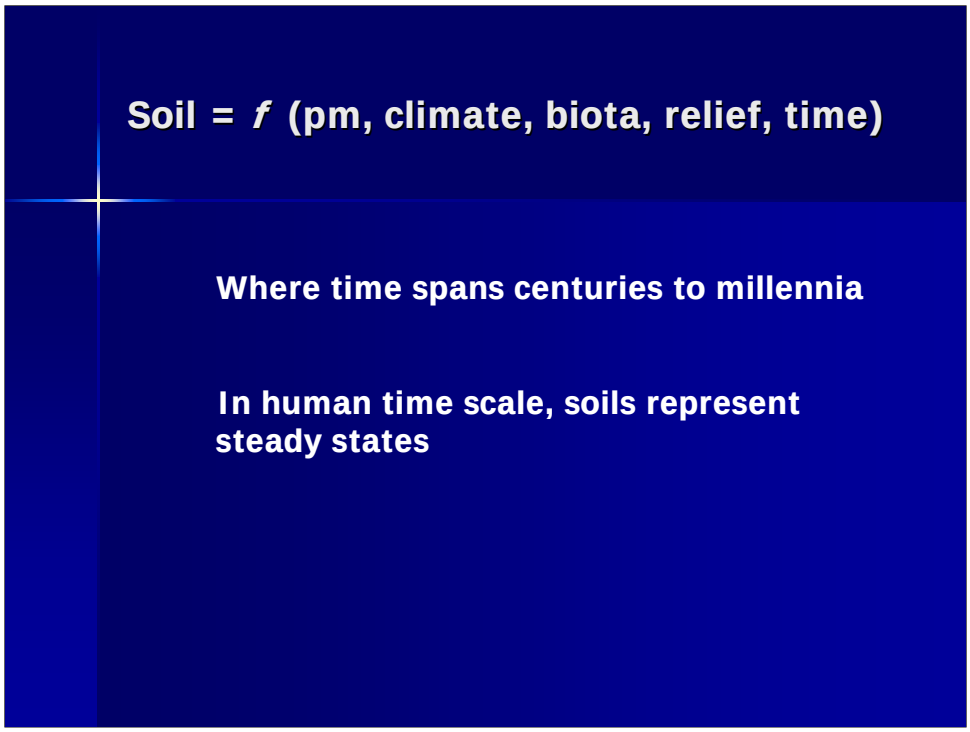
Please note that since submission of my Abstract, I have changed the title to "A Proposal to Differentiate Pedogenic and Anthropogenic Processes in Soil Taxonomy" in order to emphasize processes rather than properties. *Soil Taxonomy* has been the official classification system for the USDA National Cooperative Soil Survey Program now for 41 years. During that time span, some significant changes such as the addition of Gelisols and Andisols have occurred; but most revision to *Soil Taxonomy* has involved adjusting boundary criteria of taxa to improve the accommodation of soil units. The basic structural framework of *Soil Taxonomy* has, however, remained unchanged.

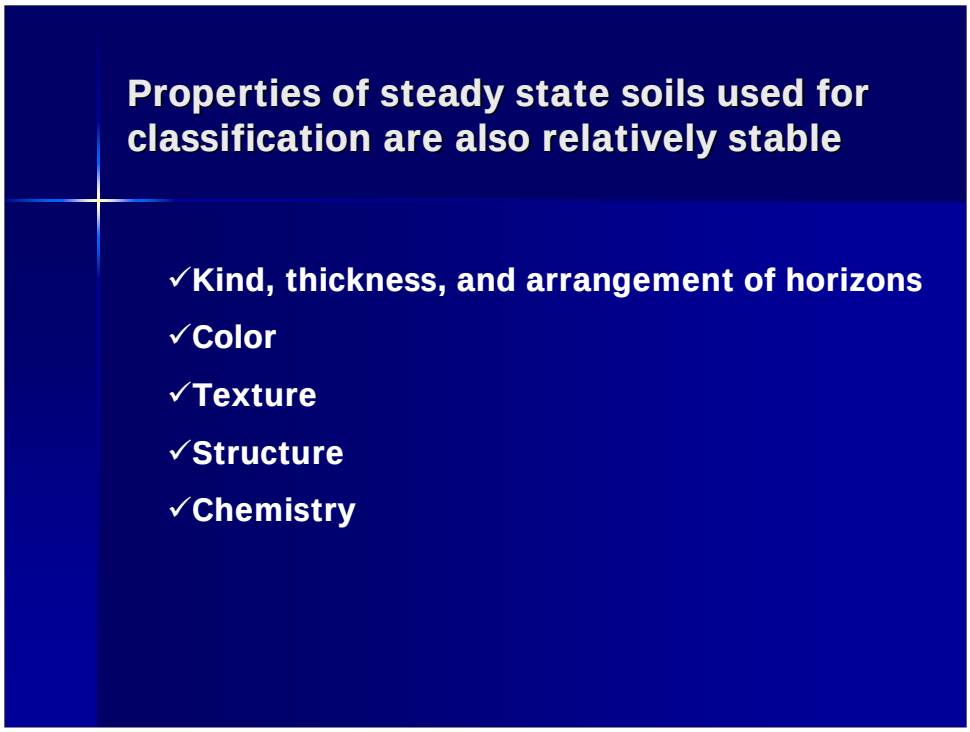
OBJECTIVE:

To propose a new categorical level below the series to accommodate soils that has been significantly altered by soil management.

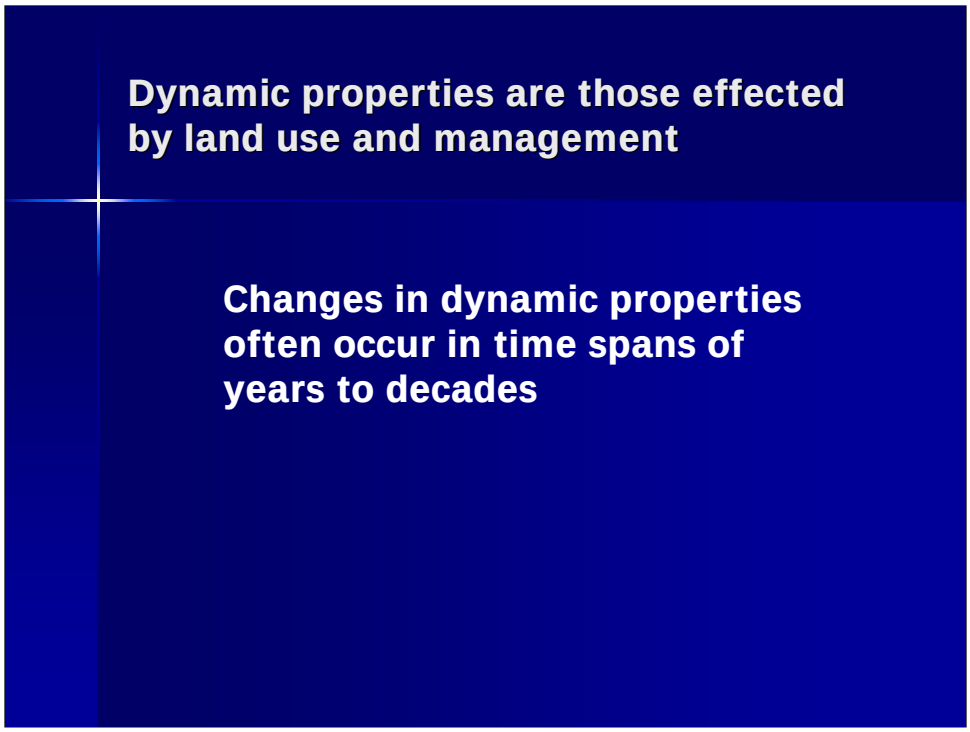
Today, my objective is to propose a new categorical level below the series to address and accommodate soils that have been significantly altered by soil management. Before proceeding with my proposal, I will set the stage by discussing soil change and two of the basic tenets employed by architects of *Soil Taxonomy*.



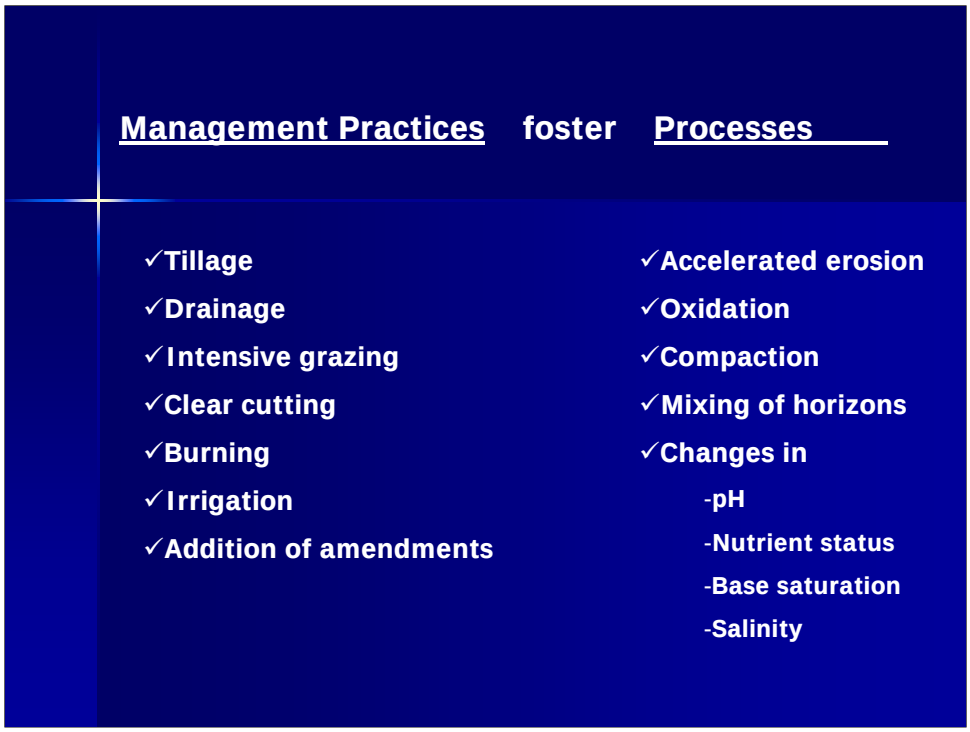
Pedologists generally agree that soils are a product of soil forming processes driven by energy inputs provided by the soil forming factors- parent material, climate, biota, relief, and time and that soil evolution occurs over pedogenic time spans of centuries to millennia. Major taxa in Soil Taxonomy have been created for mature soils which can be considered "steady state" or "static" entities because they attain quasi-equilibrium with their unique environments relative to human time scales.



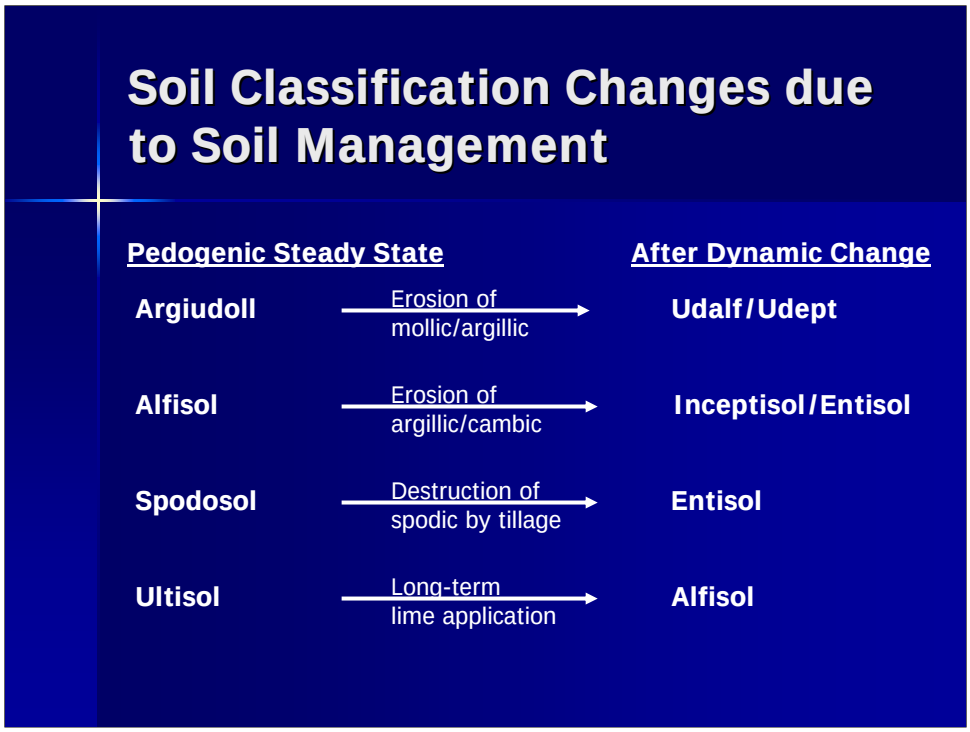
Most properties of steady state soils such as those shown here, which are used for classification purposes, are also generally stable with time. That is extremely important so that we do not need to continually reclassify soils as a result of pedogenic evolution.



Unfortunately some soil properties can be affected by land use and management wherein changes in soil properties are incurred in time spans of years or decades. Our colleagues focusing on soil quality and sustainability have adopted the term “dynamic” to refer to such soil properties. In this presentation, I will use steady state to refer to soils and properties generated by pedogenic processes and dynamic to refer to properties that are a result of human activity.



Management practices that can significantly alter dynamic soil properties include but are not limited to: tillage, drainage, intensive grazing, clear cutting of vegetation, burning, irrigation, and the addition of amendments. Processes that are fostered by these practices and result in changes in soil properties include: accelerated erosion, oxidation, compaction, mixing of horizons, and changes in pH, nutrient status, base saturation, and salinity.



Although most changes in dynamic properties, such as OM oxidation, may not effect taxonomic classification of soils, some, most notably accelerated erosion, can and often does have such consequences, at levels as high as the Order as shown in this slide. The first example refers to the well known "eroded Mollisol problem" wherein Mollic epipedons are removed by erosion; but the effect of accelerated erosion is not limited to surface horizons. Both argillic and cambic horizons can be affected or removed by erosion in many highly erosive landscapes. In Maine, tillage for potato production has destroyed spodic horizons in cultivated fields. And finally, applications of lime to intensively cultivated Ultisols over many years may eventually raise base saturation sufficiently at the critical depth in the solum to change Ultisols to Alfisols. I will have more to say about this later.

Basic Attributes of *Soil Taxonomy* (1999, p. 16)

4th - "differentiae are soil properties"

6th - "differentiae keep an undisturbed soil and its cultivated or otherwise human-modified equivalents in same taxon insofar as possible"

Now I will review and discuss two of the eight basic classification attributes listed in Soil Taxonomy (1999, p. 16):

4th -"differentiae are soil properties"

6th- "differentiae keep an undisturbed soil and its cultivated or otherwise human- modified equivalents in same taxon insofar as possible"

Genetic Thread in *Soil Taxonomy*

Diagnostic Horizon or Feature	Order
Mollic epipedon	Mollisols
Argillic horizon	Alfisols
Spodic horizon	Spodosols
Argillic / Kandic horizon	Ultisols
Oxic horizon	Oxisols
Slickensides	Vertisols
Cambic horizon	Inceptisols
Gelic materials	Gelisols
Andic materials	Andisols

In regard to classification attribute 4: The use of soil properties to classify soils is employed to simplify the process and eliminate inference and subjectivity in making decisions. Technicians acquainted with soil properties can classify soils into proper taxa without any knowledge of specific processes responsible for the formation of the soils. The "genetic thread" in Soil Taxonomy is incorporated by careful selection of soil properties for diagnostic horizons or features that are indicative of specific pedogenic processes, as shown in this slide: Mollic epipedon for Mollisols, argillic horizon for Alfisols, spodic horizon for Spodosols, and so on. Now I will move on to the sixth classification attribute of Soil Taxonomy, but before I do, I want to point out that classification of soils in at least five of the nine orders shown here - Mollisols, Alfisols, Inceptisols, Spodosols, and Ultisols can be impacted by soil management as mentioned previously.

Differentiae keep undisturbed soils and human-modified equivalents in same taxon

Solution: "use subsurface horizons for definitions of higher categories" (Smith, 1986, p. 17)

Except for Mollisols: "the use of the Mollic epipedon to group the grassland soils of the Great Plains was unavoidable with the knowledge that we had of those soils at the time we developed *Soil Taxonomy"* (Smith, 1986, p. 197)

In regard to attribute number 6, the most obvious human-induced process when Soil Taxonomy was being developed, was accelerated erosion; thus Smith concluded that in order to keep undisturbed soils and human-modified equivalents in same taxon, it was necessary to "use subsurface horizons for definitions of the higher categories." This approach was employed for all orders except Mollisols. Smith acknowledged this problem by indicating that "the use of the Mollic epipedon to group the grassland soil of the Great Plains was unavoidable with the knowledge (they had) of those soils at the time Soil Taxonomy (was developed)."

Possible solution for eroded Mollisols (Smith, 1986, p. 197):

"In classifying these soils as Mollisols, when the Mollic epipedon has been removed in places, perhaps most places even, it might be possible to write definitions such that when applied to a polypedon, the presence of these less eroded areas would be considered justification for putting the soil in the Mollisol Order."

Points to note:

1) Smith recognized need to keep eroded soils in same Order as uneroded soils

2) Smith suggested selection of unmodified pedons for classification of polypedon

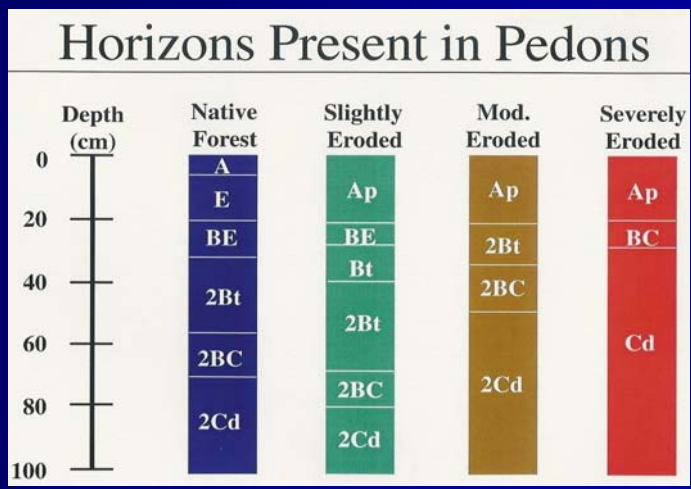
In *The Guy Smith Interviews*, Smith proposed a possible solution for eroded Mollisols: "In classifying these soils as Mollisols, when the mollic epipedon has been removed in places, perhaps most places even, it might be possible to write definitions such that when applied to a polypedon, the presence of these less eroded areas would be considered justification for putting the soil in the Mollisol Order." I want to stress two points that can be gleaned from this statement. 1) Smith recognized need to keep eroded soils in the same Order as uneroded soils and 2) Smith suggested selection of unmodified pedons for classification of polypedon rather than a representative pedon. However as I have indicated several times thus far, this is not just a problem with eroded Mollisols.

Essential information:

- Soil surveys should not ignore nor obscure the influence of soil management on soil properties that affect soil function, quality, or sustainability
- Classification of steady state soils and human modified soils in a given landscape should aid elucidation of human impact responsible for differences in such soils

I believe that it is essential that National Cooperative Soil Survey Program deliver the following information: 1) soil surveys should not ignore nor obscure the influence of soil management on soil properties that affect soil function, quality, or sustainability; and 2) the classification of steady state soils and human-modified soils in a given landscape should aid in elucidation of the human impact responsible for the difference in those soils. The current practice of placing human modified soils in different taxa than associated steady state soils does nothing to elucidate processes responsible for soil characteristics, as it confounds pedogenic and anthropogenic processes.

Pedons in 5 ha Landscape in Ohio



In order to illustrate this point, I will discuss four pedons examined in a 5 ha landscape in Ohio. The pedons included a slightly eroded pedon in a native forest, and slightly, moderately, and severely eroded pedons in a cultivated field adjoining the woodlot. Slopes ranged from 1 to 4% at the pedon sites, respectively. In the slightly eroded cultivated pedon, the A and E horizons were mixed by tillage to form an Ap horizon, the moderately eroded pedon has loss most of the eluvial horizons due to accelerated erosion, whereas erosion of the severely eroded pedon has removed the eluvial and Bt horizons except for the material presently comprising the Ap horizon. Note the progressively decreasing depth to the Cd horizons due to erosion of overlying horizons on moving from left to right across the slide.

Classification of Eroded Phases in a Landscape

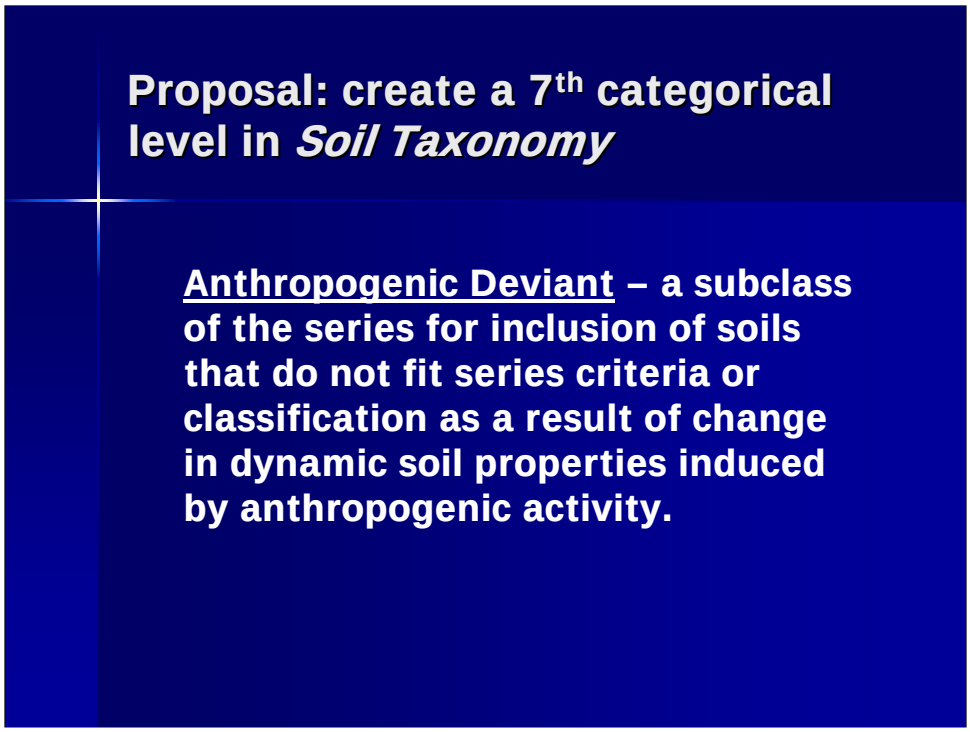
Pedon	Family Classification	Series
Forest	Fine-loamy, mixed, active, mesic Oxyaquic Hapludalf	Miami
Slightly eroded	Fine-loamy, mixed, active, mesic Oxyaquic Hapludalf	Miami
Moderately eroded	Loamy, mixed, active, mesic, shallow Oxyaquic Hapludalf	Wapahani
Severely eroded	Loamy, mixed, superactive, mesic, shallow Oxyaquic Hapludalf	Thrifton

Although the pedons have different properties and characteristics, all four classify into closely related families in Soil Taxonomy. At the series level, the forest and slightly eroded pedon classify into the Miami series, whereas the moderately and severely eroded pedons classify into the Wapahani and Thrifton series, respectively. Although the Wapahani series is just a shallow Miami series, the Thrifton series was established specifically to provide a series that is suitable for classification of severely eroded Miami soils. Prior to cultivation and ensuing accelerated erosion in the more sloping portions of this landscape, the formation of all four pedons was guided by the same set of state factors and pedogenic processes. Now properties of the forest pedon and slightly eroded cultivated pedon are primarily a reflection of pedogenic processes, leaching of carbonates and clay translocation into the argillic horizon. Although the moderately and severely eroded pedons retain some evidence of these same pedogenic processes, current properties are primarily a reflection of truncation by erosion and mixing by tillage. Unfortunately, the classification of the pedons into different series obscures the degradation of moderately and severely eroded pedons by accelerated erosion.

Important Points:

- ✓Human activity can affect the classification of pedogenically similar soils at any categorical level
- ✓*Soil* Taxonomy should differentiate between soils that are primarily pedogenic and those significantly altered by anthropogenic processes

The points I hope I have made is that human activity can effect the classification of pedogenetically similar soils at any categorical level, at the order level as discussed earlier as well as at the family and series levels just shown. To foster a proper understanding of our world soil resources, *Soil Taxonomy* should provide a mechanism to differentiate soils that are primarily a result of pedogenic processes and soils significantly altered by anthropogenic processes. The phase concept cannot be used for this purpose because representative pedons for a phase must reside within the range of criteria for a Series.



My proposal is to create a seventh categorical level in Soil Taxonomy below the series which I recommend be designated as an Anthropogenic Deviant. The Anthropogenic Deviant is intended to be a subclass of the series for inclusion of soils that do not fit series criteria or classification as a result of change in dynamic soil properties induced by anthropogenic activity. Because the structure in Soil Taxonomy presently requires that taxa at any categorical level must fit criteria for taxa at all superjacent levels, a fundamental change in the structure of *Soil Taxonomy* at the lowest level will be required to accommodate my proposal.

The terminology recommended for this new categorical level implies: deviation from an accepted norm as a result of human impact on nature. Thus Anthropogenic Deviant indicates a deviation from the series concept of a soil due to human impact.

Potential Anthropogenic Deviants

Series	Anthropogenic Deviant	Subgroup
Tama		Typic Argiudoll
	Tama Severely Eroded	Mollic Hapludalf
Miami		Oxyaquic Hapludalf
	Miami Severely Eroded	Typic Udorthent
Caribou		Typic Haplorthod
	Caribou Tilled/Eroded	Typic Udorthent
Cecil		Typic Kanhapludult
	Cecil Limed	Typic Kanhapludalf

This table provides four examples of potential Anthropogenic Deviants using four widely known soil series (Tama, Miami, Caribou, and Cecil) representing four Orders- Mollisols, Alfisols, Spodosols, and Ultisols. The use of Tama Severely Eroded anthropogenic deviant would clearly indicate why classification of this soil as a Mollic Hapludalf deviates from classification of Typic Argiudoll for the Tama Series, but use of the series in the name clearly links the anthropogenic deviant to Mollisols. This seems to be a viable solution to the "eroded Mollisol problem" that has been debated for more than a decade. The Miami Severely Eroded anthropogenic deviant could potentially be used for Miami soils on steep slopes where accelerated erosion has removed essentially all traces of the argillic horizon. The Caribou Tilled/Eroded anthropogenic deviant could potentially be used for Caribou soils in Maine where tillage for potato production has destroyed the Spodic horizon. The Cecil Limed anthropogenic deviant could potentially be used where lime applications in intensively cultivated areas have been applied for such a long period of time that base saturation at the critical depth exceeds 35%. Although base saturations greater than 35% in extensive areas of Ultisols have not been documented to date, data suggests that values in many cultivated Ultisols are approaching that threshold. I am sure that many other possibilities, in addition to those listed in this table, exist for the use of Anthropogenic Deviants.

Incorporation of Anthropogenic Deviants

- New heading following Range of Characteristics in official series description
- Each Anthropogenic Deviant would include:
  - ✓Anthropogenic activity responsible
  - ✓How properties differ from those of the series
  - ✓Classification at family level

The next question is how or where Anthropogenic Deviants should be incorporated into Soil Taxonomy. I suggest that Anthropogenic Deviants be incorporated into the Official Series Description following the Range in Characteristics. Each Anthropogenic Deviant created would be supported by information on the anthropogenic activity responsible for the change in dynamic properties, how properties differ from those of the Series, and classification at the family level.

How to Establish Linkage between Series and associated Anthropogenic Deviants?

- Examine soil properties in landscape components that extend across boundaries between managed and native areas
- Extend information from such studies to areas where such opportunities do not exist

One of the difficulties in establishing Anthropogenic Deviants for a given Series will be substantiating that anthropogenic deviants were similar to the series concept prior to human- induced modification. This is the same problem soil scientists must confront when mapping erosion phases. It requires soil scientists to study landscape and ecosystem relationships as well as to collect pedon data. Polypedons often occupy landscape components that extend across boundaries between managed and native areas. Pedons must be examined and compared in such landscapes to document changes in soil properties due to management. Furthermore information gained where such studies are possible must be extended to similar areas where opportunities for such studies do not exist. If soil properties are impacted by management to the extent that classification of managed areas differs from native areas, anthropogenic deviants should be used for the human-modified areas.

Proposed revision will:

1) Identify pedogenic relationships between Series and associated Anthropogenic Deviants
2) Provide information regarding human impact on soil properties by comparison of Series and associated Anthropogenic Deviants
3) Facilitate evaluation of dynamic change in soil quality induced by human activity

In conclusion, the proposed revision of Soil Taxonomy will: 1) identify pedogenic relationships between soils at the Series and associated Anthropogenic Deviant levels, 2) provide information regarding human impact on soil properties by comparison of Series and associated Anthropogenic Deviants, and 3) facilitate evaluations of dynamic changes in soil quality induced by human activity.