, no-till generally did not reduce yields under rainfed conditions in dry climates, but for irrigated and dry, rainfed and humid, and irrigated and humid conditions, yield was reduced for most crop groups, although not for cotton, legumes, and oilseeds (Pittelkow et al. 2015). In humid climates, crop rotation and residue return did not ameliorate yield reductions (Pittelkow et al. 2015).

To represent US production of maize, wheat, and soybean, we selected two studies as sources of estimates of the long-term effect of no-till on crop yields (Daigh et al. 2018; Pittelkow et al. 2015).

For maize and soybean we used the results from Daigh et al., (2018) because they are from multiple long-term experiments with yield results averaged over many years in the Midwest. Daigh et al. (2018) reported the site-specific, 5-year yield difference as statistically significant for some, but not all sites studied. We estimated the change in yield between NT and CT practices using the observed 5-year average yield difference averaged across all long-term no-till sites (Daigh et al. 2018). The results were changes in yield of -1.7% for maize rotated with soybean and -6.3% for continuous maize (Daigh et al., (2018).

We apply 0% change in soybean yield under NT relative to CT for all locations in the USA. Daigh et al. (2018) reported no change in soybean yield under NT relative to CT across multiple long-term experiments in the U.S. Midwest. Pittelkow et al. (2015) found that legumes generally have no yield response to NT in both humid and dryland systems. Toliver et al. (2012) found that mean value for all regions and soil textural types for shorter-term studies was -0.1%

For wheat, we apply results of Pittelkow et al. (2015) after more than 10 years of NT, reported separately for moist and dry climatic regions because effects on yield were significant in both cases, with decreases of 4.0% in humid areas and increases of 4.3% in dry areas.

We did not find suitable data for effects of reduced-till systems on yield. Under the assumption that reduced-till can ameliorate some production challenges that occur with no-till, we assumed that effects on yield from reduced-till were half of those found for no-till.

7. Indirect land use change

If crop yields are reduced, GHG emissions will increase due to displacement of the crop production to another location, i.e., indirect land use change, also called leakage. We use the results of Searchinger et al. (2018) to calculate both the effect of replacing the lost production and also the "carbon opportunity cost" which is the foregone potential of the land to sequester carbon were it not converted to cropland. This method estimates worldwide average values of the carbon opportunity cost, which is appropriate for crops such as maize, wheat, and soybean that are traded globally.

Lost crop production will be made up with a combination of intensification and extensification. Intensification means increasing yield on existing cropland. Extensification means planting crops on new cropland converted from some other use. Intensification can occur by different mechanisms, such as increased crop yield, double cropping, or bringing fallow cropland into production. The Searchinger et al. (2018) method has a parameter for the ratio of expected intensification to extensification, but does not provide a value for this parameter, because such information is scarce in the literature. We searched the literature and found one suitable publication from which we can estimate this ratio for US commodity crop production. This publication uses a global economic computable general equilibrium model (GTAP-BIO) to estimate the global indirect land use change caused by increasing demand for either maize grain or soybean in the USA (Taheripour et al. 2018). The analysis uses two models, one that does not include intensification ("old model") and one that does include intensification ("new model").

For the new model, the analysis develops estimates of the degree of intensification for each region of the world based on historical data on crop yield and harvested area. The analysis includes four scenarios of increased demand in the USA, two for maize and two for soybean, using different time periods and with different total new demand (i.e. shock). Each of the four scenarios is analyzed using both the old and new models. We estimate the ratio of intensification to extensification by calculating the average results for the two models for each of the four scenarios. The four ratios are as follows (in units of 1000 ha of new cropland): 69.4/154.8 (Table 2.B.1), 36.2/72.1 (Table 2.B.3), 510.9/1076.5 (Table 2.3), and 62.2/114.8 (Table 2.5) resulting in an average of 0.49. Thus for an increase in crop demand (which could be caused by a decrease in crop yield), about half of the new demand is predicted by GTAP-BIO to be met by intensification and about half to be met by intensification.

8. Tillage effect on N_2O emissions

Available data:
A number of reviews of this topic, especially meta-analyses, have been conducted over the last decade. Not all reviews are representative of U.S. commodity cropping systems. Below we discuss our process of extracting data for supporting Gigaton Soil Health Tool development.

Overall van Kessel et al. (2013) conducted meta-analyses including data that are most representative of U.S. commodity grain systems. Van Kessel et al. 2013 is particularly useful for the Gigaton soil health tool development because it provided analysis of tillage and yield impact across a range of subcategories for both management (long-term vs. short-term reduced (RT)/no-till (NT); shallow vs. deep N placement) and site properties (humid vs. dry). Van Kessel et al. (2013) analyzed data that are from the U.S. (29% of publications), Canada (29%), Europe (23%), Asia (10%), and other locations (10%). These data are 55% maize, 13% soybean and 45% wheat studies (note, some systems are corn-soybean or wheat-soybean). Van Kessel et al. (2013) used strict selection criteria for inclusion of a study in their analysis; of 239 studies analyzed all but 5 had the same N rate across CT and NT treatments, and no study differed by more than 15 kg N /ha /yr. Therefore, van Kessel et al. 2013 is the foundation of our tool development. We discuss details of van Kessel et al. (2013) relevant to Gigaton development below and in Table 1.

Observed trends:
Van Kessel et al. (2013, Figure 1) found an overall neutral impact of reduced tillage or no-till on area-scaled N_2O emissions. Though they report a small decline in yield under reduced tillage or no-till, they also find a neutral response to yield-scaled N_2O emissions (Van Kessel et al. 2013, Figure 1). However, when looking at subcategories of the data, distinct N_2O and yield trends emerge in response to tillage for dry compared to humid climates, and for long- compared to short-duration management of RT or NT.

Based on the van Kessel et al. (2013) analysis, overall humid systems demonstrate neutral N_2O emissions response to RT or NT. In humid systems, if RT or NT is a short-term management practice, then neutral response is the best summary value; if there is long-term RT or NT management, a humid system averaged a 10% decrease in N_2O emissions relative to the conventionally tilled system but with a confidence interval overlapping zero (van Kessel et al. 2013, Figure 2). In contrast, a dry system may have increased N_2O emissions under RT or NT;

van Kessel et al. (2013, Figure 1) shows a mean 20% increase in N_2O emissions, but with CI overlapping zero. Short-term RT or NT management in dry systems led to an average 38% increase in N_2O emissions, while long-term RT or NT in dry systems resulted in an average reduction in N_2O emissions of 34% (van Kessel et al. 2013). Table 1 outlines N_2O emission trajectories based on the duration of management. In the Soil Health Method we based N_2O emission on total system N additions. Because dry systems often require N addition to achieve the credited SOC accumulation, this additional N can be a source of additional N_2O emission.

Table 1. Effects of no-till or reduced till on N_2O emissions (units: proportional change in emissions relative to conventional tillage).

Practice	GHG source	Temperature Regime	Moisture Regime	Soil Texture	Practice duration (years)	Direction	Proportional change relative to conventional tillage	Source	
No-till / Reduced till	N_2O	Cool / Warm	Dry	all	<10	increase	0.38	Van Kessel et al. 2013	Fig. 2
No-till / Reduced till	N_2O	Cool / Warm	Dry	all	>=10	decrease	-0.34	Van Kessel et al. 2013	Fig. 2
No-till / Reduced till	N_2O	Cool / Warm	Moist	all	<10	neutral	0	Van Kessel et al. 2013	Fig. 2
No-till / Reduced till	N_2O	Cool / Warm	Moist	all	>=10	decrease	-0.1	Van Kessel et al. 2013	Fig. 2

The overall result of neutral impact of no-till or reduced-till is supported by other meta-analysis studies, though there is variability in N_2O emission trends when viewing data subsets. Han et al. (2017, Figure 1) demonstrated an overall neutral impact of RT on N_2O emissions. However, a subset of the Han et al. 2017 data demonstrated that RT resulted in an average increase in N_2O emissions of 4.3% in rainfed systems, and an average decrease of 3% in irrigated systems. A subset of the Mei et al. (2018) data that is applicable to U.S. commodity grains demonstrated that tillage impact on N_2O emissions is neutral in cool, temperate climates, as well as for systems applying N at <=150 kg N ha^{-1}. General trends of tillage impact on N_2O emissions found in Mei et al. (2018) are not directly relevant to U.S. commodity grains because they include tropical systems or systems with a high N rate. Similarly, averaged over all studies, Huang et al. (2018) found that no-till can result in higher N_2O emissions. But when the data are categorized, it is evident that high N_2O emissions are driven by fine textured soils and excessive N rates. Huang et al. (2018) included a wide range of N application rates, and they find that studies applying >200 kg N ha^{-1} are the primary source of increased N_2O emission. Therefore, this study is not directly applicable to typical U.S. commercial grain systems. Furthermore, Huang et al. (2018) included studies from North America, Europe, India, and China, but did not provide a concise description of site properties and management applied across studies. Nonetheless, general trends from Huang et al. (2018) confirm our expectations based on mechanistic understanding of N_2O drivers. Namely, Huang et al. (2018, Figure 4) found that N_2O emissions are greatly increased under no-till management relative to conventional tillage for fine textured soils, but medium and coarse textured soils have neutral trends.

A modeling study by Lugato et al. (2018) discussed the possibility that net impact of reduced till is not properly accounting for the role of N_2O emissions. In particular, this model analysis seeks to quantify the role N_2O emission plays during the initial transition to RT/NT, when SOC is aggrading, through the phase of SOC stabilization under long-term RT/NT. Our approach to considering the impact of RT/NT has been to explicitly account for SOC sequestration using a 100-year mean rates. Based on the results of van Kessel et al. (2013), we do not see evidence for N_2O emissions increasing under long-term RT/NT, with increased SOC. Rather, van Kessel et al. (2013) demonstrates long-term RT/NT led to reduced N_2O emissions in both humid and dry systems.

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Appendix D: Cover crop management (non-SOC methods)

Table of Contents

1 Overview: Cover crop management

1.1 Project scope

The overall scope for this first phase of the Gigaton Soil Health project is for U.S. crops of maize, wheat, and soybean production, crops commonly grown in rotation with these crops, and crops grown as cover crops with these crops. We focused on crop-rotation management that reduces the duration of bare-fallow periods by including cover crops.

In humid systems, cover crop management is the primary practice to reduce fallow periods. For "cover crop management" the focus is on addition of a cover crop to the annual crop rotation compared to an annual crop rotation with a fallow period. However, a cover crop rotation may also interact with other practices (such as residue return, tillage, and additional N amendment). For Gigaton project accounting, changes to rotation-scale N balance are an important parameter for N_2O emission estimates (McLellan et al., 2018; Eagle et al., 2020, Tonitto et al. in press), while cover crop growth (and subsequent residue return) are the main drivers of soil organic carbon (SOC) dynamics relative to a bare-fallow (see further discussion in the SOC Methods Appendix). While there are numerous choices for implementing cover crop rotations, the most common cover crop practices on commercial farms tend to also be those that have received the most attention in the literature. For the purposes of calculating net N balance, it is also important to know whether cover crop species are leguminous, non-leguminous, or a mixture of legume and non-legume species (bi-culture).

Common cover cropping systems for maize include: continuous maize-cereal rye, maize - cereal rye- soybean – cereal rye, maize- cereal rye – bean – cereal rye. For soybean, systems include: maize – cereal rye – soybean – cereal rye. For wheat, systems include winter wheat – clover.

In dry (arid) systems, which commonly support wheat cropping systems, the efficient method of reducing fallow periods is to diversify rotations. Diversified rotations result in fewer seasons of wheat growth, but overall more grain or forage production.

1.2 Baseline management practice

The baseline conventional rotation in U.S. commodity grain systems is an annual crop growing season followed by bare fallow; this is also the baseline in most studies that compare the impact of diversified rotations. In the U.S., the most common conventional commodity grain rotations are: 1) maize cropping systems: continuous maize, maize-soybean, or maize-bean, 2) soybean cropping systems: maize-soybean, and 3) wheat cropping systems: winter wheat-fallow or spring wheat - fallow.

2 Methods

2.1 Criteria, sources of data, lines of evidence

The highest quality data available for cover crop management analysis are systematic literature reviews, especially from carefully conducted meta-analyses.

The highest quality observations for N_2O dynamics result from sampling over the entire year, including the winter. Absent full-year data, studies that include N_2O sampling before and after the growing season (spring through fall) provide the best available data on distribution of N_2O emissions, as spring thaw has been observed to provide a large pulse of N_2O emissions (e.g. Wagner-Riddle et al. 2017; Quesnel et al. 2019). Additionally, studies with frequent sampling are more likely to capture the "hot moments" of N_2O production, especially following events that increase soil available N (fertilization, tillage) or soil moisture (precipitation). A common sampling frequency for N_2O chamber studies is every two weeks pre-planting and post-harvest, and weekly during the growing season. Experiments focused on peak events schedule sampling following precipitation events. Because full-year N_2O sampling is uncommon, most observations are from spring through fall or growing season experiments. While long-term experiments of N_2O emissions can help outline the frequency of large N_2O emission events, N_2O sampling studies are generally 1-3 years in duration. Repeated sampling of N_2O is limited to a few well-studied research sites (for example, the Kellogg Biological Station Long-Term Ecological Research site, KBS). In our analysis we focused on N_2O reviews that analyzed observations from U.S. and Canadian cropping system and that included the commodity grains (maize, soybean, and wheat).

2.2 Estimating cover crop impact on N_2O emissions.

2.2.1 Observed cover crop impact on N_2O emissions

We assessed the impact of cover crop management on N_2O emission using multiple review manuscripts (Abdalla et al. 2018; Basche et al. 2014; Han et al. 2017). For application in the Gigaton tool, we considered the Han et al. (2017) analysis to be most representative of U.S. commodity crops as they focused their analysis on comparing systems that received commercially viable N amendment rates. In addition, the data analyzed in Han et al. (2017) are from relevant geographies and cropping systems, including data that are from U.S. (43% of the data), Canada (14.5%), Europe (28%), and Japan (14.5%). Han et al. (2017) data include maize (43% of the data), soybean (13%), winter grains (17%) and other (27%).

2.3 Observed cover crop impact on cash crop yield

We assessed the impact of cover crop management on cash crop yields using multiple review publications. For U.S. maize, a meta-analysis by Miguez and Bollero (2005) is the most applicable reference, reporting cover crop impact on maize yield in the U.S. (84% of studies) and Canada (16% of studies); these data are predominantly rainfed agricultural regions (34 of the studies), but include studies from drier regions (2 from WA and 1 from NE). This meta-analysis was updated by Marcillo and Miguez (2017) to include 27 additional U.S. studies and 1 Canadian study. Additional relevant review literature includes a meta-analysis that compared cover-crop management practices restricted to N management consistent with commercial practices (Tonitto et al. 2006).

In addition to meta-analysis results, long-term observations of cereal rye cover crop management in maize-soybean systems of Michigan outlined long-term cash crop yield response to cover crop management (Snapp and Surapur 2018). For dryland cropping systems, various field observations were assessed to compare the impact of wheat-fallow conventional systems to systems that reduce the frequency of a fallow period (Mohammed and Chen 2018; Holman et al. 2018; Rosenzweig et al. 2018).

Finally, a national-scale survey of U.S. farmers provides additional information regarding cash crop yield trends following cover crop management in fields under commercial management (CTIC 2017).

2.4 Cover crop impact on farm-scale energy use

We estimated the energy budget of cover crop management relative to a conventional rotation with bare fallow using energy values established in the FEAT model (Camargo et al. 2013). We used average values from FEAT (FEAT_1_2_7.xlsx Excel model). We considered energy use for cover crop management resulting from inputs (cover crop seed production, herbicide for cover crop termination) using energy values from the AgInputs worksheet of the model. We considered cover crop management impact on farm-scale machine usage (cover crop planting, herbicide application, mechanical cover crop termination) using values from the AgInputs worksheet. These input and machine use values were converted to energy use and GHG equivalent values using the ENERGY and GHG worksheets. We assumed inputs and machine usage for cash crop management (e.g. cash crop seeds, tillage, cash crop planting, herbicide application, or crop harvest) remains the same across bare-fallow or cover crop management scenarios; changes in fertilizer N rate as a result of cover crop management are addressed in the Nitrogen technical Appendix.

3 Results

3.1 Cover crop impact on N_2O emission depends on total system N amendments

3.1.1 Non-legume cover crop observations

Recent meta-analyses of area-scaled N_2O emissions under cover cropping in temperate agricultural systems found that, in aggregate, non-legume cover crops did not alter N_2O emissions, when the control and treatment fields have the same N amendment rate (Section 3.2 in Abdalla et al. 2018; Figure 4 in Basche et al. 2014; Figure 4 in Han et al. 2017).

3.1.2 Legume cover crop observations

There are limited data addressing N_2O emissions under legume cover crop management. Legumes can add >200 kg N ha^{-1} to the cropping system. Legume analysis that is relevant to U.S. commercial cropping systems must take into account the total N inputs. Studies that include comparisons of legume cover cropping to a 0N addition control cannot be used to establish the change in N_2O under legume cover crops relative to a bare fallow commercial cropping system.

A meta-analysis by Han et al. (2017) compared different N management scenarios, including cover cropping. Overall, Han et al. (2017) concluded that changes to N rate had the largest impact on a change in N_2O emissions. Specific to legume cover crop management, Han et al. (2017) studied systems representative of commercial cropping systems, namely a legume cover cropping system compared to controls that include bare fallow and the application of inorganic N fertilizer. We performed an unpublished re-analysis of the dataset in Han et al. (2017) to examine subsets of the data. For all rainfed legume cover cropping systems in which the control received inorganic N fertilizer we found an average of 3.9% reduction in N_2O emissions. For the same data but removing a study comparing cover crop growing season N_2O emission we found an average of 6% increase in N_2O emissions. For legume cover crop data from rainfed observations with yield data we found a 30% reduction in yield-scaled N_2O emissions under legume cover crops relative to fertilized bare fallow systems. Due to the limited number of studies and the inclusion of studies in which control and treatment have differing total N input rates, it is difficult to establish a robust estimate of average N_2O emission response to legume cover crops for the same total N addition rate.

Overall bi-culture (legume+non-legume) cover crop N_2O observations are very limited. Studies suggest that bi-culture cover cropping systems do not alter N_2O emissions (Section 3.2 in Abdalla et al. 2018; Figure 4 in Basche et al. 2014).

3.1.3 Estimating N_2O emissions under cover cropping

In summary, evidence supports N rate as the strongest driver of N_2O emissions, and there is no clear evidence that non-legume or legume cover crop management alters N_2O emissions if control and treatment sites have the same total N input, or if the systems follow BMPs for total N input (Table 1). Available data supports estimating the impact of cover crop management on N_2O emissions based on how management changes total N additions to the cropping system. Total system N input will be used to estimate N_2O emissions under non-legume, legume, or bi-culture cropping systems.

Table 1. Average observed response of N_2O emission following cover crop management.

Practice	GHG source	Temperature Regime	Moisture Regime	Soil Texture	Region	Cover crop type	Cash crop	Change in N2O following cover crop (%)	Source
Cover Crop	N_2O	Cool / Warm	any	any	Global	non-legume	annual crops	0%	Abdalla et al. 2018; Basche et al. 2014; Han et al. 2017

3.2 Cover crop management generally maintains or increases cash crop yield in systems without water limitation

3.2.1 Rainfed cropping systems

Various lines of evidence indicate that cover cropping has a neutral, or potentially positive, impact on cash crop yield. Figure 3 in Miguez and Bollero (2005) and Figure 1 in Marcillo and Miguez (2017) demonstrated that, on average, non-legume cover crops had a neutral impact on cash crop yield. A neutral impact of non-legume cover crops on cash crop yield was also reported by Tonitto et al. (2006) in a meta-analysis that compared cover crop management practices restricted to N management consistent with commercial practices (in particular cash crops receiving the same N fertilizer application in both fallow and non-leguminous cover crop systems). Similarly, a long-term study of cereal rye cover crop management in maize-soybean systems of MI found that cover crops led to no statistically significant change in maize yields (Snapp and Surapur 2018).

While yield trends under non-leguminous cover crops are supported by multiple lines of evidence (Marcillo and Miguez 2017; Miguez and Bollero 2005; Snapp and Surapur 2018; Tonitto et al. 2006), yield response under leguminous cover crop management is more difficult to generalize. Legumes can be used as the sole N source in organic cropping systems or can be used to supplement inorganic N amendments. Experimental treatments do not necessarily reflect optimal N management of the control or treatment system; for example, a legume cover crop treatment may be compared to a 0N control treatment. Because many control-treatment comparisons are not designed to compare a best-case N management scenario in both the control and treatment plots, meta-analysis results can indicate that legume cover crops provide a high average yield increase, but this is misleading if control treatments included sub-optimal N fertilization (Miguez and Bollero 2005).

A comparison of optimal N management strategies in conventional bare fallow compared to legume cover cropping systems demonstrated that cash-crop yield outcomes depended on legume cover-crop establishment. A meta-analysis comparing legume cover-crop management (as the sole source of cropping system N addition) to conventional cropping systems (managed with winter bare fallow and recommended inorganic N fertilizer rates) found that cropping systems fertilized with legume cover crops averaged a 10% reduction in cash-crop yield across all studies (Figure 3 in Tonitto et al. 2006).For systems in which the legume cover crop provided > 110 kg N ha^{-1} as input, there was (on average) no yield decline (Figure 6 in Tonitto et al. 2006). Yield decline following N amendment from legume cover crops largely occurred in systems with poor legume establishment, which tended to be northern climates with short growing seasons and cold winters (Tonitto et al. 2006). Yield decline resulting from inadequate soil available N following cover crop management can be managed by developing BMPs for N fertilization that ensures the cash crop receives adequate nutrition. In particular, for a system in which a legume cover crop is providing the cash crop N, a farmer would plan to supplement with additional N fertilizer if the legume cover crop did not establish well prior to spring planting.

Additional support for a positive impact of cover crop management on yield include a broad survey of cover crop ecosystem services which found that cover crop management led to improved cash crop yield relative to systems managed with a bare fallow (Figure 10 and Table 10 in Daryanto et al. 2018). This was true of systems with or without N fertilizer addition, as well as for leguminous or non-leguminous cover crops. However, the authors did not strictly compare cover crop management to conventional bare fallow management consistent with N BMPs for a commercial farm. A survey of U.S. farmers that used cover crops indicated that 51% of farmers reported an advantage to cash crop yield, 41% reported neutral yield impact and 7% reported a disadvantage to cash crop yield (CTIC 2017, p14). This survey indicated, at the national scale, cover crop management led to a cash crop yield increase of 1.3% for maize, 3.8% for soybean, and 2.8% for wheat (CTIC 2017), but state-scale yield changes across the Midwest were largely not significant for maize or wheat. State-scale analysis was conducted for IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, and WI. Increased soybean yield under cover cropping was statistically significant for IL, IN, IA, KS, MI, MN, MO, NE, OH, and SD (CTIC 2017).

Observations indicated that cover cropping has generally beneficial or neutral impact on yield in humid, rainfed cropping systems. Because, cover crop management requires farmers to gain skill in implementing the practice, there can be a yield decline during this learning phase. In addition, cover cropping can be perceived as a risky management practice due to the possibility that heavy spring precipitation prevents tillage or other incorporation of the cover crop prior to the optimal cash crop planting schedule. However, in situations where wet soils delay planting, cover crops can reduce soil moisture, facilitating earlier access to fields. For example, Basche et al. (2016) studied detailed soil water properties under long-term (8-14 years), no-till maize-soybean management across a time period with extreme high and low precipitation relative to historic records. In this no-till system maize and soybean yields were statistically similar with or without cereal rye cover crop. The cover crop system tended toward reduced 0-15 cm soil moisture early in the spring, but generally had similar 0-15 cm moisture at crop planting; the reduced soil moisture documented in the early spring could be beneficial for field management (Basche et al. 2016). Furthermore, the cover crop system generally had higher soil moisture at 15-30 cm during the summer, providing protection against late summer water stress (Basche et al. 2016).

3.2.2 Dryland cropping systems

It is more common for cover cropping to be used in rainfed systems and therefore much of the data analyzed in literature reviews is limited to rainfed agriculture. In water-limited systems cover crops can reduce wheat yield (e.g. Mohammed and Chen 2018; Holman et al. 2018). Water stress is a key reason for wheat yield decline. For example, the removal of the fallow period in a Kansas wheat system resulted in a 1mm loss of plant available water (PAW) for each 125 kg/ha of cover crop or forage crop biomass (Holman et al. 2018).

Cropping system diversification, rather than cover-crop management, is an ecologically and economically viable strategy for reducing fallow periods in dryland systems. Diversified dryland rotations have been observed as more profitable and productive systems (Holman et al. 2018; Rosenzweig et al. 2018). Overall, diversified dryland systems that reduced fallow to every 3 or 4 years, or removed fallow altogether can increase productivity across the whole rotation, though wheat in these systems may be less productive than a wheat-fallow rotation (Rosenzweig et al. 2018).

Cover cropping in dryland systems will not be given GHG credit in this version of Gigaton Soil Health Tool. Diversified cropping systems will not be given credit in this version of the Gigaton Soil Health Tool because of their complexities and because of possible leakage due to reduced wheat yield. Accounting methods for diversified cropping systems could be considered for future improvements to the tool.

3.2.3 Data extracted for tool development

We found non-legume cover crop management to have neutral impact on maize yield based on the results of Marcillo and Miguez (2017) and Miguez and Bollero (2005). We found non-legume cover crop management to have positive impact on soybean yield (3.8 % increase) using the national average reported in the farmer survey (CTIC 2017), based on statistically significant yield increase for soybean at both the national and state scale. We generalized non-legume cover crop management to have neutral impact on wheat yield using the farmer survey (CTIC 2017). This survey indicated that, at the state-scale, cover crops had a neutral or positive impact on humid system wheat yield, but the state-scale trends were not significant. While at the national scale cover crop management was reported to increase maize (1.3 %), soybean (3.8 %), and wheat (2.8 %) yields, only the soybean yield increase was significant at the state-scale across most Midwestern states (IL, IN, IA, KS, MI, MN, MO, NE, SD, and OH) (CTIC 2017). Though average state-scale yield response was generally reported as neutral or positive, yield reductions were reported for maize (-6 % for NE, -1 % for OH), soybean (-2 % ND, -1 % WI), and wheat (-3 % ND). The larger yield decline reported in dry regions (NE and ND), though not statistically significant, suggests that arid systems may not maintain yield under cover cropping.

Table 2 National-scale yield response to cover cropping based on literature review. (NR indicates 'not reported')

Practice	GHG source	Temperature Regime	Moisture Regime	Soil Texture	Region	Cover crop type	Cash crop	Change in yield following cover crop (%)	Source
Cover Crop	yield	Cool / Warm	Moist	any	US and Canada	non-legume	maize	0%	Miguez and Bollero 2005; Marcillo and Miguez 2017; aggregate response ratio
Cover Crop	yield	Cool / Warm	any	any	US	NR	soybean	3.80%	CTIC 2017; average yield change in U.S. national survey
Cover Crop	yield	Cool / Warm	any	any	US	NR	wheat	0%	CTIC 2017; average yield change in U.S. national survey

3.3 Cover crop impact on farm-scale energy use

Annual cropping systems managed with a winter cover crop have higher energy use than those managed with a winter bare fallow.

Using values from the FEAT model (Camargo et al. 2013) we estimated cover crop management increased energy use (in kg CO_2e ha^{-1} yr^{-1}) on the order of: 37.24 (rye seed), 17.02 (red clover seed), herbicide production (21.73, chemical cover crop termination), cover crop planting (28.15 assuming a no-till drill), 6.18 (herbicide application, chemical cover crop termination), 13.2 (mechanical cover crop termination), for a total energy increase ranging from 73-79 kg CO_2e ha^{-1} yr^{-1} due to inputs and farm machinery (Table 3 Energy use).

Table 3. Energy use for cover crop management. All data are from the FEAT model (Camargo et al. 2013).

Practice	GHG source	Temperature Regime	Moisture Regime	Soil Texture	Cover crop type	Energy use relative to bare fallow	Change in energy use, (kg CO2e ha-1 y-1)	Gigaton GHG reduction benefit (kg CO2e/ha)	Gigaton GHG reduction benefit (Mg CO2e/ha)
Cover crop	seed energy	all	all	all	rye	increase	37.24	-37.24	-0.037
Cover crop	seed energy	all	all	all	red clover	increase	17.02	-17.02	-0.017
Cover crop	herbicide energy (CC chemical termination)	all	all	all	all	increase	21.73	-21.73	-0.022
Cover crop	Planting into prepared seedbed	all	all	all	all	increase	15.48	-15.48	-0.015
Cover crop	Drilling into prepared seedbed	all	all	all	all	increase	12.24	-12.24	-0.012
Cover crop	Planting into no-till seedbed	all	all	all	all	increase	23.03	-23.03	-0.023
Cover crop	No-till grain drill	all	all	all	all	increase	28.15	-28.15	-0.028
Cover crop	herbicide application (CC chemical termination)	all	all	all	all	increase	6.18	-6.18	-0.006
Cover crop	CC mechanical termination	all	all	all	all	increase	13.2	-13.20	-0.013
Cover crop	Low end energy inrease	all	all	all		increase	73.07	-73.07	-0.073
Cover crop	High end energy increase	all	all	all		increase	78.59	-78.59	-0.079

Gigaton tool default values assume rye as the dominant non-legume and clover as the dominant legume cover crop in U.S. commodity grain systems (Table 4).

Table 4. Cover crop management in U.S. landscapes based on results from the 2016 national farmer cover crop survey (CTIC 2017).

	2016 national survey of cover crop species			
cover crop	**acreage**	**proportion of all cover crops**	**proportion of grass cover**	**proportion of non-legume cover**
cereal rye	289,068	0.23	0.42	0.29
oat	159,607	0.13	0.23	0.16
winter wheat	93,899	0.08	0.14	0.09
annual ryegrass	76,148	0.06	0.11	0.08
triticale	36,001	0.03	0.05	0.04
winter barley	26,824	0.02	0.04	0.03
			proportion of brassica cover	
radish	139,476	0.11	0.43	0.14
rapeseed	98,577	0.08	0.31	0.10
turnip	70,002	0.06	0.22	0.07
canola	14,503	0.01	0.04	0.01
			proportion of legume cover	
crimson clover	74,352	0.06	0.31	
winter pea	42,355	0.03	0.18	
hairy vetch	39,266	0.03	0.16	
other clovers	24,096	0.02	0.10	
cowpea	22,129	0.02	0.09	
red clover	21,561	0.02	0.09	
sunn hemp	11,406	0.01	0.05	
other vetches	6,089	0.00	0.03	

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Appendix F

Soil Organic Carbon Sequestration from Cover Crops

Dominic Woolf, Peter Woodbury, Christina Tonitto

Jun 8, 2020

Summary

Currently-available published data do not support model-derived or statistical dis-aggregation of soil organic carbon (SOC) accumulation under cover crops by soil, cover-crop type or cash-crop type. We therefore use the average of published values as the best available estimate, dis-aggregated into groups for dry and moist climate zones.

The average rate of SOC accumulation in moist climates is 0.19 Mg C ha^{-1} yr^{-1}. No SOC-sequestration credit is given for cover cropping in dry-land systems, primarily because measured SOC in dry climates was not significantly different from zero, but also because use of cover crops in dry-lands is expected to deplete soil water. This would, in turn, lead to a loss in yield of the main crop and/or an increase in irrigation demand. Not only would these considerations make cover crops impractical in drylands, but would also lead to indirect land use change (ILUC) emissions greater than the on-site SOC sequestration.

These average SOC sequestration rates are derived from published measurements, filtered to include only data (a) using annual cover crops (b) in non-organic systems, (c) after at least 3 years of cover-cropping, (d) where there was no difference between tillage or manure inputs between control and cover-crop treatment, (e) excluding Histosols, and (f) excluding implausible outliers where reported rates of SOC sequestration were higher than 1.5 times estimated potential net primary production.

The average length of cover-crop treatment over which this sequestration was measured was seven years. To calculate the CO_2-equivalent credit provided in the Project Gigaton method the SOC sequestration during the first years after conversion to cover cropping is multiplied by a factor $f100_{CC}$, to account for the facts that annual sequestration rates diminish over time, and that long-term implementation is required to ensure permanence of the sequestered carbon. $f100_{CC}$ is calculated as the cumulative SOC sequestered over 100 years, expressed as a fraction of the SOC that would be sequestered if the initial annual sequestration rate remained constant over 100 years. $f100_{CC}$ is 0.26 in warm-moist climates, and 0.28 in cool-moist climates. Values of $f100_{CC}$ were also calculated for dry climates (0.26 in warm-dry, and 0.29 in cool-dry), however it should be noted that these will not affect the net credit given, since the default SOC sequestration rate in dry climates is zero.

Methods

The soil health database, version 3 (Jian et al. 2020) was used to find published studies on cover crops. Data were also added from cover crop studies that were absent from the database (Astier et al. 2006, Goyal et al. 1999; Hansen et al. 2000; Hermawan and Bomke, 1997; Kuo et al. 1997; Mandal et al. 2003; N'Dayegamiye and Tran, 2001; and Utomo et al. 1990). This yielded a total of 5927 measurements from 329 studies. Studies were then identified from this database that met the following criteria:

1. All of the following parameters were reported: location; SOM and/or SOC; number of years of experiment.
2. We excluded experiments from organic systems, agroforestry, orchards, vegetables, and perennial crops.
3. We excluded experiments where there was a difference in tillage or manure inputs between the control and cover-crop treatments.

After sub-setting the data by these criteria, the final dataset comprised 64 studies (Abdallahi & N'dayegamiye, 2000; Abdollahi & Munkholm, 2014; Abunyewa & Padi, 2003; Alessandria et al., 2013; Amado, Bayer, Conceição, Spagnollo, Campos, et al., 2006; Amado, Bayer, Conceição, Spagnollo, De Campos, et al., 2006; Astier et al., 2006; Bandick & Dick, 1999; Bayer et al., 2009, 2015; Beare & Russell Bruce, 1993; Benjamin et al., 2007; Blanco-Canqui et al., 2011, 2013; Brown et al., 2000; Campbell, Biederbeck, et al., 1991; Campbell, Zentner, et al., 1991; Clark et al., 2017; Constantin et al., 2010; Curtin et al., 2000; Drinkwater et al., 1998; Eckert, 1991; Goyal et al., 1999; Hansen et al., 2000; Haque et al., 2013; Hargrove, 1986; Hermawan & Bomke, 1997; Hubbard et al., 2013; Idowu et al., 2009; W. Jokela et al., 2011; W. E. Jokela et al., 2009; Kaho et al., 2004; Kim et al., 2013; Kuo et al., 1997; Langdale et al., 1992; Mandal et al., 2003; Marriott & Wander, 2006; Mazzoncini et al., 2011; Mbuthia et al., 2015; McVay et al., 1989; Metay et al., 2007; Mitchell, 1996; Moore et al., 2014; Muleba, 1999; Myaka et al., 2006; Nascente et al., 2013; N'Dayegamiye & Tran, 2001; Ndiaye et al., 2000; Nyakatawa et al., 2001; Olson et al., 2014; Onim et al., 1990; Osborne et al., 2014; Poeplau & Don, 2015; Sadat-Dastegheibi, 1974; Sainju et al., 2006; Scott et al., 1990; Smestad et al., 2002; Steele et al., 2012; Terra et al., 2005; Thomsen & Christensen, 2004; Utomo et al., 1990; Veum et al., 2015; Villamil et al., 2006, 2006; Wilson et al., 1982; Yu et al., 2014; Zimmer & Roschke, 2001)

Where the original studies reported Soil Organic Matter (SOM) rather than SOC, we used a conversion factor of 0.58 to convert to SOC. Where the original studies used the Walkley-Black method to measure SOC, we applied a conversion factor of 1.3.

The cover-crop soil health database was the analyzed using machine learning, process modeling, and analysis of variance, as described in the following sections. Of these methods, analysis of variance was found to provide the most robust results and was therefore used as the basis for the final results of SOC sequestration rates reported here.

Machine learning

Random forest regression tree models of SOC sequestration rate were conducted using the Ranger package of the R Statistical Programming language, using a range of explanatory variables including:

1. e**xperimental treament**: time after cover crop introduction; cover crop group; grain crop group; cover crop biomass (which was only reported in a few studies and imputed as the mean for other cases).
2. **climatic**: mean annual temperature, mean annual precipitation, reference evapo-transpiration. aridity, and USDA climate zone.
3. **bioclimatic**: mean diurnal range, isothermality, temperature seasonality, maximum temperature in warmest month, minimum temperature in coldest month, temperature range, mean temperature in wettest quarter, mean temperature in driest quarter, mean temperature in warmest quarter, mean temperature in coldest quarter, precipitation in wettest month, precipitation in driest month, precipitation seasonality, precipitation in wettest quarter, precipitation in driest quarter, precipitation in warmest quarter, and precipitation in coldest quarter
4. **Net Primary Production (NPP)**: Annual mean NPP (MODIS), Annual potential NPP (estimated by Community Land Model v4.5 20th century mean), monthly potential NPP (estimated by Community Land Model v4.5 20th century mean), and potential NPP in cover-crop growing months (estimated by Community Land Model v4.5 20th century mean).
5. **Soil**: clay, sand, silt, bulk density, cation exchange capacity, mean annual soil moisture (estimated by Community Land Model v4.5 20th century mean), and mean annual soil temperature (estimated by Community Land Model v4.5 20th century mean).

Spatial distribution of these co-variates is shown in section 5 below.

Out-of-bag prediction R^2 was 0.20, which is not considered high enough for robust extrapolation of the model to the whole of the USA. The predictors with greatest importance (by permutation), in decreasing order of importance, were: clay, SOC, precipitation seasonality, precipitation in wettest quarter, precipitation in the coldest quarter, mean soil temperature, minimum temperature in the coldest month, mean annual temperature, and maximum temperature in the warmest month. Given the low R^2 value, the machine learning approach was rejected as a method to predict geospatially-referenced SOC sequestration rates from available spatial data-sets.

4. Process modeling

The RothC soil carbon model (Coleman & Jenkinson, 2008) has previously been shown to correlate with cover crop SOC sequestration, using an smaller dataset than the one applied here (Poeplau & Don, 2015). We therefore investigated the use of RothC as a means to predict spatio-temporal variability in SOC accumulation under cover crops.

First, organic carbon inputs were estimated for each experimental treatment, by minimizing the squared variance between measured and modeled SOC using numerical optimization with carbon inputs as the control parameter. The optimization method was “Brent”, using the “optimise” function in R, with a 100-year spin-up length from an initial SOC estimate set to the measured control SOC. Once carbon inputs had been calculated, the next step was to simulate measured change in SOC after introduction of cover cropping. Several modeling protocols were tried for this, including optimizing the change in organic matter inputs, (i) as a fraction of control organic matter input, (ii) as a fraction of annual NPP, (iii) as a fraction of potential NPP during the cover crop season. The optimization objective function was the sum of squares of residuals in SOC sequestration, expressed as (i) mean annual change in SOC stocks to standardized depth, (ii) total change in SOC stocks to standardized depth, (iii) annual change in SOC concentration, and (iv) total change in SOC concentration. In none of these cases was an R^2 of greater than around 5% achieved. Therefore, it was concluded that, despite process modeling with RothC providing a good fit for a small subset of these data in earlier studies (Poeplau & Don, 2015), the large variance in the current dataset was not readily explainable using this method. This is likely because the actual production of cover-crop organic matter, in practice, is a complex interaction of weather during the experimental seasons, establishment and growing management practices, varietal selections, pest and disease pressure, seed germination rates and establishment viability etc., with these parameters not being adequately predictable using available spatial correlates.

5. Analysis of variance

Having shown both machine learning and process modeling to provide low correlation with observed variability in SOC accumulation under cover crops, our estimates of average SOC sequestration rates were based on sample means of the observations. ANOVA models were generated for rate of change of SOC stocks to a standardized (30 cm) depth as a function of USDA climate zone, moisture zone (i.e. dry versus moist climates in the USDA classification), cover-crop type, and main-crop type, using the function "aov" in R. Means were grouped using Tukey HSD for unbalanced data (using function "HSD.test" from the agricolae package in R). SOC sequestration rate did not vary significantly (at 95% confidence) with climate zone or cover crop type (Figs. 1 and 3). However, a significant difference was found between sequestration rates in dry versus moist climates (Fig. 2), with the rate in dry climates not being significantly different from zero.. Although continuous soybean showed a different mean to cereals or mixed cropping rotations (Fig. 4) none of the continuous soy data were from the USA, and random forest analysis (see next section) did not show main crop type as a significant predictor when multiple interactive effects between parameters are also considered. We therefore disaggregate SOC sequestration rates only by moisture zone.

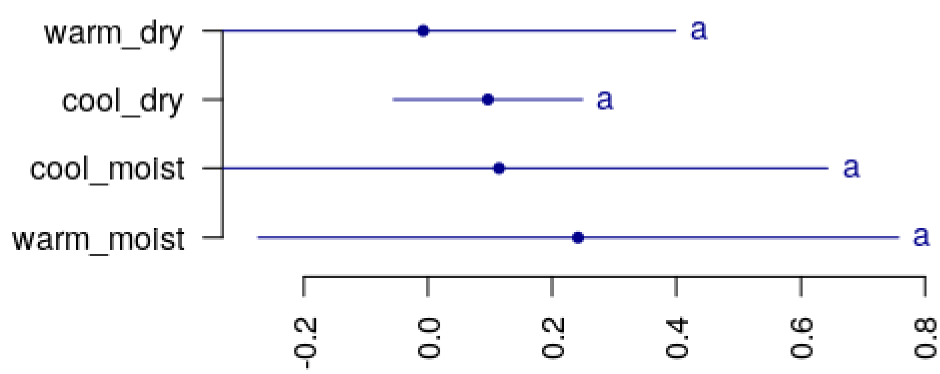

Figure 1: Mean and standard deviation of carbon sequestration rate (Mg C ha^{-1} yr^{-1}), dis-aggregated by USDA climate zone, with ANOVA groups determined by Tukey HSD for unbalanced data (using agricolae package in R).

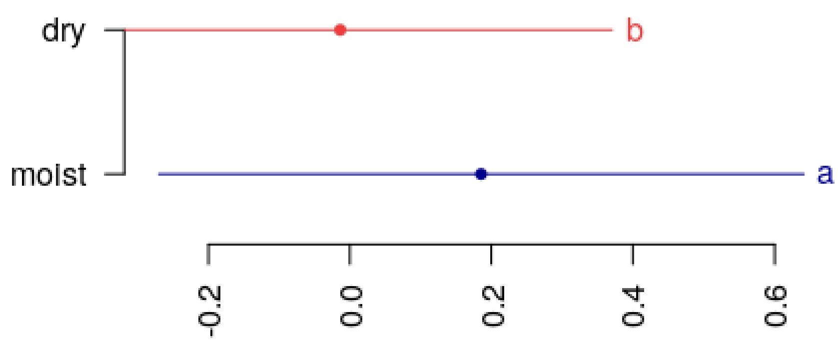

Figure 2: Mean and standard deviation of carbon sequestration rate (Mg C ha^{-1} yr^{-1}), dis-aggregated by moisture zone, with ANOVA groups determined by Tukey HSD for unbalanced data (using agricolae package in R).

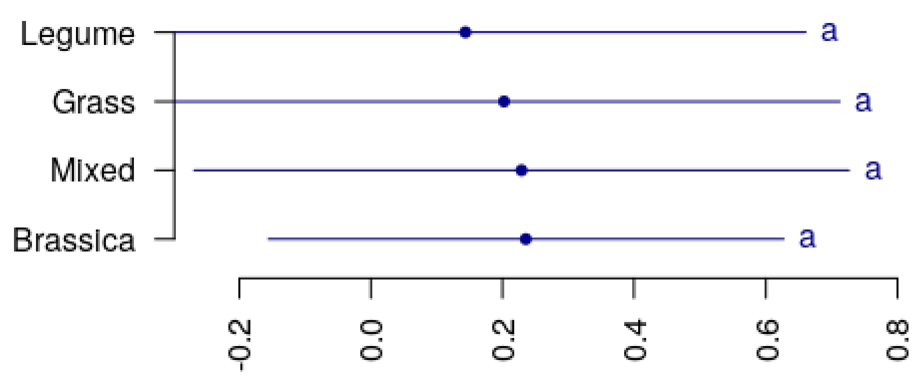

Figure 3: Mean and standard deviation of carbon sequestration rate (Mg C ha^{-1} yr^{-1}), dis-aggregated by cover-crop type, with ANOVA groups determined by Tukey HSD for unbalanced data (using agricolae package in R).

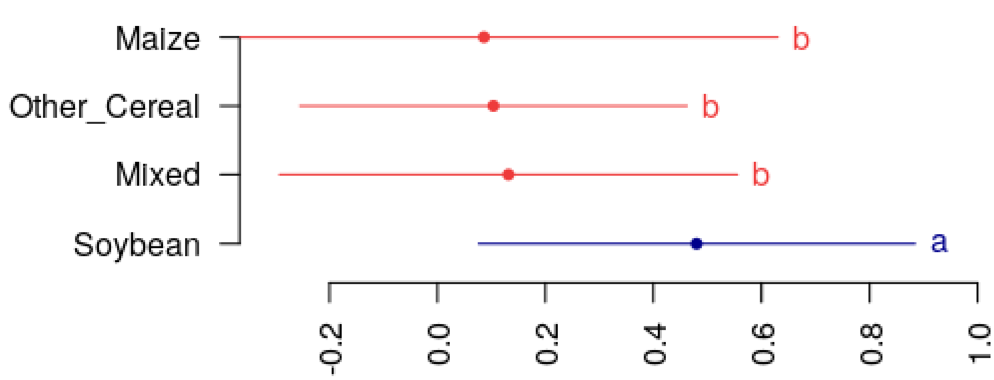

Figure 4: Mean and standard deviation of carbon sequestration rate (Mg C ha^{-1} yr^{-1}), dis-aggregated by main-crop type, with ANOVA groups determined by Tukey HSD for unbalanced data (using agricolae package in R).

6. Accounting for sequestration rate variation with time

As described in the Overall Methods document, annualized SOC credits are attenuated by an SOC adjustment factor ($f100_{CC}$) to account for the fact that annual sequestration rates diminish over time. It is calculated as the cumulative SOC sequestered over 100 years, expressed as a fraction of the SOC that would be sequestered if the initial annual sequestration rate remained constant over 100 years:

$$f100_{CC} = \Delta SOC_{100} / (100 * \Delta SOC_{1})$$

where,

ΔSOC_{100} is the net cumulative carbon sequestered over 100 years, and

ΔSOC_{1} is the initial annual carbon sequestration rate (averaged over the first 8 years, which is the mean length of the experiments used in deriving the empirical estimate).

ΔSOC100 was calculated using the RothC model, spun up over 1000 years to current SOC stocks, then forced by a step change in carbon input to give a value of ΔSOC1 equal to the empirical estimate of 0.19 Mg C ha-1 yr-1 from published cover crop trials. Current SOC was estimated using the FAO / Global Soil Partnership GSOC version 1.5.0 (Global Soil Partnership, 2018). Monthly temperature, precipitation and potential evapotranspiration were estimated using Climatic Research Unit (CRU) Time-Series (TS) version 4.03 of high-resolution gridded data of month-by-month variation in climate. Soil texture (clay content) was estimated using the gridded harmonized world soils database (Wieder et al., 2014).

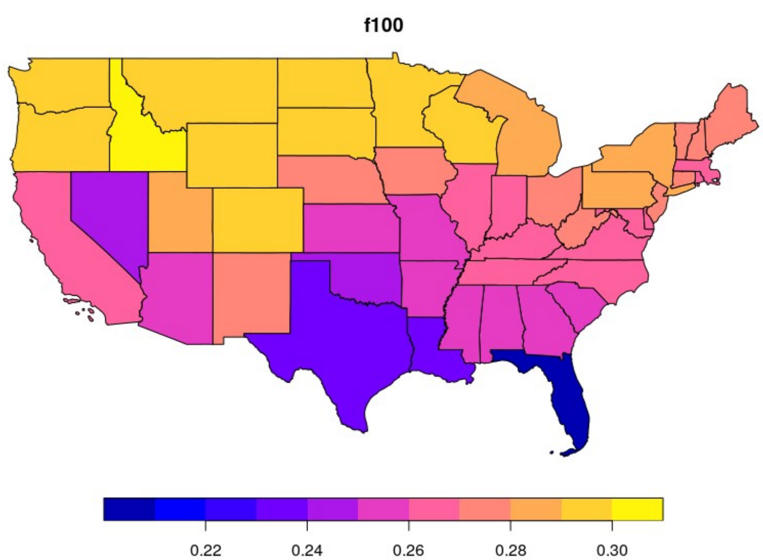

Figure 5: Adjustment factor ($f100_{cc}$) to account for reduced sequestration rates over time, for each State in the coterminous USA.

Table 1: Adjustment factor ($f100_{cc}$) to account for reduced sequestration rates over time, for each State in the coterminous USA.

NAME	$f100_{cc}$	NAME	$f100_{cc}$
Alabama	0.25	Nebraska	0.27
Arizona	0.26	Nevada	0.24
Arkansas	0.26	New Hampshire	0.27
California	0.27	New Jersey	0.27
Colorado	0.29	New Mexico	0.27
Connecticut	0.27	New York	0.28
Delaware	0.26	North Carolina	0.26
Florida	0.21	North Dakota	0.29
Georgia	0.25	Ohio	0.28
Idaho	0.30	Oklahoma	0.25
Illinois	0.26	Oregon	0.29
Indiana	0.27	Pennsylvania	0.29
Iowa	0.27	Rhode Island	0.27
Kansas	0.26	South Carolina	0.25
Kentucky	0.26	South Dakota	0.29
Louisiana	0.24	Tennessee	0.27
Maine	0.28	Texas	0.24
Maryland	0.27	Utah	0.28
Massachusetts	0.27	Vermont	0.28
Michigan	0.28	Virginia	0.27
Minnesota	0.30	Washington	0.30
Mississippi	0.25	West Virginia	0.28
Missouri	0.26	Wisconsin	0.29
Montana	0.30	Wyoming	0.29

7. Environmental covariates

Several environmental parameters (related to climate, soil properties and net primary production) were explored as potential explanatory variables of variance in SOC sequestration. Spatial distributions of these environmental parameters are shown in Figs. 6 -

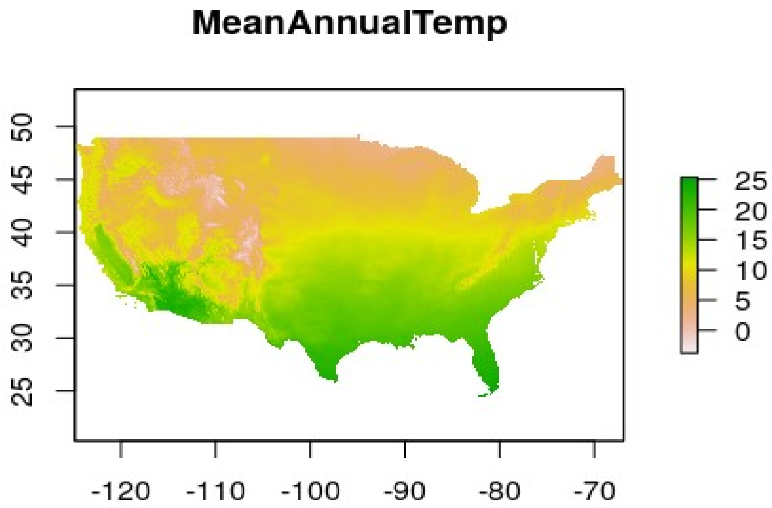

Figure 6: Mean Annual Temperature (WorldClim).

39.

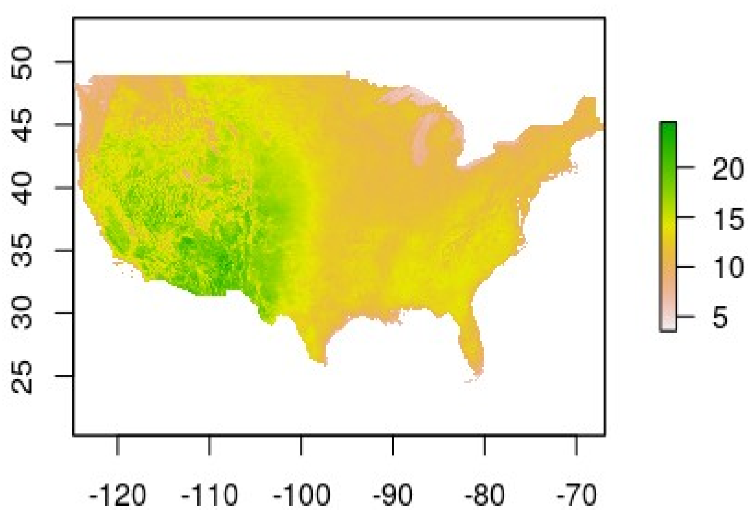

Figure 7: Mean diurnal range (WorldClim).

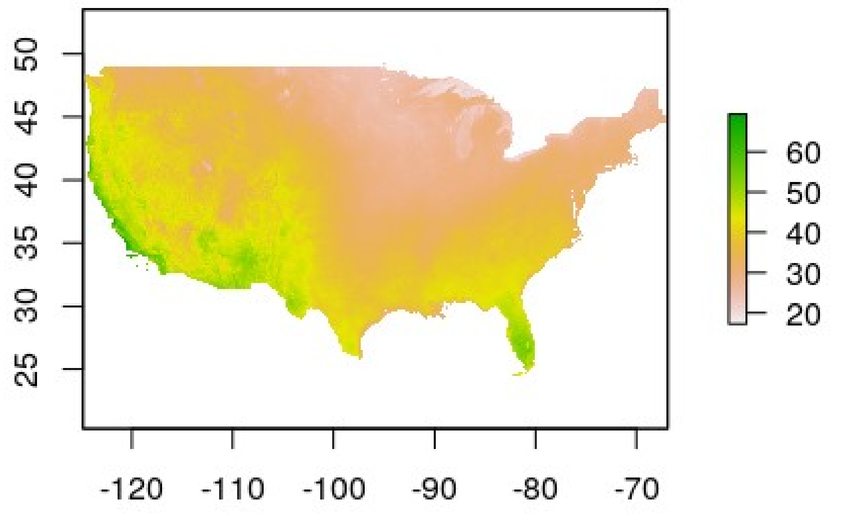

Figure 8: Isothermality (WorldClim).

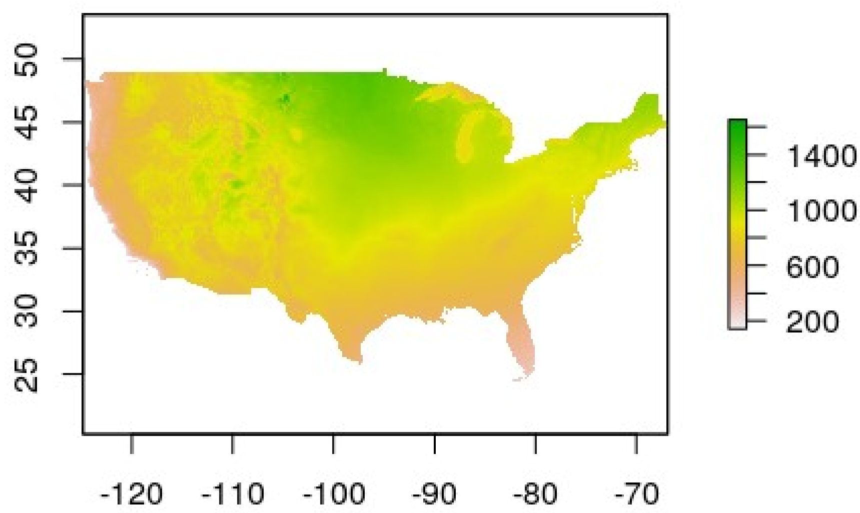

Figure 9: Mean temperature seasonality (WorldClim).

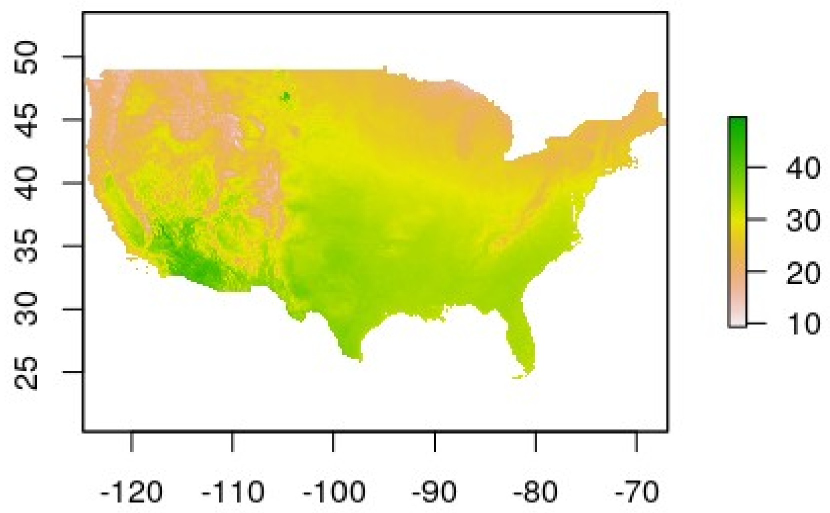

Figure 10: Maximum temperature in the warmest month (WorldClim).

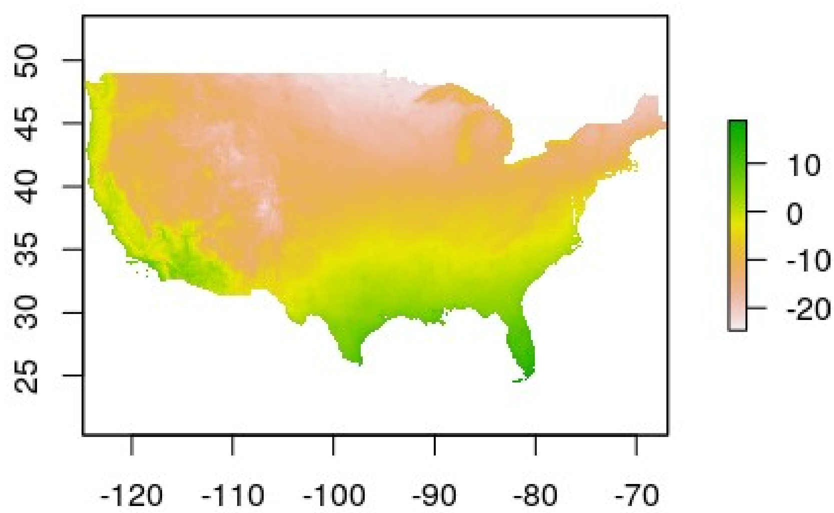

Figure 11: Minimum temperature in coldest month (WorldClim).

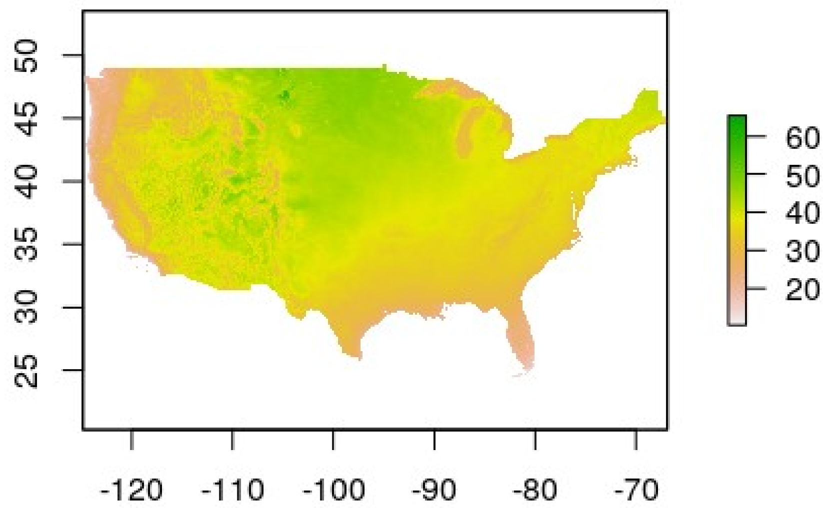

Figure 12: Mean temperature range (WorldClim).

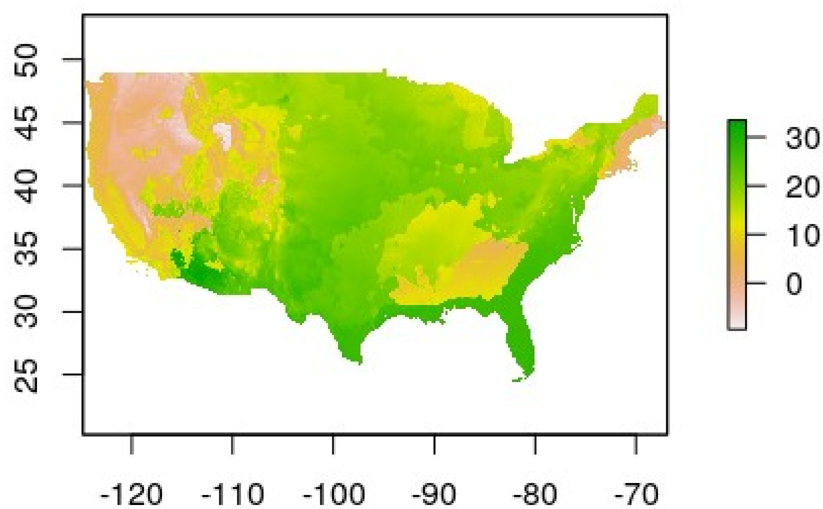

Figure 13: Mean temperature in wettest quarter (WorldClim).

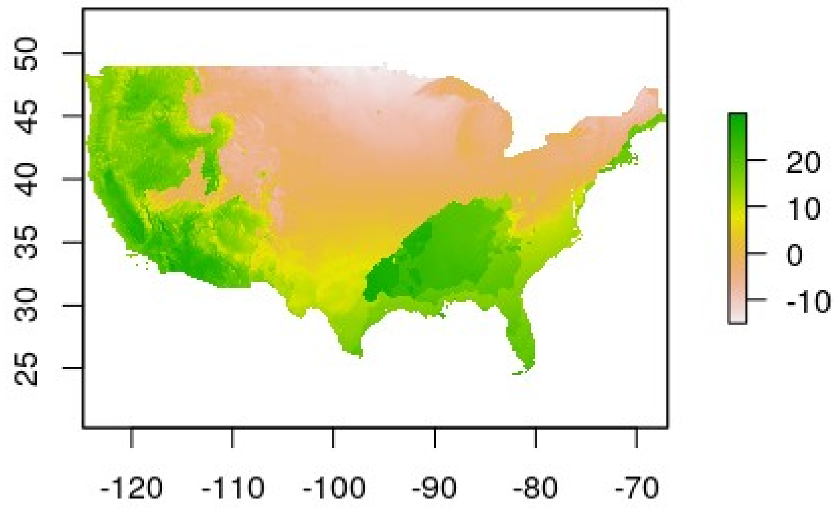

Figure 14: Mean temperature in driest quarter (WorldClim).

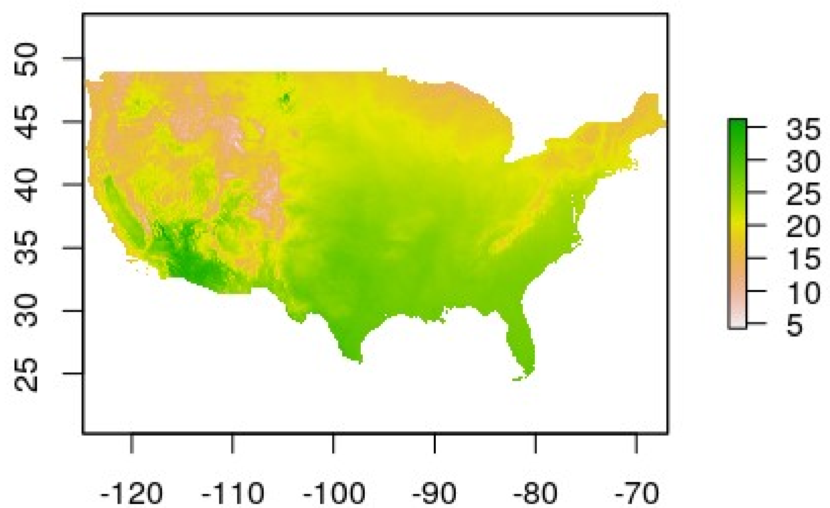

Figure 15: Mean temperature in warmest quarter (WorldClim).

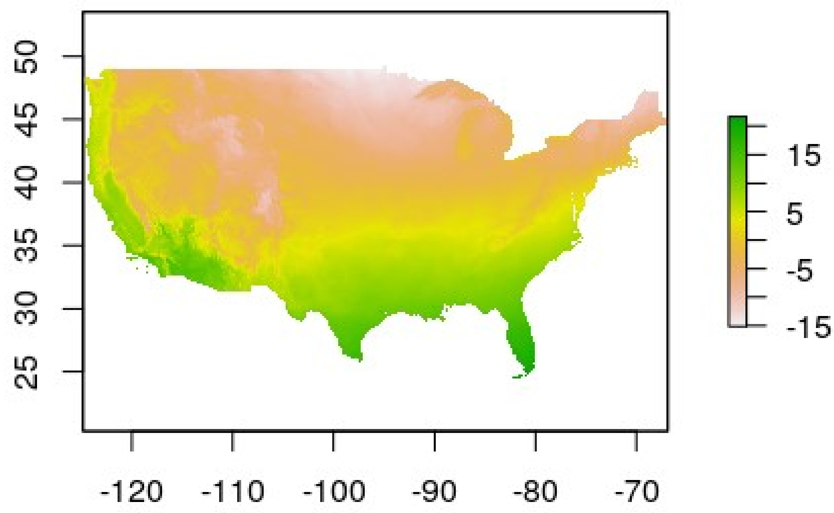

Figure 16: Mean temperature in coldest quarter (WorldClim).

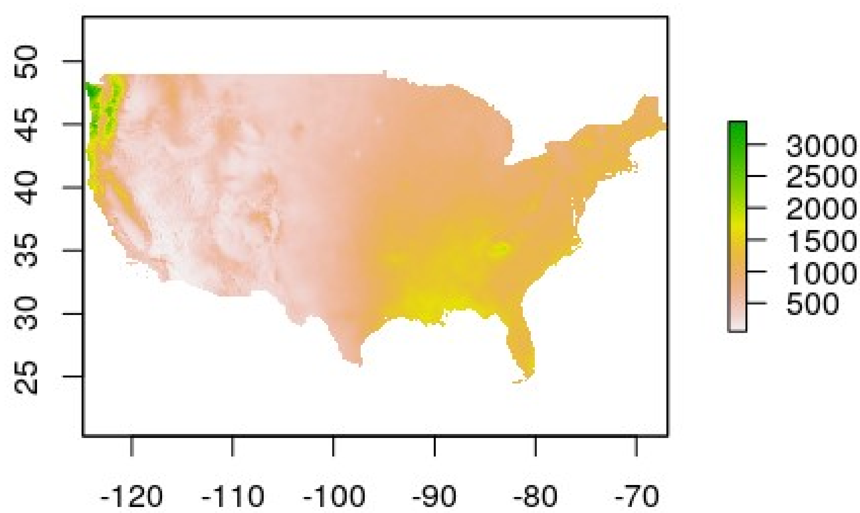

Figure 17: Mean annual precipitation (WorldClim).

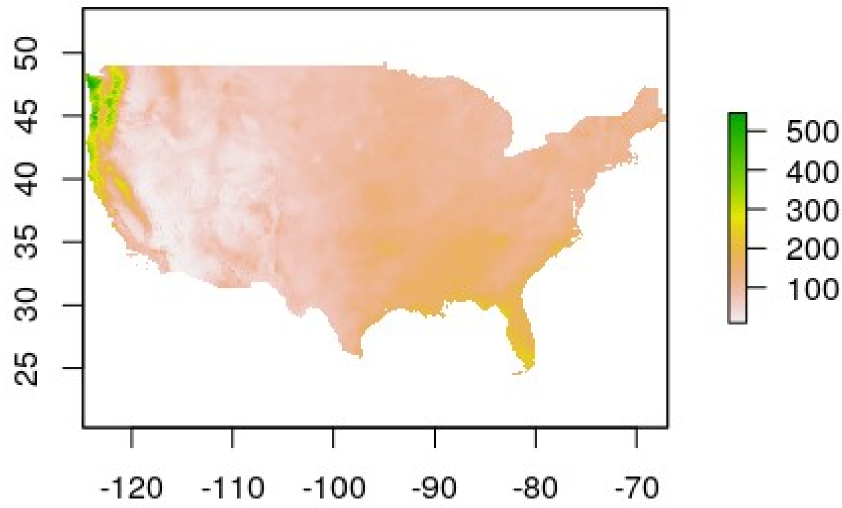

Figure 18: Mean precipitation in wettest month (WorldClim).

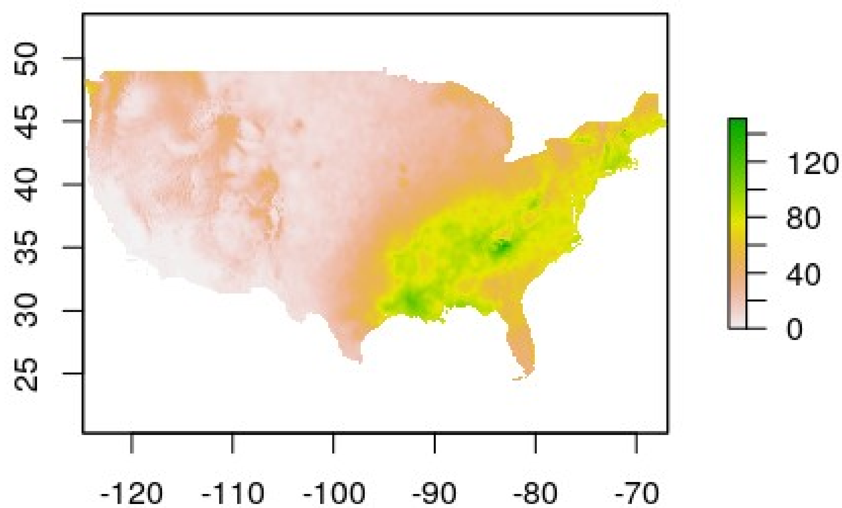

Figure 19: Mean precipitation in driest month (WorldClim).

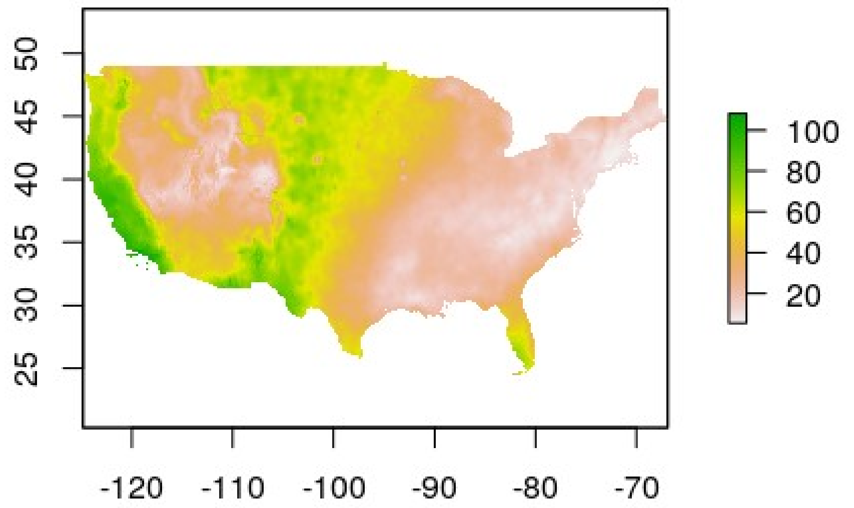

Figure 20: Precipitation seasonality (WorldClim).

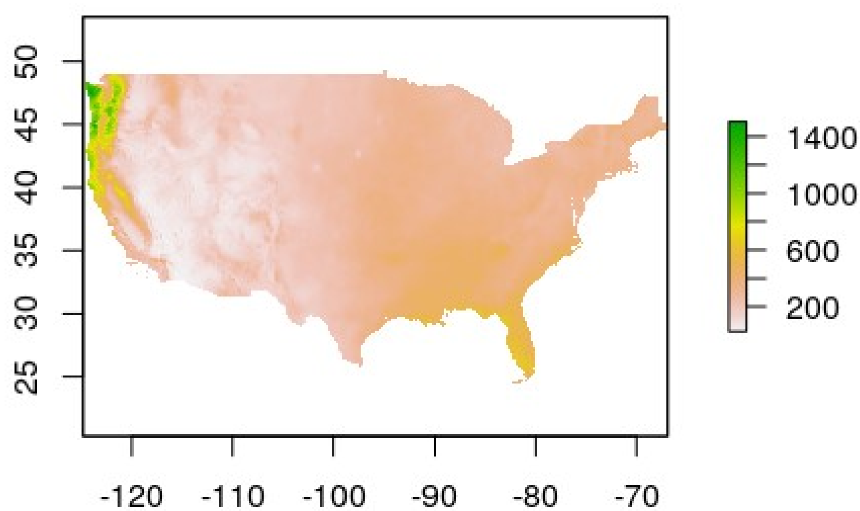

Figure 21: Mean precipitation in wettest quarter (WorldClim).

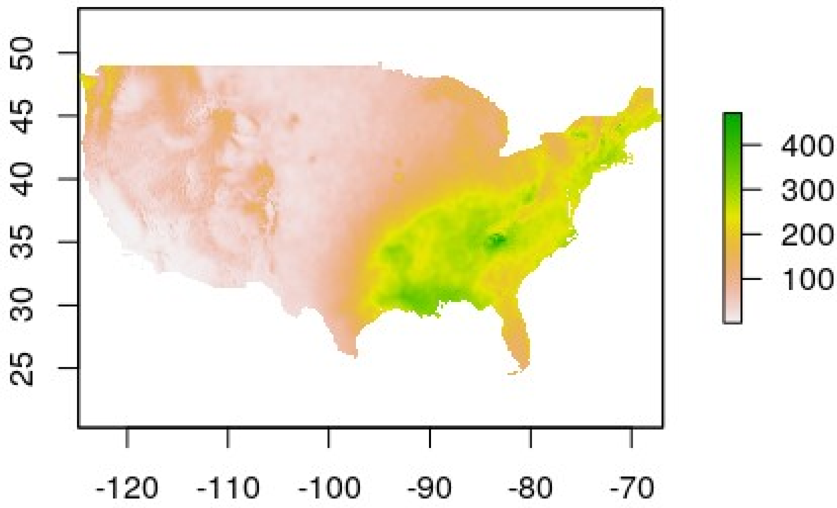

Figure 22: Mean precipitation in driest quarter (WorldClim).

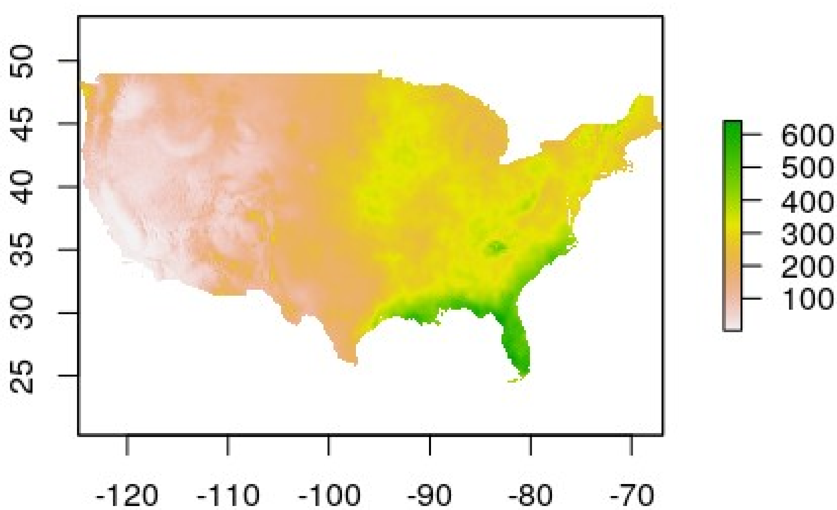

Figure 23: Mean precipitation in warmest quarter (WorldClim).

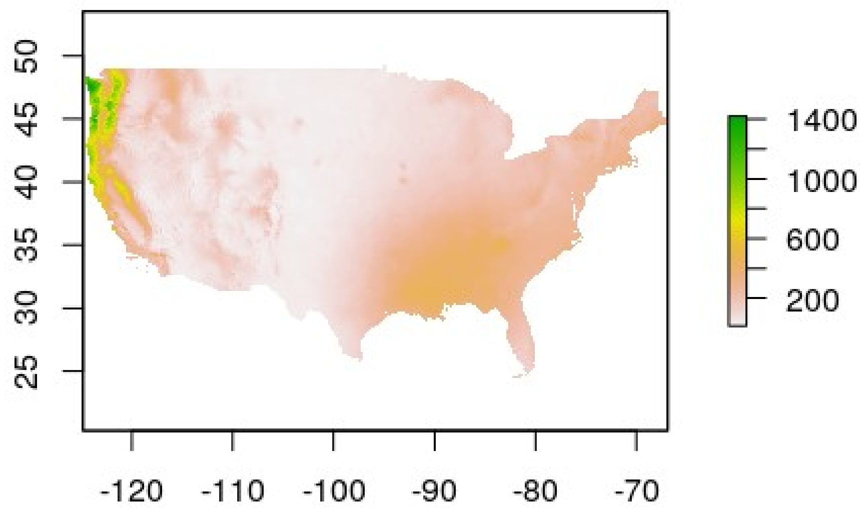

Figure 24: Mean precipitation in coldest quarter (WorldClim).

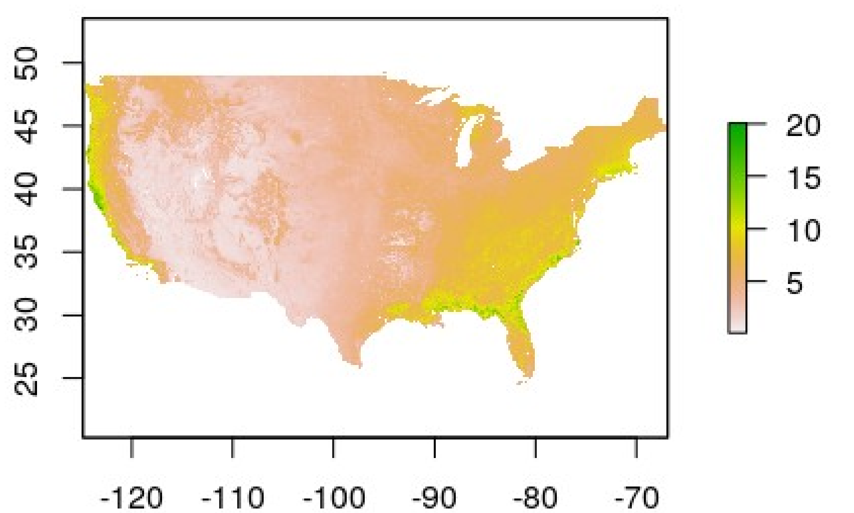

Figure 25: Mean annual net primary production 2000-2015 (NASA MODIS MOD17a3).

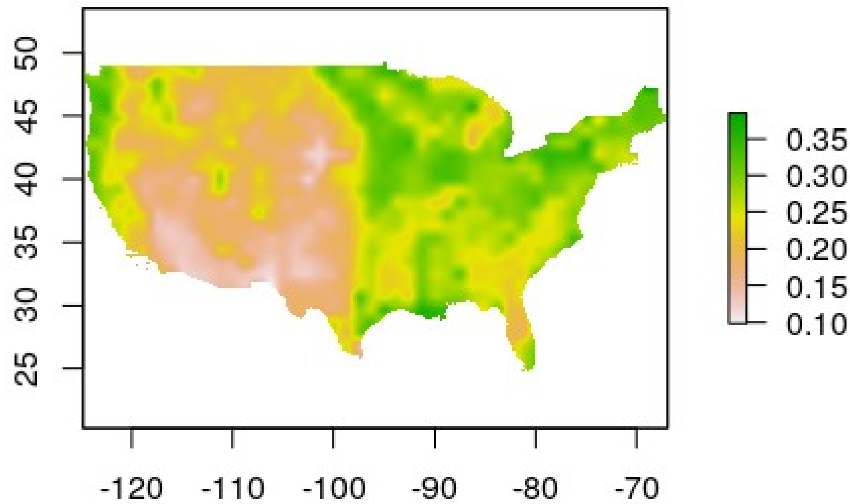

Figure 26: Mean soil moisture 0-30cm. Derived from Community Land Model 4.5 20th century historic runs.

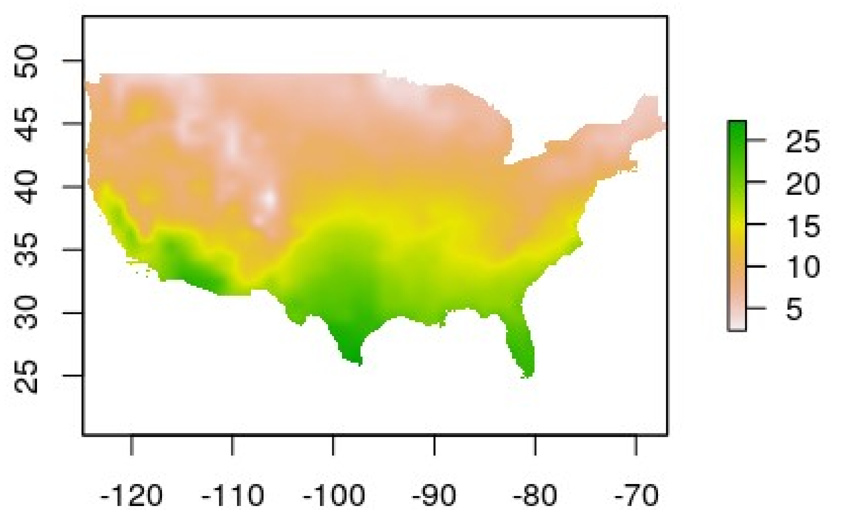

Figure 27: Mean soil temperature 0-30cm. Derived from Community Land Model 4.5 20th century historic runs.

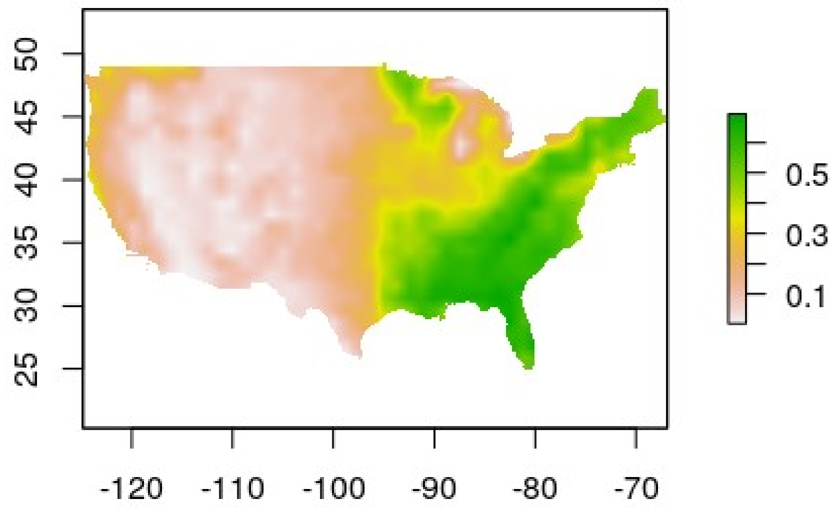

Figure 28: Potential net primary production (monthly mean). Derived from Community Land Model 4.5 20th century historic runs.

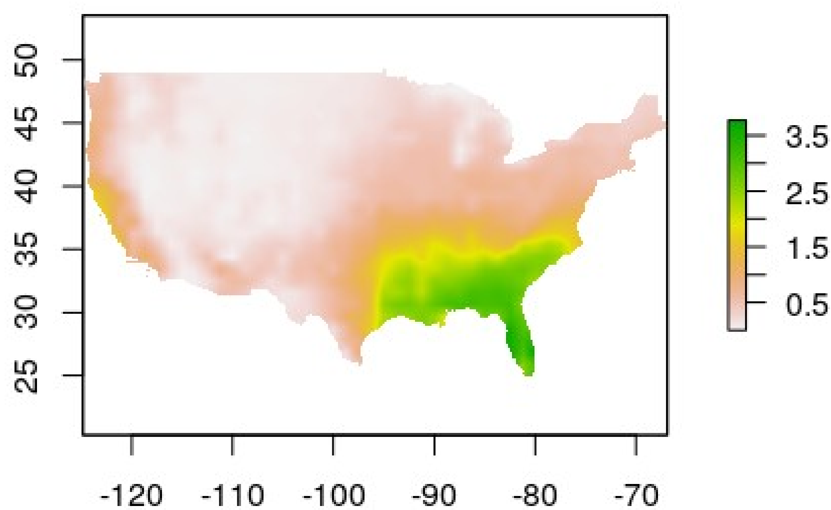

Figure 29: Potential net primary production during Oct-Mar. Derived from Community Land Model 4.5 20th century historic runs.

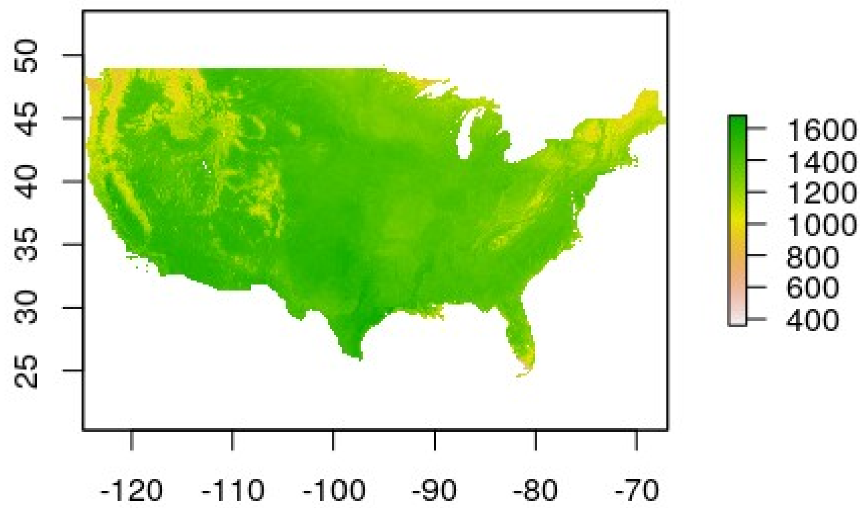

Figure 30: Bulk density (g/m^3). (SoilGrids).

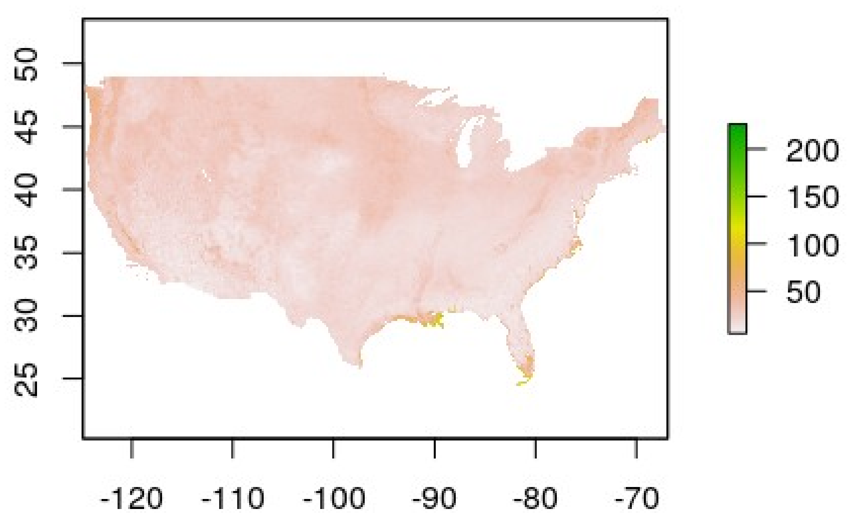

Figure 31: Cation exchange capacity (SoilGrids).

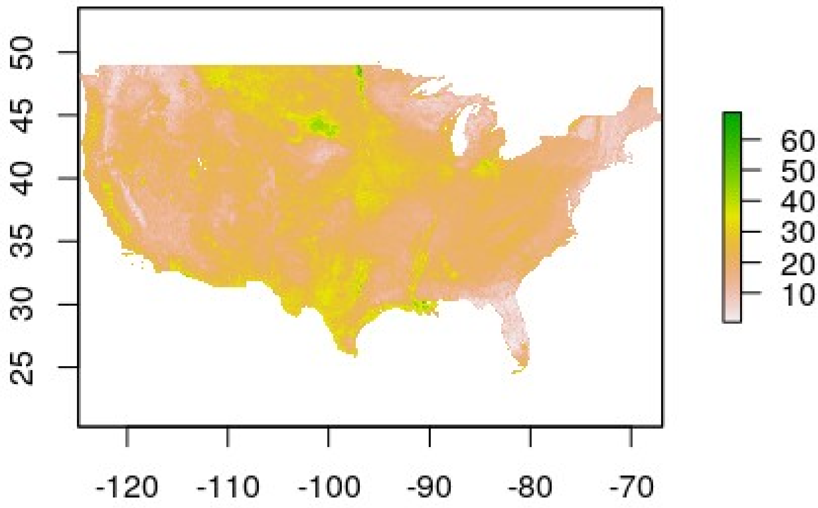

Figure 32: Clay content (SoilGrids).

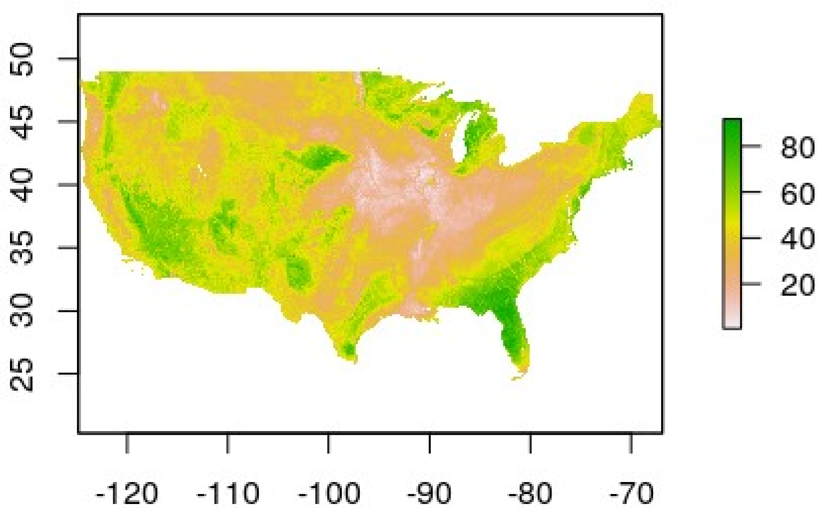

Figure 33: Sand content (SoilGrids).

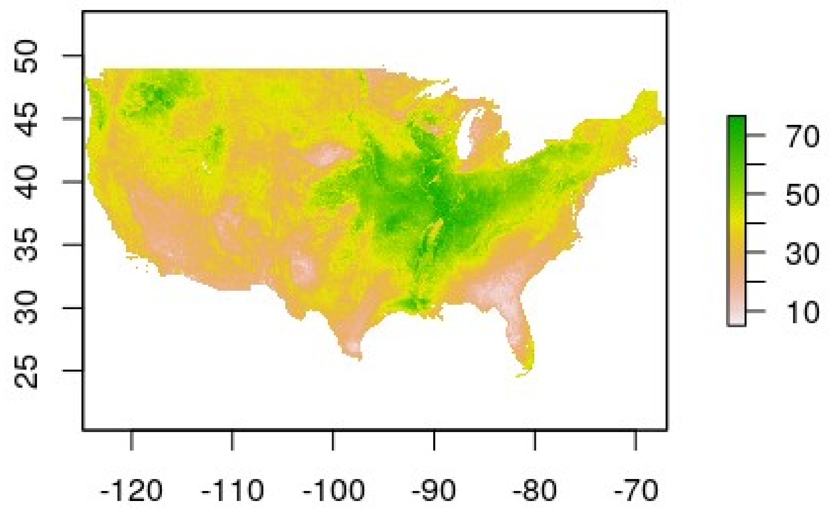

Figure 34: Silt content (SoilGrids).

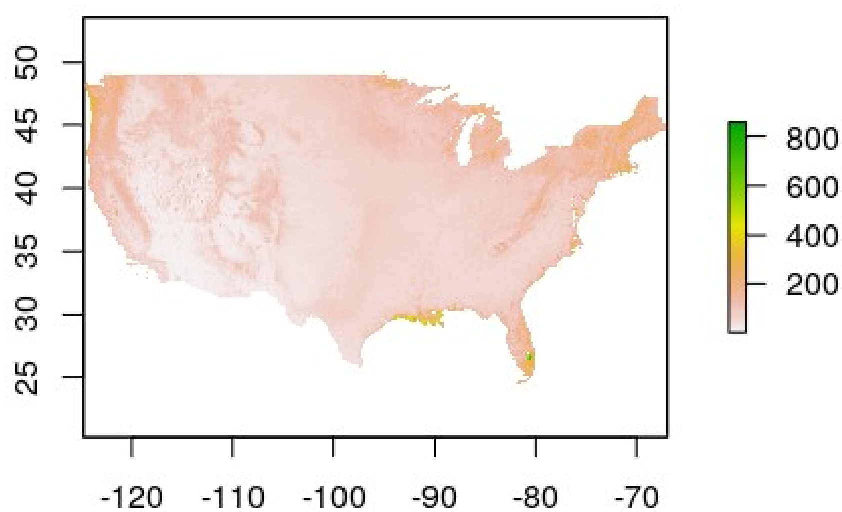

Figure 35: Soil carbon stocks to 30 cm (Mg/ha). (SoilGrids). Note that high end of range corresponds to histosols.

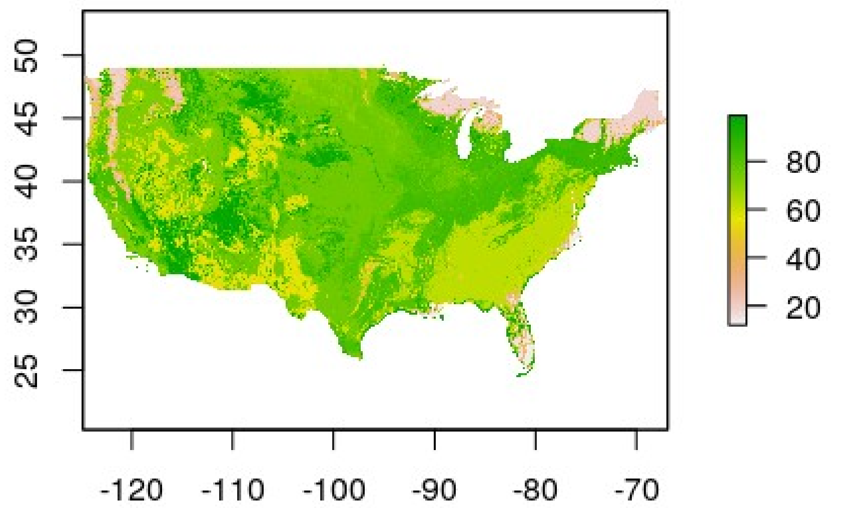

Figure 36: Soil taxonomy (USDA). Refer to SoilGrids.org for conversion from numeric values to classes

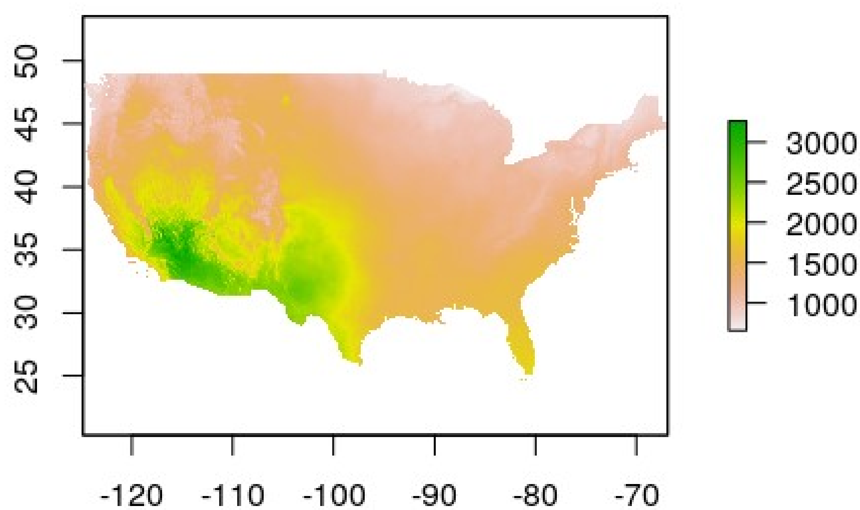

Figure 37: Annual reference evapotranspiration (mm).

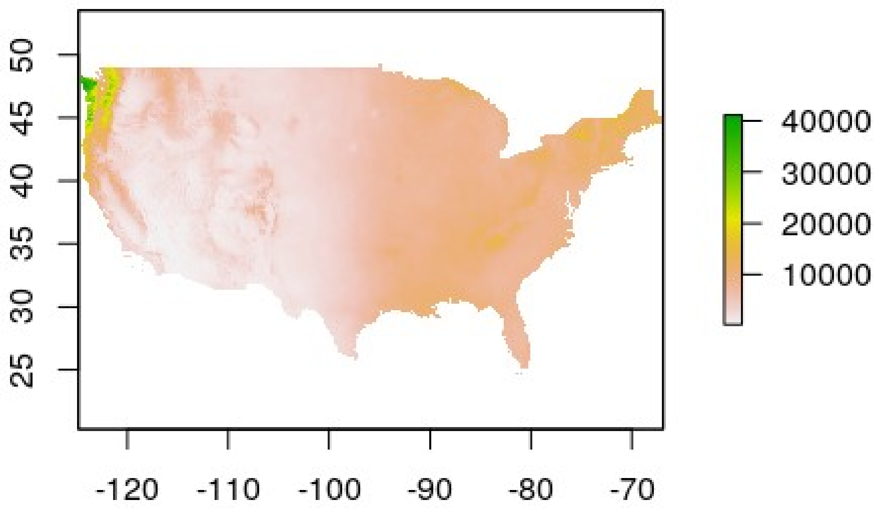

*Figure 38: Aridity Index (annual precipitation/ reference evapotranspiration * 10000). Note scale factor of 10,000.*

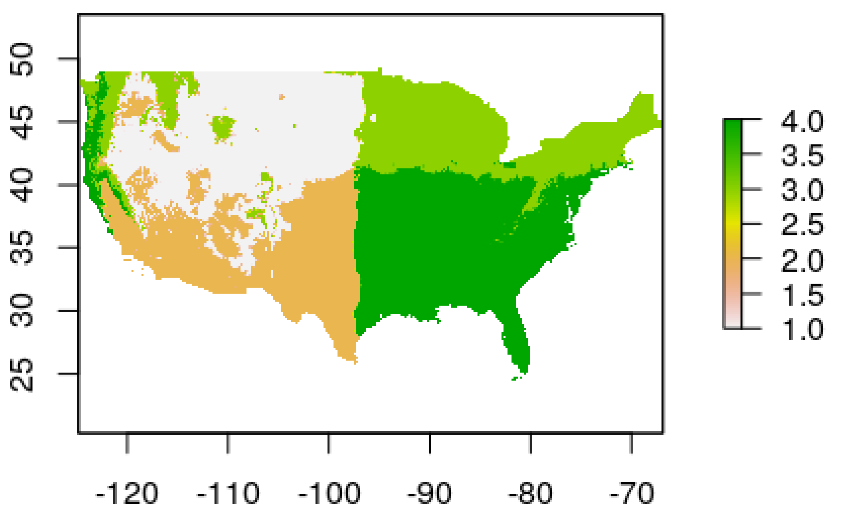

Figure 39: Climate zone. 1 = cool-dry. 2 = warm-dry. 3 = cool-moist. 4 = warm-moist.

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Appendix F: Nitrogen technical appendix

Table of Contents

1 Overview

1.1 N management and GHG emissions

N management accounting includes: 1) cropping system N rate changes due to soil health practices (tillage or cover cropping), 2) N rate changes due to N optimization methods (for example, precision agriculture or model N optimization recommendations), 3) GHG emissions from fertilizer production, 4) change in direct N_2O emissions resulting from change in N rate, and 5) change in indirect N_2O emission due to a change in N rate.

Reducing excess reactive nitrogen is the key management pathway for reducing N loss from agricultural systems. Optimal N application rates should provide N to maintain crop yield as well as N to maintain SOM stocks. To achieve optimal N rates, a farmer manages system N balance, the difference between system N inputs and N harvested in crop biomass. While N rate recommendations from N-optimization methods generally reduce N balance, the use of these methods does not guarantee that a farmer has implemented the specific N rate recommendation nor does it give a precise value for the magnitude of the N rate reduction. To ensure that a reduction in N rate has occurred, the most accurate estimate of N_2O emission resulting from agricultural management requires N application rate information. We recommend N rate information as a minimum requirement for estimating agricultural management impact on N_2O emissions.

However, information on N rate may be difficult to obtain for voluntary supply chain GHG mitigation efforts. Therefore, in this appendix, we outline default values that could be applied in the absence of user-provided N management data.

2 Nitrogen management methods

2. 1 Cover crop rotations and N fertilizer management

We searched the Extension and peer-reviewed literature using search terms 'cover crop' and 'nitrogen management'. We used Google Scholar and https://impact.extension.org/ to search the Extension literature; we used Web of Science to search the academic literature. We reviewed relevant articles from literature searches, however current results are not an exhaustive review of all relevant sources.

2. 2 Tillage and N fertilizer management

Similar to cover-crop analysis, we conducted a review of the Extension and peer-reviewed literature to assess how use of no-till or reduced-till alters farmer N management decisions. For tillage, we used search terms including: 'tillage impact on N fertilizer', or 'tillage and nitrogen management', as well as 'corn' and 'wheat' to limit the search to relevant references. We reviewed relevant articles from literature searches, however current results are not an exhaustive review of all relevant sources.

2. 3 N fertilizer optimization

N accounting and default N rates

For all management practices (cover crop, reduced- or no-till, or N optimization), the reduction in N_2O attributed to a practice is calculated as a function of N rate. As with other recommendations in this methodology, the most accurate GHG accounting will result if real data (either farm-scale or aggregated) are available, in particular N rate, crop yield, information about soil health techniques (cover crops or tillage), and information about N optimization practices (such as side-dressing, precision agriculture, or professional consultation to improve nitrogen use efficiency (NUE)).

Baseline N fertilization rates representing conventional management practices can be estimated from state-scale average fertilizer application data. We recommend USDA ERS fertilizer rate data as the most reliable source of average N fertilizer application rate (https://www.ers.usda.gov/data-products/fertilizer-use-and-price/). These N fertilizer data do not include estimates of N from manure sources, which are a substantial proportion of N applied in regions with livestock. However, using ERS data does indicate the change in inorganic N fertilizer rate. Additionally, in regions with high livestock production we expect higher rates of silage maize and hay production, both of which are currently excluded from this Phase 1 Soil Health Gigaton (SHG) method.

Estimating N rate change

We estimate the average observed N rate reduction that resulted from the implementation of a few well studied N optimization techniques. These default N rate reduction values will be available for a SHG method user to select. For users who provide specific information about N rate a more detailed accounting is available. In either case, the change in N rate will be used to estimate potential N_2O losses for a given practice.

We reviewed the literature to quantify the impact of N best management practices (BMPs) on reducing N rate. Estimates of N rate reduction due to N management methods was summarized from experiments documented in the peer-reviewed literature. We searched 'Web of Science' using terms 'precision agriculture or nitrogen optimization' and 'corn' or 'wheat'. We extracted key synthesis literature and traced articles that cited these manuscripts.

2. 4 Energy from N fertilizer production

Net GHG emissions from N fertilizer production vary widely across N type. In the SHG method, we applied the average GHG emission associated with N fertilizer production of 4.41 kg CO_2 kg N^{-1}, from the recent US national Natural Climate Solutions analysis of emissions reduction potential from agriculture, forests, and wetlands (Fargione et al. 2018).

2. 5 Estimating N_2O emissions from agricultural management

We estimate both direct and indirect N_2O emissions associated with agricultural N management. In Phase 1 applications of the Soil Health Gigaton method, we expect users will infrequently provide field-scale estimates of N rate and N harvested in grain. Because we anticipate users will frequently rely on default values, we apply N-rate based approaches to quantifying N_2O emission rather than N balance approaches.

For direct N_2O emissions in wheat and dryland maize cropping systems we apply the Intergovernmental Panel on Climate Change (IPCC) methodology (IPCC 2019). For direct N_2O emissions in moist maize cropping systems we apply a statistical, linear mixed-effects (LME) model derived for U.S. maize systems (Tonitto et al. 2020). This LME statistical modeling approach for estimating N_2O emission was developed using both N-rate and N-balance, with the N-balance approach giving slightly more precise predictions.

For the soybean production years of a rotation, we do not calculate a change in N_2O emission resulting from N management changes under soil health practices or N optimization. Soybean is typically grown without N fertilizer additions. Current literature review (see cover crop appendix) indicates that N rate, rather than N source, is the largest driver of a change in N_2O emission for all management scenarios, including systems applying soil health management practices. If management does not change N rate, there is no basis in our method for calculating N_2O emission change in soybean years of a rotation.

For indirect N_2O emission estimates, we apply the IPCC methodology (IPCC 2019).

3 Accounting for N management

3.1 N fertilizer and cover crop management

3.1.1 Sources of cover crop management information:

University Extension and outreach publications provide limited information for managing N with cover crops. All major agricultural states provide cover crop publications, outreach, and links to resources. However, cover crop publications and resources often focus on selecting cover crop species, planting techniques, and cover crop termination, rather than nutrient management.

In addition to individual state Extension outreach, cover crop management recommendations are provided through regional organizations such as the Midwest Cover Crops Council (MCCC, http://mccc.msu.edu/), Northeast Cover Crops Council (NECCC, http://northeastcovercrops.com/), Southern Cover Crops Council (SCCC, https://southerncovercrops.org/), or at the national level through USDA Sustainable Agriculture Research & Education (SARE, https://www.sare.org/). Regional organic farming resources, such as the Northeast Organic Farming Association (NOFA, https://nofa.org/) are additional resources regarding nutrient accessibility from cover crops, but organic systems have different N dynamics as they do not receive inorganic fertilizer.

Regional cover crop association resources have the highest quantity of user-friendly information regarding: choosing cover crop varieties based on management goals, planting techniques, termination techniques, and cash crop planting following cover crop management. There is less information provided on nutrient management of the cash crop following cover crop management.

Penn State University provides various tools to support cover crop management. Cover crop management is extensively discussed in The Agronomy Guide (https://extension.psu.edu/the-penn-state-agronomy-guide) developed at PSU. In addition, the PSU website includes cover crop management in their on-line N management tool (though documentation of the data behind this model is not transparent).

Maryland has extensive support for cover crop adoption to reduce nutrient losses to the Chesapeake Bay (MDA, https://mda.maryland.gov/resource_conservation/pages/cover_crop.aspx). The MDA cover crop program is widely accessed by farmers throughout the state.

3.1.2 Cover crop management: Fertilizer amendment at planting and management timing

Cover crop management is often promoted as a way to reduce post-harvest N losses from annual cropping systems. Therefore, general recommendations are no N fertilizer amendment at fall planting. For compliance with cover crop initiatives to reduce nitrate leaching, no fall fertilizer N amendment is a requirement in fertilizer-based row cropping systems (https://mda.maryland.gov/resource_conservation/pages/cover_crop.aspx). However, following survey information indicating interest in cover crops in systems that include animals, MD has changed cover crop guidelines to include cover cropping systems that receive fall manure and to allow for spring harvest of the cover crop as forage.

In continuous maize, maize-soybean, or maize-bean cropping systems, cover-crop management in cool, moist regions is recommended without fall N-fertilization (Iowa state Extension, MCCC, MD cover crop protocol). In southern warm, moist regions these maize or maize-bean systems are also managed without fall N fertilization to the cover crop. For other cropping systems, the SCCC includes fall N fertilizer recommendations to optimize cover crop growth; the SCCC recommendation is 25-50 lb N ac^{-1} (28 – 56 kg N ha^{-1}) to the fall cover crop in rotations that do not include maize. Optimizing cover crop NPP is logical if the cover crop is harvested or being used as forage, as this rotation would be akin to double cropping.

We use the MD cover crop program as an example, because it is the cover crop program with the broadest participation (https://mda.maryland.gov/resource_conservation/counties/2019CCBrochure_F.pdf). In order to maximize cover crop N uptake, management timing is a key compliance point in the MD cover crop program. Different monetary compensation rates are listed for planting early. Planting deadlines differ by cover crop type and method. Cover crop termination is allowed between March 1 to June 1 (which allows flexibility to optimize cover crop biomass mineralization or weed issues), but higher payments are offered if termination occurs after May 1.

Extension recommendations indicate that cover crops are easily managed as part of a no-till or strip-till practice (Kaspar and Licht 2020). Planting cover crop recommendations include aerial seeding before cash crop harvest or drilling into residue. Purdue Extension (and others) also recommend no-till drill or broadcast of rye seed.

3.1.3 Fertilizer amendment rate changes for cash crop growth

To avoid nutrient insufficiency during early cash crop growth due to N immobilization during cover crop OM decomposition, farmers may alter the timing of cover crop termination or increase the total rate of N fertilizer addition following cover crop use. For example, additional N fertilizer amendment for successful cash crop growth is allowed for compliance with nutrient reduction efforts in MD.

Cover crop termination timing is critical for successful cover crop management. Cover crop management guidelines emphasize terminating the cover crop during the vegetative growth phase when cover crop residue is more readily decomposed. Guidelines also emphasize termination of cereal cover crops at least two weeks prior to planting maize or soybean (Basche et al. 2016). For example, specific recommendations for Iowa are to terminate when the rye crop is 6-12 inches (15-30 cm) tall, actively growing, and at least 10 days before planting soybean, whichever comes first (Kaspar and Licht 2020).

N fertilizer timing is also important for successful cover crop management. Iowa State Extension does not recommend increasing total N applied if the N rate applied to maize is at least 150 lb N ac^{-1} (168 kg N ha^{-1}); for an N rate <150 lb N ac^{-1} (<168 kg N ha^{-1}) starter fertilizer is recommended and a 10 % increase in N fertilizer rate is recommended to prevent corn N deficit (Basche 2016).

Observations of optimal N rate across Corn Belt experiments have been variable. Observations of optimal N rate across four sites over three years in Iowa indicated that systems managed with a rye cover crop should apply 3.5 lb N ac^{-1} (3.9 kg N ha^{-1}) more than bare fallow systems (Basche et al. 2016). On the other hand, N rate trials in Wisconsin testing winter rye, triticale, and oat cover crops prior to sweet corn indicated that systems using cover crops required 29 lb N ac^{-1} (32.5 kg N ha^{-1}) less than bare fallow systems and that yields were 22 bu ac^{-1} (1.4 Mg ha^{-1}) higher under cover crops relative to bare fallow (Basche et al. 2016). Research from IL indicated that radish cover crops returned 91% of fall applied N as inorganic N compared to 66% for the control treatment and 57% for the winter rye treatment (Basche et al. 2016).

The PSU maize N fertilizer recommendation calculator assesses N rate changes due to cover cropping (https://extension.psu.edu/nitrogen-recommendations-for-corn). The model is sensitive to soil clay content. For intermediate to high clay soils, the model recommends additional N relative to rates under bare fallow. For sandier soils, cover crops (including non-legume cover crops) provide an N credit.

3.1.4 Cover crop management combined with no-till

Observations of no-till combined with cover crop management suggest this is a viable option in moist, cold regions. However, in many studies the data suggest that no-till management leads to a small yield decline, the combination of no-till and cover cropping does not increase this yield decline.

- In a long-term study in Indiana (Purdue University Agronomy Center for Research and Education, ACRE) from 2003-2011, Anderson et al. (2020) reported no difference in average yield for maize or soybean following the same N amendment rate (though N rate was not reported) across a comparison of conventional tillage (fall chisel plow and spring disk) to no-till or no-till and rye cover.

- Otte et al. (2019) compared no-till maize with and without a rye cover at the USDA Beltsville Agricultural Research Center in Maryland. N was applied at a rate of 56 kg N-UAN ha^{-1} at planting and side-dress of 112 kg N- UAN ha^{-1} in June. Their goal was to compare timing of rye termination. Early termination led to statistically similar yield to no-till without cover crop treatment in both experimental years; late termination resulted in a small maize grain yield decline in the first experimental year.

- Waring et al. (2020) compared cover crop and no-tillage management in Iowa maize-soybean rotations. Winter cereal rye was drill seeded into both no-till and chisel till plots in mid-October. Nitrogen side-dress was applied to maize in mid-June at a rate of 168 kg N ha^{-1} to all plots. Both no-till and cover crop (and combined no-till and cover crop) reduced nitrate leachate concentration a similar magnitude (25-35 % reduction). Soybean yield was similar across conventional-till, no-till, and cover cropped systems; maize yield was highest in the conventional-till, and statistically equivalent in no-till, conventional-till with cover crop, or no-till with cover crop systems.

- Another Indiana study at ACRE (Nevins et al. 2020) concluded that microbial enzyme activity during maize emergence through tassling indicated the possibility that N immobilization under cover cropping could reduce plant available N. This study demonstrated no yield impact on soybean yield for no-till compared to chisel plow, with or without rye cover. However, relative to the chisel plow and fallow system, no-till maize had lower yields as did cover crop on chisel plow; relative to chisel plow and fallow, no-till and no-till with cover crop had equivalent yield decline.

- Patel et al. (2019) tested tillage, cover crop, and starter N fertilizer effect on maize yield in Iowa. They concluded that maize-soybean rotations managed with cover crops had improved yield under tillage, but did not benefit from additional starter fertilizer. In this work management of a rye cover crop and tillage resulted in <1.5% yield decline in maize relative to tillage management without cover crop. The no-till system averaged a 3.1% yield decline with or without rye cover crop, this decline in yield was not improved by additional starter fertilizer.

3.1.5 Soil Health Gigaton cover crop N amendment accounting

The SHG methods require **N rate** to calculate changes in N_2O emission and change in net GHG emission due to fertilizer production. Because we expect that the typical Soil Health Gigaton method user may have information on the use of cover crops, but not the details of cover crop species and management, the SHG methods use default values for cover crop species. For continuous maize or maize-bean rotations, we assume non-legume cover crops to be cereal rye (or other similar winter-hardy cereal) and legume cover crops to be clover (using red clover as an example). Cover crops are not credited in wheat systems.

We cannot derive a standard N addition practice following cover cropping based on the reviewed literature. One could assume no additional N is added based on Extension recommendations (Basche 2016) and experimental results (Anderson et al. 2020; Otte et al. 2019; Patel et al. 2019). However, other N rate tools recommend additional N under certain circumstances, for example the PSU N rate calculator recommends applying additional N to maize following winter cover crop depending on soil texture. We based N addition for cash crop management (over that applied to the bare fallow system) on achieving the SON required to accumulate the SOC credited under cover crops as indicated below.

The default SOC accumulation rate under cover crop management is the average observed SOC accumulation from many experimental studies across disparate soil textures and climates. We assume this increase in SOC is associated with SOM of an average C:N ratio of 13.8 (from Table 1 in Cleveland and Liptzin 2007). To conserve N mass balance, we assume the N required to build this average annual SOM (ΔSON = 0.07 x ΔSOC) will be acquired either due to sufficient N surplus from the cash crop system, or by assuming additional inorganic N was added to the cropping system.

For legume systems we assume the SON necessary to achieve observed average SOC accumulation results from N-fixation. Because clover species are the most common legume cover crop, we derive default values assuming red clover is the species grown. We assume an average clover biomass of 1.87 Mg yr^{-1} (Poeplea and Don 2015) and 2.8% N (Phyllis2 database). We assume a farmer would reduce inorganic N fertilizer rate by (0.052 Mg N – ΔSON) in response to this legume N credit. We assume that in attaining this average biomass and %N, the legume adjusts its N-fixation rate depending on how much residual N is available during the cover crop growing season.

For non-legume cover crops, we apply the IPCC indirect N_2O equations (IPCC 2019, see section 3.5.2) to estimate N uptake due to cover crops. The N to support ΔSON accumulation under cover crop management is derived from residual N uptake by cover crops. For cover crops following a cash crop that receives inorganic N fertilizer (such as maize cash crop) we apply IPCC (2019) indirect equations as follows: in humid systems nitrate leaching potential is 24% of applied N and we assume cover crops take up 54% of this residual N on average (Woodbury et al. 2018). If N uptake cannot satisfy the N need for ΔSON accumulation, then we assume the farmer ads more inorganic N to accommodate SON accumulation.

For cover crops following an N-fixing cash crop (such as soybean cash crop), we apply IPCC (2019) crop residue equations to estimate potential N lost following soybean harvest and subsequent uptake of N by cover crops (see section 3.5.3 for equations). In humid systems nitrate leaching potential is 24% of crop residue N (IPCC 2019) and we assume cover crops take up 54% of this residual N on average (Woodbury et al. 2018). If N uptake cannot satisfy the N need for ΔSON accumulation, then we assume the farmer ads more inorganic N to accommodate SON accumulation.

3.2 N fertilizer management with no-till and reduced-till

3.2.1 Fertilizer N rate changes to cash crop management

Increased N application may be recommended with no-till management. Reasons for increased N recommendation include: 1) for coarser soils, increased moisture due to no-till may lead to increased crop yield, and 2) increased SOC due to no-till results in more SON stored in the soil. Long-term studies of dryland wheat systems suggest increased N rate for 15 years may be needed to off-set crop yield decline (McConkey et al. 2002) due to N needed for SOM accumulation.

Reducing tillage can reduce the mixing of plant available nutrients throughout the root zone, leading to nutrient stratification and different plant rooting patterns (Beegle 1996; Dinkins et al. 2014). Furthermore, surface application of urea in no-till systems is inefficient as it can lead to high N loss through volatilization (Beegle 1996; Dinkins et al. 2014). Subsurface fertilizer injection can both reduce N losses to volatilization as well as potential N immobilization by decomposing residue (Beegle 1996; Dinkins et al. 2014).

A review of N dynamics under no-till management using ^{15}N tracer studies concluded that no-till had little impact on ^{15}N fertilizer recovery or the mineralization of 'native' soil organic matter (Smith and Chalk 2019). There was no consistent pattern of tillage effect on gross or net N mineralization and immobilization (Smith and Chalk 2019). These tracer studies were predominantly conducted on wheat and maize cropping systems, but also included barley, sorghum, and cotton systems.

Application of an N-optimization modeling tool (Adapt-N) recommended an increased N rate of 10 kg N ha^{-1} for no-till vs plow-till (181 vs 171 kg N ha^{-1}, respectively) in moist maize systems in NY (van Es et al. 2020).

Long-term studies of tillage demonstrate that optimal N rate (and the yield-benefit of no-till) shows large variation depending on weather. A long-term (30-year) study of maize tillage management in Nebraska demonstrated that in dry and normal years, no-till fields had higher yields than disked or plowed fields, and no-till had an optimum N rate of 120 kg N ha^{-1} (no benefit was observed for the highest 160 kg N ha^{-1} rate tested (Shekhar and Shapiro 2019). In wet years, the plowed or disked fields had highest yield, and optimum N rate was calculated as 150 kg N ha^{-1} for maize-soybean and 220 kg N ha^{-1} for continuous maize systems (Shekhar and Shapiro 2019).

Montana Extension provides an N rate calculator for adjusting N rate based on stubble calculations. Prior season grain is used to estimate crop biomass, and therefore stubble remaining, with 10 lb N/1000 lb stubble (4.5 kg N / 454 kg stubble) recommended, up to 40 lb N ac^{-1} (45 kg N ha^{-1}) (Dinkins et al. 2014).

3.2.2 Soil Health Gigaton no-till and reduced-till fertilizer N accounting

No-till has been broadly adopted in dryland systems. University of Missouri Extension promotes no-till for increased yields due to reduce soil erosion, decreased water runoff, reduced fuel costs, and reduce management time. Montana is predominantly under no-till management (64 %), with remaining croplands split between minimum till (16 %) and conventional tillage (18 %) (Dinkins et al. 2014). We expect no-till or reduced till management to be more common in dryland wheat systems due to the need to prevent soil erosion. In humid maize systems, the combined practice of no-till and cover cropping is promoted, but these soil health practices have limited adoption.

As in cover crop systems, we cannot define a standard change in cash crop N management practice due to no-till or reduce tillage. Similar to cover crop systems, the anticipated SOM increase due to no-till or reduced till management results in more N remaining in the soil. Recent studies in humid, tile-drained Corn Belt regions indicate that no-till has similar capacity to cover crops for reducing nitrate leaching following harvest (Waring et al. 2020). The ability of no-till systems to reduce nitrate leaching suggests that in rainfed systems N accumulation in SOM can be attained from avoided nitrate leaching of excess N following crop harvest. This is also supported by studies that found conventional till and no-till maize had comparable yields (Anderson et al. 2020; Otte et al. 2019). Though reviews of crop yield found that both short-term (Tolliver et al. 2012) and long-term (Daigh et al. 2018) no-till management in maize systems resulted in reduced yields, N rate experiments indicated that when yield decline is present in no-till humid maize systems, additional N fertilizer does not reliably eliminate the yield reduction (Patel et al. 2019).

In dryland agriculture observations suggest that additional N application is beneficial to offset yield decline during the initial high rate of SOM accumulation (McConkey et al. 2002). In dryland agricultural states with widespread no-till adoption, N rate calculators are promoted to calculate N required to offset immobilization in no-till stubble (Dinkins et al. 2014).

We define default farmer practice as no additional N applied in no-till or reduce-till systems if the system N balance can meet the N required to support annual SOM accumulation. As for cover crop systems, we assume the observed average increase in SOC due to tillage management is associated with SOM of an average C:N ratio of 13.8 (from Table 1 in Cleveland and Liptzin 2007). To conserve N mass balance, we assume the N required to build this average annual SOM will be acquired either due to sufficient N surplus from the cash crop system, or by assuming additional N was added to the cropping system. As in cover crop systems, following a cash crop that received N fertilizer we apply the IPCC indirect N_2O equations (IPCC 2019, see section 3.5.2) to estimate nitrate leaching as 24% of N applied in humid systems. Following an N-fixing cash crop we apply the IPCC 2019 crop residue equations and indirect leaching equations (see section 3.5.3), with leaching estimated as 24% of crop residue N. Based on Waring et al (2020) we assume that no-till can reduce nitrate leaching by 25% and reduced-till by 12.5%. If residual N uptake is insufficient to account for the SOM increase assumed under no-till, then we assume the N difference is added during cash crop management.

3.3 N fertilizer optimization

3.3.1 Observed benefits of N fertilizer optimization techniques

Variable rate N application: Precision agriculture, sensor technologies, and N reference plots

A variety of low-tech and technology-based methods exist to tailor N rate recommendations during the crop growing season to optimize NUE and reduce excess N application. One low-tech method requires a farmer to manage small reference plots or strips with varying rates of N, with these reference areas being used to compare the sufficiency of a given N rate for crop need. In the simplest case, a farmer looks at crop greenness (or biomass) and chooses the lowest N application rate at which no visual difference is noticed between the rate and the higher N rates. A more complex approach uses the same N reference areas, but includes the use of hand-held sensors to distinguish crop greenness. More complex variable rate N methods use equipment-mounted sensors to spatially vary N rate combined with side-dress N application based on crop growth to temporally vary N rate. Corti et al. (2018) reviewed the use of sensors in crop management and concluded that passive sensors averaged $R^2 = 0.49$, active sensors averaged $R^2 = 0.63$, overall sensors averaged $R^2 = 0.56$ in comparison of crop spectral properties to optimum N rate. This result indicates current sensor technologies have moderate ability to accurately predict crop N needs.

Thirty-year N rate trials in Oklahoma demonstrated high variation in optimal N rate, ranging from 0 to >140 kg N ha^{-1}, with an average deviation between average and annual optimal N rate of 44 kg N ha^{-1} (Girma et al. 2007). Given the large annual change in wheat growth potential, there is large potential to improve fertilizer N rate beyond the common practice of field-averaged N rate recommendations. Trials using reference N rate methods demonstrated that visual assessment reduced N rate by at least 40 kg N ha^{-1} and sensor-based assessment reduce N rate by at least 60 kg N ha^{-1}, relative to farmer practice and maintained yields (Girma et al. 2007). These trials indicate that significant reduction in N rate is accessible to all scales of farming.

Similarly, in on-farm N rate trials for winter wheat in Oklahoma, Butchee et al. (2011) found sensor-based N rate management reduced N application by 20.2 lbs N ac^{-1} (or -34.6 %, 22.6 kg N ha^{-1}) on average.

Scharf et al. (2011) found sensor-based N rates led to average reductions of 16 kg N ha^{-1} (or 8.2 %) for on-farm maize trials on 55 sites in Missouri from 2004-2008. They indicated that sensor-based N management was most effective if fields received limited (<75 kg N ha^{-1}) of N amendment prior to planting. Fields that met this condition had an average of 24 kg N ha^{-1} reduction in total N rate. In periods when N rate was reduced, yield was not affected. In the relatively moist year (2008) the sensor-based management recommended additional N for many sites, but this was justified as additional N resulted in an average of 526 kg ha^{-1} increase in yields.

Using outcomes summarized in a review of sensor-based N rate trials (Colaço and Bramley 2018), we estimate mean reduction in N rate of 13% for maize and 26% for wheat for in-season sensor-based N rate application, relative to farmer practice. Values are derived by weighting the average value reported for each study by the number of trials in a study. The total number of trial sites was 91 (maize) and 129 (wheat)] This decrease in N rate has resulted in a weighted average increase in yield of 1.1% for maize and 1.8% for wheat, as well as a weighted increase in Partial Factor Productivity (PFP = kg yield per kg N applied) of 22% for maize and 40% for wheat.

Interactions between N rate and timing

In Ottawa maize field trials Ma et al. (2014) observed NUE response to canopy-reflectance-based N rate and N timing; they concluded that increased NUE resulted from applying N as side-dressing. In these trials, reduced N fertilization as 1) side-dress management (80kg N ha^{-1}) and 2) pre-plant (30 kgN ha^{-1}) plus side-dress (80 kgN ha^{-1}) had the same yields as fields managed as pre-plant fertilized system (at 180 kg N ha^{-1}), indicating side-dress management can reduce N rate by 70 kg N $ha.^{-1}$

Model-based N optimization using real time data

Adapt-N is one example of field-calibrated modeling tools that use management information and real-time weather data to predict N crop needs. Adapt-N has been broadly tested for application in U.S. maize systems. These field trials can be used to quantify average N rate benefits of model-based N optimization.

Specific results from Adapt-N field trials include:

1) Adapt-N field evaluation in NY and Iowa from 2011-2014 recommended on average 45 kg N ha^{-1} lower application compared to conventional grower practice (Sela et al. 2016).

2) Adapt-N trials in grain maize and silage maize across IA, IN, WI, OH, NY, ME, and NC demonstrated an average of 32% reduction in N rate recommended by Adapt-N relative to farmer practice with no impact on yield (Sela et al. 2018b).

3) Adapt-N nitrogen rate trials in IN (12 trials), OH (1 trial), and WI (3 trials) during 2013-14 growing seasons resulted in an average 13% reduction in N rate relative to MRTN N rate calculations while maintaining maize yield (Sela et al. 2018a).

4) Adapt-N trials in NY comparing no-till and plow-till on clay loam and loamy sand showed average N rate reduction of 66 kg N ha^{-1} (-46%) for Adapt-N relative to NY CNC tool (van Es et al. 2020).

Adapt-N trials have repeatedly demonstrated the ability to optimize N rate relative to baseline grower practice. Based on Adapt-N field trials, a low-end average estimate of 13% reduction in N rate (or a high-end estimate of 32% N rate reduction) could be applied as an N optimization credit for use of model-based N optimization tools. Because Adapt-N is a tool for optimizing side-dress N rates, it may represent a combination of improved timing and reduced rate compared to conventional practice.

3.3.2 Default N rate reduction for N optimization in the SHG method

Based on peer-reviewed N optimization observations, we recommend crediting a default N rate reduction for a few well-studied techniques as follows:

- N optimization using variable rate technology (VRT) methods results in an average N rate reduction of:
    - 13% in maize systems (Colaço and Bramley 2018)
    - 26% in wheat systems (Colaço and Bramley 2018)
- N optimization using models coupled to real-time data (such as Adapt-N) results in an average N rate reduction of 13% (Sela et al. 2018a).
- Improved N fertilizer timing reduces N rate by 9% (Eagle et al. 2012).

3.3.3 Additional N optimization practices

To receive further N optimization reduction credits a user must provide N rate and yield information when applying the Soil Health Gigaton method.

3.4 Emissions from fertilizer production

Reduction or increase of N fertilizer rate is converted to CO_{2e} for net GHG accounting as described above in Section 2.4.

3.5 N_2O from fertilizer application

3.5.1 Direct N_2O emissions

Nitrous oxide emissions are estimated based on the rate of N applied to maize and wheat systems. In rainfed maize systems we calculate N_2O emission using the N-rate equation described in Tonitto et al. (2020, supplement). This model was developed using rainfed maize data from the U.S. and Canada, including N rate and soil texture as fixed effects. This model analysis demonstrated that clay explained a large amount of observed variation in N_2O emission. Equation 1 and Figure 1 demonstrate the relationship between N rate, soil texture, and predicted N_2O emission.

Equation 1:

N_2O flux (kg N/ha) = 1.1280 - 0.00000007602 × N rate (kg N/ha) + 0.6678 × clay proportion + 0.05368 × N rate × clay proportion

To calculate the change in N_2O flux resulting from a change in N fertilizer rate, we assume the N-rate coefficient is negligible and derive the change in N_2O flux from the interaction term as follows (Equation 2).

Equation 2:

Δ N_2O flux (kg N / ha) = 0.054 x ΔN rate (kg N / ha) x clay proportion

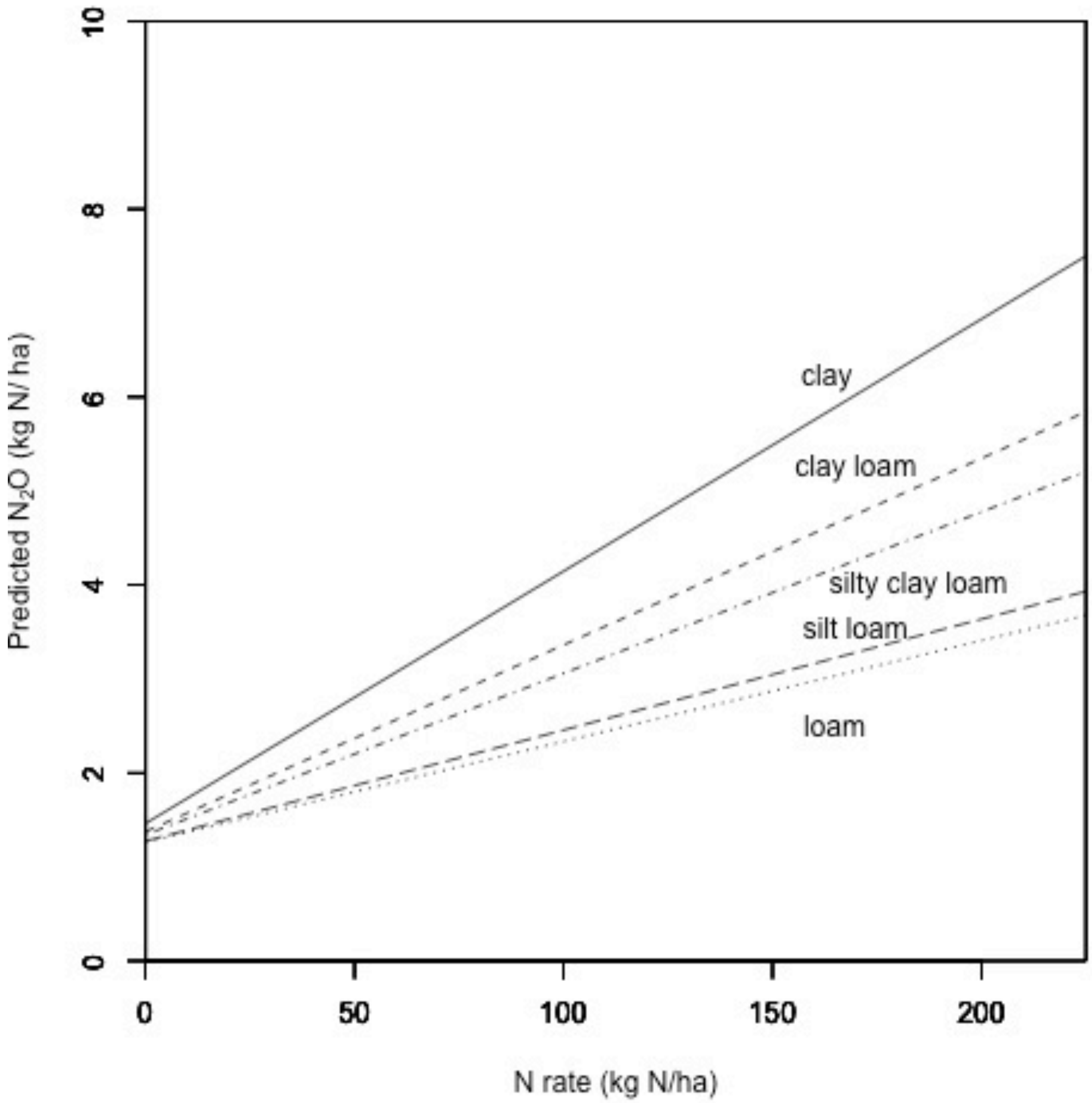

Figure 1. Modeled area-scaled N_2O emission (kg N-N_2O / ha) across gradients of N rate (kg N / ha), presented for soil textural classes observed in the data set. The maize N_2O emission equation is applied using the mean clay proportion in the U.S. Corn Belt for each soil textural class (0.20, 0.22, 0.32, 0.37, and 0.50 for loam, silt loam, silty clay loam, clay loam, and clay soils, respectively).

For wheat systems and dryland maize we use IPCC N_2O accounting methods (IPCC 2019; Hergoualc'h et al. 2019). The 2019 IPCC revision applies direct N_2O EF values: 1) EF_{dry} = 0.005 for all N input in dry climates, 2) EF_{wet} = 0.016 for synthetic fertilizer in wet systems, and 3) EF_{wet_other} = 0.006 for other N inputs in wet climates. In the SHG method we assess N_2O emissions resulting from a change in fertilizer N inputs or organic N inputs due to soil heath management practices.

Equation 3. Application of IPCC direct N_2O emission equations (Eq. 11.1 and 11.2 in Hergoualc'h et al. 2019)

$N_2O\text{-}N_{direct}$ (kg N_2O-N yr^{-1}) = [$N_{fertilizer} + N_{organic} + N_{crop\ residue} + N_{SOM}$] x EF_1

For:

$N_2O\text{-}N_{direct}$ (kg N_2O-N yr^{-1}) = annual direct N_2O-N produced from agricultural soils.

$N_{fertilizer}$ (kg N yr^{-1}) = annual synthetic fertilizer N application

$N_{organic}$ (kg N yr^{-1}) = organic N additions including animal manure, compost, sewer sludge

$N_{crop\ residue}$ (kg N yr^{-1}) = annual return of N in crop residues (above- and below-ground)

N_{SOM} (kg N yr^{-1}) = annual N mineralized from loss of SOC due to land use change or management

EF_1 (kg N_2O-N / kg N inputs) = emission factor for N_2O emissions from N inputs

$N_2O_{direct} = N_2O\text{-}N_{direct}$ x 44/28

Table 1. IPCC direct N_2O EF values (see Table 11.1 in Hergoualc'h et al. 2019)

Parameter	Disaggregated	value
EF1	default	0.01
	wet climate, synthetic N	0.016
	wet climate, other N	0.006
	dry climate, all N	0.005

3.5.2 Indirect N_2O emissions

Indirect N_2O emissions in maize and wheat cropping systems are estimated using IPCC methods (2019; Hergoualc'h et al. 2019).

We calculate indirect emissions resulting from inorganic N fertilization and changes in organic N additions resulting from soil health practices. Indirect N_2O includes emissions resulting from N volatilization (IPCC 2019; Hergoualc'h et al. 2019, Equation 11.9, 11.11) and N loss as nitrate leaching and runoff (IPCC 2019; Hergoualc'h et al. 2019, Equation 11.10).

The 2019 IPCC revision applies indirect N_2O EF values: 1) EF_{dry} = 0.005 for volatilized synthetic N fertilizer in dry climates, 2) EF_{wet} = 0.014 for volatilized synthetic N fertilizer in wet climates, and 3) $EF_{leachate}$ = 0.011 for nitrate leachate. Rate of volatilization for synthetic gas is defined as: 1) $Frac_{GASF}$ = 0.11 for any unknown N fertilizer type, 2) $Frac_{GASF}$ = 0.15 for urea, 3) $Frac_{GASF}$ = 0.08 for ammonium-based fertilizer, 4) $Frac_{GASF}$ = 0.01 for nitrate-based fertilizer, and $Frac_{GASF}$ = 0.05 for ammonium-nitrate based fertilizer. Based on the distribution of N fertilizer type used in Fargione et al. (2018, Table 2) we apply a weighted average $Frac_{GASF}$ = 0.11. Rate of leaching is assumed to be zero in dry climates, $Frac_{LEACH}$ = 0.24 in wet systems (IPCC 2019). Substantial evidence demonstrates that cover crops reduce nitrate leaching (e.g. Tonitto et al. 2006; Waring et al. 2020; Woodbury et al. 2018), we reduce $Frac_{LEACH}$ by 54% in in cover cropping systems based on a review of observed reductions under cereal rye in U.S. cropping systems (Woodbury et al. 2018). Based on recent evidence that no-till reduced nitrate leaching in tile-drained maize systems (Waring et al. 2020), we reduce $Frac_{LEACH}$ by 25% in no-till systems and 12.5% in reduced-till systems.

Table 2. Distribution of N fertilizer type used in U.S. cropping systems (developed for Fargione et al. 2018).

Type	Current N fertilizer use
Anhydrous ammonia	31.03%
Aqueous ammonia	0.28%
Ammonium nitrate	2.76%
Urea	27.06%
Urea-ammonium nitrate	30.75%
Ammonium sulfate	2.83%
Other	5.29%

Equation 4. Indirect N_2O resulting from volatilization, applying IPCC volatilization Eq 11.9 (Hergoualc'h et al. 2019)

$N_2O\text{-}N_{volatilization}$ (kg N_2O-N yr^{-1})= $[N_{fertilizer} \times Frac_{GASF} + N_{organic} \times Frac_{GASM}] \times EF_4$

For:

$N_2O\text{-}N_{volatilization}$ (kg N_2O-N yr^{-1}) = annual N_2O-N produced from atmospheric deposition of N volatilized from agricultural soils.

$N_{fertilizer}$ (kg N yr^{-1}) = annual synthetic fertilizer N application

$N_{organic}$ (kg N yr^{-1}) = organic N additions including animal manure, compost, sewer sludge

$Frac_{GASF}$ = fraction of synthetic fertilizer N that volatilizes to NH_3 and NO_x (kg N volatilized / kg N addition)

$Frac_{GASM}$ = fraction of organic N that volatilizes to NH_3 and NO_x (kg N volatilized / kg N addition)

EF_4 (kg N_2O-N / kg NH_3-N + kg NO_x-N volatilized) = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces.

$N_2O_{volatilization} = N_2O\text{-}N_{volatilization} \times 44/28$

Equation 5. Indirect N_2O resulting from leaching, applying IPCC leaching 11.10 (Hergoualc'h et al. 2019)

$N_2O\text{-}N_{leaching} = (N_{fertilizer} + N_{organic} + N_{crop\ residue} + N_{SOM}) \times Frac_{Leach\text{-}H} \times EF_5$

For:

$N_2O\text{-}N_{leaching}$ (kg N_2O-N yr^{-1}) = annual N_2O-N produced from N lost through leaching or runoff from agricultural soils.

$N_{fertilizer}$ (kg N yr^{-1}) = annual synthetic fertilizer N application.

$N_{organic}$ (kg N yr^{-1}) = annual organic N additions including animal manure, compost, sewer sludge.

$N_{crop\ residue}$ (kg N yr^{-1}) = annual return of N in crop residues (above- and below-ground) in regions where leaching or runoff occur.

N_{SOM} (kg N yr^{-1}) = annual N mineralized from loss of SOC due to land use change or management in regions where leaching or runoff occur.

$Frac_{Leach\text{-}H}$ = fraction of N addition or N mineralized that is lost through leaching or runoff in kg N / kg N additions.

EF_5 (kg N2O-N / kg N addition) = emission factor for N_2O emissions from N lost through leaching or runoff.

$N_2O_{leaching} = N_2O\text{-}N_{leaching} \times 44/28$

Table 3. IPCC indirect parameter values (see Table 11.3 in Hergoualc'h et al. 2019)

Parameter	Disaggregated	value
EF4	default	0.01
EF4	wet climate	0.014
EF4	dry climate	0.005
EF5	default	0.011
$Frac_{GASF}$	Default	0.11
	Urea	0.15
	Ammonium-based	0.08
	Nitrate-based	0.01
	Ammonium-nitrate-based	0.05
$Frac_{GASM}$		0.21
$Frac_{Leach\text{-}H}$	wet climate	0.24
	dry climate	0

3.5.3 Calculating N-fixing cash crop residue N

In order to estimate N uptake following N-fixing cash crops (such as soybeans), we apply the IPCC crop residue methods (IPCC 2019) to estimate residue N (Equation 6) and subsequent leaching potential (Table 6). Cover crops are estimated to take up 54% of leachable N (Woodbury et al. 2018), no-till is estimated to take up 25% of leachable N (Waring et al. 2020), and reduced-till is estimated to take up12.5% of leachable N.

As an example, for an average soybean yield of 3220 kg ha^{-1}, the IPCC 2019 crop residue equations estimate 63 kg N ha^{-1} in total residues, resulting in 15 kg N ha^{-1} in potential N leaching. Therefore, in humid systems we estimate and average N uptake of 8.1 kg N per ha for cover crops, 3.8 kg N per ha for no-till, and 1.9 kg N per ha for reduced-till (Table 6).

Equation 6. Crop residue N estimated from applying IPCC 2019 (see Eq 11.6 and 11.7 in Hergoualc'h et al. 2019)

$F_{cr} = AGR \times N_{AG} \times (1 - Frac_{Removed}) + BGR \times N_{BG}$

$AGR = AG_{DM} \times Area$
$BGR = (Crop + AG_{DM}) \times RS \times Area$
$AG_{DM} = Crop \times R_{AG}$
Crop (kg dry matter ha^{-1}) = Yield x DRY

For:

F_{cr} (kg N yr^{-1}) = annual N in crop residue (above and below ground)
AGR (kg dry matter yr^{-1}) = annual total aboveground crop residue
BGR = annual total belowground residue (kg dry matter yr^{-1})

$Frac_{Remove}$ = annual fraction of aboveground residue of crop removed
N_{AG} = N content of aboveground crop residue (kg N kg^{-1} dry matter)
N_{BG} = N content of belowground crop residue (kg N kg^{-1} dry matter)
RS = ratio of belowground root biomass to aboveground shoot biomass for crop (kg dry matter per ha / kg dry matter per ha)

AG_{DM} (kg ha^{-1}) = aboveground residue dry matter
R_{AG} = ratio of aboveground residue dry matter to harvested yield for crop (AG kg dry matter per ha / kg crop dm per ha)

Crop = harvested annual dry matter yield (kg dry matter ha^{-1})
Yield = harvested fresh yield (kg fresh mass ha^{-1})
DRY = dry matter fraction of harvested crop (kg dry matter per kg fresh weight)

Area = harvested area (ha yr^{-1})

Table 4. IPCC crop residue parameters for soybean (see Table 11.1A in Hergoualc'h et al. 2019)

Parameter	Description	Value
N_{AG}	N content above ground (AG) residue	0.008
N_{BG}	N content below ground (BG) residue	0.008
$Frac_{Remove}$	Fraction of AG residue removed	0
R_{AG}	Ratio AG residue dry matter : harvested yield	2.1
RS	Ratio BG biomass : AG biomass	0.19
DRY	Dry mater fraction of harvest product	0.91

Table 5. IPCC crop residue equations applied to soybean

Parameter	Soybean values	Units
Yield	3220	kg fresh/ha
Crop DM	2930	kg dry /ha
AG DM	6153	kg AG /ha
BGR	1726	kg BG / ha
Ncr	63	kg N /ha

Table 6. Potential leaching and N uptake following soybean harvest based on IPCC crop residue estimates

N loss and uptake potential	Rate (kg per ha)
Soybean residue N leaching	15
Cover crop N uptake	8.1
No-till N uptake	3.8
Reduced-till N uptake	1.9

3.5.4 N-fixation observations

N fixation was studied using ^{15}N tracers on deep fertile soil profiles with shallow water tables in Iowa. Córdova et al. (2019) reported:

1) Soybean biological N fixation (BNF) averaged 45% of the total aboveground N accumulation, ranging from 23-65%.
2) Soybean N-fixation can supply up to 3 kg N/ha/day while soil inorganic N supplied up to 4.6 kg N /ha/day in Iowa cropping systems.
3) BNF can be estimated from biomass accumulation. Soil inorganic N or moisture was not as useful for predicting BNF.
4) On average soybean BNF resulted in 0.013 kg N / kg biomass produced.

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