

# Integration of NRCS Soils Databases in Agronomic Modeling



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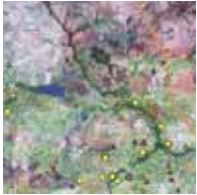
**5/21/09**





# Contents

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**1 The Use of Soils Data in Hydrologic/Agronomic Modeling**

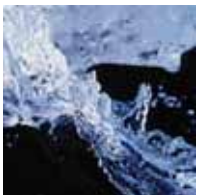


**2 The ALMANAC Crop Growth Model**



**3 The ALMANAC Interface**

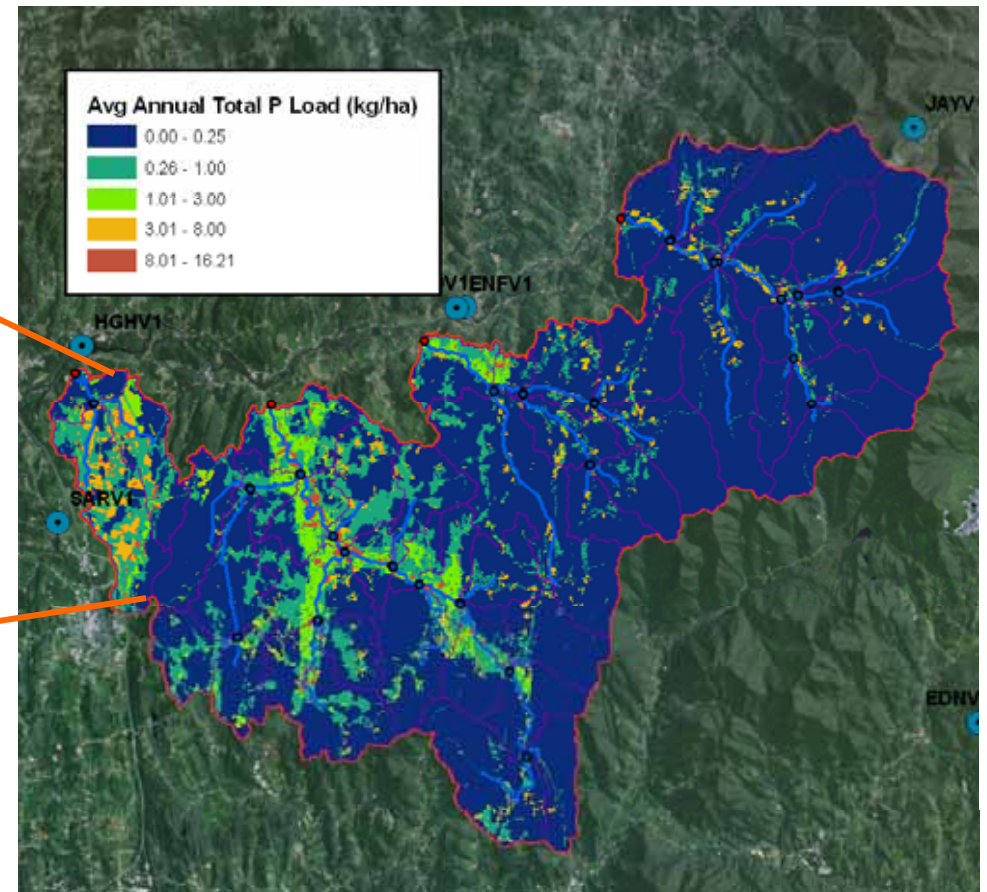
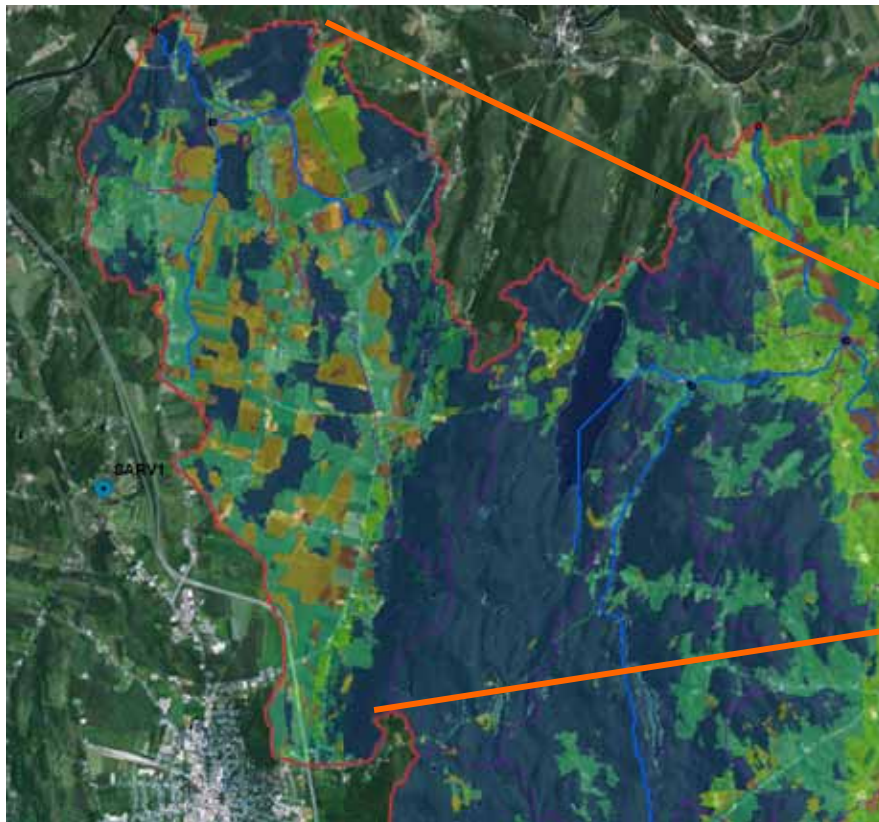
**4 Future Plans and Data Needs**





# Use of Soils Data in Hydrologic & Agronomic Modeling

- Soils are a critical driver in determining the hydrologic/biologic response in hydrologic and agronomic models
- For example, a SWAT model simulation of phosphorus export





# The ALMANAC Model: Background

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- ALMANAC: Agricultural Land Management Alternatives with Numerical Assessment Criteria Model
- Developed by the US Department of Agriculture, Agricultural Research Service in Temple, Texas (approximately 1992)
- Based upon two predecessor models from Temple, Texas:
  - EPIC crop growth model
  - CERES maize and CERES wheat models



# The ALMANAC Model: Overview

- Predicts annual crop yields and biomass
- Simulation of environments with multiple plant species accounts for:
  - Impacts of weed infestation on crop yields
  - Plants compete for light, water, nutrients
  - Complex ecosystems, such as forests
- Model basics
  - Field scale
  - Physically based
  - Daily time step
  - Continuous (1 to many years)





# The ALMANAC Model: Inputs and Outputs

## ■ Model Inputs

- Site topography
- Weather
- Crop/plant species characteristics
- **Soil conditions**
- Land management practices
  - Plant/harvest
  - Irrigation
  - Fertilization
  - Tillage
  - Furrows/dikes

## ■ Model Outputs

- Crop yield
- Plant biomass
- Water yield (runoff)
- Water quality (nutrient transport)
- Soil erosion
- Water balance components (ET, soil moisture, percolation)
- Soil nutrients (N, P balance)



# The ALMANAC Model: Recent Applications

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- Impacts of weed competition on corn yield in Kansas  
(<http://krex.k-state.edu/dspace/bitstream/2097/377/1/DwainRule2007.pdf>)
- Modeling harvested forest vegetation development using a coupled SWAT/ALMANAC model in Canada  
(<http://www.brc.tamus.edu/swat/4thswatconf/docs/session18/PutzSWAT2007Conf.pdf>)
- Natural Resources Defense Council report on the use of biofuels to end dependence on foreign oil  
(<http://www.bio.org/ind/GrowingEnergy.pdf>)



# The ALMANAC Model Interface: Past

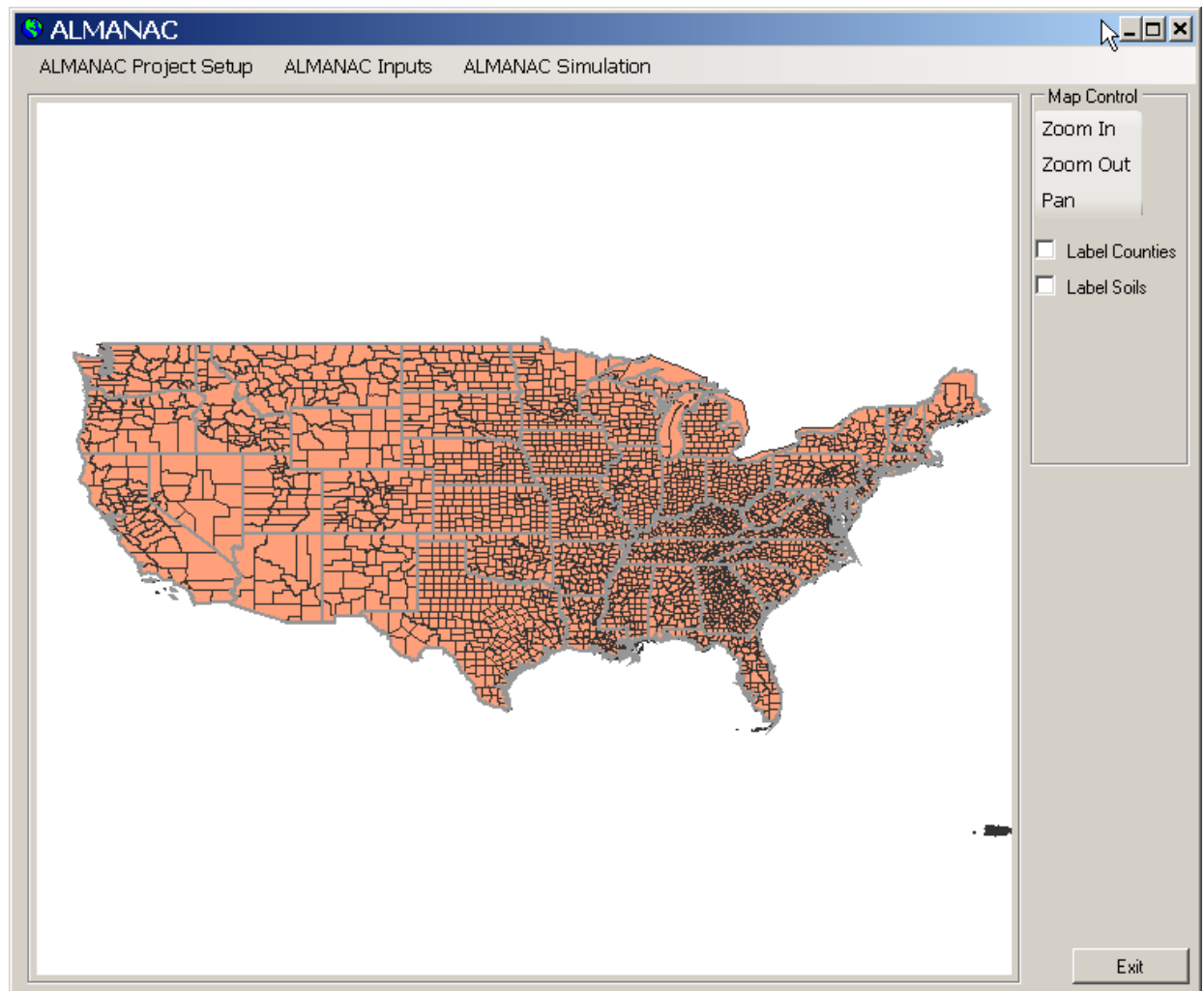
- Until recently, ALMANAC has been run under a DOS-based interface
- The interface accesses the MUUF soils database, which was searchable by soil component name

```
MS-DOS Prompt - UTIL
Auto
CORN 15:07 12:43 6Jan94 8:44 28May 2
TXTEMPLE.DAT
WEA: 72 TX TEMPLE WI: 72 TX TEMPLE SOIL: 353 HOUSTON BLACK D
 2 1 1 1 03 123 0 0 1
 1.00 86.0 .10 .0250 .0500 .0500 1.0 30.67 76.2 .0
 .8 50.0
 50.0 .0001 1.00 0.
 85.10 180.60 8.00 .0 .0
14.15 16.39 20.98 25.62 29.01 33.00 35.49 35.81 32.02 26.92 20.45 16.02
 1.92 3.84 7.82 13.13 17.42 21.19 22.91 22.67 19.66 14.05 7.78 3.53
 7.80 7.10 6.09 4.48 3.52 2.92 2.51 2.76 3.97 4.97 6.19 6.48
 6.03 5.31 5.33 4.61 3.33 2.31 1.39 1.65 3.44 4.63 5.35 5.28
 47.5 69.1 50.8 78.4 109.3 83.3 40.1 54.7 87.0 87.1 66.6 56.7
 10.4 15.2 11.2 13.7 18.3 20.1 14.5 16.5 18.5 21.1 14.5 13.0
 5.31 3.79 2.18 .44 1.36 1.73 1.99 .96 1.76 2.34 1.46 1.84
 .160 .180 .170 .180 .190 .130 .090 .100 .150 .120 .130 .140
 .470 .470 .380 .410 .410 .440 .400 .380 .480 .480 .490 .460
 7.19 7.35 6.67 7.01 7.55 5.65 4.04 4.31 6.72 5.81 6.09 6.38
 10.7 16.0 15.7 28.4 39.9 27.4 46.7 33.5 33.5 35.1 14.5 11.2
 10.6 13.5 17.8 20.1 23.4 27.0 25.8 24.8 21.0 16.8 12.7 10.3
UTIL2501:ALNC Line: 1 File:test3.dat
 1 TITLE(1) - Description of dataset
Character Field
I|HELP 2|ANLYZ 3|EXIT 4|SAVE 5|LINEDT 6|STAT 7|AUTOE 8|QUIT 9|LSTC 10|COMNDS
```



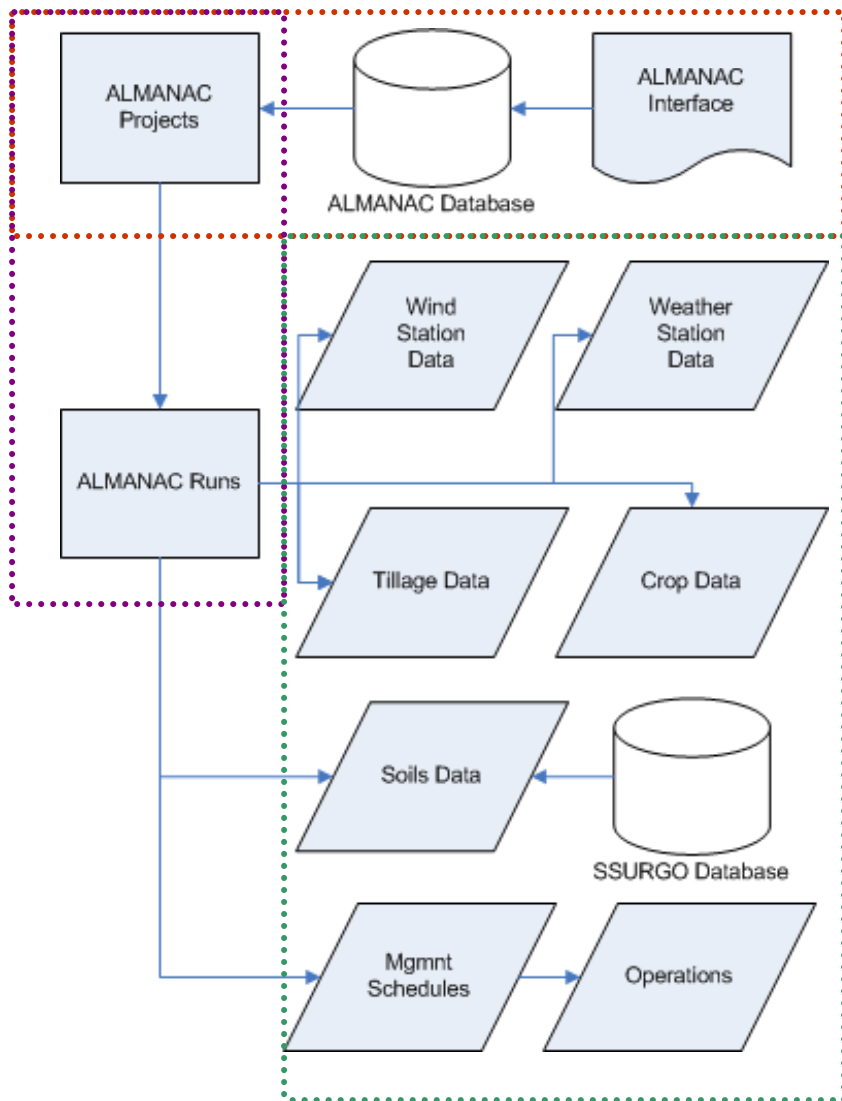
# The ALMANAC Model Interface: Present / Future

- We are nearing completion on the development of a Windows-based interface to the ALMANAC model
- The interface includes
  - “Light” GIS functionality
  - Direct integration with SSURGO databases





# The ALMANAC Model Interface: Conceptual Design



- The ALMANAC interface links with a database that stores information on ALL ALMANAC modeling projects.
- An ALMANAC project may have multiple model run scenarios for a site which vary parameters and management strategies. New management scenarios can be created and saved in the database.
- Weather, crop, and tillage information is stored in the database and may be edited by the user.
- Any SSURGO soils database may be linked to the ALMANAC database to provide the required soil attributes.



# The ALMANAC Model Interface: Acquiring Necessary Soils Data

- Users must access the NRCS Soil Data Mart and choose the soil survey area of interest to download
- Spatial and tabular data is required (must select geographic coordinate system)

United States Department of Agriculture  
**NRCS** Natural Resources Conservation Service

VT003 - Bennington County, Vermont  
Bennington County  
Vermont

**Soil Data Mart**

Home Select State State Contacts Template Databases SSURGO Metadata Status Map US General Soil Map Logon/Register Help

Please select the class of data you wish to download: ( Survey Area Version 13 , Tabular Version 12 , Spatial Version 1 )  
 Tabular Data Only  Tabular and Spatial Data  Spatial Data Only  Template Database Only

Please select a spatial format:  
ArcView Shapefile

Please select a coordinate system:  
Geographic Coordinate System (NAD83)

Reset Default

Please select a template database (optional):  
Clear Selection

State	Access	Version	Size	File Name	Size
UT	Access 2002	33		soildb_UT_2003	1.8M
UT	Access 2000	33		soildb_UT_2000	1.8M
VT	Access 2002	33.3		soildb_VT_2002	2.0M
VT	Access 2000	33.3		soildb_VT_2000	1.9M
VA	Access 2002	33.1		soildb_VA_2002	1.7M

**Description:** Vermont SSURGO Template version 33.3 description:  
This template should be used with Vermont data. It contains the following locally developed reports:

- \* Soil Fact Sheet (VT) 2007 version
- \* Field Office Conservation Planning Soil Fact Sheet
- \* Forest Value Groups (VT)
- \* Prime and Important Farmlands (VT) - Vermont Act 250 Primary Agricultural Soils (with Oct. 1, 2005 updates)
- \* Sewage Disposal Onsite Septic Ratings (VT) - Vermont 2002 Environmental Protection Rules
- \* Agricultural Disposal of Manure, Food-processing Waste, and Sewage Sludge (VT)
- \* Agricultural Disposal of Wastewater by Irrigation and Overland Flow (VT)
- \* Agricultural Disposal of Wastewater by Rapid Infiltration and Slow Rate Treatment (VT)
- \* Forestland Roads, Log Landings, and Equipment Operability (VT)
- \* Ponds and Embankments (VT)
- \* Source of Sand and Gravel (VT)

Please enter your e-mail address:  
mwinchell@stone-env.com

If the e-mail account entered above is protected by spam blocking software, you will need to authorize e-mail from SoilDataMart@nrcs.usda.gov in order to receive e-mail notification once your request has been processed.

Select Survey Area Submit Request View Metadata See Disclaimer Generate Reports Subscribe



# The ALMANAC Model Interface: Extracting Soils Data for ALMANAC

- The ALMANAC interface only requires the “raw” spatial and “tabular” folders. The Access database is not used.
- The interface uses the following tables:
  - Mapunit.txt
  - Component.txt
  - Chorizon.txt
- The interface assumes (hopes) that the format of these tables are consistent throughout ALL survey areas.

Name	Size	Type	Date Modified
ccancov.txt	0 KB	Text Document	3/18/2008 3:03 ...
ccrpyd.txt	72 KB	Text Document	3/18/2008 3:03 ...
cdfeat.txt	0 KB	Text Document	3/18/2008 3:03 ...
cecoclas.txt	0 KB	Text Document	3/18/2008 3:03 ...
ceplants.txt	178 KB	Text Document	3/18/2008 3:03 ...
cerosnac.txt	0 KB	Text Document	3/18/2008 3:03 ...
cfprod.txt	257 KB	Text Document	3/18/2008 3:03 ...
cfprodo.txt	0 KB	Text Document	3/18/2008 3:03 ...
cgeomord.txt	26 KB	Text Document	3/18/2008 3:03 ...
chaashto.txt	122 KB	Text Document	3/18/2008 3:03 ...
chconsis.txt	59 KB	Text Document	3/18/2008 3:03 ...
chdsuffx.txt	1 KB	Text Document	3/18/2008 3:03 ...
chfrags.txt	192 KB	Text Document	3/18/2008 3:03 ...
chorizon.txt	516 KB	Text Document	3/18/2008 3:03 ...
chpores.txt	0 KB	Text Document	3/18/2008 3:03 ...
chstr.txt	73 KB	Text Document	3/18/2008 3:03 ...
chstrgrp.txt	81 KB	Text Document	3/18/2008 3:03 ...
chtexgrp.txt	211 KB	Text Document	3/18/2008 3:03 ...
chtexmod.txt	39 KB	Text Document	3/18/2008 3:03 ...
chtex.txt	830 KB	Text Document	3/18/2008 3:03 ...
chtextr.txt	152 KB	Text Document	3/18/2008 3:03 ...
chunifie.txt	155 KB	Text Document	3/18/2008 3:03 ...



# The ALMANAC Model Interface: SSURGO-Based Soils Inputs

- ALMANAC extracts the following parameters from SSURGO:

Number of Layers
Hydro Group
Albedo
Layer Depth
Bulk Density
Wilting Point
Field Capacity
Sand %
Silt %
Soil pH
Organic Carbon
Coarse Fraction
Dry Oven Bulk Density
Saturated Conductivity

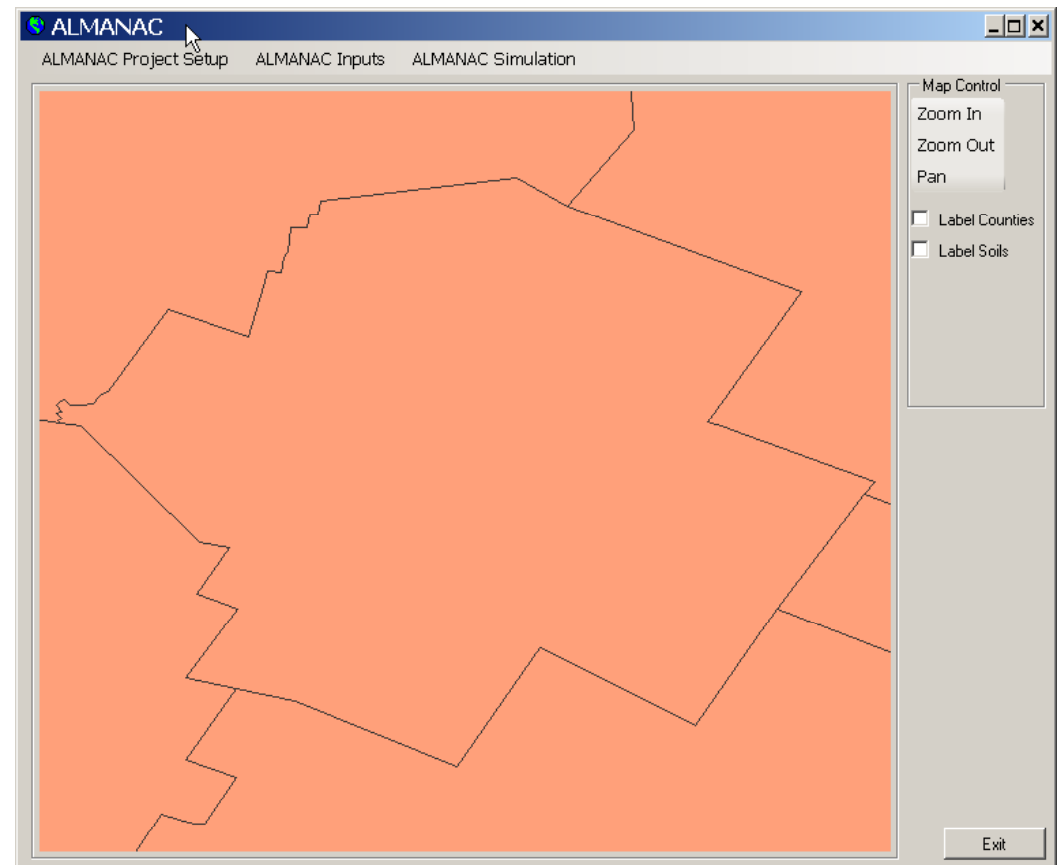
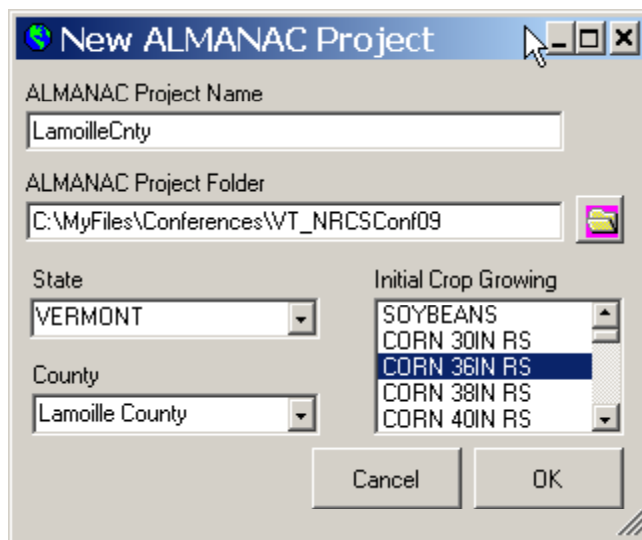
- Additional ALMANAC soil parameters not (commonly) found in SSURGO:

Min Depth to Water Table
Max Depth to Water Table
Organic N Conc
Sum of Bases
Calcium Carbonate Conc.
Cation Exchange Capacity
Nitrate Conc.
Labile P Conc.
Crop Residue
P Sorption Ratio
Organic P Conc.



# The ALMANAC Model Interface: Starting a New Project

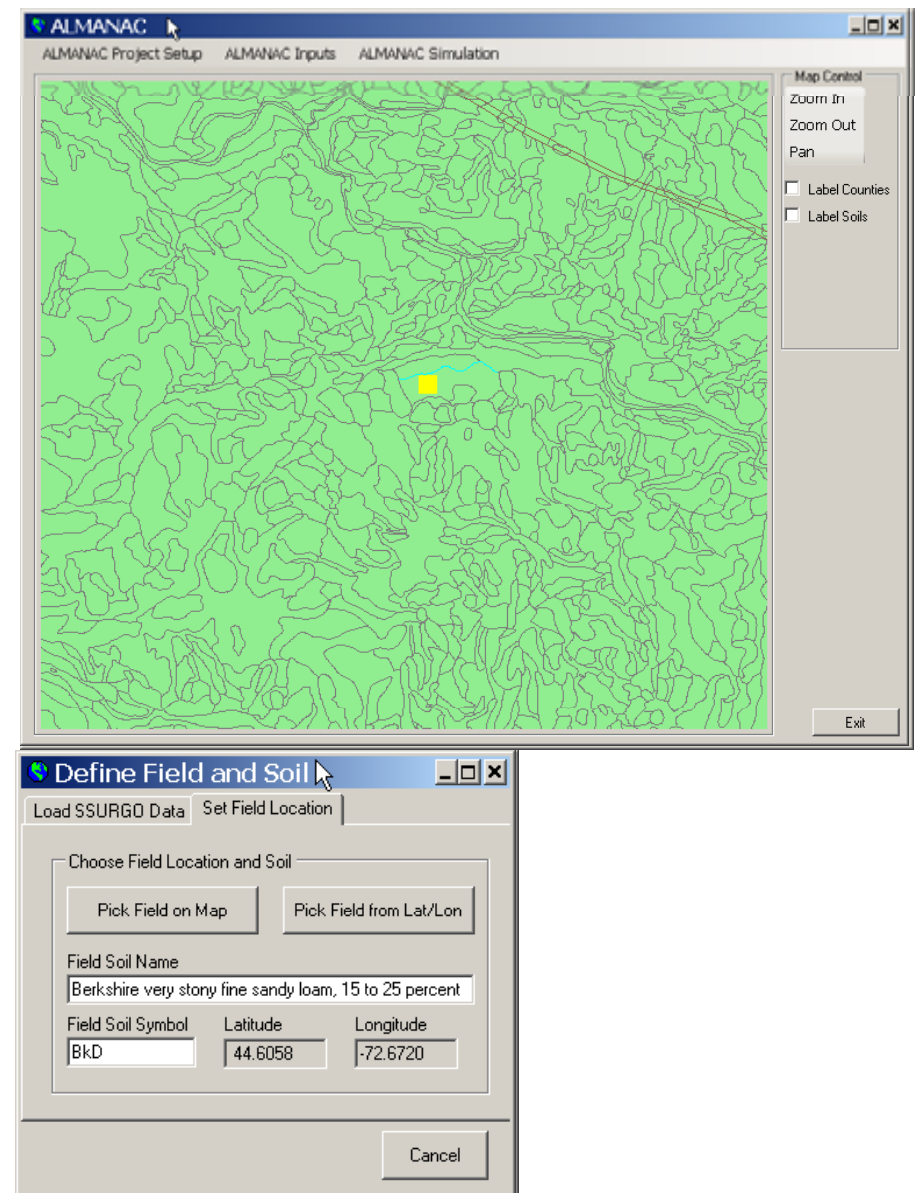
- User opens the ALMANAC interface
- Specifies project name
- Specifies county to model
- Defines the initial crop





# The ALMANAC Model Interface: Defining the Field Soil

- The soils for an ALMANAC simulation are based upon the geographic location of a field that the user has specified.
- The field location can be specified in one of two ways:
  - Interactively through the map
  - Based on latitude and longitude
- Later on, users have the option of changing the soil used in the simulation and running it as a separate “scenario”





# The ALMANAC Model Interface: Defining the Weather Data Inputs

- ALMANAC requires the following daily weather inputs: precipitation, temperature, relative humidity, wind speed, solar radiation
- ALMANAC can use weather time series from the following sources:
  - Observed daily time series
  - Time series from built-in weather generator based on monthly statistical data (missing data in observed time series also filled in this way)

Define Weather Inputs

Weather Generator Data

Monthly Weather Statistics

US Database  
 Custom Database

Locations Table:

Monthly Wind Statistics

US Database  
 Custom Database

Locations Table:

Observed Weather Data

Choose Observed Inputs

Observed Precipitation  
 Observed Temperature  
 Observed Realive Humidity  
 Observed Wind Speed  
 Observed Solar Radiation

Weather File:

Cancel Load Weather Data

Status:



# The ALMANAC Model Interface: Modifying SSURGO-Based Soils Inputs

- Soil parameters may be individually changed and saved. Note that these changes are made only to the ALMANAC database copy of the soils data, not the SSURGO data itself
- A different soil series may be chosen from the SSURGO database and loaded into the ALMANAC simulation (limited by the series available in the current survey area)

**Edit ALMANAC Run Data**

Run Information | Site Information | **Soil Component** | Management

MUNAME: Tunbridge-Lyman fine sandy loams, rock | Select New | MUSYM: TuE | COMPNAME: Lyman

**Component Attributes**

NLAYER: 4	HSG: D	SALB: 0.23	TSLA: 10
ZQT: 0	ZF: 0	FFC: 0	WTMN: 0
WTMX: 0	WTBL: 0	XIDS: 0	RFTT: 0

**Layer Attributes**

LAYER: 1	Z: 0.01	BD: 0.98	U: 0.07
FC: 0.163	SAN: 63.5	SIL: 30.5	WN: 0
PH: 5.2	SMB: 0	CBN: 2.941176	CAC: 0
CEC: 0	ROK: 3	WNO3: 0	AP: 0
RSD: 0	BDD: 1.03	PSP: 0	SC: 101.5999
RT: 0	WP: 0		

**Choose From List**

County Soils

- 281876: Adams loamy fine sand, 2 to 8
- 281877: Adams loamy fine sand, 8 to 1
- 281878: Adams loamy fine sand, 15 to
- 281879: Adams loamy fine sand, 25 to
- 281880: Adams-Adams variant loamy fi
- 281881: Adams-Adams variant loamy fi
- 281882: Adams-Adams variant loamy fi
- 281883: Allagash very fine sandy loam,
- 281884: Berkshire fine sandy loam, 3 to
- 281885: Berkshire fine sandy loam, 8 to
- 281886: Berkshire fine sandy loam, 15

Buttons: Edit Run, Cancel Edits, Save Edits, Exit



# The ALMANAC Model Interface: Definition of Management Schedules

- Management schedules are defined to specify land management operations applied to the field
- Different management schedules (planting, harvest times, fertilization) may be defined to evaluate the impacts on crop yields and water quality

**Management Schedules**

- Corn-Soy-Soy
- Corn-Soy
- Corn
- CornVT**

**General Management Settings**

DESC: CornVT

NRD: 1	IDR: 0	BFT: 0
NIRR: 1	IFFR: 1	FNP: 0
IRR: 0	BIR: 0	FMX: 0
IRI: 0	EFI: 0	DRT: 0
IFA: 0	VIMX: 0	FDSF: 0
LM: 0	ARMN: 0	
IFD: 0	ARMX: 0	

**Management Operations**

	Operation	Year	Month	Day
	TILL	1	4	20
	FERT	1	5	1
▶	TILL	1	5	10
	TILL	1	9	30
*				

**Operation Parameters**

Year: 1  
Month: 5  
Day: 10  
COD: 17 (Select) PLANT DR  
CRP: 2 (Select) CORN 30IN RS  
MAT: 0  
PHU: 1800  
CND: 78  
PLANTPO: 50

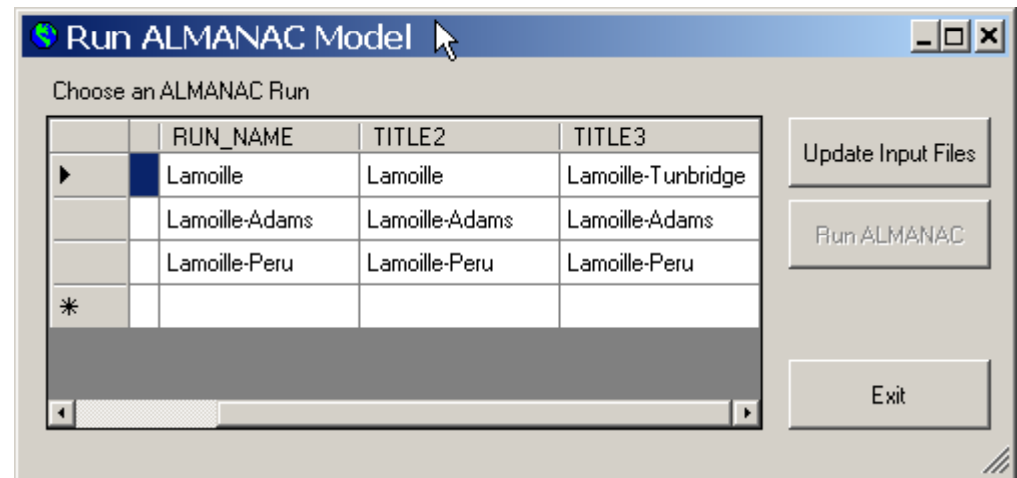
**Parameter Detail**

PHU: Potential Heat Units (1)  
Must input if a plant operation. If unknown put a dummy number here, then run program, check output at yld = line and find max. hu. = then input this number for heat units at this position and rerun.  
PHU()=[ .00] If this tillage operation is not a PLANT operation.



# The ALMANAC Model Interface: Making ALMANAC Model Runs

- Multiple scenarios based on different soils may be saved and run in ALMANAC
- Results will include average annual crop yield and biomass production



```
ALNC_Run.out - Notepad
File Edit Format View Help
-----AVE ANNUAL VALUES
10  TMX  11.55  TMN   0.17  RAD   13.16  RAIN  804.45  SNOW  182.91  RHUM   0.00  UNO3   92.22  PEP    6.44   Q     82.00
    SSF   3.80  PRK   92.72  ET    618.55  EP    265.82  PET   1752.69  TMP    6.19  MUSL   0.97   C     0.41  YW    0.00
    YON   3.61  YNO3  16.47  PRKN  50.70  SSFN   3.66  MNN   42.90  IMN   18.67  DN     0.00  NFIX   0.00  UNO3  92.22
    HMN  12.30  IRGA   0.00  FN   200.00  FP    50.00  CN    79.12  HU2   0.00  LAI2   0.00  WV     3.40  PEP    6.44
    LIME -0.04  COST  185.22  RTRN   0.00
-----AVE ANNUAL CROP YLD DATA
CROP  YLD  BIOM  RAD  HU  RD
      (T/HA) (T/HA) (MJ/M2) (C) (M)
CO30  4.97  5.91  2502.  1165.  1.52
-----AVE STRESS DAYS
-----BIOMASS-----
WATER  N  P  TEMP  AIR  BD  ALSAT  TEMP
60.5  0.1  0.0  23.8  0.0  0.0  2.4  0.0
-----ROOT GROWTH-----
```



# The ALMANAC Model Interface: ALMANAC Simulation Results

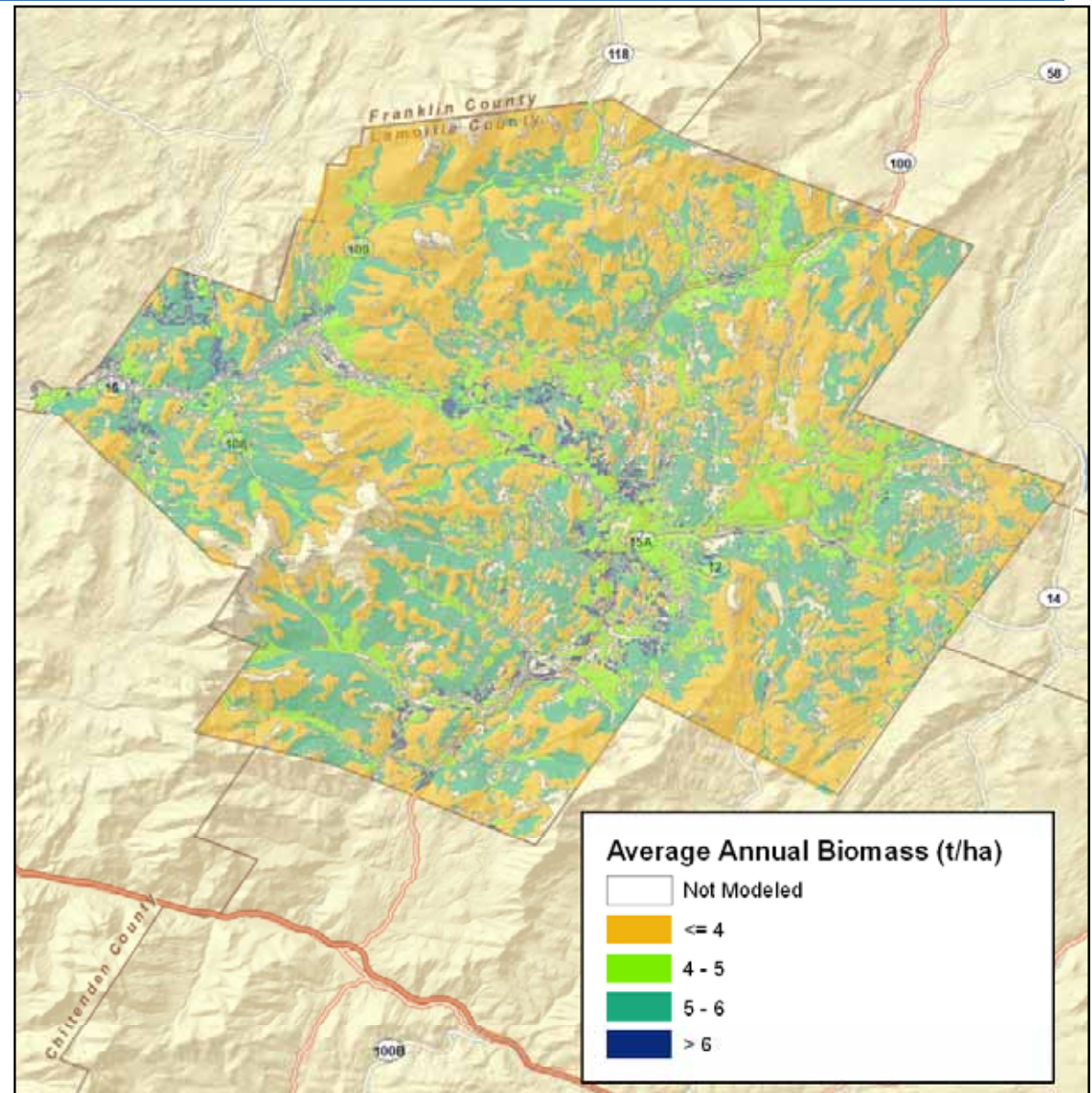
- Switchgrass was simulated on 10 soils in Lamoille County, Vermont
- Simulation was over a 15 year period
- The crop was fertilized

Soil	Biomass (Mg/ha)	Eroded Soil Depth (mm)
Adams	4.99	0.1
Berkshire	5.58	0.3
Boothbay	6.18	1.1
Colton	4.13	0.1
Marlow	5.34	0.7
Peru	5.33	0.7
Potsdam	5.67	0.9
Salmon	5.6	0.4
Teel	6.36	0.5
Tunbridge	3.64	1.6



# The ALMANAC Model Interface: ALMANAC Simulation Results

- Results from ALMANAC can easily be re-mapped back to SSURGO
- Areas with highest potential for switchgrass biomass production occur along the Lamoille valley and Route 100 from Stowe to Morrisville in Vermont





# Future Plans and Data Needs

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- Modify the interface to perform “batch” runs of many soils at one time. Ideally, this would access a SSURGO database (spatial and tabular) that is larger than a single county.
- Explore the possibility of hooking into the Web Soil Survey from the ALMANAC interface to extract soil parameters.
  - Submit lat/lon or mukey or musym to Web Soil Survey
  - Web Soil Survey generates .csv file of soil attributes for selected soil that is downloaded to user
  - ALMANAC extracts necessary parameters from .csv file
  - Spatial SSURGO data offered as a web mapping service
- For many purposes in hydrologic and agronomic modeling, a national SSURGO database would be invaluable