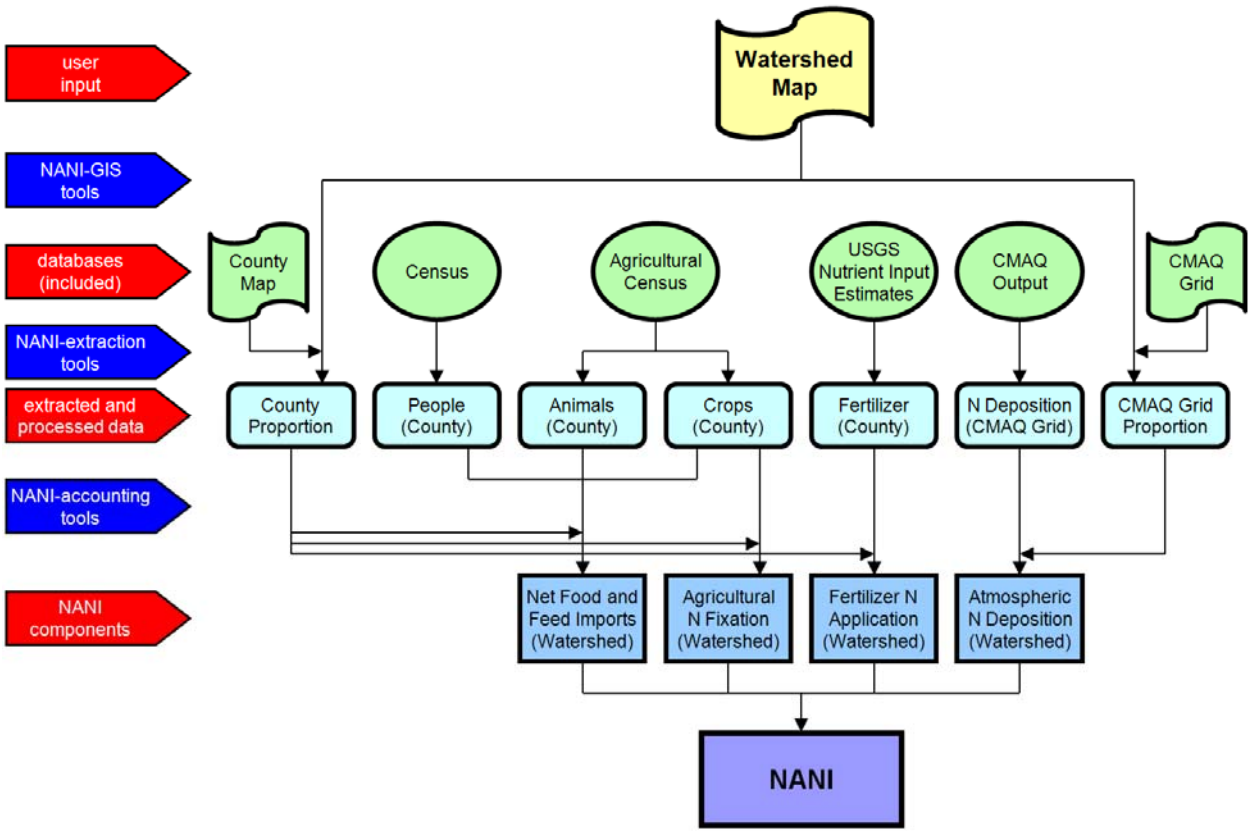
NANI Calculator Toolbox Documentation



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1. Overview

NANI (Net Anthropogenic Nitrogen Inputs), first introduced by Howarth et al. (1996), estimate the human-induced nitrogen inputs to a watershed and have been shown to be a good predictor of riverine nitrogen export at a large scale, multi-year average basis. NANI have been calculated as the sum of four major components (Figure 1.1): atmospheric N deposition, fertilizer N application, agricultural N fixation, and net food and feed imports, which in turn are composed of crop and animal N production (negative fluxes removing N from watersheds) and animal and human N consumption (positive fluxes adding N to watersheds). Assuming approximate steady-state behavior, riverine N export is a fixed proportion of net nitrogen inputs.

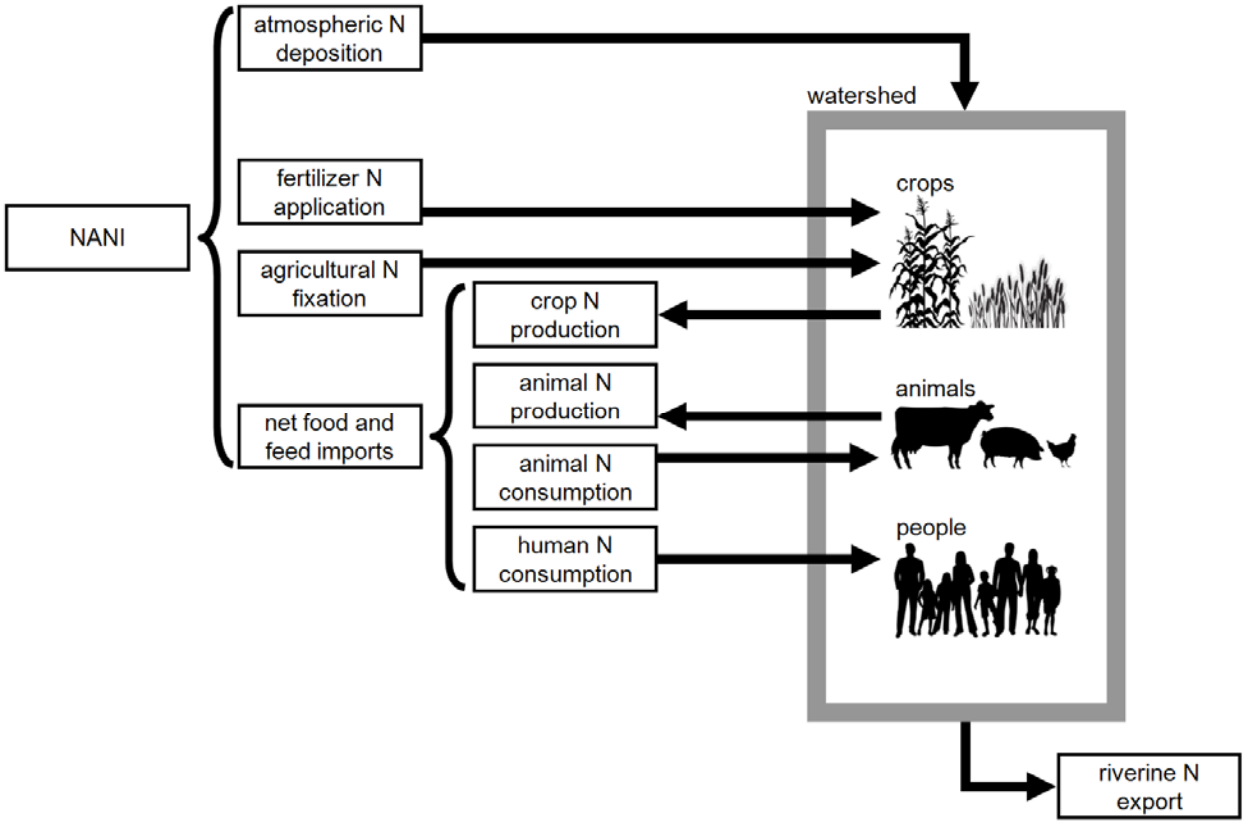


Figure 1.1. Overview of NANI.

The NANI Calculator Toolbox allows the user to calculate NANI in any area within the contiguous United States (e.g., watershed, county, etc.) from nationally available databases downloadable from the Internet. The toolbox is composed of a set of tools that: (1) calculate the proportions of various regions (political or gridded) in which data are collected that fall into areas of interest such as watersheds ("NANI-GIS tools"; Section 3), (2) extract and organize relevant data downloaded from web-based datasets to be used by the accounting tools ("NANI-extraction tools"; Section 4), and (3) calculate NANI, their components, and other relevant items such as animal excretion ("NANI-accounting tools"; Section 5).

The toolbox is designed so that for the contiguous United States, the only input the user needs to provide is a map of areas of interest (see Section 2 for input preparation). All other inputs, such as Agricultural Census data, are included in the toolbox package. Individual components of the toolbox are divided into independent modules, with output from one tool directly used as input to another, and flexible enough to be replaced as new datasets become available. At present, the tools are designed for the US datasets only, but we are currently expanding its use to global datasets such as the European databases (see Section 6 for more discussion).

This document describes how each of the tools in the toolbox works, using the NANI calculation of selected US watersheds as an example. Figure 1.2 below shows an overview of the NANI calculation applied in this example. Note that how the specific calculation is performed may be altered depending on the availability of dataset. For example, in this example the watershed population is estimated based on the county level census data. If desired, however, the same calculation can be performed at the census block level by incorporating appropriate datasets.

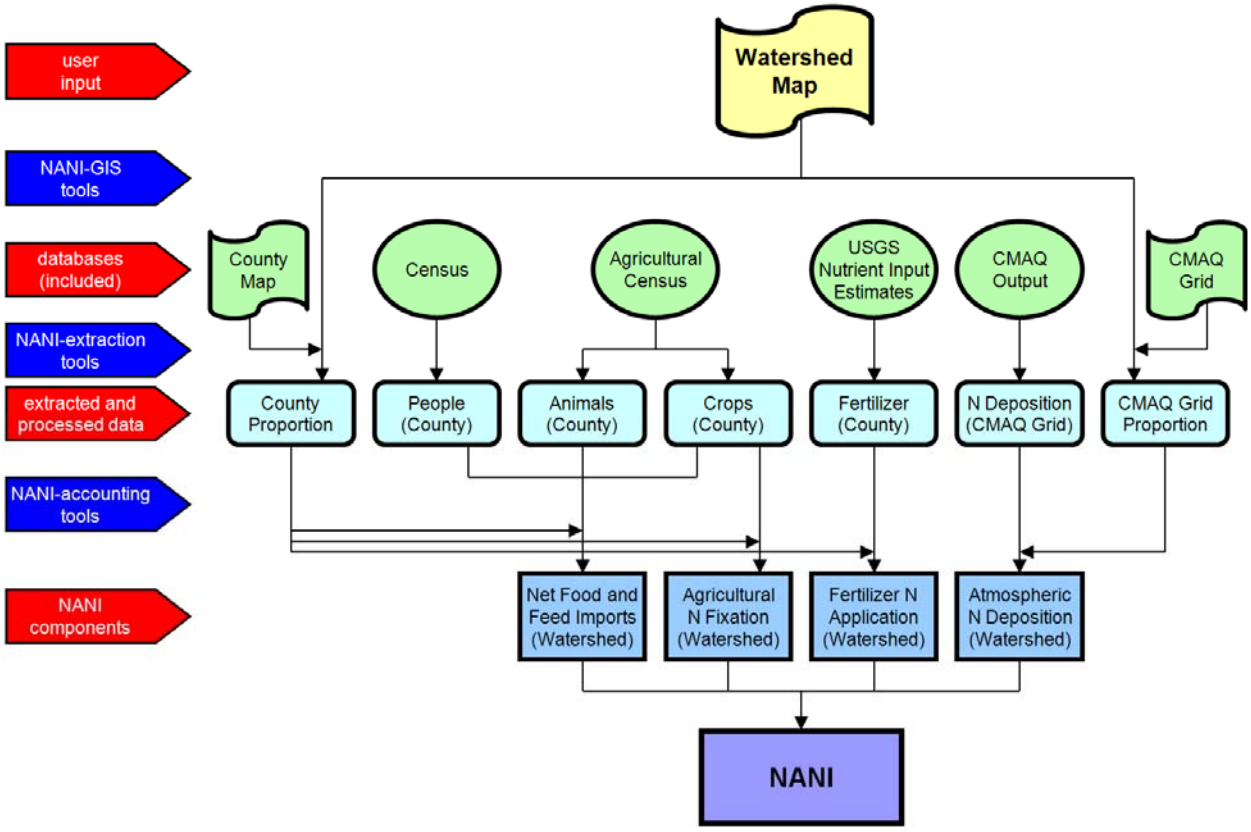


Figure 1.2. Overview of NANI Calculator Toolbox.

2. Input Preparation

Before using the toolbox, the user needs to prepare a map of watershed(s) that can be read by the ESRI ArcGIS software (http://www.esri.com/software/arcgis/index.html). The watershed map may be delineated by the user from an elevation map or downloaded from the Internet, for example from the National Hydrography Dataset (NHD) website at http://nhd.usgs.gov/index.html. In this example, we use a total of 144 US watersheds including (Figure 2.1):

- 29 Northeastern US Watersheds
- 12 Southeastern US Watersheds
- 18 Lake Michigan Watersheds
- 23 Western US Watersheds
- 62 Mississippi Watersheds

Note that Figure 2.1 is showing only some selected watersheds where NANI, or related "proxy" variables that can be used to estimate NANI, have been reported in the previous publications. For example, out of the 29 Northeastern US watersheds used in this example, only the 16 watersheds where the NANI had been previously reported by Howarth et al. (2006) are shown in Figure 2.1. A complete list of the 144 US watersheds (available as a shapefile "US_Watersheds.shp" in the toolbox package) and their description are given in Table 2.1 below.

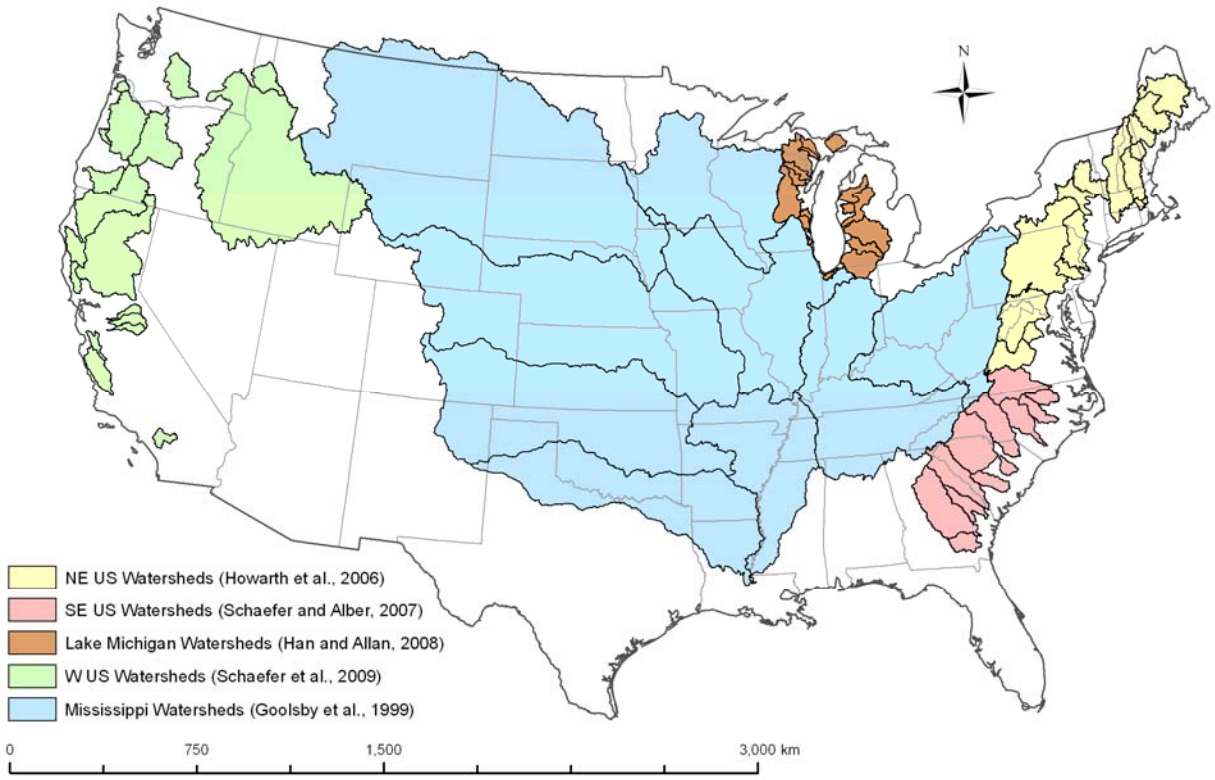


Figure 2.1. A map of US watersheds used as input.

Table 2.1. Description of US watersheds used as input.

Group	Watershed Code	Watershed Name	Area (km^2)	Description
Northeastern US Watersheds	PEN	Penobscot	20,101	USGS 01036390, Howarth et al. (2006)
	KEN	Kennebec	13,994	USGS 01049265, Howarth et al. (2006)
	AND	Androscoggin	8,437	USGS 01059000, Howarth et al. (2006)
	SAC	Saco	3,354	USGS 01066000, Howarth et al. (2006)
	MERR	Merrimack	12,043	USGS 01100000, Howarth et al. (2006)
	CHA	Charles	464	USGS 01103500, Howarth et al. (2006)
	BLA	Blackstone	1,091	USGS 01112500, Howarth et al. (2006)
	CON	Connecticut	26,317	USGS 01184000, Howarth et al. (2006)
	HUD	Hudson	11,952	USGS 01357540, Howarth et al. (2006)
	MOH	Mohawk	9,107	USGS 01357500, Howarth et al. (2006)
	DEL	Delaware	17,543	USGS 01463500, Howarth et al. (2006)
	SCH	Schuylkill	4,925	USGS 01474500, Howarth et al. (2006)
	SUS	Susquehanna	70,152	USGS 01578310, Howarth et al. (2006)
	POT	Potomac	29,997	USGS 01646500, Howarth et al. (2006)
	RAP	Rappahannock	4,152	USGS 01668000, Howarth et al. (2006)
	JAM	James	16,190	USGS 02035000, Howarth et al. (2006)
	HUD_LOWER	Lower Hudson	17,053	Hudson River Basin (Lower)
	HUD_BASIN	Hudson River Basin	38,123	Hudson River Basin (Whole)
	HUD_UPPER_01	Upper Hudson Subbasin	4,305	Upper Hudson, New York (HUC 02020001)
	HUD_UPPER_02	Sacandaga Subbasin	2,724	Sacandaga, New York (HUC 02020002)
	HUD_UPPER_03	Hudson-Hoosic Subbasin	4,931	Hudson-Hoosic, New York, Massachusetts, Vermont (HUC 02020003)
	HUD_MOHAWK_01	Mohawk Subbasin	6,702	Mohawk, New York (HUC 02020004)
	HUD_MOHAWK_02	Schoharie Subbasin	2,407	Schoharie, New York (HUC 02020005)
	HUD_LOWER_01	Middle Hudson Subbasin	6,286	Middle Hudson, Massachusetts, New York (HUC 02020006)
	HUD_LOWER_02	Rondout Subbasin	3,154	Rondout, New Jersey, New York (HUC 02020007)
	HUD_LOWER_03	Hudson-Wappinger Subbasin	2,431	Hudson-Wappinger, New York (HUC 02020008)
	HUD_LOWER_04	Lower Hudson Subbasin	1,866	Lower Hudson, Connecticut, New Jersey, New York (HUC 02030101)
	HUD_LOWER_05	Bronx Subbasin	375	Bronx, New York (HUC 02030102)
	HUD_LOWER_06	Hackensack-Passaic Subbasin	2,940	Hackensack-Passaic, New Jersey, New York (HUC 02030103)
Southeastern US Watersheds	ROA	Roanoke	21,988	Schaefer and Alber (2007)
	PAM	Pamlico	5,743	Schaefer and Alber (2007)
	NEU	Neuse	7,029	Schaefer and Alber (2007)
	CFR	Cape Fear	13,601	Schaefer and Alber (2007)
	PEE	Pee Dee	22,812	Schaefer and Alber (2007)
	SNT	Santee	33,372	Schaefer and Alber (2007)
	BLK	Black	3,277	Schaefer and Alber (2007)
	EDI	Edisto	6,949	Schaefer and Alber (2007)
	SAV	Savannah	25,495	Schaefer and Alber (2007)
	OGE	Ogeechee	8,420	Schaefer and Alber (2007)
	ALT	Altamaha	35,171	Schaefer and Alber (2007)
	SAT	Satilla	7,348	Schaefer and Alber (2007)

Table 2.1. Description of US watersheds used as input.

Group	Watershed Code	Watershed Name	Area (km^2)	Description
Lake Michigan Watersheds	LM_01	Root	465	USGS 04087242, Han and Allan (2008)
	LM_02	Milwaukee	1,732	USGS 04087010, Han and Allan (2008)
	LM_03	Sheboygan	1,164	USGS 04086000, Han and Allan (2008)
	LM_04	Fox	15,795	USGS 04085059, Han and Allan (2008)
	LM_05	Oconto	2,507	USGS 04071775, Han and Allan (2008)
	LM_06	Peshtigo	3,018	USGS 04069500, Han and Allan (2008)
	LM_07	Menominee	10,543	USGS 04067651, Han and Allan (2008)
	LM_08	Ford	1,199	USGS 04059500, Han and Allan (2008)
	LM_09	Escanaba	2,393	USGS 04059000, Han and Allan (2008)
	LM_10	Manistique	3,797	USGS 04049500, Han and Allan (2008)
	LM_11	Manistee	4,936	USGS 04126000, Han and Allan (2008)
	LM_12	Pere Marquette	1,814	USGS 04122500, Han and Allan (2008)
	LM_13	Muskegon	7,092	USGS 04122150, Han and Allan (2008)
	LM_14	Grand	14,395	USGS 04120250, Han and Allan (2008)
	LM_15	Kalamazoo	5,250	USGS 04108670, Han and Allan (2008)
	LM_16	St Joseph	12,157	USGS 04102533, Han and Allan (2008)
	LM_17	Trail Creek	166	USGS 04095380, Han and Allan (2008)
	LM_18	Burns Ditch	869	USGS 04095090, Han and Allan (2008)
Western US Watersheds	SPO	Spokane	9,932	Schaefer et al. (2009)
	YAK	Yakima	14,542	Schaefer et al. (2009)
	SNA	Snake	279,438	Schaefer et al. (2009)
	NEH	Nehalem	1,747	Schaefer et al. (2009)
	DES	Deschutes	27,787	Schaefer et al. (2009)
	JDY	John Day	19,764	Schaefer et al. (2009)
	WIL	Willamette	28,992	Schaefer et al. (2009)
	SIU	Siuslaw	1,531	Schaefer et al. (2009)
	ROG	Rogue	10,188	Schaefer et al. (2009)
	KLA	Klamath	40,356	Schaefer et al. (2009)
	EEL	Eel	8,058	Schaefer et al. (2009)
	RUS	Russian	3,470	Schaefer et al. (2009)
	SCR	Sacramento	68,332	Schaefer et al. (2009)
	STN	Stanislaus	2,809	Schaefer et al. (2009)
	SJQ	San Joaquin	72,129	Schaefer et al. (2009)
	TUO	Tuolumne	4,824	Schaefer et al. (2009)
	MERC	Merced	3,245	Schaefer et al. (2009)
	PAJ	Pajaro	3,063	Schaefer et al. (2009)
	SAL	Salinas	10,568	Schaefer et al. (2009)
	CUY	Cuyama	2,279	Schaefer et al. (2009)
	STC	Santa Clara	1,694	Schaefer et al. (2009)
	STA	Santa Ana	3,881	Schaefer et al. (2009)
	SJQ_NET	San Joaquin (Net)	61,251	SJQ - STN - TUO - MER, Schaefer et al. (2009)

Table 2.1 (Continued).

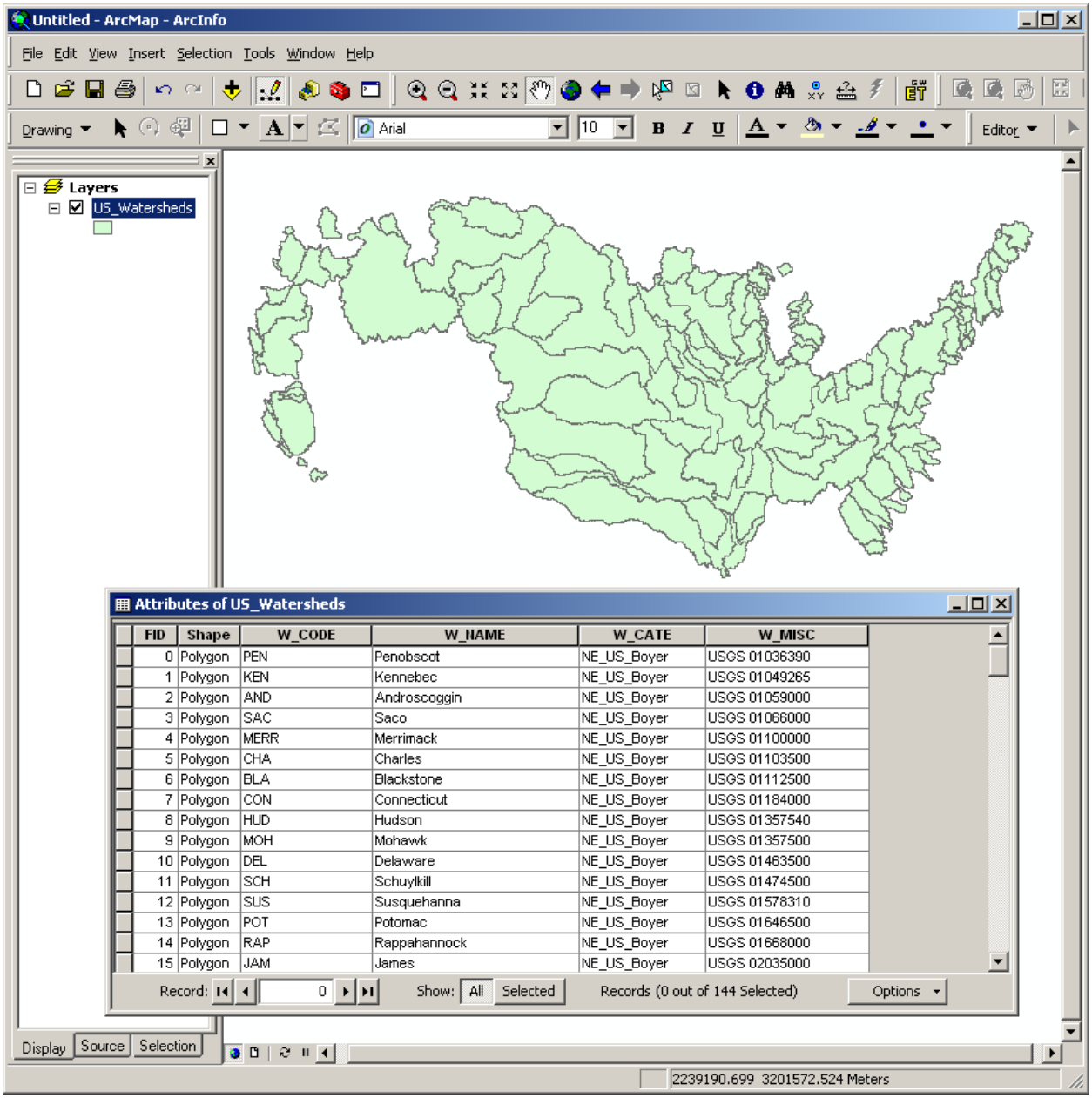
Group	Watershed Code	Watershed Name	Area (km^2)	Description
Mississippi Watersheds (Large)	MS_L_01	Upper Ohio	249,888	Ohio River at Cannelton Dam, KY (USGS 03303280), Goolsby et al. (1999)
	MS_L_02	Lower Ohio	277,767	Ohio River at Grand Chain, IL (USGS 03612500), Goolsby et al. (1999)
	MS_L_03	Upper Missouri	831,577	Missouri River at Omaha, NE (USGS 06610000), Goolsby et al. (1999)
	MS_L_04	Lower Missouri	515,589	Missouri River at Hermann, MO (USGS 06934500), Goolsby et al. (1999)
	MS_L_05	Upper Mississippi	222,049	Mississippi River at Clinton, IA (USGS 05420500), Goolsby et al. (1999)
	MS_L_06	Middle Mississippi	271,828	Mississippi River at Thebes, IL (USGS 07022000), Goolsby et al. (1999)
	MS_L_07	Arkansas	408,379	Arkansas River at Little Rock, AR (USGS 07263620), Goolsby et al. (1999)
	MS_L_08	Lower Mississippi	189,924	Mississippi River at St. Francisville, LA (USGS 07373420), Goolsby et al. (1999)
	MS_L_09	Red and Ouachita	240,477	Atchafalaya River at Melville, LA (USGS 07381495), Goolsby et al. (1999)
	MS_L_06_UPPER	Middle Mississippi (Upper)	224,375	Mississippi River below Grafton, IL (USGS 05587455), Aulenbach et al. (2007)
	MS_L_06_LOWER	Middle Mississippi (Lower)	47,714	MS_L_06 - MS_L_06_UPPER, Aulenbach et al. (2007)
Mississippi Watersheds (Small)	MS_S_01	Allegheny R at New Kensington	29,951	Allegheny River at New Kensington, PA, Goolsby et al. (1999)
	MS_S_02	Monongahela R at Braddock	19,031	Monongahela River at Braddock, PA, Goolsby et al. (1999)
	MS_S_03	Muskingham R at McConnelsville	19,349	Muskingham River at McConnelsville, OH, Goolsby et al. (1999)
	MS_S_04	Kanawha R at Winfield	30,674	Kanawha River at Winfield, WV, Goolsby et al. (1999)
	MS_S_05	Scioto R at Higby	13,224	Scioto River at Higby, OH, Goolsby et al. (1999)
	MS_S_06	Great Miami at New Baltimore	10,008	Great Miami at New Baltimore, OH, Goolsby et al. (1999)
	MS_S_07	Kentucky R at Lockport	15,886	Kentucky River at Lockport, KY, Goolsby et al. (1999)
	MS_S_08	Wabash R at New Harmony	75,874	Wabash River at New Harmony, IN, Goolsby et al. (1999)
	MS_S_09	Cumberland R near Grand Rivers	45,760	Cumberland River near Grand Rivers, KY, Goolsby et al. (1999)
	MS_S_10	Tennessee R near Paducah	105,872	Tennessee River near Paducah, KY, Goolsby et al. (1999)
	MS_S_11	Mississippi R near Royalton	30,178	Mississippi River near Royalton, MN, Goolsby et al. (1999)
	MS_S_12	Minnesota R at Jordan	42,480	Minnesota River at Jordan, MN, Goolsby et al. (1999)
	MS_S_13	St Croix R at St Croix Falls	16,542	St. Croix River at St. Croix Falls, WI, Goolsby et al. (1999)
	MS_S_14	Chippewa R at Durand	23,475	Chippewa River at Durand, WI, Goolsby et al. (1999)
	MS_S_15	Wisconsin R at Muscoda	27,156	Wisconsin River at Muscoda, WI, Goolsby et al. (1999)
	MS_S_16	Rock R near Joslin	24,961	Rock River near Joslin, IL, Goolsby et al. (1999)
	MS_S_17	Cedar R at Cedar Falls	12,439	Cedar River at Cedar Falls, IA, Goolsby et al. (1999)
	MS_S_18	Iowa R at Wapello	20,065	Iowa River at Wapello, IA, Goolsby et al. (1999)
	MS_S_19	Skunk R at Augusta	11,222	Skunk River at Augusta, IA, Goolsby et al. (1999)
	MS_S_20	Raccoon R at Van Meter	8,904	Raccoon River at Van Meter/Des Moines, IA, Goolsby et al. (1999)
	MS_S_21	Des Moines at St Francisville	28,238	Des Moines at St. Francisville, MO, Goolsby et al. (1999)
	MS_S_22	Illinois R at Marseilles	21,359	Illinois River at Marseilles, IL, Goolsby et al. (1999)
	MS_S_23	Illinois R at Valley City	47,733	Illinois River at Valley City, IL, Goolsby et al. (1999)
	MS_S_24	Kaskaskia R near Venedy Station	11,344	Kaskaskia River near Venedy Station, IL, Goolsby et al. (1999)
	MS_S_25	Milk R near Nashua	59,015	Milk River near Nashua, MT, Goolsby et al. (1999)
	MS_S_26	Missouri R near Culbertson	183,610	Missouri River near Culbertson, MT, Goolsby et al. (1999)
	MS_S_27	Bighorn R near Bighorn	59,344	Bighorn River near Bighorn, MT, Goolsby et al. (1999)
	MS_S_28	Yellowstone R near Sydney	119,493	Yellowstone River near Sydney, MT, Goolsby et al. (1999)
	MS_S_29	Cheyenne R at Cherry Creek	62,809	Cheyenne River at Cherry Creek, SD, Goolsby et al. (1999)
	MS_S_30	James R near Scotland	54,522	James River near Scotland, SD, Goolsby et al. (1999)

Table 2.1 (Continued).

Group	Watershed Code	Watershed Name	Area (km^2)	Description
Mississippi Watersheds (Small)	MS_S_31	Platte R near Louisville	221,481	Platte River near Louisville, NE, Goolsby et al. (1999)
	MS_S_32	Kansas R at Desoto	155,020	Kansas River at Desoto, KS, Goolsby et al. (1999)
	MS_S_33	Grand R near Sumner	18,012	Grand River near Sumner, MO, Goolsby et al. (1999)
	MS_S_34	Osage R below St Thomas	37,777	Osage River below St. Thomas, MO, Goolsby et al. (1999)
	MS_S_35	St Francis Bay at Riverfront	16,908	St. Francis Bay at Riverfront, AR, Goolsby et al. (1999)
	MS_S_36	White R at Clarendon	66,063	White River at Clarendon, AR, Goolsby et al. (1999)
	MS_S_37	Arkansas R at Tulsa	192,978	Arkansas River at Tulsa, OK, Goolsby et al. (1999)
	MS_S_38	Canadian R at Calvin	71,574	Canadian River at Calvin, OK, Goolsby et al. (1999)
	MS_S_39	Yazoo R at Redwood	32,335	Yazoo River at Redwood, MS, Goolsby et al. (1999)
	MS_S_40	Big Black R near Bovina	7,104	Big Black River near Bovina, MS, Goolsby et al. (1999)
	MS_S_41	Red R at Alexandria	174,163	Red River at Alexandria, LA, Goolsby et al. (1999)
	MS_S_42	Ouachita R near Columbia	40,824	Ouachita River near Columbia, LA, Goolsby et al. (1999)
	MS_S_NET_01	Upper Ohio (Net)	111,446	MS_L_01 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_02	Lower Ohio (Net)	50,118	MS_L_02 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_03	Upper Missouri (Net)	292,140	MS_L_03 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_04	Lower Missouri (Net)	82,725	MS_L_04 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_05	Upper Mississippi (Net)	82,262	MS_L_05 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_06	Middle Mississippi (Net)	85,081	MS_L_06 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_07	Arkansas (Net)	143,696	MS_L_07 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_08	Lower Mississippi (Net)	67,504	MS_L_08 - MS_S Watersheds, Goolsby et al. (1999)
	MS_S_NET_09	Red and Ouachita (Net)	25,711	MS_L_09 - MS_S Watersheds, Goolsby et al. (1999)

Note that all the watersheds and their sub-watersheds, although some may be overlapping each other, are stored as a single ArcGIS shapefile and noted in this document as “a map of watershed(s)”. For example, the Bronx Subbasin (HUC 02030102) “HUD_LOWER_05” (Table 2.1) is a part of the Lower Hudson Watershed “HUD_LOWER”, which in turn is a part of the Whole Hudson River Basin “HUD_BASIN”.

Figure 2.2 below shows how the watershed map and its attribute table look like when opened with ArcMap. The attribute table of the watershed map can have multiple columns, but there must be a column containing the unique identifier for each watershed that will be used as input to the NANI-GIS tools of the toolbox (in this example, “W_CODE”).



FID	Shape	W_CODE	W_NAME	W_CATE	W_MISC
0	Polygon	PEN	Penobscot	NE_US_Boyer	USGS 01036390
1	Polygon	KEN	Kennebec	NE_US_Boyer	USGS 01049265
2	Polygon	AND	Androscoggin	NE_US_Boyer	USGS 01059000
3	Polygon	SAC	Saco	NE_US_Boyer	USGS 01066000
4	Polygon	MERR	Merrimack	NE_US_Boyer	USGS 01100000
5	Polygon	CHA	Charles	NE_US_Boyer	USGS 01103500
6	Polygon	BLA	Blackstone	NE_US_Boyer	USGS 01112500
7	Polygon	CON	Connecticut	NE_US_Boyer	USGS 01184000
8	Polygon	HUD	Hudson	NE_US_Boyer	USGS 01357540
9	Polygon	MOH	Mohawk	NE_US_Boyer	USGS 01357500
10	Polygon	DEL	Delaware	NE_US_Boyer	USGS 01463500
11	Polygon	SCH	Schuylkill	NE_US_Boyer	USGS 01474500
12	Polygon	SUS	Susquehanna	NE_US_Boyer	USGS 01578310
13	Polygon	POT	Potomac	NE_US_Boyer	USGS 01646500
14	Polygon	RAP	Rappahannock	NE_US_Boyer	USGS 01668000
15	Polygon	JAM	James	NE_US_Boyer	USGS 02035000

Figure 2.2. Input watershed map and its attribute table opened with ArcMap.

3. NANI-GIS Tools

3.1. Calculating County Proportions

As a first step, one of the NANI-GIS tools "Calculate Map Proportions" (Figure 3.1.1) is used to calculate the proportions of the US counties falling into each of the 144 US watersheds. The resulting output table is then used as an input to the NANI-extraction and NANI-accounting tools described in Sections 4 and 5, respectively. (Another NANI-GIS tool "Distribute Map Data" shown in Figure 3.1.1 has been developed for the application to the European databases and will not be discussed in this document.)

To use the tool, start ArcMap and open the "NANI_GIS_Tool.mxd" file included in the toolbox package. A toolbar "NANI-GIS Tools" will appear (Figure 3.1.1). Add the US county map "US_Counties.shp" included in the toolbox package and the input watershed map "US_Watersheds.shp" described in Section 2 (Figure 3.1.2).

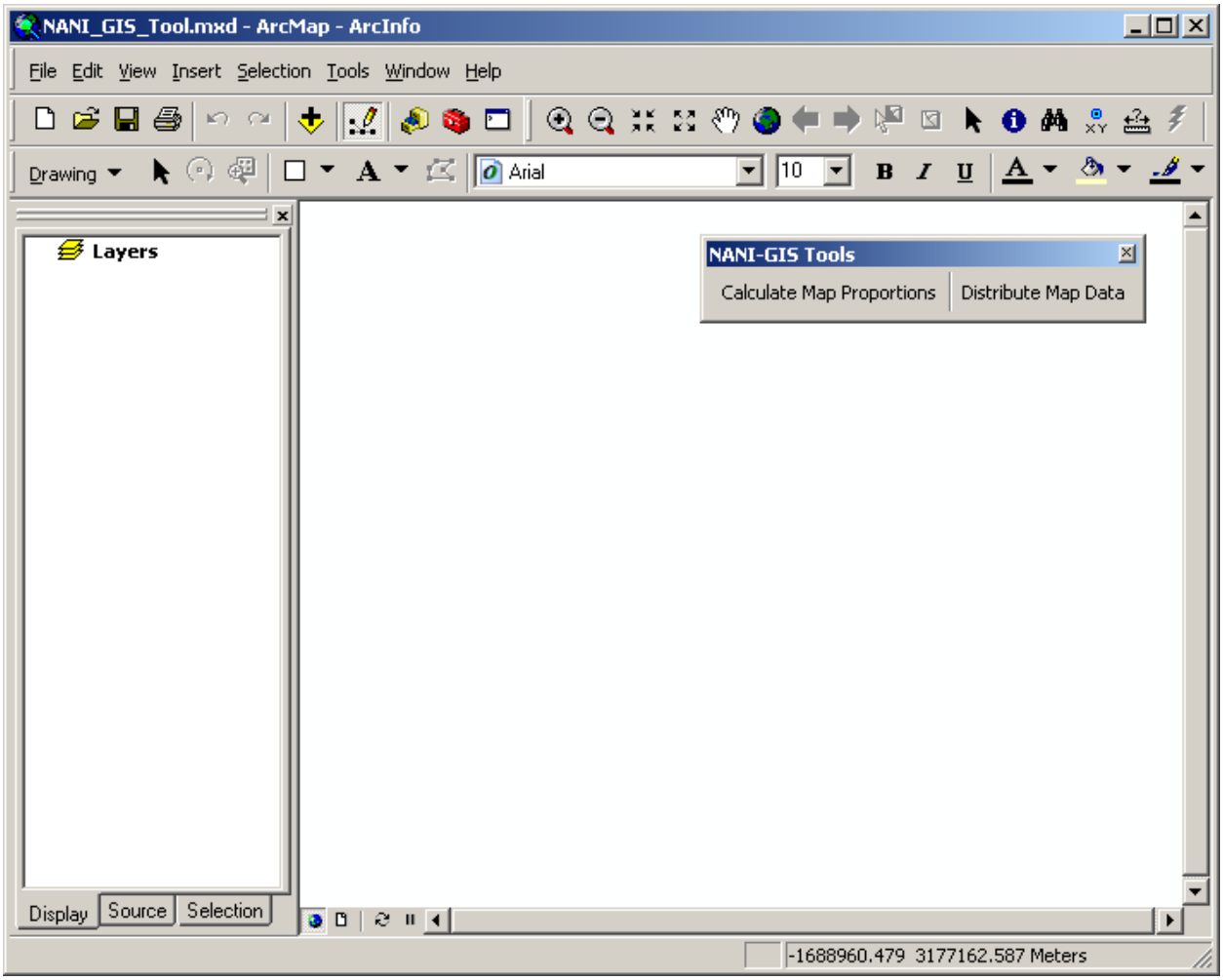


Figure 3.1.1. NANI-GIS tools running in ArcMap.

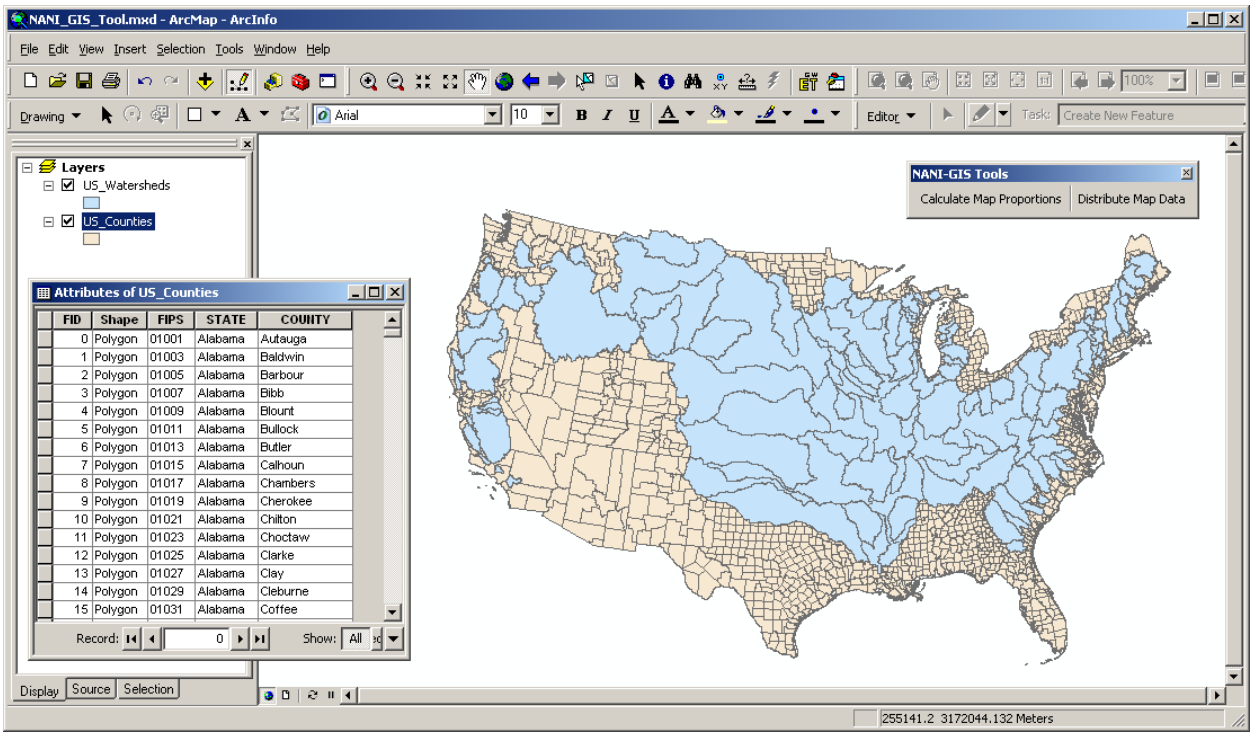


Figure 3.1.2. US county and watershed maps added as input to NANI-GIS tool.

Figure 3.1.2 is showing the attribute table of the US county map included in the toolbox package. As in the watershed map, the county map (or any other data map used as input to the NANI-GIS tools) must have a column containing the unique identifier (in this example, “FIPS”).

Click on “Calculate Map Proportions” and a tool window will appear (Figure 3.1.3). Choose the names of the watershed and county maps (“US_Watersheds” and “US_Counties”, respectively) and their unique identifiers (“W_CODE” and “FIPS”, respectively). Since the NANI-extraction tools described in Section 4 require the county proportion table to have state and county names, the “STATE” and “COUNTY” should be selected as additional output field names (Figure 3.1.3). In this example, the output table and map names are specified as “Cnty_Prop.txt” and “Cnty_Prop.shp”, respectively.

The calculation will be performed after clicking “OK”. The tool first calculates the watershed and county areas, intersect the watershed and county maps, calculate the areas of intersected polygons, and calculate the proportions of counties falling into each input watershed. The intersect map “Cnty_Prop.shp” is added to ArcMap as output shapefile (Figure 3.1.4) and the output table “Cnty_Prop.txt” (comma-delimited text file), which is used as input to the NANI-extraction (Sections 4.1, 4.2, and 4.3) and NANI-accounting (Section 5.1, 5.2, and 5.3) tools, is created in the output folder. Figure 3.1.5 shows how the table looks like when opened with Microsoft Excel.

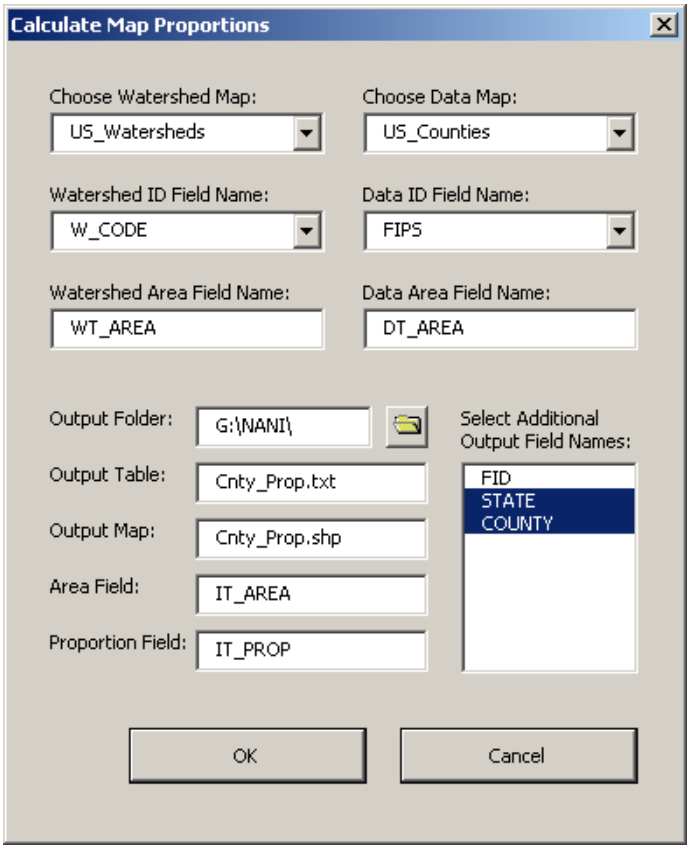


Figure 3.1.3. NANI-GIS tool window for calculating county proportions.

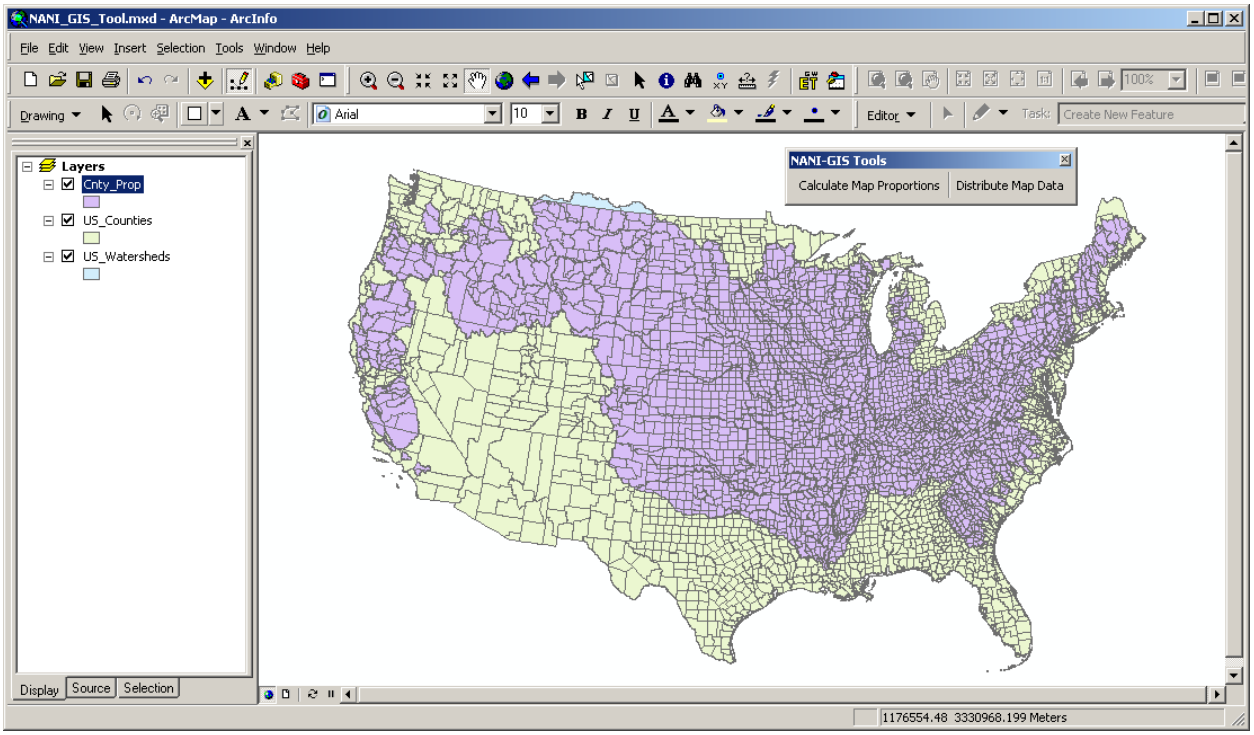
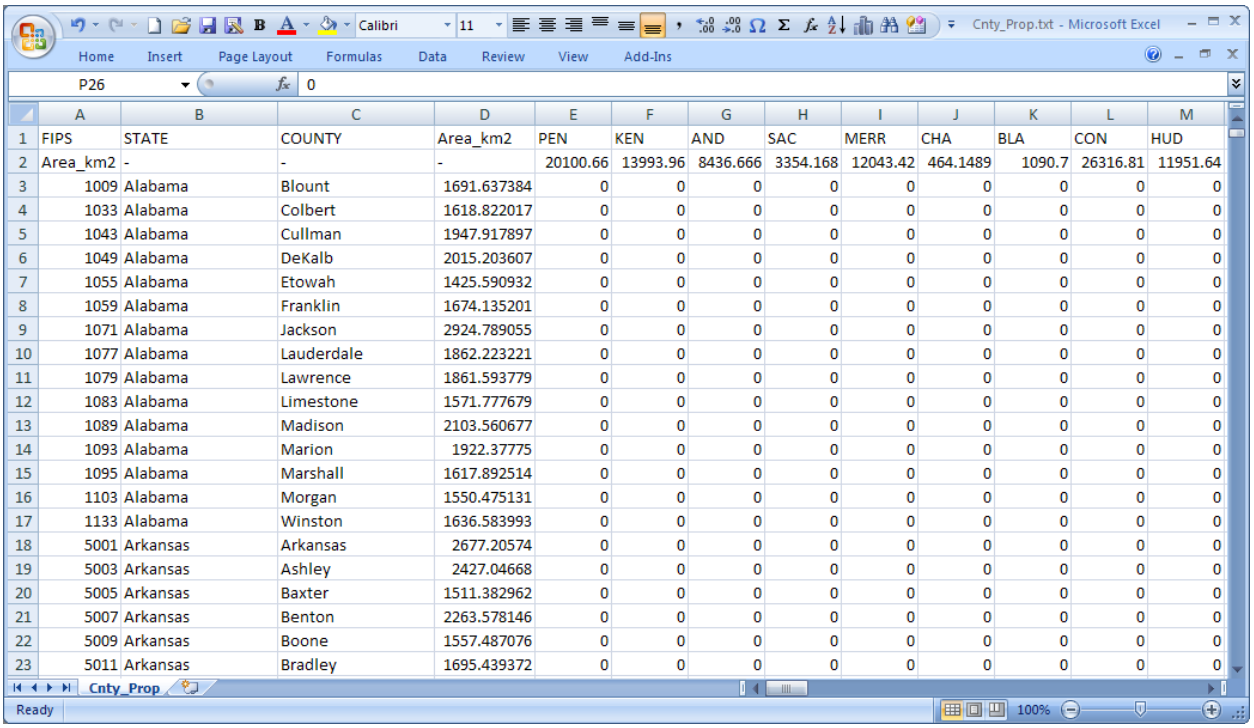


Figure 3.1.4. County intersect output map created by NANI-GIS tool.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	FIPS	STATE	COUNTY	Area_km2	PEN	KEN	AND	SAC	MERR	CHA	BLA	CON	HUD
2	Area_km2	-	-	-	20100.66	13993.96	8436.666	3354.168	12043.42	464.1489	1090.7	26316.81	11951.64
3	1009	Alabama	Blount	1691.637384	0	0	0	0	0	0	0	0	0
4	1033	Alabama	Colbert	1618.822017	0	0	0	0	0	0	0	0	0
5	1043	Alabama	Cullman	1947.917897	0	0	0	0	0	0	0	0	0
6	1049	Alabama	DeKalb	2015.203607	0	0	0	0	0	0	0	0	0
7	1055	Alabama	Etowah	1425.590932	0	0	0	0	0	0	0	0	0
8	1059	Alabama	Franklin	1674.135201	0	0	0	0	0	0	0	0	0
9	1071	Alabama	Jackson	2924.789055	0	0	0	0	0	0	0	0	0
10	1077	Alabama	Lauderdale	1862.223221	0	0	0	0	0	0	0	0	0
11	1079	Alabama	Lawrence	1861.593779	0	0	0	0	0	0	0	0	0
12	1083	Alabama	Limestone	1571.777679	0	0	0	0	0	0	0	0	0
13	1089	Alabama	Madison	2103.560677	0	0	0	0	0	0	0	0	0
14	1093	Alabama	Marion	1922.37775	0	0	0	0	0	0	0	0	0
15	1095	Alabama	Marshall	1617.892514	0	0	0	0	0	0	0	0	0
16	1103	Alabama	Morgan	1550.475131	0	0	0	0	0	0	0	0	0
17	1133	Alabama	Winston	1636.583993	0	0	0	0	0	0	0	0	0
18	5001	Arkansas	Arkansas	2677.20574	0	0	0	0	0	0	0	0	0
19	5003	Arkansas	Ashley	2427.04668	0	0	0	0	0	0	0	0	0
20	5005	Arkansas	Baxter	1511.382962	0	0	0	0	0	0	0	0	0
21	5007	Arkansas	Benton	2263.578146	0	0	0	0	0	0	0	0	0
22	5009	Arkansas	Boone	1557.487076	0	0	0	0	0	0	0	0	0
23	5011	Arkansas	Bradley	1695.439372	0	0	0	0	0	0	0	0	0

Figure 3.1.5. County proportion output table created by NANI-GIS tool.

3.2. Calculating CMAQ Grid Proportions

Unlike other NANI components, the atmospheric N deposition is not estimated from the county-based data in this example. Instead, it is based on the 36 km × 36 km grid map containing various N deposition estimates generated by the Community Multiscale Air Quality (CMAQ) model (Byun and Schere 2006). The CMAQ grid map and deposition estimates for each grid cell can be obtained using the Watershed Deposition Tool (WDT) available at http://www.epa.gov/AMD/EcoExposure/depositionMapping.html (Figure 3.2.1). A detailed instruction on obtaining and processing CMAQ data can be found in the documentation "Generating N Deposition Maps for SE US Watersheds" available at http://www.eeb.cornell.edu/biogeo/nanc/GIS_methods/gis_methods.htm.

As done in Section 3.1, start by opening the "NANI_GIS_Tool.mxd" file included in the toolbox package (Figure 3.1.1). Add the CMAQ grid map "CMAQ_Grid.shp" included in the toolbox package and the watershed map "US_Watersheds.shp" described in Section 2 (Figure 3.2.2). The attribute table of the CMAQ grid map is also shown in Figure 3.2.2. Again, the CMAQ grid map must have a column containing the unique identifier (in this example, "GRID_NAME").

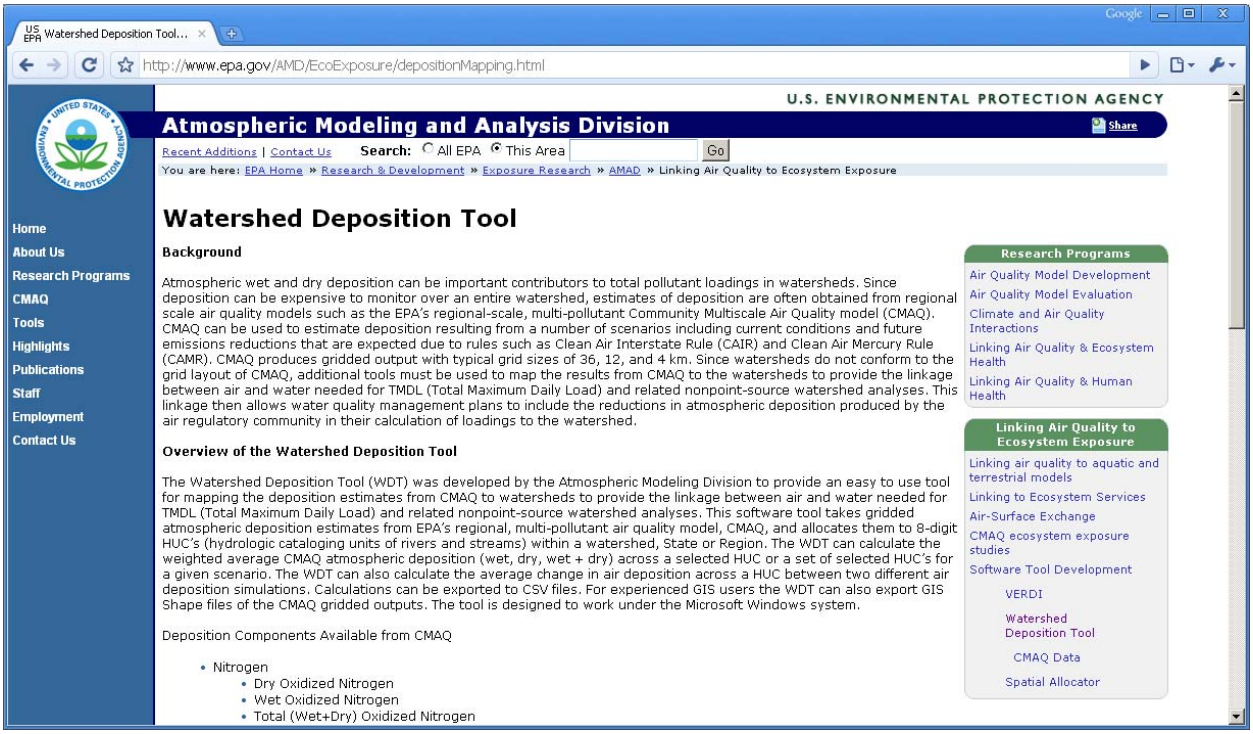


Figure 3.2.1. Watershed Deposition Tool website.

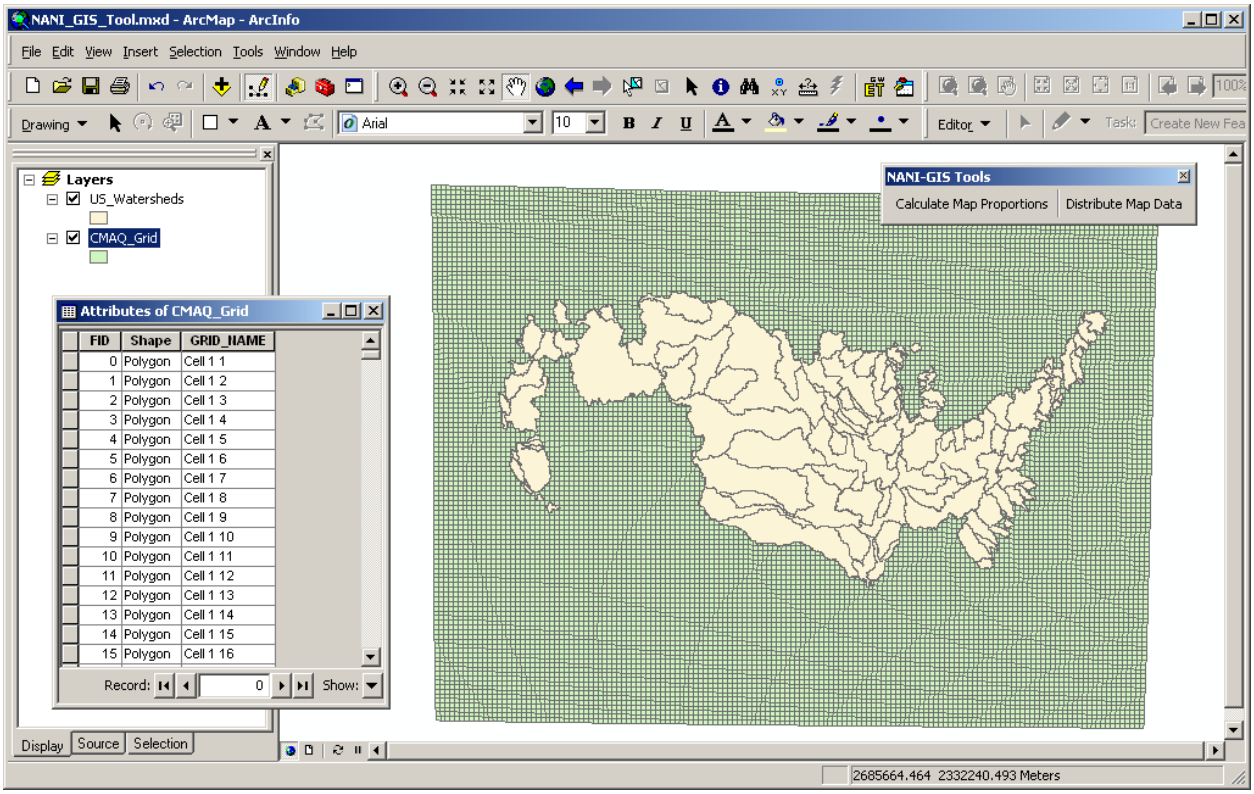


Figure 3.2.2. CMAQ grid and watershed maps added as input to NANI-GIS tool.

Click on “Calculate Map Proportions” and a tool window will appear (Figure 3.2.3). Choose the names of the watershed and CMAQ grid maps (“US_Watersheds” and “CMAQ_Grid”, respectively) and their unique identifiers (“W_CODE” and “GRID_NAME”, respectively). Unlike in the calculation of county proportion (Section 3.1), no additional output field names are selected (Figure 3.2.3). In this example, the output table and map names are specified as “Grid_Prop.txt” and “Grid_Prop.shp”, respectively.

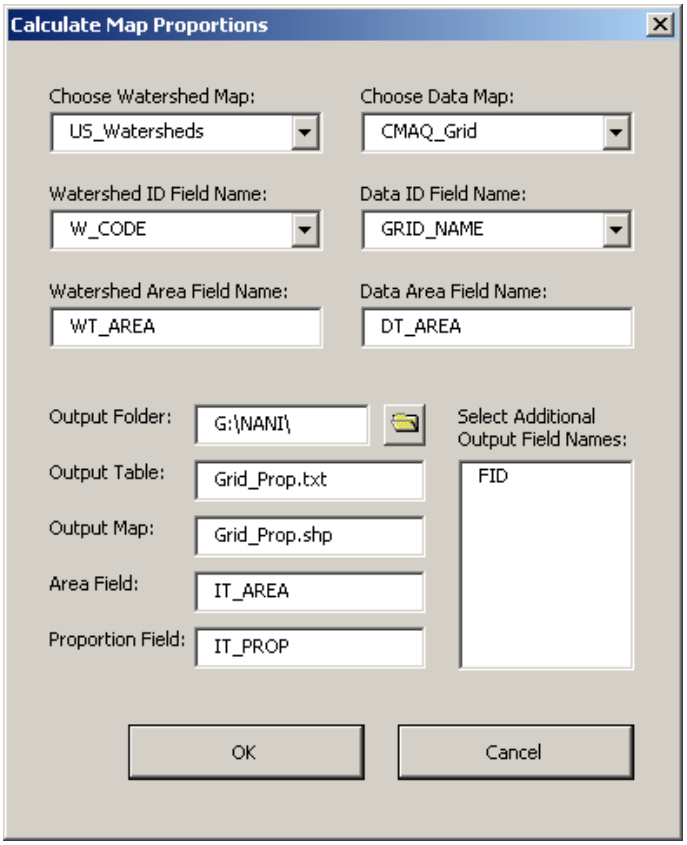


Figure 3.2.3. NANI-GIS tool window for calculating CMAQ grid proportions.

The calculation will be performed after clicking “OK”. Again, the tool first calculates the watershed and grid areas, intersect the watershed and grid maps, calculate the areas of intersected polygons, and calculate the proportions of CMAQ grids falling into each input watershed. The intersect map “Grid_Prop.shp” is added to ArcMap as output shapefile (Figure 3.2.4) and the output table “Grid_Prop.txt” (comma-delimited text file), which is used as input to the NANI-extraction (Section 4.4) and NANI-accounting (Section 5.4) tools, is created in the output folder. Figure 3.2.5 shows how the table looks like when opened with Microsoft Excel.

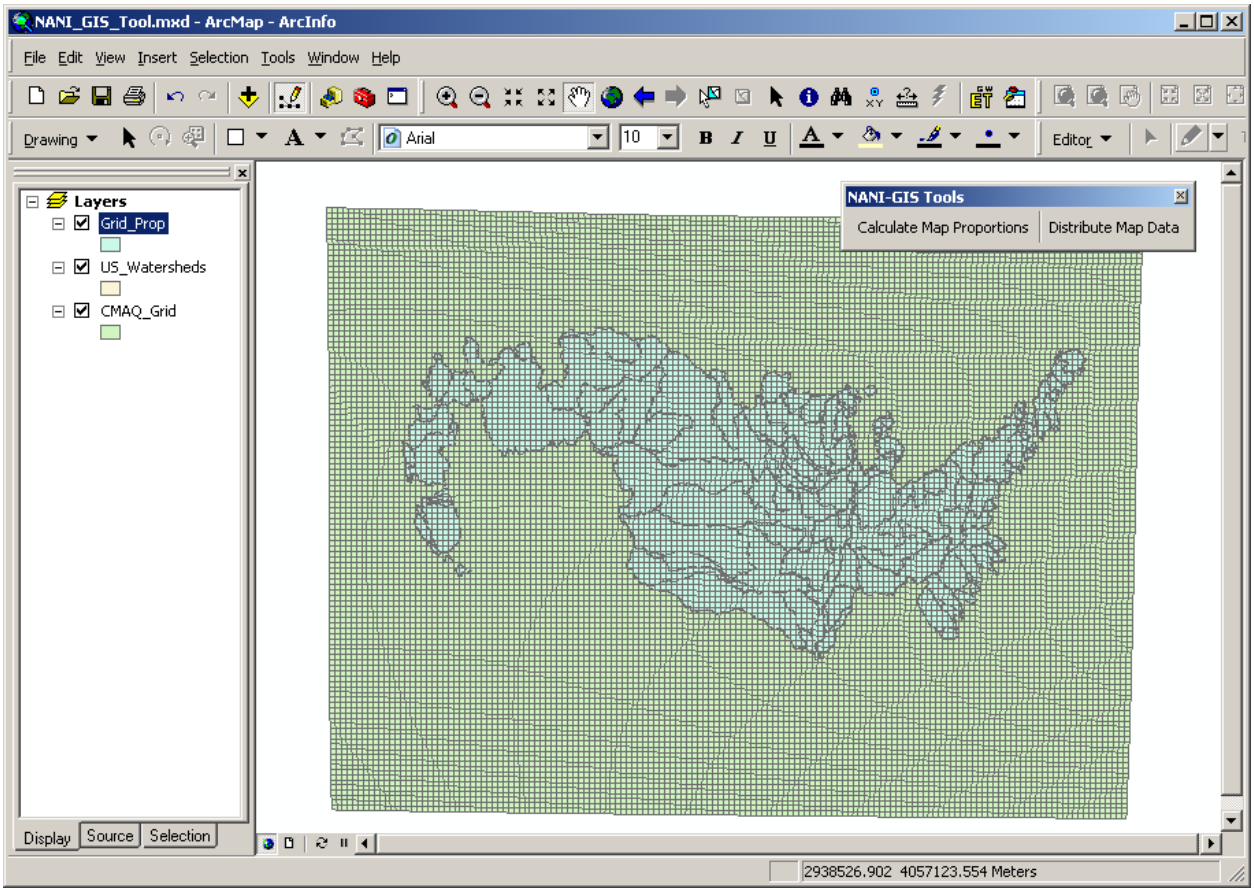
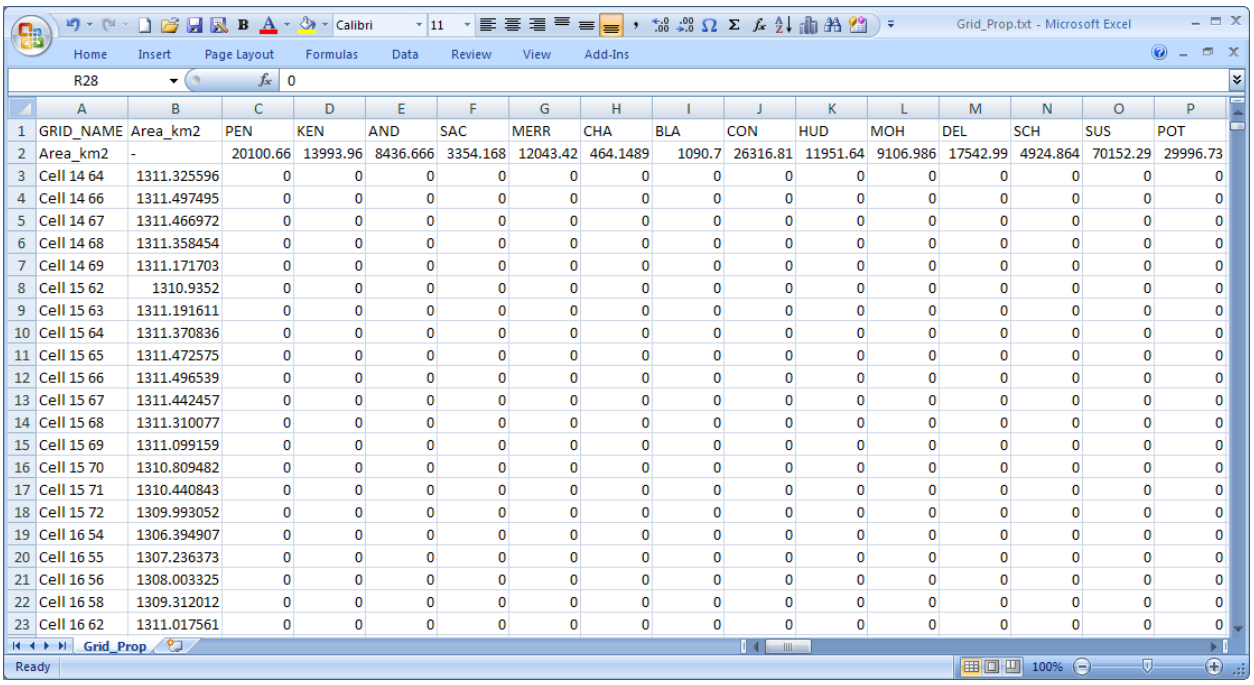


Figure 3.2.4. Grid intersect output map created by NANI-GIS tool.



Grid_Prop.txt - Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	GRID_NAME	Area_km2	PEN	KEN	AND	SAC	MERR	CHA	BLA	CON	HUD	MOH	DEL	SCH	SUS	POT
2	Area_km2	-	20100.66	13993.96	8436.666	3354.168	12043.42	464.1489	1090.7	26316.81	11951.64	9106.986	17542.99	4924.864	70152.29	29996.73
3	Cell 14 64	1311.325596	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Cell 14 66	1311.497495	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Cell 14 67	1311.466972	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Cell 14 68	1311.358454	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Cell 14 69	1311.171703	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Cell 15 62	1310.9352	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Cell 15 63	1311.191611	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Cell 15 64	1311.370836	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Cell 15 65	1311.472575	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Cell 15 66	1311.496539	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Cell 15 67	1311.442457	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	Cell 15 68	1311.310077	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Cell 15 69	1311.099159	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Cell 15 70	1310.809482	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Cell 15 71	1310.440843	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Cell 15 72	1309.993052	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Cell 16 54	1306.394907	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	Cell 16 55	1307.236373	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Cell 16 56	1308.003325	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Cell 16 58	1309.312012	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Cell 16 62	1311.017561	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3.2.5. Grid proportion output table created by NANI-GIS tool.

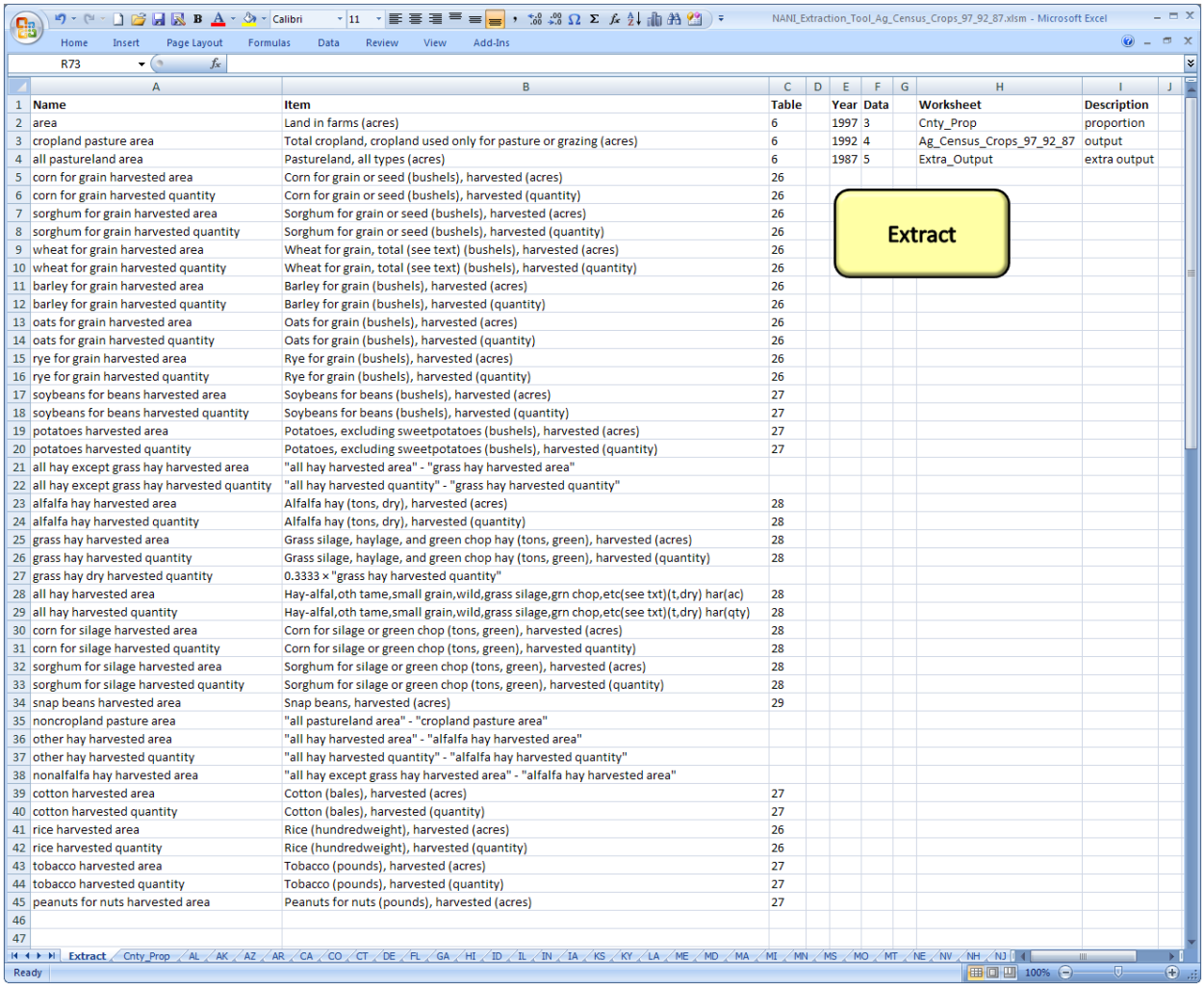
4. NANI-Extraction Tools

4.1. Extracting Agricultural Census Data

4.1.1. Extracting 1987, 1992, and 1997 Data

4.1.1.1. Extracting Crop Data

The Agricultural Census data are used to obtain the harvested crop areas and quantities and animal inventory and sales data, which in turn are used to calculate various NANI components such as crop and animal N production, animal N consumption, and agricultural N fixation. In this section, the harvested crop areas and quantities in 1987, 1992, and 1997 are extracted from the Agricultural Census database (downloaded from the Internet and stored in the form of its original structure) and organized into a format suitable as input to the NANI-accounting tools (Section 5) using one of the NANI-extraction tools included in the toolbox package "NANI_Extraction_Tool_Ag_Census_Crops_97_92_87.xlsm" (Figure 4.1.1.1.1).



	Name	Item	Table	Year	Data	Worksheet	Description
2	area	Land in farms (acres)	6	1997	3	Cnty_Prop	proportion
3	cropland pasture area	Total cropland, cropland used only for pasture or grazing (acres)	6	1992	4	Ag_Census_Crops_97_92_87	output
4	all pastureland area	Pastureland, all types (acres)	6	1987	5	Extra_Output	extra output
5	corn for grain harvested area	Corn for grain or seed (bushels), harvested (acres)	26				
6	corn for grain harvested quantity	Corn for grain or seed (bushels), harvested (quantity)	26				
7	sorghum for grain harvested area	Sorghum for grain or seed (bushels), harvested (acres)	26				
8	sorghum for grain harvested quantity	Sorghum for grain or seed (bushels), harvested (quantity)	26				
9	wheat for grain harvested area	Wheat for grain, total (see text) (bushels), harvested (acres)	26				
10	wheat for grain harvested quantity	Wheat for grain, total (see text) (bushels), harvested (quantity)	26				
11	barley for grain harvested area	Barley for grain (bushels), harvested (acres)	26				
12	barley for grain harvested quantity	Barley for grain (bushels), harvested (quantity)	26				
13	oats for grain harvested area	Oats for grain (bushels), harvested (acres)	26				
14	oats for grain harvested quantity	Oats for grain (bushels), harvested (quantity)	26				
15	rye for grain harvested area	Rye for grain (bushels), harvested (acres)	26				
16	rye for grain harvested quantity	Rye for grain (bushels), harvested (quantity)	26				
17	soybeans for beans harvested area	Soybeans for beans (bushels), harvested (acres)	27				
18	soybeans for beans harvested quantity	Soybeans for beans (bushels), harvested (quantity)	27				
19	potatoes harvested area	Potatoes, excluding sweetpotatoes (bushels), harvested (acres)	27				
20	potatoes harvested quantity	Potatoes, excluding sweetpotatoes (bushels), harvested (quantity)	27				
21	all hay except grass hay harvested area	"all hay harvested area" - "grass hay harvested area"					
22	all hay except grass hay harvested quantity	"all hay harvested quantity" - "grass hay harvested quantity"					
23	alfalfa hay harvested area	Alfalfa hay (tons, dry), harvested (acres)	28				
24	alfalfa hay harvested quantity	Alfalfa hay (tons, dry), harvested (quantity)	28				
25	grass hay harvested area	Grass silage, haylage, and green chop hay (tons, green), harvested (acres)	28				
26	grass hay harvested quantity	Grass silage, haylage, and green chop hay (tons, green), harvested (quantity)	28				
27	grass hay dry harvested quantity	0.3333 × "grass hay harvested quantity"					
28	all hay harvested area	Hay-alfal,oth tame,small grain,wild,grass silage,grn chop,etc(see txt)(t,dry) har(ac)	28				
29	all hay harvested quantity	Hay-alfal,oth tame,small grain,wild,grass silage,grn chop,etc(see txt)(t,dry) har(qty)	28				
30	corn for silage harvested area	Corn for silage or green chop (tons, green), harvested (acres)	28				
31	corn for silage harvested quantity	Corn for silage or green chop (tons, green), harvested quantity)	28				
32	sorghum for silage harvested area	Sorghum for silage or green chop (tons, green), harvested (acres)	28				
33	sorghum for silage harvested quantity	Sorghum for silage or green chop (tons, green), harvested (quantity)	28				
34	snap beans harvested area	Snap beans, harvested (acres)	29				
35	noncropland pasture area	"all pastureland area" - "cropland pasture area"					
36	other hay harvested area	"all hay harvested area" - "alfalfa hay harvested area"					
37	other hay harvested quantity	"all hay harvested quantity" - "alfalfa hay harvested quantity"					
38	nonalfalfa hay harvested area	"all hay except grass hay harvested area" - "alfalfa hay harvested area"					
39	cotton harvested area	Cotton (bales), harvested (acres)	27				
40	cotton harvested quantity	Cotton (bales), harvested (quantity)	27				
41	rice harvested area	Rice (hundredweight), harvested (acres)	26				
42	rice harvested quantity	Rice (hundredweight), harvested (quantity)	26				
43	tobacco harvested area	Tobacco (pounds), harvested (acres)	27				
44	tobacco harvested quantity	Tobacco (pounds), harvested (quantity)	27				
45	peanuts for nuts harvested area	Peanuts for nuts (pounds), harvested (acres)	27				

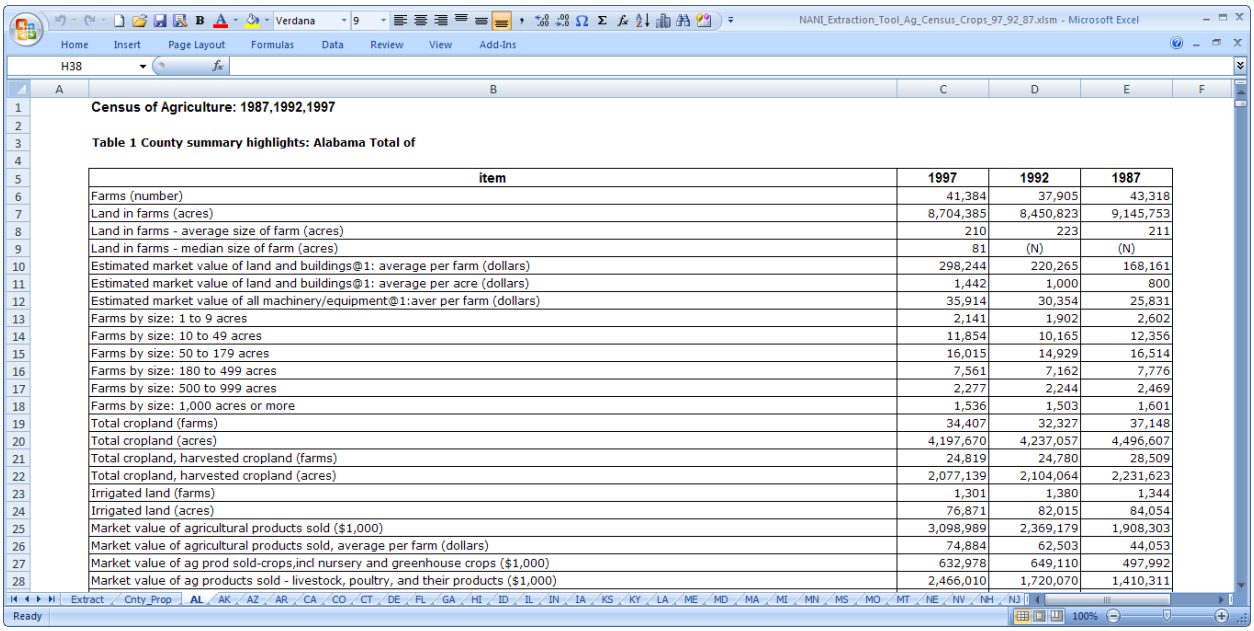
Figure 4.1.1.1.1. Extracting 1987, 1992, and 1997 crop data from Agricultural Census.

The extraction tool is implemented as a Microsoft Excel 2007 workbook (xlsm extension). Although the same tool may be implemented as the Microsoft Excel 97-2003 workbook (xls extension), Excel 2007 is more efficient in dealing with large datasets, and so is the version of choice for this application. To extract the 1987, 1992, and 1997 crop data from Agricultural Census, open the file "NANI_Extraction_Tool_Ag_Census_Crops_97_92_87.xlsm" with Excel 2007 (Figure 4.1.1.1.1). (Note that the 2002 and 2007 Agricultural Census data have a different structure and are extracted using a separate extraction tool, as described in Section 4.1.2.)

The first worksheet "Extract" contains a list of Agricultural Census items to be extracted. Although both the crop and animal items can be extracted using a single extraction tool, in this example only the crop items are extracted for the ease of organizing the extracted data. (The animal items are extracted using the same tool in Section 4.1.1.2.) Column A contains the user-specified names of the Agricultural Census items, and Columns B and C contain the full names and table numbers, respectively, that can be found in the Agricultural Census database. Note that some items are expressed as simple algebraic equations in Column B, for example "all hay harvested area" - "grass hay harvested area" (Cell B21). These items are not extracted from the Agricultural Census database but derived by combining multiple Agricultural Census items that can be found from the list. Calculation of the derived items is based on Boyer et al. (2002). Algebraic expressions that can be used by the user include:

- Addition or subtraction of multiple items: "+" or "-" (e.g., "a" + "b" - "c")
- Multiplication of coefficient: "×" or "*" (e.g., 2 × "a" or 2 * "a")
- Minimum or maximum of two items: "MIN" or "MAX" (e.g., MIN: "a", "b")

Column E of the extraction worksheet contains a list of years for the extraction, and Column G specifies the column number where the data for each specified year can be found in the data worksheets (Figure 4.1.1.1.2).



item	1997	1992	1987
Farms (number)	41,384	37,905	43,318
Land in farms (acres)	8,704,385	8,450,823	9,145,753
Land in farms - average size of farm (acres)	210	223	211
Land in farms - median size of farm (acres)	81	(N)	(N)
Estimated market value of land and buildings@1: average per farm (dollars)	298,244	220,265	168,161
Estimated market value of land and buildings@1: average per acre (dollars)	1,442	1,000	800
Estimated market value of all machinery/equipment@1:aver per farm (dollars)	35,914	30,354	25,831
Farms by size: 1 to 9 acres	2,141	1,902	2,602
Farms by size: 10 to 49 acres	11,854	10,165	12,356
Farms by size: 50 to 179 acres	16,015	14,929	16,514
Farms by size: 180 to 499 acres	7,561	7,162	7,776
Farms by size: 500 to 999 acres	2,277	2,244	2,469
Farms by size: 1,000 acres or more	1,536	1,503	1,601
Total cropland (farms)	34,407	32,327	37,148
Total cropland (acres)	4,197,670	4,237,057	4,496,607
Total cropland, harvested cropland (farms)	24,819	24,780	28,509
Total cropland, harvested cropland (acres)	2,077,139	2,104,064	2,231,623
Irrigated land (farms)	1,301	1,380	1,344
Irrigated land (acres)	76,871	82,015	84,054
Market value of agricultural products sold ($1,000)	3,098,989	2,369,179	1,908,303
Market value of agricultural products sold, average per farm (dollars)	74,884	62,503	44,053
Market value of ag prod sold-crops,incl nursery and greenhouse crops ($1,000)	632,978	649,110	497,992
Market value of ag products sold - livestock, poultry, and their products ($1,000)	2,466,010	1,720,070	1,410,311

Figure 4.1.1.1.2. Worksheets containing 1987, 1992, and 1997 Agricultural Census data.

Columns H and I of the extraction worksheet are used to specify the names of the input and output worksheets. The user needs to specify the names of the input worksheet "proportion" (county proportion worksheet imported from the text file output created by the NANI-GIS tool described in Section 3.1; see Figure 3.1.5), and the output worksheets "output" (used as input to the NANI-accounting tool in Sections 5.1.1 and 5.2) and "extra output" (additional information that is not directly used by the NANI-accounting tool). The worksheets that follow the county proportion worksheet "Cnty_Prop" contain the Agricultural Census data downloaded from http://agcensus.mannlib.cornell.edu/ (Figure 4.1.1.1.3).

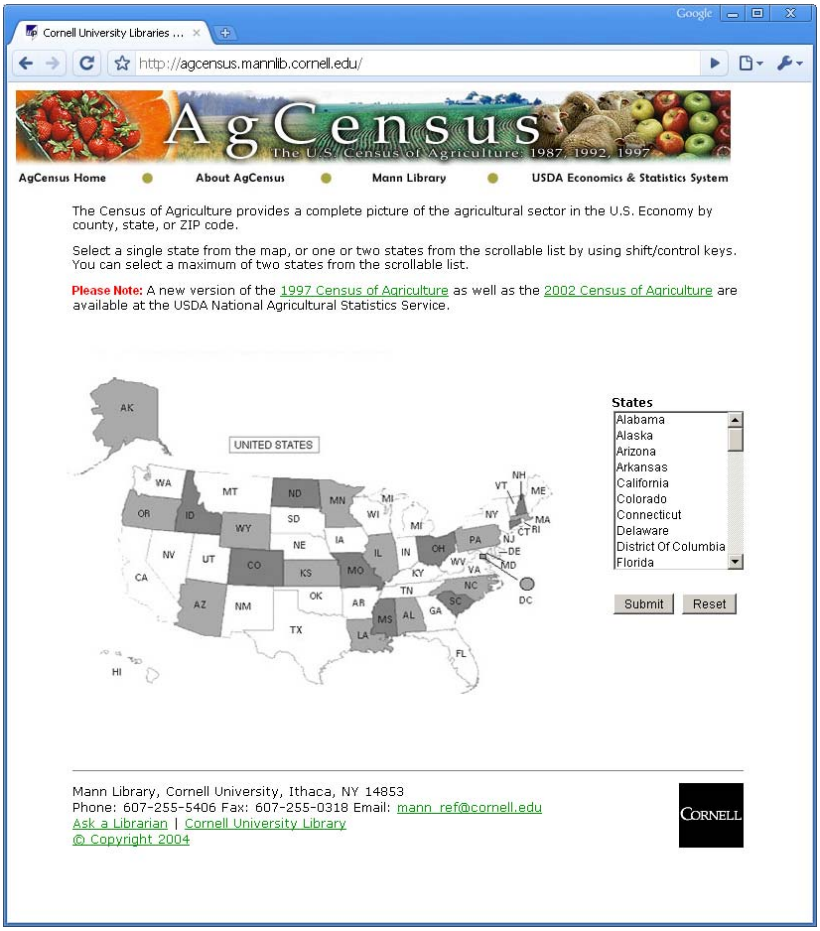


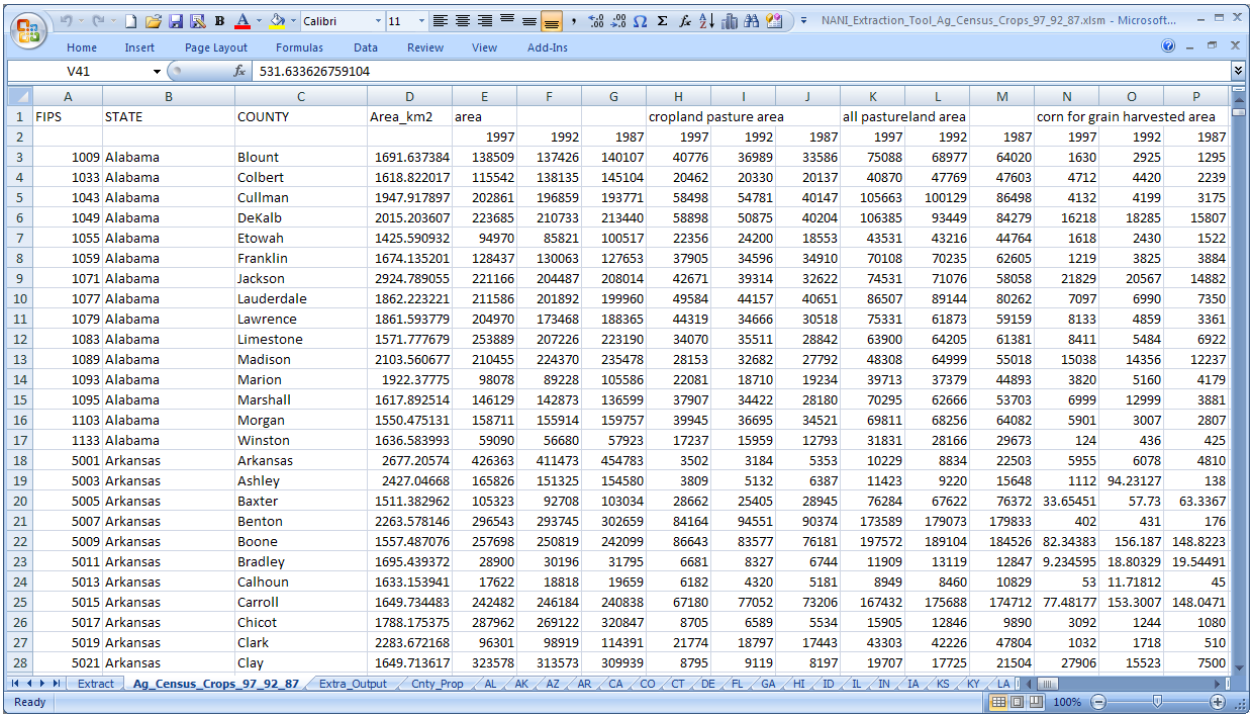
Figure 4.1.1.1.3. Agricultural Census data available at http://agcensus.mannlib.cornell.edu/.

The website provides Agricultural Census data in 1987, 1992, and 1997. To download the data, first select the state, click on "Submit Query", select counties of interest, click on "Submit Query" again, select tables of interest, and click on "Submit Query" again. After the relevant data are downloaded, they can be saved as an html file, which can then be imported into Microsoft Excel as shown in Figure 4.1.1.1.2. The extraction tool included in the toolbox package contains the entire Agricultural Census data downloaded from this website, each state stored in a separate worksheet. The original dataset available on the web had a number of issues and some modifications were needed before being used as input to the extraction tool:

- When the data for Arkansas County, Arkansas were downloaded, the Arkansas state data were provided instead of the county data.
- Sometimes the same item for the same county appeared twice, and when it appeared the second time, the reported value was incorrect. The current version of the extraction tool issues warning messages for the items that appear more than once, and the duplicated items are ignored.
- Data for Woodford County, Kentucky were missing.
- Pottawattamie County, Iowa was misspelled as "Pottawattami".

Data problems were fixed based on the original Agricultural Census publications (pdf files downloadable from http://www.agcensus.usda.gov/) before being used as input to the extraction tool. Adjustments were also made in the county names of the US county map (Figure 3.1.2) to resolve the misspelling and other county name discrepancy issues.

Before running the extraction tool, the user may replace the county proportion table and revise the list of Agricultural Census items as appropriate. Click on the "Extract" button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example "Ag_Census_Crops_97_92_87" (Figure 4.1.1.1.4).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	FIPS	STATE	COUNTY	Area_km2	area			cropland pasture area			all pastureland area			corn for grain harvested area		
2					1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
3	1009	Alabama	Blount	1691.637384	138509	137426	140107	40776	36989	33586	75088	68977	64020	1630	2925	1295
4	1033	Alabama	Colbert	1618.822017	115542	138135	145104	20462	20330	20137	40870	47769	47603	4712	4420	2239
5	1043	Alabama	Cullman	1947.917897	202861	196859	193771	58498	54781	40147	105663	100129	86498	4132	4199	3175
6	1049	Alabama	DeKalb	2015.203607	223685	210733	213440	58898	50875	40204	106385	93449	84279	16218	18285	15807
7	1055	Alabama	Etowah	1425.590932	94970	85821	100517	22356	24200	18553	43531	43216	44764	1618	2430	1522
8	1059	Alabama	Franklin	1674.135201	128437	130063	127653	37905	34596	34910	70108	70235	62605	1219	3825	3884
9	1071	Alabama	Jackson	2924.789055	221166	204487	208014	42671	39314	32622	74531	71076	58058	21829	20567	14882
10	1077	Alabama	Lauderdale	1862.223221	211586	201892	199960	49584	44157	40651	86507	89144	80262	7097	6990	7350
11	1079	Alabama	Lawrence	1861.593779	204970	173468	188365	44319	34666	30518	75331	61873	59159	8133	4859	3361
12	1083	Alabama	Limestone	1571.777679	253889	207226	223190	34070	35511	28842	63900	64205	61381	8411	5484	6922
13	1089	Alabama	Madison	2103.560677	210455	224370	235478	28153	32682	27792	48308	64999	55018	15038	14356	12237
14	1093	Alabama	Marion	1922.37775	98078	89228	105586	22081	18710	19234	39713	37379	44893	3820	5160	4179
15	1095	Alabama	Marshall	1617.892514	146129	142873	136599	37907	34422	28180	70295	62666	53703	6999	12999	3881
16	1103	Alabama	Morgan	1550.475131	158711	155914	159757	39945	36695	34521	69811	68256	64082	5901	3007	2807
17	1133	Alabama	Winston	1636.583993	59090	56680	57923	17237	15959	12793	31831	28166	29673	124	436	425
18	5001	Arkansas	Arkansas	2677.20574	426363	411473	454783	3502	3184	5353	10229	8834	22503	5955	6078	4810
19	5003	Arkansas	Ashley	2427.04668	165826	151325	154580	3809	5132	6387	11423	9220	15648	1112	94.23127	138
20	5005	Arkansas	Baxter	1511.382962	105323	92708	103034	28662	25405	28945	76284	67622	76372	33.65451	57.73	63.3367
21	5007	Arkansas	Benton	2263.578146	296543	293745	302659	84164	94551	90374	173589	179073	179833	402	431	176
22	5009	Arkansas	Boone	1557.487076	257698	250819	242099	86643	83577	76181	197572	189104	184526	82.34383	156.187	148.8223
23	5011	Arkansas	Bradley	1695.439372	28900	30196	31795	6681	8327	6744	11909	13119	12847	9.234595	18.80329	19.54491
24	5013	Arkansas	Calhoun	1633.153941	17622	18818	19659	6182	4320	5181	8949	8460	10829	53	11.71812	45
25	5015	Arkansas	Carroll	1649.734483	242482	246184	240838	67180	77052	73206	167432	175688	174712	77.48177	153.3007	148.0471
26	5017	Arkansas	Chicot	1788.175375	287962	269122	320847	8705	6589	5534	15905	12846	9890	3092	1244	1080
27	5019	Arkansas	Clark	2283.672168	96301	98919	114391	21774	18797	17443	43303	42226	47804	1032	1718	510
28	5021	Arkansas	Clay	1649.713617	323578	313573	309939	8795	9119	8197	19707	17725	21504	27906	15523	7500

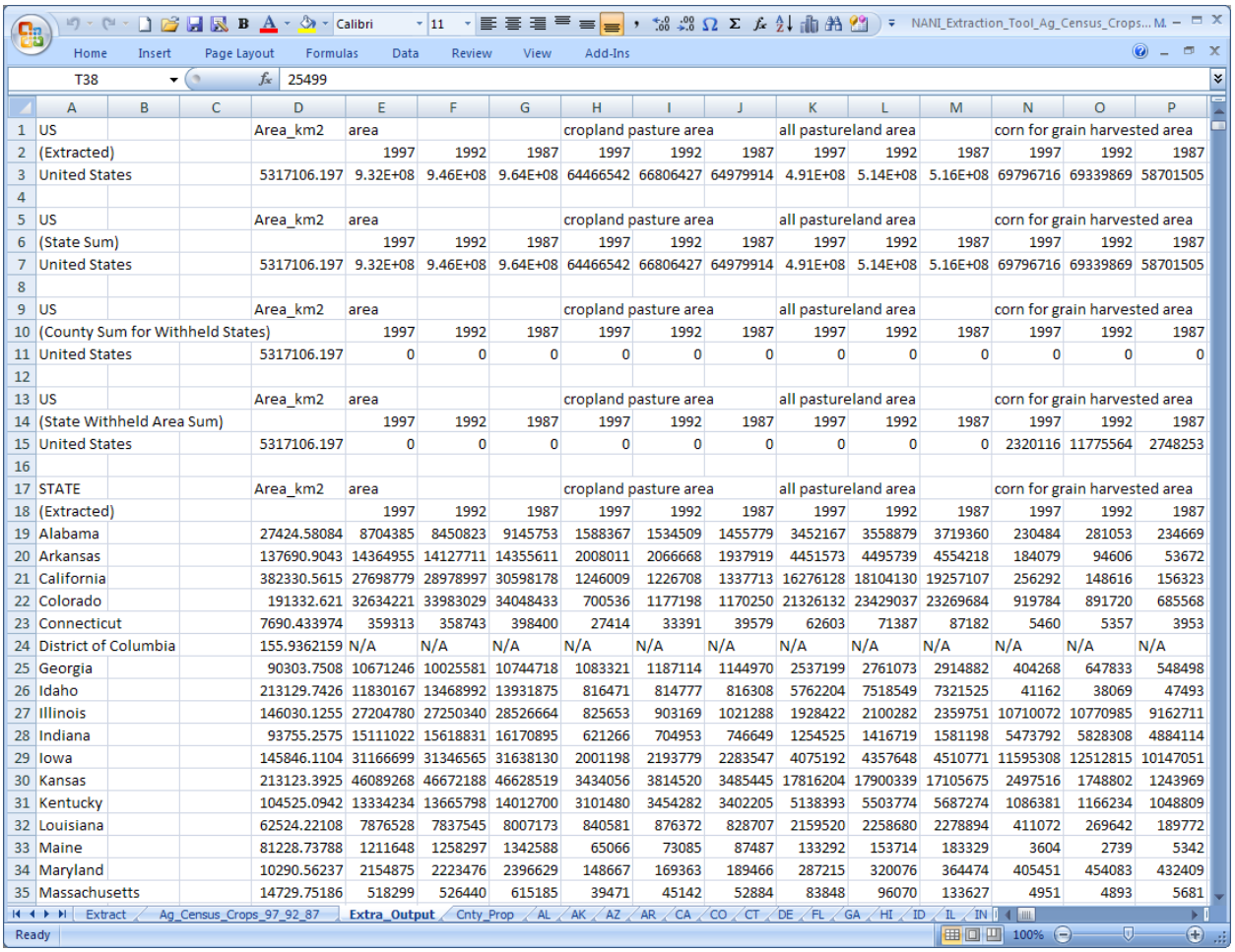
Figure 4.1.1.1.4. The 1987, 1992, and 1997 crop data extracted using NANI-extraction tool.

In the original Agricultural Census data (Figure 4.1.1.1.2), the "(D)" and "(N)" represent "withheld to avoid disclosing data for individual farms" and "not available", respectively. The current extraction tool allows the user to estimate the values of missing or withheld items. Following the guidelines described in Chinkin et al. (2003), the toolbox estimates the items withheld at the county level by calculating the difference between the value for the state

(reported in Agricultural Census) and the total for the counties where the item of interest is not withheld, and apportioning the difference to each of the withheld counties in proportion to the variable of the user's choice that can be found in the Agricultural Census. The variable used for apportioning must be specified as the first item of the list given in the "Extract" worksheet, in this example "Land in farms (acres)" with the user-specified item name "area" (Figure 4.1.1.1.1). In case where the state data are withheld, they are estimated by applying the same procedure using the value for the US (again reported in Agricultural Census).

The "N/A" in the output worksheet is noted by the extraction tool, indicating that the item is not found from the database at the specified county. The Agricultural Census data are not reported in some counties such as District of Columbia and "independent cities" (e.g., Buena Vista) in Virginia, although the Census data (e.g., population) may be reported in those counties. Any missing, incomplete, or inaccurate items may be modified by the user at this stage before being used as input to the NANI-accounting tool (Section 5), if auxiliary data exist.

There is a number of additional information reported to the "extra output" worksheet, in this example "Extra_Output" (Figure 4.1.1.1.5), that may be useful for checking calculations or other purposes.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	US			Area_km2	area			cropland pasture area			all pastureland area			corn for grain harvested area		
2	(Extracted)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
3	United States			5317106.197	9.32E+08	9.46E+08	9.64E+08	64466542	66806427	64979914	4.91E+08	5.14E+08	5.16E+08	69796716	69339869	58701505
4																
5	US			Area_km2	area			cropland pasture area			all pastureland area			corn for grain harvested area		
6	(State Sum)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
7	United States			5317106.197	9.32E+08	9.46E+08	9.64E+08	64466542	66806427	64979914	4.91E+08	5.14E+08	5.16E+08	69796716	69339869	58701505
8																
9	US			Area_km2	area			cropland pasture area			all pastureland area			corn for grain harvested area		
10	(County Sum for Withheld States)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
11	United States			5317106.197	0	0	0	0	0	0	0	0	0	0	0	0
12																
13	US			Area_km2	area			cropland pasture area			all pastureland area			corn for grain harvested area		
14	(State Withheld Area Sum)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
15	United States			5317106.197	0	0	0	0	0	0	0	0	0	2320116	11775564	2748253
16																
17	STATE			Area_km2	area			cropland pasture area			all pastureland area			corn for grain harvested area		
18	(Extracted)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
19	Alabama			27424.58084	8704385	8450823	9145753	1588367	1534509	1455779	3452167	3558879	3719360	230484	281053	234669
20	Arkansas			137690.9043	14364955	14127711	14355611	2008011	2066668	1937919	4451573	4495739	4554218	184079	94606	53672
21	California			382330.5615	27698779	28978997	30598178	1246009	1226708	1337713	16276128	18104130	19257107	256292	148616	156323
22	Colorado			191332.621	32634221	33983029	34048433	700536	1177198	1170250	21326132	23429037	23269684	919784	891720	685568
23	Connecticut			7690.433974	359313	358743	398400	27414	33391	39579	62603	71387	87182	5460	5357	3953
24	District of Columbia			155.9362159	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25	Georgia			90303.7508	10671246	10025581	10744718	1083321	1187114	1144970	2537199	2761073	2914882	404268	647833	548498
26	Idaho			213129.7426	11830167	13468992	13931875	816471	814777	816308	5762204	7518549	7321525	41162	38069	47493
27	Illinois			146030.1255	27204780	27250340	28526664	825653	903169	1021288	1928422	2100282	2359751	10710072	10770985	9162711
28	Indiana			93755.2575	15111022	15618831	16170895	621266	704953	746649	1254525	1416719	1581198	5473792	5828308	4884114
29	Iowa			145846.1104	31166699	31346565	31638130	2001198	2193779	2283547	4075192	4357648	4510771	11595308	12512815	10147051
30	Kansas			213123.3925	46089268	46672188	46628519	3434056	3814520	3485445	17816204	17900339	17105675	2497516	1748802	1243969
31	Kentucky			104525.0942	13334234	13665798	14012700	3101480	3454282	3402205	5138393	5503774	5687274	1086381	1166234	1048809
32	Louisiana			62524.22108	7876528	7837545	8007173	840581	876372	828707	2159520	2258680	2278894	411072	269642	189772
33	Maine			81228.73788	1211648	1258297	1342588	65066	73085	87487	133292	153714	183329	3604	2739	5342
34	Maryland			10290.56237	2154875	2223476	2396629	148667	169363	189466	287215	320076	364474	405451	454083	432409
35	Massachusetts			14729.75186	518299	526440	615185	39471	45142	52884	83848	96070	133627	4951	4893	5681

Figure 4.1.1.1.5. Extra output generated while extracting 1987, 1992, and 1997 crop data.

The tables generated in the extra output worksheet include (in the order of appearance):

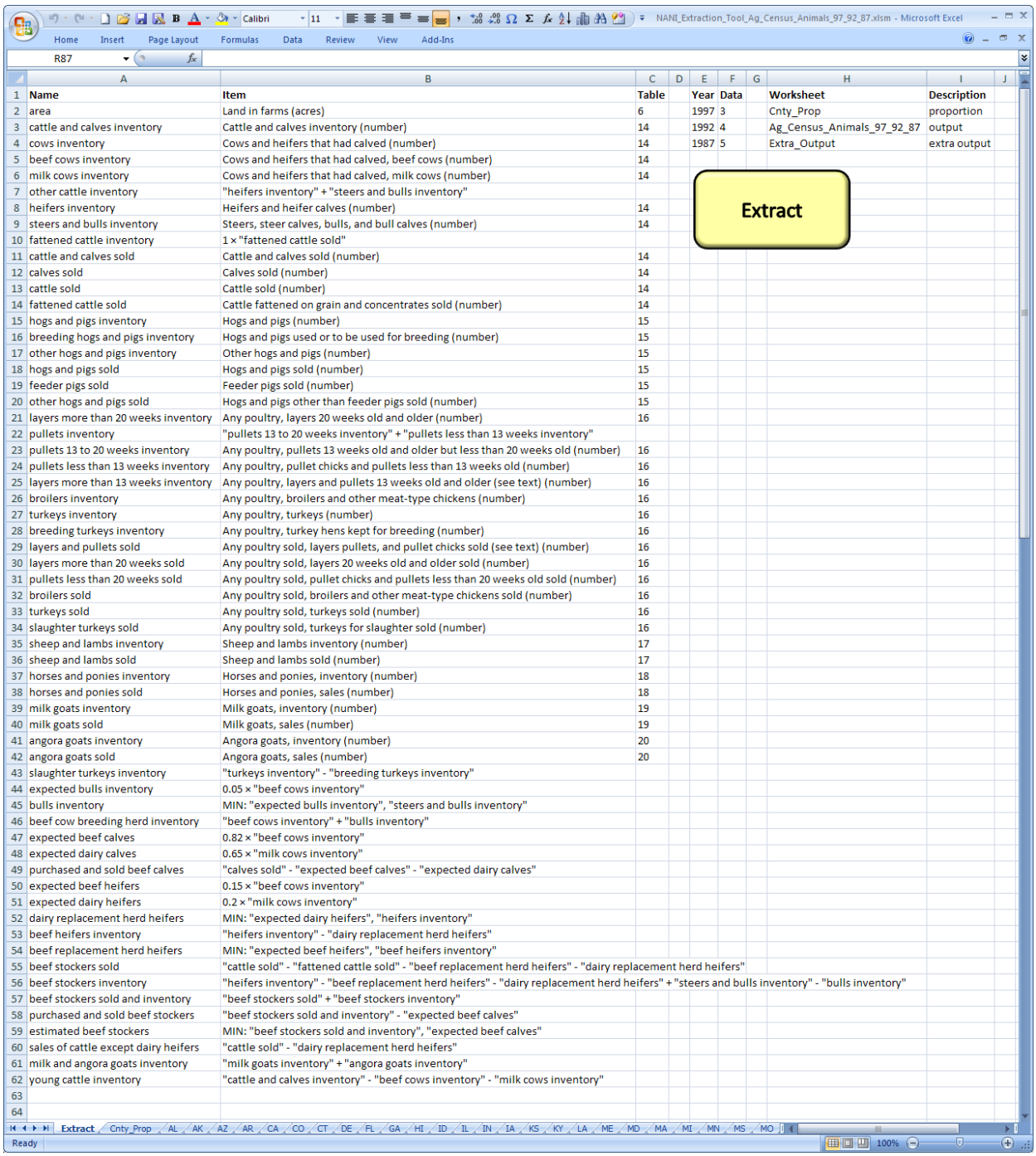
- US values extracted from the original Agricultural Census database (before the withheld are estimated).
- US total for the states where the item of interest is not withheld.
- Sum of the values for the counties where the item of interest is withheld in their states.
- Sum of the "area" values for the withheld states.
- State values extracted from the original Agricultural Census database (before the withheld are estimated).
- State values with the withheld data estimated following the procedure described in this section (Chinkin et al. 2003).
- State total for the counties where the item of interest is not withheld. (The "all other counties", if exist, are excluded.)
- Values for the "all other counties", if exist.
- Sum of the "area" values for the withheld counties.
- County values extracted from the original Agricultural Census database (before the withheld are estimated).

After the crop data are extracted from the Agricultural Census database, they can be used as input to the NANI-accounting tool calculating crop N production (Section 5.1.1) and agricultural N fixation (Section 5.2).

4.1.1.2. Extracting Animal Data

In this section, the animal inventory and sales data in 1987, 1992, and 1997 are extracted from the Agricultural Census database (downloaded from the Internet and stored in the form of its original structure) and organized into a format suitable as input to the NANI-accounting tools (Section 5) using one of the NANI-extraction tools included in the toolbox package "NANI_Extraction_Tool_Ag_Census_Animals_97_92_87.xlsm" (Figure 4.1.1.2.1). Note that it is the same extraction tool as "NANI_Extraction_Tool_Ag_Census_Crops_97_92_87.xlsm" described in Section 4.1.1.1, except for the list of items to be extracted. It is possible to extract the crop and animal data in a single run, although in this example they are extracted separately for the data organization purpose. Detailed descriptions on the specification of the extraction tool, input data structure, and output worksheets are given in Section 4.1.1.1.

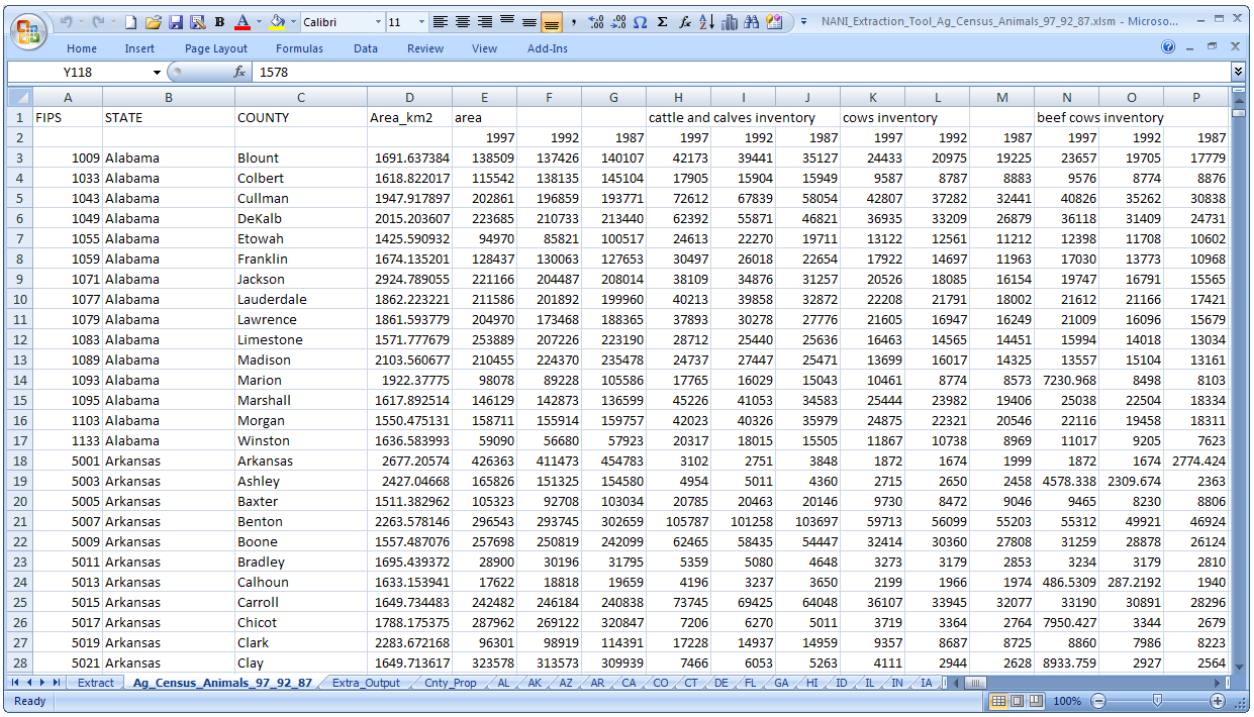
To extract the 1987, 1992, and 1997 animal data from Agricultural Census, open the file "NANI_Extraction_Tool_Ag_Census_Animals_97_92_87.xlsm" with Excel 2007 (Figure 4.1.1.2.1). Before running the extraction tool, the user may replace the county proportion table and revise the list of Agricultural Census items as appropriate. Calculation of the derived items shown in Figure 4.1.1.2.1 is based on Kellogg et al. (2000) and Boyer et al. (2002). Click on the "Extract" button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example "Ag_Census_Animals_97_92_87" (Figure 4.1.1.2.2).



	Name	Item	Table	Year	Data	Worksheet	Description
2	area	Land in farms (acres)	6	1997	3	Cnty_Prop	proportion
3	cattle and calves inventory	Cattle and calves inventory (number)	14	1992	4	Ag_Census_Animals_97_92_87	output
4	cows inventory	Cows and heifers that had calved (number)	14	1987	5	Extra_Output	extra output
5	beef cows inventory	Cows and heifers that had calved, beef cows (number)	14				
6	milk cows inventory	Cows and heifers that had calved, milk cows (number)	14				
7	other cattle inventory	"heifers inventory" + "steers and bulls inventory"					
8	heifers inventory	Heifers and heifer calves (number)	14				
9	steers and bulls inventory	Steers, steer calves, bulls, and bull calves (number)	14				
10	fattened cattle inventory	1 × "fattened cattle sold"					
11	cattle and calves sold	Cattle and calves sold (number)	14				
12	calves sold	Calves sold (number)	14				
13	cattle sold	Cattle sold (number)	14				
14	fattened cattle sold	Cattle fattened on grain and concentrates sold (number)	14				
15	hogs and pigs inventory	Hogs and pigs (number)	15				
16	breeding hogs and pigs inventory	Hogs and pigs used or to be used for breeding (number)	15				
17	other hogs and pigs inventory	Other hogs and pigs (number)	15				
18	hogs and pigs sold	Hogs and pigs sold (number)	15				
19	feeder pigs sold	Feeder pigs sold (number)	15				
20	other hogs and pigs sold	Hogs and pigs other than feeder pigs sold (number)	15				
21	layers more than 20 weeks inventory	Any poultry, layers 20 weeks old and older (number)	16				
22	pullets inventory	"pullets 13 to 20 weeks inventory" + "pullets less than 13 weeks inventory"					
23	pullets 13 to 20 weeks inventory	Any poultry, pullets 13 weeks old and older but less than 20 weeks old (number)	16				
24	pullets less than 13 weeks inventory	Any poultry, pullet chicks and pullets less than 13 weeks old (number)	16				
25	layers more than 13 weeks inventory	Any poultry, layers and pullets 13 weeks old and older (see text) (number)	16				
26	broilers inventory	Any poultry, broilers and other meat-type chickens (number)	16				
27	turkeys inventory	Any poultry, turkeys (number)	16				
28	breeding turkeys inventory	Any poultry, turkey hens kept for breeding (number)	16				
29	layers and pullets sold	Any poultry sold, layers pullets, and pullet chicks sold (see text) (number)	16				
30	layers more than 20 weeks sold	Any poultry sold, layers 20 weeks old and older sold (number)	16				
31	pullets less than 20 weeks sold	Any poultry sold, pullet chicks and pullets less than 20 weeks old sold (number)	16				
32	broilers sold	Any poultry sold, broilers and other meat-type chickens sold (number)	16				
33	turkeys sold	Any poultry sold, turkeys sold (number)	16				
34	slaughter turkeys sold	Any poultry sold, turkeys for slaughter sold (number)	16				
35	sheep and lambs inventory	Sheep and lambs inventory (number)	17				
36	sheep and lambs sold	Sheep and lambs sold (number)	17				
37	horses and ponies inventory	Horses and ponies, inventory (number)	18				
38	horses and ponies sold	Horses and ponies, sales (number)	18				
39	milk goats inventory	Milk goats, inventory (number)	19				
40	milk goats sold	Milk goats, sales (number)	19				
41	angora goats inventory	Angora goats, inventory (number)	20				
42	angora goats sold	Angora goats, sales (number)	20				
43	slaughter turkeys inventory	"turkeys inventory" - "breeding turkeys inventory"					
44	expected bulls inventory	0.05 × "beef cows inventory"					
45	bulls inventory	MIN: "expected bulls inventory", "steers and bulls inventory"					
46	beef cow breeding herd inventory	"beef cows inventory" + "bulls inventory"					
47	expected beef calves	0.82 × "beef cows inventory"					
48	expected dairy calves	0.65 × "milk cows inventory"					
49	purchased and sold beef calves	"calves sold" - "expected beef calves" - "expected dairy calves"					
50	expected beef heifers	0.15 × "beef cows inventory"					
51	expected dairy heifers	0.2 × "milk cows inventory"					
52	dairy replacement herd heifers	MIN: "expected dairy heifers", "heifers inventory"					
53	beef heifers inventory	"heifers inventory" - "dairy replacement herd heifers"					
54	beef replacement herd heifers	MIN: "expected beef heifers", "beef heifers inventory"					
55	beef stockers sold	"cattle sold" - "fattened cattle sold" - "beef replacement herd heifers" - "dairy replacement herd heifers"					
56	beef stockers inventory	"heifers inventory" - "beef replacement herd heifers" - "dairy replacement herd heifers" + "steers and bulls inventory" - "bulls inventory"					
57	beef stockers sold and inventory	"beef stockers sold" + "beef stockers inventory"					
58	purchased and sold beef stockers	"beef stockers sold and inventory" - "expected beef calves"					
59	estimated beef stockers	MIN: "beef stockers sold and inventory", "expected beef calves"					
60	sales of cattle except dairy heifers	"cattle sold" - "dairy replacement herd heifers"					
61	milk and angora goats inventory	"milk goats inventory" + "angora goats inventory"					
62	young cattle inventory	"cattle and calves inventory" - "beef cows inventory" - "milk cows inventory"					
63							
64							

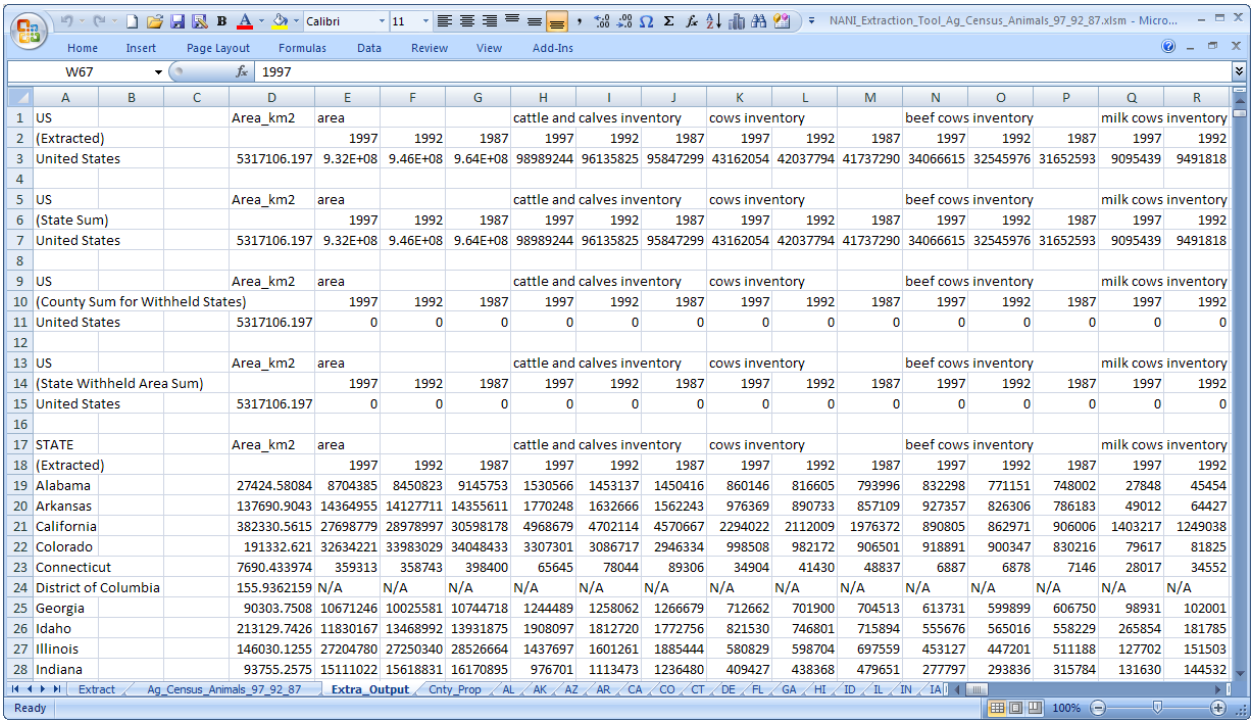
Figure 4.1.1.2.1. Extracting 1987, 1992, and 1997 animal data from Agricultural Census.

There is also a number of additional information reported to the “extra output” worksheet, in this example “Extra_Output” (Figure 4.1.1.2.3), that may be useful for checking calculations or other purposes. The list of tables generated in the extra output worksheet is given in Section 4.1.1.1. After the animal data are extracted from the Agricultural Census database, they can be used as input to the NANI-accounting tool calculating animal N production and animal N consumption (Section 5.1.2).



FIPS	STATE	COUNTY	Area_km2	area			cattle and calves inventory			cows inventory			beef cows inventory		
				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987
1009	Alabama	Blount	1691.637384	138509	137426	140107	42173	39441	35127	24433	20975	19225	23657	19705	17779
1033	Alabama	Colbert	1618.822017	115542	138135	145104	17905	15904	15949	9587	8787	8883	9576	8774	8876
1043	Alabama	Cullman	1947.917897	202861	196859	193771	72612	67839	58054	42807	37282	32441	40826	35262	30838
1049	Alabama	DeKalb	2015.203607	223685	210733	213440	62392	55871	46821	36935	33209	26879	36118	31409	24731
1055	Alabama	Etowah	1425.590932	94970	85821	100517	24613	22270	19711	13122	12561	11212	12398	11708	10602
1059	Alabama	Franklin	1674.135201	128437	130063	127653	30497	26018	22654	17922	14697	11963	17030	13773	10968
1071	Alabama	Jackson	2924.789055	221166	204487	208014	38109	34876	31257	20526	18085	16154	19747	16791	15565
1077	Alabama	Lauderdale	1862.223221	211586	201892	199960	40213	39858	32872	22208	21791	18002	21612	21166	17421
1079	Alabama	Lawrence	1861.593779	204970	173468	188365	37893	30278	27776	21605	16947	16249	21009	16096	15679
1083	Alabama	Limestone	1571.777679	253889	207226	223190	28712	25440	25636	16463	14565	14451	15994	14018	13034
1089	Alabama	Madison	2103.560677	210455	224370	235478	24737	27447	25471	13699	16017	14325	13557	15104	13161
1093	Alabama	Marion	1922.37775	98078	89228	105586	17765	16029	15043	10461	8774	8573	7230.968	8498	8103
1095	Alabama	Marshall	1617.892514	146129	142873	136599	45226	41053	34583	25444	23982	19406	25038	22504	18334
1103	Alabama	Morgan	1550.475131	158711	155914	159757	42023	40326	35979	24875	22321	20546	22116	19458	18311
1133	Alabama	Winston	1636.583993	59090	56680	57923	20317	18015	15505	11867	10738	8969	11017	9205	7623
5001	Arkansas	Arkansas	2677.20574	426363	411473	454783	3102	2751	3848	1872	1674	1999	1872	1674	2774.424
5003	Arkansas	Ashley	2427.04668	165826	151325	154580	4954	5011	4360	2715	2650	2458	4578.338	2309.674	2363
5005	Arkansas	Baxter	1511.382962	105323	92708	103034	20785	20463	20146	9730	8472	9046	9465	8230	8806
5007	Arkansas	Benton	2263.578146	296543	293745	302659	105787	101258	103697	59713	56099	55203	55312	49921	46924
5009	Arkansas	Boone	1557.487076	257698	250819	242099	62465	58435	54447	32414	30360	27808	31259	28878	26124
5011	Arkansas	Bradley	1695.439372	28900	30196	31795	5359	5080	4648	3273	3179	2853	3234	3179	2810
5013	Arkansas	Calhoun	1633.153941	17622	18818	19659	4196	3237	3650	2199	1966	1974	486.5309	287.2192	1940
5015	Arkansas	Carroll	1649.734483	242482	246184	240838	73745	69425	64048	36107	33945	32077	33190	30891	28296
5017	Arkansas	Chicot	1788.175375	287962	269122	320847	7206	6270	5011	3719	3364	2764	7950.427	3344	2679
5019	Arkansas	Clark	2283.672168	96301	98919	114391	17228	14937	14959	9357	8687	8725	8860	7986	8223
5021	Arkansas	Clay	1649.713617	323578	313573	309939	7466	6053	5263	4111	2944	2628	8933.759	2927	2564

Figure 4.1.1.2.2. The 1987, 1992, and 1997 animal data extracted using NANI-extraction tool.



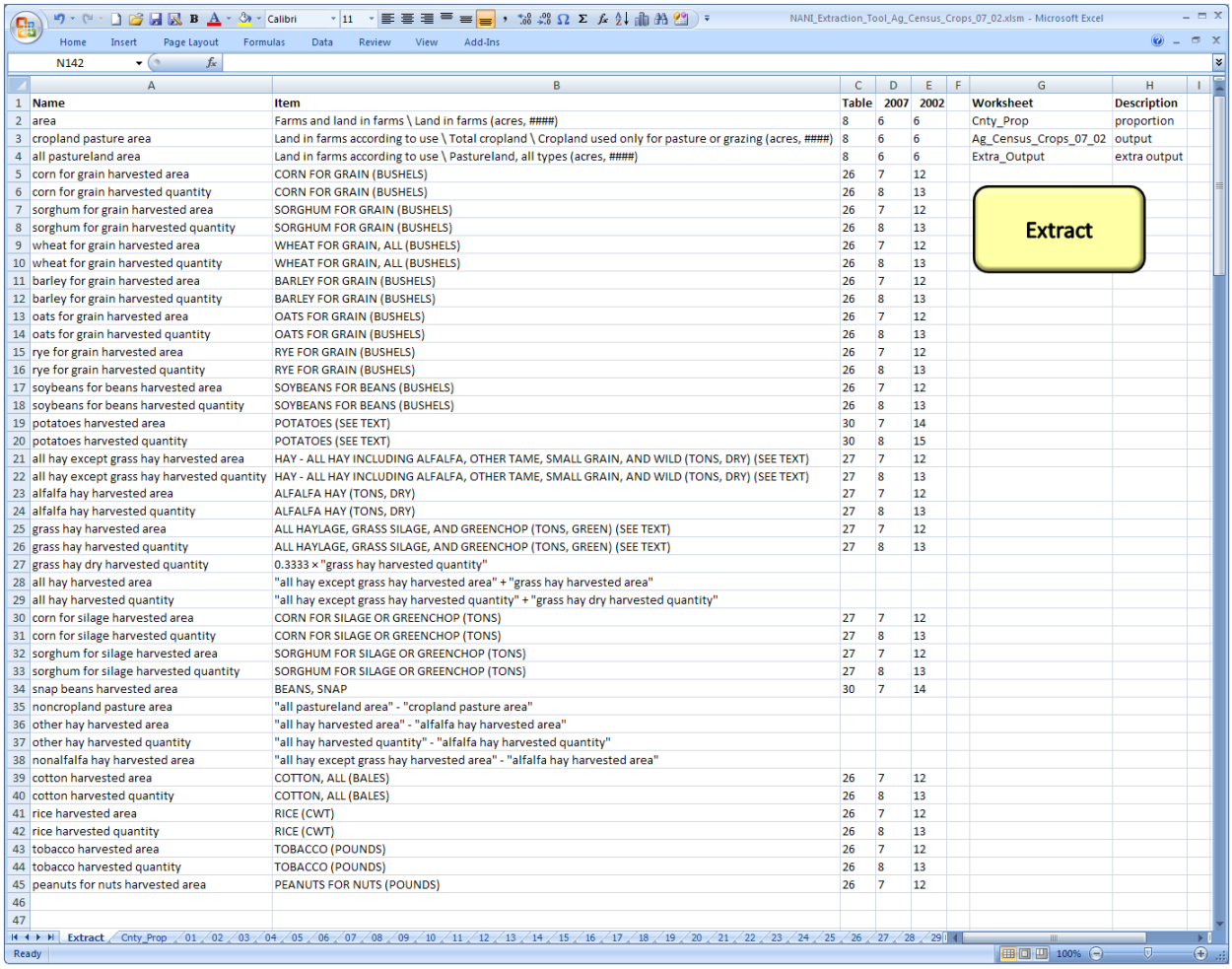
US			Area_km2	area			cattle and calves inventory			cows inventory			beef cows inventory			milk cows inventory	
(Extracted)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992
United States			5317106.197	9.32E+08	9.46E+08	9.64E+08	98989244	96135825	95847299	43162054	42037794	41737290	34066615	32545976	31652593	9095439	9491818
US			Area_km2	area			cattle and calves inventory			cows inventory			beef cows inventory			milk cows inventory	
(State Sum)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992
United States			5317106.197	9.32E+08	9.46E+08	9.64E+08	98989244	96135825	95847299	43162054	42037794	41737290	34066615	32545976	31652593	9095439	9491818
US			Area_km2	area			cattle and calves inventory			cows inventory			beef cows inventory			milk cows inventory	
(County Sum for Withheld States)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992
United States			5317106.197	0	0	0	0	0	0	0	0	0	0	0	0	0	0
US			Area_km2	area			cattle and calves inventory			cows inventory			beef cows inventory			milk cows inventory	
(State Withheld Area Sum)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992
United States			5317106.197	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STATE			Area_km2	area			cattle and calves inventory			cows inventory			beef cows inventory			milk cows inventory	
(Extracted)				1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992	1987	1997	1992
Alabama			27424.58084	8704385	8450823	9145753	1530566	1453137	1450416	860146	816605	793996	832298	771151	748002	27848	45454
Arkansas			137690.9043	14364955	14127711	14355611	1770248	1632666	1562243	976369	890733	857109	927357	826306	786183	49012	64427
California			382330.5615	27698779	28978997	30598178	4968679	4702114	4570667	2294022	2112009	1976372	890805	862971	906006	1403217	1249038
Colorado			191332.621	32634221	33983029	34048433	3307301	3086717	2946334	998508	982172	906501	918891	900347	830216	79617	81825
Connecticut			7690.433974	359313	358743	398400	65645	78044	89306	34904	41430	48837	6887	6878	7146	28017	34552
District of Columbia			155.9362159	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Georgia			90303.7508	10671246	10025581	10744718	1244489	1258062	1266679	712662	701900	704513	613731	599899	606750	98931	102001
Idaho			213129.7426	11830167	13468992	13931875	1908097	1812720	1772756	821530	746801	715894	555676	565016	558229	265854	181785
Illinois			146030.1255	27204780	27250340	28526664	1437697	1601261	1885444	580829	598704	697559	453127	447201	511188	127702	151503
Indiana			93755.2575	15111022	15618831	16170895	976701	1113473	1236480	409427	438368	479651	277797	293836	315784	131630	144532

Figure 4.1.1.2.3. Extra output generated while extracting 1987, 1992, and 1997 animal data.

4.1.2. Extracting 2002 and 2007 Data

4.1.2.1. Extracting Crop Data

In this section, the harvested crop areas and quantities in 2002 and 2007 are extracted from the Agricultural Census database (downloaded from the Internet and stored in the form of its original structure) and organized into a format suitable as input to the NANI-accounting tools (Section 5) using one of the NANI-extraction tools included in the toolbox package "NANI_Extraction_Tool_Ag_Census_Crops_07_02.xlsm" (Figure 4.1.2.1.1).

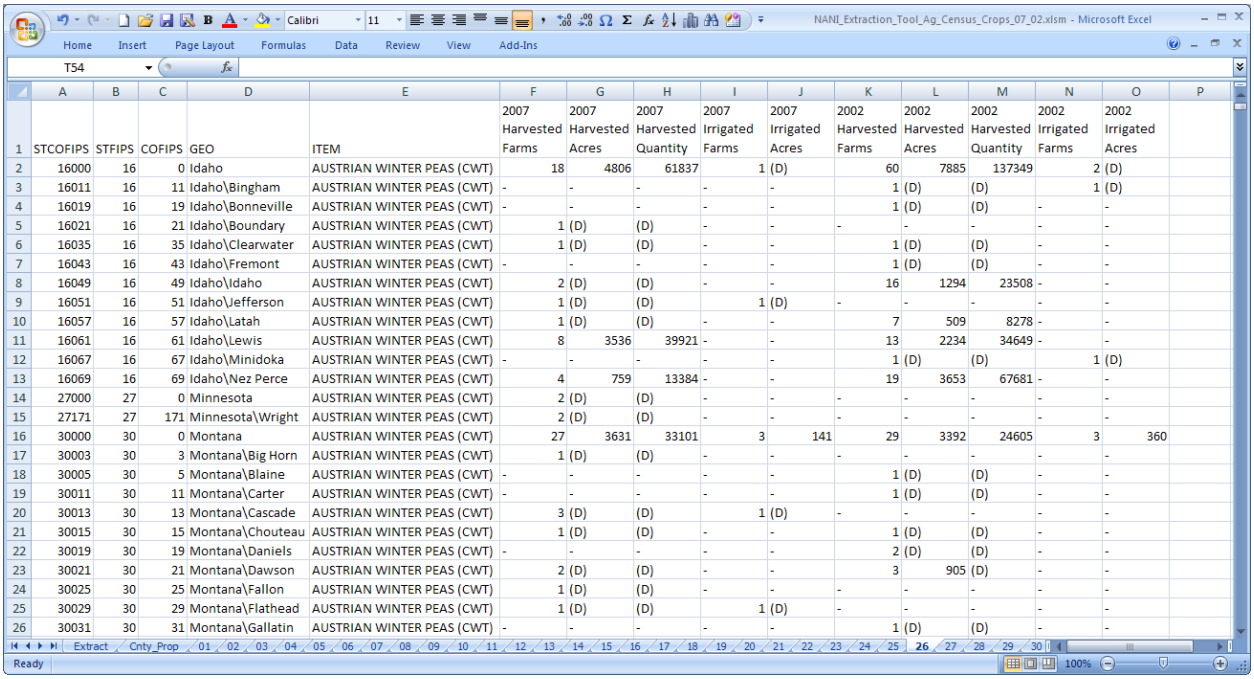


	A	B	C	D	E	F	G	H	I
1	**Name**	**Item**	**Table**	**2007**	**2002**		**Worksheet**	**Description**	
2	area	Farms and land in farms \ Land in farms (acres, ####)	8	6	6		Cnty_Prop	proportion	
3	cropland pasture area	Land in farms according to use \ Total cropland \ Cropland used only for pasture or grazing (acres, ####)	8	6	6		Ag_Census_Crops_07_02	output	
4	all pastureland area	Land in farms according to use \ Pastureland, all types (acres, ####)	8	6	6		Extra_Output	extra output	
5	corn for grain harvested area	CORN FOR GRAIN (BUSHELS)	26	7	12				
6	corn for grain harvested quantity	CORN FOR GRAIN (BUSHELS)	26	8	13				
7	sorghum for grain harvested area	SORGHUM FOR GRAIN (BUSHELS)	26	7	12				
8	sorghum for grain harvested quantity	SORGHUM FOR GRAIN (BUSHELS)	26	8	13				
9	wheat for grain harvested area	WHEAT FOR GRAIN, ALL (BUSHELS)	26	7	12				
10	wheat for grain harvested quantity	WHEAT FOR GRAIN, ALL (BUSHELS)	26	8	13				
11	barley for grain harvested area	BARLEY FOR GRAIN (BUSHELS)	26	7	12				
12	barley for grain harvested quantity	BARLEY FOR GRAIN (BUSHELS)	26	8	13				
13	oats for grain harvested area	OATS FOR GRAIN (BUSHELS)	26	7	12				
14	oats for grain harvested quantity	OATS FOR GRAIN (BUSHELS)	26	8	13				
15	rye for grain harvested area	RYE FOR GRAIN (BUSHELS)	26	7	12				
16	rye for grain harvested quantity	RYE FOR GRAIN (BUSHELS)	26	8	13				
17	soybeans for beans harvested area	SOYBEANS FOR BEANS (BUSHELS)	26	7	12				
18	soybeans for beans harvested quantity	SOYBEANS FOR BEANS (BUSHELS)	26	8	13				
19	potatoes harvested area	POTATOES (SEE TEXT)	30	7	14				
20	potatoes harvested quantity	POTATOES (SEE TEXT)	30	8	15				
21	all hay except grass hay harvested area	HAY - ALL HAY INCLUDING ALFALFA, OTHER TAME, SMALL GRAIN, AND WILD (TONS, DRY) (SEE TEXT)	27	7	12				
22	all hay except grass hay harvested quantity	HAY - ALL HAY INCLUDING ALFALFA, OTHER TAME, SMALL GRAIN, AND WILD (TONS, DRY) (SEE TEXT)	27	8	13				
23	alfalfa hay harvested area	ALFALFA HAY (TONS, DRY)	27	7	12				
24	alfalfa hay harvested quantity	ALFALFA HAY (TONS, DRY)	27	8	13				
25	grass hay harvested area	ALL HAYLAGE, GRASS SILAGE, AND GREENCHOP (TONS, GREEN) (SEE TEXT)	27	7	12				
26	grass hay harvested quantity	ALL HAYLAGE, GRASS SILAGE, AND GREENCHOP (TONS, GREEN) (SEE TEXT)	27	8	13				
27	grass hay dry harvested quantity	0.3333 × "grass hay harvested quantity"							
28	all hay harvested area	"all hay except grass hay harvested area" + "grass hay harvested area"							
29	all hay harvested quantity	"all hay except grass hay harvested quantity" + "grass hay dry harvested quantity"							
30	corn for silage harvested area	CORN FOR SILAGE OR GREENCHOP (TONS)	27	7	12				
31	corn for silage harvested quantity	CORN FOR SILAGE OR GREENCHOP (TONS)	27	8	13				
32	sorghum for silage harvested area	SORGHUM FOR SILAGE OR GREENCHOP (TONS)	27	7	12				
33	sorghum for silage harvested quantity	SORGHUM FOR SILAGE OR GREENCHOP (TONS)	27	8	13				
34	snap beans harvested area	BEANS, SNAP	30	7	14				
35	noncropland pasture area	"all pastureland area" - "cropland pasture area"							
36	other hay harvested area	"all hay harvested area" - "alfalfa hay harvested area"							
37	other hay harvested quantity	"all hay harvested quantity" - "alfalfa hay harvested quantity"							
38	nonalfalfa hay harvested area	"all hay except grass hay harvested area" - "alfalfa hay harvested area"							
39	cotton harvested area	COTTON, ALL (BALES)	26	7	12				
40	cotton harvested quantity	COTTON, ALL (BALES)	26	8	13				
41	rice harvested area	RICE (CWT)	26	7	12				
42	rice harvested quantity	RICE (CWT)	26	8	13				
43	tobacco harvested area	TOBACCO (POUNDS)	26	7	12				
44	tobacco harvested quantity	TOBACCO (POUNDS)	26	8	13				
45	peanuts for nuts harvested area	PEANUTS FOR NUTS (POUNDS)	26	7	12				
46									
47									

Figure 4.1.2.1.1. Extracting 2002 and 2007 crop data from Agricultural Census.

Although the general extraction procedure applied is similar to that described in Section 4.1.1.1 (extracting the 1987, 1992, and 1997 crop data), the Agricultural Census database downloaded from the Internet has a different data structure, hence requiring a separate extraction tool. To extract the 2002 and 2007 crop data from Agricultural Census, open the file "NANI_Extraction_Tool_Ag_Census_Crops_07_02.xlsm" with Excel 2007 (Figure 4.1.2.1.1).

The first worksheet "Extract" contains a list of Agricultural Census items to be extracted. Although both the crop and animal items can be extracted using a single extraction tool, in this example only the crop items are extracted for the ease of organizing the extracted data. (The animal items are extracted using the same tool in Section 4.1.2.2.) Column A contains the user-specified names of the Agricultural Census items. These names are identical to those listed in Section 4.1.1.1 (Figure 4.1.1.1.1), and should be consistent throughout the analysis. Columns B and C contain the full names and table numbers, respectively, that can be found in the Agricultural Census database. (The "####" in the item name is replaced with the year number by the extraction tool.) Columns D and E specify the column numbers where the data for each specified year can be found in the data worksheets (Figure 4.1.2.1.2).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	STCOFIPS	STFIPS	COFIPS	GEO	ITEM	2007 Harvested Farms	2007 Harvested Acres	2007 Harvested Quantity	2007 Irrigated Farms	2007 Irrigated Acres	2002 Harvested Farms	2002 Harvested Acres	2002 Harvested Quantity	2002 Irrigated Farms	2002 Irrigated Acres	
2	16000	16	0	Idaho	AUSTRIAN WINTER PEAS (CWT)	18	4806	61837	1	(D)	60	7885	137349	2	(D)	
3	16011	16	11	Idaho\Bingham	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	1	(D)	
4	16019	16	19	Idaho\Bonneville	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	-	-	
5	16021	16	21	Idaho\Boundary	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	-	-	-	-	-	-	-	
6	16035	16	35	Idaho\Clearwater	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	-	-	1	(D)	(D)	-	-	
7	16043	16	43	Idaho\Fremont	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	-	-	
8	16049	16	49	Idaho\Idaho	AUSTRIAN WINTER PEAS (CWT)	2	(D)	(D)	-	-	16	1294	23508	-	-	
9	16051	16	51	Idaho\Jefferson	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	1	(D)	-	-	-	-	-	
10	16057	16	57	Idaho\Latah	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	-	-	7	509	8278	-	-	
11	16061	16	61	Idaho\Lewis	AUSTRIAN WINTER PEAS (CWT)	8	3536	39921	-	-	13	2234	34649	-	-	
12	16067	16	67	Idaho\Minidoka	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	1	(D)	
13	16069	16	69	Idaho\Nez Perce	AUSTRIAN WINTER PEAS (CWT)	4	759	13384	-	-	19	3653	67681	-	-	
14	27000	27	0	Minnesota	AUSTRIAN WINTER PEAS (CWT)	2	(D)	(D)	-	-	-	-	-	-	-	
15	27171	27	171	Minnesota\Wright	AUSTRIAN WINTER PEAS (CWT)	2	(D)	(D)	-	-	-	-	-	-	-	
16	30000	30	0	Montana	AUSTRIAN WINTER PEAS (CWT)	27	3631	33101	3	141	29	3392	24605	3	360	
17	30003	30	3	Montana\Big Horn	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	-	-	-	-	-	-	-	
18	30005	30	5	Montana\Blaine	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	-	-	
19	30011	30	11	Montana\Carter	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	-	-	
20	30013	30	13	Montana\Cascade	AUSTRIAN WINTER PEAS (CWT)	3	(D)	(D)	1	(D)	-	-	-	-	-	
21	30015	30	15	Montana\Chouteau	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	-	-	1	(D)	(D)	-	-	
22	30019	30	19	Montana\Daniels	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	2	(D)	(D)	-	-	
23	30021	30	21	Montana\Dawson	AUSTRIAN WINTER PEAS (CWT)	2	(D)	(D)	-	-	3	905	(D)	-	-	
24	30025	30	25	Montana\Fallon	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	-	-	-	-	-	-	-	
25	30029	30	29	Montana\Flathead	AUSTRIAN WINTER PEAS (CWT)	1	(D)	(D)	1	(D)	-	-	-	-	-	
26	30031	30	31	Montana\Gallatin	AUSTRIAN WINTER PEAS (CWT)	-	-	-	-	-	1	(D)	(D)	-	-	

Figure 4.1.2.1.2. Worksheets containing 2002 and 2007 Agricultural Census data.

Note that some items are expressed as simple algebraic equations in Column B of the extraction worksheet (Figure 4.1.2.1.1), for example 0.3333 × "grass hay harvested quantity" (Cell B27). These items are not extracted from the Agricultural Census database but derived by combining multiple Agricultural Census items that can be found from the list (see Section 4.1.1.1 for more detail). Calculation of the derived items is based on Boyer et al. (2002). Cells D1 and E1 are used to specify the years for the extraction, and can be extended further as the data for the new years are added. Columns G and H are used to specify the names of the input and output worksheets. The user needs to specify the names of the input worksheet "proportion" (county proportion worksheet imported from the text file output created by the NANI-GIS tool described in Section 3.1; see Figure 3.1.5), and the output worksheets "output" (used as input to the NANI-accounting tool in Sections 5.1.1 and 5.2) and "extra output" (additional information that is not directly used by the NANI-accounting tool).

The worksheets that follow the county proportion worksheet "Cnty_Prop" contain the Agricultural Census data obtained using the Desktop Data Query Tool (Figure 4.1.2.1.3), that can be downloaded via http://www.agcensus.usda.gov/, along with the user's manual.

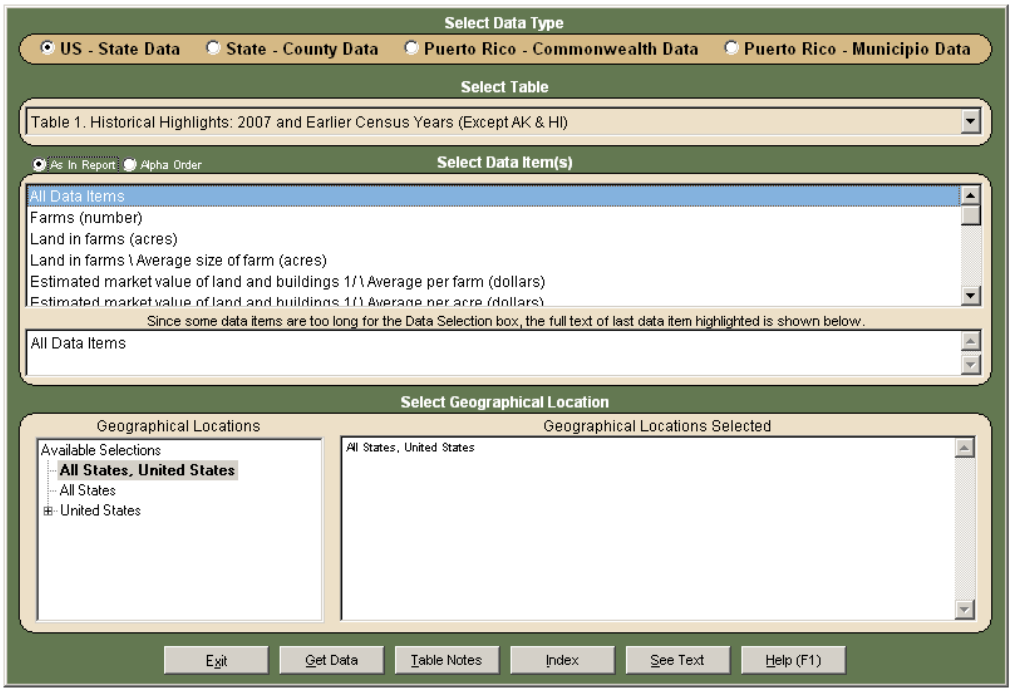
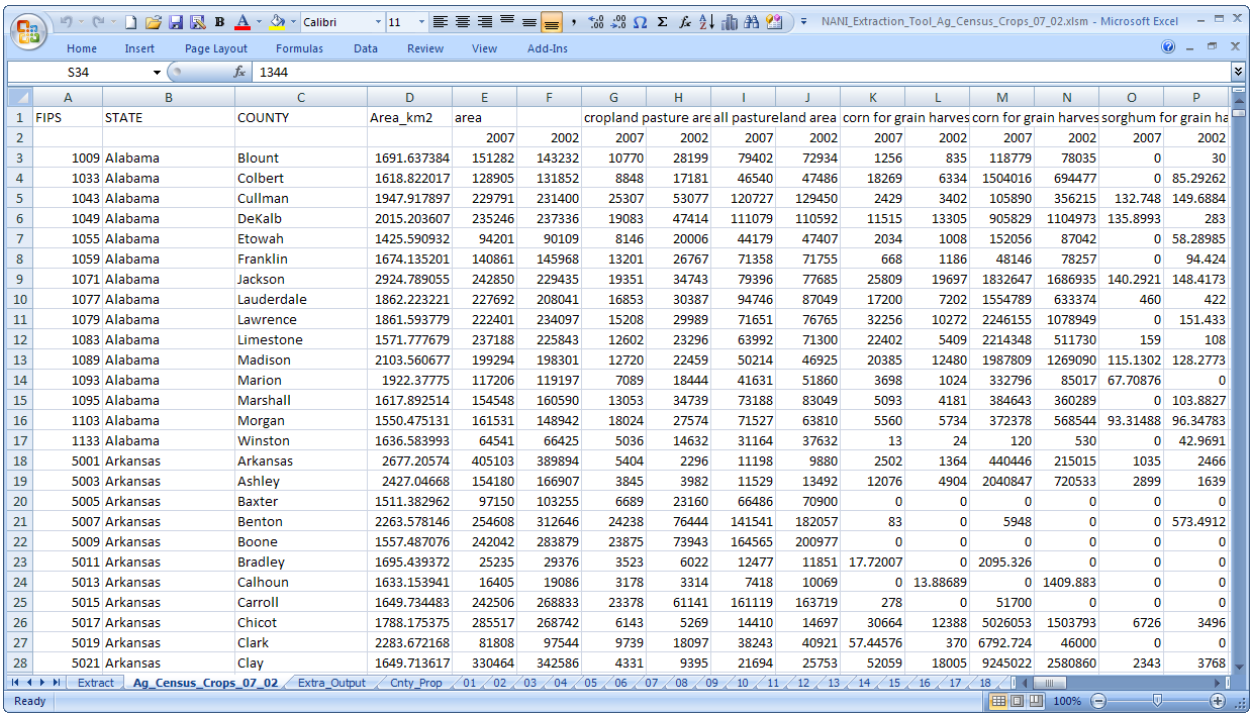


Figure 4.1.2.1.3. Desktop Data Query Tool generating 2007 and 2002 Agricultural Census data.

The extraction tool included in the toolbox package contains the entire Agricultural Census data obtained using the Desktop Data Query Tool, each Agricultural Census table stored in a separate worksheet (e.g., Figure 4.1.2.1.2 showing Agricultural Census table 26). The original dataset obtained using the Desktop Data Query Tool had a number of issues and some modifications were needed before being used as input to the extraction tool:

- The horses, milk goats, and angora goats are not reported in the year of 2002. These items are manually added to the worksheet tables using the original Agricultural Census publications (pdf files downloadable from http://www.agcensus.usda.gov/).
- Unlike the 1987-1997 Agricultural Census data (Figure 4.1.1.1.3), data for the potatoes are not generated in cwt (hundredweight). These data are either added manually from the 2002 Agricultural Census publications or estimated from the 2007 NASS (National Agricultural Statistics Service; http://www.nass.usda.gov/) data for potatoes.

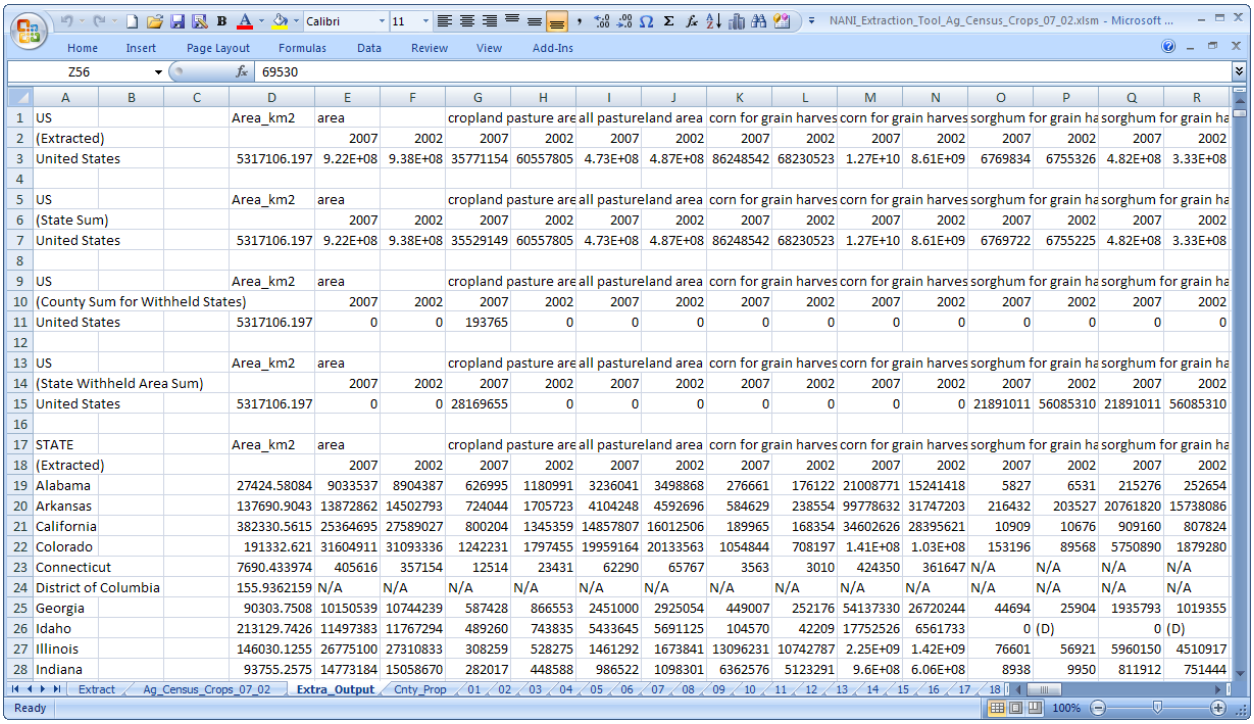
Before running the extraction tool, the user may replace the county proportion table and revise the list of Agricultural Census items as appropriate. Click on the "Extract" button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example "Ag_Census_Crops_07_02" (Figure 4.1.2.1.4).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	FIPS	STATE	COUNTY	Area_km2	area		cropland	pasture are	all pasture	land area	corn for grain	harves	corn for grain	harves	sorghum for grain	ha
2					2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
3	1009	Alabama	Blount	1691.637384	151282	143232	10770	28199	79402	72934	1256	835	118779	78035	0	30
4	1033	Alabama	Colbert	1618.822017	128905	131852	8848	17181	46540	47486	18269	6334	1504016	694477	0	85.29262
5	1043	Alabama	Cullman	1947.917897	229791	231400	25307	53077	120727	129450	2429	3402	105890	356215	132.748	149.6884
6	1049	Alabama	DeKalb	2015.203607	235246	237336	19083	47414	111079	110592	11515	13305	905829	1104973	135.8993	283
7	1055	Alabama	Etowah	1425.590932	94201	90109	8146	20006	44179	47407	2034	1008	152056	87042	0	58.28985
8	1059	Alabama	Franklin	1674.135201	140861	145968	13201	26767	71358	71755	668	1186	48146	78257	0	94.424
9	1071	Alabama	Jackson	2924.789055	242850	229435	19351	34743	79396	77685	25809	19697	1832647	1686935	140.2921	148.4173
10	1077	Alabama	Lauderdale	1862.223221	227692	208041	16853	30387	94746	87049	17200	7202	1554789	633374	460	422
11	1079	Alabama	Lawrence	1861.593779	222401	234097	15208	29989	71651	76765	32256	10272	2246155	1078949	0	151.433
12	1083	Alabama	Limestone	1571.777679	237188	225843	12602	23296	63992	71300	22402	5409	2214348	511730	159	108
13	1089	Alabama	Madison	2103.560677	199294	198301	12720	22459	50214	46925	20385	12480	1987809	1269090	115.1302	128.2773
14	1093	Alabama	Marion	1922.37775	117206	119197	7089	18444	41631	51860	3698	1024	332796	85017	67.70876	0
15	1095	Alabama	Marshall	1617.892514	154548	160590	13053	34739	73188	83049	5093	4181	384643	360289	0	103.8827
16	1103	Alabama	Morgan	1550.475131	161531	148942	18024	27574	71527	63810	5560	5734	372378	568544	93.31488	96.34783
17	1133	Alabama	Winston	1636.583993	64541	66425	5036	14632	31164	37632	13	24	120	530	0	42.9691
18	5001	Arkansas	Arkansas	2677.20574	405103	389894	5404	2296	11198	9880	2502	1364	440446	215015	1035	2466
19	5003	Arkansas	Ashley	2427.04668	154180	166907	3845	3982	11529	13492	12076	4904	2040847	720533	2899	1639
20	5005	Arkansas	Baxter	1511.382962	97150	103255	6689	23160	66486	70900	0	0	0	0	0	0
21	5007	Arkansas	Benton	2263.578146	254608	312646	24238	76444	141541	182057	83	0	5948	0	0	573.4912
22	5009	Arkansas	Boone	1557.487076	242042	283879	23875	73943	164565	200977	0	0	0	0	0	0
23	5011	Arkansas	Bradley	1695.439372	25235	29376	3523	6022	12477	11851	17.72007	0	2095.326	0	0	0
24	5013	Arkansas	Calhoun	1633.153941	16405	19086	3178	3314	7418	10069	0	13.88689	0	1409.883	0	0
25	5015	Arkansas	Carroll	1649.734483	242506	268833	23378	61141	161119	163719	278	0	51700	0	0	0
26	5017	Arkansas	Chicot	1788.175375	285517	268742	6143	5269	14410	14697	30664	12388	5026053	1503793	6726	3496
27	5019	Arkansas	Clark	2283.672168	81808	97544	9739	18097	38243	40921	57.44576	370	6792.724	46000	0	0
28	5021	Arkansas	Clay	1649.713617	330464	342586	4331	9395	21694	25753	52059	18005	9245022	2580860	2343	3768

Figure 4.1.2.1.4. The 2002 and 2007 crop data extracted using NANI-extraction tool.

There is a number of additional information reported to the "extra output" worksheet, in this example "Extra_Output" (Figure 4.1.2.1.5), that may be useful for checking calculations or other purposes.



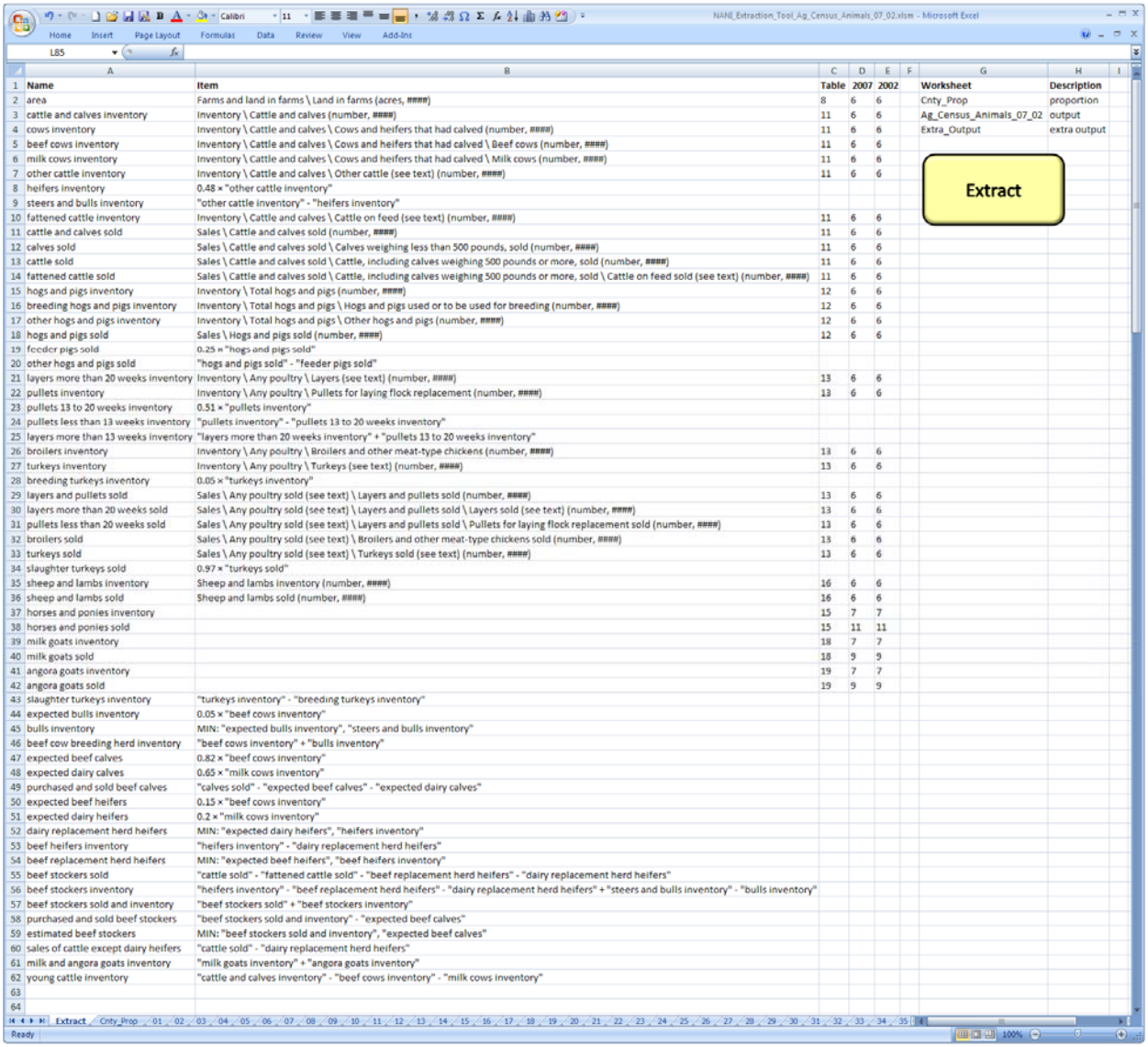
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	US			Area_km2	area		cropland	pasture are	all pasture	land area	corn for grain	harves	corn for grain	harves	sorghum for grain	ha	sorghum for grain	ha
2	(Extracted)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
3	United States			5317106.197	9.22E+08	9.38E+08	35771154	60557805	4.73E+08	4.87E+08	86248542	68230523	1.27E+10	8.61E+09	6769834	6755326	4.82E+08	3.33E+08
4																		
5	US			Area_km2	area		cropland	pasture are	all pasture	land area	corn for grain	harves	corn for grain	harves	sorghum for grain	ha	sorghum for grain	ha
6	(State Sum)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
7	United States			5317106.197	9.22E+08	9.38E+08	35529149	60557805	4.73E+08	4.87E+08	86248542	68230523	1.27E+10	8.61E+09	6769722	6755225	4.82E+08	3.33E+08
8																		
9	US			Area_km2	area		cropland	pasture are	all pasture	land area	corn for grain	harves	corn for grain	harves	sorghum for grain	ha	sorghum for grain	ha
10	(County Sum for Withheld States)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
11	United States			5317106.197	0	0	193765	0	0	0	0	0	0	0	0	0	0	0
12																		
13	US			Area_km2	area		cropland	pasture are	all pasture	land area	corn for grain	harves	corn for grain	harves	sorghum for grain	ha	sorghum for grain	ha
14	(State Withheld Area Sum)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
15	United States			5317106.197	0	0	28169655	0	0	0	0	0	0	0	21891011	56085310	21891011	56085310
16																		
17	STATE			Area_km2	area		cropland	pasture are	all pasture	land area	corn for grain	harves	corn for grain	harves	sorghum for grain	ha	sorghum for grain	ha
18	(Extracted)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
19	Alabama			27424.58084	9033537	8904387	626995	1180991	3236041	3498868	276661	176122	21008771	15241418	5827	6531	215276	252654
20	Arkansas			137690.9043	13872862	14502793	724044	1705723	4104248	4592696	584629	238554	99778632	31747203	216432	203527	20761820	15738086
21	California			382330.5615	25364695	27589027	800204	1345359	14857807	16012506	189965	168354	34602626	28395621	10909	10676	909160	807824
22	Colorado			191332.621	31604911	31093336	1242231	1797455	19959164	20133563	1054844	708197	1.41E+08	1.03E+08	153196	89568	5750890	1879280
23	Connecticut			7690.433974	405616	357154	12514	23431	62290	65767	3563	3010	424350	361647	N/A	N/A	N/A	N/A
24	District of Columbia			155.9362159	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25	Georgia			90303.7508	10150539	10744239	587428	866553	2451000	2925054	449007	252176	54137330	26720244	44694	25904	1935793	1019355
26	Idaho			213129.7426	11497383	11767294	489260	743835	5433645	5691125	104570	42209	17752526	6561733	0	(D)	0	(D)
27	Illinois			146030.1255	26775100	27310833	308259	528275	1461292	1673841	13096231	10742787	2.25E+09	1.42E+09	76601	56921	5960150	4510917
28	Indiana			93755.2575	14773184	15058670	282017	448588	986522	1098301	6362576	5123291	9.6E+08	6.06E+08	8938	9950	811912	751444

Figure 4.1.2.1.5. Extra output generated while extracting 2002 and 2007 crop data.

Detailed description on the output worksheets generated by the extraction tools is given in Section 4.1.1.1. After the crop data are extracted from the Agricultural Census database, they can be used as input to the NANI-accounting tool calculating crop N production (Section 5.1.1) and agricultural N fixation (Section 5.2).

4.1.2.2. Extracting Animal Data

In this section, the animal inventory and sales data in 2002 and 2007 are extracted from the Agricultural Census database (downloaded from the Internet and stored in the form of its original structure) and organized into a format suitable as input to the NANI-accounting tools (Section 5) using one of the NANI-extraction tools included in the toolbox package "NANI_Extraction_Tool_Ag_Census_Animals_07_02.xlsm" (Figure 4.1.2.2.1).

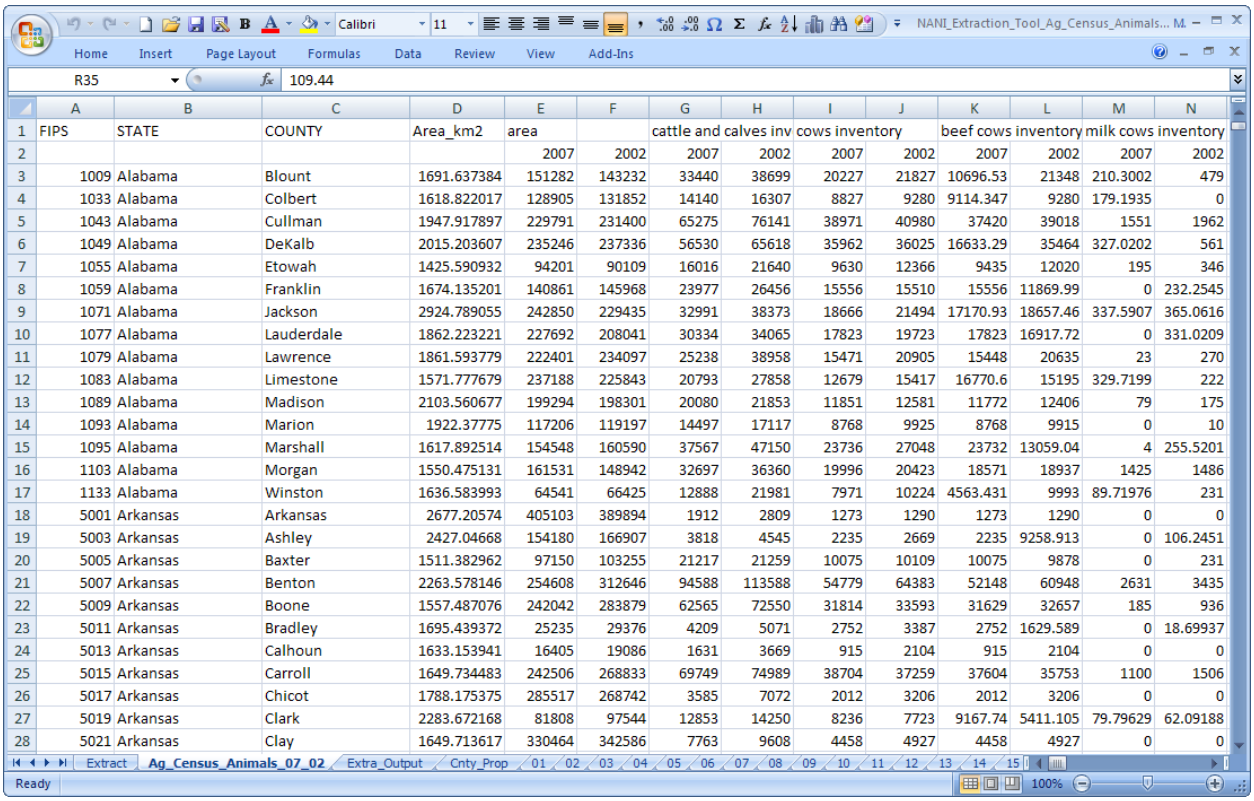


	Name	Item	Table	2007	2002	Worksheet	Description
2	area	Farms and land in farms \ Land in farms (acres, ####)	8	6	6	Cnty_Prop	proportion
3	cattle and calves inventory	Inventory \ Cattle and calves (number, ####)	11	6	6	Ag_Census_Animals_07_02	output
4	cows inventory	Inventory \ Cattle and calves \ Cows and heifers that had calved (number, ####)	11	6	6	Extra_Output	extra output
5	beef cows inventory	Inventory \ Cattle and calves \ Cows and heifers that had calved \ Beef cows (number, ####)	11	6	6		
6	milk cows inventory	Inventory \ Cattle and calves \ Cows and heifers that had calved \ Milk cows (number, ####)	11	6	6		
7	other cattle inventory	Inventory \ Cattle and calves \ Other cattle (see text) (number, ####)	11	6	6		
8	heifers inventory	0.48 × "other cattle inventory"					
9	steers and bulls inventory	"other cattle inventory" - "heifers inventory"					
10	fattened cattle inventory	Inventory \ Cattle and calves \ Cattle on feed (see text) (number, ####)	11	6	6		
11	cattle and calves sold	Sales \ Cattle and calves sold (number, ####)	11	6	6		
12	calves sold	Sales \ Cattle and calves sold \ Calves weighing less than 500 pounds, sold (number, ####)	11	6	6		
13	cattle sold	Sales \ Cattle and calves sold \ Cattle, including calves weighing 500 pounds or more, sold (number, ####)	11	6	6		
14	fattened cattle sold	Sales \ Cattle and calves sold \ Cattle, including calves weighing 500 pounds or more, sold \ Cattle on feed sold (see text) (number, ####)	11	6	6		
15	hogs and pigs inventory	Inventory \ Total hogs and pigs (number, ####)	12	6	6		
16	breeding hogs and pigs inventory	Inventory \ Total hogs and pigs \ Hogs and pigs used or to be used for breeding (number, ####)	12	6	6		
17	other hogs and pigs inventory	Inventory \ Total hogs and pigs \ Other hogs and pigs (number, ####)	12	6	6		
18	hogs and pigs sold	Sales \ Hogs and pigs sold (number, ####)	12	6	6		
19	feeder pigs sold	0.25 × "hogs and pigs sold"					
20	other hogs and pigs sold	"hogs and pigs sold" - "feeder pigs sold"					
21	layers more than 20 weeks inventory	Inventory \ Any poultry \ Layers (see text) (number, ####)	13	6	6		
22	pullets inventory	Inventory \ Any poultry \ Pullets for laying flock replacement (number, ####)	13	6	6		
23	pullets 13 to 20 weeks inventory	0.51 × "pullets inventory"					
24	pullets less than 13 weeks inventory	"pullets inventory" - "pullets 13 to 20 weeks inventory"					
25	layers more than 13 weeks inventory	"layers more than 20 weeks inventory" + "pullets 13 to 20 weeks inventory"					
26	broilers inventory	Inventory \ Any poultry \ Broilers and other meat-type chickens (number, ####)	13	6	6		
27	turkeys inventory	Inventory \ Any poultry \ Turkeys (see text) (number, ####)	13	6	6		
28	breeding turkeys inventory	0.05 × "turkeys inventory"					
29	layers and pullets sold	Sales \ Any poultry sold (see text) \ Layers and pullets sold (number, ####)	13	6	6		
30	layers more than 20 weeks sold	Sales \ Any poultry sold (see text) \ Layers and pullets sold \ Layers sold (see text) (number, ####)	13	6	6		
31	pullets less than 20 weeks sold	Sales \ Any poultry sold (see text) \ Layers and pullets sold \ Pullets for laying flock replacement sold (number, ####)	13	6	6		
32	broilers sold	Sales \ Any poultry sold (see text) \ Broilers and other meat-type chickens sold (number, ####)	13	6	6		
33	turkeys sold	Sales \ Any poultry sold (see text) \ Turkeys sold (see text) (number, ####)	13	6	6		
34	slaughter turkeys sold	0.97 × "turkeys sold"					
35	sheep and lambs inventory	Sheep and lambs inventory (number, ####)	16	6	6		
36	sheep and lambs sold	Sheep and lambs sold (number, ####)	16	6	6		
37	horses and ponies inventory		15	7	7		
38	horses and ponies sold		15	11	11		
39	milk goats inventory		18	7	7		
40	milk goats sold		18	9	9		
41	angora goats inventory		19	7	7		
42	angora goats sold		19	9	9		
43	slaughter turkeys inventory	"turkeys inventory" - "breeding turkeys inventory"					
44	expected bulls inventory	0.05 × "beef cows inventory"					
45	bulls inventory	MIN: "expected bulls inventory", "steers and bulls inventory"					
46	beef cow breeding herd inventory	"beef cows inventory" + "bulls inventory"					
47	expected beef calves	0.82 × "beef cows inventory"					
48	expected dairy calves	0.65 × "milk cows inventory"					
49	purchased and sold beef calves	"calves sold" - "expected beef calves" - "expected dairy calves"					
50	expected beef heifers	0.15 × "beef cows inventory"					
51	expected dairy heifers	0.2 × "milk cows inventory"					
52	dairy replacement herd heifers	MIN: "expected dairy heifers", "heifers inventory"					
53	beef heifers inventory	"heifers inventory" - "dairy replacement herd heifers"					
54	beef replacement herd heifers	MIN: "expected beef heifers", "beef heifers inventory"					
55	beef stockers sold	"cattle sold" - "fattened cattle sold" - "beef replacement herd heifers" - "dairy replacement herd heifers"					
56	beef stockers inventory	"heifers inventory" - "beef replacement herd heifers" - "dairy replacement herd heifers" + "steers and bulls inventory" - "bulls inventory"					
57	beef stockers sold and inventory	"beef stockers sold" + "beef stockers inventory"					
58	purchased and sold beef stockers	"beef stockers sold and inventory" - "expected beef calves"					
59	estimated beef stockers	MIN: "beef stockers sold and inventory", "expected beef calves"					
60	sales of cattle except dairy heifers	"cattle sold" - "dairy replacement herd heifers"					
61	milk and angora goats inventory	"milk goats inventory" + "angora goats inventory"					
62	young cattle inventory	"cattle and calves inventory" - "beef cows inventory" - "milk cows inventory"					
63							
64							

Figure 4.1.2.2.1. Extracting 2002 and 2007 animal data from Agricultural Census.

Note that, except for the list of items to be extracted, this file is the same extraction tool as "NANI_Extraction_Tool_Ag_Census_Crops_07_02.xlsm" described in Section 4.1.2.1. It is possible to extract the crop and animal data in a single run, although in this example they are extracted separately for the data organization purpose. Detailed descriptions on the specification of the extraction tool, input data structure, and output worksheets are given in Section 4.1.1.1.

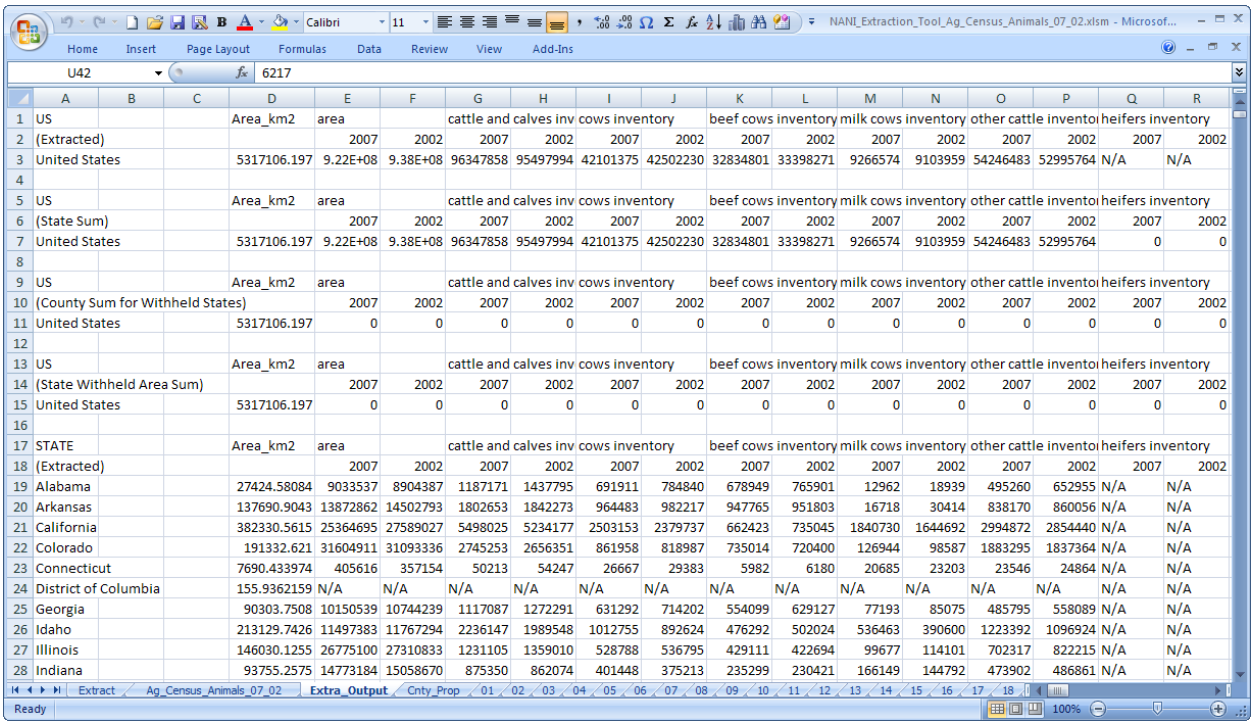
To extract the 2002 and 2007 animal data from Agricultural Census, open the file "NANI_Extraction_Tool_Ag_Census_Animals_07_02.xlsm" with Excel 2007 (Figure 4.1.2.2.1). Before running the extraction tool, the user may replace the county proportion table and revise the list of Agricultural Census items as appropriate. Calculation of the derived items shown in Figure 4.1.2.2.1 is based on Kellogg et al. (2000) and Boyer et al. (2002). Click on the "Extract" button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example "Ag_Census_Animals_07_02" (Figure 4.1.2.2.2).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	FIPS	STATE	COUNTY	Area_km2	area		cattle and calves inv		cows inventory		beef cows inventory		milk cows inventory	
2					2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
3	1009	Alabama	Blount	1691.637384	151282	143232	33440	38699	20227	21827	10696.53	21348	210.3002	479
4	1033	Alabama	Colbert	1618.822017	128905	131852	14140	16307	8827	9280	9114.347	9280	179.1935	0
5	1043	Alabama	Cullman	1947.917897	229791	231400	65275	76141	38971	40980	37420	39018	1551	1962
6	1049	Alabama	DeKalb	2015.203607	235246	237336	56530	65618	35962	36025	16633.29	35464	327.0202	561
7	1055	Alabama	Etowah	1425.590932	94201	90109	16016	21640	9630	12366	9435	12020	195	346
8	1059	Alabama	Franklin	1674.135201	140861	145968	23977	26456	15556	15510	15556	11869.99	0	232.2545
9	1071	Alabama	Jackson	2924.789055	242850	229435	32991	38373	18666	21494	17170.93	18657.46	337.5907	365.0616
10	1077	Alabama	Lauderdale	1862.223221	227692	208041	30334	34065	17823	19723	17823	16917.72	0	331.0209
11	1079	Alabama	Lawrence	1861.593779	222401	234097	25238	38958	15471	20905	15448	20635	23	270
12	1083	Alabama	Limestone	1571.777679	237188	225843	20793	27858	12679	15417	16770.6	15195	329.7199	222
13	1089	Alabama	Madison	2103.560677	199294	198301	20080	21853	11851	12581	11772	12406	79	175
14	1093	Alabama	Marion	1922.37775	117206	119197	14497	17117	8768	9925	8768	9915	0	10
15	1095	Alabama	Marshall	1617.892514	154548	160590	37567	47150	23736	27048	23732	13059.04	4	255.5201
16	1103	Alabama	Morgan	1550.475131	161531	148942	32697	36360	19996	20423	18571	18937	1425	1486
17	1133	Alabama	Winston	1636.583993	64541	66425	12888	21981	7971	10224	4563.431	9993	89.71976	231
18	5001	Arkansas	Arkansas	2677.20574	405103	389894	1912	2809	1273	1290	1273	1290	0	0
19	5003	Arkansas	Ashley	2427.04668	154180	166907	3818	4545	2235	2669	2235	9258.913	0	106.2451
20	5005	Arkansas	Baxter	1511.382962	97150	103255	21217	21259	10075	10109	10075	9878	0	231
21	5007	Arkansas	Benton	2263.578146	254608	312646	94588	113588	54779	64383	52148	60948	2631	3435
22	5009	Arkansas	Boone	1557.487076	242042	283879	62565	72550	31814	33593	31629	32657	185	936
23	5011	Arkansas	Bradley	1695.439372	25235	29376	4209	5071	2752	3387	2752	1629.589	0	18.69937
24	5013	Arkansas	Calhoun	1633.153941	16405	19086	1631	3669	915	2104	915	2104	0	0
25	5015	Arkansas	Carroll	1649.734483	242506	268833	69749	74989	38704	37259	37604	35753	1100	1506
26	5017	Arkansas	Chicot	1788.175375	285517	268742	3585	7072	2012	3206	2012	3206	0	0
27	5019	Arkansas	Clark	2283.672168	81808	97544	12853	14250	8236	7723	9167.74	5411.105	79.79629	62.09188
28	5021	Arkansas	Clay	1649.713617	330464	342586	7763	9608	4458	4927	4458	4927	0	0

Figure 4.1.2.2.2. The 2002 and 2007 animal data extracted using NANI-extraction tool.

There is also a number of additional information reported to the "extra output" worksheet, in this example "Extra_Output" (Figure 4.1.2.2.3), that may be useful for checking calculations or other purposes. The list of tables generated in the extra output worksheet is given in Section 4.1.1.1. After the animal data are extracted from the Agricultural Census database, they can be used as input to the NANI-accounting tool calculating animal N production and animal N consumption (Section 5.1.2).

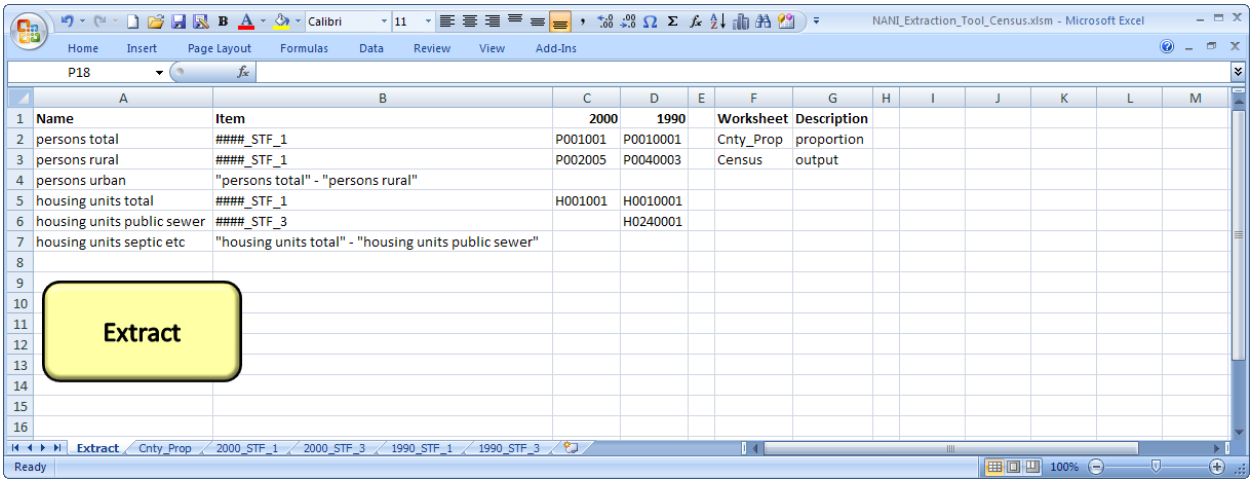


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	US			Area_km2	area		cattle and calves inv		cows inventory		beef cows inventory		milk cows inventory		other cattle inventor		heifers inventory	
2	(Extracted)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
3	United States			5317106.197	9.22E+08	9.38E+08	96347858	95497994	42101375	42502230	32834801	33398271	9266574	9103959	54246483	52995764	N/A	N/A
4																		
5	US			Area_km2	area		cattle and calves inv		cows inventory		beef cows inventory		milk cows inventory		other cattle inventor		heifers inventory	
6	(State Sum)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
7	United States			5317106.197	9.22E+08	9.38E+08	96347858	95497994	42101375	42502230	32834801	33398271	9266574	9103959	54246483	52995764	0	0
8																		
9	US			Area_km2	area		cattle and calves inv		cows inventory		beef cows inventory		milk cows inventory		other cattle inventor		heifers inventory	
10	(County Sum for Withheld States)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
11	United States			5317106.197	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12																		
13	US			Area_km2	area		cattle and calves inv		cows inventory		beef cows inventory		milk cows inventory		other cattle inventor		heifers inventory	
14	(State Withheld Area Sum)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
15	United States			5317106.197	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16																		
17	STATE			Area_km2	area		cattle and calves inv		cows inventory		beef cows inventory		milk cows inventory		other cattle inventor		heifers inventory	
18	(Extracted)				2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002
19	Alabama			27424.58084	9033537	8904387	1187171	1437795	691911	784840	678949	765901	12962	18939	495260	652955	N/A	N/A
20	Arkansas			137690.9043	13872862	14502793	1802653	1842273	964483	982217	947765	951803	16718	30414	838170	860056	N/A	N/A
21	California			382330.5615	25364695	27589027	5498025	5234177	2503153	2379737	662423	735045	1840730	1644692	2994872	2854440	N/A	N/A
22	Colorado			191332.621	31604911	31093336	2745253	2656351	861958	818987	735014	720400	126944	98587	1883295	1837364	N/A	N/A
23	Connecticut			7690.433974	405616	357154	50213	54247	26667	29383	5982	6180	20685	23203	23546	24864	N/A	N/A
24	District of Columbia			155.9362159	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25	Georgia			90303.7508	10150539	10744239	1117087	1272291	631292	714202	554099	629127	77193	85075	485795	558089	N/A	N/A
26	Idaho			213129.7426	11497383	11767294	2236147	1989548	1012755	892624	476292	502024	536463	390600	1223392	1096924	N/A	N/A
27	Illinois			146030.1255	26775100	27310833	1231105	1359010	528788	536795	429111	422694	99677	114101	702317	822215	N/A	N/A
28	Indiana			93755.2575	14773184	15058670	875350	862074	401448	375213	235299	230421	166149	144792	473902	486861	N/A	N/A

Figure 4.1.2.2.3. Extra output generated while extracting 2002 and 2007 animal data.

4.2. Extracting Census Data

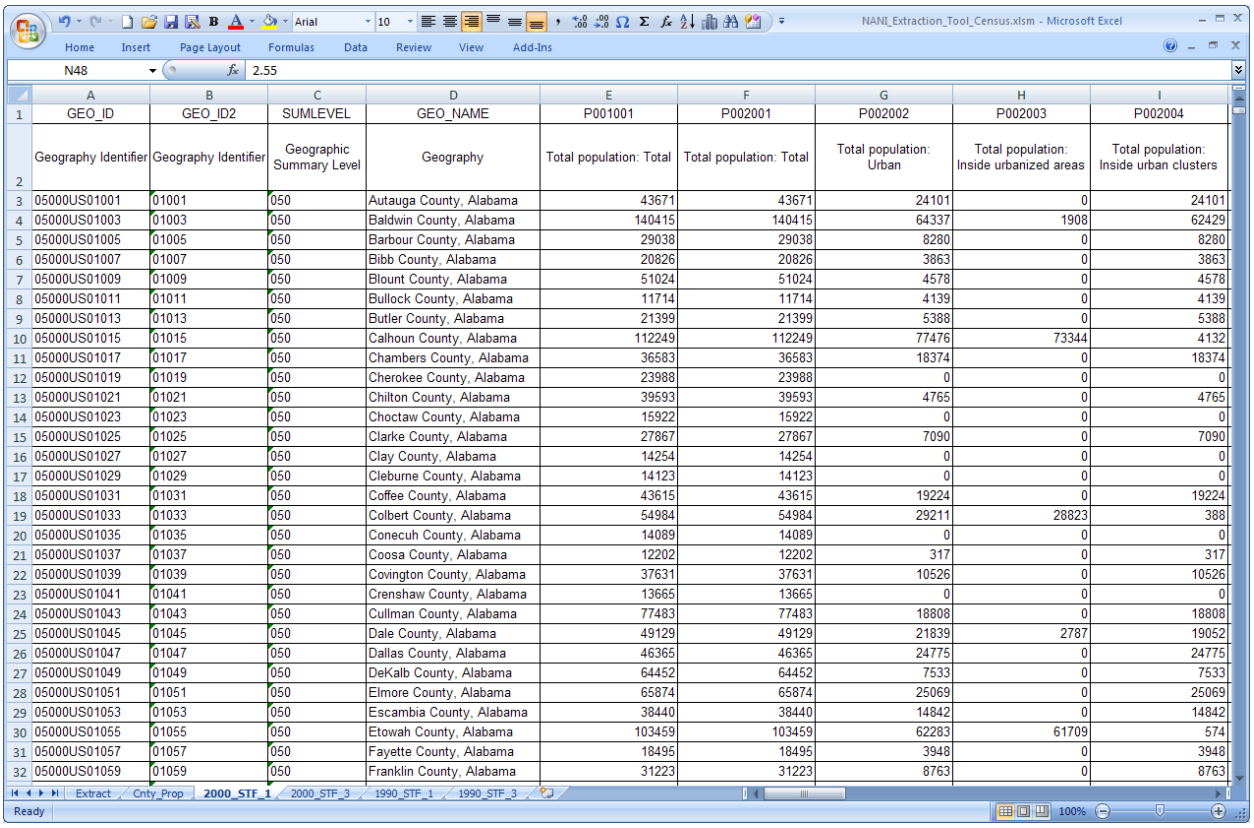
The Census data are used to estimate the population density, which in turn is used to calculate the human N consumption. In this section, the 1990 and 2000 population data are extracted from the Census database (downloaded from the Internet and stored in the form of its original structure) and organized into a format suitable as input to the NANI-accounting tools (Section 5) using one of the NANI-extraction tools included in the toolbox package "NANI_Extraction_Tool_Census.xlsm" (Figure 4.2.1).



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Name**	**Item**	**2000**	**1990**		**Worksheet**	**Description**						
2	persons total	####_STF_1	P001001	P0010001		Cnty_Prop	proportion						
3	persons rural	####_STF_1	P002005	P0040003		Census	output						
4	persons urban	"persons total" - "persons rural"											
5	housing units total	####_STF_1	H001001	H0010001									
6	housing units public sewer	####_STF_3		H0240001									
7	housing units septic etc	"housing units total" - "housing units public sewer"											

Figure 4.2.1. Extracting 1990 and 2000 population data from Census.

To extract the 1990 and 2000 population data (and other relevant items) from Census, open the file "NANI_Extraction_Tool_Census.xlsm" with Excel 2007 (Figure 4.2.1). The first worksheet "Extract" contains a list of Census items to be extracted. Column A contains the user-specified names of the Census items, and Column B contains the names of the worksheets where the desired Census item can be found. (The "####" in the worksheet name is replaced with the year number by the extraction tool.) Columns C and D specify the column headings where the data for each specified year can be found in the data worksheets (Figure 4.2.2).



	A	B	C	D	E	F	G	H	I
1	GEO_ID	GEO_ID2	SUMLEVEL	GEO_NAME	P001001	P002001	P002002	P002003	P002004
2	Geography Identifier	Geography Identifier	Geographic Summary Level	Geography	Total population: Total	Total population: Total	Total population: Urban	Total population: Inside urbanized areas	Total population: Inside urban clusters
3	05000US01001	01001	050	Autauga County, Alabama	43671	43671	24101	0	24101
4	05000US01003	01003	050	Baldwin County, Alabama	140415	140415	64337	1908	62429
5	05000US01005	01005	050	Barbour County, Alabama	29038	29038	8280	0	8280
6	05000US01007	01007	050	Bibb County, Alabama	20826	20826	3863	0	3863
7	05000US01009	01009	050	Blount County, Alabama	51024	51024	4578	0	4578
8	05000US01011	01011	050	Bullock County, Alabama	11714	11714	4139	0	4139
9	05000US01013	01013	050	Butler County, Alabama	21399	21399	5388	0	5388
10	05000US01015	01015	050	Calhoun County, Alabama	112249	112249	77476	73344	4132
11	05000US01017	01017	050	Chambers County, Alabama	36583	36583	18374	0	18374
12	05000US01019	01019	050	Cherokee County, Alabama	23988	23988	0	0	0
13	05000US01021	01021	050	Chilton County, Alabama	39593	39593	4765	0	4765
14	05000US01023	01023	050	Choctaw County, Alabama	15922	15922	0	0	0
15	05000US01025	01025	050	Clarke County, Alabama	27867	27867	7090	0	7090
16	05000US01027	01027	050	Clay County, Alabama	14254	14254	0	0	0
17	05000US01029	01029	050	Cleburne County, Alabama	14123	14123	0	0	0
18	05000US01031	01031	050	Coffee County, Alabama	43615	43615	19224	0	19224
19	05000US01033	01033	050	Colbert County, Alabama	54984	54984	29211	28823	388
20	05000US01035	01035	050	Conecuh County, Alabama	14089	14089	0	0	0
21	05000US01037	01037	050	Coosa County, Alabama	12202	12202	317	0	317
22	05000US01039	01039	050	Covington County, Alabama	37631	37631	10526	0	10526
23	05000US01041	01041	050	Crenshaw County, Alabama	13665	13665	0	0	0
24	05000US01043	01043	050	Cullman County, Alabama	77483	77483	18808	0	18808
25	05000US01045	01045	050	Dale County, Alabama	49129	49129	21839	2787	19052
26	05000US01047	01047	050	Dallas County, Alabama	46365	46365	24775	0	24775
27	05000US01049	01049	050	DeKalb County, Alabama	64452	64452	7533	0	7533
28	05000US01051	01051	050	Elmore County, Alabama	65874	65874	25069	0	25069
29	05000US01053	01053	050	Escambia County, Alabama	38440	38440	14842	0	14842
30	05000US01055	01055	050	Etowah County, Alabama	103459	103459	62283	61709	574
31	05000US01057	01057	050	Fayette County, Alabama	18495	18495	3948	0	3948
32	05000US01059	01059	050	Franklin County, Alabama	31223	31223	8763	0	8763

Figure 4.2.2. Worksheets containing 1990 and 2000 Census data.

Note that some worksheet names are expressed as simple algebraic equations in Column B of the extraction worksheet (Figure 4.2.1), for example "persons total" - "persons rural" (Cell B4). These items are not extracted from the Census database but derived by combining multiple Census items that can be found from the list (see Section 4.1.1.1 for more detail). Cells C1 and D1 are used to specify the years for the extraction, and can be extended further as the data for the new years are added. Columns F and G are used to specify the names of the input and output worksheets. The user needs to specify the names of the input worksheet "proportion" (county proportion worksheet imported from the text file output created by the NANI-GIS tool described in Section 3.1; see Figure 3.1.5), and the output worksheet "output" (used as input to the NANI-accounting tool in Sections 5.1.3).

The worksheets that follow the county proportion worksheet “Cnty_Prop” contain the Census data downloaded from the American FactFinder Data Sets webpage (Figure 4.2.3; start from http://www.census.gov/ and click on “American FactFinder”, “Data Sets”, and the desired Census year).

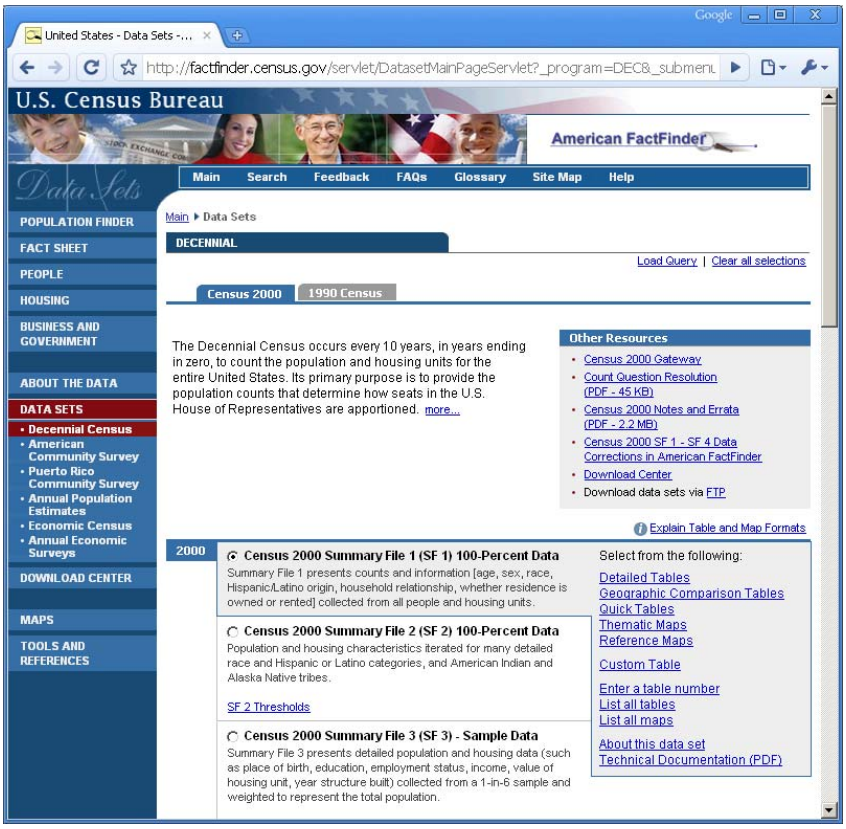


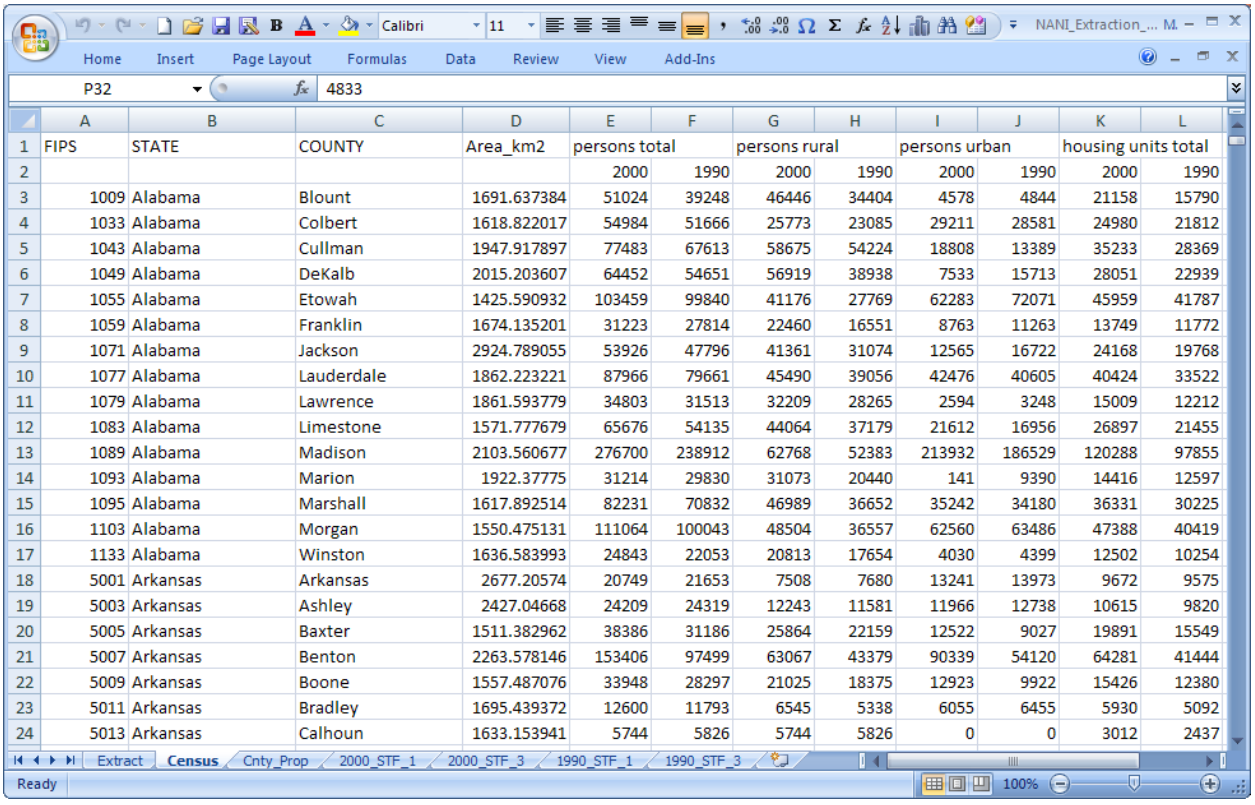
Figure 4.2.3. American FactFinder Data Sets webpage for downloading Census data.

The “Summary Tape File 1” (STF 1) reports values based on 100 percent of the data (e.g., total population), and the “Summary Tape File 3” (STF 3) reports values based on sampled data (e.g., sewered and unsewered housing units). To download the data, first select either “STF 1” or “STF 3”, click on “Detailed Tables,” select “County” as a geographic type, select the state of interest and add all counties for the state. Counties from more than one state can be added in this way. After all counties are added, select “Next” to choose the Census items of interest. The selected items can be downloaded in a Microsoft Excel format and imported directly into the extraction tool (Figure 4.2.2). The Census items that are downloaded in this way and currently available for extraction include:

- Total population
- Urban and rural (total population)
- Households
- Population in households
- Average household size

- Housing units
- Urban and rural (housing units)
- Occupancy status (housing units)
- Tenure (occupied housing units)
- Vacancy status (vacant housing units)
- Total population in occupied housing units
- Household size (occupied housing units)
- Plumbing facilities
- Sewage disposal

Before running the extraction tool, the user may replace the county proportion table and revise the list of Census items as appropriate. Click on the "Extract" button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example "Census" (Figure 4.2.4). Any missing, incomplete, or inaccurate items may be modified by the user at this stage before being used as input to the NANI-accounting tool (Section 5), if auxiliary data exist.



	A	B	C	D	E	F	G	H	I	J	K	L
1	FIPS	STATE	COUNTY	Area_km2	persons total		persons rural		persons urban		housing units total	
2					2000	1990	2000	1990	2000	1990	2000	1990
3	1009	Alabama	Blount	1691.637384	51024	39248	46446	34404	4578	4844	21158	15790
4	1033	Alabama	Colbert	1618.822017	54984	51666	25773	23085	29211	28581	24980	21812
5	1043	Alabama	Cullman	1947.917897	77483	67613	58675	54224	18808	13389	35233	28369
6	1049	Alabama	DeKalb	2015.203607	64452	54651	56919	38938	7533	15713	28051	22939
7	1055	Alabama	Etowah	1425.590932	103459	99840	41176	27769	62283	72071	45959	41787
8	1059	Alabama	Franklin	1674.135201	31223	27814	22460	16551	8763	11263	13749	11772
9	1071	Alabama	Jackson	2924.789055	53926	47796	41361	31074	12565	16722	24168	19768
10	1077	Alabama	Lauderdale	1862.223221	87966	79661	45490	39056	42476	40605	40424	33522
11	1079	Alabama	Lawrence	1861.593779	34803	31513	32209	28265	2594	3248	15009	12212
12	1083	Alabama	Limestone	1571.777679	65676	54135	44064	37179	21612	16956	26897	21455
13	1089	Alabama	Madison	2103.560677	276700	238912	62768	52383	213932	186529	120288	97855
14	1093	Alabama	Marion	1922.37775	31214	29830	31073	20440	141	9390	14416	12597
15	1095	Alabama	Marshall	1617.892514	82231	70832	46989	36652	35242	34180	36331	30225
16	1103	Alabama	Morgan	1550.475131	111064	100043	48504	36557	62560	63486	47388	40419
17	1133	Alabama	Winston	1636.583993	24843	22053	20813	17654	4030	4399	12502	10254
18	5001	Arkansas	Arkansas	2677.20574	20749	21653	7508	7680	13241	13973	9672	9575
19	5003	Arkansas	Ashley	2427.04668	24209	24319	12243	11581	11966	12738	10615	9820
20	5005	Arkansas	Baxter	1511.382962	38386	31186	25864	22159	12522	9027	19891	15549
21	5007	Arkansas	Benton	2263.578146	153406	97499	63067	43379	90339	54120	64281	41444
22	5009	Arkansas	Boone	1557.487076	33948	28297	21025	18375	12923	9922	15426	12380
23	5011	Arkansas	Bradley	1695.439372	12600	11793	6545	5338	6055	6455	5930	5092
24	5013	Arkansas	Calhoun	1633.153941	5744	5826	5744	5826	0	0	3012	2437

Figure 4.2.4. The 1990 and 2000 Census data extracted using NANI-extraction tool.

After the population data are extracted from the Census database, they can be used as input to the NANI-accounting tool calculating human N consumption (Section 5.1.3).

4.3. Extracting USGS Nutrient Input Estimates

County-level nutrient inputs were estimated by Ruddy et al. (2006) and available on the Internet at http://pubs.usgs.gov/sir/2006/5012/ (Figure 4.3.1). By clicking on the link "Nutrient-input data" at the bottom of the webpage, an Excel file containing the estimates of various nutrient inputs, including the annual fertilizer N application during the 1987-2001 periods, can be downloaded (Figure 4.3.2).

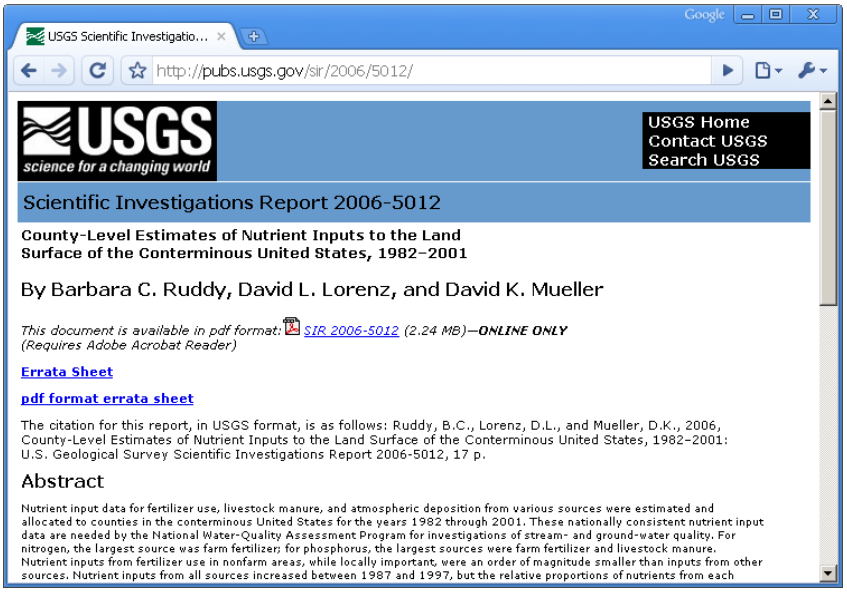
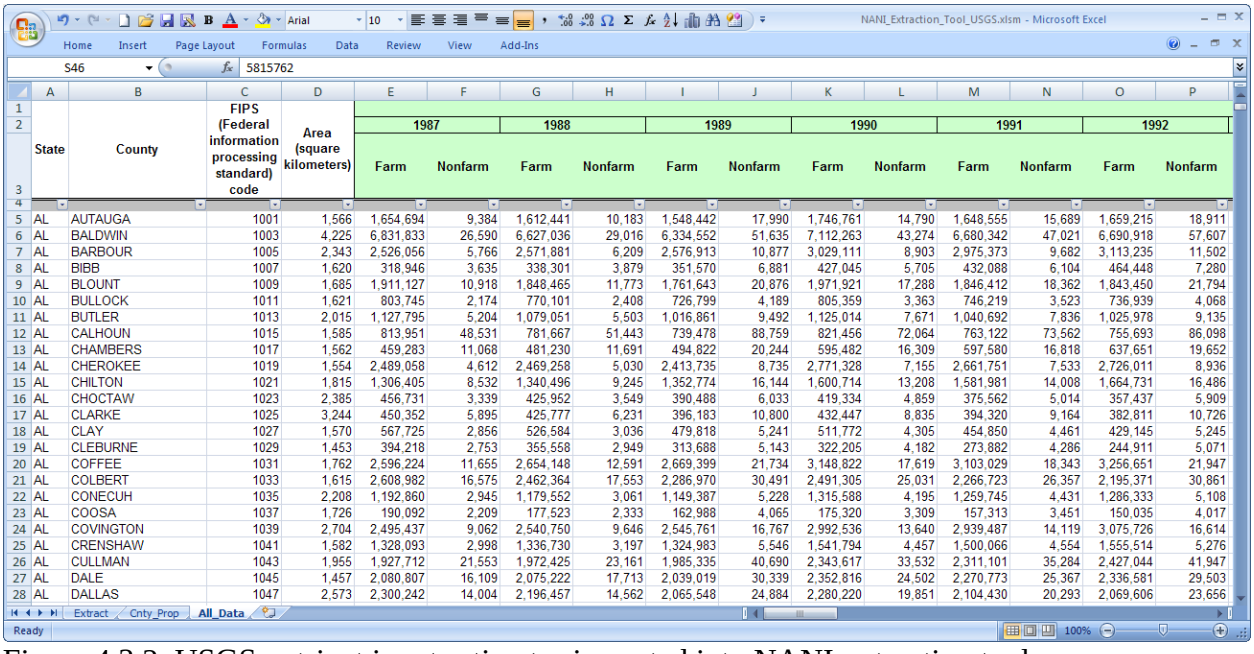


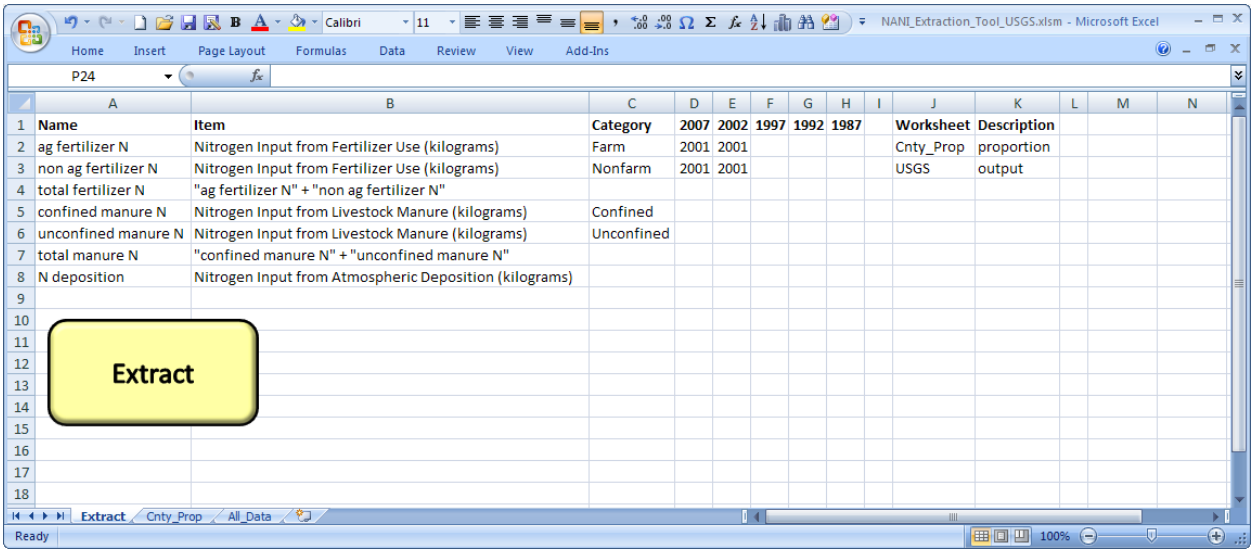
Figure 4.3.1. USGS website providing county-level estimates of nutrient inputs.



	State	County	FIPS (Federal information processing standard) code	Area (square kilometers)	1987		1988		1989		1990		1991		1992	
					Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm	Farm	Nonfarm
5	AL	AUTAUGA	1001	1,566	1,654,694	9,384	1,612,441	10,183	1,548,442	17,990	1,746,761	14,790	1,648,555	15,689	1,659,215	18,911
6	AL	BALDWIN	1003	4,225	6,831,833	26,590	6,627,036	29,016	6,334,552	51,635	7,112,263	43,274	6,680,342	47,021	6,690,918	57,607
7	AL	BARBOUR	1005	2,343	2,526,056	5,766	2,571,881	6,209	2,576,913	10,877	3,029,111	8,903	2,975,373	9,682	3,113,235	11,502
8	AL	BIBB	1007	1,620	318,946	3,635	338,301	3,879	351,570	6,881	427,045	5,705	432,088	6,104	464,448	7,280
9	AL	BLOUNT	1009	1,685	1,911,127	10,918	1,848,465	11,773	1,761,643	20,876	1,971,921	17,288	1,846,412	18,362	1,843,450	21,794
10	AL	BULLOCK	1011	1,621	803,745	2,174	770,101	2,408	726,799	4,189	805,359	3,363	746,219	3,523	736,939	4,068
11	AL	BUTLER	1013	2,015	1,127,795	5,204	1,079,051	5,503	1,016,861	9,492	1,125,014	7,671	1,040,692	7,836	1,025,978	9,135
12	AL	CALHOUN	1015	1,585	813,951	48,531	781,667	51,443	739,478	88,759	821,456	72,064	763,122	73,562	755,693	86,098
13	AL	CHAMBERS	1017	1,562	459,283	11,068	481,230	11,691	494,822	20,244	595,482	16,309	597,580	16,818	637,651	19,652
14	AL	CHEROKEE	1019	1,554	2,489,058	4,612	2,469,258	5,030	2,413,735	8,735	2,771,328	7,155	2,661,751	7,533	2,726,011	8,936
15	AL	CHILTON	1021	1,815	1,306,405	8,532	1,340,496	9,245	1,352,774	16,144	1,600,714	13,208	1,581,981	14,008	1,664,731	16,486
16	AL	CHOCTAW	1023	2,385	456,731	3,339	425,952	3,549	390,488	6,033	419,334	4,859	375,562	5,014	357,437	5,909
17	AL	CLARKE	1025	3,244	450,352	5,895	425,777	6,231	396,183	10,800	432,447	8,835	394,320	9,164	382,811	10,726
18	AL	CLAY	1027	1,570	567,725	2,856	526,584	3,036	479,818	5,241	511,772	4,305	454,850	4,461	429,145	5,245
19	AL	CLEBURNE	1029	1,453	394,218	2,753	355,558	2,949	313,688	5,143	322,205	4,182	273,882	4,286	244,911	5,071
20	AL	COFFEE	1031	1,762	2,596,224	11,655	2,654,148	12,591	2,669,399	21,734	3,148,822	17,619	3,103,029	18,343	3,256,651	21,947
21	AL	COLBERT	1033	1,615	2,608,982	16,575	2,462,364	17,553	2,286,970	30,491	2,491,305	25,031	2,266,723	26,357	2,195,371	30,861
22	AL	CONECUH	1035	2,208	1,192,860	2,945	1,179,552	3,061	1,149,387	5,228	1,315,588	4,195	1,259,745	4,431	1,286,333	5,108
23	AL	COOSA	1037	1,726	190,092	2,209	177,523	2,333	162,988	4,065	175,320	3,309	157,313	3,451	150,035	4,017
24	AL	COVINGTON	1039	2,704	2,495,437	9,062	2,540,750	9,646	2,545,761	16,767	2,992,536	13,640	2,939,487	14,119	3,075,726	16,614
25	AL	CRENSHAW	1041	1,582	1,328,093	2,998	1,336,730	3,197	1,324,983	5,546	1,541,794	4,457	1,500,066	4,554	1,555,514	5,276
26	AL	CULLMAN	1043	1,955	1,927,712	21,553	1,972,425	23,161	1,985,335	40,690	2,343,617	33,532	2,311,101	35,284	2,427,044	41,947
27	AL	DALE	1045	1,457	2,080,807	16,109	2,075,222	17,713	2,039,019	30,339	2,352,816	24,502	2,270,773	25,367	2,336,581	29,503
28	AL	DALLAS	1047	2,573	2,300,242	14,004	2,196,457	14,562	2,065,548	24,884	2,280,220	19,851	2,104,430	20,293	2,069,606	23,656

Figure 4.3.2. USGS nutrient input estimates imported into NANI-extraction tool.

These data are downloaded and imported into the “All_Data” worksheet of the NANI-extraction tool “NANI_Extraction_Tool_USGS.xlsm” (Figure 4.3.2) for extraction of county-level fertilizer N application, which in turn is used as input to the NANI-accounting tool (Section 5). To extract the fertilizer N application (and other relevant items) from USGS nutrient input estimates, open the file “NANI_Extraction_Tool_USGS.xlsm” with Excel 2007 (Figure 4.3.3).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Name**	**Item**	**Category**	**2007**	**2002**	**1997**	**1992**	**1987**		**Worksheet**	**Description**			
2	ag fertilizer N	Nitrogen Input from Fertilizer Use (kilograms)	Farm	2001	2001					Cnty_Prop	proportion			
3	non ag fertilizer N	Nitrogen Input from Fertilizer Use (kilograms)	Nonfarm	2001	2001					USGS	output			
4	total fertilizer N	"ag fertilizer N" + "non ag fertilizer N"												
5	confined manure N	Nitrogen Input from Livestock Manure (kilograms)	Confined											
6	unconfined manure N	Nitrogen Input from Livestock Manure (kilograms)	Unconfined											
7	total manure N	"confined manure N" + "unconfined manure N"												
8	N deposition	Nitrogen Input from Atmospheric Deposition (kilograms)												

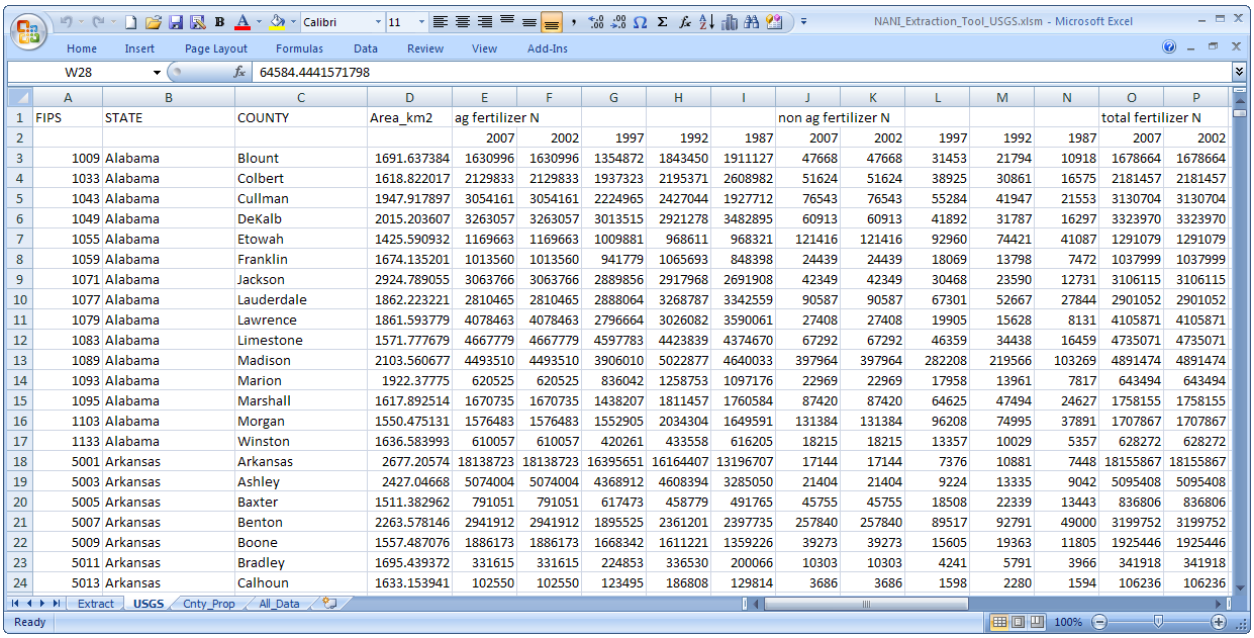
Figure 4.3.3. Extracting USGS nutrient input estimates.

The first worksheet “Extract” contains a list of items to be extracted. Column A contains the user-specified names of the items, and Columns B and C contain the full names and the categories in which the items belong to (e.g., “Farm” or “Nonfarm” in Row 3 in Figure 4.3.2.), respectively, that can be found in the nutrient input data worksheet. Note that some item names are expressed as simple algebraic equations in Column B of the extraction worksheet, for example "ag fertilizer N" + "non ag fertilizer N" (Cell B4). These items are not extracted from the nutrient input data worksheet but derived by combining multiple items that can be found from the list (see Section 4.1.1.1 for more detail).

Columns D to H of the extraction worksheet contain a list of years for the extraction. If the cells in these columns are left blank, the desired items will be extracted from the corresponding years. If these cells have year numbers, the extraction will instead be made in the user-specified years (in Figure 4.3.3, for example, the values for the “ag fertilizer N” in 2002 and 2007 will be replaced with those in 2001). Cells D1 to H1 are used to specify the years for the extraction, and can be extended further as the data for the new years are added.

Columns J and K are used to specify the names of the input and output worksheets. The user needs to specify the names of the input worksheet “proportion” (county proportion worksheet imported from the text file output created by the NANI-GIS tool described in Section 3.1; see Figure 3.1.5), and the output worksheet “output” (used as input to the NANI-accounting tool in Section 5.3).

Before running the extraction tool, the user may replace the county proportion worksheet "Cnty_Prop" and revise the list of items as appropriate. Click on the "Extract" button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example "USGS" (Figure 4.3.4). Any missing, incomplete, or inaccurate items may be modified by the user at this stage before being used as input to the NANI-accounting tool (Section 5), if auxiliary data exist.



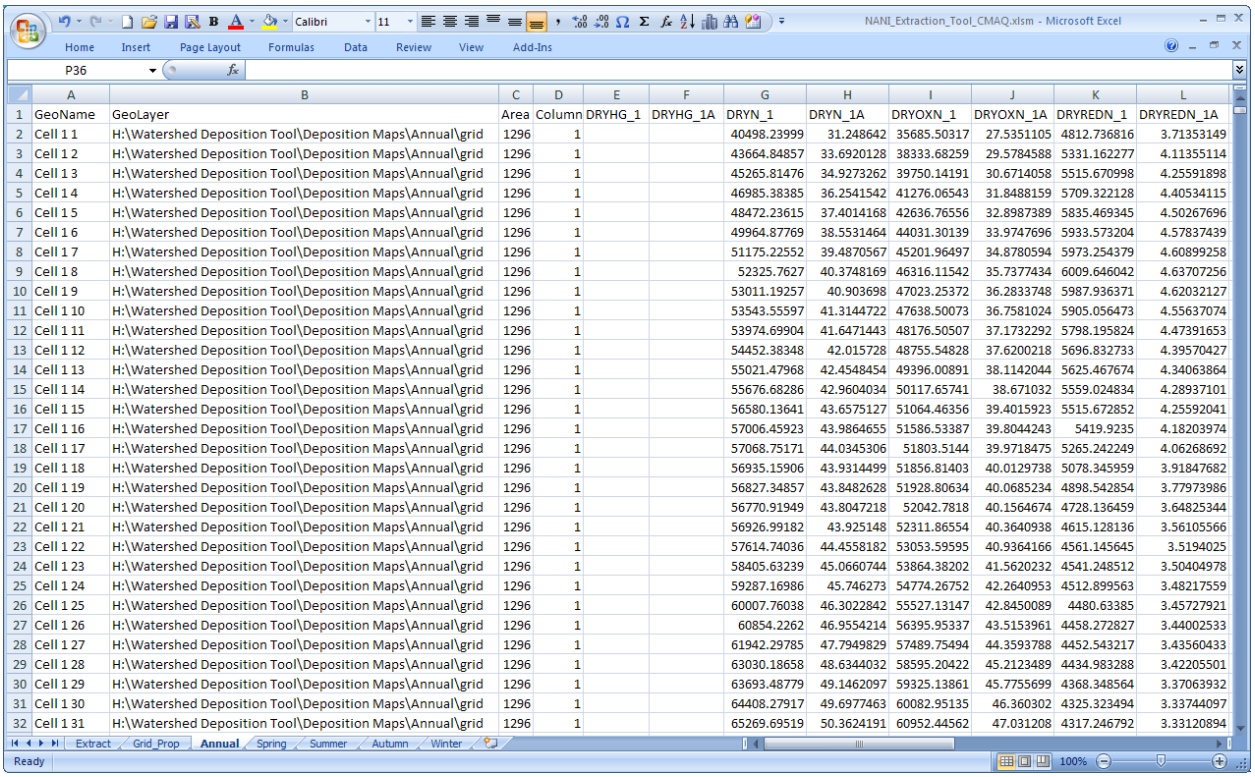
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	FIPS	STATE	COUNTY	Area_km2	ag fertilizer N					non ag fertilizer N					total fertilizer N	
2					2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002
3	1009	Alabama	Blount	1691.637384	1630996	1630996	1354872	1843450	1911127	47668	47668	31453	21794	10918	1678664	1678664
4	1033	Alabama	Colbert	1618.822017	2129833	2129833	1937323	2195371	2608982	51624	51624	38925	30861	16575	2181457	2181457
5	1043	Alabama	Cullman	1947.917897	3054161	3054161	2224965	2427044	1927712	76543	76543	55284	41947	21553	3130704	3130704
6	1049	Alabama	DeKalb	2015.203607	3263057	3263057	3013515	2921278	3482895	60913	60913	41892	31787	16297	3323970	3323970
7	1055	Alabama	Etowah	1425.590932	1169663	1169663	1009881	968611	968321	121416	121416	92960	74421	41087	1291079	1291079
8	1059	Alabama	Franklin	1674.135201	1013560	1013560	941779	1065693	848398	24439	24439	18069	13798	7472	1037999	1037999
9	1071	Alabama	Jackson	2924.789055	3063766	3063766	2889856	2917968	2691908	42349	42349	30468	23590	12731	3106115	3106115
10	1077	Alabama	Lauderdale	1862.223221	2810465	2810465	2888064	3268787	3342559	90587	90587	67301	52667	27844	2901052	2901052
11	1079	Alabama	Lawrence	1861.593779	4078463	4078463	2796664	3026082	3590061	27408	27408	19905	15628	8131	4105871	4105871
12	1083	Alabama	Limestone	1571.777679	4667779	4667779	4597783	4423839	4374670	67292	67292	46359	34438	16459	4735071	4735071
13	1089	Alabama	Madison	2103.560677	4493510	4493510	3906010	5022877	4640033	397964	397964	282208	219566	103269	4891474	4891474
14	1093	Alabama	Marion	1922.37775	620525	620525	836042	1258753	1097176	22969	22969	17958	13961	7817	643494	643494
15	1095	Alabama	Marshall	1617.892514	1670735	1670735	1438207	1811457	1760584	87420	87420	64625	47494	24627	1758155	1758155
16	1103	Alabama	Morgan	1550.475131	1576483	1576483	1552905	2034304	1649591	131384	131384	96208	74995	37891	1707867	1707867
17	1133	Alabama	Winston	1636.583993	610057	610057	420261	433558	616205	18215	18215	13357	10029	5357	628272	628272
18	5001	Arkansas	Arkansas	2677.20574	18138723	18138723	16395651	16164407	13196707	17144	17144	7376	10881	7448	18155867	18155867
19	5003	Arkansas	Ashley	2427.04668	5074004	5074004	4368912	4608394	3285050	21404	21404	9224	13335	9042	5095408	5095408
20	5005	Arkansas	Baxter	1511.382962	791051	791051	617473	458779	491765	45755	45755	18508	22339	13443	836806	836806
21	5007	Arkansas	Benton	2263.578146	2941912	2941912	1895525	2361201	2397735	257840	257840	89517	92791	49000	3199752	3199752
22	5009	Arkansas	Boone	1557.487076	1886173	1886173	1668342	1611221	1359226	39273	39273	15605	19363	11805	1925446	1925446
23	5011	Arkansas	Bradley	1695.439372	331615	331615	224853	336530	200066	10303	10303	4241	5791	3966	341918	341918
24	5013	Arkansas	Calhoun	1633.153941	102550	102550	123495	186808	129814	3686	3686	1598	2280	1594	106236	106236

Figure 4.3.4. USGS nutrient input estimates extracted using NANI-extraction tool.

After the fertilizer N application is extracted from the USGS nutrient input estimates, it can be used as input to the NANI-accounting tool (Section 5.3).

4.4. Extracting CMAQ Deposition Estimates

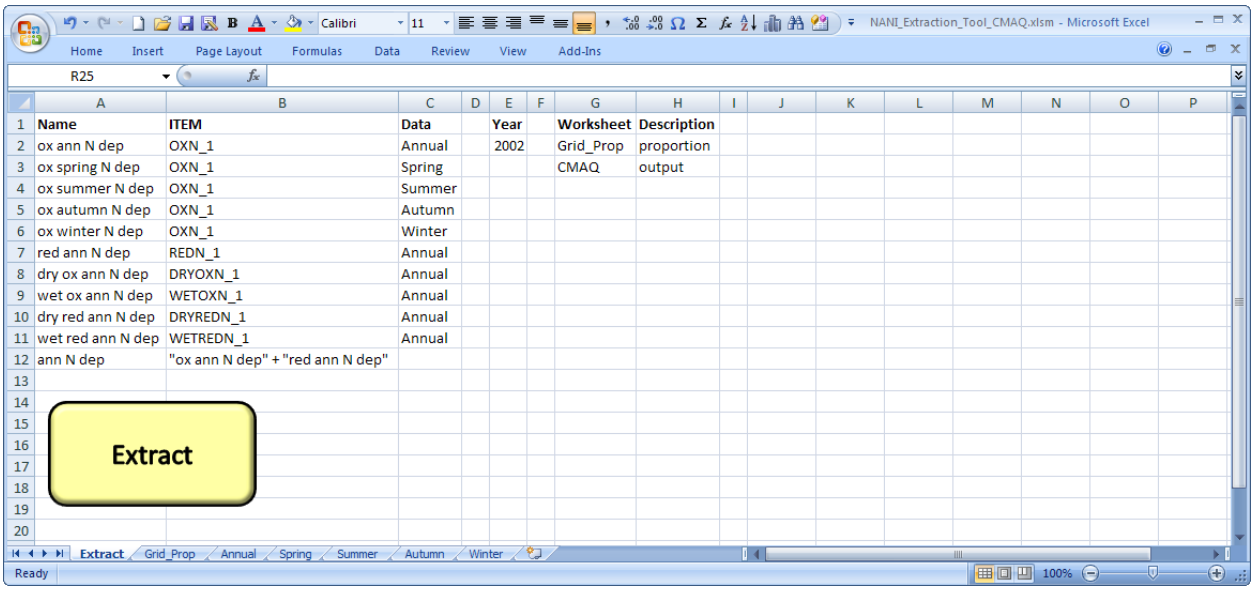
Unlike other NANI components (Sections 4.1, 4.2, and 4.3), atmospheric N deposition is not estimated from the county-based data but based on a grid map containing various deposition estimates generated by the CMAQ model. Using the Watershed Deposition Tool described in Section 3.2, the N deposition estimates in each CMAQ grid cell are exported as a dbf file, which is then imported into the annual and seasonal data worksheets of the NANI-extraction tool "NANI_Extraction_Tool_CMAQ.xlsm" (Figure 4.4.1). Instructions on obtaining and processing the CMAQ data can be found in "Generating N Deposition Maps for SE US Watersheds" document available at http://www.eeb.cornell.edu/biogeo/nanc/GIS_methods/gis_methods.htm.



	A	B	C	D	E	F	G	H	I	J	K	L
1	GeoName	GeoLayer	Area	Column	DRYHG_1	DRYHG_1A	DRYN_1	DRYN_1A	DRYOXN_1	DRYOXN_1A	DRYREDN_1	DRYREDN_1A
2	Cell 1 1	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			40498.23999	31.248642	35685.50317	27.5351105	4812.736816	3.71353149
3	Cell 1 2	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			43664.84857	33.6920128	38333.68259	29.5784588	5331.162277	4.11355114
4	Cell 1 3	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			45265.81476	34.9273262	39750.14191	30.6714058	5515.670998	4.25591898
5	Cell 1 4	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			46985.38385	36.2541542	41276.06543	31.8488159	5709.322128	4.40534115
6	Cell 1 5	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			48472.23615	37.4014168	42636.76556	32.8987389	5835.469345	4.50267696
7	Cell 1 6	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			49964.87769	38.5531464	44031.30139	33.9747696	5933.573204	4.57837439
8	Cell 1 7	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			51175.22552	39.4870567	45201.96497	34.8780594	5973.254379	4.60899258
9	Cell 1 8	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			52325.7627	40.3748169	46316.11542	35.7377434	6009.646042	4.63707256
10	Cell 1 9	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			53011.19257	40.903698	47023.25372	36.2833748	5987.936371	4.62032127
11	Cell 1 10	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			53543.55597	41.3144722	47638.50073	36.7581024	5905.056473	4.55637074
12	Cell 1 11	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			53974.69904	41.6471443	48176.50507	37.1732292	5798.195824	4.47391653
13	Cell 1 12	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			54452.38348	42.015728	48755.54828	37.6200218	5696.832733	4.39570427
14	Cell 1 13	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			55021.47968	42.4548454	49396.00891	38.1142044	5625.467674	4.34063864
15	Cell 1 14	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			55676.68286	42.9604034	50117.65741	38.671032	5559.024834	4.28937101
16	Cell 1 15	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			56580.13641	43.6575127	51064.46356	39.4015923	5515.672852	4.25592041
17	Cell 1 16	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			57006.45923	43.9864655	51586.53387	39.8044243	5419.9235	4.18203974
18	Cell 1 17	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			57068.75171	44.0345306	51803.5144	39.9718475	5265.242249	4.06268692
19	Cell 1 18	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			56935.15906	43.9314499	51856.81403	40.0129738	5078.345959	3.91847682
20	Cell 1 19	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			56827.34857	43.8482628	51928.80634	40.0685234	4898.542854	3.77973986
21	Cell 1 20	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			56770.91949	43.8047218	52042.7818	40.1564674	4728.136459	3.64825344
22	Cell 1 21	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			56926.99182	43.925148	52311.86554	40.3640938	4615.128136	3.56105566
23	Cell 1 22	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			57614.74036	44.4558182	53053.59595	40.9364166	4561.145645	3.5194025
24	Cell 1 23	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			58405.63239	45.0660744	53864.38202	41.5620232	4541.248512	3.50404978
25	Cell 1 24	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			59287.16986	45.746273	54774.26752	42.2640953	4512.899563	3.48217559
26	Cell 1 25	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			60007.76038	46.3022842	55527.13147	42.8450089	4480.63385	3.45727921
27	Cell 1 26	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			60854.2262	46.9554214	56395.95337	43.5153961	4458.272827	3.44002533
28	Cell 1 27	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			61942.29785	47.7949829	57489.75494	44.3593788	4452.543217	3.43560433
29	Cell 1 28	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			63030.18658	48.6344032	58595.20422	45.2123489	4434.983288	3.42205501
30	Cell 1 29	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			63693.48779	49.1462097	59325.13861	45.7755699	4368.348564	3.37063932
31	Cell 1 30	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			64408.27917	49.6977463	60082.95135	46.360302	4325.323494	3.33744097
32	Cell 1 31	H:\Watershed Deposition Tool\Deposition Maps\Annual\grid	1296	1			65269.69519	50.3624191	60952.44562	47.031208	4317.246792	3.33120894

Figure 4.4.1. CMAQ deposition estimates imported into NANI-extraction tool.

In this section, the atmospheric N deposition and other relevant items are extracted from CMAQ deposition estimates, and organized into a format suitable as input to the NANI-accounting tools (Section 5). Open the file "NANI_Extraction_Tool_CMAQ.xlsm" with Excel 2007 (Figure 4.4.2).



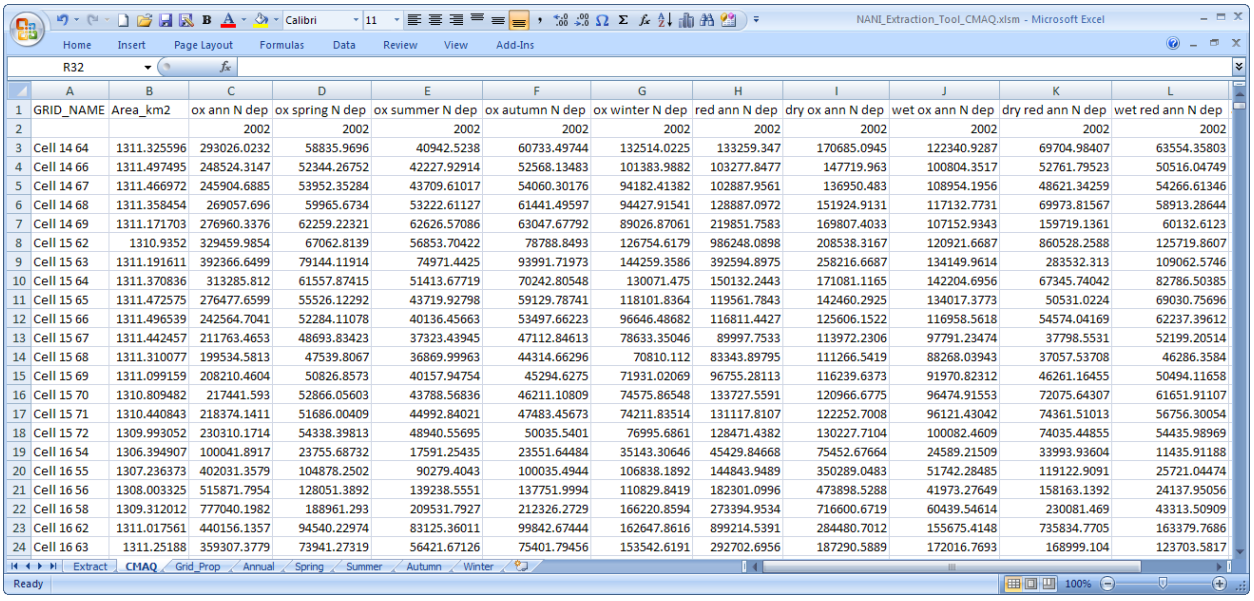
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Name**	**ITEM**	**Data**		**Year**		**Worksheet**	**Description**								
2	ox ann N dep	OXN_1	Annual		2002		Grid_Prop	proportion								
3	ox spring N dep	OXN_1	Spring				CMAQ	output								
4	ox summer N dep	OXN_1	Summer													
5	ox autumn N dep	OXN_1	Autumn													
6	ox winter N dep	OXN_1	Winter													
7	red ann N dep	REDN_1	Annual													
8	dry ox ann N dep	DRYOXN_1	Annual													
9	wet ox ann N dep	WETOXN_1	Annual													
10	dry red ann N dep	DRYREDN_1	Annual													
11	wet red ann N dep	WETREDN_1	Annual													
12	ann N dep	"ox ann N dep" + "red ann N dep"														

Figure 4.4.2. Extracting CMAQ deposition estimates.

The first worksheet “Extract” contains a list of items to be extracted. Column A contains the user-specified names of the items, and Columns B and C contain the names of the column headings and data worksheets, respectively, where the desired items can be found (Figure 4.4.1). Note that some item names are expressed as simple algebraic equations in Column B of the extraction worksheet, for example "ox ann N dep" + "red ann N dep" (Cell B12). These items are not extracted from the data worksheets but derived by combining multiple items that can be found from the list (see Section 4.1.1.1 for more detail).

Cell E2 of the extraction worksheet specifies the year for the extraction. The CMAQ deposition estimates are currently available only for the year of 2002, and this tool is intended for extracting data (originally from dbf files generated by exporting the attribute tables of GIS maps) for a single year. Columns G and H are used to specify the names of the input and output worksheets. The user needs to specify the names of the input worksheet “proportion” (CMAQ grid proportion worksheet imported from the text file output created by the NANI-GIS tool described in Section 3.2; see Figure 3.2.5), and the output worksheet “output” (used as input to the NANI-accounting tool in Section 5.4).

Before running the extraction tool, the user may replace the grid proportion worksheet “Grid_Prop” and revise the list of items as appropriate. Click on the “Extract” button in the extraction worksheet and the relevant data will be extracted and reported to the user-specified output worksheet, in this example “CMAQ” (Figure 4.4.3). Any missing, incomplete, or inaccurate items may be modified by the user at this stage before being used as input to the NANI-accounting tool (Section 5), if auxiliary data exist.



	A	B	C	D	E	F	G	H	I	J	K	L
1	GRID_NAME	Area_km2	ox ann N dep	ox spring N dep	ox summer N dep	ox autumn N dep	ox winter N dep	red ann N dep	dry ox ann N dep	wet ox ann N dep	dry red ann N dep	wet red ann N dep
2			2002	2002	2002	2002	2002	2002	2002	2002	2002	2002
3	Cell 14 64	1311.325596	293026.0232	58835.9696	40942.5238	60733.49744	132514.0225	133259.347	170685.0945	122340.9287	69704.98407	63554.35803
4	Cell 14 66	1311.497495	248524.3147	52344.26752	42227.92914	52568.13483	101383.9882	103277.8477	147719.963	100804.3517	52761.79523	50516.04749
5	Cell 14 67	1311.466972	245904.6885	53952.35284	43709.61017	54060.30176	94182.41382	102887.9561	136950.483	108954.1956	48621.34259	54266.61346
6	Cell 14 68	1311.358454	269057.696	59965.6734	53222.61127	61441.49597	94427.91541	128887.0972	151924.9131	117132.7731	69973.81567	58913.28644
7	Cell 14 69	1311.171703	276960.3376	62259.22321	62626.57086	63047.67792	89026.87061	219851.7583	169807.4033	107152.9343	159719.1361	60132.6123
8	Cell 15 62	1310.9352	329459.9854	67062.8139	56853.70422	78788.8493	126754.6179	986248.0898	208538.3167	120921.6687	860528.2588	125719.8607
9	Cell 15 63	1311.191611	392366.6499	79144.11914	74971.4425	93991.71973	144259.3586	392594.8975	258216.6687	134149.9614	283532.313	109062.5746
10	Cell 15 64	1311.370836	313285.812	61557.87415	51413.67719	70242.80548	130071.475	150132.2443	171081.1165	142204.6956	67345.74042	82786.50385
11	Cell 15 65	1311.472575	276477.6599	55526.12292	43719.92798	59129.78741	118101.8364	119561.7843	142460.2925	134017.3773	50531.0224	69030.75696
12	Cell 15 66	1311.496539	242564.7041	52284.11078	40136.45663	53497.66223	96646.48682	116811.4427	125606.1522	116958.5618	54574.04169	62237.39612
13	Cell 15 67	1311.442457	211763.4653	48693.83423	37323.43945	47112.84613	78633.35046	89997.7533	113972.2306	97791.23474	37798.5531	52199.20514
14	Cell 15 68	1311.310077	199534.5813	47539.8067	36869.99963	44314.66296	70810.112	83343.89795	111266.5419	88268.03943	37057.53708	46286.3584
15	Cell 15 69	1311.099159	208210.4604	50826.8573	40157.94754	45294.6275	71931.02069	96755.28113	116239.6373	91970.82312	46261.16455	50494.11658
16	Cell 15 70	1310.809482	217441.593	52866.05603	43788.56836	46211.10809	74575.86548	133727.5591	120966.6775	96474.91553	72075.64307	61651.91107
17	Cell 15 71	1310.440843	218374.1411	51686.00409	44992.84021	47483.45673	74211.83514	131117.8107	122252.7008	96121.43042	74361.51013	56756.30054
18	Cell 15 72	1309.993052	230310.1714	54338.39813	48940.55695	50035.5401	76995.6861	128471.4382	130227.7104	100082.4609	74035.44855	54435.98969
19	Cell 16 54	1306.394907	100041.8917	23755.68732	17591.25435	23551.64484	35143.30646	45429.84668	75452.67664	24589.21509	33993.93604	11435.91188
20	Cell 16 55	1307.236373	402031.3579	104878.2502	90279.4043	100035.4944	106838.1892	144843.9489	350289.0483	51742.28485	119122.9091	25721.04474
21	Cell 16 56	1308.003325	515871.7954	128051.3892	139238.5551	137751.9994	110829.8419	182301.0996	473898.5288	41973.27649	158163.1392	24137.95056
22	Cell 16 58	1309.312012	777040.1982	188961.293	209531.7927	212326.2729	166220.8594	273394.9534	716600.6719	60439.54614	230081.469	43313.50909
23	Cell 16 62	1311.017561	440156.1357	94540.22974	83125.36011	99842.67444	162647.8616	899214.5391	284480.7012	155675.4148	735834.7705	163379.7686
24	Cell 16 63	1311.25188	359307.3779	73941.27319	56421.67126	75401.79456	153542.6191	292702.6956	187290.5889	172016.7693	168999.104	123703.5817

Figure 4.4.3. CMAQ deposition estimates extracted using NANI-extraction tool.

After the atmospheric N deposition is extracted from the CMAQ deposition estimates, it can be used as input to the NANI-accounting tool (Section 5.4).

5. NANI-Accounting Tools

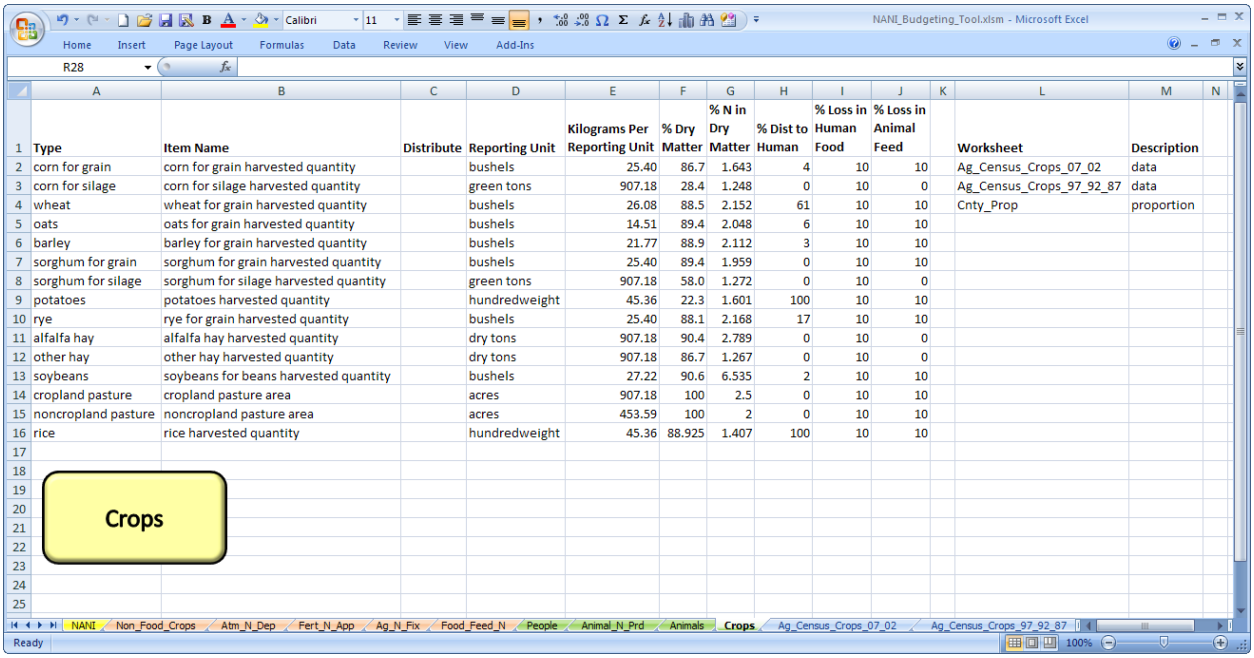
Using the NANI-accounting tools described in this section, the user can calculate all the components of NANI, including the net food and feed imports (Section 5.1), agricultural N fixation (Section 5.2), fertilizer N application (Section 5.3), atmospheric N deposition (Section 5.4), and non-food crop exports (Section 5.5), as well as NANI (Section 5.6).

5.1. Calculating Net Food and Feed Imports

The net food and feed imports are composed of crop and animal N production (negative fluxes removing N from watersheds) and animal and human N consumption (positive fluxes adding N to watersheds). Calculations of crop N production (Section 5.1.1), animal N production and N consumption (Section 5.1.2), and human N consumption (Section 5.1.3) are performed in the "Crops", "Animals", and "People" worksheets, respectively, of the NANI-accounting tool. These results in turn are used for the calculation of net food and feed imports in the "Food_Feed_N" worksheet, as described in Section 5.1.4.

5.1.1. Calculating Crop N Production

In this section, crop N production is calculated in the "Crops" worksheet of the NANI-accounting tool. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Crops" worksheet (Figure 5.1.1.1).



	Type	Item Name	Distribute	Reporting Unit	Kilograms Per Reporting Unit	% Dry Matter	% N in Dry Matter	% Dist to Human	% Loss in Human Food	% Loss in Animal Feed		Worksheet	Description
2	corn for grain	corn for grain harvested quantity		bushels	25.40	86.7	1.643	4	10	10		Ag_Census_Crops_07_02	data
3	corn for silage	corn for silage harvested quantity		green tons	907.18	28.4	1.248	0	10	0		Ag_Census_Crops_97_92_87	data
4	wheat	wheat for grain harvested quantity		bushels	26.08	88.5	2.152	61	10	10		Cnty_Prop	proportion
5	oats	oats for grain harvested quantity		bushels	14.51	89.4	2.048	6	10	10			
6	barley	barley for grain harvested quantity		bushels	21.77	88.9	2.112	3	10	10			
7	sorghum for grain	sorghum for grain harvested quantity		bushels	25.40	89.4	1.959	0	10	10			
8	sorghum for silage	sorghum for silage harvested quantity		green tons	907.18	58.0	1.272	0	10	0			
9	potatoes	potatoes harvested quantity		hundredweight	45.36	22.3	1.601	100	10	10			
10	rye	rye for grain harvested quantity		bushels	25.40	88.1	2.168	17	10	10			
11	alfalfa hay	alfalfa hay harvested quantity		dry tons	907.18	90.4	2.789	0	10	0			
12	other hay	other hay harvested quantity		dry tons	907.18	86.7	1.267	0	10	0			
13	soybeans	soybeans for beans harvested quantity		bushels	27.22	90.6	6.535	2	10	10			
14	cropland pasture	cropland pasture area		acres	907.18	100	2.5	0	10	10			
15	noncropland pasture	noncropland pasture area		acres	453.59	100	2	0	10	10			
16	rice	rice harvested quantity		hundredweight	45.36	88.925	1.407	100	10	10			

Figure 5.1.1.1. "Crops" worksheet of NANI-accounting tool.

The worksheet contains a list of crops for the calculation of crop N production (Column A) and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figures 4.1.1.1.4 and 4.1.2.1.4). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. Examples of its application can be found in Sections 5.1.2.1 and 5.1.3. The "Crops" worksheet also has all the crop parameters that are needed for the calculation of crop N production, including the reporting unit (Column D), kilograms per reporting unit (Column E), percent dry matter (Column F), percent N in dry matter (Column G), percent distribution to human (Column H), percent loss of N during the processing of human food (Column I), and percent loss of N during the processing of animal feed (Column J). The values of these parameters used in this example and their references are summarized in Table 5.1.1.1. (Note that the cotton and tobacco in Table 5.1.1.1 are non-food crops used for the calculation of non-food crop exports as described in Section 5.5.)

The worksheet also contains the names of worksheets used as input (Columns L and M). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the county-based Agricultural Census data for the crops in 1987, 1992, and 1997, created by the NANI-extraction tool described in Section 4.1.1.1 ("Ag_Census_Crops_97_92_87" shown in Figure 4.1.1.1.4).
- A "data" worksheet containing the county-based Agricultural Census data for the crops in 2002 and 2007, created by the NANI-extraction tool described in Section 4.1.2.1 ("Ag_Census_Crops_07_02" shown in Figure 4.1.2.1.4).
- A "proportion" worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 ("Cnty_Prop" shown in Figure 3.1.5).

Click on the "Crops" button to run the calculation. The results will be reported in the same worksheet starting from Column O (Figure 5.1.1.2), summarized into six separate tables, reporting:

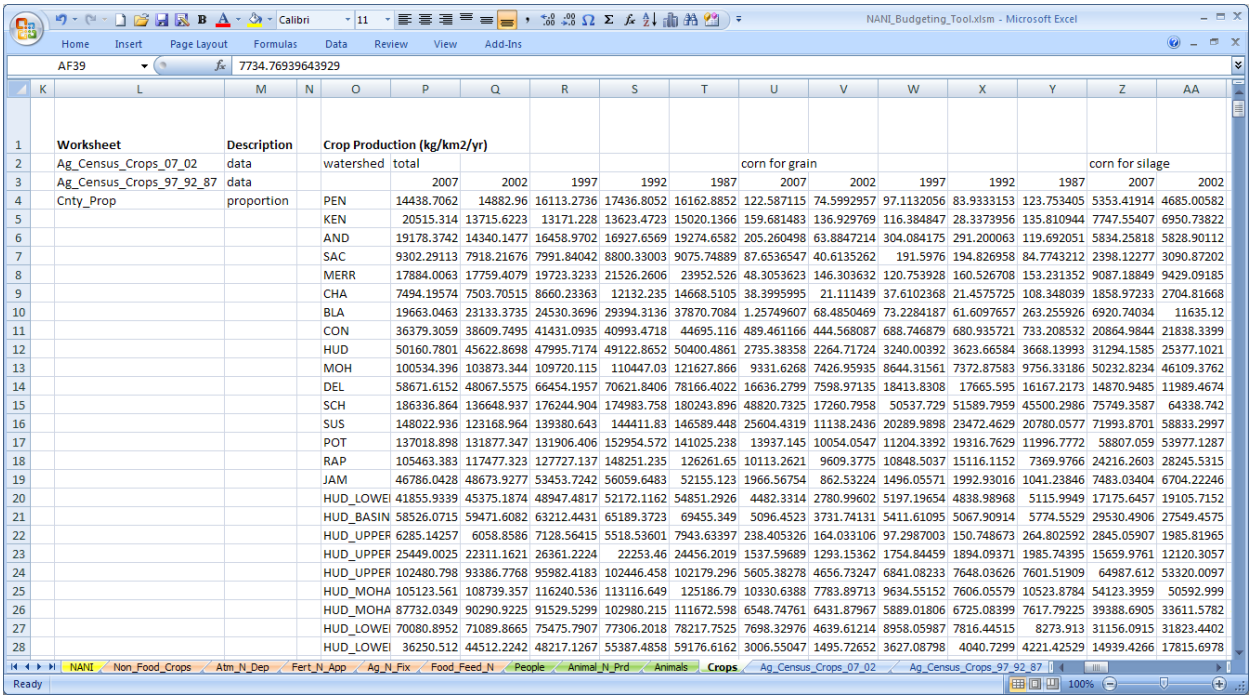
- Crop Production (kg/km^2/yr)
- Crop N Production (kg-N/km^2/yr)
- Crop N Production for Humans (kg-N/km^2/yr)
- Crop N Production for Animals (kg-N/km^2/yr)
- N in Human Food Products (kg-N/km^2/yr)
- N in Animal Feed Products (kg-N/km^2/yr)

The first table is created by converting the reporting units into kilograms of biomass by multiplying by the conversion factors (Column E) and then by their proportions within the watershed, summing over all the counties, and dividing by the watershed area. The second table is created by converting them into kilograms of nitrogen by multiplying by the percent dry matter (Column F) and then the percent nitrogen (Column G). These conversion factors may not be reported separately in the original literature but as combined (i.e., pre-multiplied) factors. The combined factors may be entered in either Column F or G, while leaving the other column blank.

Table 5.1.1.1. Crop parameters used in the calculation of crop N production. Variables in the square brackets are obtained from Agricultural Census (Sections 4.1.1.1 and 4.1.2.1) and those in the double quotation marks are derived from other variables.

Name	Agricultural Census Item Name	Yield Unit	Kilograms Harvested Per Yield Unit[a]	Percent Dry Matter[a]	Percent N in Dry Matter[a]	Percent Distributed to Human[b]	Percent Loss after Processing for Human[c]	Percent Loss after Processing for Animals[c]
corn for grain	[corn for grain or seed]	bushels	25.4	86.7	1.64	4	10	10
sorghum for grain	[sorghum for grain or seed]	bushels	25.4	89.4	1.96	0	-	10
wheat	[wheat for grain]	bushels	26.1	88.5[d]	2.15[d]	61	10	10
barley	[barley for grain]	bushels	21.8	88.9	2.11	3	10	10
oats	[oats for grain]	bushels	14.5	89.4	2.05	6	10	10
rice	[rice]	hundredweight	45.4	88.9	1.41	100	10	-
rye	[rye for grain]	bushels	25.4	88.1	2.17	17	10	10
cotton	[cotton]	bales	226.8	92.2	3.30	100	10	-
tobacco	[tobacco]	pounds	0.45	-	3.19[de]	100	10	-
soybeans	[soybeans for beans]	bushels	27.2	90.6	6.54	2	10	10
potatoes	[potatoes]	hundredweight	45.4	22.3	1.60	100	10	-
alfalfa hay	[alfalfa hay]	dry tons	907.2	90.4	2.79	0	-	0
other hay	"other hay"[f]	dry tons	907.2	86.7[d]	1.27[d]	0	-	0
corn for silage	[corn for silage or green chop]	green tons	907.2	28.4	1.25	0	-	0
sorghum for silage	[sorghum for silage or green chop]	green tons	907.2	58.0	1.27	0	-	0
cropland pasture	[cropland pasture]	acres	907.2	-	2.5	0	-	10
noncropland pasture	"noncropland pasture"[g]	acres	453.6	-	2.0	0	-	10

[a] Lander et al. (1998); Boyer et al. (2002)
[b] Jordan and Weller (1996); Boyer et al. (2002)
[c] Boyer et al. (2002)
[d] Values for varieties or subcategories averaged
[e] percent dry matter × percent N in dry matter
[f] "other hay" = [all hay] – [alfalfa hay]
[g] "noncropland pasture" = [all pastureland] – [cropland pasture]



	Worksheet	Description		Crop Production (kg/km2/yr)												
2	Ag_Census_Crops_07_02	data		watershed	total					corn for grain					corn for silage	
3	Ag_Census_Crops_97_92_87	data			2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002
4	Cnty_Prop	proportion		PEN	14438.7062	14882.96	16113.2736	17436.8052	16162.8852	122.587115	74.5992957	97.1132056	83.9333153	123.753405	5353.41914	4685.00582
5				KEN	20515.314	13715.6223	13171.228	13623.4723	15020.1366	159.681483	136.929769	116.384847	28.3373956	135.810944	7747.55407	6950.73822
6				AND	19178.3742	14340.1477	16458.9702	16927.6569	19274.6582	205.260498	63.8847214	304.084175	291.200063	119.692051	5834.25818	5828.90112
7				SAC	9302.29113	7918.21676	7991.84042	8800.33003	9075.74889	87.6536547	40.6135262	191.5976	194.826958	84.7743212	2398.12277	3090.87202
8				MERR	17884.0063	17759.4079	19723.3233	21526.2606	23952.526	48.3053623	146.303632	120.753928	160.526708	153.231352	9087.18849	9429.09185
9				CHA	7494.19574	7503.70515	8660.23363	12132.235	14668.5105	38.3995995	21.111439	37.6102368	21.4575725	108.348039	1858.97233	2704.81668
10				BLA	19663.0463	23133.3735	24530.3696	29394.3136	37870.7084	1.25749607	68.4850469	73.2284187	61.6097657	263.255926	6920.74034	11635.12
11				CON	36379.3059	38609.7495	41431.0935	40993.4718	44695.116	489.461166	444.568087	688.746879	680.935721	733.208532	20864.9844	21838.3399
12				HUD	50160.7801	45622.8698	47995.7174	49122.8652	50400.4861	2735.38358	2264.71724	3240.00392	3623.66584	3668.13993	31294.1585	25377.1021
13				MOH	100534.396	103873.344	109720.115	110447.03	121627.866	9331.6268	7426.95935	8644.31561	7372.87583	9756.33186	50232.8234	46109.3762
14				DEL	58671.6152	48067.5575	66454.1957	70621.8406	78166.4022	16636.2799	7598.97135	18413.8308	17665.595	16167.2173	14870.9485	11989.4674
15				SCH	186336.864	136648.937	176244.904	174983.758	180243.896	48820.7325	17260.7958	50537.729	51589.7959	45500.2986	75749.3587	64338.742
16				SUS	148022.936	123168.964	139380.643	144411.83	146589.448	25604.4319	11138.2436	20289.9898	23472.4629	20780.0577	71993.8701	58833.2997
17				POT	137018.898	131877.347	131906.406	152954.572	141025.238	13937.145	10054.0547	11204.3392	19316.7629	11996.7772	58807.059	53977.1287
18				RAP	105463.383	117477.323	127727.137	148251.235	126261.65	10113.2621	9609.3775	10848.5037	15116.1152	7369.9766	24216.2603	28245.5315
19				JAM	46786.0428	48673.9277	53453.7242	56059.6483	52155.123	1966.56754	862.53224	1496.05571	1992.93016	1041.23846	7483.03404	6704.22246
20				HUD_LOWEI	41855.9339	45375.1874	48947.4817	52172.1162	54851.2926	4482.3314	2780.99602	5197.19654	4838.98968	5115.9949	17175.6457	19105.7152
21				HUD_BASIN	58526.0715	59471.6082	63212.4431	65189.3723	69455.349	5096.4523	3731.74131	5411.61095	5067.90914	5774.5529	29530.4906	27549.4575
22				HUD_UPPER	6285.14257	6058.8586	7128.56415	5518.53601	7943.63397	238.405326	164.033106	97.2987003	150.748673	264.802592	2845.05907	1985.81965
23				HUD_UPPER	25449.0025	22311.1621	26361.2224	22253.46	24456.2019	1537.59689	1293.15362	1754.84459	1894.09371	1985.74395	15659.9761	12120.3057
24				HUD_UPPER	102480.798	93386.7768	95982.4183	102446.458	102179.296	5605.38278	4656.73247	6841.08233	7648.03626	7601.51909	64987.612	53320.0097
25				HUD_MOHA	105123.561	108739.357	116240.536	113116.649	125186.79	10330.6388	7783.89713	9634.55152	7606.05579	10523.8784	54123.3959	50592.999
26				HUD_MOHA	87732.0349	90290.9225	91529.5299	102980.215	111672.598	6548.74761	6431.87967	5889.01806	6725.08399	7617.79225	39388.6905	33611.5782
27				HUD_LOWEI	70080.8952	71089.8665	75475.7907	77306.2018	78217.7525	7698.32976	4639.61214	8958.05987	7816.44515	8273.913	31156.0915	31823.4402
28				HUD_LOWEI	36250.512	44512.2242	48217.1267	55387.4858	59176.6162	3006.55047	1495.72652	3627.08798	4040.7299	4221.42529	14939.4266	17815.6978

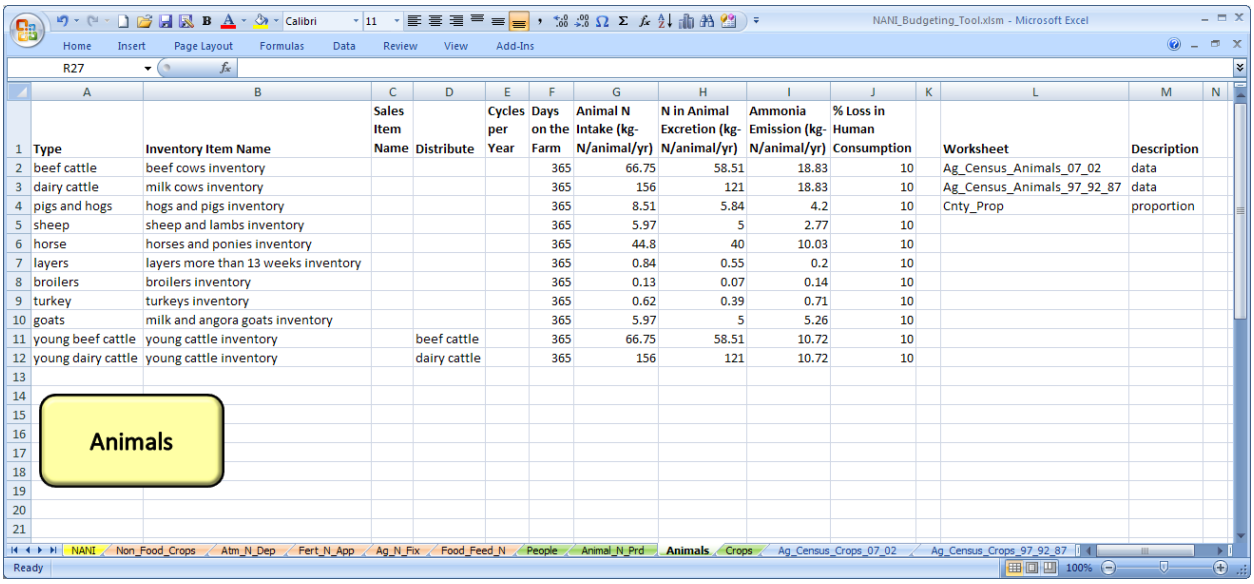
Figure 5.1.1.2. Crop N production calculated by NANI-accounting tool.

After the crop N production is calculated, it is distributed into the human and animal use (third and fourth tables, respectively) using the information given in Column H. Finally, in the fifth and sixth tables, N in human food and animal feed products are reported, respectively, applying the proportions lost during the processing (specified in Columns I and J, respectively). The fifth and sixth tables are used in the calculation of net food and feed imports, as described in Section 5.1.4.

5.1.2. Calculating Animal N Production and N Consumption

5.1.2.1. Static Livestock Model

In this section, animal N production and N consumption are calculated in the "Animals" worksheet of the NANI-accounting tool, using an approach referred to as "static livestock model" (Boyer et al. 2002), that involves obtaining the animal numbers of each of the 11 livestock groups from the inventory data of Agricultural Census, and multiplying the animal parameters to obtain the animal N production and N consumption. The application of an alternative approach referred to as "dynamic livestock model" (Han and Allan 2008) is described in Section 5.1.2.2. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Animals" worksheet (Figure 5.1.2.1.1).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Type	Inventory Item Name	Sales Item Name	Distribute	Cycles per Year	Days on the Farm	Animal N Intake (kg-N/animal/yr)	N in Animal Excretion (kg-N/animal/yr)	Ammonia Emission (kg-N/animal/yr)	% Loss in Human Consumption		Worksheet	Description	
2	beef cattle	beef cows inventory				365	66.75	58.51	18.83	10		Ag_Census_Animals_07_02	data	
3	dairy cattle	milk cows inventory				365	156	121	18.83	10		Ag_Census_Animals_97_92_87	data	
4	pigs and hogs	hogs and pigs inventory				365	8.51	5.84	4.2	10		Cnty_Prop	proportion	
5	sheep	sheep and lambs inventory				365	5.97	5	2.77	10				
6	horse	horses and ponies inventory				365	44.8	40	10.03	10				
7	layers	layers more than 13 weeks inventory				365	0.84	0.55	0.2	10				
8	broilers	broilers inventory				365	0.13	0.07	0.14	10				
9	turkey	turkeys inventory				365	0.62	0.39	0.71	10				
10	goats	milk and angora goats inventory				365	5.97	5	5.26	10				
11	young beef cattle	young cattle inventory		beef cattle		365	66.75	58.51	10.72	10				
12	young dairy cattle	young cattle inventory		dairy cattle		365	156	121	10.72	10				
13														
14														
15														
16														
17														
18														
19														
20														
21														

Figure 5.1.2.1.1. "Animals" worksheet of NANI-accounting tool (static livestock model).

The worksheet contains a list of animals for the calculation of animal N production and N consumption (Column A) and their user-specified inventory item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figures 4.1.1.2.2 and 4.1.2.2.2). Column C, with the column heading "Sales Item Name" is left blank in the static approach, which uses only the inventory data to estimate animal numbers. Column D, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. In this example, the user wants to calculate the numbers of "young beef cattle" and "young dairy cattle" (Rows 11 and 12, respectively) to assign different animal parameters. As shown in Figure 5.1.2.1.1, the number of total young cattle ("young cattle inventory" calculated as "cattle and calves inventory" – "beef cows inventory" – "milk cows inventory"; see Figures 4.1.1.2.1 and Figure 4.1.2.2.1) is distributed between the "young beef cattle" and "young dairy cattle" according to the relative proportions of the "beef cattle" and "dairy cattle" (adults), respectively, that are available in Agricultural Census.

The "Animals" worksheet also has all the animal parameters that are needed for the calculation of animal N production and N consumption (and other relevant items), including the animal N intake (Column G), N in animal excretion (Column H), ammonia emission (Column I), and percent loss of N during the conversion into the human food products, such as milk, meat, eggs, etc. (Column J). (The parameters in Columns E and F are used in the dynamic approach, and for the static approach Column E should be left blank and Column F should be set to 365.) The values of animal parameters used in this example and their references are summarized in Table 5.1.2.1.1.

The worksheet also contains the names of worksheets used as input (Columns L and M). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

Table 5.1.2.1.1. Animal parameters used in the static livestock model. Variables in the square brackets are obtained from Agricultural Census (Sections 4.1.1.2 and 4.1.2.2) and those in the double quotation marks are derived from other variables. Parameter values were obtained from Boyer et al. (2002).

Name	Agricultural Census Item Name	Animal N Intake (kg-N/animal/yr)	N in Animal Excretion (kg-N/animal/yr)	Ammonia Emission (kg-N/animal/yr)
beef cattle	[beef cows inventory]	66.75	58.51	18.83
dairy cattle	[milk cows inventory]	156	121	18.83
pigs and hogs	[hogs and pigs inventory]	8.51	5.84	4.2
layers	[layers 13 weeks old and older inventory]	0.84	0.55	0.2
broilers	[broilers inventory]	0.13	0.07	0.14
turkey	[turkeys inventory]	0.62	0.39	0.71
sheep	[sheep and lambs inventory]	5.97	5	2.77
horse	[horses and ponies inventory]	44.8	40	10.03
goats	[milk and angora goats inventory]	5.97	5	5.26
other beef cattle	"other beef cattle inventory"[a]	N/A[b]	N/A[b]	10.72
other dairy cattle	"other dairy cattle inventory"[c]	N/A[d]	N/A[d]	10.72

[a] "other beef cattle inventory" = "other cattle inventory"[e] × [beef cows inventory] / ([beef cows inventory] + [milk cows inventory])
[b] estimated from beef cattle
[c] "other dairy cattle inventory" = "other cattle inventory"[e] × [milk cows inventory] / ([beef cows inventory] + [milk cows inventory])
[d] estimated from dairy cattle
[e] "other cattle inventory" = [cattle and calves inventory] – [beef cows inventory] – [milk cows inventory]

- A “data” worksheet containing the county-based Agricultural Census data for the animals in 1987, 1992, and 1997, created by the NANI-extraction tool described in Section 4.1.1.2 (“Ag_Census_Animals_97_92_87” shown in Figure 4.1.1.2.2).
- A “data” worksheet containing the county-based Agricultural Census data for the animals in 2002 and 2007, created by the NANI-extraction tool described in Section 4.1.2.2 (“Ag_Census_Animals_07_02” shown in Figure 4.1.2.2.2).
- A “proportion” worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 (“Cnty_Prop” shown in Figure 3.1.5).

Click on the “Animals” button to run the calculation. The results will be reported in the same worksheet starting from Column O (Figure 5.1.2.1.2), summarized into six separate tables, reporting:

- Animal Density (animals/km^2)
- Ammonia Emission (kg-N/km^2/yr)
- N in Animal Excretion (kg-N/km^2/yr)
- Animal Requirements of N (kg-N/km^2/yr)
- Animal Production for Human Consumption (kg-N/km^2/yr)
- N in Animal Products (Milk, Meat, Eggs, etc) (kg-N/km^2/yr)

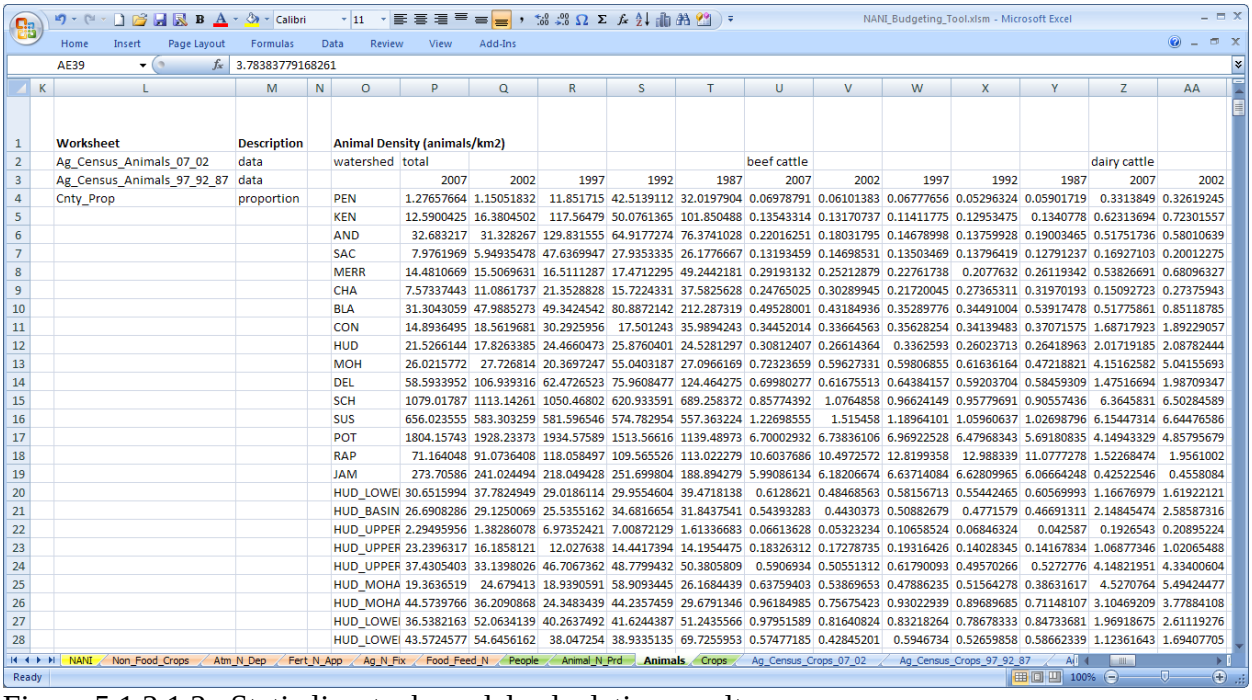


Figure 5.1.2.1.2. Static livestock model calculation results.

The first table (animal density) is created by multiplying the animal inventory numbers (as specified in Column B) by their proportions within the watershed, summing over all the counties, and dividing by the watershed area. The second, third, and fourth tables are created by multiplying the animal densities by the ammonia emission parameters (Column I), animal excretion parameters (Column H), and animal intake parameters (Column G), respectively, to obtain ammonia emission, N in animal excretion, and animal requirements of N (i.e., animal N consumption), respectively. The fifth table is created by subtracting the N in animal excretion (third table) from the animal requirements of N (fourth table), and represents the animal production of nitrogen available for human consumption. Finally, N in animal products (i.e., animal N production) is reported in the sixth table, applying the proportions lost during the processing (specified in Column J). The fourth (animal N consumption) and sixth (animal N production) tables are used in the calculation of net food and feed imports, as described in Section 5.1.4.

5.1.2.2. Dynamic Livestock Model

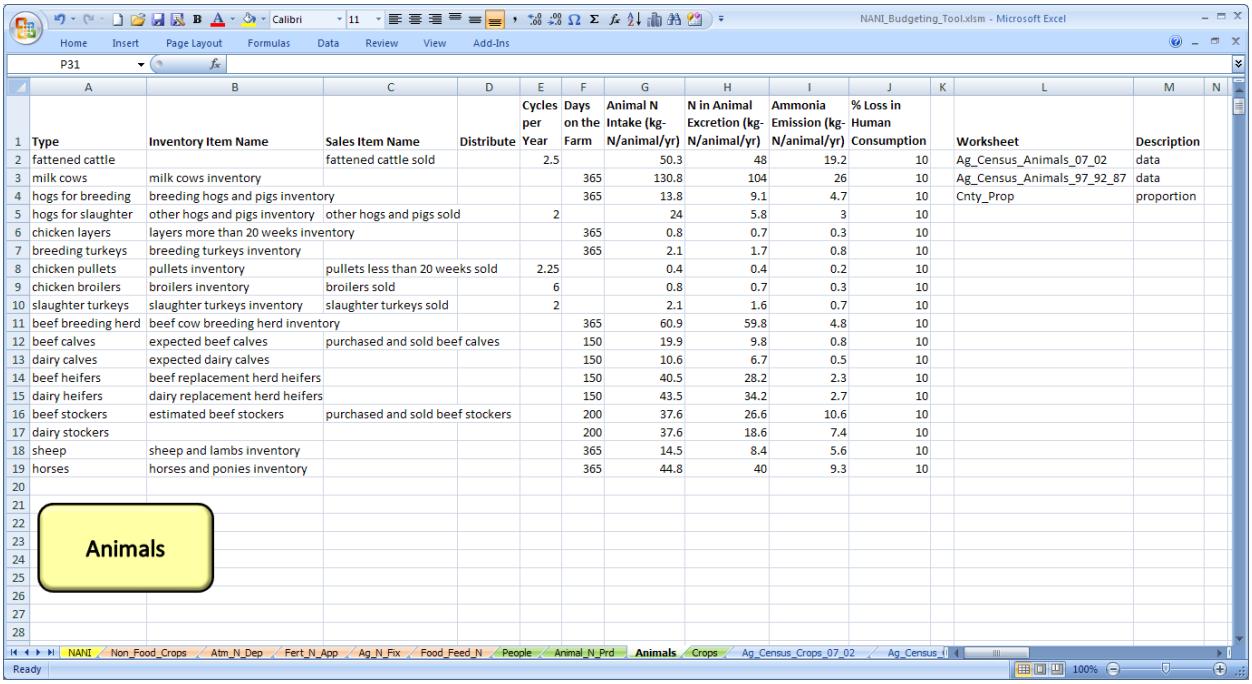
In this section, animal N production and N consumption are calculated in the "Animals" worksheet of the NANI-accounting tool, using an approach referred to as "dynamic livestock model" (Han and Allan 2008). A simpler approach, referred to as "static livestock model" (Boyer et al. 2002), is described in Section 5.1.2.1. The dynamic method applied by Han and Allan (2008) involves disaggregation of animals into 18 livestock groups and estimation of the "average" animal numbers using the sales data, as well as the inventory data, with the consideration of the life cycle of animals or the number of days per year the animals stay on the farm. When the value for the animal life cycle is given, the average number of animals is calculated as:

$$\text{Average Number} = \text{Inventory} \times \frac{1}{\text{Cycles}} + \text{Sales} \times \frac{1}{\text{Cycles}} \times \frac{\text{Cycles} - 1}{\text{Cycles}} \qquad (5.1.2.2.1)$$

When the number of days on the farm is given:

$$\text{Average Number} = \text{Inventory} \times \frac{\text{Days}}{365} + \text{Sales} \times \frac{\text{Days}}{365} \times \frac{1}{2} \qquad (5.1.2.2.2)$$

If no sales data are given, only the inventory data are applied, resulting in the same number of animals as the static method when the life cycle is one or the number of days on the farm is 365. If only the sales data are available, they are treated as the inventory data. A full description of the animal model and mathematical derivation of these equations can be found in Kellogg et al. (2000). To calculate animal N production and N consumption using the dynamic approach, the "Animals" worksheet of the NANI-accounting tool can be set as shown in Figure 5.1.2.2.1. (Note that, except for the list of animals and parameter values, it is the same accounting tool as "NANI_Budgeting_Tool.xlsm" described in Section 5.1.2.1.)

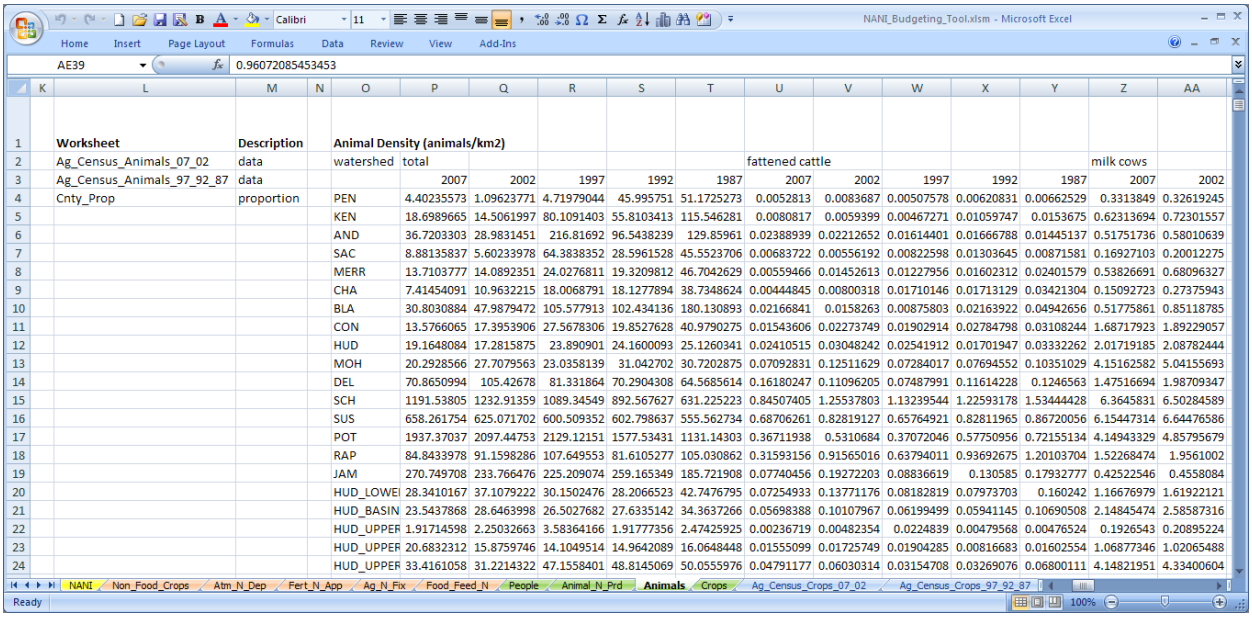


	Type	Inventory Item Name	Sales Item Name	Distribute	Cycles per Year	Days on the Farm	Animal N Intake (kg-N/animal/yr)	N in Animal Excretion (kg-N/animal/yr)	Ammonia Emission (kg-N/animal/yr)	% Loss in Human Consumption	Worksheet	Description
2	fattened cattle		fattened cattle sold		2.5		50.3	48	19.2	10	Ag_Census_Animals_07_02	data
3	milk cows	milk cows inventory				365	130.8	104	26	10	Ag_Census_Animals_97_92_87	data
4	hogs for breeding	breeding hogs and pigs inventory				365	13.8	9.1	4.7	10	Cnty_Prop	proportion
5	hogs for slaughter	other hogs and pigs inventory	other hogs and pigs sold		2		24	5.8	3	10		
6	chicken layers	layers more than 20 weeks inventory				365	0.8	0.7	0.3	10		
7	breeding turkeys	breeding turkeys inventory				365	2.1	1.7	0.8	10		
8	chicken pullets	pullets inventory	pullets less than 20 weeks sold		2.25		0.4	0.4	0.2	10		
9	chicken broilers	broilers inventory	broilers sold		6		0.8	0.7	0.3	10		
10	slaughter turkeys	slaughter turkeys inventory	slaughter turkeys sold		2		2.1	1.6	0.7	10		
11	beef breeding herd	beef cow breeding herd inventory				365	60.9	59.8	4.8	10		
12	beef calves	expected beef calves	purchased and sold beef calves			150	19.9	9.8	0.8	10		
13	dairy calves	expected dairy calves				150	10.6	6.7	0.5	10		
14	beef heifers	beef replacement herd heifers				150	40.5	28.2	2.3	10		
15	dairy heifers	dairy replacement herd heifers				150	43.5	34.2	2.7	10		
16	beef stockers	estimated beef stockers	purchased and sold beef stockers			200	37.6	26.6	10.6	10		
17	dairy stockers					200	37.6	18.6	7.4	10		
18	sheep	sheep and lambs inventory				365	14.5	8.4	5.6	10		
19	horses	horses and ponies inventory				365	44.8	40	9.3	10		

Animals

Figure 5.1.2.2.1. “Animals” worksheet of NANI-accounting tool (dynamic livestock model).

A detailed description on the “Animals” worksheet is given in Section 5.1.2.1. In contrast to the static approach, the sales item names may be provided in Column C (in addition to the inventory item names in Column B), as well as animal life cycle (Column E) and number of days on the farm (Column F). Click on the “Animals” button to run the calculation. The results will be reported in the same worksheet starting from Column O (Figure 5.1.2.2.2). The values of animal parameters used in this example and their references are summarized in Table 5.1.2.2.1.



	Worksheet	Description	Animal Density (animals/km2)														
2	Ag_Census_Animals_07_02	data	watershed	total					fattened cattle					milk cows			
3	Ag_Census_Animals_97_92_87	data		2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002		
4	Cnty_Prop	proportion	PEN	4.40235573	1.09623771	4.71979044	45.995751	51.1725273	0.0052813	0.0083687	0.00507578	0.00620831	0.00662529	0.3313849	0.32619245		
5			KEN	18.6989665	14.5061997	80.1091403	55.8103413	115.546281	0.0080817	0.0059399	0.00467271	0.01059747	0.0153675	0.62313694	0.72301557		
6			AND	36.7203303	28.9831451	216.81692	96.5438239	129.85961	0.02388939	0.02212652	0.01614401	0.01666788	0.01445137	0.51751736	0.58010639		
7			SAC	8.88135837	5.60233978	64.3838352	28.5961528	45.5523706	0.00683722	0.00556192	0.00822598	0.01303645	0.00871581	0.16927103	0.20012275		
8			MERR	13.7103777	14.0892351	24.0276811	19.3209812	46.7042629	0.00559466	0.01452613	0.01227956	0.01602312	0.02401579	0.53826691	0.68096327		
9			CHA	7.41454091	10.9632215	18.0068791	18.1277894	38.7348624	0.00444845	0.00800318	0.01710146	0.01713129	0.03421304	0.15092723	0.27375943		
10			BLA	30.8030884	47.9879472	105.577913	102.434136	180.130893	0.02166841	0.0158263	0.00875803	0.02163922	0.04942656	0.51775861	0.85118785		
11			CON	13.5766065	17.3953906	27.5678306	19.8527628	40.9790275	0.01543606	0.02273749	0.01902914	0.02784798	0.03108244	1.68717923	1.89229057		
12			HUD	19.1648084	17.2815875	23.890901	24.1600093	25.1260341	0.02410515	0.03048242	0.02541912	0.01701947	0.03332262	2.01719185	2.08782444		
13			MOH	20.2928566	27.7079563	23.0358139	31.042702	30.7202875	0.07092831	0.12511629	0.07284017	0.07694552	0.10351029	4.15162582	5.04155693		
14			DEL	70.8650994	105.42678	81.331864	70.2904308	64.5685614	0.16180247	0.11096205	0.07487991	0.11614228	0.1246563	1.47516694	1.98709347		
15			SCH	1191.53805	1232.91359	1089.34549	892.567627	631.225223	0.84507405	1.25537803	1.13239544	1.22593178	1.53444428	6.3645831	6.50284589		
16			SUS	658.261754	625.071702	600.509352	602.798637	555.562734	0.68706261	0.82819127	0.65764921	0.82811965	0.86720056	6.15447314	6.64476586		
17			POT	1937.37037	2097.44753	2129.12151	1577.53431	1131.14303	0.36711938	0.5310684	0.37072046	0.57750956	0.72155134	4.14943329	4.85795679		
18			RAP	84.8433978	91.1598286	107.649553	81.6105277	105.030862	0.31593156	0.91565016	0.63794011	0.93692675	1.20103704	1.52268474	1.9561002		
19			JAM	270.749708	233.766476	225.209074	259.165349	185.721908	0.07740456	0.19272203	0.08836619	0.130585	0.17932777	0.42522546	0.4558084		
20			HUD_LOWEI	28.3410167	37.1079222	30.1502476	28.2066523	42.7476795	0.07254933	0.13771176	0.08182819	0.07973703	0.160242	1.16676979	1.61922121		
21			HUD_BASIN	23.5437868	28.6463998	26.5027682	27.6335142	34.3637266	0.05698388	0.10107967	0.06199499	0.05941145	0.10690508	2.14845474	2.58587316		
22			HUD_UPPER	1.91714598	2.25032663	3.58364166	1.91777356	2.47425925	0.00236719	0.00482354	0.0224839	0.00479568	0.00476524	0.1926543	0.20895224		
23			HUD_UPPER	20.6832312	15.8759746	14.1049514	14.9642089	16.0648448	0.01555099	0.01725749	0.01904285	0.00816683	0.01602554	1.06877346	1.02065488		
24			HUD_UPPER	33.4161058	31.2214322	47.1558401	48.8145069	50.0555976	0.04791177	0.06030314	0.03154708	0.03269076	0.06800111	4.14821951	4.33400604		

Figure 5.1.2.2.2. Dynamic livestock model calculation results.

Table 5.1.2.2.1. Animal parameters used in the dynamic livestock model. Variables in the square brackets are obtained from Agricultural Census (Sections 4.1.1.2 and 4.1.2.2) and those in the double quotation marks are derived from other variables as described in detail in Kellogg et al. (2000). Parameter values were obtained from Han and Allan (2008).

Name	Agricultural Census Item Name (Inventory Variable)	Agricultural Census Item Name (Sales Variable)	Cycles per Year	Days on the Farm	Animal N Intake (kg-N/ animal/yr)	N in Animal Excretion (kg-N/ animal/yr)	Ammonia Emission (kg-N/ animal/yr)
fattened cattle		[fattened cattle sold]	2.5		50.3	48	19.2
milk cows	[milk cows inventory]			365	130.8	104	26
hogs for breeding	[breeding hogs and pigs inventory]			365	13.8	9.1	4.7
hogs for slaughter	[other hogs and pigs inventory]	[other hogs and pigs sold]	2		24	5.8	3
chicken layers	[layers 20 weeks old and older inventory]			365	0.8	0.7	0.3
breeding turkeys	[breeding turkeys inventory]			365	2.1	1.7	0.8
chicken pullets	[pullets less than 20 weeks old inventory]	[pullets less than 20 weeks old sold]	2.25		0.4	0.4	0.2
chicken broilers	[broilers inventory]	[broilers sold]	6		0.8	0.7	0.3
slaughter turkeys	[slaughter turkeys inventory]	[slaughter turkeys sold]	2		2.1	1.6	0.7
beef breeding herd	"beef cow breeding herd inventory"[a]			365	60.9	59.8	4.8
beef calves	"expected beef calves"[b]	"purchased and sold beef calves"[c]		150	19.9	9.8	0.8
dairy calves	"expected dairy calves"[d]			150	10.6	6.7	0.5
beef heifers	"beef replacement herd heifers"[e]			150	40.5	28.2	2.3
dairy heifers	"dairy replacement herd heifers"[f]			150	43.5	34.2	2.7
beef stockers	"estimated beef stockers"[g]	"purchased and sold beef stockers"[h]		200	37.6	26.6	10.6
dairy stockers				200	37.6	18.6	7.4
sheep	[sheep and lambs inventory]			365	14.5	8.4	5.6
horses	[horses and ponies inventory]			365	44.8	40	9.3

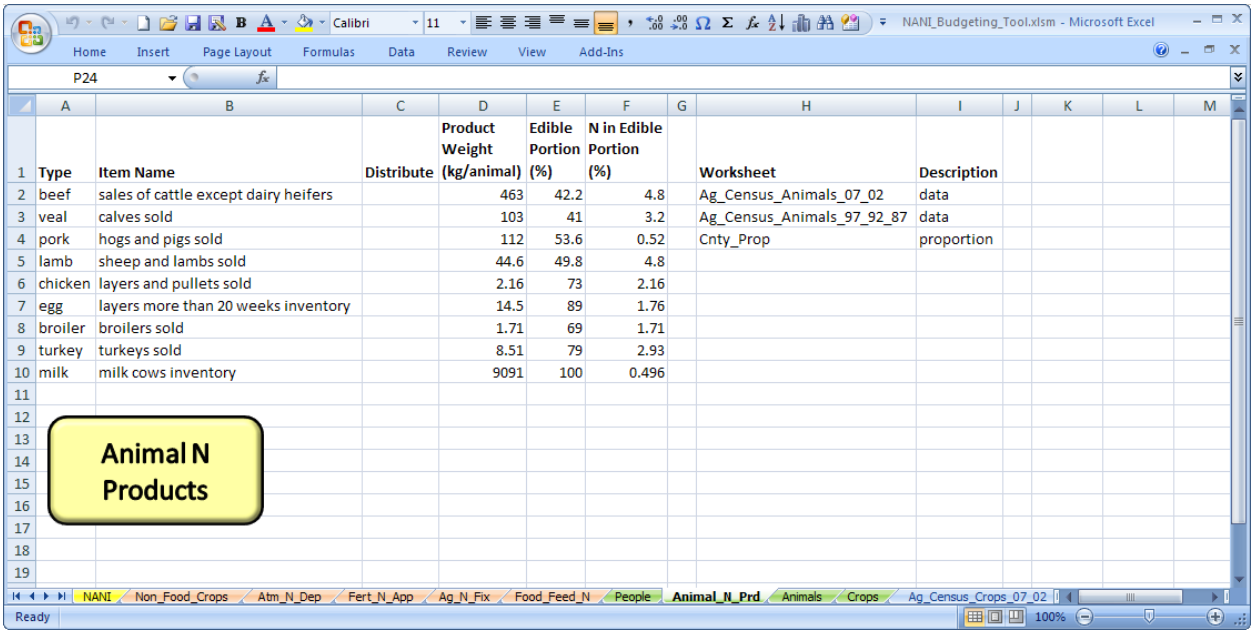
[a] "beef cow breeding herd inventory" = [beef cows inventory] + "bulls inventory"[i]
[b] "expected beef calves" = 0.82 × [beef cows inventory]
[c] "purchased and sold beef calves" = [calves sold] – "expected beef calves"[b] – "expected dairy calves"[d]
[d] "expected dairy calves" = 0.65 × [milk cows inventory]
[e] "beef replacement herd heifers" = Minimum (0.15 × [beef cows inventory], "beef heifers inventory"[j])
[f] "dairy replacement herd heifers" = Minimum (0.2 × [milk cows inventory], [heifers inventory])
[g] "estimated beef stockers" = Minimum ("beef stockers sold and inventory"[k], "expected beef calves"[b])
[h] "purchased and sold beef stockers" = "beef stockers sold and inventory"[k] – "expected beef calves"[b]
[i] "bulls inventory" = Minimum (0.05 × [beef cows inventory], [steers and bulls inventory])
[j] "beef heifers inventory" = [heifers inventory] – "dairy replacement herd heifers"[f]
[k] "beef stockers sold and inventory" = "beef stockers sold"[l] + "beef stockers inventory"[m]
[l] "beef stockers sold" = [cattle sold] – [fattened cattle sold] – "beef replacement herd heifers" – "dairy replacement herd heifers"
[m] "beef stockers inventory" = [heifers inventory] – "beef replacement herd heifers" – "dairy replacement herd heifers" + [steers and bulls inventory] – "bulls inventory"

The accounting tool calculates the "average" animal numbers by applying the Equation 5.1.2.2.1 or 5.1.2.2.2, depending on the parameter specification. Subsequent calculations of animal N production and N consumption and generation of output tables in the "Animals" worksheet are the same as those described in Section 5.1.2.1. Again, the fourth (animal N consumption) and sixth (animal N production) tables generated by the accounting tool are used in the calculation of net food and feed imports (Section 5.1.4).

5.1.2.3. Animal N Products

In the previous two sections, animal N production was calculated as the difference between the animal N consumption and animal N excretion, that were estimated from the animal numbers and parameters based on the "static" (Section 5.1.2.1) and "dynamic" (Section 5.1.2.2) livestock models. The dynamic approach described in Han and Allan (2008) and Han et al. (2009) also included the calculation of animal N production from slaughtered livestock sales data multiplied by their live weights, edible portions, and the nitrogen content in the edible portion. Using the toolbox, any combination of the animal calculation methods (disaggregation of animal groups, assignment of parameter values, choice of calculation modules, etc.) can be made by the user.

To estimate animal N production from the N content of the edible portion of animals (instead of the difference between the animal N consumption and animal N excretion), open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Animal_N_Prd" worksheet (Figure 5.1.2.3.1).



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Type	Item Name	Distribute	Product Weight (kg/animal)	Edible Portion (%)	N in Edible Portion (%)		Worksheet	Description				
2	beef	sales of cattle except dairy heifers		463	42.2	4.8		Ag_Census_Animals_07_02	data				
3	veal	calves sold		103	41	3.2		Ag_Census_Animals_97_92_87	data				
4	pork	hogs and pigs sold		112	53.6	0.52		Cnty_Prop	proportion				
5	lamb	sheep and lambs sold		44.6	49.8	4.8							
6	chicken	layers and pullets sold		2.16	73	2.16							
7	egg	layers more than 20 weeks inventory		14.5	89	1.76							
8	broiler	broilers sold		1.71	69	1.71							
9	turkey	turkeys sold		8.51	79	2.93							
10	milk	milk cows inventory		9091	100	0.496							

Figure 5.1.2.3.1. "Animal_N_Prd" worksheet of NANI-accounting tool.

The worksheet contains a list of animal products for the calculation of animal N production (Column A) and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figures 4.1.1.2.2 and 4.1.2.2.2). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. Examples of its application can be found in Sections 5.1.2.1 and 5.1.3. The worksheet also contains the animal parameters that are needed for the calculation of animal N production, including the live weights of animals (e.g., cattle, swine, sheep, etc.) or animal products (milk, eggs, etc.) (Column D), their edible portions (Column E), and the nitrogen contents of the edible portions (Column F). The values of animal parameters used in this example and their references are summarized in Table 5.1.2.3.1.

The worksheet also contains the names of worksheets used as input (Columns H and I). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the county-based Agricultural Census data for the animals in 1987, 1992, and 1997, created by the NANI-extraction tool described in Section 4.1.1.2 ("Ag_Census_Animals_97_92_87" shown in Figure 4.1.1.2.2).
- A "data" worksheet containing the county-based Agricultural Census data for the animals in 2002 and 2007, created by the NANI-extraction tool described in Section 4.1.2.2 ("Ag_Census_Animals_07_02" shown in Figure 4.1.2.2.2).
- A "proportion" worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 ("Cnty_Prop" shown in Figure 3.1.5).

Click on the "Animal N Products" button to run the calculation. The results will be reported in the same worksheet starting from Column K (Figure 5.1.2.3.2), summarized into three separate tables, reporting:

- Total Animal Production (kg/km^2/yr)
- Edible Animal Production (kg/km^2/yr)
- N in Animal Products (Milk, Meat, Eggs, etc) (kg-N/km^2/yr)

The first table is created by multiplying the animal numbers (as specified in Column B) by the live weights of animals or animal products (Column D) and then by their proportions within the watershed, summing over all the counties, and dividing by the watershed area. The second table is created by multiplying their edible portions (Column E), and the third table is created by multiplying the percent nitrogen in the edible portions (Column F), resulting in N in animal products (i.e., animal N production).

As described in Section 5.1.4, for the calculation of net food and feed imports, the user has an option to choose the third table of the "Animal_N_Prd" worksheet (animal N production calculated from the N content of the edible portion of animals), instead of the sixth tables of the "Animals" worksheet (animal N production calculated from the difference between the animal N consumption and animal N excretion; see Sections 5.1.2.1 and 5.1.2.2).

Table 5.1.2.3.1. Animal parameters used in the calculation of animal N products. Variables in the square brackets are obtained from Agricultural Census (Sections 4.1.1.2 and 4.1.2.2) and those in the double quotation marks are derived from other variables. Parameter values, unless otherwise noted, were obtained from Han et al. (2009).

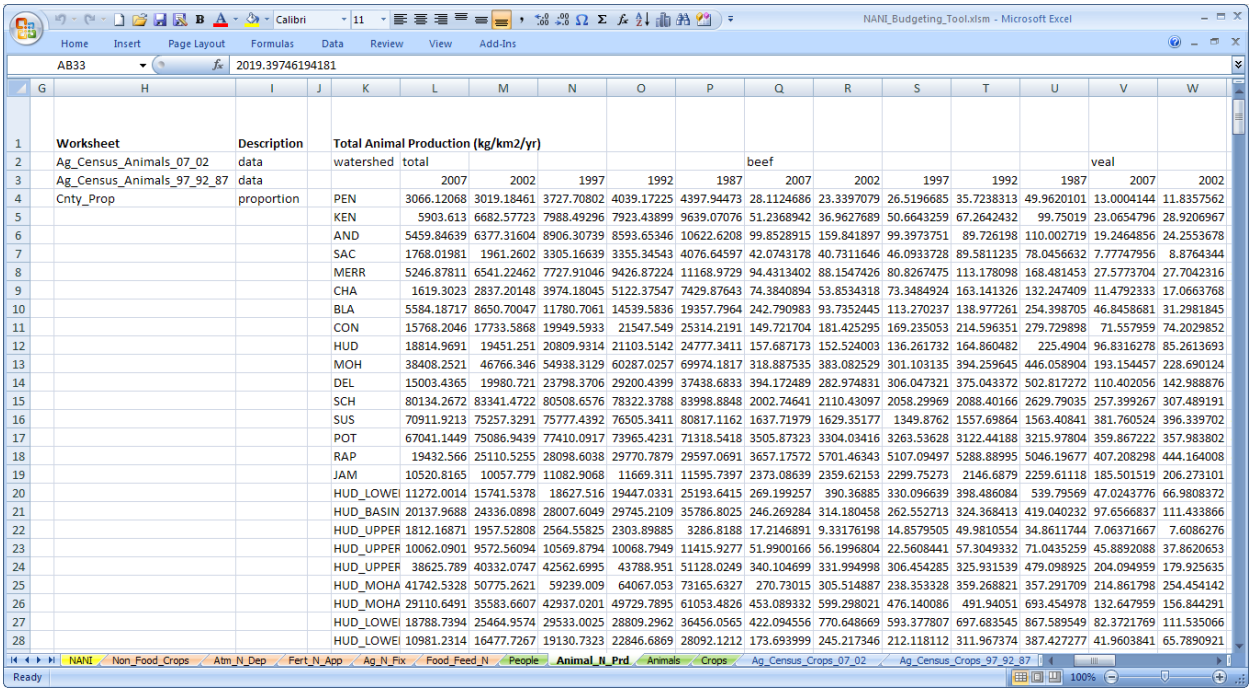
Name	Agricultural Census Item Name	Live Weight (kg/animal)	Edible Portion (%)	N in Edible Portion (%)
beef	"sales of cattle except dairy heifers"[a]	463	42.2	4.8
veal	[calves sold]	103	41	3.2
pork	[hogs and pigs sold]	112	53.6	0.52
lamb	[sheep and lambs sold]	44.6	49.8	4.8
chicken	[layers and pullets sold]	2.16	73	2.16
egg	[layers more than 20 weeks inventory]	14.5[c]	89	1.76
broiler	[broilers sold]	1.71	69	1.71
turkey	[turkeys sold]	8.51	79	2.93
milk	[milk cows inventory]	9091[d]	100	0.496

[a] "sales of cattle except dairy heifers" = [cattle sold] - "dairy replacement herd heifers"[b]

[b] "dairy replacement herd heifers" = Minimum (0.2 × [milk cows inventory], [heifers inventory]) (Kellogg et al., 2000)

[c] 250 (average eggs laid annually per layer; USDA/NASS, 1987-2007) × 0.058 kg/egg

[d] milk produced annually per milk cow (kg/animal/yr)

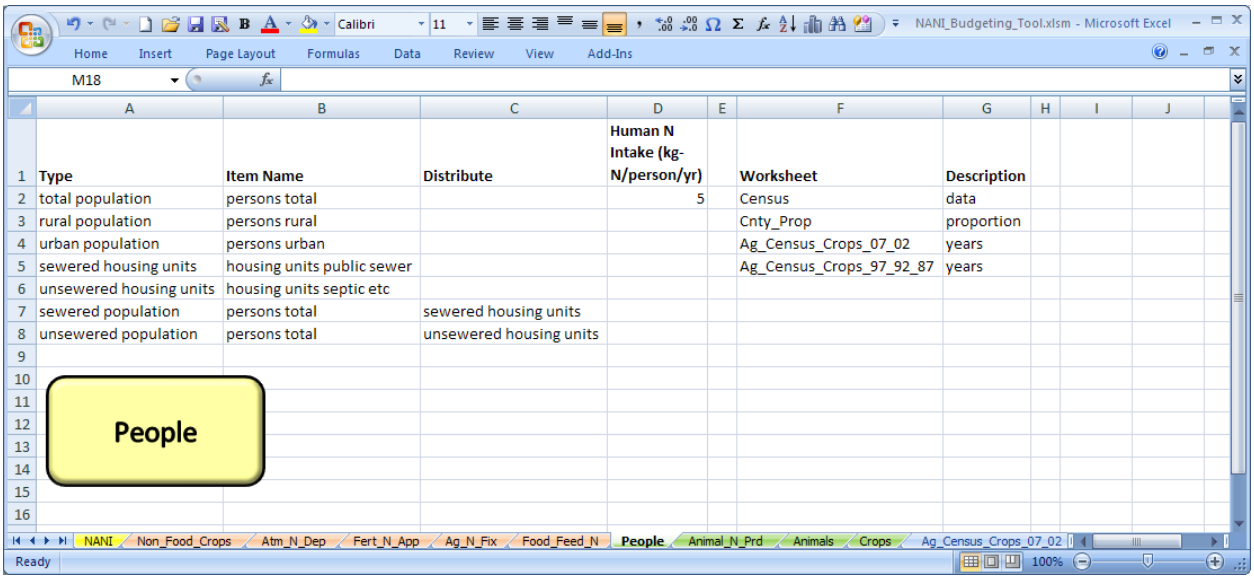


	Worksheet	Description	Total Animal Production (kg/km2/yr)												
2	Ag_Census_Animals_07_02	data	watershed	total					beef					veal	
3	Ag_Census_Animals_97_92_87	data		2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002
4	Cnty_Prop	proportion	PEN	3066.12068	3019.18461	3727.70802	4039.17225	4397.94473	28.1124686	23.3397079	26.5196685	35.7238313	49.9620101	13.0004144	11.8357562
5			KEN	5903.613	6682.57723	7988.49296	7923.43899	9639.07076	51.2368942	36.9627689	50.6643259	67.2642432	99.75019	23.0654796	28.9206967
6			AND	5459.84639	6377.31604	8906.30739	8593.65346	10622.6208	99.8528915	159.841897	99.3973751	89.726198	110.002719	19.2464856	24.2553678
7			SAC	1768.01981	1961.2602	3305.16639	3355.34543	4076.64597	42.0743178	40.7311646	46.0933728	89.5811235	78.0456632	7.77747956	8.8764344
8			MERR	5246.87811	6541.22462	7727.91046	9426.87224	11168.9729	94.4313402	88.1547426	80.8267475	113.178098	168.481453	27.5773704	27.7042316
9			CHA	1619.3023	2837.20148	3974.18045	5122.37547	7429.87643	74.3840894	53.8534318	73.3484924	163.141326	132.247409	11.4792333	17.0663768
10			BLA	5584.18717	8650.70047	11780.7061	14539.5836	19357.7964	242.790983	93.7352445	113.270237	138.977261	254.398705	46.8458681	31.2981845
11			CON	15768.2046	17733.5868	19949.5933	21547.549	25314.2191	149.721704	181.425295	169.235053	214.596351	279.729898	71.557959	74.2029852
12			HUD	18814.9691	19451.251	20809.9314	21103.5142	24777.3411	157.687173	152.524003	136.261732	164.860482	225.4904	96.8316278	85.2613693
13			MOH	38408.2521	46766.346	54938.3129	60287.0257	69974.1817	318.887535	383.082529	301.103135	394.259645	446.058904	193.154457	228.690124
14			DEL	15003.4365	19980.721	23798.3706	29200.4399	37438.6833	394.172489	282.974831	306.047321	375.043372	502.817272	110.402056	142.988876
15			SCH	80134.2672	83341.4722	80508.6576	78322.3788	83998.8848	2002.74641	2110.43097	2058.29969	2088.40166	2629.79035	257.399267	307.489191
16			SUS	70911.9213	75257.3291	75777.4392	76505.3411	80817.1162	1637.71979	1629.35177	1349.8762	1557.69864	1563.40841	381.760524	396.339702
17			POT	67041.1449	75086.9439	77410.0917	73965.4231	71318.5418	3505.87323	3304.03416	3263.53628	3122.44188	3215.97804	359.867222	357.983802
18			RAP	19432.566	25110.5255	28098.6038	29770.7879	29597.0691	3657.17572	5701.46343	5107.09497	5288.88995	5046.19677	407.208298	444.164008
19			JAM	10520.8165	10057.779	11082.9068	11669.311	11595.7397	2373.08639	2359.62153	2299.75273	2146.6879	2259.61118	185.501519	206.273101
20			HUD_LOWE	11272.0014	15741.5378	18627.516	19447.0331	25193.6415	269.199257	390.36885	330.096639	398.486084	539.79569	47.0243776	66.9808372
21			HUD_BASIN	20137.9688	24336.0898	28007.6049	29745.2109	35786.8025	246.269284	314.180458	262.552713	324.368413	419.040232	97.6566837	111.433866
22			HUD_UPPER	1812.16871	1957.52808	2564.55825	2303.89885	3286.8188	17.2146891	9.33176198	14.8579505	49.9810554	34.8611744	7.06371667	7.6086276
23			HUD_UPPER	10062.0901	9572.56094	10569.8794	10068.7949	11415.9277	51.9900166	56.1996804	22.5608441	57.3049332	71.0435259	45.8892088	37.8620653
24			HUD_UPPER	38625.789	40332.0747	42562.6995	43788.951	51128.0249	340.104699	331.994998	306.454285	325.931539	479.098925	204.094959	179.925635
25			HUD_MOHA	41742.5328	50775.2621	59239.009	64067.053	73165.6327	270.73015	305.514887	238.353328	359.268821	357.291709	214.861798	254.454142
26			HUD_MOHA	29110.6491	35583.6607	42937.0201	49729.7895	61053.4826	453.089332	599.298021	476.140086	491.94051	693.454978	132.647959	156.844291
27			HUD_LOWE	18788.7394	25464.9574	29533.0025	28809.2962	36456.0565	422.094556	770.648669	593.377807	697.683545	867.589549	82.3721769	111.535066
28			HUD_LOWE	10981.2314	16477.7267	19130.7323	22846.6869	28092.1212	173.693999	245.217346	212.118112	311.967374	387.427277	41.9603841	65.7890921

Figure 5.1.2.3.2. Animal N products calculated by NANI-accounting tool.

5.1.3. Calculating Human N Consumption

In this section, human N consumption is calculated in the "People" worksheet of the NANI-accounting tool, based on the population extracted from the Census data (Section 4.2). Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "People" worksheet (Figure 5.1.3.1).



	Type	Item Name	Distribute	Human N Intake (kg-N/person/yr)		Worksheet	Description
2	total population	persons total		5		Census	data
3	rural population	persons rural				Cnty_Prop	proportion
4	urban population	persons urban				Ag_Census_Crops_07_02	years
5	sewered housing units	housing units public sewer				Ag_Census_Crops_97_92_87	years
6	unsewered housing units	housing units septic etc					
7	sewered population	persons total	sewered housing units				
8	unsewered population	persons total	unsewered housing units				

People

Figure 5.1.3.1. "People" worksheet of NANI-accounting tool.

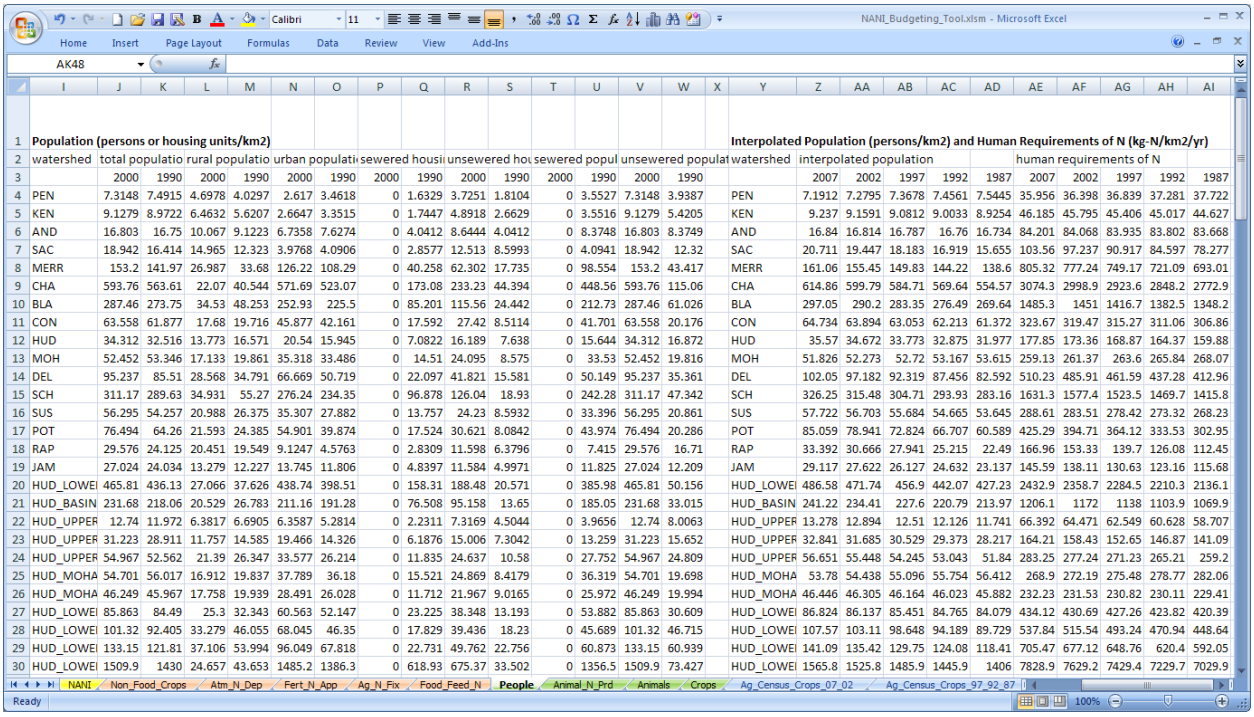
The worksheet contains a list of Census items for the calculation of human N consumption and other relevant variables (Column A), and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figure 4.2.4). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. In this example, the user wants to calculate "sewered population" and "unsewered population" (Rows 7 and 8, respectively), that are not directly available from the Census data. As shown in Figure 5.1.3.1, the total population ("persons total" extracted from the Census data; see Figure 4.2.1) is distributed between the "sewered population" and "unsewered population" according to the relative proportions of the "sewered housing units" and "unsewered housing units", respectively, that are available in the Census data (Figure 4.2.1). Human intake of nitrogen in kg-N/person/year should be specified in Column D, at the row where the total population variable can be found (Row 2 in this example). In this example, human N consumption was calculated by assuming the per-capita annual rate of 5 kg-N/person/yr (Boyer et al. 2002), multiplied by the population density (persons/km^2) obtained from the Census data.

The worksheet also contains the names of worksheets used as input (Columns F and G). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the county-based Census data for the population in 1990 and 2000, created by the NANI-extraction tool described in Section 4.2 ("Census" shown in Figure 4.2.4).
- A "proportion" worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 ("Cnty_Prop" shown in Figure 3.1.5).
- A "years" worksheet containing the county-based Agricultural Census data in 1987, 1992, and 1997, created by the NANI-extraction tool described in Section 4.1.1.1 ("Ag_Census_Crops_97_92_87" shown in Figure 4.1.1.1.4) or in Section 4.1.1.2 ("Ag_Census_Animals_97_92_87" shown in Figure 4.1.1.2.2).
- A "years" worksheet containing the county-based Agricultural Census data in 2002 and 2007, created by the NANI-extraction tool described in Section 4.1.2.1 ("Ag_Census_Crops_07_02" shown in Figure 4.1.2.1.4) or in Section 4.1.2.2 ("Ag_Census_Animals_07_02" shown in Figure 4.1.2.2.2).

The "years" worksheets are not directly used for the calculation of human N consumption but for identifying the years of Agricultural Census data. Since the Census and Agricultural Census data are not available in the same years and our primary interest in this analysis is to estimate NANI in Agricultural Census years, the populations extracted for the Census years (1990 and 2000) are used to estimate populations in Agricultural Census years (1987, 1992, 1997, 2002, and 2007) through interpolation or extrapolation.

Click on the "People" button to run the calculation. The results will be reported in the same worksheet starting from Column I (Figure 5.1.3.2), summarized into two separate tables (horizontally arranged).



Population (persons or housing units/km2)																Interpolated Population (persons/km2) and Human Requirements of N (kg-N/km2/yr)										
watershed	total populatio		rural populatio		urban populati		sewered housi		unsewered hou		sewered popul		unsewered popul			watershed	interpolated population					human requirements of N				
	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990			2007	2002	1997	1992	1987	2007	2002	1997	1992	1987
PEN	7.3148	7.4915	4.6978	4.0297	2.617	3.4618	0	1.6329	3.7251	1.8104	0	3.5527	7.3148	3.9387		PEN	7.1912	7.2795	7.3678	7.4561	7.5445	35.956	36.398	36.839	37.281	37.722
KEN	9.1279	8.9722	6.4632	5.6207	2.6647	3.3515	0	1.7447	4.8918	2.6629	0	3.5516	9.1279	5.4205		KEN	9.237	9.1591	9.0812	9.0033	8.9254	46.185	45.795	45.406	45.017	44.627
AND	16.803	16.75	10.067	9.1223	6.7358	7.6274	0	4.0412	8.6444	4.0412	0	8.3748	16.803	8.3749		AND	16.84	16.814	16.787	16.76	16.734	84.201	84.068	83.935	83.802	83.668
SAC	18.942	16.414	14.965	12.323	3.9768	4.0906	0	2.8577	12.513	8.5993	0	4.0941	18.942	12.32		SAC	20.711	19.447	18.183	16.919	15.655	103.56	97.237	90.917	84.597	78.277
MERR	153.2	141.97	26.987	33.68	126.22	108.29	0	40.258	62.302	17.735	0	98.554	153.2	43.417		MERR	161.06	155.45	149.83	144.22	138.6	805.32	777.24	749.17	721.09	693.01
CHA	593.76	563.61	22.07	40.544	571.69	523.07	0	173.08	233.23	44.394	0	448.56	593.76	115.06		CHA	614.86	599.79	584.71	569.64	554.57	3074.3	2998.9	2923.6	2848.2	2772.9
BLA	287.46	273.75	34.53	48.253	252.93	225.5	0	85.201	115.56	24.442	0	212.73	287.46	61.026		BLA	297.05	290.2	283.35	276.49	269.64	1485.3	1451	1416.7	1382.5	1348.2
CON	63.558	61.877	17.68	19.716	45.877	42.161	0	17.592	27.42	8.5114	0	41.701	63.558	20.176		CON	64.734	63.894	63.053	62.213	61.372	323.67	319.47	315.27	311.06	306.86
HUD	34.312	32.516	13.773	16.571	20.54	15.945	0	7.0822	16.189	7.638	0	15.644	34.312	16.872		HUD	35.57	34.672	33.773	32.875	31.977	177.85	173.36	168.87	164.37	159.88
MOH	52.452	53.346	17.133	19.861	35.318	33.486	0	14.51	24.095	8.575	0	33.53	52.452	19.816		MOH	51.826	52.273	52.72	53.167	53.615	259.13	261.37	263.6	265.84	268.07
DEL	95.237	85.51	28.568	34.791	66.669	50.719	0	22.097	41.821	15.581	0	50.149	95.237	35.361		DEL	102.05	97.182	92.319	87.456	82.592	510.23	485.91	461.59	437.28	412.96
SCH	311.17	289.63	34.931	55.27	276.24	234.35	0	96.878	126.04	18.93	0	242.28	311.17	47.342		SCH	326.25	315.48	304.71	293.93	283.16	1631.3	1577.4	1523.5	1469.7	1415.8
SUS	56.295	54.257	20.988	26.375	35.307	27.882	0	13.757	24.23	8.5932	0	33.396	56.295	20.861		SUS	57.722	56.703	55.684	54.665	53.645	288.61	283.51	278.42	273.32	268.23
POT	76.494	64.26	21.593	24.385	54.901	39.874	0	17.524	30.621	8.0842	0	43.974	76.494	20.286		POT	85.059	78.941	72.824	66.707	60.589	425.29	394.71	364.12	333.53	302.95
RAP	29.576	24.125	20.451	19.549	9.1247	4.5763	0	2.8309	11.598	6.3796	0	7.415	29.576	16.71		RAP	33.392	30.666	27.941	25.215	22.49	166.96	153.33	139.7	126.08	112.45
JAM	27.024	24.034	13.279	12.227	13.745	11.806	0	4.8397	11.584	4.9971	0	11.825	27.024	12.209		JAM	29.117	27.622	26.127	24.632	23.137	145.59	138.11	130.63	123.16	115.68
HUD_LOWE	465.81	436.13	27.066	37.626	438.74	398.51	0	158.31	188.48	20.571	0	385.98	465.81	50.156		HUD_LOWE	486.58	471.74	456.9	442.07	427.23	2432.9	2358.7	2284.5	2210.3	2136.1
HUD_BASIN	231.68	218.06	20.529	26.783	211.16	191.28	0	76.508	95.158	13.65	0	185.05	231.68	33.015		HUD_BASIN	241.22	234.41	227.6	220.79	213.97	1206.1	1172	1138	1103.9	1069.9
HUD_UPPER	12.74	11.972	6.3817	6.6905	6.3587	5.2814	0	2.2311	7.3169	4.5044	0	3.9656	12.74	8.0063		HUD_UPPER	13.278	12.894	12.51	12.126	11.741	66.392	64.471	62.549	60.628	58.707
HUD_UPPER	31.223	28.911	11.757	14.585	19.466	14.326	0	6.1876	15.006	7.3042	0	13.259	31.223	15.652		HUD_UPPER	32.841	31.685	30.529	29.373	28.217	164.21	158.43	152.65	146.87	141.09
HUD_UPPER	54.967	52.562	21.39	26.347	33.577	26.214	0	11.835	24.637	10.58	0	27.752	54.967	24.809		HUD_UPPER	56.651	55.448	54.245	53.043	51.84	283.25	277.24	271.23	265.21	259.2
HUD_MOHA	54.701	56.017	16.912	19.837	37.789	36.18	0	15.521	24.869	8.4179	0	36.319	54.701	19.698		HUD_MOHA	53.78	54.438	55.096	55.754	56.412	268.9	272.19	275.48	278.77	282.06
HUD_MOHA	46.249	45.967	17.758	19.939	28.491	26.028	0	11.712	21.967	9.0165	0	25.972	46.249	19.994		HUD_MOHA	46.446	46.305	46.164	46.023	45.882	232.23	231.53	230.82	230.11	229.41
HUD_LOWE	85.863	84.49	25.3	32.343	60.563	52.147	0	23.225	38.348	13.193	0	53.882	85.863	30.609		HUD_LOWE	86.824	86.137	85.451	84.765	84.079	434.12	430.69	427.26	423.82	420.39
HUD_LOWE	101.32	92.405	33.279	46.055	68.045	46.35	0	17.829	39.436	18.23	0	45.689	101.32	46.715		HUD_LOWE	107.57	103.11	98.648	94.189	89.729	537.84	515.54	493.24	470.94	448.64
HUD_LOWE	133.15	121.81	37.106	53.994	96.049	67.818	0	22.731	49.762	22.756	0	60.873	133.15	60.939		HUD_LOWE	141.09	135.42	129.75	124.08	118.41	705.47	677.12	648.76	620.4	592.05
HUD_LOWE	1509.9	1430	24.657	43.653	1485.2	1386.3	0	618.93	675.37	33.502	0	1356.5	1509.9	73.427		HUD_LOWE	1565.8	1525.8	1485.9	1445.9	1406	7828.9	7629.2	7429.4	7229.7	7029.9

Figure 5.1.3.2. Human N consumption calculated by NANI-accounting tool.

The first table reports the population density (in persons/km^2) and other auxiliary information in the Census years (1990 and 2000), calculated by multiplying the extracted numbers (people or housing units) by their proportions within the watershed, summing over all the counties, and dividing by the watershed area. The second table reports the population density interpolated or extrapolated for the Agricultural Census years (1987, 1992, 1997, 2002, and 2007) and the human requirements of N (i.e., human N consumption) calculated by multiplying the human intake of nitrogen (5 kg-N/person/year from Boyer et al. 2002) to the estimated population density. The human N consumption is used in the calculation of net food and feed imports, as described in Section 5.1.4.

5.1.4. Calculating Net Food and Feed Imports

In this section, net food and feed imports (one of the NANI components; see Figure 1.1) are calculated in the "Food_Feed_N" worksheet of the NANI-accounting tool, from the outputs stored in the "Crops", "Animals", and "People" worksheets containing the crop N production (Section 5.1.1), animal N production and N consumption (Section 5.1.2), and human N consumption (Section 5.1.3), respectively. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Food_Feed_N" worksheet (Figure 5.1.4.1).

The "Food_Feed_N" worksheet contains the names of worksheets used as input (Columns A and B). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

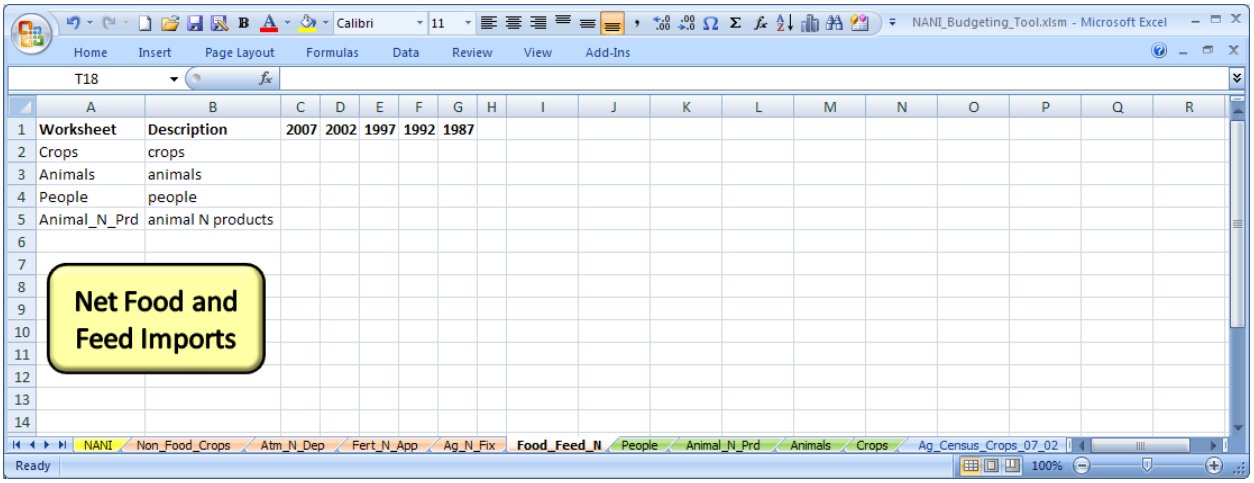


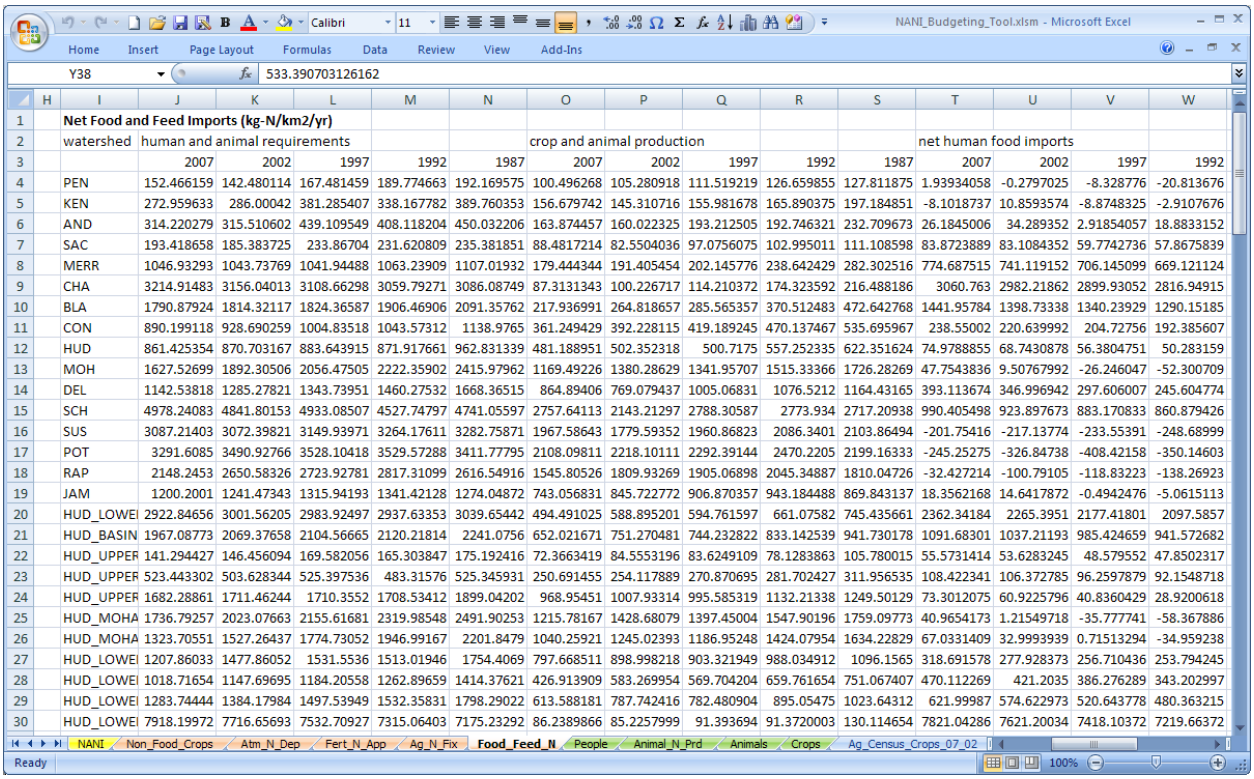
Figure 5.1.4.1. "Food_Feed_N" worksheet of NANI-accounting tool.

- A "crops" worksheet containing the crop N production calculated by the NANI-accounting tool described in Section 5.1.1 ("Crops" shown in Figure 5.1.1.2).
- An "animals" worksheet containing the animal N production and N consumption calculated by the NANI-accounting tool described in Section 5.1.2.1 ("Animals" shown in Figure 5.1.2.1.2, showing the results from the static livestock model) or Section 5.1.2.2 ("Animals" shown in Figure 5.1.2.2.2, showing the results from the dynamic livestock model).
- A "people" worksheet containing the human N consumption calculated by the NANI-accounting tool described in Section 5.1.3 ("People" shown in Figure 5.1.3.2).
- An optional "animal N products" worksheet containing the animal N production calculated by the NANI-accounting tool described in Section 5.1.2.3 ("Animal_N_Prd" shown in Figure 5.1.2.3.2).

The worksheet name for the "animal N products" can be left blank if the user chooses to calculate animal N production from the difference between the animal N consumption and animal N excretion, as described in 5.1.2.1 and 5.1.2.2. Alternatively, the user can specify the name of worksheet containing the animal N production calculated from the N content of the edible portion of animals ("Animal_N_Prd" in this example, as described in Section 5.1.2.3).

Columns C to G of the worksheet contain a list of years for the calculation. If the cells in these columns are left blank, the calculation will be based on the values in the corresponding years. If these cells have year numbers, the values in the user-specified years will be used instead. An example of the application of this feature can be found in Section 5.6. Cells C1 to G1 are used to specify the years for the calculation, and may be shortened or extended as appropriate for the analysis.

Click on the "Net Food and Feed Imports" button to run the calculation. The output will be generated in the same worksheet starting from Column I (Figure 5.1.4.2), reporting five horizontally arranged variables, all in the unit of kg-N/km^2/yr:



Net Food and Feed Imports (kg-N/km2/yr)

watershed	human and animal requirements					crop and animal production					net human food imports				
	2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002	1997	1992
PEN	152.466159	142.480114	167.481459	189.774663	192.169575	100.496268	105.280918	111.519219	126.659855	127.811875	1.93934058	-0.2797025	-8.328776	-20.813676
KEN	272.959633	286.00042	381.285407	338.167782	389.760353	156.679742	145.310716	155.981678	165.890375	197.184851	-8.1018737	10.8593574	-8.8748325	-2.9107676
AND	314.220279	315.510602	439.109549	408.118204	450.032206	163.874457	160.022325	193.212505	192.746321	232.709673	26.1845006	34.289352	2.91854057	18.8833152
SAC	193.418658	185.383725	233.86704	231.620809	235.381851	88.4817214	82.5504036	97.0756075	102.995011	111.108598	83.8723889	83.1084352	59.7742736	57.8675839
MERR	1046.93293	1043.73769	1041.94488	1063.23909	1107.01932	179.444344	191.405454	202.145776	238.642429	282.302516	774.687515	741.119152	706.145099	669.121124
CHA	3214.91483	3156.04013	3108.66298	3059.79271	3086.08749	87.3131343	100.226717	114.210372	174.323592	216.488186	3060.763	2982.21862	2899.93052	2816.94915
BLA	1790.87924	1814.32117	1824.36587	1906.46906	2091.35762	217.936991	264.818657	285.565357	370.512483	472.642768	1441.95784	1398.73338	1340.23929	1290.15185
CON	890.199118	928.690259	1004.83518	1043.57312	1138.9765	361.249429	392.228115	419.189245	470.137467	535.695967	238.55002	220.639992	204.72756	192.385607
HUD	861.425354	870.703167	883.643915	871.917661	962.831339	481.188951	502.352318	500.7175	557.252335	622.351624	74.9788855	68.7430878	56.3804751	50.283159
MOH	1627.52699	1892.30506	2056.47505	2222.35902	2415.97962	1169.49226	1380.28629	1341.95707	1515.33366	1726.28269	47.7543836	9.50767992	-26.246047	-52.300709
DEL	1142.53818	1285.27821	1343.73951	1460.27532	1668.36515	864.89406	769.079437	1005.06831	1076.5212	1164.43165	393.113674	346.996942	297.606007	245.604774
SCH	4978.24083	4841.80153	4933.08507	4527.74797	4741.05597	2757.64113	2143.21297	2788.30587	2773.934	2717.20938	990.405498	923.897673	883.170833	860.879426
SUS	3087.21403	3072.39821	3149.93971	3264.17611	3282.75871	1967.58643	1779.59352	1960.86823	2086.3401	2103.86494	-201.75416	-217.13774	-233.55391	-248.68999
POT	3291.6085	3490.92766	3528.10418	3529.57288	3411.77795	2108.09811	2218.10111	2292.39144	2470.2205	2199.16333	-245.25275	-326.84738	-408.42158	-350.14603
RAP	2148.2453	2650.58326	2723.92781	2817.31099	2616.54916	1545.80526	1809.93269	1905.06898	2045.34887	1810.04726	-32.427214	-100.79105	-118.83223	-138.26923
JAM	1200.2001	1241.47343	1315.94193	1341.42128	1274.04872	743.056831	845.722772	906.870357	943.184488	869.843137	18.3562168	14.6417872	-0.4942476	-5.0615113
HUD_LOWEI	2922.84656	3001.56205	2983.92497	2937.63353	3039.65442	494.491025	588.895201	594.761597	661.07582	745.435661	2362.34184	2265.3951	2177.41801	2097.5857
HUD_BASIN	1967.08773	2069.37658	2104.56665	2120.21814	2241.0756	652.021671	751.270481	744.232822	833.142539	941.730178	1091.68301	1037.21193	985.424659	941.572682
HUD_UPPER	141.294427	146.456094	169.582056	165.303847	175.192416	72.3663419	84.5553196	83.6249109	78.1283863	105.780015	55.5731414	53.6283245	48.579552	47.8502317
HUD_UPPER	523.443302	503.628344	525.397536	483.31576	525.345931	250.691455	254.117889	270.870695	281.702427	311.956535	108.422341	106.372785	96.2597879	92.1548718
HUD_UPPER	1682.28861	1711.46244	1710.3552	1708.53412	1899.04202	968.95451	1007.93314	995.585319	1132.21338	1249.50129	73.3012075	60.9225796	40.8360429	28.9200618
HUD_MOHA	1736.79257	2023.07663	2155.61681	2319.98548	2491.90253	1215.78167	1428.68079	1397.45004	1547.90196	1759.09773	40.9654173	1.21549718	-35.777741	-58.367886
HUD_MOHA	1323.70551	1527.26437	1774.73052	1946.99167	2201.8479	1040.25921	1245.02393	1186.95248	1424.07954	1634.22829	67.0331409	32.9993939	0.71513294	-34.959238
HUD_LOWEI	1207.86033	1477.86052	1531.5536	1513.01946	1754.4069	797.668511	898.998218	903.321949	988.034912	1096.1565	318.691578	277.928373	256.710436	253.794245
HUD_LOWEI	1018.71654	1147.69695	1184.20558	1262.89659	1414.37621	426.913909	583.269954	569.704204	659.761654	751.067407	470.112269	421.2035	386.276289	343.202997
HUD_LOWEI	1283.74444	1384.17984	1497.53949	1532.35831	1798.29022	613.588181	787.742416	782.480904	895.05475	1023.64312	621.99987	574.622973	520.643778	480.363215
HUD_LOWEI	7918.19972	7716.65693	7532.70927	7315.06403	7175.23292	86.2389866	85.2257999	91.393694	91.3720003	130.114654	7821.04286	7621.20034	7418.10372	7219.66372

Figure 5.1.4.2. Net food and feed imports calculated by NANI-accounting tool.

- Human and Animal Requirements = Human Requirements of N (Section 5.1.3, 2nd table, 2nd variable) + Animal Requirements of N (Section 5.1.2.1, 4th table for static approach or Section 5.1.2.2, 4th table for dynamic approach)
- Crop and Animal Production = N in Human Food Products (Section 5.1.1, 5th table) + N in Animal Feed Products (Section 5.1.1, 6th table) + N in Animal Products (Milk, Meat, Eggs, etc) (Section 5.1.2.1, 6th table for static difference approach, or Section 5.1.2.2, 6th table for dynamic difference approach, or Section 5.1.2.3, 3rd table for edible portion approach)
- Net Human Food Imports = Human Requirements of N (Section 5.1.3, 2nd table, 2nd variable) – N in Human Food Products (Section 5.1.1, 5th table) – N in Animal Products (Milk, Meat, Eggs, etc) (Section 5.1.2.1, 6th table for static difference approach, or Section 5.1.2.2, 6th table for dynamic difference approach, or Section 5.1.2.3, 3rd table for edible portion approach)
- Net Animal Feed Imports = Animal Requirements of N (Section 5.1.2.1, 4th table for static approach or Section 5.1.2.2, 4th table for dynamic approach) – N in Animal Feed Products (Section 5.1.1, 6th table)
- Net Food and Feed Imports = Human and Animal Requirements – Crop and Animal Production = Net Human Food Imports + Net Animal Feed Imports

Note that the positive and negative values in the 3rd, 4th, and 5th variables represent net imports and exports of nitrogen, respectively. These variables, as well as any of the earlier intermediate results, can be linked to the input map described in Section 2 (Figure 2.2) and displayed as a map using ArcGIS. As an example, Figure 5.1.4.3 below shows the net food and feed imports in the US watersheds in 1992 calculated by the NANI-accounting tool using the static difference approach. The net food and feed imports are used in the calculation of NANI, as described in Section 5.6.

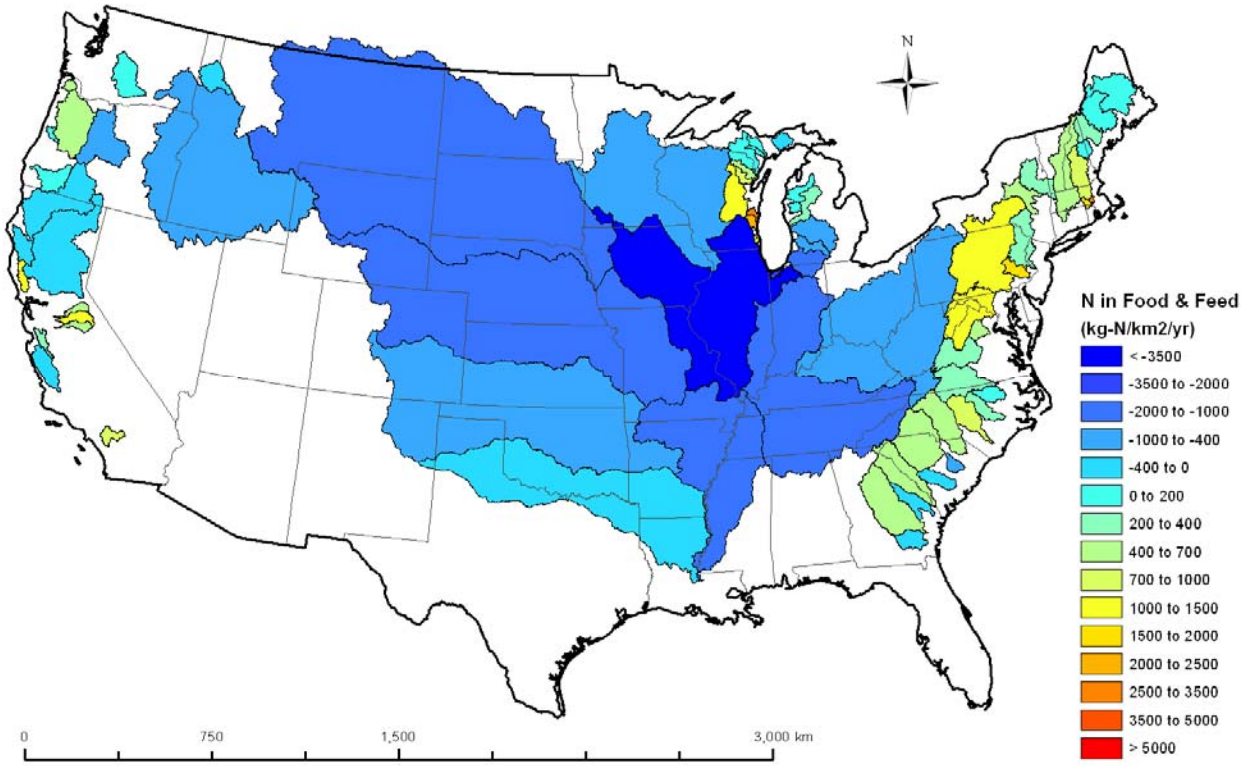


Figure 5.1.4.3. Net food and feed imports (kg-N/km^2/yr) in the US watersheds in 1992.

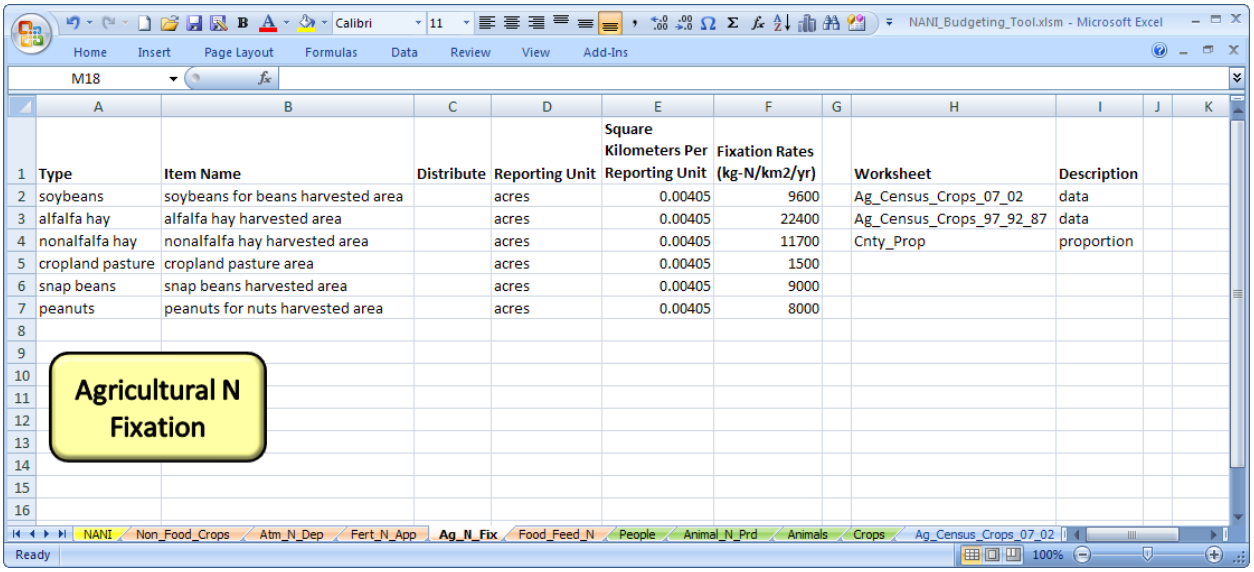
5.2. Calculating Agricultural N Fixation

In this section, agricultural N fixation (one of the NANI components; see Figure 1.1) is calculated in the "Ag_N_Fix" worksheet of the NANI-accounting tool. Agricultural N fixation is calculated by multiplying the area-based fixation rates (Table 5.2.1) to the acreages of N fixing crops reported in Agricultural Census. Following Schaefer and Alber (2007), peanut is added to the list of N fixing crops originally used by Boyer et al. (2002), as a crop of regional importance (Table 5.2.1). Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Ag_N_Fix" worksheet (Figure 5.2.1).

Table 5.2.1. Crop parameters used in the calculation of agricultural N fixation. Variables in the square brackets are obtained from Agricultural Census (Sections 4.1.1.1 and 4.1.2.1) and those in the double quotation marks are derived from other variables. Parameter values were obtained from Boyer et al. (2002) and Schaefer and Alber (2007).

Name	Agricultural Census Item Name	N Fixation Rates (kg-N/km^2/yr)
soybeans	[soybeans for beans harvested area]	9,600
alfalfa hay	[alfalfa hay harvested area]	22,400
nonalfalfa hay	"nonalfalfa hay harvested area"[a]	11,700
cropland pasture	[cropland pasture area]	1,500
snap beans	[snap beans harvested area]	9,000
peanuts	[peanuts harvested area]	8,000

[a] "nonalfalfa hay harvested area" = [all hay harvested area] – [alfalfa hay harvested area] – [grass hay harvested area]



	A	B	C	D	E	F	G	H	I	J	K
1	Type	Item Name	Distribute	Reporting Unit	Square Kilometers Per Reporting Unit	Fixation Rates (kg-N/km2/yr)		Worksheet	Description		
2	soybeans	soybeans for beans harvested area		acres	0.00405	9600		Ag_Census_Crops_07_02	data		
3	alfalfa hay	alfalfa hay harvested area		acres	0.00405	22400		Ag_Census_Crops_97_92_87	data		
4	nonalfalfa hay	nonalfalfa hay harvested area		acres	0.00405	11700		Cnty_Prop	proportion		
5	cropland pasture	cropland pasture area		acres	0.00405	1500					
6	snap beans	snap beans harvested area		acres	0.00405	9000					
7	peanuts	peanuts for nuts harvested area		acres	0.00405	8000					

Figure 5.2.1. "Ag_N_Fix" worksheet of NANI-accounting tool.

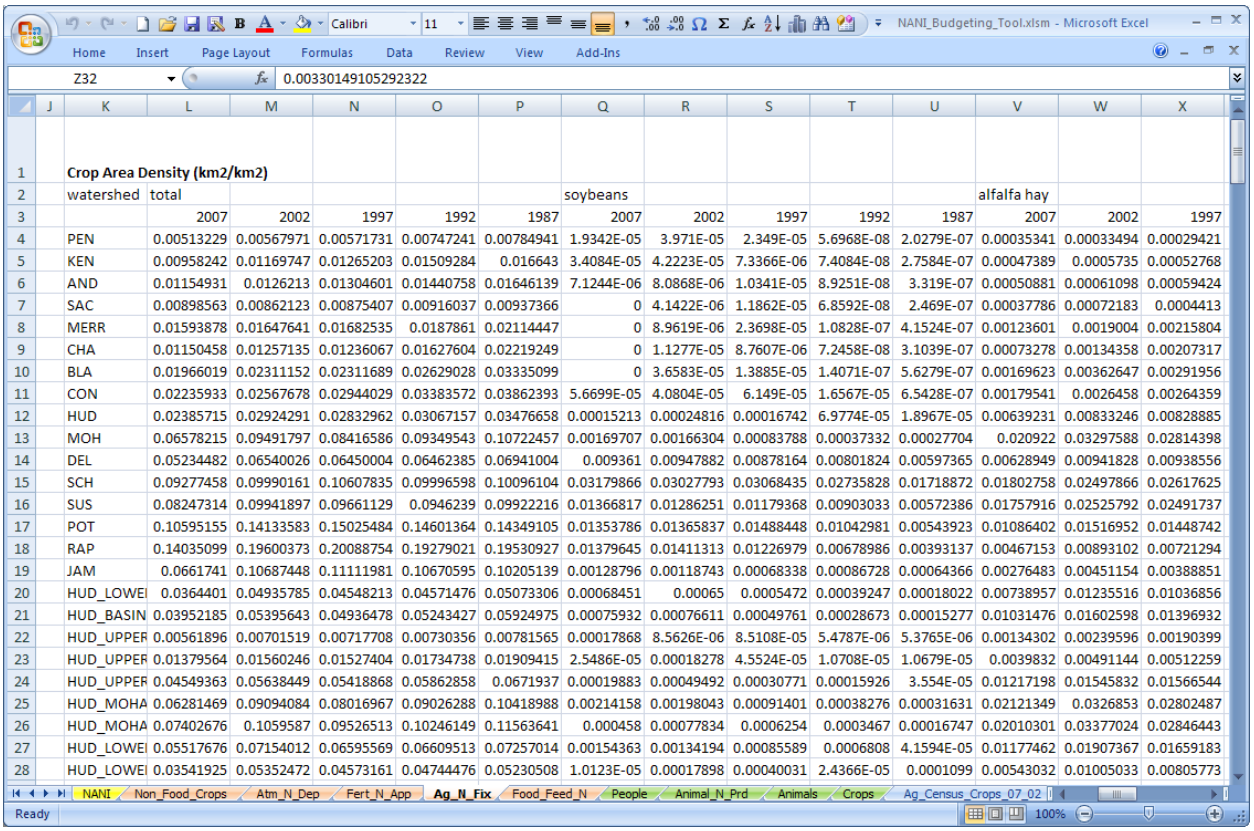
The worksheet contains a list of crops for the calculation of agricultural N fixation (Column A) and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figures 4.1.1.1.4 and 4.1.2.1.4). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. Examples of its application can be found in Sections 5.1.2.1 and 5.1.3. The worksheet also has the reporting unit (Column D), square kilometers per reporting unit (area conversion factor) (Column E), and area-based fixation rates in kg-N/km^2/yr (Column F). The values of these parameters used in this example and their references are summarized in Table 5.2.1. Since Agricultural Census reports the crop areas in acres, the conversion factors in Column E are set to "0.00405", converting them to square kilometers. More detailed consideration of the specification of the conversion factor is given in Section 5.3.

The worksheet also contains the names of worksheets used as input (Columns H and I). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the county-based Agricultural Census data for the crops in 1987, 1992, and 1997, created by the NANI-extraction tool described in Section 4.1.1.1 ("Ag_Census_Crops_97_92_87" shown in Figure 4.1.1.1.4).
- A "data" worksheet containing the county-based Agricultural Census data for the crops in 2002 and 2007, created by the NANI-extraction tool described in Section 4.1.2.1 ("Ag_Census_Crops_07_02" shown in Figure 4.1.2.1.4).
- A "proportion" worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 ("Cnty_Prop" shown in Figure 3.1.5).

Click on the "Agricultural N Fixation" button to run the calculation. The results will be reported in the same worksheet starting from Column K (Figure 5.2.2), summarized into two separate tables, reporting:

- Crop Area Density (km^2/km^2)
- Agricultural N Fixation (kg-N/km^2/yr)



NANI_Budgeting_Tool.xlsm - Microsoft Excel

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Z32 | 0.00330149105292322

	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	**Crop Area Density (km2/km2)**													
2	watershed	total					soybeans					alfalfa hay		
3		2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002	1997
4	PEN	0.00513229	0.00567971	0.00571731	0.00747241	0.00784941	1.9342E-05	3.971E-05	2.349E-05	5.6968E-08	2.0279E-07	0.00035341	0.00033494	0.00029421
5	KEN	0.00958242	0.01169747	0.01265203	0.01509284	0.016643	3.4084E-05	4.2223E-05	7.3366E-06	7.4084E-08	2.7584E-07	0.00047389	0.0005735	0.00052768
6	AND	0.01154931	0.0126213	0.01304601	0.01440758	0.01646139	7.1244E-06	8.0868E-06	1.0341E-05	8.9251E-08	3.319E-07	0.00050881	0.00061098	0.00059424
7	SAC	0.00898563	0.00862123	0.00875407	0.00916037	0.00937366	0	4.1422E-06	1.1862E-05	6.8592E-08	2.469E-07	0.00037786	0.00072183	0.0004413
8	MERR	0.01593878	0.01647641	0.01682535	0.0187861	0.02114447	0	8.9619E-06	2.3698E-05	1.0828E-07	4.1524E-07	0.00123601	0.0019004	0.00215804
9	CHA	0.01150458	0.01257135	0.01236067	0.01627604	0.02219249	0	1.1277E-05	8.7607E-06	7.2458E-08	3.1039E-07	0.00073278	0.00134358	0.00207317
10	BLA	0.01966019	0.02311152	0.02311689	0.02629028	0.03335099	0	3.6583E-05	1.3885E-05	1.4071E-07	5.6279E-07	0.00169623	0.00362647	0.00291956
11	CON	0.02235933	0.02567678	0.02944029	0.03383572	0.03862393	5.6699E-05	4.0804E-05	6.149E-05	1.6567E-05	6.5428E-07	0.00179541	0.0026458	0.00264359
12	HUD	0.02385715	0.02924291	0.02832962	0.03067157	0.03476658	0.00015213	0.00024816	0.00016742	6.9774E-05	1.8967E-05	0.00639231	0.00833246	0.00828885
13	MOH	0.06578215	0.09491797	0.08416586	0.09349543	0.10722457	0.00169707	0.00166304	0.00083788	0.00037332	0.00027704	0.020922	0.03297588	0.02814398
14	DEL	0.05234482	0.06540026	0.06450004	0.06462385	0.06941004	0.009361	0.00947882	0.00878164	0.00801824	0.00597365	0.00628949	0.00941828	0.00938556
15	SCH	0.09277458	0.09990161	0.10607835	0.09996598	0.10096104	0.03179866	0.03027793	0.03068435	0.02735828	0.01718872	0.01802758	0.02497866	0.02617625
16	SUS	0.08247314	0.09941897	0.09661129	0.0946239	0.09922216	0.01366817	0.01286251	0.01179368	0.00903033	0.00572386	0.01757916	0.02525792	0.02491737
17	POT	0.10595155	0.14133583	0.15025484	0.14601364	0.14349105	0.01353786	0.01365837	0.01488448	0.01042981	0.00543923	0.01086402	0.01516952	0.01448742
18	RAP	0.14035099	0.19600373	0.20088754	0.19279021	0.19530927	0.01379645	0.01411313	0.01226979	0.00678986	0.00393137	0.00467153	0.00893102	0.00721294
19	JAM	0.0661741	0.10687448	0.11111981	0.10670595	0.10205139	0.00128796	0.00118743	0.00068338	0.00086728	0.00064366	0.00276483	0.00451154	0.00388851
20	HUD_LOWEI	0.0364401	0.04935785	0.04548213	0.04571476	0.05073306	0.00068451	0.00065	0.0005472	0.00039247	0.00018022	0.00738957	0.01235516	0.01036856
21	HUD_BASIN	0.03952185	0.05395643	0.04936478	0.05243427	0.05924975	0.00075932	0.00076611	0.00049761	0.00028673	0.00015277	0.01031476	0.01602598	0.01396932
22	HUD_UPPER	0.00561896	0.00701519	0.00717708	0.00730356	0.00781565	0.00017868	8.5626E-06	8.5108E-05	5.4787E-06	5.3765E-06	0.00134302	0.00239596	0.00190399
23	HUD_UPPER	0.01379564	0.01560246	0.01527404	0.01734738	0.01909415	2.5486E-05	0.00018278	4.5524E-05	1.0708E-05	1.0679E-05	0.0039832	0.00491144	0.00512259
24	HUD_UPPER	0.04549363	0.05638449	0.05418868	0.05862858	0.0671937	0.00019883	0.00049492	0.00030771	0.00015926	3.554E-05	0.01217198	0.01545832	0.01566544
25	HUD_MOHA	0.06281469	0.09094084	0.08016967	0.09026288	0.10418988	0.00214158	0.00198043	0.00091401	0.00038276	0.00031631	0.02121349	0.0326853	0.02802487
26	HUD_MOHA	0.07402676	0.1059587	0.09526513	0.10246149	0.11563641	0.000458	0.00077834	0.0006254	0.0003467	0.00016747	0.02010301	0.03377024	0.02846443
27	HUD_LOWEI	0.05517676	0.07154012	0.06595569	0.06609513	0.07257014	0.00154363	0.00134194	0.00085589	0.0006808	4.1594E-05	0.01177462	0.01907367	0.01659183
28	HUD_LOWEI	0.03541925	0.05352472	0.04573161	0.04744476	0.05230508	1.0123E-05	0.00017898	0.00040031	2.4366E-05	0.0001099	0.00543032	0.01005033	0.00805773

NANI | Non_Food_Crops | Atm_N_Dep | Fert_N_App | Ag_N_Fix | Food_Feed_N | People | Animal_N_Prd | Animals | Crops | Ag_Census_Crops_07_02

Ready | 100%

Figure 5.2.2. Agricultural N fixation calculated by NANI-accounting tool.

The first table (crop area density) is created by converting the reporting units (acres) into square kilometers by multiplying by the area conversion factors (Column E) and then by their proportions within the watershed, summing over all the counties, and dividing by the watershed area. The second table is created by multiplying the crop area densities by the area-based fixation rates (Column F) to obtain the agricultural N fixation.

These variables, as well as any of the intermediate results, can be linked to the input map described in Section 2 (Figure 2.2) and displayed as a map using ArcGIS. As an example, Figure 5.2.3 shows the agricultural N fixation in the US watersheds in 1992 calculated by the NANI-accounting tool. The agricultural N fixation is used in the calculation of NANI, as described in Section 5.6.

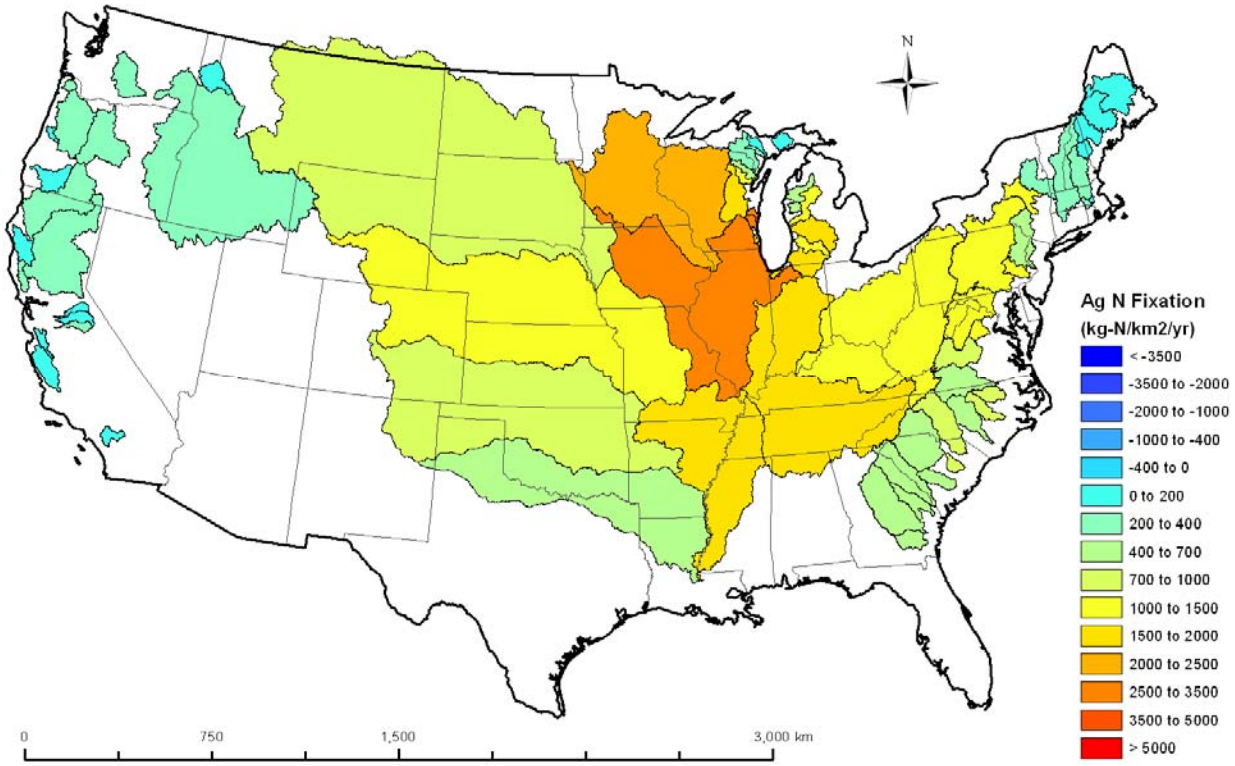
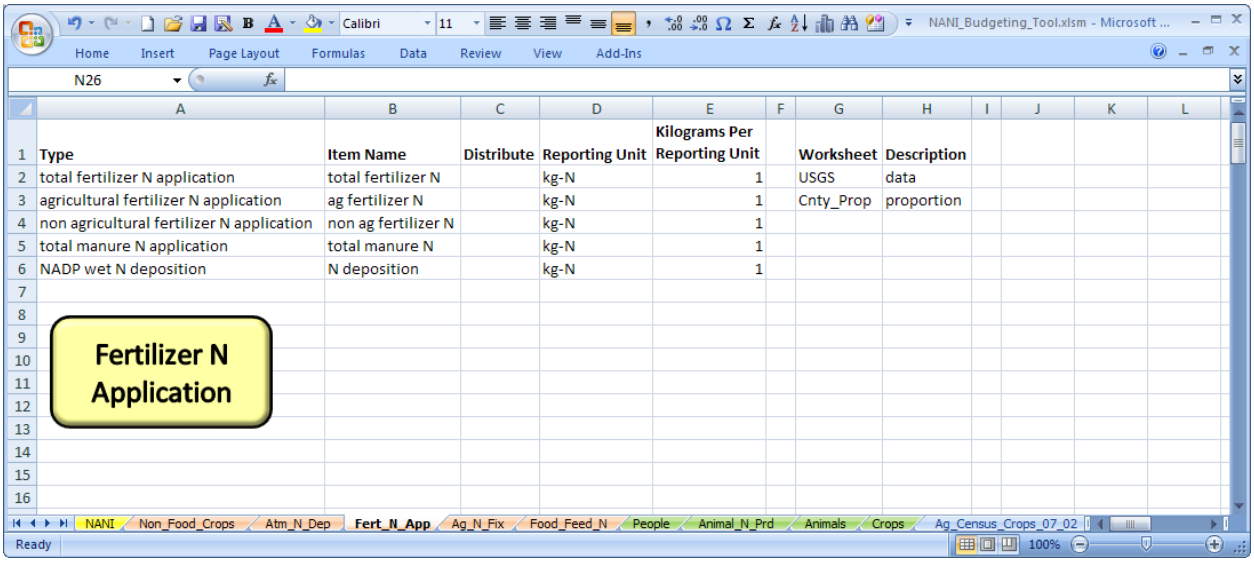


Figure 5.2.3. Agricultural N fixation (kg-N/km^2/yr) in the US watersheds in 1992.

5.3. Calculating Fertilizer N Application

In this section, fertilizer N application (one of the NANI components; see Figure 1.1), obtained from USGS nutrient input estimates (Section 4.3), is calculated in the "Fert_N_App" worksheet of the NANI-accounting tool. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Fert_N_App" worksheet (Figure 5.3.1). The worksheet contains a list of items for the calculation of fertilizer N application and other auxiliary variables (Column A) and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figure 4.3.4). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. Examples of its application can be found in Sections 5.1.2.1 and 5.1.3. The "Fert_N_App" worksheet also has the reporting units (Column D) and kilograms of nutrient inputs per reporting unit (conversion factor) (Column E).

Since USGS nutrient input estimates are reported as amount of application in kilograms (of N or P), the conversion factors in Column E are set to "1" (no conversion). The data may be reported as area-based rates of application in other databases, for example kilograms of nutrient input per square kilometer. In such a case, the conversion factor can be specified as "[AREA]", indicating that the extracted data are area-based. Multiplication factors may be added to the expression, for example "1000 × [AREA]" or "1000 * [AREA]" to convert the extracted data in metric tons per square kilometer to kilograms of nutrient input.



	A	B	C	D	E	F	G	H	I	J	K	L
1	Type	Item Name	Distribute	Reporting Unit	Kilograms Per Reporting Unit		Worksheet	Description				
2	total fertilizer N application	total fertilizer N		kg-N	1		USGS	data				
3	agricultural fertilizer N application	ag fertilizer N		kg-N	1		Cnty_Prop	proportion				
4	non agricultural fertilizer N application	non ag fertilizer N		kg-N	1							
5	total manure N application	total manure N		kg-N	1							
6	NADP wet N deposition	N deposition		kg-N	1							

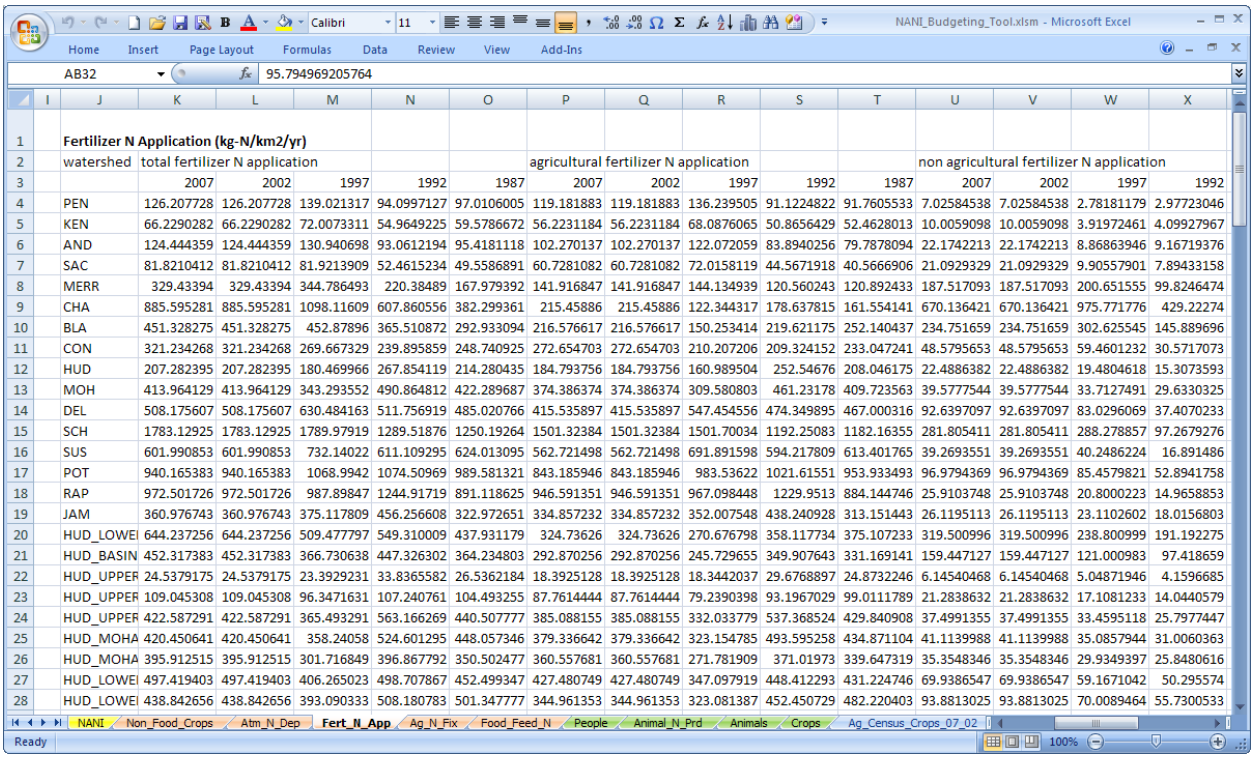
Figure 5.3.1. "Fert_N_App" worksheet of NANI-accounting tool.

The worksheet also contains the names of worksheets used as input (Columns G and H). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the county-based USGS nutrient input estimates, created by the NANI-extraction tool described in Section 4.3 ("USGS" shown in Figure 4.3.4).
- A "proportion" worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 ("Cnty_Prop" shown in Figure 3.1.5).

Click on the "Fertilizer N Application" button to run the calculation. The output will be generated in the same worksheet starting from Column J (Figure 5.3.2), reporting horizontally arranged variables as listed by the user in Column A, all in the unit of kg-N/km^2/yr. These values are calculated by converting the extracted values into kilograms of N or P by applying the conversion factors (as specified in Column E) and multiplying by their proportions within the watershed, summing over all the counties, and dividing by the watershed area.

These variables, as well as any of the auxiliary information, can be linked to the input map described in Section 2 (Figure 2.2) and displayed as a map using ArcGIS. As an example, Figure 5.3.3 shows the fertilizer N application in the US watersheds in 1992 calculated by the NANI-accounting tool. The fertilizer N application is used in the calculation of NANI, as described in Section 5.6. Note that the NANI-accounting tool assumes that the first item listed in the "Fert_N_App" worksheet (i.e., "total fertilizer N application" in Row 2) is the NANI component used in the NANI calculation in Section 5.6. Thus, for example, if the user wants to use the "agricultural fertilizer N application" instead (Row 3) for the calculation of NANI, the item must be placed first on the list.



Fertilizer N Application (kg-N/km2/yr)

watershed	total fertilizer N application					agricultural fertilizer N application					non agricultural fertilizer N application				
	2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002	1997	1992
PEN	126.207728	126.207728	139.021317	94.0997127	97.0106005	119.181883	119.181883	136.239505	91.1224822	91.7605533	7.02584538	7.02584538	2.78181179	2.97723046
KEN	66.2290282	66.2290282	72.0073311	54.9649225	59.5786672	56.2231184	56.2231184	68.0876065	50.8656429	52.4628013	10.0059098	10.0059098	3.91972461	4.09927967
AND	124.444359	124.444359	130.940698	93.0612194	95.4181118	102.270137	102.270137	122.072059	83.8940256	79.7878094	22.1742213	22.1742213	8.86863946	9.16719376
SAC	81.8210412	81.8210412	81.9213909	52.4615234	49.5586891	60.7281082	60.7281082	72.0158119	44.5671918	40.5666906	21.0929329	21.0929329	9.90557901	7.89433158
MERR	329.43394	329.43394	344.786493	220.38489	167.979392	141.916847	141.916847	144.134939	120.560243	120.892433	187.517093	187.517093	200.651555	99.8246474
CHA	885.595281	885.595281	1098.11609	607.860556	382.299361	215.45886	215.45886	122.344317	178.637815	161.554141	670.136421	670.136421	975.771776	429.22274
BLA	451.328275	451.328275	452.87896	365.510872	292.933094	216.576617	216.576617	150.253414	219.621175	252.140437	234.751659	234.751659	302.625545	145.889696
CON	321.234268	321.234268	269.667329	239.895859	248.740925	272.654703	272.654703	210.207206	209.324152	233.047241	48.5795653	48.5795653	59.4601232	30.5717073
HUD	207.282395	207.282395	180.469966	267.854119	214.280435	184.793756	184.793756	160.989504	252.54676	208.046175	22.4886382	22.4886382	19.4804618	15.3073593
MOH	413.964129	413.964129	343.293552	490.864812	422.289687	374.386374	374.386374	309.580803	461.23178	409.723563	39.5777544	39.5777544	33.7127491	29.6330325
DEL	508.175607	508.175607	630.484163	511.756919	485.020766	415.535897	415.535897	547.454556	474.349895	467.000316	92.6397097	92.6397097	83.0296069	37.4070233
SCH	1783.12925	1783.12925	1789.97919	1289.51876	1250.19264	1501.32384	1501.32384	1501.70034	1192.25083	1182.16355	281.805411	281.805411	288.278857	97.2679276
SUS	601.990853	601.990853	732.14022	611.109295	624.013095	562.721498	562.721498	691.891598	594.217809	613.401765	39.2693551	39.2693551	40.2486224	16.891486
POT	940.165383	940.165383	1068.9942	1074.50969	989.581321	843.185946	843.185946	983.53622	1021.61551	953.933493	96.9794369	96.9794369	85.4579821	52.8941758
RAP	972.501726	972.501726	987.89847	1244.91719	891.118625	946.591351	946.591351	967.098448	1229.9513	884.144746	25.9103748	25.9103748	20.8000223	14.9658853
JAM	360.976743	360.976743	375.117809	456.256608	322.972651	334.857232	334.857232	352.007548	438.240928	313.151443	26.1195113	26.1195113	23.1102602	18.0156803
HUD_LOWEI	644.237256	644.237256	509.477797	549.310009	437.931179	324.73626	324.73626	270.676798	358.117734	375.107233	319.500996	319.500996	238.800999	191.192275
HUD_BASIN	452.317383	452.317383	366.730638	447.326302	364.234803	292.870256	292.870256	245.729655	349.907643	331.169141	159.447127	159.447127	121.000983	97.418659
HUD_UPPEF	24.5379175	24.5379175	23.3929231	33.8365582	26.5362184	18.3925128	18.3925128	18.3442037	29.6768897	24.8732246	6.14540468	6.14540468	5.04871946	4.1596685
HUD_UPPEF	109.045308	109.045308	96.3471631	107.240761	104.493255	87.7614444	87.7614444	79.2390398	93.1967029	99.0111789	21.2838632	21.2838632	17.1081233	14.0440579
HUD_UPPEF	422.587291	422.587291	365.493291	563.166269	440.507777	385.088155	385.088155	332.033779	537.368524	429.840908	37.4991355	37.4991355	33.4595118	25.7977447
HUD_MOHA	420.450641	420.450641	358.24058	524.601295	448.057346	379.336642	379.336642	323.154785	493.595258	434.871104	41.1139988	41.1139988	35.0857944	31.0060363
HUD_MOHA	395.912515	395.912515	301.716849	396.867792	350.502477	360.557681	360.557681	271.781909	371.01973	339.647319	35.3548346	35.3548346	29.9349397	25.8480616
HUD_LOWEI	497.419403	497.419403	406.265023	498.707867	452.499347	427.480749	427.480749	347.097919	448.412293	431.224746	69.9386547	69.9386547	59.1671042	50.295574
HUD_LOWEI	438.842656	438.842656	393.090333	508.180783	501.347777	344.961353	344.961353	323.081387	452.450729	482.220403	93.8813025	93.8813025	70.0089464	55.7300533

Figure 5.3.2. Fertilizer N application calculated by NANI-accounting tool.

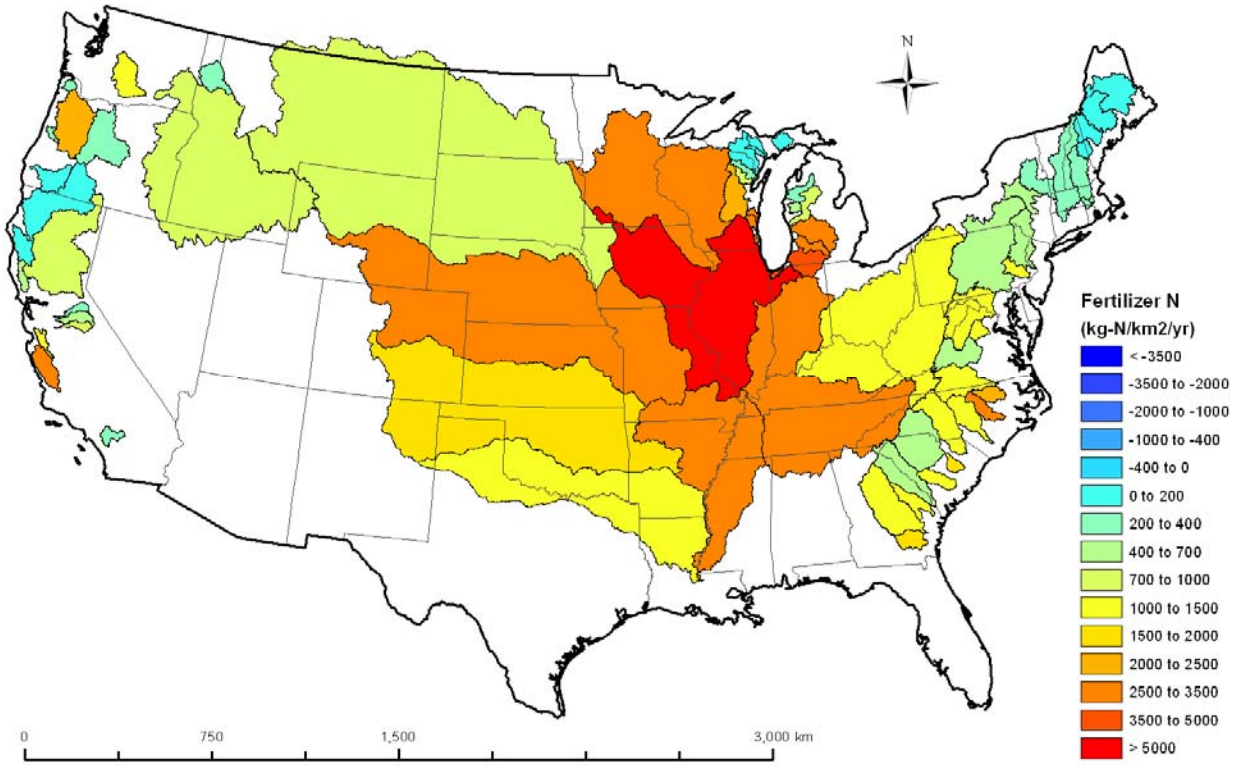
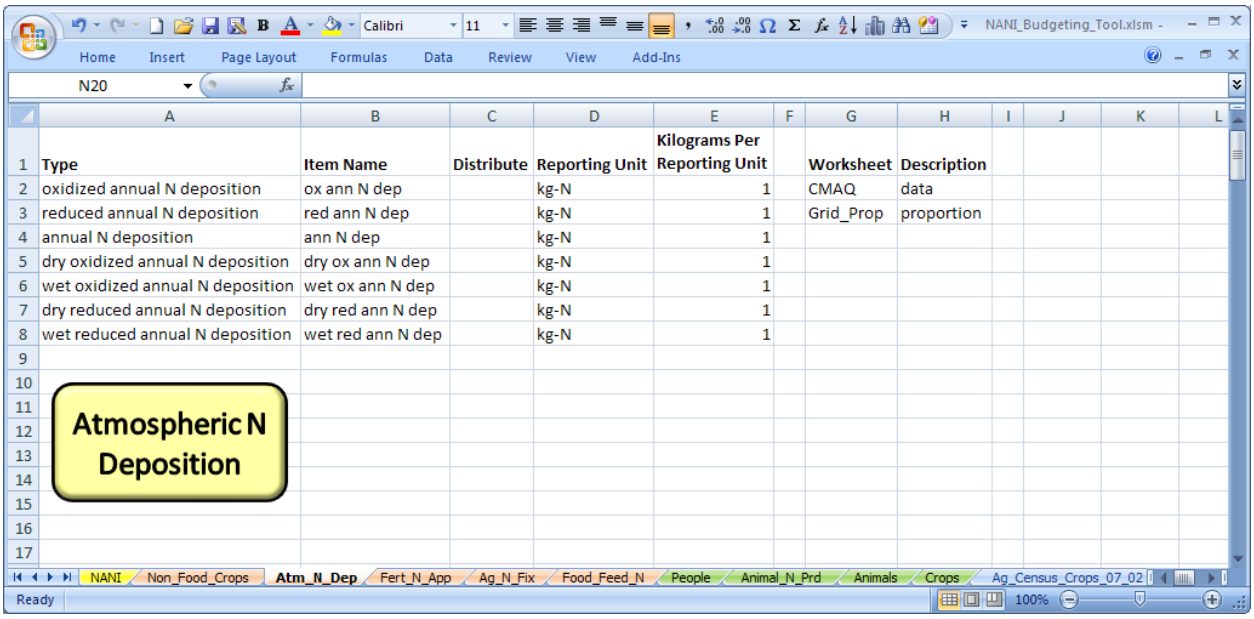


Figure 5.3.3. Fertilizer N application (kg-N/km^2/yr) in the US watersheds in 1992.

5.4. Calculating Atmospheric N Deposition

In this section, atmospheric N deposition (one of the NANI components; see Figure 1.1), obtained from CMAQ deposition estimates (Section 4.4), is calculated in the "Atm_N_Dep" worksheet of the NANI-accounting tool. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Atm_N_Dep" worksheet (Figure 5.4.1).



	A	B	C	D	E	F	G	H	I	J	K	L
1	Type	Item Name	Distribute	Reporting Unit	Kilograms Per Reporting Unit		Worksheet	Description				
2	oxidized annual N deposition	ox ann N dep		kg-N	1		CMAQ	data				
3	reduced annual N deposition	red ann N dep		kg-N	1		Grid_Prop	proportion				
4	annual N deposition	ann N dep		kg-N	1							
5	dry oxidized annual N deposition	dry ox ann N dep		kg-N	1							
6	wet oxidized annual N deposition	wet ox ann N dep		kg-N	1							
7	dry reduced annual N deposition	dry red ann N dep		kg-N	1							
8	wet reduced annual N deposition	wet red ann N dep		kg-N	1							

Figure 5.4.1. "Atm_N_Dep" worksheet of NANI-accounting tool.

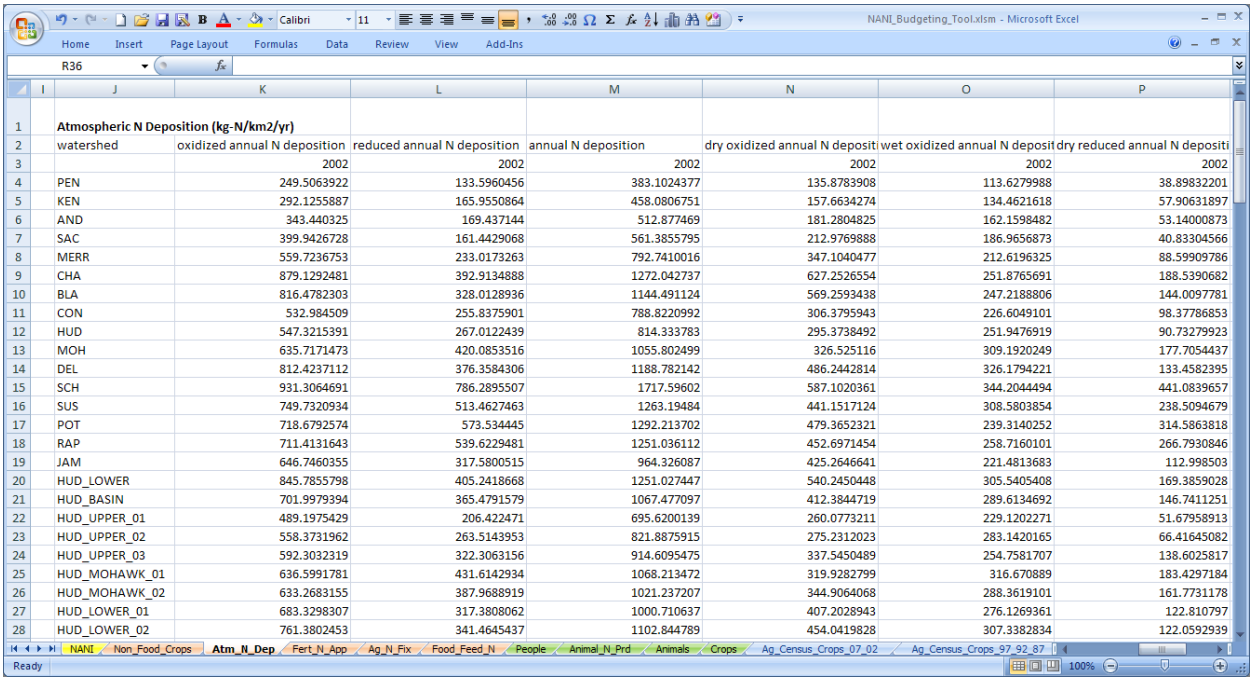
The worksheet contains a list of items for the calculation of atmospheric N deposition and other auxiliary variables (Column A) and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figure 4.4.3). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. Examples of its application can be found in Sections 5.1.2.1 and 5.1.3. The "Atm_N_Dep" worksheet also has the reporting units (Column D) and kilograms of deposition per reporting unit (conversion factor) (Column E). Since CMAQ deposition estimates are reported as amount of deposition in kilograms of nutrients, the conversion factors in Column E are set to "1" (no conversion). Detailed consideration of the specification of the conversion factor is given in Section 5.3.

The worksheet also contains the names of worksheets used as input (Columns G and H). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the CMAQ grid-based deposition estimates, created by the NANI-extraction tool described in Section 4.4 ("CMAQ" shown in Figure 4.4.3).

- A "proportion" worksheet containing the proportions of CMAQ grid cells falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.2 ("Grid_Prop" shown in Figure 3.2.5).

Click on the "Atmospheric N Deposition" button to run the calculation. The output will be generated in the same worksheet starting from Column J (Figure 5.4.2), reporting horizontally arranged variables as listed by the user in Column A, all in the unit of kg-N/km^2/yr. These values are calculated by converting the extracted values into kilograms of nutrients by applying the conversion factors (as specified in Column E) and multiplying by their proportions within the watershed, summing over all the grids, and dividing by the watershed area.



	J	K	L	M	N	O	P
1	**Atmospheric N Deposition (kg-N/km2/yr)**						
2	watershed	oxidized annual N deposition	reduced annual N deposition	annual N deposition	dry oxidized annual N deposit	wet oxidized annual N deposit	dry reduced annual N deposit
3		2002	2002	2002	2002	2002	2002
4	PEN	249.5063922	133.5960456	383.1024377	135.8783908	113.6279988	38.89832201
5	KEN	292.1255887	165.9550864	458.0806751	157.6634274	134.4621618	57.90631897
6	AND	343.440325	169.437144	512.877469	181.2804825	162.1598482	53.14000873
7	SAC	399.9426728	161.4429068	561.3855795	212.9769888	186.9656873	40.83304566
8	MERR	559.7236753	233.0173263	792.7410016	347.1040477	212.6196325	88.59909786
9	CHA	879.1292481	392.9134888	1272.042737	627.2526554	251.8765691	188.5390682
10	BLA	816.4782303	328.0128936	1144.491124	569.2593438	247.2188806	144.0097781
11	CON	532.984509	255.8375901	788.8220992	306.3795943	226.6049101	98.37786853
12	HUD	547.3215391	267.0122439	814.333783	295.3738492	251.9476919	90.73279923
13	MOH	635.7171473	420.0853516	1055.802499	326.525116	309.1920249	177.7054437
14	DEL	812.4237112	376.3584306	1188.782142	486.2442814	326.1794221	133.4582395
15	SCH	931.3064691	786.2895507	1717.59602	587.1020361	344.2044494	441.0839657
16	SUS	749.7320934	513.4627463	1263.19484	441.1517124	308.5803854	238.5094679
17	POT	718.6792574	573.534445	1292.213702	479.3652321	239.3140252	314.5863818
18	RAP	711.4131643	539.6229481	1251.036112	452.6971454	258.7160101	266.7930846
19	JAM	646.7460355	317.5800515	964.326087	425.2646641	221.4813683	112.998503
20	HUD_LOWER	845.7855798	405.2418668	1251.027447	540.2450448	305.5405408	169.3859028
21	HUD_BASIN	701.9979394	365.4791579	1067.477097	412.3844719	289.6134692	146.7411251
22	HUD_UPPER_01	489.1975429	206.422471	695.6200139	260.0773211	229.1202271	51.67958913
23	HUD_UPPER_02	558.3731962	263.5143953	821.8875915	275.2312023	283.1420165	66.41645082
24	HUD_UPPER_03	592.3032319	322.3063156	914.6095475	337.5450489	254.7581707	138.6025817
25	HUD_MOHAWK_01	636.5991781	431.6142934	1068.213472	319.9282799	316.670889	183.4297184
26	HUD_MOHAWK_02	633.2683155	387.9688919	1021.237207	344.9064068	288.3619101	161.7731178
27	HUD_LOWER_01	683.3298307	317.3808062	1000.710637	407.2028943	276.1269361	122.810797
28	HUD_LOWER_02	761.3802453	341.4645437	1102.844789	454.0419828	307.3382834	122.0592939

Figure 5.4.2. Atmospheric N deposition calculated by NANI-accounting tool.

These variables, as well as any of the auxiliary information, can be linked to the input map described in Section 2 (Figure 2.2) and displayed as a map using ArcGIS. As an example, Figure 5.4.3 shows the atmospheric N deposition in the US watersheds in 2002 calculated by the NANI-accounting tool. (As discussed in Section 4.4, currently the CMAQ deposition estimates are available only for the year of 2002.) The atmospheric N deposition is used in the calculation of NANI, as described in Section 5.6. Note that the NANI-accounting tool assumes that the first item listed in the "Atm_N_Dep" worksheet (i.e., "oxidized annual N deposition" in Row 2) is the NANI component used in the NANI calculation in Section 5.6. Thus, for example, if the user wants to use the "annual N deposition" instead (Row 4) for the calculation of NANI, the item must be placed first on the list. In this analysis, atmospheric N deposition includes only the oxidized form, assuming that most of the ammonia/ammonium emission from a watershed is redeposited on the same watershed (Howarth et al. 1996, 2006).

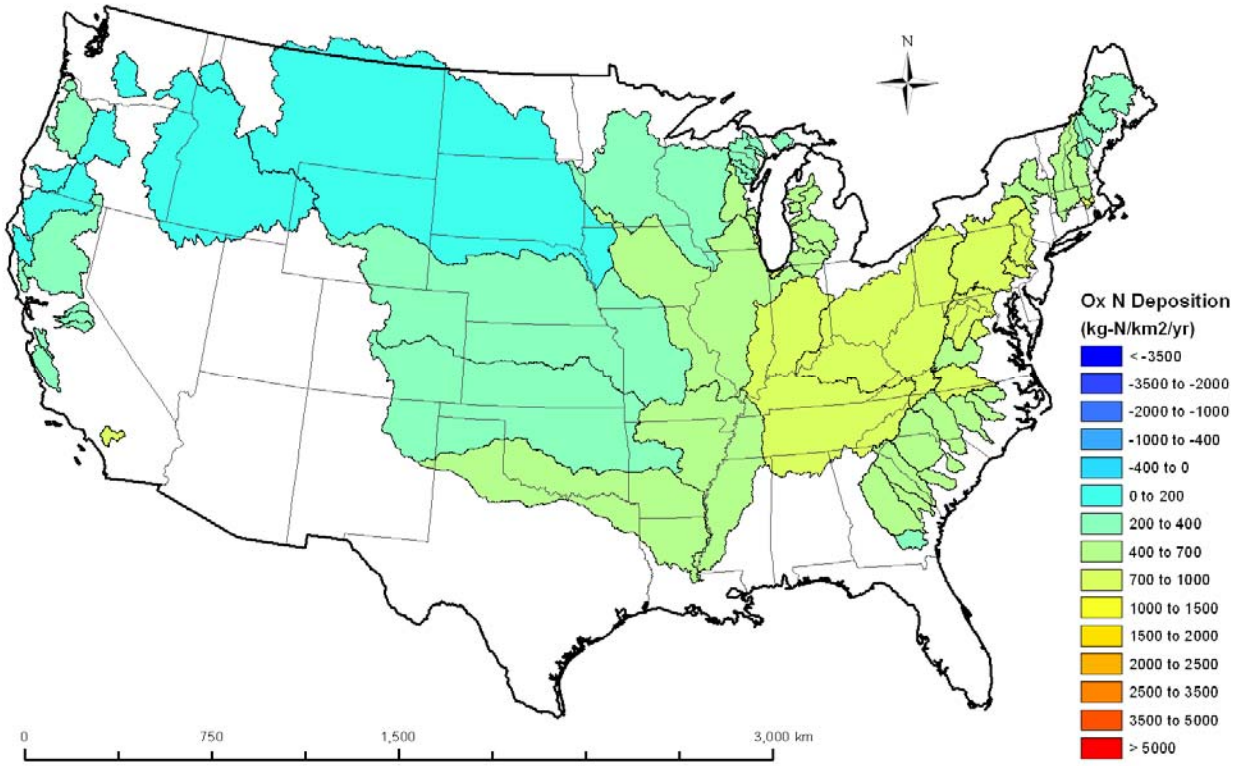


Figure 5.4.3. Atmospheric N deposition (kg-N/km^2/yr) in the US watersheds in 2002.

5.5. Calculating Non-Food Crop Exports

Following Schaefer and Alber (2007), who treated the nitrogen contained in cotton and tobacco production (that are not consumed by human and animals as food and feed) as "non-food crop exports", a module calculating the non-food crop exports was added to the toolbox, calculating the nitrogen in cotton and tobacco harvested for sale and exported elsewhere for non-food use. The non-food crop exports are calculated in the "Non_Food_Crops" worksheet of the NANI-accounting tool. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "Non_Food_Crops" worksheet (Figure 5.5.1).

The worksheet contains a list of crops for the calculation of non-food crop exports (Column A) and their user-specified item names (Column B) that are used by the accounting tool to find the corresponding values from the output worksheets generated by the extraction tools (Figures 4.1.1.1.4 and 4.1.2.1.4). Column C, with the column heading "Distribute", provides a way of estimating values of items when they are not directly available in the database. Examples of its application can be found in Sections 5.1.2.1 and 5.1.3. The "Non_Food_Crops" worksheet also has the crop parameters that are needed for the calculation of non-food crop exports, including the reporting unit (Column D), kilograms per reporting unit (Column E), percent dry matter (Column F), percent N in dry matter (Column G), percent loss of N during the processing (Column H), and percent exported or converted to an "unavailable" form (Column I). The values of these parameters for the cotton and tobacco are given in Table 5.1.1.1.

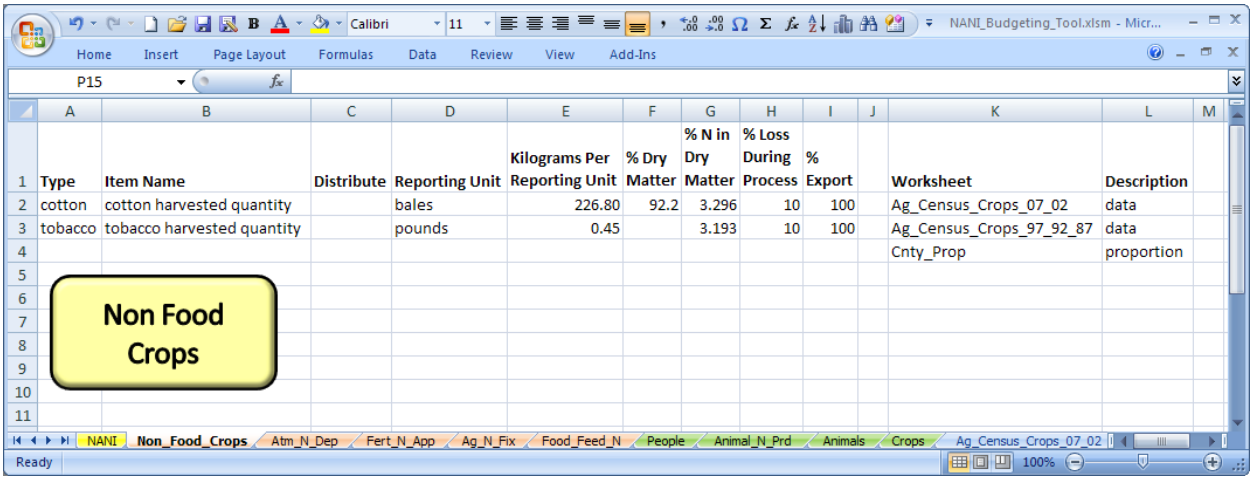


Figure 5.5.1. "Non_Food_Crops" worksheet of NANI-accounting tool.

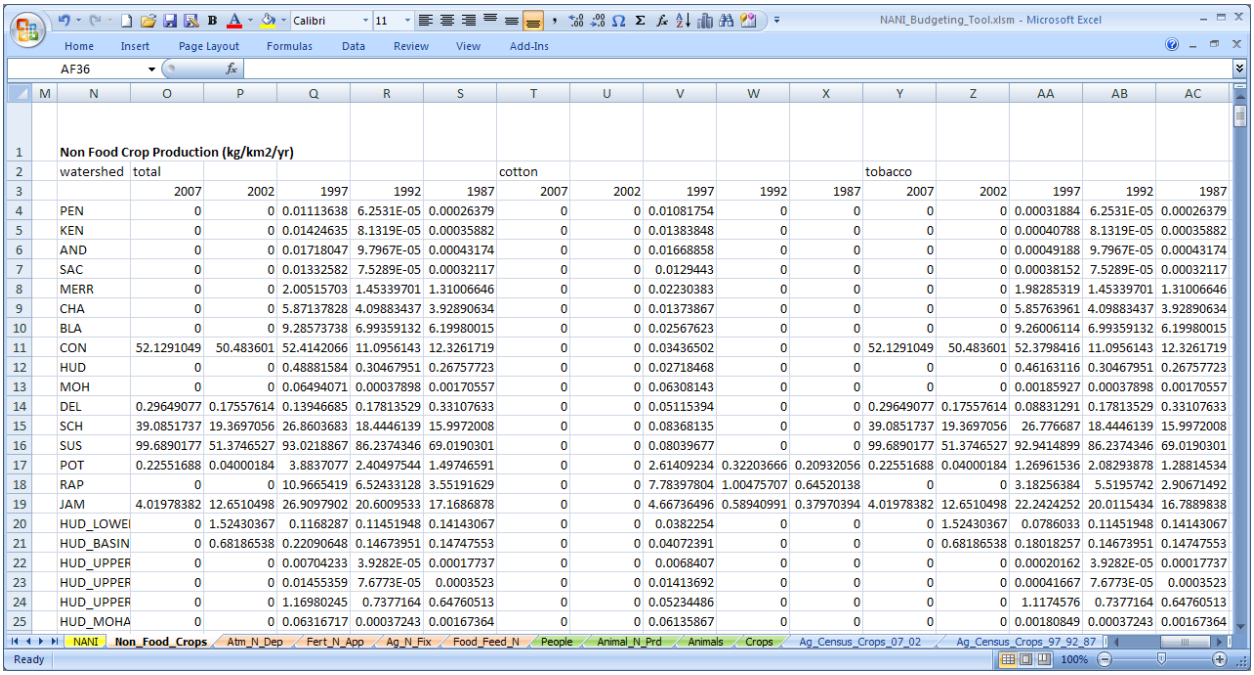
The worksheet also contains the names of worksheets used as input (Columns K and L). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed:

- A "data" worksheet containing the county-based Agricultural Census data for the crops in 1987, 1992, and 1997, created by the NANI-extraction tool described in Section 4.1.1.1 ("Ag_Census_Crops_97_92_87" shown in Figure 4.1.1.1.4).
- A "data" worksheet containing the county-based Agricultural Census data for the crops in 2002 and 2007, created by the NANI-extraction tool described in Section 4.1.2.1 ("Ag_Census_Crops_07_02" shown in Figure 4.1.2.1.4).
- A "proportion" worksheet containing the proportions of counties falling into the watersheds of interest, created by the NANI-GIS tool described in Section 3.1 ("Cnty_Prop" shown in Figure 3.1.5).

Click on the "Non Food Crops" button to run the calculation. The results will be reported in the same worksheet starting from Column N (Figure 5.5.2), summarized into four separate tables, reporting:

- Non Food Crop Production (kg/km^2/yr)
- Non Food Crop N Production (kg-N/km^2/yr)
- N in Non Food Crop Products (e.g. Cotton) (kg-N/km^2/yr)
- Non Food Crop N Export (kg-N/km^2/yr)

The first table is created by converting the reporting units into kilograms of biomass by multiplying by the conversion factors (Column E) and then by their proportions within the watershed, summing over all the counties, and dividing by the watershed area. The second table is created by converting them into kilograms of nitrogen by multiplying by the percent dry matter (Column F) and then the percent nitrogen (Column G). These conversion factors may not be reported separately in the original literature but as combined (i.e., pre-multiplied) factors. The combined factors may be entered in either Column F or G, while leaving the other column blank (e.g., Cells F3 and G3).



Non Food Crop Production (kg/km2/yr)

watershed	total					cotton					tobacco				
	2007	2002	1997	1992	1987	2007	2002	1997	1992	1987	2007	2002	1997	1992	1987
PEN	0	0	0.01113638	6.2531E-05	0.00026379	0	0	0.01081754	0	0	0	0	0.00031884	6.2531E-05	0.00026379
KEN	0	0	0.01424635	8.1319E-05	0.00035882	0	0	0.01383848	0	0	0	0	0.00040788	8.1319E-05	0.00035882
AND	0	0	0.01718047	9.7967E-05	0.00043174	0	0	0.01668858	0	0	0	0	0.00049188	9.7967E-05	0.00043174
SAC	0	0	0.01332582	7.5289E-05	0.00032117	0	0	0.0129443	0	0	0	0	0.00038152	7.5289E-05	0.00032117
MERR	0	0	2.00515703	1.45339701	1.31006646	0	0	0.02230383	0	0	0	0	1.98285319	1.45339701	1.31006646
CHA	0	0	5.87137828	4.09883437	3.92890634	0	0	0.01373867	0	0	0	0	5.85763961	4.09883437	3.92890634
BLA	0	0	9.28573738	6.99359132	6.19980015	0	0	0.02567623	0	0	0	0	9.26006114	6.99359132	6.19980015
CON	52.1291049	50.483601	52.4142066	11.0956143	12.3261719	0	0	0.03436502	0	0	52.1291049	50.483601	52.3798416	11.0956143	12.3261719
HUD	0	0	0.48881584	0.30467951	0.26757723	0	0	0.02718468	0	0	0	0	0.46163116	0.30467951	0.26757723
MOH	0	0	0.06494071	0.00037898	0.00170557	0	0	0.06308143	0	0	0	0	0.00185927	0.00037898	0.00170557
DEL	0.29649077	0.17557614	0.13946685	0.17813529	0.33107633	0	0	0.05115394	0	0	0.29649077	0.17557614	0.08831291	0.17813529	0.33107633
SCH	39.0851737	19.3697056	26.8603683	18.4446139	15.9972008	0	0	0.08368135	0	0	39.0851737	19.3697056	26.776687	18.4446139	15.9972008
SUS	99.6890177	51.3746527	93.0218867	86.2374346	69.0190301	0	0	0.08039677	0	0	99.6890177	51.3746527	92.9414899	86.2374346	69.0190301
POT	0.22551688	0.04000184	3.8837077	2.40497544	1.49746591	0	0	2.61409234	0.32203666	0.20932056	0.22551688	0.04000184	1.26961536	2.08293878	1.28814534
RAP	0	0	10.9665419	6.52433128	3.55191629	0	0	7.78397804	1.00475707	0.64520138	0	0	3.18256384	5.5195742	2.90671492
JAM	4.01978382	12.6510498	26.9097902	20.6009533	17.1686878	0	0	4.66736496	0.58940991	0.37970394	4.01978382	12.6510498	22.2424252	20.0115434	16.7889838
HUD_LOWEI	0	1.52430367	0.1168287	0.11451948	0.14143067	0	0	0.0382254	0	0	0	1.52430367	0.0786033	0.11451948	0.14143067
HUD_BASIN	0	0.68186538	0.22090648	0.14673951	0.14747553	0	0	0.04072391	0	0	0	0.68186538	0.18018257	0.14673951	0.14747553
HUD_UPPER	0	0	0.00704233	3.9282E-05	0.00017737	0	0	0.0068407	0	0	0	0	0.00020162	3.9282E-05	0.00017737
HUD_UPPER	0	0	0.01455359	7.6773E-05	0.0003523	0	0	0.01413692	0	0	0	0	0.00041667	7.6773E-05	0.0003523
HUD_UPPER	0	0	1.16980245	0.7377164	0.64760513	0	0	0.05234486	0	0	0	0	1.1174576	0.7377164	0.64760513
HUD_MOHA	0	0	0.06316717	0.00037243	0.00167364	0	0	0.06135867	0	0	0	0	0.00180849	0.00037243	0.00167364

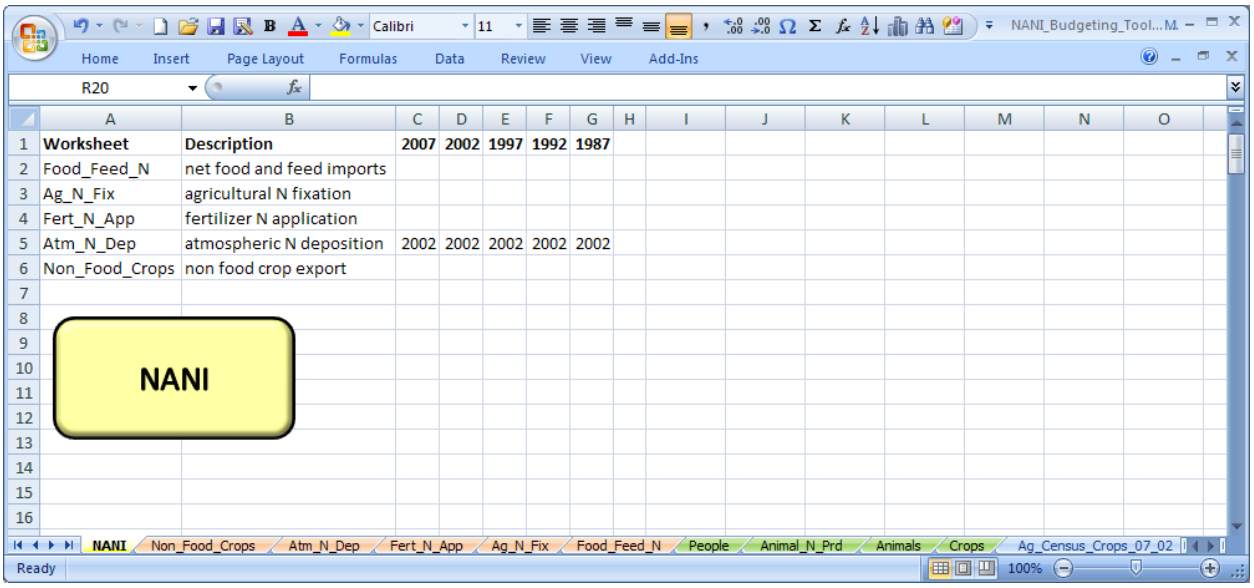
Figure 5.5.2. Non-food crop exports calculated by NANI-accounting tool**.**

The third table is created by applying the proportions lost during the processing (specified in Column H) and the fourth table is created by applying, in turn, the percent exported or converted to an "unavailable" form (specified in Column I), resulting in the non-food crop exports. The non-food crop exports may be used in the calculation of NANI, as described in Section 5.6. (Inclusion of non-food crop exports in the NANI calculation is optional.)

5.6. Calculating NANI

In this section, net anthropogenic nitrogen inputs are calculated in the "NANI" worksheet of the NANI-accounting tool, from the outputs stored in the "Food_Feed_N", "Ag_N_Fix", "Fert_N_App", "Atm_N_Dep", and "Non_Food_Crops" worksheets containing the net food and feed imports (Section 5.1.4), agricultural N fixation (Section 5.2), fertilizer N application (Section 5.3), atmospheric N deposition (Section 5.4), and non-food crop exports (Section 5.5), respectively. Open the file "NANI_Budgeting_Tool.xlsm" with Excel 2007 and find the "NANI" worksheet (Figure 5.6.1).

The "NANI" worksheet contains the names of worksheets used as input (Columns A and B). Before running the calculation, the user should make sure that the following input worksheets are included in the same file and revise them as needed (note that the worksheet name for the "non food crop export" can be left blank if the user chooses to calculate NANI without including the non-food crop exports):

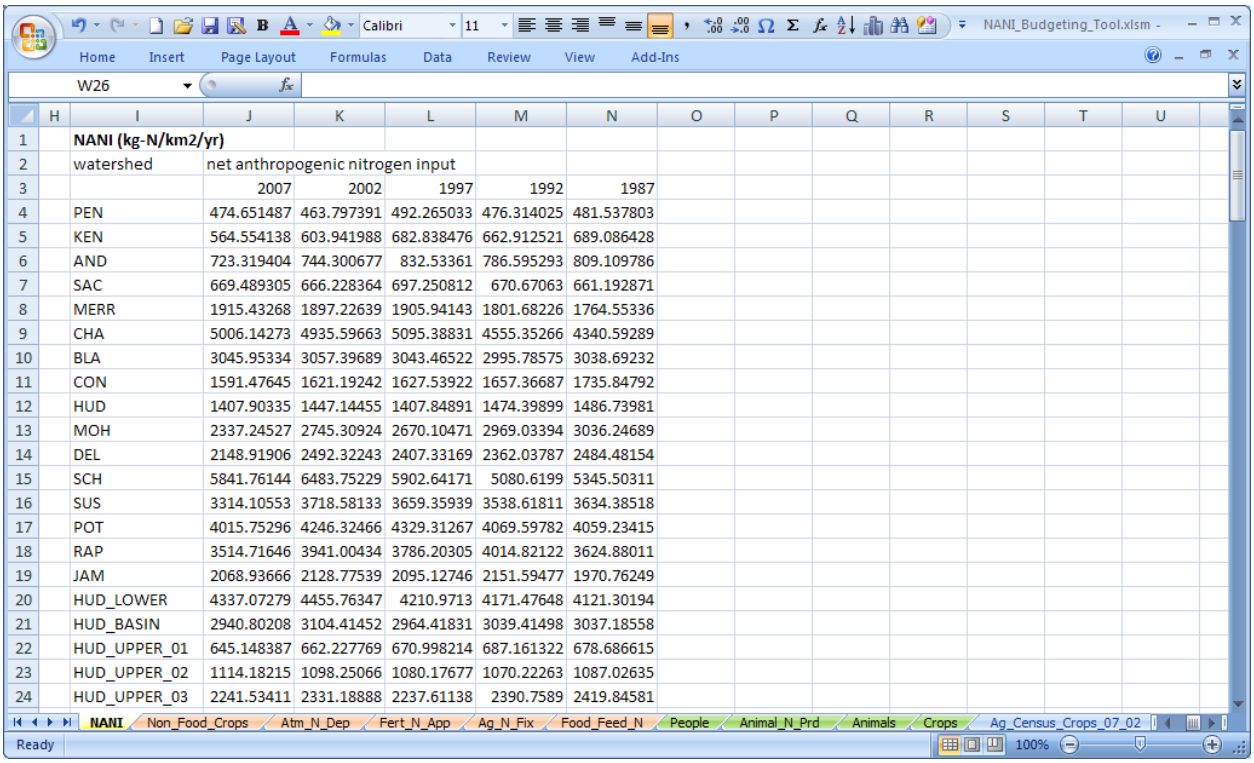


	A	B	C	D	E	F	G
1	**Worksheet**	**Description**	**2007**	**2002**	**1997**	**1992**	**1987**
2	Food_Feed_N	net food and feed imports					
3	Ag_N_Fix	agricultural N fixation					
4	Fert_N_App	fertilizer N application					
5	Atm_N_Dep	atmospheric N deposition	2002	2002	2002	2002	2002
6	Non_Food_Crops	non food crop export					

Figure 5.6.1. "NANI" worksheet of NANI-accounting tool.

- A "net food and feed imports" worksheet containing the net food and feed imports calculated by the NANI-accounting tool described in Section 5.1.4 ("Food_Feed_N" shown in Figure 5.1.4.2).
- An "agricultural N fixation" worksheet containing the agricultural N fixation calculated by the NANI-accounting tool described in Section 5.2 ("Ag_N_Fix" shown in Figure 5.2.2).
- A "fertilizer N application" worksheet containing the fertilizer N application calculated by the NANI-accounting tool described in Section 5.3 ("Fert_N_App" shown in Figure 5.3.2).
- An "atmospheric N deposition" worksheet containing the atmospheric N deposition calculated by the NANI-accounting tool described in Section 5.4 ("Atm_N_Dep" shown in Figure 5.4.2).
- An optional "non food crop export" worksheet containing the non-food crop exports calculated by the NANI-accounting tool described in Section 5.5 ("Non_Food_Crops" shown in Figure 5.5.2).

Columns C to G of the "NANI" worksheet contain a list of years for the calculation. If the cells in these columns are left blank, the calculation will be based on the values in the corresponding years. If these cells have year numbers, the values in the user-specified years will be used instead. In this analysis, the 2002 estimates of atmospheric N deposition obtained from CMAQ are applied for all years of calculation (1987, 1992, 1997, and 2007, as well as 2002), by specifying Cells C5 to G5 as "2002". (As discussed in Section 4.4, currently the CMAQ deposition estimates are available only for the year of 2002.) Cells C1 to G1 are used to specify the years for the NANI calculation, and may be shortened or extended as appropriate for the analysis.



	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1		**NANI (kg-N/km2/yr)**												
2		watershed	net anthropogenic nitrogen input											
3			2007	2002	1997	1992	1987							
4		PEN	474.651487	463.797391	492.265033	476.314025	481.537803							
5		KEN	564.554138	603.941988	682.838476	662.912521	689.086428							
6		AND	723.319404	744.300677	832.53361	786.595293	809.109786							
7		SAC	669.489305	666.228364	697.250812	670.67063	661.192871							
8		MERR	1915.43268	1897.22639	1905.94143	1801.68226	1764.55336							
9		CHA	5006.14273	4935.59663	5095.38831	4555.35266	4340.59289							
10		BLA	3045.95334	3057.39689	3043.46522	2995.78575	3038.69232							
11		CON	1591.47645	1621.19242	1627.53922	1657.36687	1735.84792							
12		HUD	1407.90335	1447.14455	1407.84891	1474.39899	1486.73981							
13		MOH	2337.24527	2745.30924	2670.10471	2969.03394	3036.24689							
14		DEL	2148.91906	2492.32243	2407.33169	2362.03787	2484.48154							
15		SCH	5841.76144	6483.75229	5902.64171	5080.6199	5345.50311							
16		SUS	3314.10553	3718.58133	3659.35939	3538.61811	3634.38518							
17		POT	4015.75296	4246.32466	4329.31267	4069.59782	4059.23415							
18		RAP	3514.71646	3941.00434	3786.20305	4014.82122	3624.88011							
19		JAM	2068.93666	2128.77539	2095.12746	2151.59477	1970.76249							
20		HUD_LOWER	4337.07279	4455.76347	4210.9713	4171.47648	4121.30194							
21		HUD_BASIN	2940.80208	3104.41452	2964.41831	3039.41498	3037.18558							
22		HUD_UPPER_01	645.148387	662.227769	670.998214	687.161322	678.686615							
23		HUD_UPPER_02	1114.18215	1098.25066	1080.17677	1070.22263	1087.02635							
24		HUD_UPPER_03	2241.53411	2331.18888	2237.61138	2390.7589	2419.84581							

Figure 5.6.2. NANI calculated by NANI-accounting tool**.**

Click on the "NANI" button to run the calculation. NANI in kg-N/km^2/yr will be reported in the same worksheet starting from Column I (Figure 5.6.2), calculated as the sum of the following components as shown in Figure 1.1:

- Net Food and Feed Imports (Section 5.1.4, 5th variable)
- Agricultural N Fixation (Section 5.2, 2nd table)
- Fertilizer N Application (Section 5.3, 1st variable)
- Atmospheric N Deposition (Section 5.4, 1st variable)

In addition, if the user chooses to include the non-food crop exports, the following component will be subtracted:

- Non Food Crop N Export (Section 5.5, 4th table)

These variables, as well as any of the earlier intermediate results, can be linked to the input map described in Section 2 (Figure 2.2) and displayed as a map using ArcGIS. As an example, Figure 5.6.3 shows NANI in the US watersheds in 1992 calculated by the NANI-accounting tool, with the animal calculation based on the static difference approach (Section 5.1.2.1), with the atmospheric N deposition including only the oxidized form in 2002 (Section 5.4), and with the non-food crop exports included (Section 5.5).

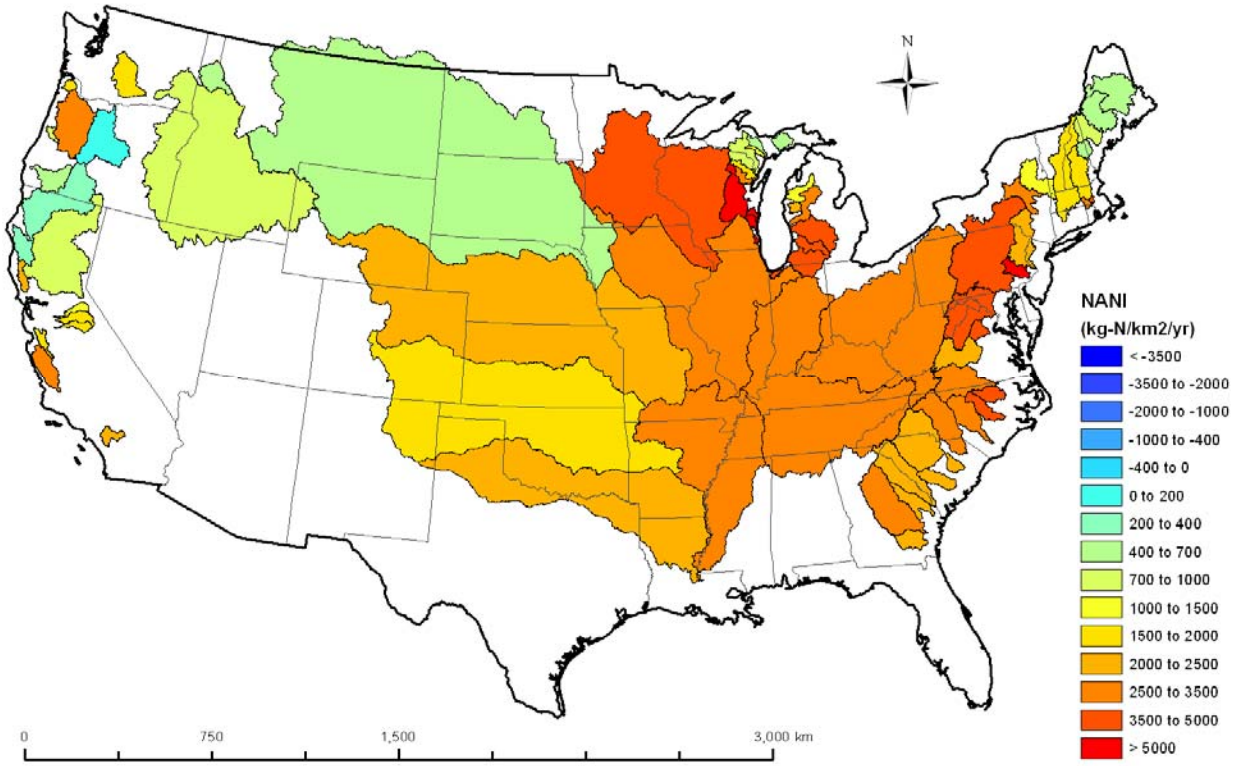


Figure 5.6.3. Net anthropogenic nitrogen inputs (kg-N/km^2/yr) in the US watersheds in 1992.

6. Ongoing and future developments

The NANI Calculator Toolbox described in this document is intended to facilitate the application of NANI at the national scale, representing the first phase of our efforts to develop a set of user-friendly tools that, collectively, allow the user to estimate the human-induced nitrogen inputs anywhere in the contiguous United States simply from an input map of areas of interest. Further improvements to the current version of the toolbox would facilitate its application to other areas, both geographically and contextually. Below are the areas of improvements that we are currently focusing on.

- Expanding databases read by the NANI-extraction tool: In developing the extraction tools of the NANI Calculator Toolbox, it was our intent to keep the structure of the databases close to their original forms as obtained from the Web, minimizing the effort the user has to invest as new databases become available. Currently, the extraction tools of the toolbox read a variety of databases (e.g., Agricultural Census, Census, CMAQ output, etc.), and more extraction tools are being developed for other generally available databases, including outside the US (e.g., European databases). Users with their own datasets may find it desirable to reformat their datasets similar to one of the databases included in the package if their data structure is not compatible with them.

- Allowing spatial and temporal variations in NANI parameters: The current version of the toolbox assumes fixed values for all the NANI parameters, limiting its applicability to incorporating the real regional variations in crops, animals, and people, and evaluating their impacts on NANI. Allowing spatial variation of the NANI parameters can be an important and practical functionality for the application of toolbox to multiple coastal watersheds from several countries draining to international waters, which may be subject to varying agronomic practices and substantially different dietary preferences (Eriksson Hägg et al. 2010), while allowing temporal variation would be useful in assessing the historical changes in human-induced nitrogen inputs.

- Adding sensitivity and uncertainty analysis features: A virtue of the NANI Calculator Toolbox is to make it easy to estimate error propagation from either known standard errors in the data, or assumptions about uncertainties in parameters. All the parameters and assumptions applied in the NANI calculation are given in the worksheets of the accounting tool, making it feasible to develop additional tools of sensitivity/uncertainty estimation, running the NANI calculation multiple times with alternative parameters and assumptions.

- Applying a similar approach to other nutrients: Similar watershed-scale nutrient accounting approaches considering anthropogenic inputs of other nutrients have been applied in other studies, e.g., phosphorus (Russell et al. 2008) and silica (Sferratore et al. 2006). Although other nutrients may be governed by different processes, the overall principle of mass balance applies, and a general accounting procedure similar to that of the NANI calculations may be developed for large-scale assessment of these nutrient fluxes to coastal waters. Preliminary work on a phosphorus calculator has shown promise, and a version should be forthcoming soon.

- Providing input parameters to ReNuMa (Regional Nutrient Management) model: ReNuMa (http://www.eeb.cornell.edu/biogeo/nanc/usda/renuma.htm) is a regional hydrology and nutrient loading model, running in a large-watershed-scale similar to the scale in which NANI is estimated. ReNuMa is designed to allow planners and other stakeholders to explore scenarios for reducing N fluxes from the landscape. Most of the nutrient model parameters of ReNuMa are either the components of NANI (e.g., atmospheric N deposition, fertilizer N application, and agricultural N fixation) or indirectly estimated during the NANI calculation (e.g., unsewered population and animal N excretion). We are currently developing additional tools generating ReNuMa parameter worksheets using outputs from the NANI-accounting tool.

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