Benchmark Soils

Tom Reedy, Soil Scientist, NSSC
Tomas Reinsch, Soil Scientist, NSSC
Sharon Waltman, Soil Scientist, NGDC

DEFINITION

1. It is to the research community's advantage to focus their investigative effort on key soils. These soils have the greatest potential for applying new technology across large areas, and also for transferring new technologies to similar soils, thereby optimizing cost–benefit ratios. We refer to these soils as "benchmark soils."
2. Because soil survey is ongoing, maintaining the list of benchmark soils and evaluating completeness of lab data is also ongoing. Benchmark soils maintenance *reaffirms* the NCSS program to complete a geospatially representative national laboratory dataset.
3. The current list is a compilation of states' preferences. Because benchmark soils transcend administrative boundaries, there is a strong argument for creating a list that reflects geographic areas (MLRAs).

APPLICATION

1. assessment of conservation effects
2. as sites for evaluating interpretations
3. macro/micronutrient and trace element studies
4. dynamic soil property change and other monitoring studies
5. Elrashidi et al. 2004, 7 of 9 soils were benchmark in "Phosphorus loss by runoff for an Agricultural Watershed in Southeast Nebraska**"**
6. saturated hydraulic conductivity studies
7. soil quality
8. studies of soil erodibility factors
9. crop and range plant adaptation and yield
10. soil fertility
11. source for training materials and onsite training activities
12. crop/soil/pesticide modeling scenarios for surface water and groundwater assessments
13. pedotransfer function modeling
14. EPA Office of Pesticide Programs–crop/soil/pesticide modeling scenarios for surface water and groundwater assessments. Bill Effland successfully argued for benchmarks soils as a foundation for these studies. "EPA didn't even know there was a list until I got a hold of one in the early 90s" (Marketing opportunity?)
15. IQuum inc. is developing an analytical device that can extract nucleic acids from environmental and clinical samples, as well as perform real time polymerase chain reaction (PCR) amplification of the extracted materials. They are interested in a set of representative soil types that are widely distributed in the US

CRITERIA

1. Benchmark Soil Criteria:
   a) EXTENT: commonly of large extent (>100,000 acres) in the Land Resource Region (LRR); moderate or large extent in the MLRA (> 10,000 acres). "A series of relatively high extent in the MLRA." Not all series of moderate or large extent are benchmark soils.
   b) KEY SOILS: holds a key position in the soil classification system,

c) IMPORTANT SOILS: that are important for specialty crops and engineering uses (such as forestry, ranching, recreational development, urban development, wetland restoration, or other uses), OR
d) EXISTING DATA: there are large amounts of data.

2. MLRA Criteria:
   a) EXTENT: Total extent of benchmark soils should comprise about 20 to 25 percent of the total soil area of the MLRA, and
   b) Since benchmark soils represent similar soils, about 60 to 80 percent of all soils in the MLRA are collectively represented.

CURRENT STATUS

1. About 1215 benchmark soil series.
2. Last updated in the 1980s, well before the completion of many soil surveys (once over).
3. Taxonomic summary — NO benchmark soils with classification errors.
   NO benchmark soils with obsolete subgroups
4. NSSL characterization data status of the 1215 benchmark soils: Table 1 indicates NASIS acres, and the data completeness index (DCI) status for benchmark soil pedons[1]. The DCI maximum value is important, since it indicates the most complete dataset(s) in the system. The goal would be to strive for a max DCI = 9. ***State university labs are not reflected in the following table***. Table 2 summarizes the NSSL dataset.

Table 1 – Indicates # pedons correlated and # pedons sampled as, not correlated (low apples), along with their range in data completeness index (DCI). **Click here to link to the entire report: DCI_benchmark_soils_min_max.rtf**

MLRA Office 1
OREGON

		correlated as			*sampled as*		
			DCI			*DCI*	
seriesname	***acres***	***count***	***min***	***max***	***count***	***min***	***max***
DESCHUTES	47336	3	8	8	5	5	8
DIGGER	230166	1	8	8	5	5	8
HANKINS	81313				3	7	8
HEMBRE	86049	2	8	9	3	8	9
HENLINE	23979						
HONEYGROVE	204798	3	4	7	6	7	9
JORY	213078	10	6	8	27	2	9
KEEL	45426	2	8	8	1	8	8
KINNEY	206622	2	5	5	2	5	5
LAPINE	122240	7	7	9	9	6	9

[1] Pedon data in the database were evaluated to determine the quantity of data available for each pedon and a data completeness index (DCI) assigned. Data frequency for each data element was determined for each horizon. A one was assigned if data were present and a zero if no data were present. The frequencies were grouped by similar analysis and a representative data element chosen to represent the most common analysis suites. The indicators were clay, organic carbon, extractable sodium, cation exchange capacity by ammonium acetate at pH 7, pH in water, bulk density at 1/3 bar, gravimetric water content at 15 bar, volume of <2mm divided by volume of whole soil at 1/3 bar, and mineralogy. If either sand or clay mineralogy existed for any horizon within a pedon, the pedon was considered to have complete mineralogy data. The data indicators for each horizon were averaged for a pedon and scaled to an index range of 0 to 9.

Table 2 – Row 3 is a subset of row 2. In row 3 we're trying to identify pedons that have "fully characterized data" (i.e., lab characterization data with DCI > 6), which would indicate benchmark soils with a low level of "data gaps."

Benchmark Soils (1215)	NSSL Status	Data Completeness Index (DCI)
218 (18%)	No Data	
711 (58%)	At least one correlated pedon	1 – 9
592 (48%)	At least one correlated pedon "*fully characterized*"	7 – 9
286 (24%)	At least one pedon "*sampled as, not correlated*"	1 – 9
1215		

5. 17 (32%) State Soils are not on the Benchmark list (Table 3):

Table 3 – State Soils are not on the Benchmark list

AL	BAMA	NV	OROVADA
AR	STUTTGART	OK	PORT
CO	SEITZ	PR	BAYAMON
DE	GREENWICH	TN	DICKSON
FL	MYAKKA	UT	TAYLORSFLAT
GU	AKINA	VA	PAMUNKEY
ID	THREEBEAR	VI	VICTORY
ME	CHESUNCOOK	WY	FORKWOOD
MS	NATCHEZ		

6. SPATIAL COVERAGE: Figure 1 – Approximation of spatial coverage of current benchmark soils list by STATSGO units for the U.S. We assumed all STATSGO units have at least one benchmark soil. Data sources are STATSGO (1994) and MLRA (version 4.0) data-and benchmark soils list (SC file query). The areas with no color disproved our assumption.

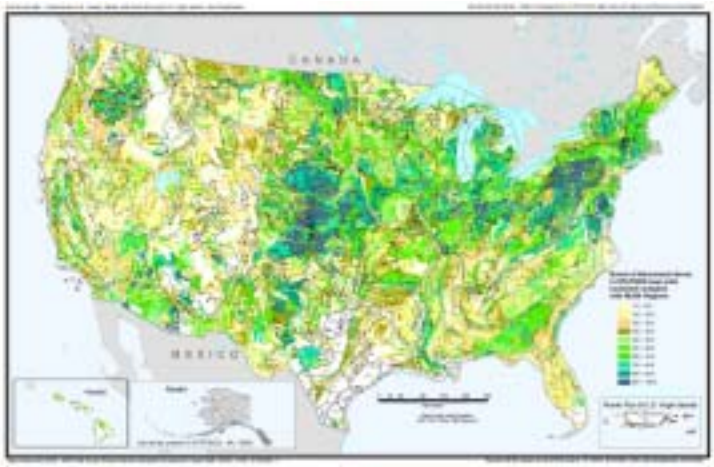

Figure 1 – Approximation of spatial coverage of current benchmark soils list by STATSGO units for the conterminous U.S. Click here to view PDF file: benchmark_statsgo_mlra.pdf

7. Approximation of spatial

coverage of current benchmark soils list by MLRA. Data sources are STATSGO (version 1994), revised MLRA (version 4.0) data, and benchmark soils list (SC file query). With multiple STATSGO units per MLRA, this map should guarantee some coverage in each MLRA (Figure 2).

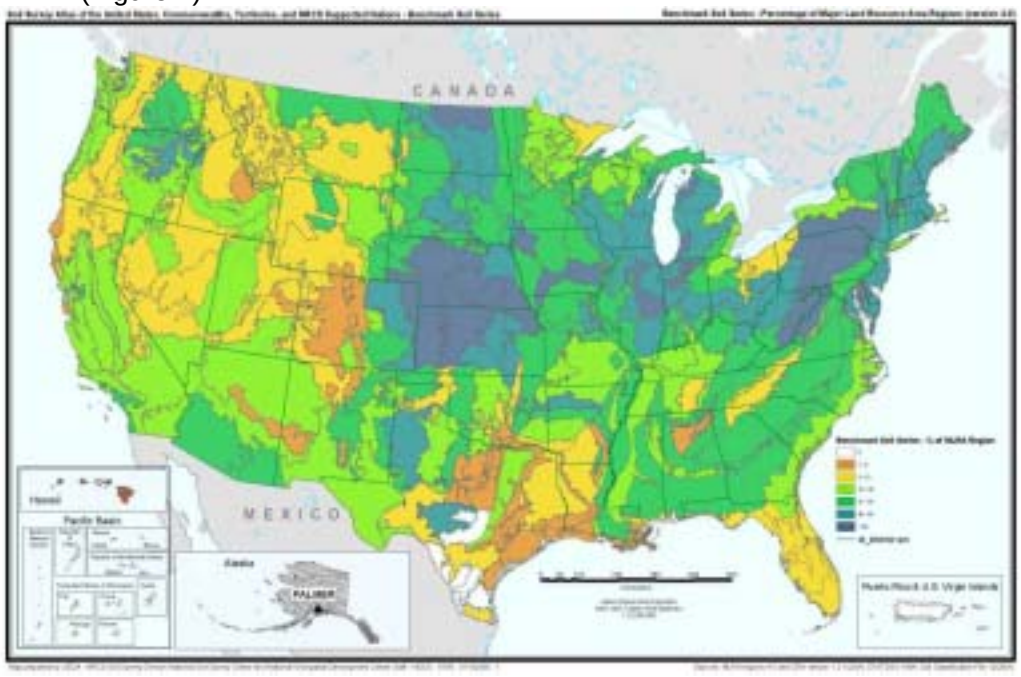

Figure 2– There are ways to explain the differences in coverage. 1) benchmark soils were originally geared for agriculture (cropland), hence more extensive in central than western. 2) At the time the list was last revised, predominance of extensive benchmark soils in Central and Eastern states suggest a higher degree of completion of the once-over. 3) Taxonomic diversity is higher in the west than the rest of the country and so centering on BM series results in relatively low total coverage for the MLRAs. Note that some MLRAs contain no STATSGO units whose components are a benchmark soil. Click here to view PDF file: Generalized_benchmark_statsgo_mlra.pdf

REVISION ANALYSES — How real is it?"

At the summer 2004 MO Leaders' meeting, Bob Ahrens encouraged the MO's to work with the States and "Revise the benchmark list to reflect reality."

1. Analysis hurdle: is there a dependable database from which component acres by MLRA, or series correlated by MLRA, can be analyzed?

   a) **NASIS?** Since the project to revise *LRRs and MLRAs of the U.S.*, (Handbook 296), **NASIS is no longer current**. In addition, **some datasets do not contain MLRA area overlap tables.**

Conclusion, ***NASIS*** *is reliable only where*
1) MLRA area overlap is available, and
2) MLRAs have not changed geospatially or alphanumerically.

b) **The SC FILE?** The SC file indicates the MLRAs in which series are correlated. A series listed as benchmark may have been correlated in 3 MLRAs, but it may not be dominant in all of them (i.e. no data on acreage extent). In addition, since the project to revise *MLRA,* new MLRAs have been added, previous MLRAs have been split (into A, B, C, etc.), and delineations have been significantly altered in most parts of the country (Tables 4 and 5). Practically NONE of the MLRA revisions are reflected in the SC file at the current time. Example:

Table 4 – In the SC file, there are 90 active MLRAs (32%) with no series. Click here to view PDF file: Count Benchmark MLRA using.pdf

Count of Obsolete MLRA Using for Benchmark Series		Count of Active MLRA Using for Benchmark Series	
OBSOLETE MLRA	Count BM Soils	ACTIVE MLRA	Count BM Soils
90	44	90A	0
		90B	0
91	38	91A	0
		91B	0
		92	7
93	21	93A	0
		93B	0
		94A	18
		94B	16
		94C	0
		94D	0

Some (or all) of 94A goes to 94C and 94D

Table 5 – There are 427 benchmark soils (35%) associated with obsolete MLRAs. Click here to view XLS file: Benchmark soils with obsolete MLRA using.xls

Benchmark Series with Obsolete MLRA Using in the SC Database Obsolete MLRAs shown in Bold Type					
MLRA	**Series**			**Type**	**Used In**
Office	**Name**	**Status**	**MLRA Using**	**Location**	**STATSGO**
1	FREEMAN	E	**43**, 9	WA	Y
1	RIDGECREST	E	13, **43**	ID	Y
1	SOUTHWICK	E	**43**, 9	ID	Y
1	TETONIA	E	13, **43**	ID	Y
2	APAKUIE	E	**161**	HI	Y
2	HANALEI	E	158, **159**, 164, 167	HI	Y
2	HILO	E	**159**	HI	Y
2	HONUAULU	E	**159**, 160	HI	Y

Conclusion, ***SC is not reliable and in DIRE NEED OF CORRECTION.***

Note: One solution to the SC file issue is to overlay MLRA map over series distribution and extent maps to recreate MLRA correlated (Figure 3). If there is good SSURGO coverage in the MLRA, update the SC file with SSURGO data. This component information from SSURGO can also be used to revise the list of benchmark soils.

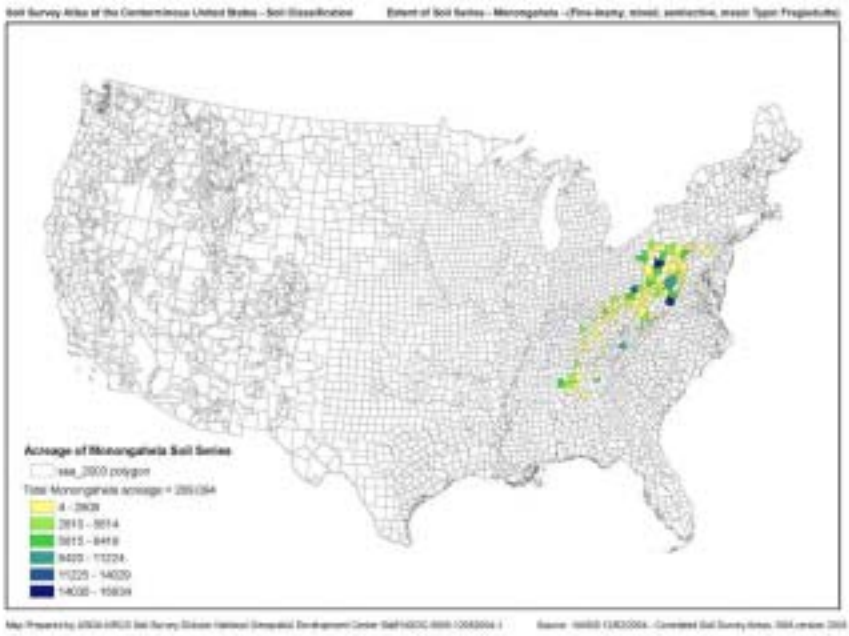

Figure 3 – The MLRA status of series in the SC file is not current, but it can be updated with GIS. Solution: Overlay MLRA map with geospatial distribution and extent maps for each series. monongahela_extent.pdf

2. Recommended Analysis: The integrity and completeness of available datasets will determine the most appropriate analysis approach. Refer to the following priority sequence identified in items a), b), and c) below.

   a) **Revise and maintain benchmark soils with GIS analysis tools**. If SSURGO coverage for the MLRA is complete or nearly so, the best way to accurately evaluate and revise benchmark soils is to use it in combination with the revised MLRA map. This is our analysis of choice. ***Contact Sharon Waltman at the National Geospatial Development Center for advice*** (Sharon.Waltman@mail.wvu.edu).

   EXAMPLE: As a result of the project to revise *LRRs and MLRAs of the U.S.*, MLRA 94D has undergone significant geospatial revisions. NASIS data is useless, but this MLRA has a nearly complete SSURGO dataset. In the following demonstration, we cookie-cut MLRA 94D from SSURGO and conducted the following 3 analyses**:**

   1) Since we had no idea which benchmark soils from the current list occurred in the revised MLRA 94D, we recreated the list of benchmark soils for MLRA 94D by comparing SSURGO with the current list (Figure 5). Four existing benchmark soils were "discovered" to occur in MLRA 94D (Antigo, Rubicon, Loxley, Carbondale).

Figure 4 is a plot of the distribution of each of the 4 benchmark soils from the current list that were "discovered" this way.

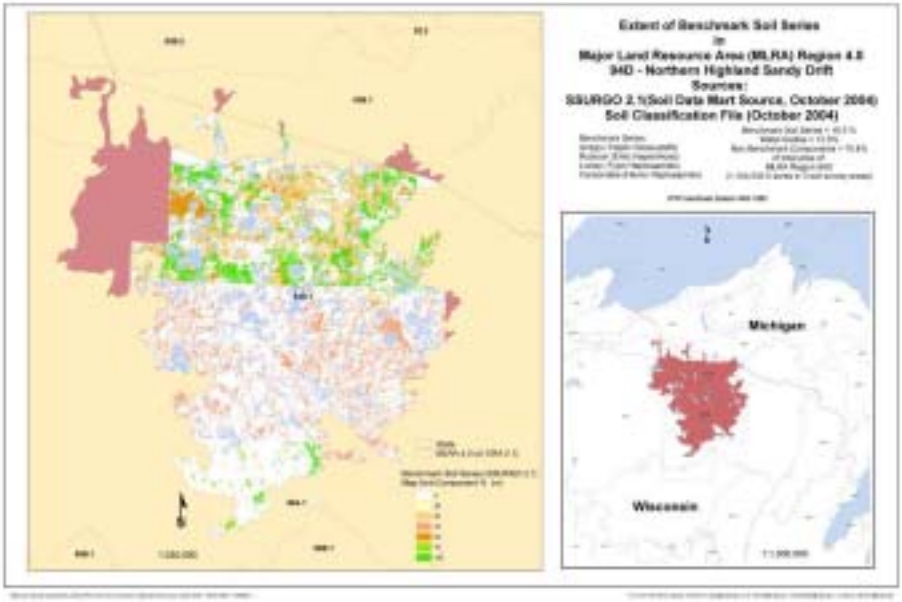

Figure 4– SSURGO and MLRA 4.0 were used to extract SSURGO in MLRA 94D. Components were compared to the benchmark soils list (SC file) to identify the bench mark soils mapped in 94D. Click here to view PDF file: bench_mark_94d_new.pdf

2) Then we asked "If we were to construct a new benchmark list of MLRA 94D from scratch, what would we need?" We would query the database to get a list of **ALL** the series components, subtotal acres by series name, and sort by acre-extent in descending order. We would also include the family classification of each series (Table 6).

Table 6–query of MLRA 94D to report series by acreage extent in descending order. Of the first 7 series, only two existing benchmark soil makes the list. Also the first 7 series represent only 5 families (Sayner, Rubicon, and Vilas are in the same family). Geospatial representation for the MLRA is 66 %.

Series	acres	Percent MLRA	Family_class
Sayner	148564	15.52	SANDY, MIXED, FRIGID ENTIC HAPLORTHODS
Padus	109701	11.46	COARSE-LOAMY, MIXED, SUPERACTIVE, FRIGID ALFIC HAPLORTHODS
Rubicon	104488	10.92	SANDY, MIXED, FRIGID ENTIC HAPLORTHODS
Pence	86028	8.99	SANDY, MIXED, FRIGID TYPIC HAPLORTHODS
Vilas	78661	8.22	SANDY, MIXED, FRIGID ENTIC HAPLORTHODS
Keweenaw	53533	5.59	SANDY, MIXED, FRIGID ALFIC HAPLORTHODS
Loxley	49345	5.15	DYSIC, FRIGID TYPIC HAPLOSAPRISTS
Carbondale	22186	2.32	EUIC, FRIGID HEMIC HAPLOSAPRISTS
Antigo	3455	0.36	COARSE-LOAMY OVER SANDY OR SANDY-SKELETAL, MIXED, SUPERACTIVE, FRIGID HAPLIC GLOSSUDALFS

3) Another query would be to report family extent in descending order, and assign a representative series in cases where there are more than 1 series per family (Table

7). With the assumption that series within families typically behave similarly compared to series among families, this analyses should significantly expand the "effective geographic extent" for any given benchmark soil constructed this way. This in turn translates into greater inference space with regard to technology transfer (81% representation in table 7 compared to 66% in table 6). The results from table 7 suggest that this is the preferred analysis.

Table 7– query of MLRA 94D to family by acreage extent in descending order, then series w/in family in descending order. Here, 7 families = 81 % of MLRA, and 7 series (one from each family, highlighted in yellow) are selected to represent the same 81 %. Green highlight soils are current benchmark soils. Even though the Rubicon is not dominant, it is codominant. Depending on available data and research information, there may not be a reason to replace Rubicon with Sayner. Only one other existing benchmark soil (Loxley) made the 81% list.

Family_class	Family acres	Family %_of MLRA	Series name	Series acres	
SANDY, MIXED, FRIGID ENTIC HAPLORTHODS	366973	38.34	Sayner	148564	
			Rubicon	104488	
			Vilas	78661	
			Karlin	32696	
			Rousseau	2564	
COARSE-LOAMY, MIXED, SUPERACTIVE, FRIGID ALFIC HAPLORTHODS	116911	12.21	Padus	109701	
			Goodman	4243	
			Padwet	2227	
			Sarona	731	
			Newot	9	
			Mequithy	0	
SANDY, MIXED, FRIGID TYPIC HAPLORTHODS	86028	8.99	Pence	86028	
SANDY, MIXED, FRIGID OXYAQUIC HAPLORTHODS	60377	6.31	Croswell	48815	
			Croswood	9189	
			Manitowish	2373	
SANDY, MIXED, FRIGID ALFIC HAPLORTHODS	53533	5.59	Keweenaw	53533	
DYSIC, FRIGID TYPIC HAPLOSAPRISTS	49345	5.15	Loxley	49345	
EUIC, FRIGID TYPIC HAPLOSAPRISTS	42863	4.48	Lupton	27264	81%

b) <u>If MLRA area overlap exists and MLRA boundaries and MLRAs have not been significantly altered, use NASIS.</u>

Joe Chiaretti, NRCS, Reno, NV, used NASIS to evaluate benchmark soils by MLRA in Nevada. Joe's comments: "The Nevada benchmark list grew by 42 percent from 104 to 148 series. Only 47 of the series on the current list are still present on the revised list of 148. Fifty seven series currently listed as benchmark for Nevada will no longer be benchmark soils. The 148 proposed benchmark soils are less than 9 percent of the total number of series used in the state.") Click here to view Joe's detailed procedural analysis: NV Benchmark update procedure.doc.

c) <u>Use STATSGO (1994) and MLRA 4.0 to evaluate series and family extent.</u> Reinsch's top 25 percent list generated from STATSGO can be used to revise the Benchmark Soil

list. Tom tabulated acres for each component, sorted in descending order, then subtotaled to 25% for the MLRA

Table 8 – Top 25 percent extensive STATSGO components by MLRA. **mlra_top 25%_series_benchmark.xls**

MLRA	COMPNAME	mlraacres	mlrapct	benchmark
94B	KALKASKA	571509	9	Y
	RUBICON	508830	8	Y
	CARBONDALE	311749	5	Y
	MENAHGA	280851	4	
94C	RUBICON	88176	7	Y
	EMMET	69950	5	Y
	DETOUR	67219	5	
	WATER	56729	4	
	GRAYCALM	52840	4	
	ROSCOMMON	52165	4	Y
94D	SAYNER	209009	16	
	PADUS	149499	11	
95A	KEWAUNEE	615452	15	Y
	ONAWAY	297211	7	Y
	MANAWA	233815	6	Y

NSSH Revision

Click here to view draft NSSH 630: proposed 630 Benchmarksoils_2002-4.doc

1. 630.00 Definition and Purpose
2. 630.01 Policy and Responsibilities
3. 630.02 Criteria for Selecting Benchmark Soils
4. 630.03 Evaluating and Revising the Status of Benchmark Soils
5. 630.04 Maintaining a Record of Benchmark Soil Data Needs
6. Exhibit 630-1 Sample Narrative Record for Benchmark Soils

Parts 630.00 Definition and Purpose, 630.02 Criteria for Selecting Benchmark Soils, and 630.03 Evaluating and Revising the Status of Benchmark Soils have already been addressed in this paper. The remaining sections follow.
****

1. 630.01 Policy and Responsibilities

   MO Leaders

   – exchanging information on benchmark soils with state offices,
   – maintaining the benchmark status of soil series in the soil classification database,
   – maintaining a narrative record for benchmark soils that are on the MLRA list,
   – coordinating benchmark soils with the state soil scientists in states that share the major land resource area, and
   – focusing long-range plans for soil survey investigations on benchmark soils and their characteristics.

State Soil Scientists

- proposing changes and additions to the benchmark soils list,
- ensuring interdisciplinary input in the selection of benchmark soils,
- ensuring input from cooperators in the selection of benchmark soils, and
- encouraging the use of benchmark soils in organizing and planning the research by state agricultural experiment stations and other agencies.

The National Soil Survey Center

- providing guidance in the selection of benchmark soils,
- assuring that internet access and query routines for benchmark soils are available to researchers in experiment stations, highway departments, and other organizations that conduct research on soils,
- performing laboratory characterization, and
- maintaining the laboratory database.

The National Geospatial Development Center

- Develop web-based geospatial analysis tools for use in analyzing and revising benchmark soils by MLRA,
- Develop web-based map products useful for marketing purposes.

2. 630.04 Maintaining a Record of Benchmark Soil Data Needs

Each MLRA Regional Soil Survey Office Leader, in consultation with the State Soil Scientists and research institutions:

Maintains a narrative record of the disposition of each benchmark soil in regard to kinds of data and information that are useful in predicting the soil behavior relative to the MLRA. The record helps to facilitate long range planning, and is useful for discussing ventures with research institutions. Discuss the kinds of special studies and soil properties needed. Include literature references of research studies on the benchmark soil. Refer to Exhibit 630-1 for an example of a narrative record.

3. Exhibit 630-1 Sample Narrative Record for Benchmark Soils

BETA SERIES – a member of the fine-loamy, mixed, superactive, frigid Typic Argiustolls family. It dominantly occurs in the Rolling Soft Shale Plains, Major Land Resource Area (MLRA) 54, but it also extends into the Southern Dark Brown Glaciated Plains, MLRA 53C. The Beta series is about 105,000 acres in extent.

Beta soils are 40 to 60 inches deep to soft bedrock and formed in material weathered from sandstone, siltstone, and shale.

Information needs: In MLRA 54, knowledge of the properties, qualities, and behavior of the Beta soils is useful in understanding (1) the effect of cropping systems and management practices on dynamic soil property change, (2) the penetration of roots and the movement of water into the soft bedrock, (3) pesticide and nutrient fate and transport for surface water and groundwater assessment, (4) the use of soils with soft bedrock for septic tank absorption fields, (5) the Silty range site, (6) and the use of soils with soft bedrock for building sites. The Beta soils are underlain by strippable coal, and the knowledge of soil properties, qualities, and behavior is important for the development of effective soil reclamation measures.

Data needs: The following dynamic properties and morphological attributes are needed across the common crop management systems: saturated hydraulic conductivity, soil bulk density, organic carbon, surface roughness, consistence, structure, and macropore characteristics

(geometry, frequency, distribution, and continuity). It is intended to integrate the macopore characteristic with structure, particle-size distribution, and mineralogy in order to develop a pedotransfer function that predicts saturated hydraulic conductivity.

Laboratory data:

NRCS NSSC Soil Characterization Database:

User Pedon ID
82STATEFIPS031005
84STATEFIPS021002
87STATEFIPS005001
91STATEFIPS007007
97STATEFIPS013011

ANYSTATE University pedon data
(List sources and contacts where information can be acquired)