Soil Classification

Information on soils must be organized to be:

1. Understandable
2. Useable

Soils are organized into groups with similar:

1. Observed Properties (field or lab)

   NATURAL CLASSIFICATION SYSTEM – Soil Taxonomy

2. Inferred Properties (determined to exist based on observed properties)

TECHNICAL CLASSIFICATION – potential yield classification

Natural Classification Systems

Phylogeny vs. Taxonomy

Genetypic vs. Phenotype

- Genotype or Phylogenetic- The use of relatively “conserved” biological molecules to quantify evolutionary relationships and timelines
- Phenotype or Taxonomic – The use of structural and functional abilities to qualify evolutionary relationships and timelines

SOIL TAXONOMY –
USDA Natural Classification System

Defines "Soil Individuals" by the properties of the pedon in the field

– number, kind, arrangements of horizons, color, texture, structure, pH, etc…

Soil Taxonomy

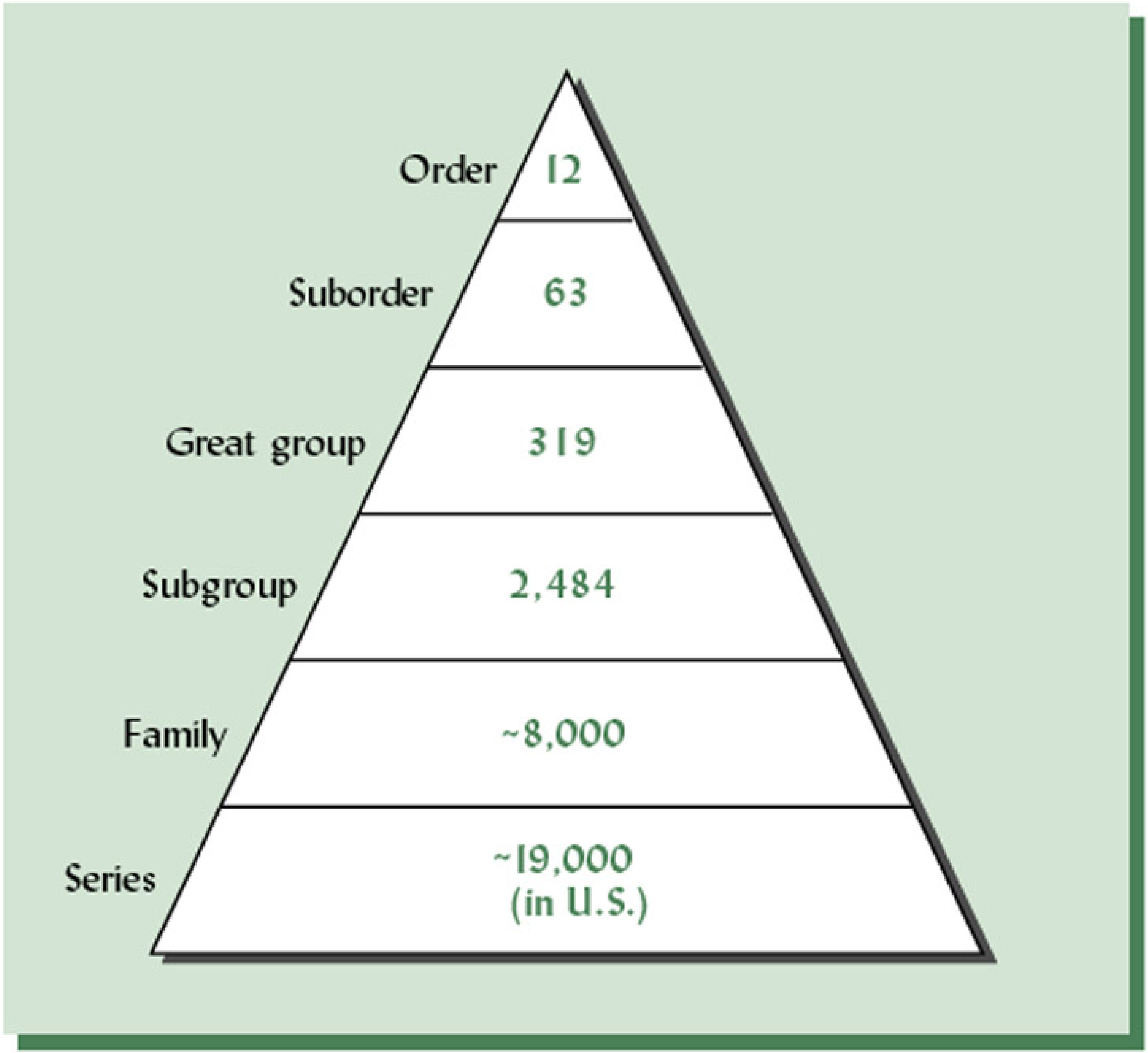
All soils in the world fit within one of 12 Orders

	biological classification
Order	- Phylum
Suborder	- Class
Great Group	- Subclass
Subgroup	- Order
Family	- Family
Series	- Genus
Phase	- Species

Soil Series is the most detailed category in Soil Taxonomy

There are presently over 19 000 recognize series in the US…

Soil Phase is the most detailed category in Soil Survey


Order
12
Suborder
63
Great group
319
Subgroup
2,484
Family
~8,000
Series
~19,000
(in U.S.)

Five Soil Forming Factors

Soil Genesis = f(pm, climate, biota, relief and time)

Four Soil Forming Processes

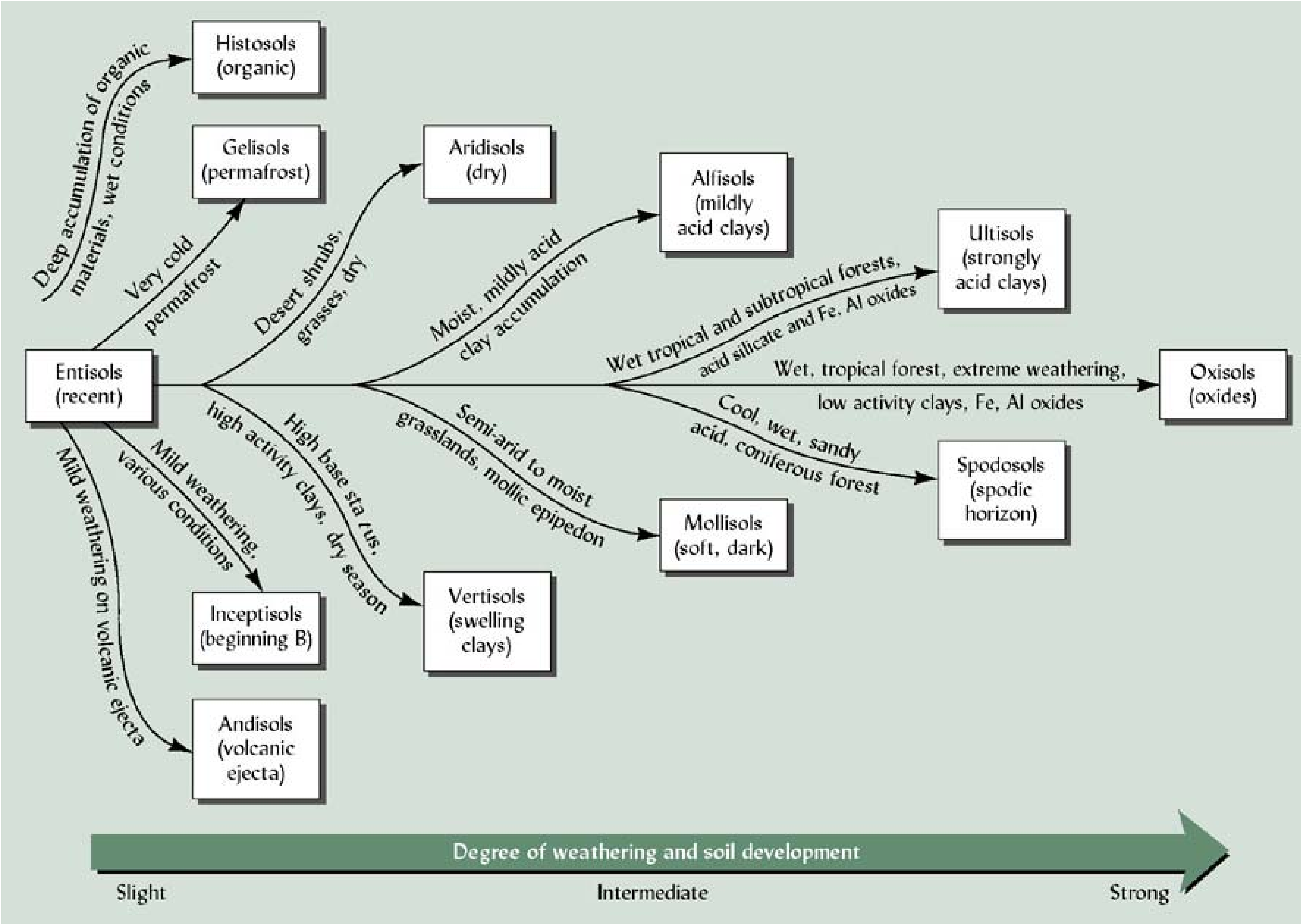
Additions

Losses

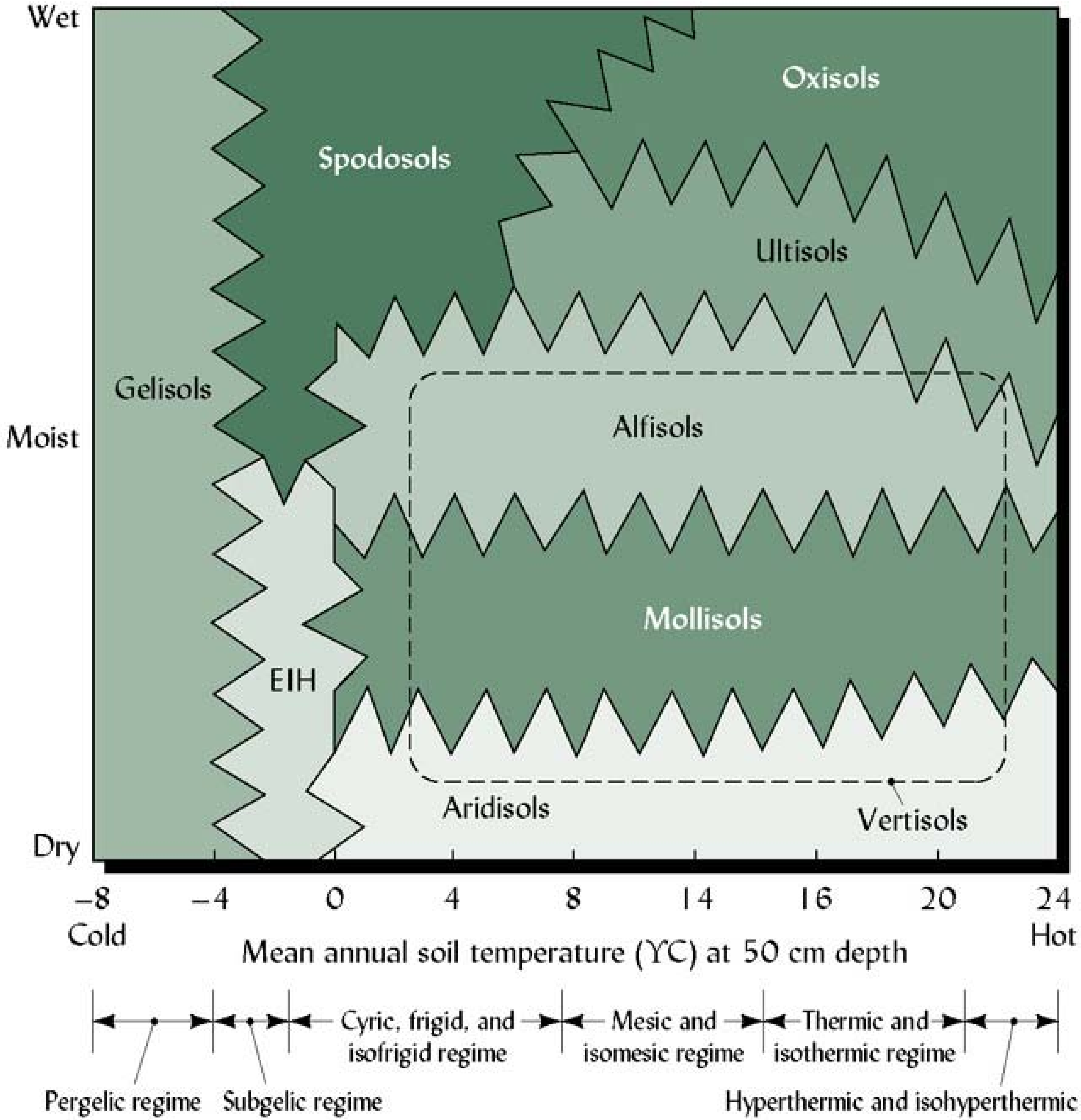
Transformations

Translocations

Name	*Formative element*	*Derivation*	*Pronunciation*	*Major characteristics*
Alfisols	alf	Nonsense symbol	Ped*alf*er	Argillic, natric, or kandic horizon; high to medium base saturation
Andisols	and	Jap. *ando,* blacksoil	*And*esite	From volcanic ejecta, dominated by allophane or Al-humic complexes
Aridisols	id	L. *aridus,* dry	A*rid*	Dry soil, ochric epipedon, sometimes argillic or natric horizon
Entisols	ent	Nonsense symbol	Rec*ent*	Little profile development, ochric epipedon common
Gelisols	el	Gk. *gelid,* very cold	*Jel*ly	Permafrost, often with cryoturbation (frost churning)
Histosols	ist	Gk. *histos,* tissue	*Hist*ology	Peat or bog; >20% organic matter
Inceptisols	ept	L. *inceptum,* beginning	Inc*ept*ion	Embryonic soils with few diagnostic features, ochric or umbric epipedon, cambic horizon
Mollisols	oll	L. *mollis,* soft	M*oll*ify	Mollic epipedon, high base saturation, dark soils, some with argillic or natric horizons
Oxisols	ox	Fr. *oxide,* oxide	O*x*ide	Oxic horizon, no argillic horizon, highly weathered
Spodosols	od	Gk. *spodos,* wood ash	*Pod*zol; odd	Spodic horizon commonly with Fe, Al oxides and humus accumulation
Ultisols	ult	L. *ultimus,* last	*Ult*imate	Argillic or kandic horizon, low base saturation
Vertisols	ert	L. *verto,* turn	In*vert*	High in swelling clays; deep cracks when soil dry



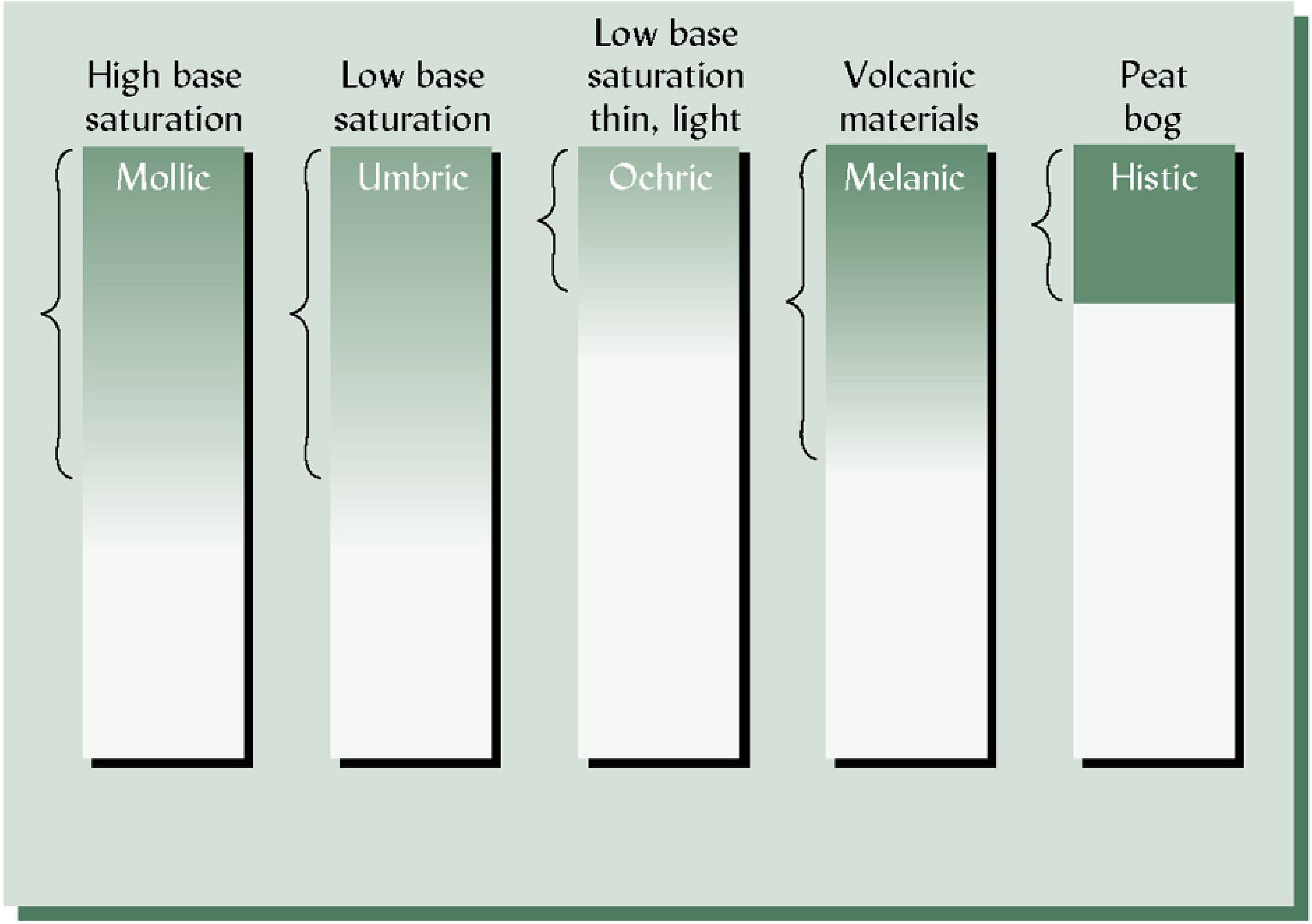
Histosols (organic)
Deep accumulation of organic materials, wet conditions
Gelisols (permafrost)
Very cold permafrost
Aridisols (dry)
Desert shrubs, grasses, dry
Alfisols (mildly acid clays)
Moist, mildly acid clay accumulation
Ultisols (strongly acid clays)
Wet tropical and subtropical forests, acid silicate and Fe, Al oxides
Entisols (recent)
Wet, tropical forest, extreme weathering, low activity clays, Fe, Al oxides
Oxisols (oxides)
Cool, wet, sandy acid, coniferous forest
Spodosols (spodic horizon)
Semi-arid to moist grasslands, mollic epipedon
Mollisols (soft, dark)
High base sta rus, high activity clays, dry season
Vertisols (swelling clays)
Mild weathering, various conditions
Inceptisols (beginning B)
Mild weathering on volcanic ejecta
Andisols (volcanic ejecta)
Degree of weathering and soil development
Slight
Intermediate
Strong



Wet
Moist
Dry
Oxisols
Spodosols
Ultisols
Gelisols
Alfisols
Mollisols
EIH
Aridisols
Vertisols
–8
–4
0
4
8
14
16
20
24
Cold
Hot
Mean annual soil temperature (YC) at 50 cm depth
Cyric, frigid, and isofrigid regime
Mesic and isomesic regime
Thermic and isothermic regime
Pergelic regime
Subgelic regime
Hyperthermic and isohyperthermic

Diagnostic Surface Horizons

- Called epipedons (epi=over, pedon=soil)
- May include part of the B horizon if significantly darkened by OM
- Anthropic- human modified, high in P
- Plaggen- human modified by years of manuring


High base saturation
Mollic
Low base saturation
Umbric
Low base saturation thin, light
Ochric
Volcanic materials
Melanic
Peat bog
Histic

Diagnostic Subsurface Horizon

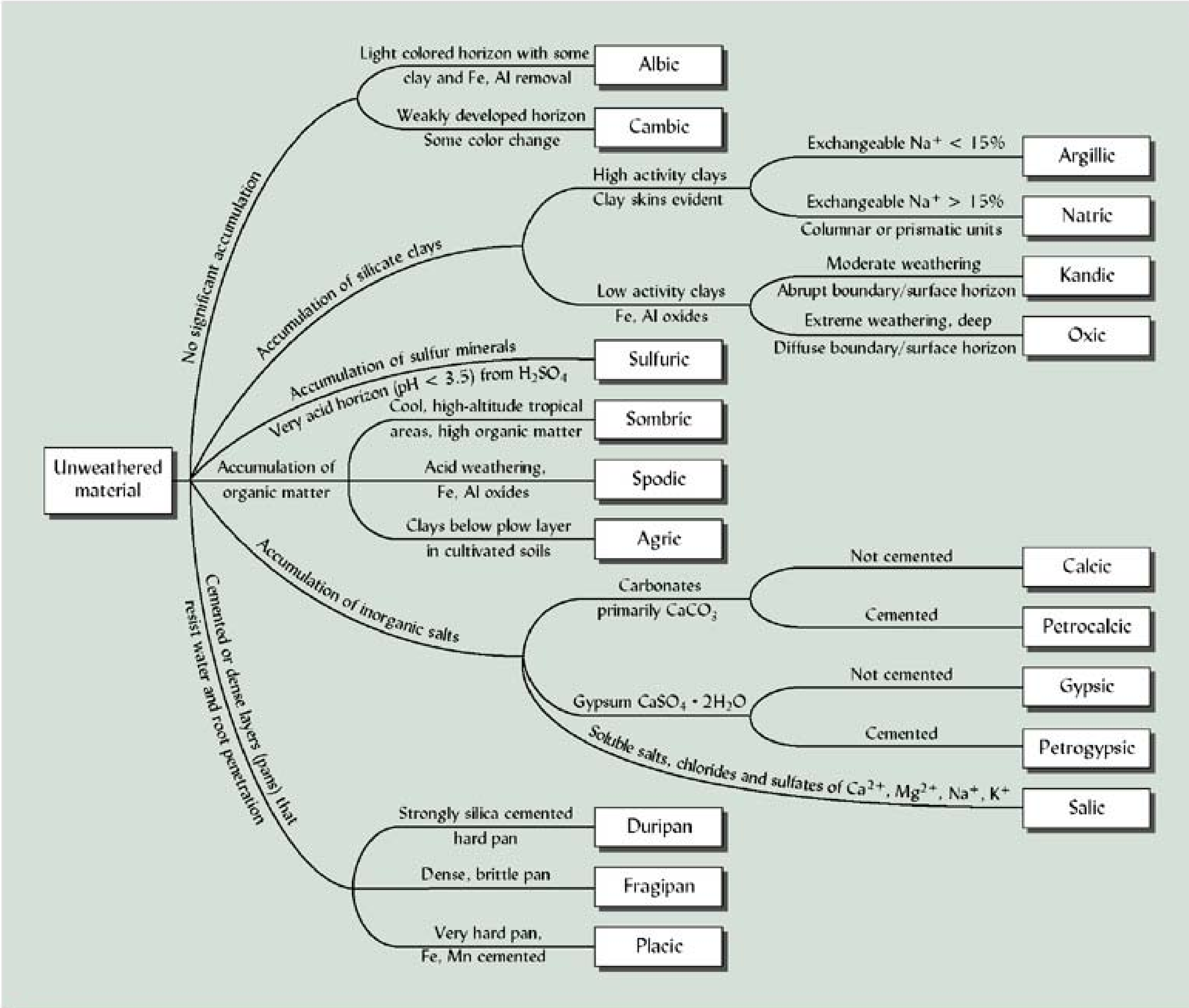
- Soils have oxic, kandic, spodic, argillic, natric and cambic horizons due to the amount of time they have been developing and the weathering environment

Soil Genesis

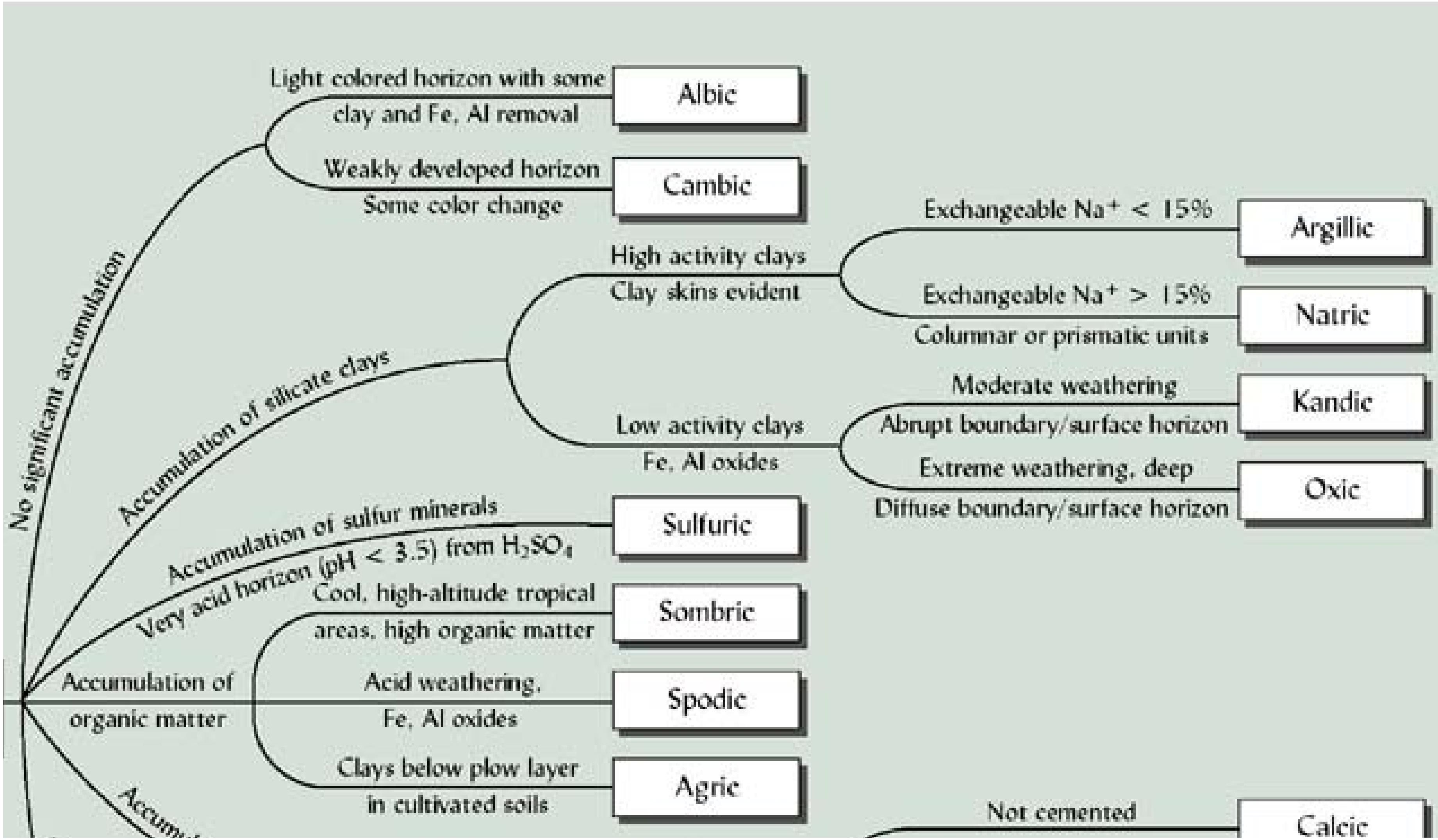
- Because these features represent differences in soil genesis, they are used to group soils of many different series into a few large groups

Soil Orders

- Oxic horizon -> Oxi**sol**
- Kandic or argillic horizon and little Na+, K+, Ca2+ or Mg2+ (exchangeable base) -> Ulti**sol**
- Spodic horizon -> Spodo**sol**
- Kandic or argillic or natric horizon -> Alfi**sol**
- Cambic horizon -> Incepti**sol**



Unweathered material
No significant accumulation
Light colored horizon with some clay and Fe, Al removal
Albic
Weakly developed horizon Some color change
Cambic
Accumulation of silicate clays
High activity clays Clay skins evident
Exchangeable Na+ < 15%
Argillic
Exchangeable Na+ > 15% Columnar or prismatic units
Natric
Low activity clays Fe, Al oxides
Moderate weathering Abrupt boundary/surface horizon
Kandic
Extreme weathering, deep Diffuse boundary/surface horizon
Oxic
Accumulation of sulfur minerals Very acid horizon (pH < 3.5) from H2SO4
Sulfuric
Accumulation of organic matter
Cool, high-altitude tropical areas, high organic matter
Sombric
Acid weathering, Fe, Al oxides
Spodic
Clays below plow layer in cultivated soils
Agric
Accumulation of inorganic salts
Carbonates primarily CaCO3
Not cemented
Calcic
Cemented
Petrocalcic
Gypsum CaSO4 · 2H2O
Not cemented
Gypsic
Cemented
Petrogypsic
Soluble salts, chlorides and sulfates of Ca2+, Mg2+, Na+, K+
Salic
Cemented or dense layers (pans) that resist water and root penetration
Strongly silica cemented hard pan
Duripan
Dense, brittle pan
Fragipan
Very hard pan, Fe, Mn cemented
Placic



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Light colored horizon with some clay and Fe, Al removal
Albic
Weakly developed horizon
Some color change
Cambic
Accumulation of silicate clays
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Clay skins evident
Exchangeable Na⁺ < 15%
Argillic
Exchangeable Na⁺ > 15%
Columnar or prismatic units
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Fe, Al oxides
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Clays below plow layer in cultivated soils
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Not cemented
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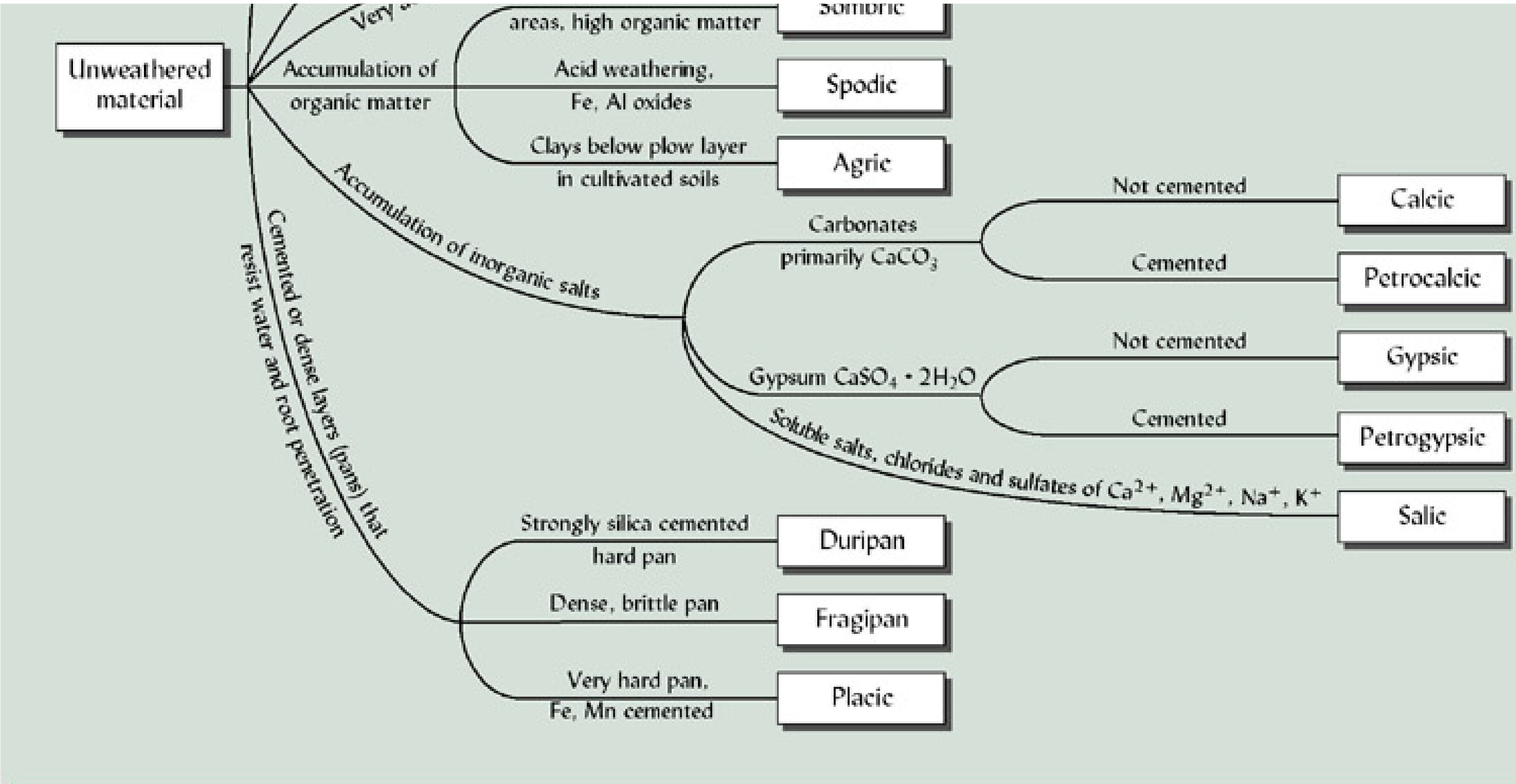
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Acid weathering, Fe, Al oxides
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Agric
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Carbonates primarily $CaCO_3$
Not cemented
Calcic
Cemented
Petrocalcic
Gypsum $CaSO_4 \cdot 2H_2O$
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Dense, brittle pan
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Very hard pan, Fe, Mn cemented
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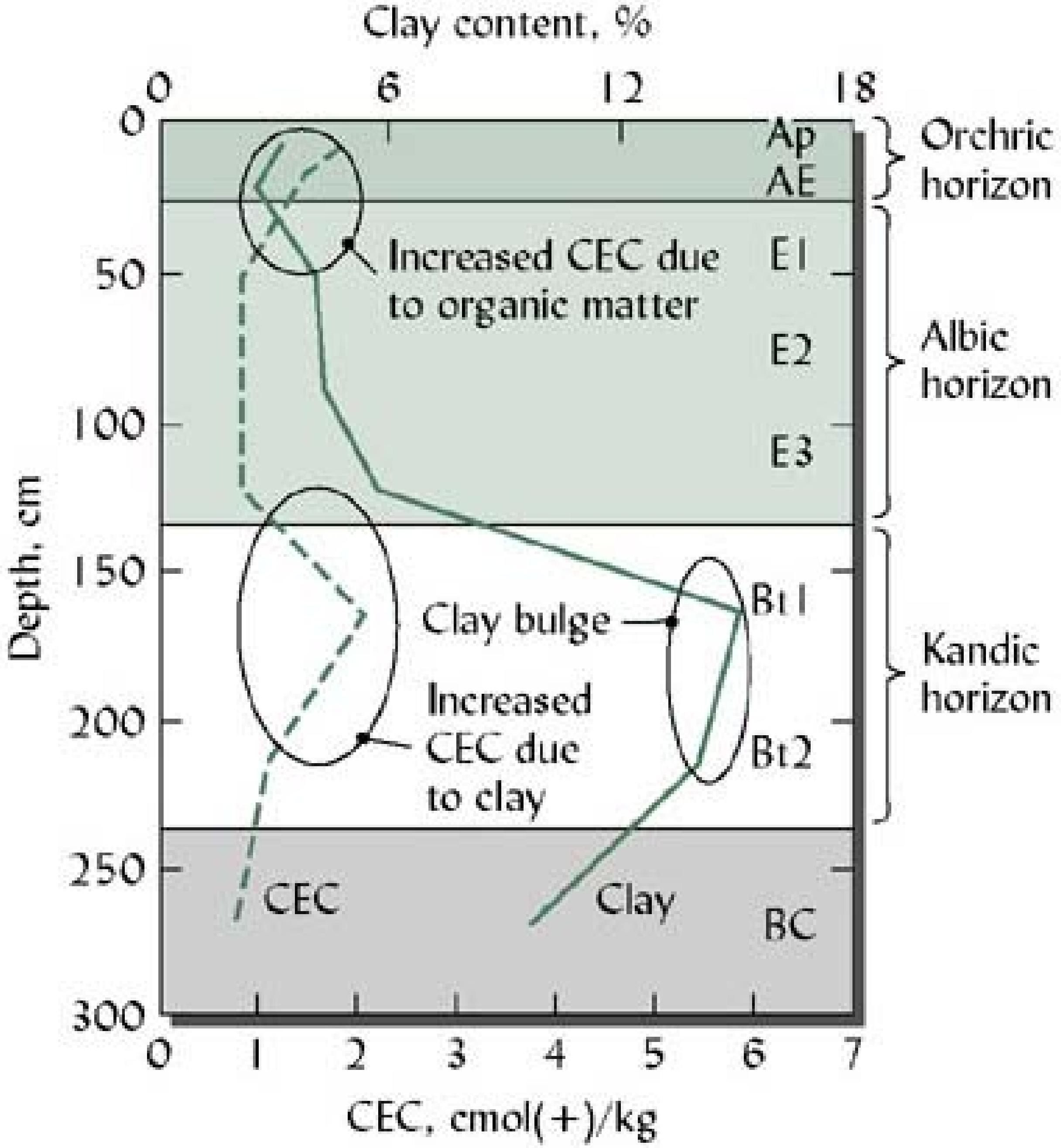
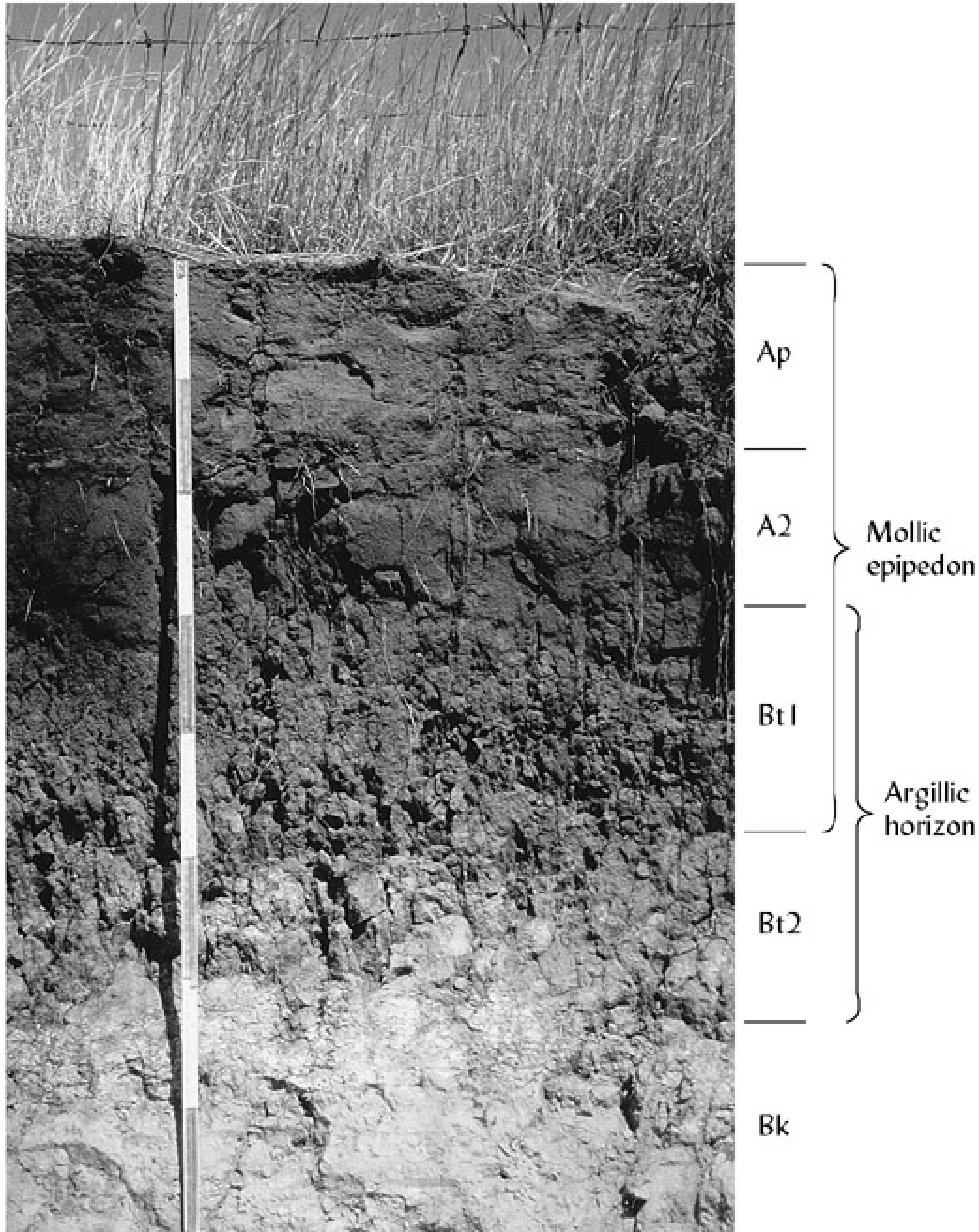
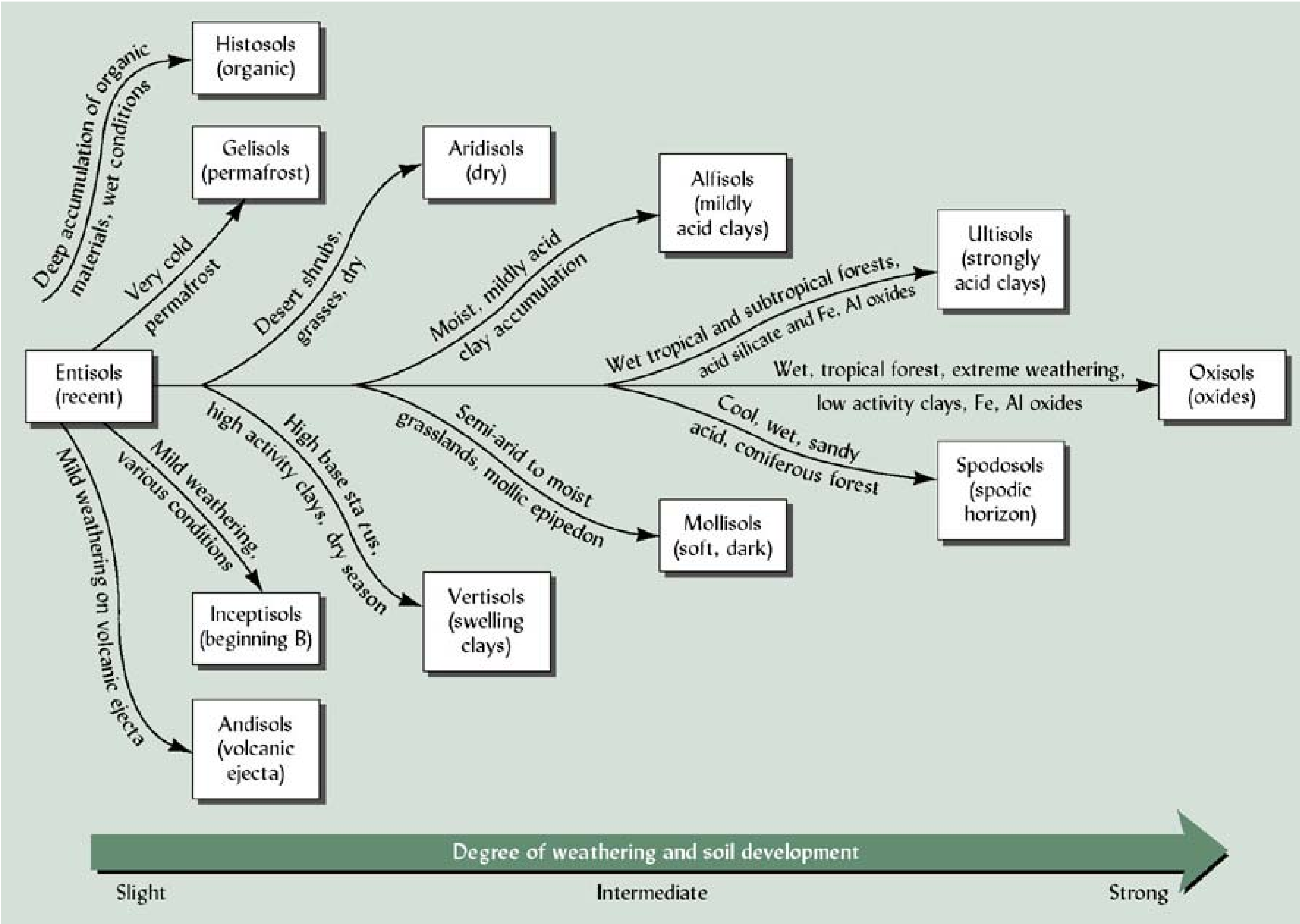
Figure 3.6



Clay content, %
0
6
12
18
Ap
AE
Orchric horizon
Increased CEC due to organic matter
E1
E2
E3
Albic horizon
Depth, cm
0
50
100
150
200
250
300
Clay bulge
Bt1
Bt2
Increased CEC due to clay
Kandic horizon
CEC
Clay
BC
0
1
2
3
4
5
6
7
CEC, cmol(+)/kg


Ap
A2
Mollic
epipedon
Bt1
Argillic
horizon
Bt2
Bk


Histosols (organic)
Gelisols (permafrost)
Aridisols (dry)
Alfisols (mildly acid clays)
Ultisols (strongly acid clays)
Entisols (recent)
Oxisols (oxides)
Spodosols (spodic horizon)
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Andisols (volcanic ejecta)
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Degree of weathering and soil development
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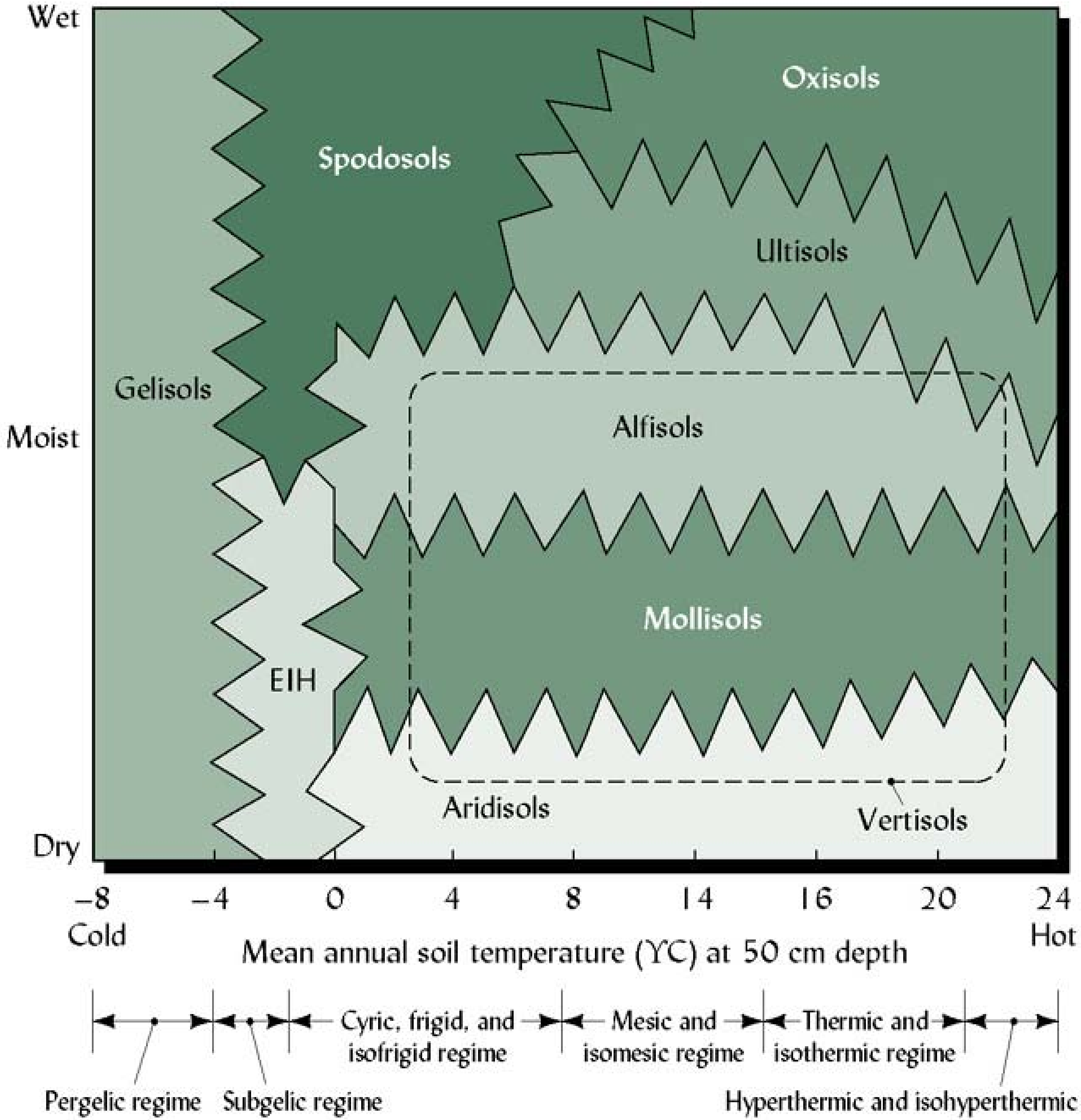
Strong



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24
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Pergelic regime
Subgelic regime
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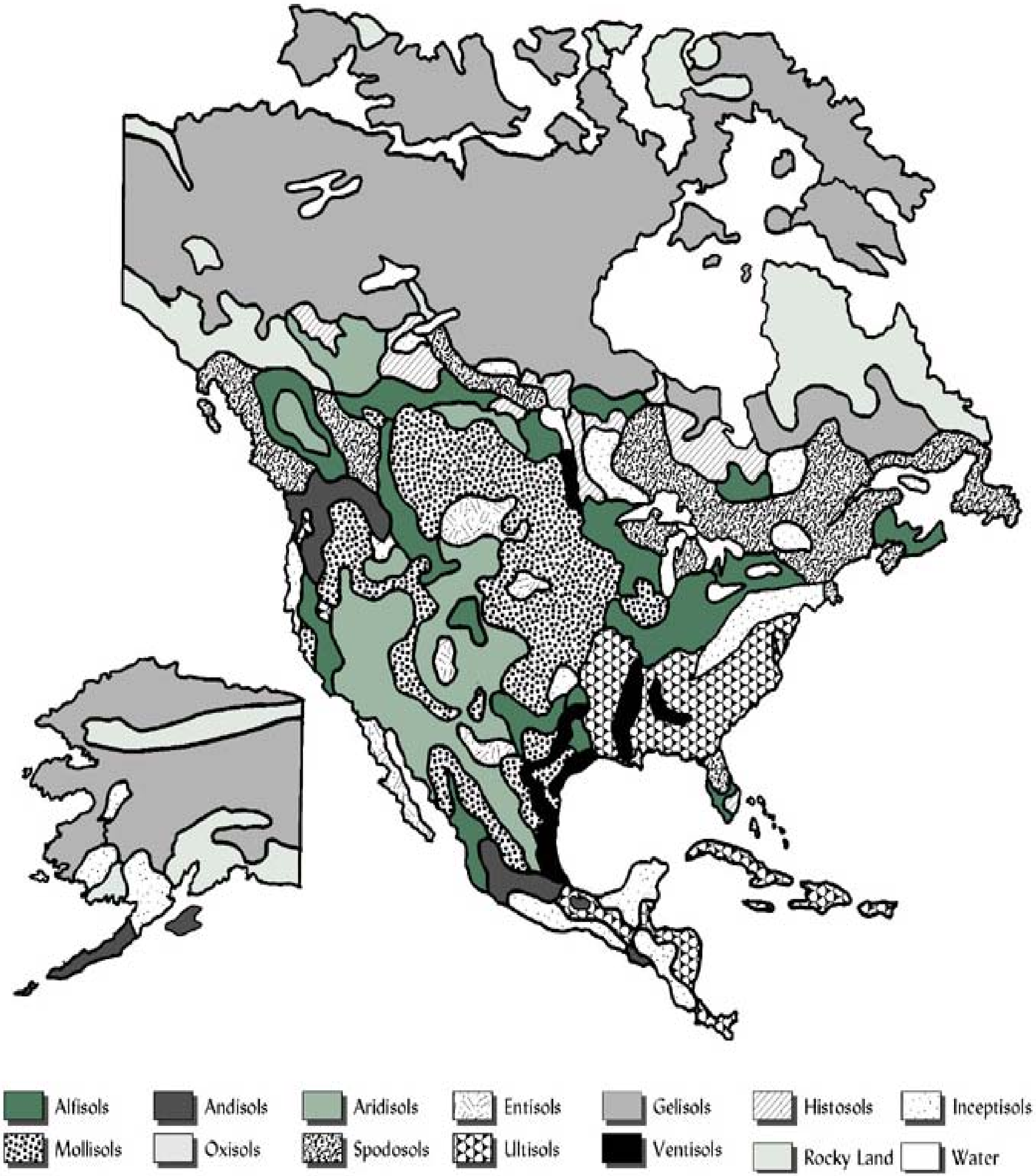

Alfisols
Andisols
Aridisols
Entisols
Gelisols
Histosols
Inceptisols
Mollisols
Oxisols
Spodosols
Ultisols
Ventisols
Rocky Land
Water

United States
Department of Agriculture

Natural Resources Conservation Service

Keys to Soil Taxonomy

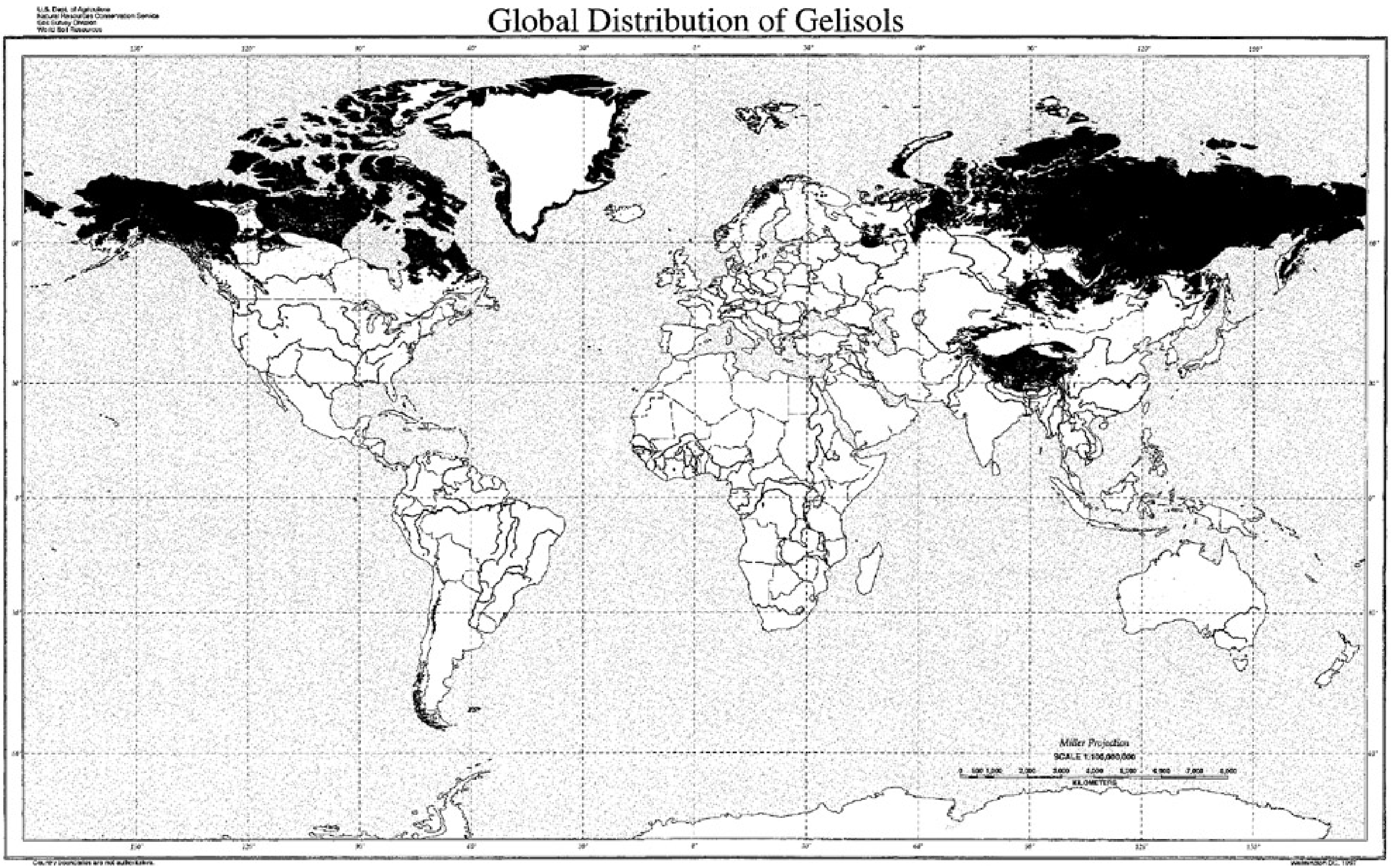
Ninth Edition, 2003

Major Diagnostic Features		Soil Order
Soils with permafrost within 100 cm or cryoturbation and permafrost within 200 cm	Yes →	Gelisols
No ↓ Soils with organic soil materials extending down to an impermeable layer or with an organic layer that is more than 40 cm thick and without andic properties	Yes →	Histosols
No ↓ Soils with a spodic horizon within 2 m of soil surface and without andic properties	Yes →	Spodosols
No ↓ Soils with andic properties (low density, glass, pumice, short-range order minerals)	Yes →	Andisols
No ↓ Soils with an oxic horizon within 150 cm of soil surface	Yes →	Oxisols
No ↓ Soils with 30% or more clay to a depth of 50 cm and shrinking/swelling properties	Yes →	Vertisols
No ↓ Soils with an aridic soil moisture regime and some B horizon development or a salic horizon	Yes →	Aridisols
No ↓ Soils with an argillic or kandic horizon or fragipan and a base saturation of <35% at 2 m depth or 75 cm below a fragipan	Yes →	Ultisols
No ↓ Soils with a mollic epipedon and a base saturation of >50% to an impermeable layer or at 1.8 m from soil surface	Yes →	Mollisols
No ↓ Soils with an argillic, kandic or natric horizon or a fragipan with clay skins	Yes →	Alfisols
No ↓ Soils with a cambic, sulfuric, calcic, gypsic, petrocalcic, or petrogypsic horizon, or with a mollic, umbric, or histic epipedon, or with an exchangeable sodium percentage (ESP) of >15%, or a fragipan	Yes →	Inceptisols
No ↓ Other soils	Yes →	Entisols

GELISOLS

Young Soils with little profile development

Form in the presence of Permafrost and frost churning



Key to Soil Orders

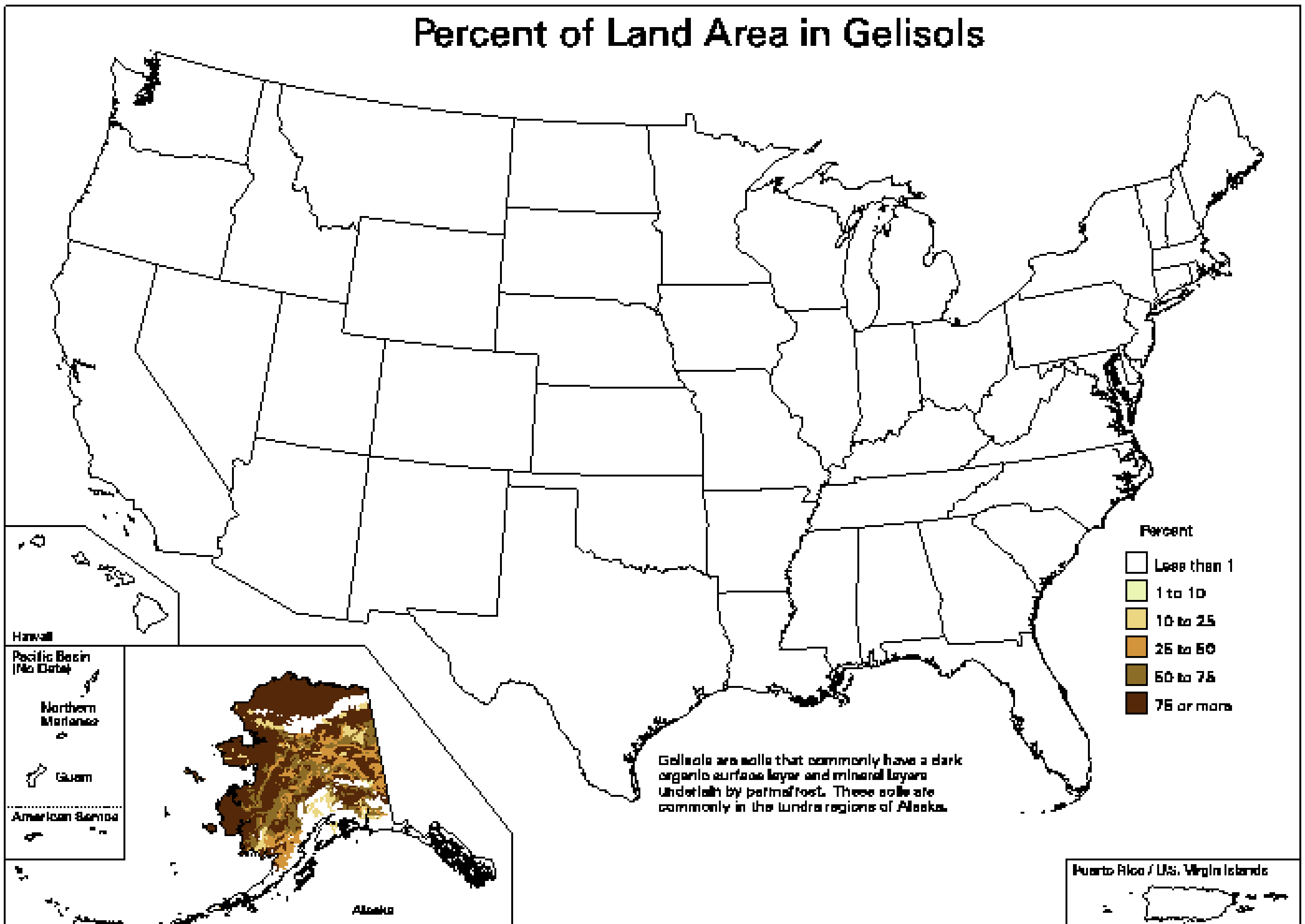
A. Soils that have:

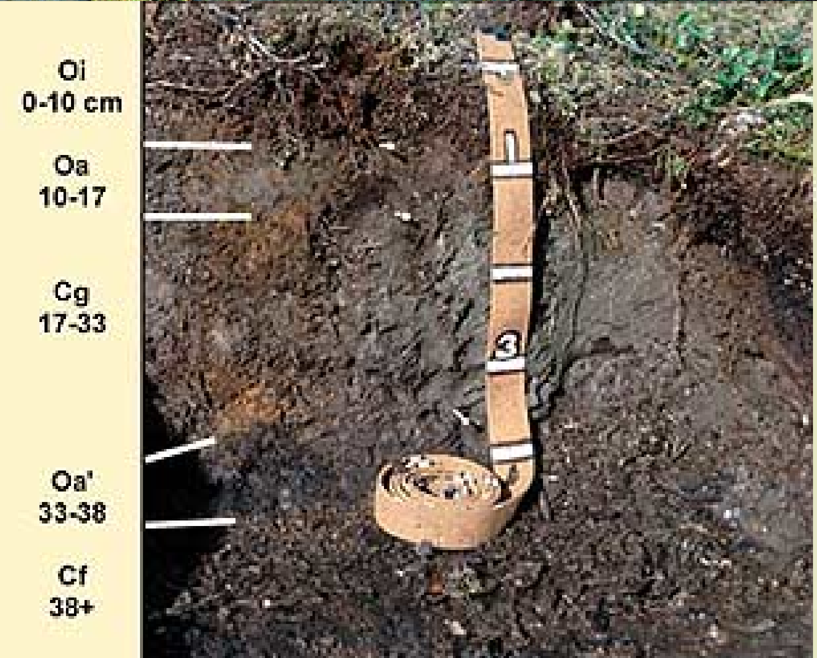
1. Permafrost within 100 cm of the soil surface; *or*

2. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Gelisols, p. 445

Gelic = frost churning (cryoturbation)





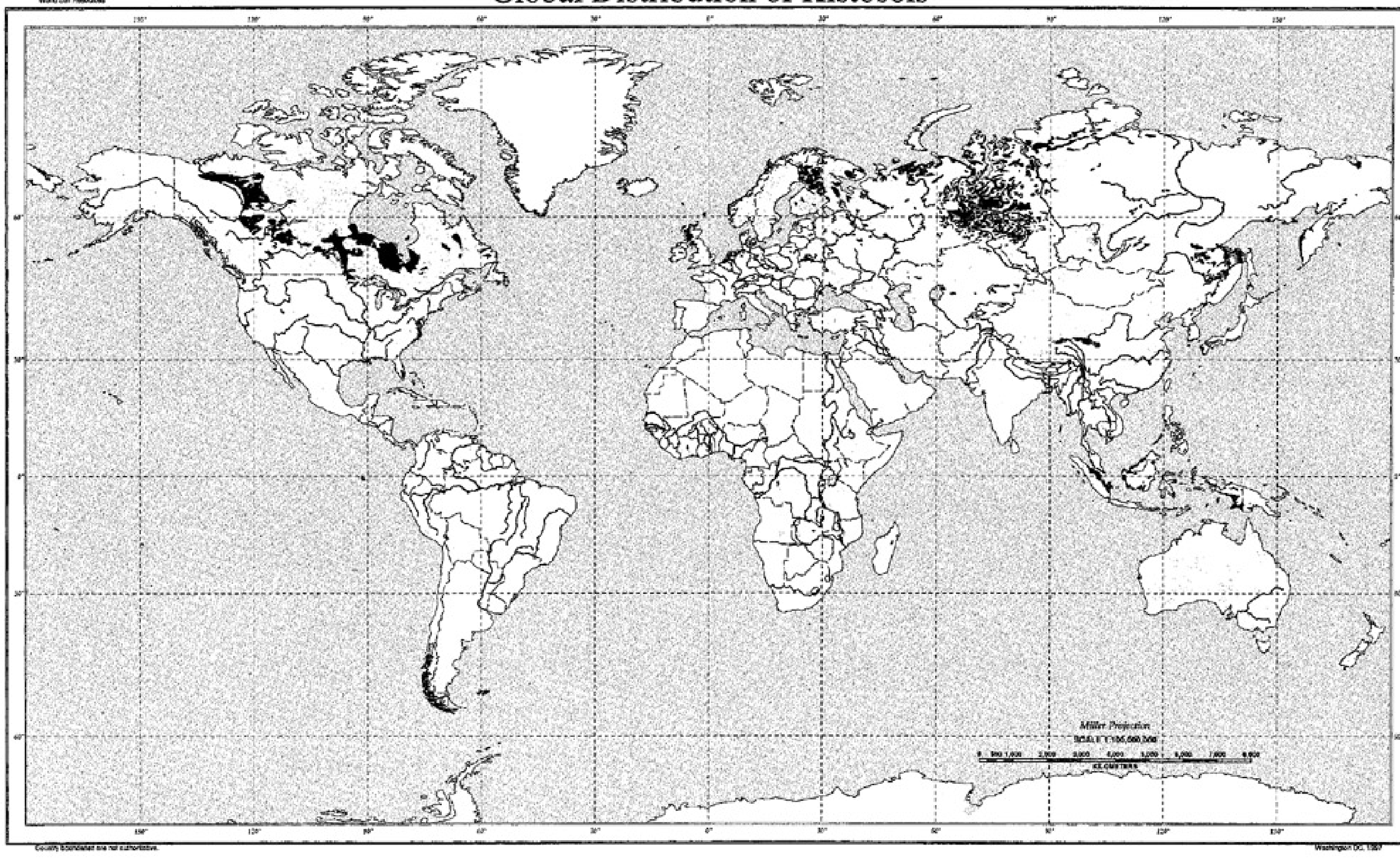
Oi
0-10 cm
Oa
10-17
Cg
17-33
Oa'
33-38
Cf
38+

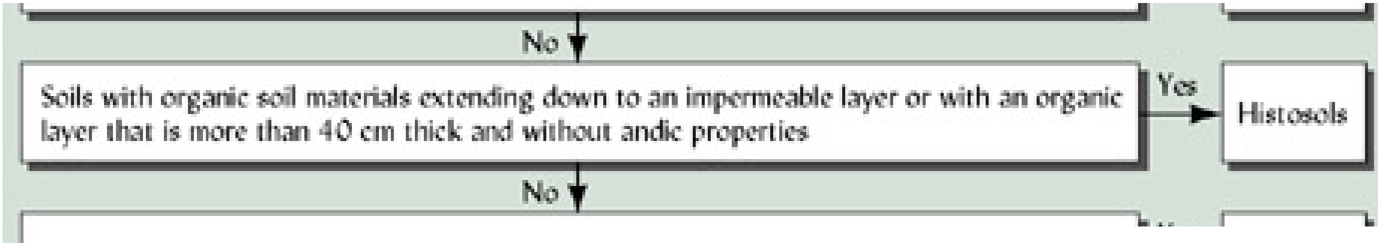
RIDGE
A
0-30 cm
Oe
30-38
Cf
38+

HISTOSOLS

All organic soils (peats, mucks, etc.)
At least 20-30% organic matter

Global Distribution of Histosols





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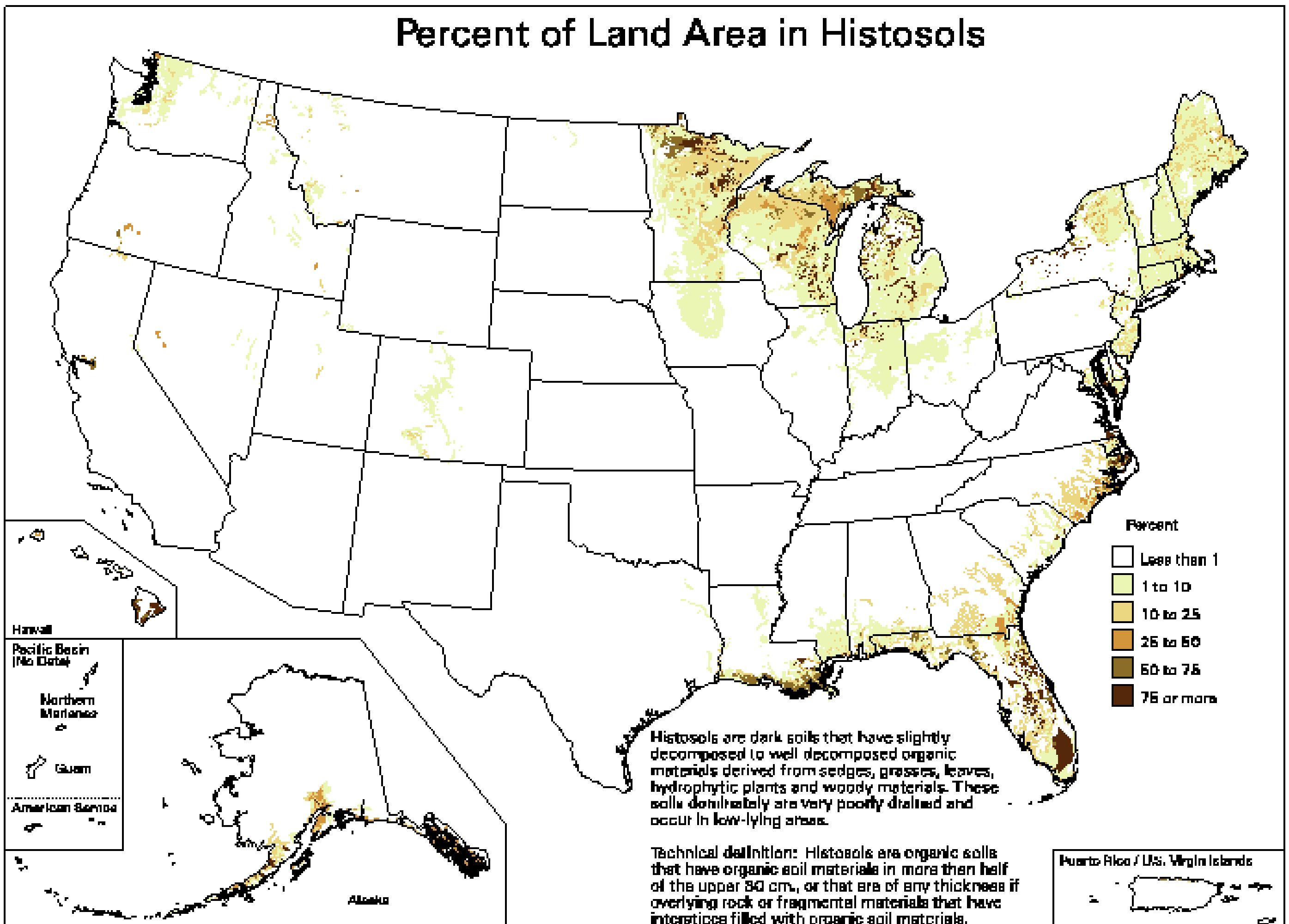
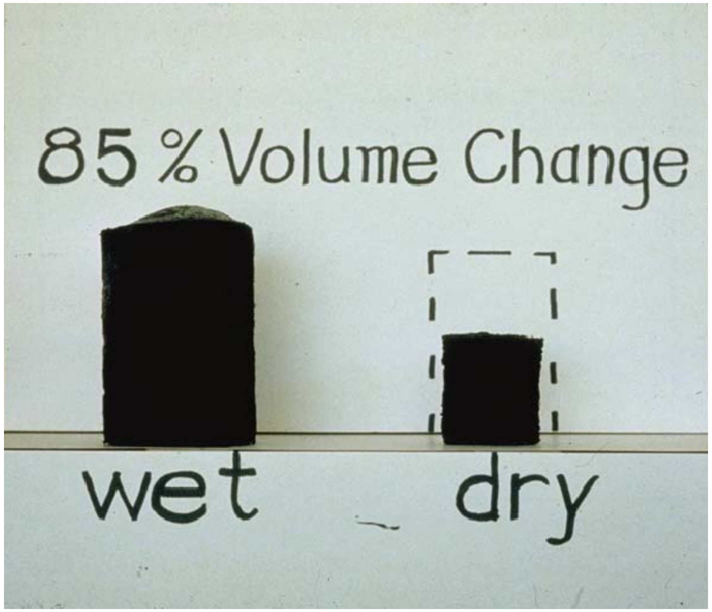



IX
VIII
VII
VI
V


85 % Volume Change
wet
dry

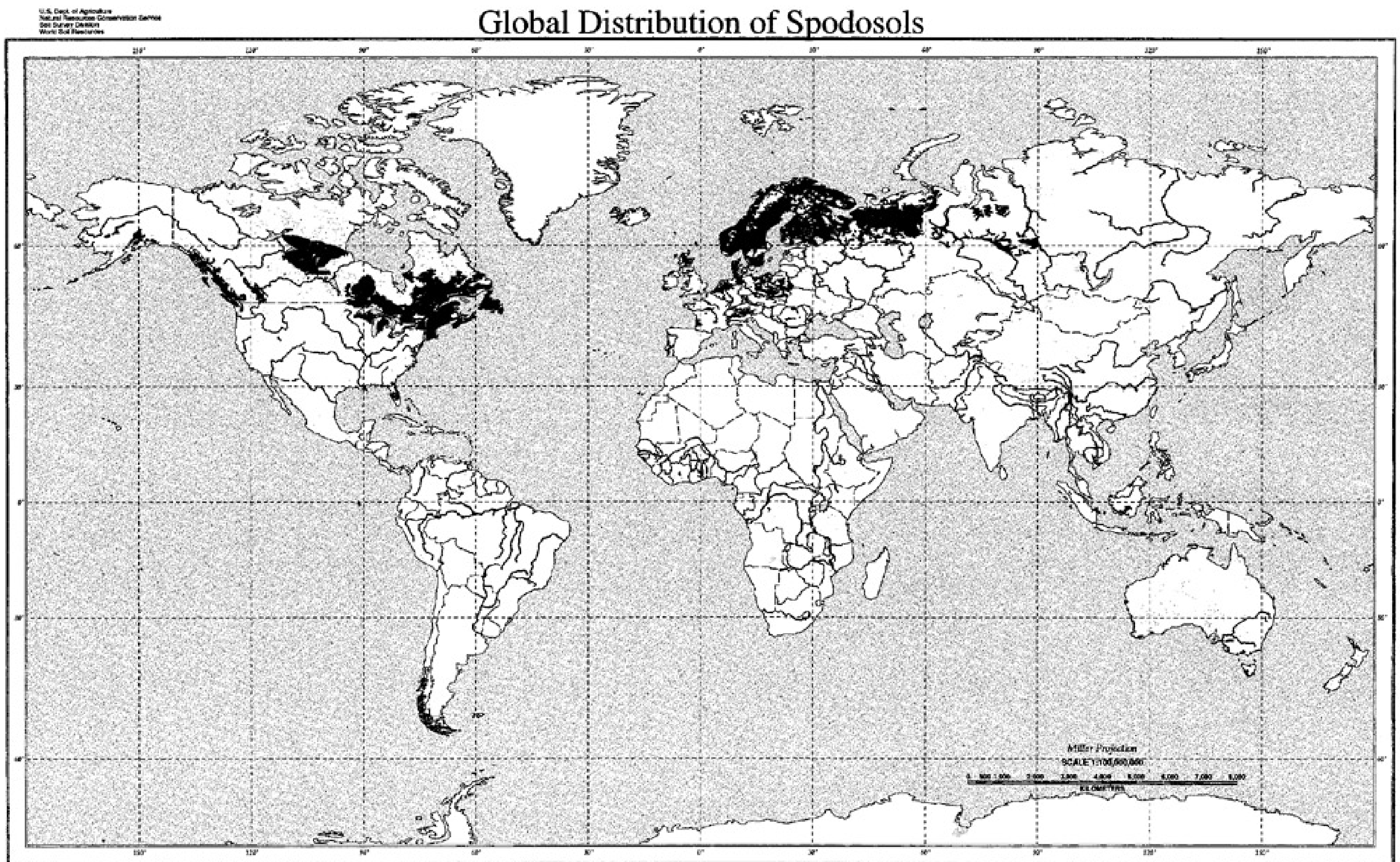

M
F
.2
1
.4
.6
2
.8
3
1
.2
4

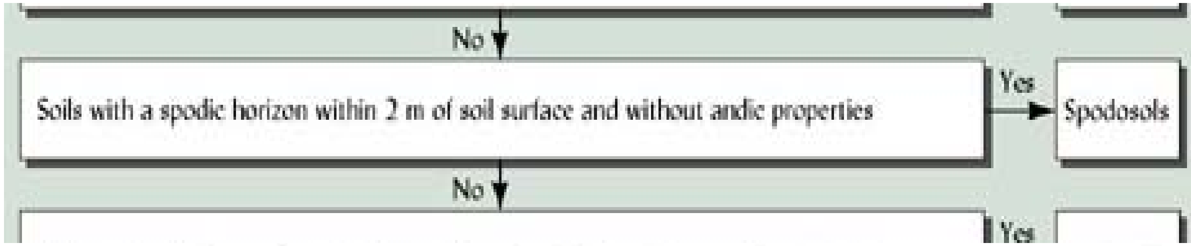
3
6
9
12
15

SPODOSOLS

- Spodic horizon of illuviated humus, Fe & Al oxides
- Common in cool, humid regions on coarse-textured parent materials

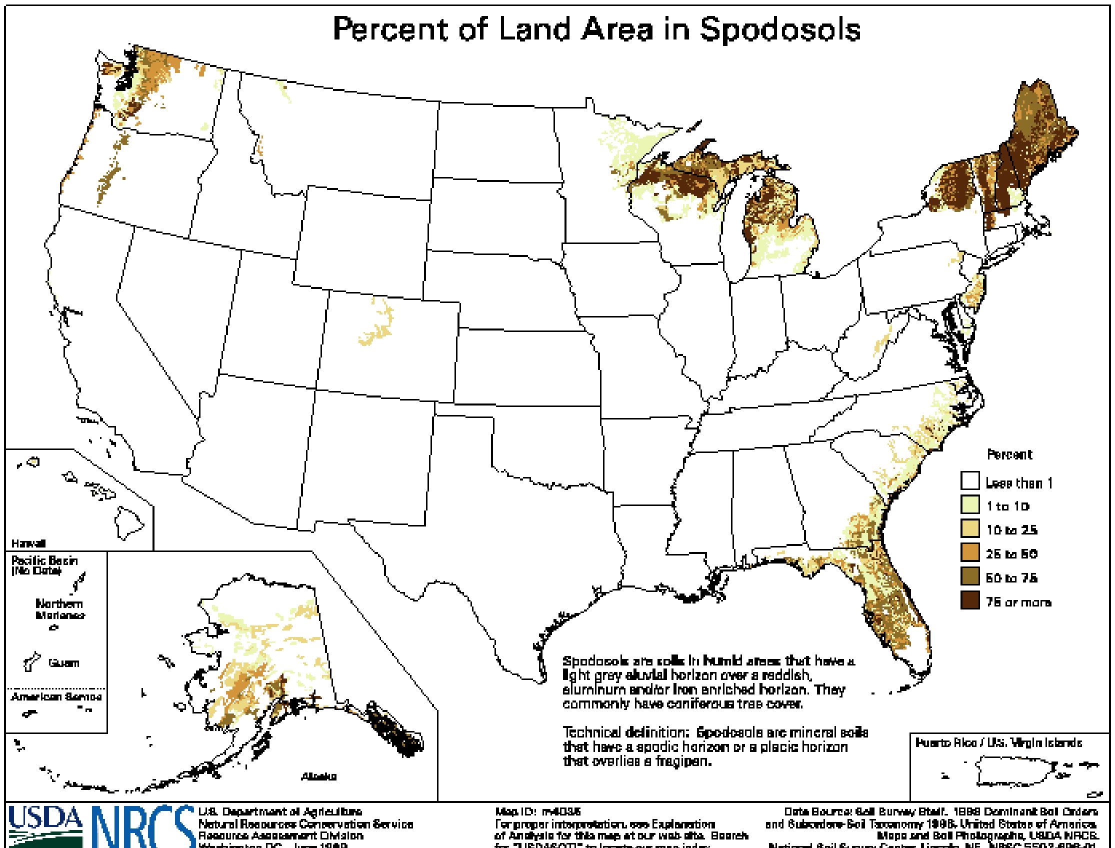
Global Distribution of Spodosols

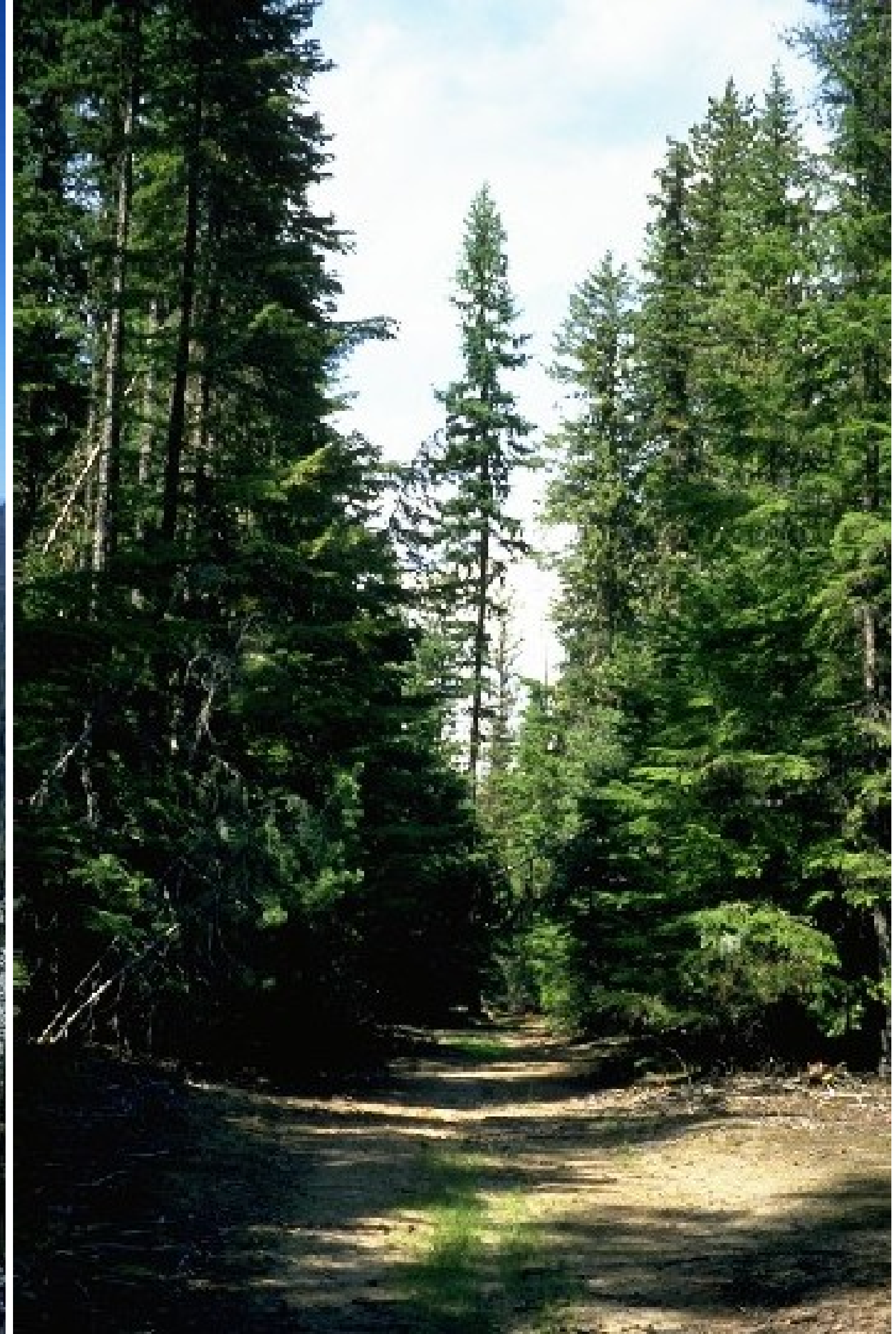




Spodic horizon of illuviated humus, Fe & Al oxides

Common in cool, humid regions on coarse-textured parent materials




M
F
.2
1
.4
.6
2
.8
3
1
.2
4
.4
5

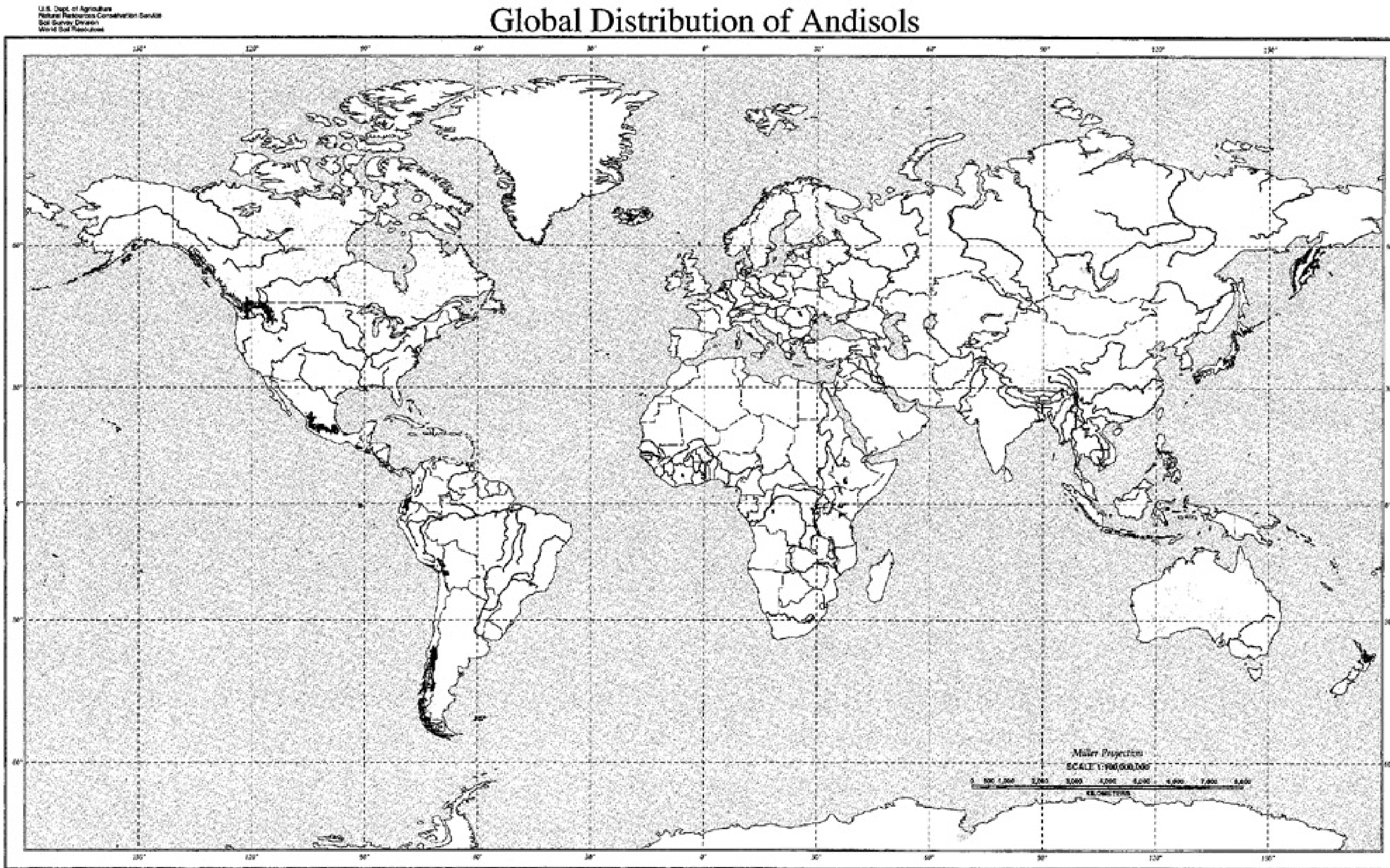

C
F
0
2
1
4
6
2
8
3
10
12
4

1
3
6

ANDISOL

Volcanic ash parent materials
Mineralogy contains high amount of amorphous materials

Global Distribution of Andisols



No

Soils with andic properties (low density, glass, pumice, short-range order minerals) → Yes → Andisols

No

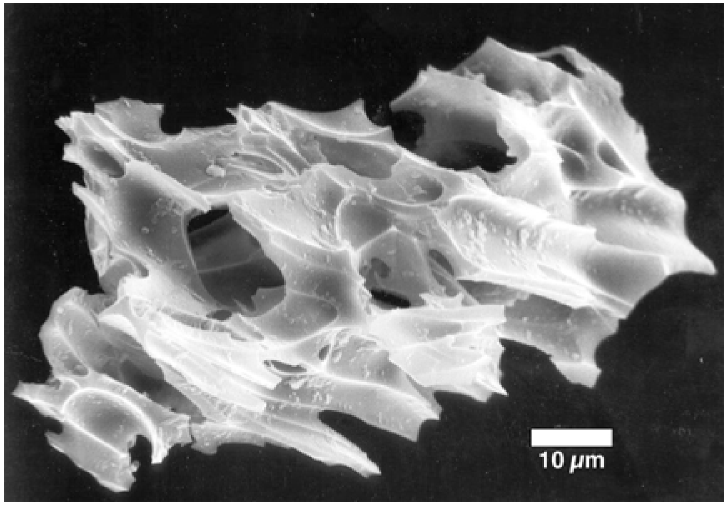
D. Other soils that have andic soil properties in 60 percent or more of the thickness *either*:

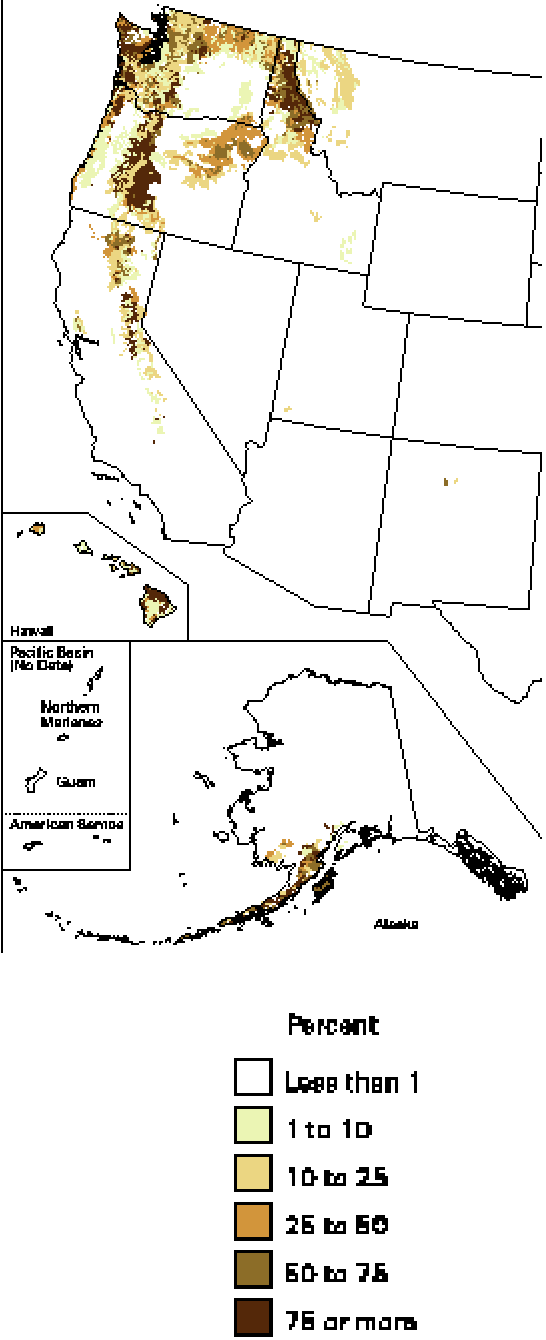
1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

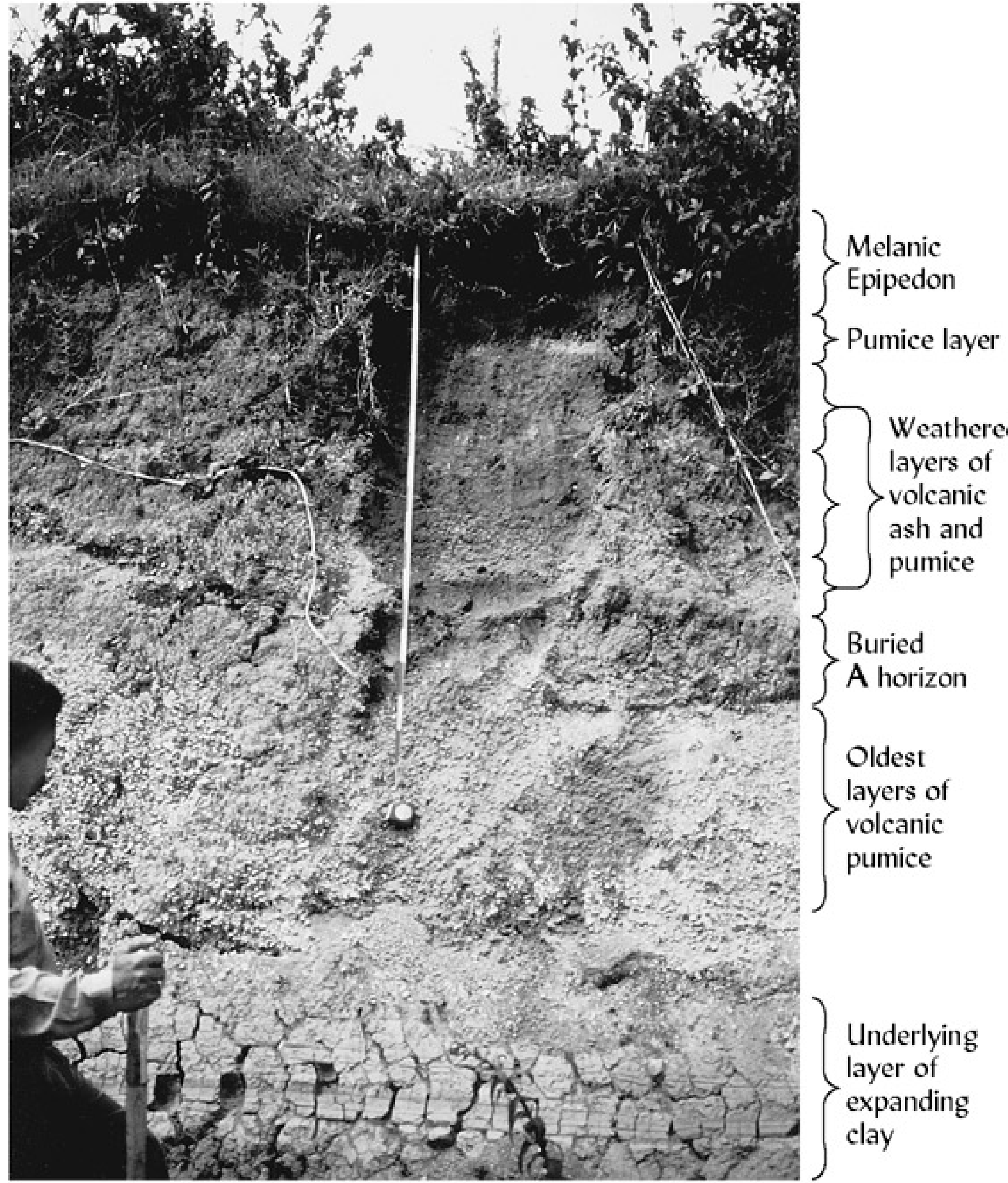
Andisols, p. 271

Volcanic ash parent materials
Mineralogy contains high amount of amorphous materials

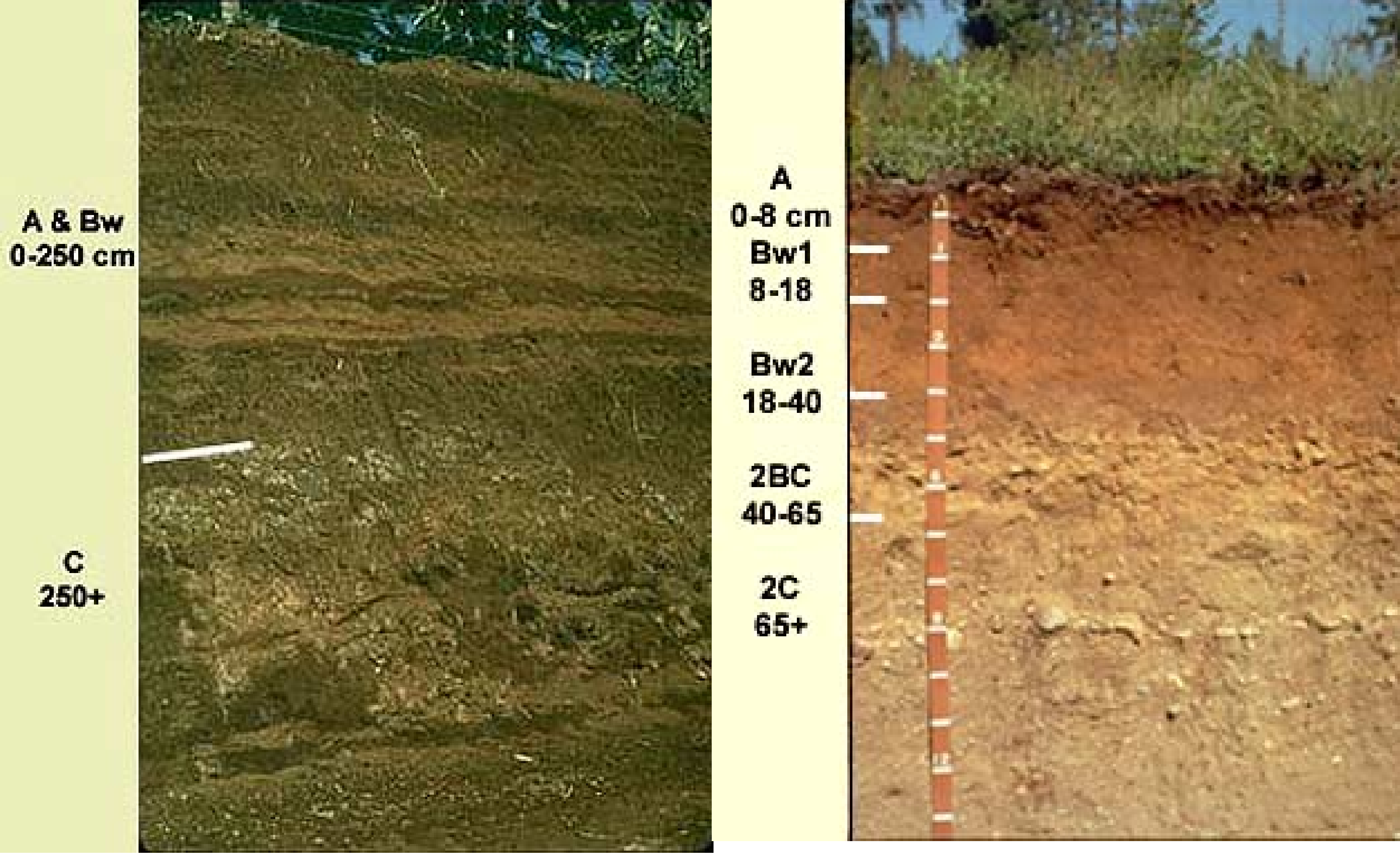

10 μm



Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska
Percent
Less than 1
1 to 10
10 to 25
25 to 50
50 to 75
75 or more



Melanic Epipedon
Pumice layer
Weathered layers of volcanic ash and pumice
Buried A horizon
Oldest layers of volcanic pumice
Underlying layer of expanding clay


A & Bw
0-250 cm
C
250+
A
0-8 cm
Bw1
8-18
Bw2
18-40
2BC
40-65
2C
65+

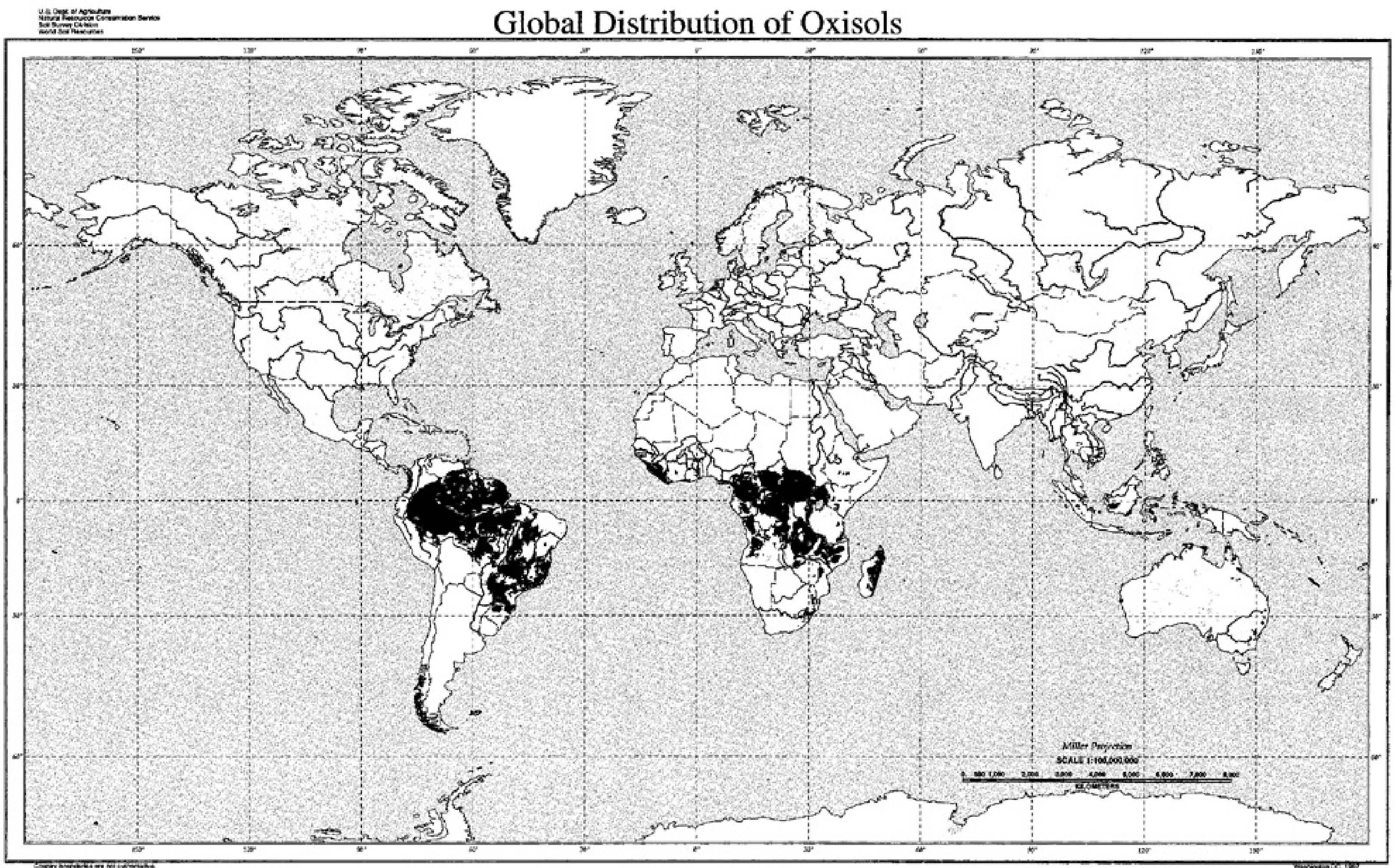
OXISOLS

Common in hot, humid climates with intense weathering and leaching

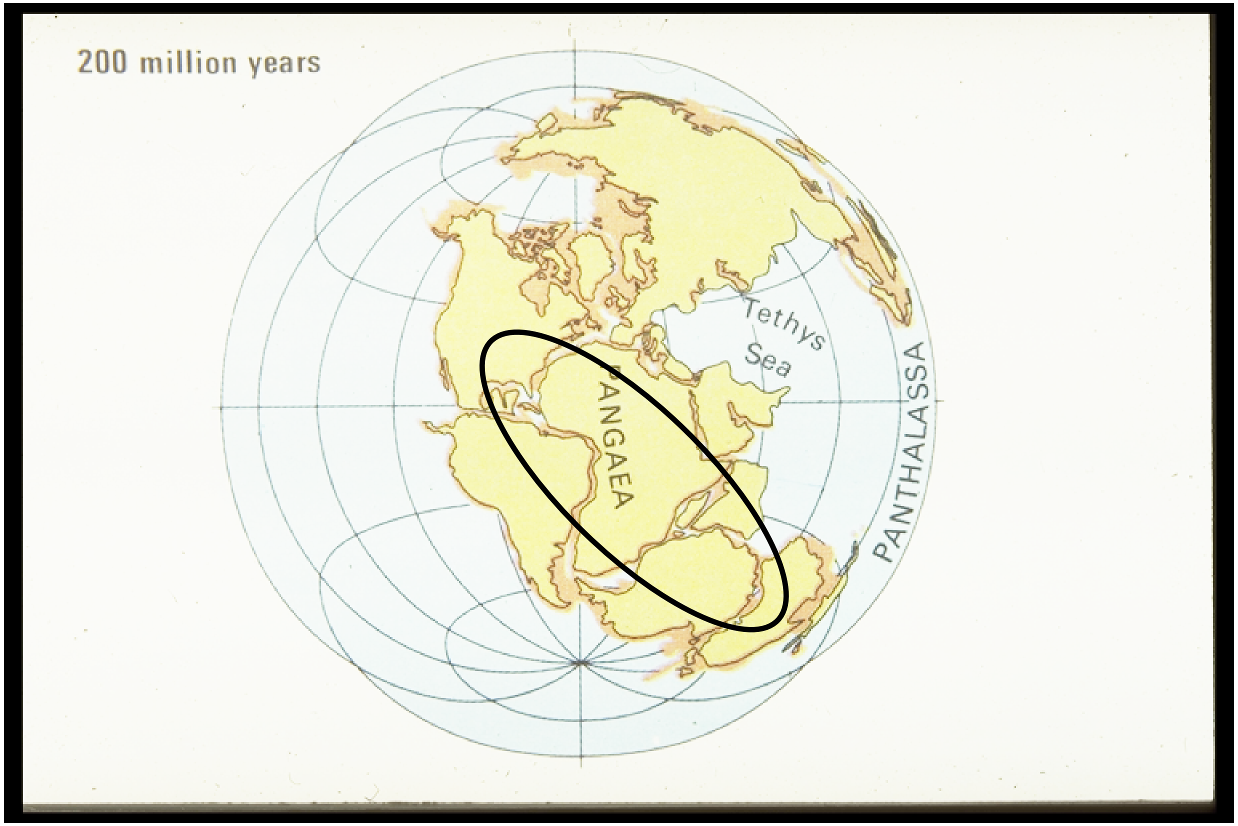
Dominant minerals: quartz, Fe & Al oxides, kaolinite

Commonly infertile

Global Distribution of Oxisols



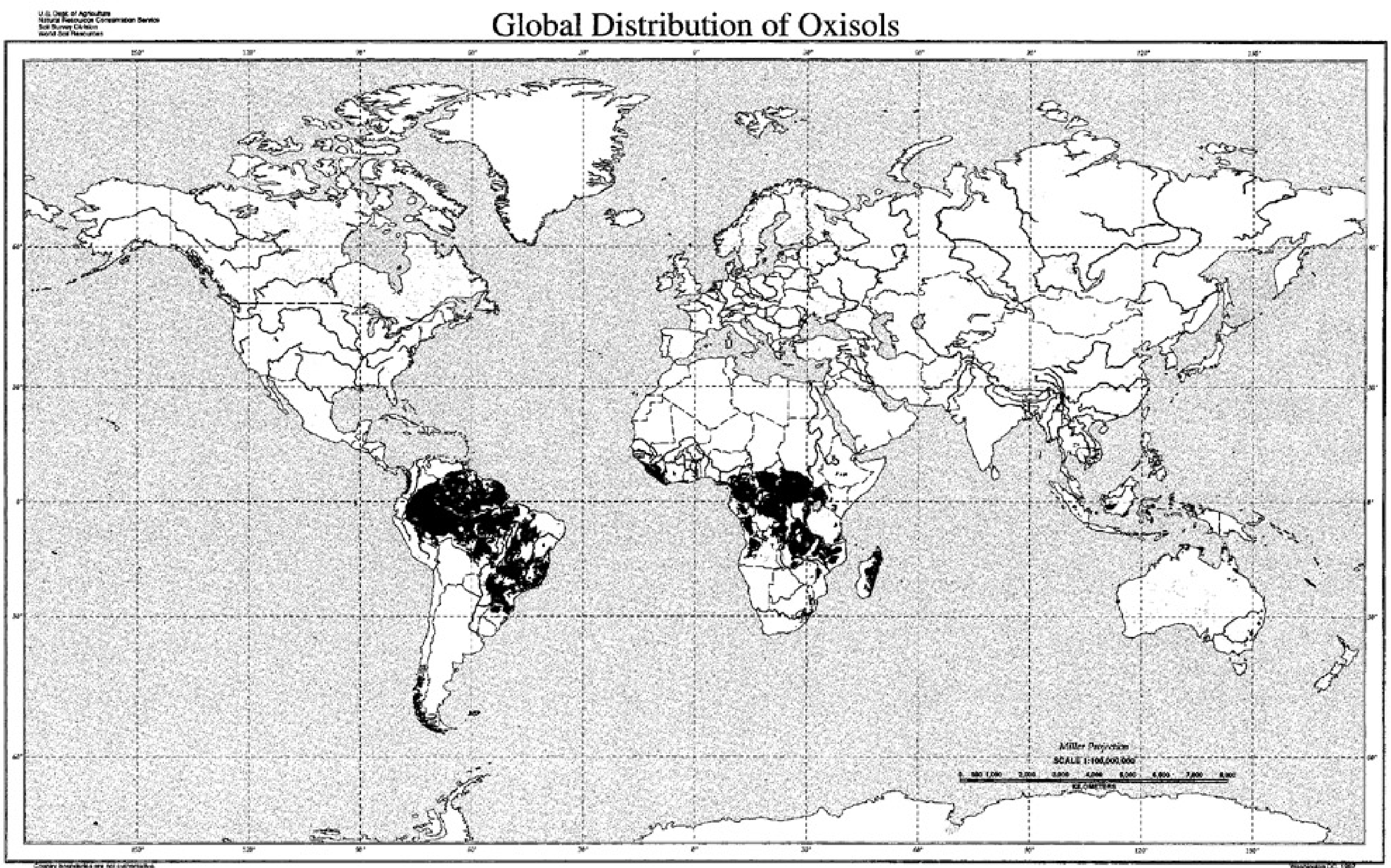
The region inside the black oval was the continental interior of Pangaea 200 million years ago

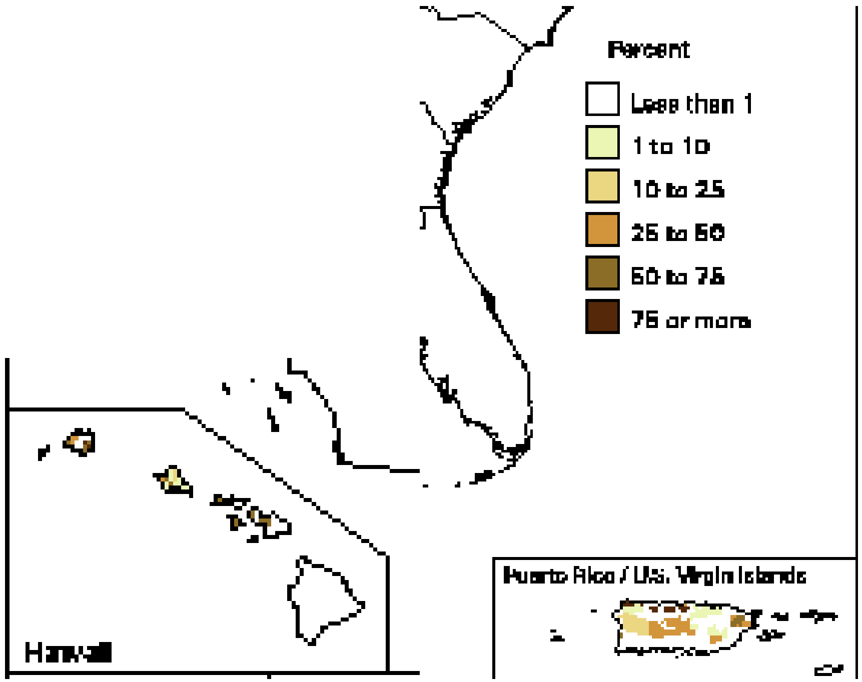


OXISOLS

Common in hot, humid climates with intense weathering and leaching
Dominant minerals: quartz, Fe & Al oxides, kaolinite
Commonly infertile

Global Distribution of Oxisols





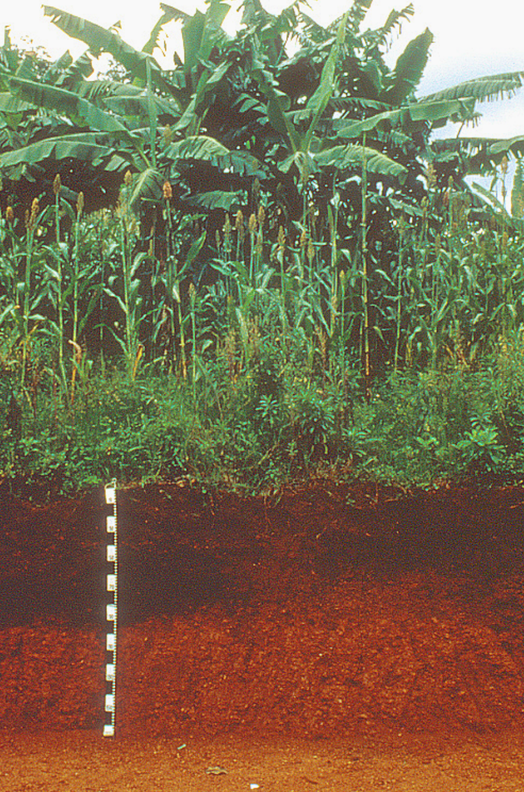
Common in hot, humid climates with intense weathering and leaching

Dominant minerals: quartz, Fe & Al oxides, kaolinite

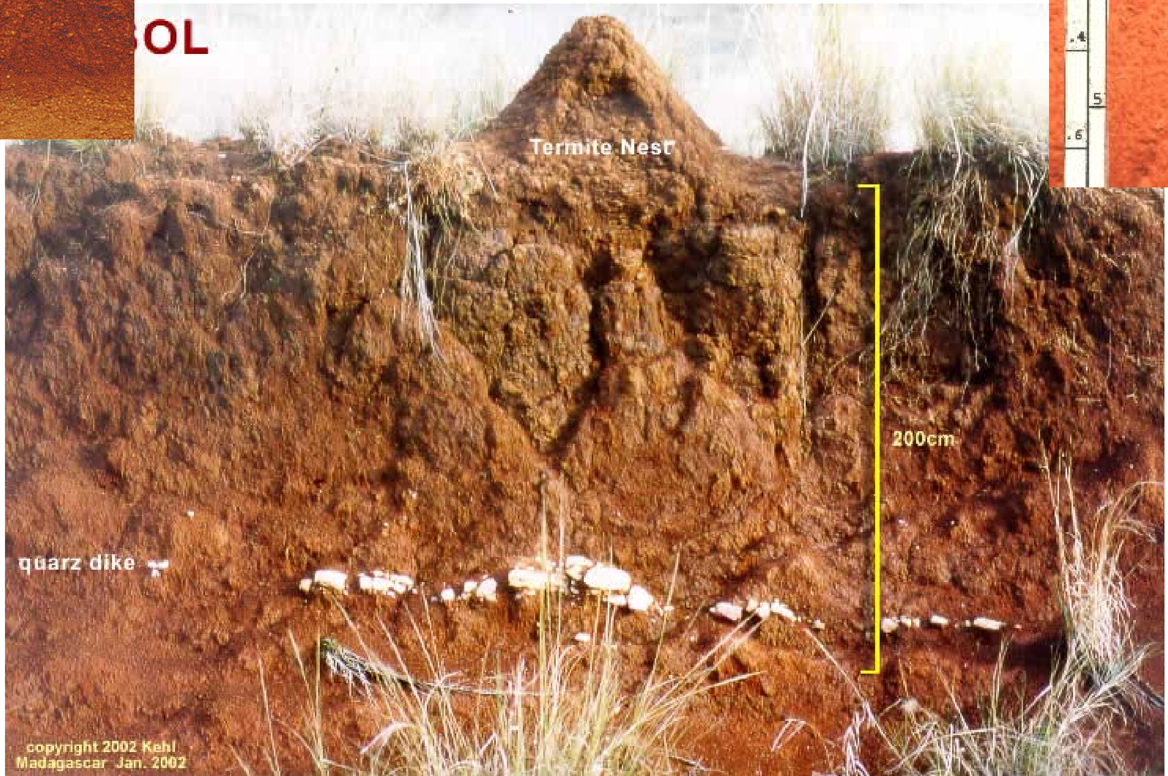
Commonly infertile



SOL



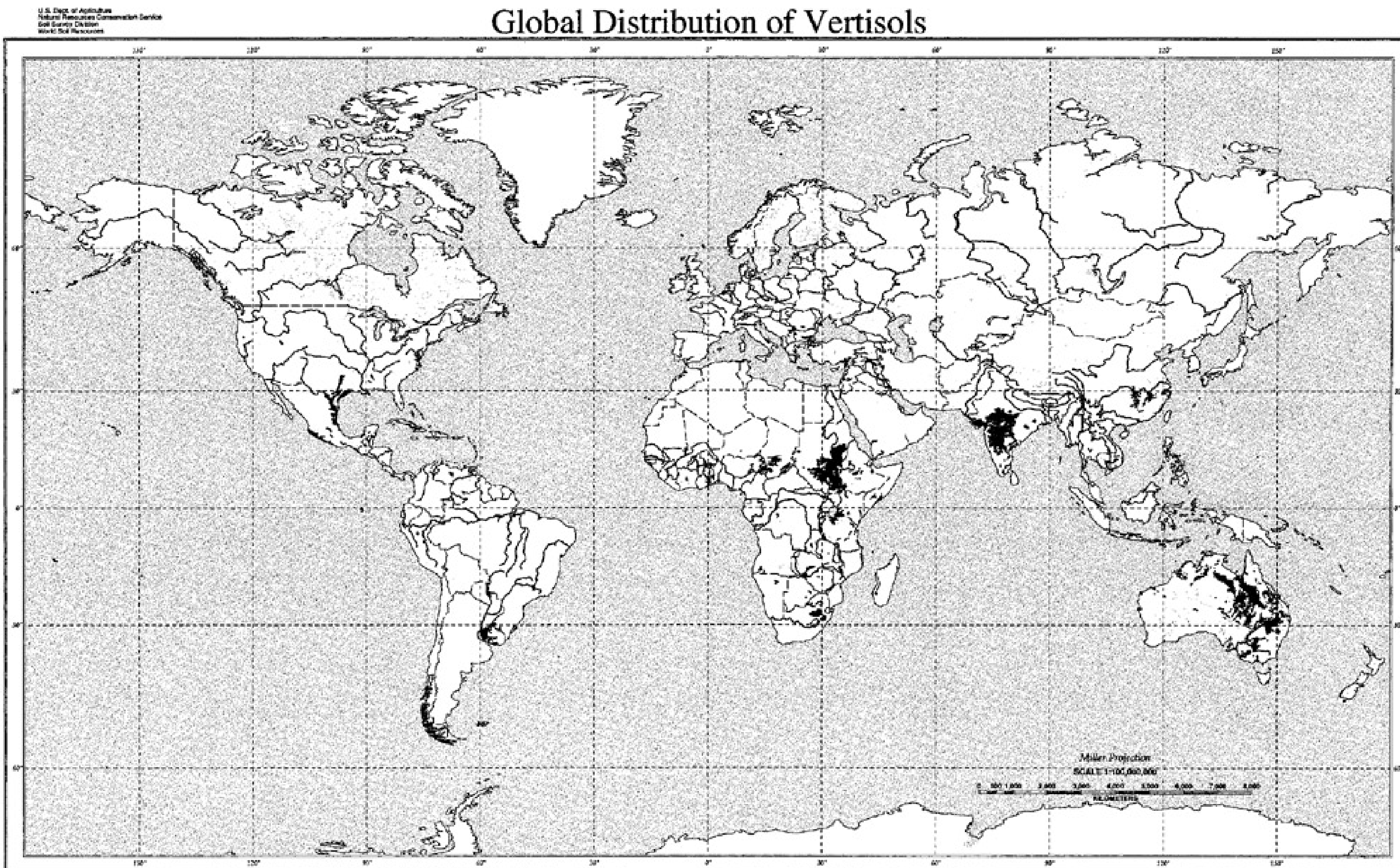

M
F
.2
1
.4
.6
2
.8
3
1
.2
4
.4
5
.6

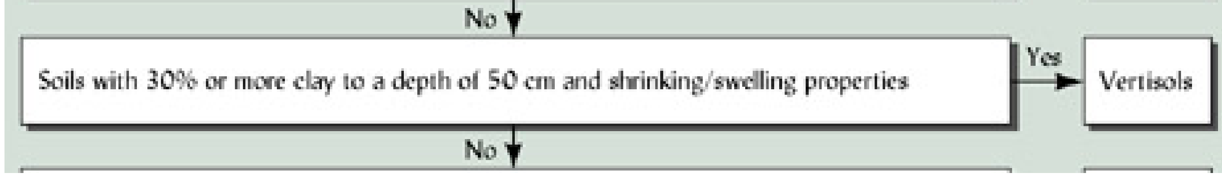

Termite Nest
200cm
quarz dike
copyright 2002 Kehl
Madagascar Jan. 2002

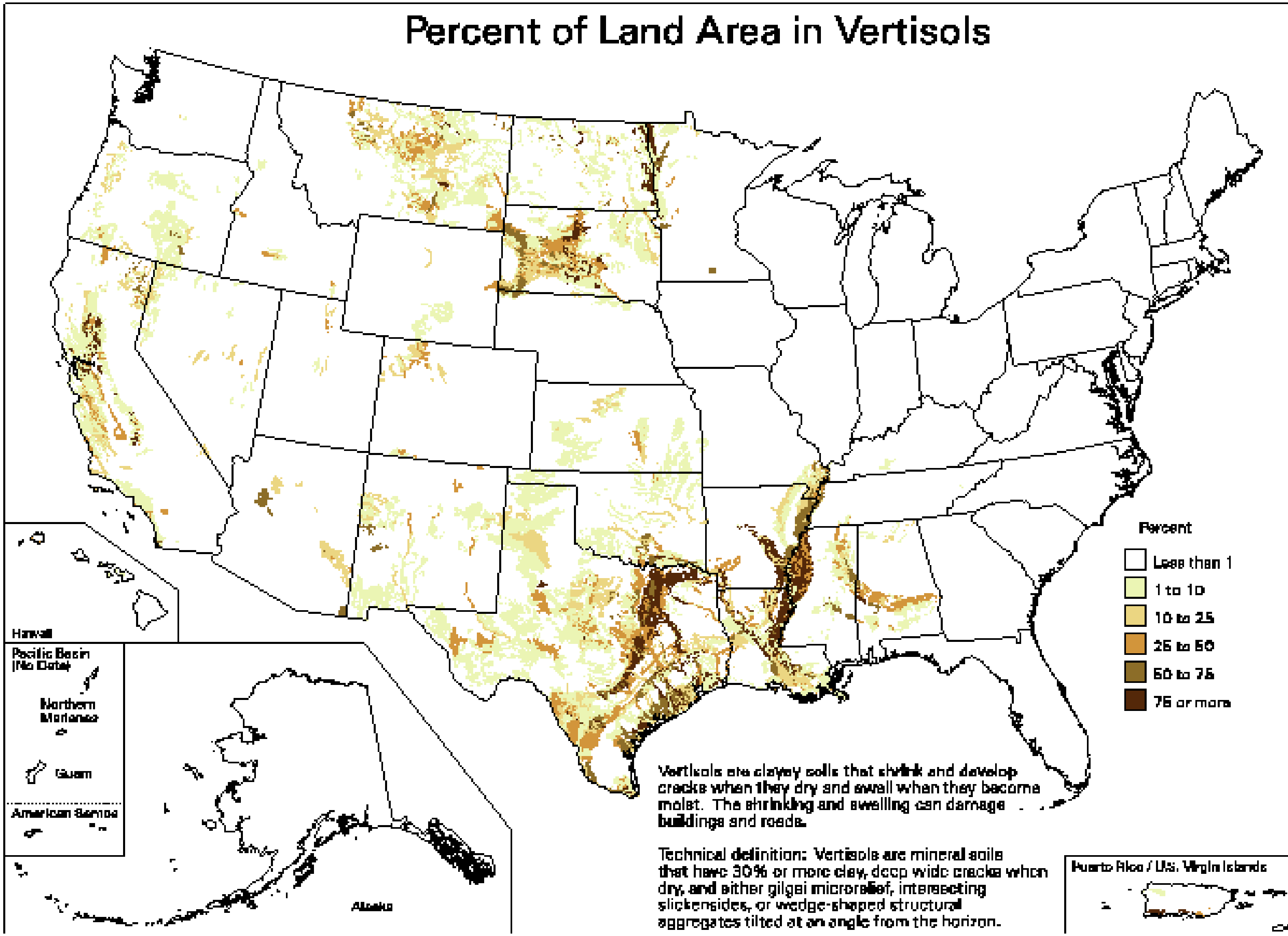
VERTISOLS

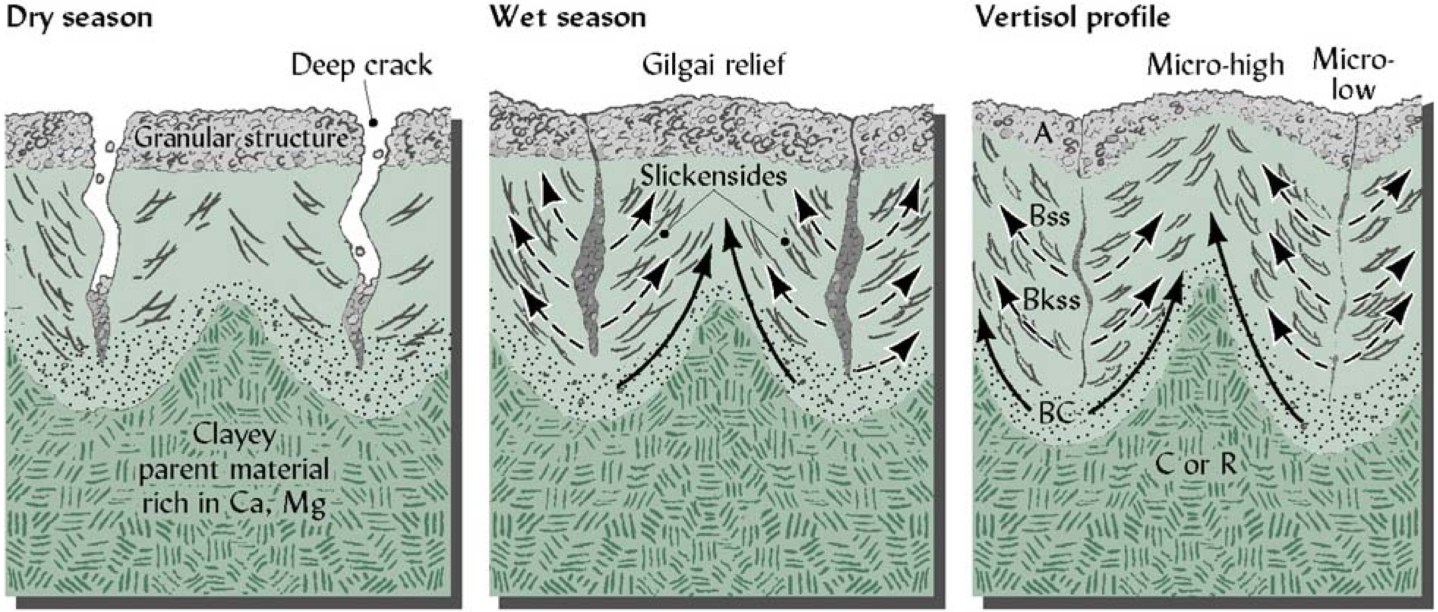
Form in clayey parent material
Shrink-swell behavior
Found in climates dry enough to form wide cracks

Global Distribution of Vertisols




No
Soils with 30% or more clay to a depth of 50 cm and shrinking/swelling properties
Yes
Vertisols
No


Percent of Land Area in Vertisols
Percent
Less than 1
1 to 10
10 to 25
25 to 50
50 to 75
75 or more
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska
Puerto Rico / U.S. Virgin Islands
Vertisols are clayey soils that shrink and develop cracks when they dry and swell when they become moist. The shrinking and swelling can damage buildings and roads.
Technical definition: Vertisols are mineral soils that have 30% or more clay, deep wide cracks when dry, and either gilgai microrelief, intersecting slickensides, or wedge-shaped structural aggregates tilted at an angle from the horizon.

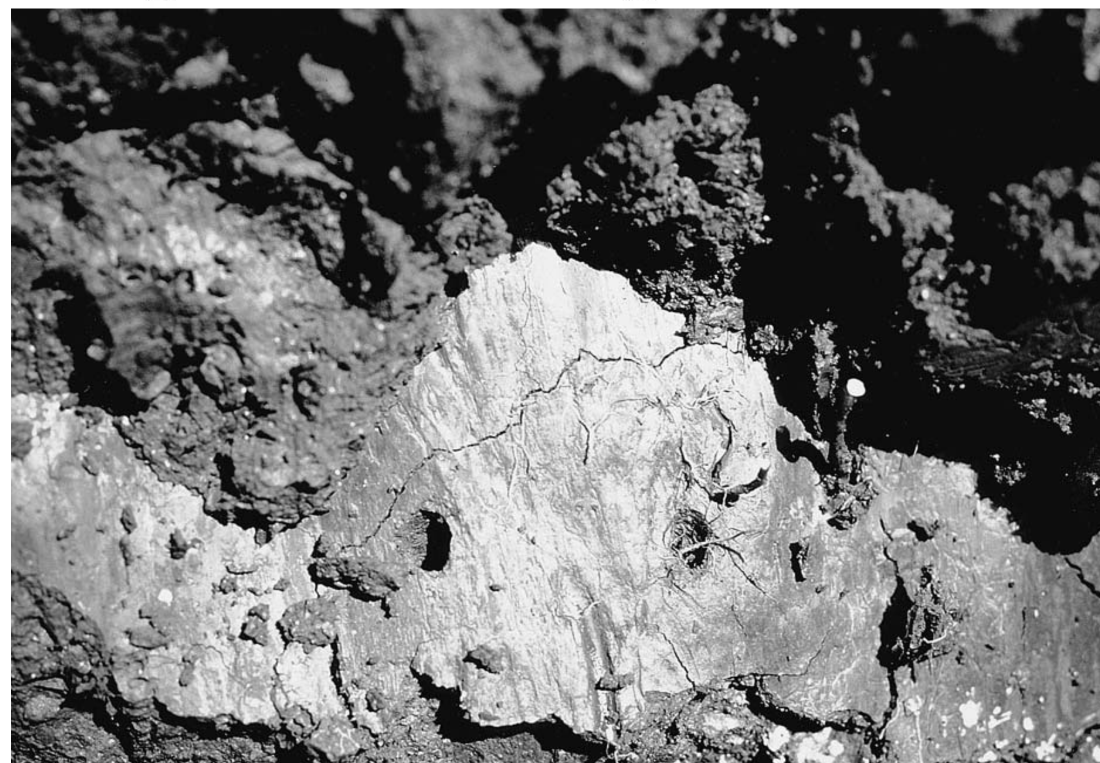


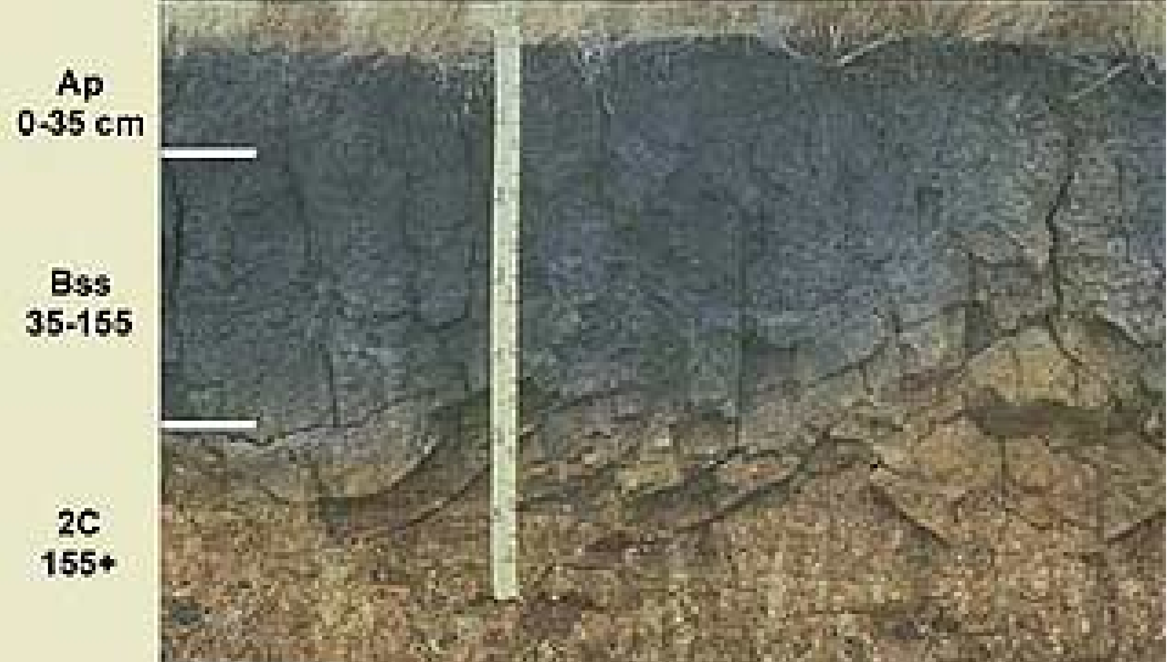
Dry season
Deep crack
Granular structure
Clayey
parent material
rich in Ca, Mg
Wet season
Gilgai relief
Slickensides
Vertisol profile
Micro-high
Micro-
low
A
Bss
Bkss
BC
C or R

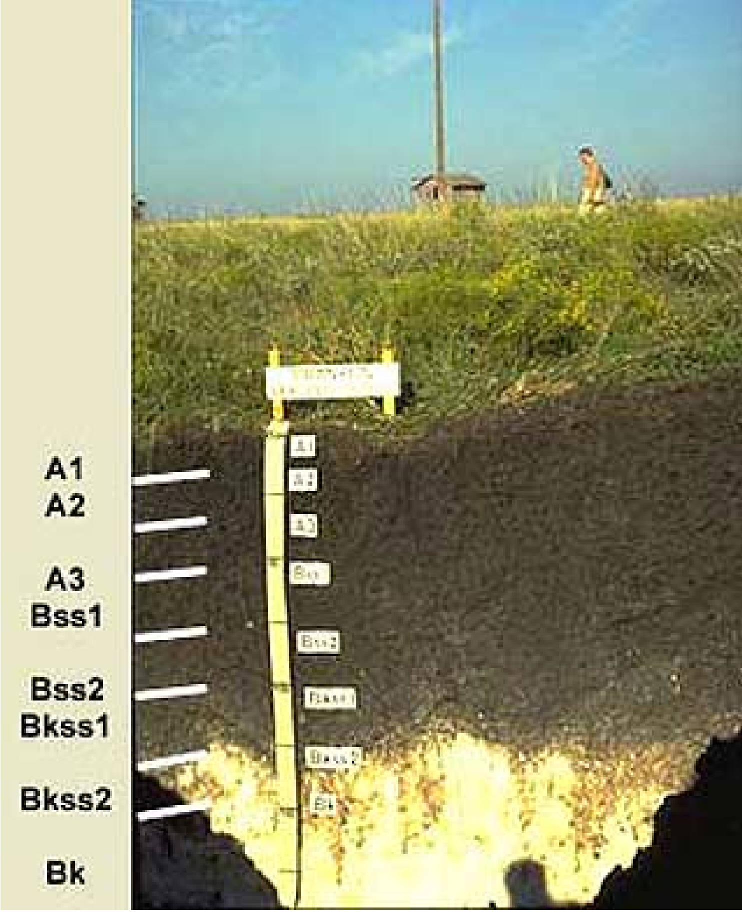
(a)

(b)

(c)

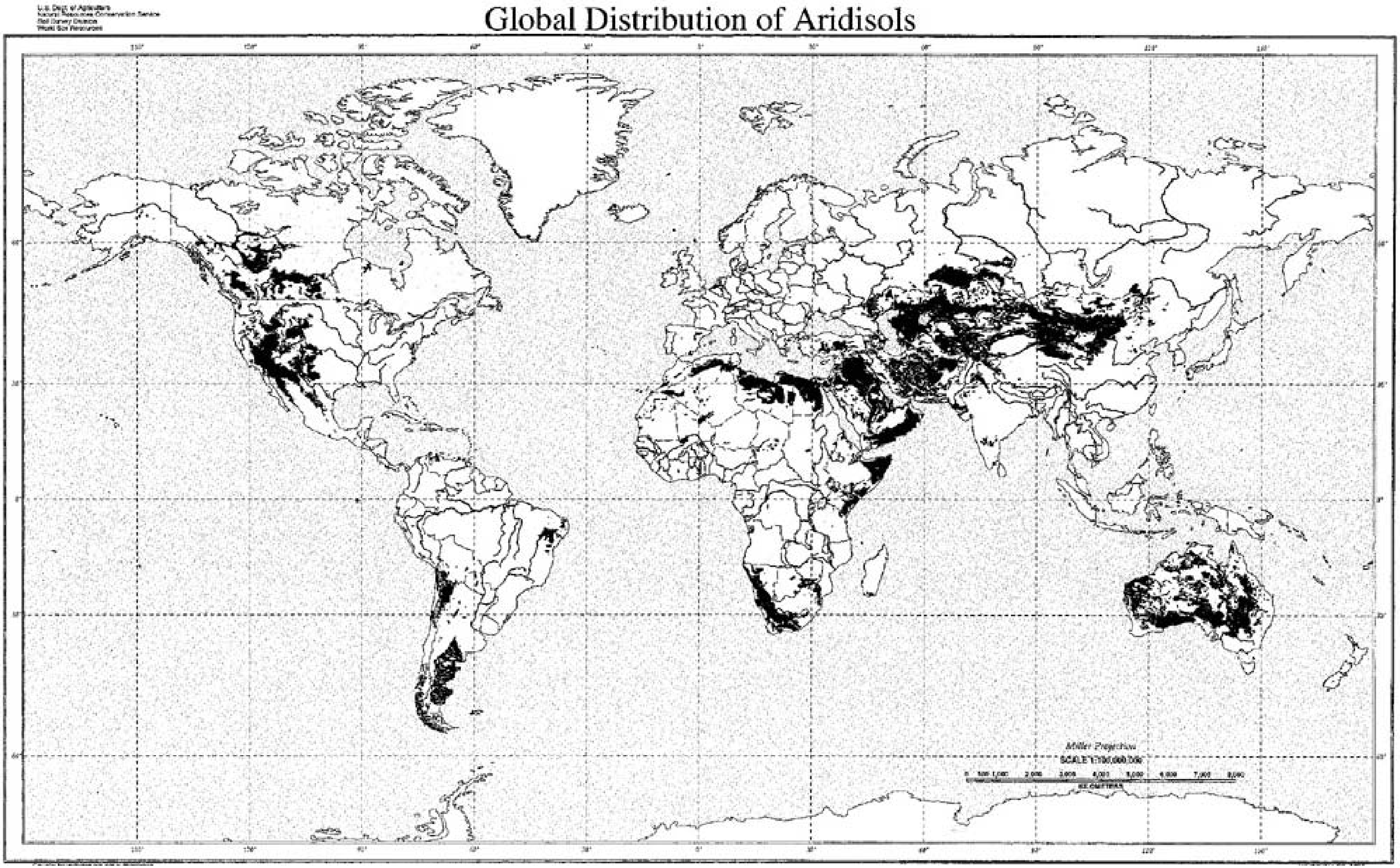


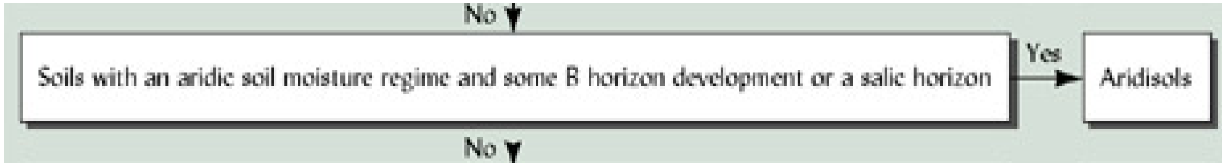

Ap
0-35 cm
Bss
35-155
2C
155+

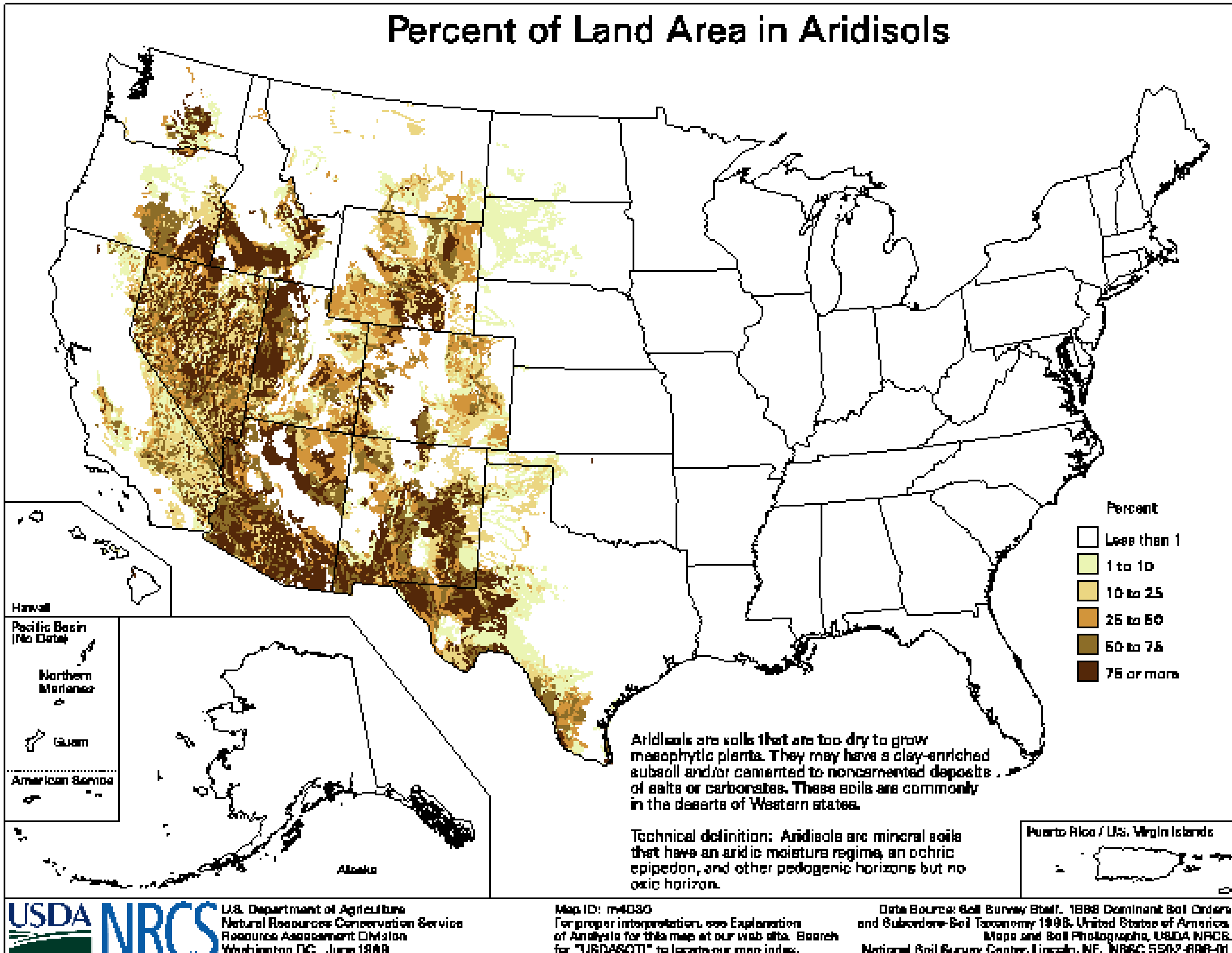

A1
A2
A3
Bss1
Bss2
Bkss1
Bkss2
Bk

ARIDISOLS

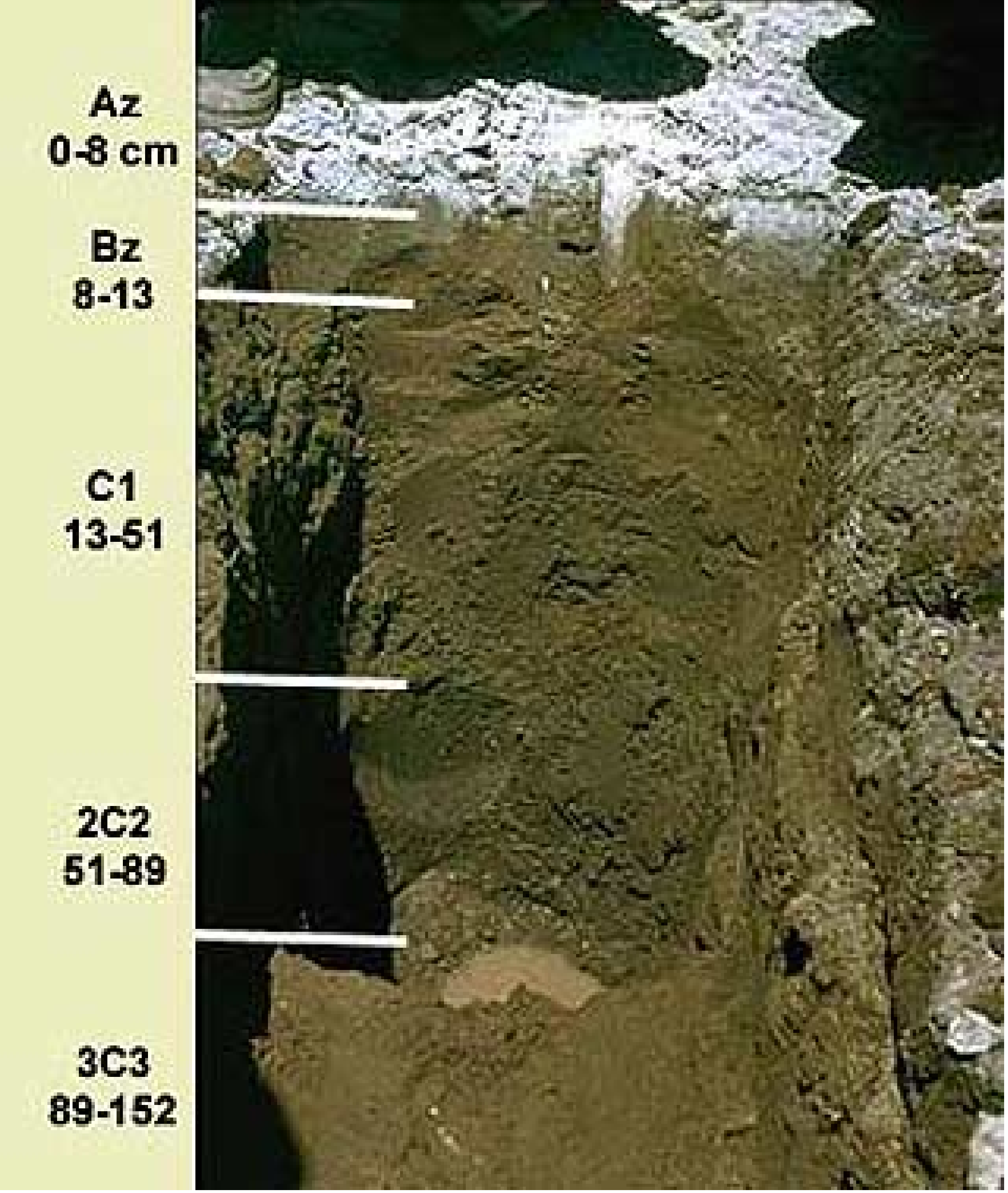
Soils of arid region (classified by climate)

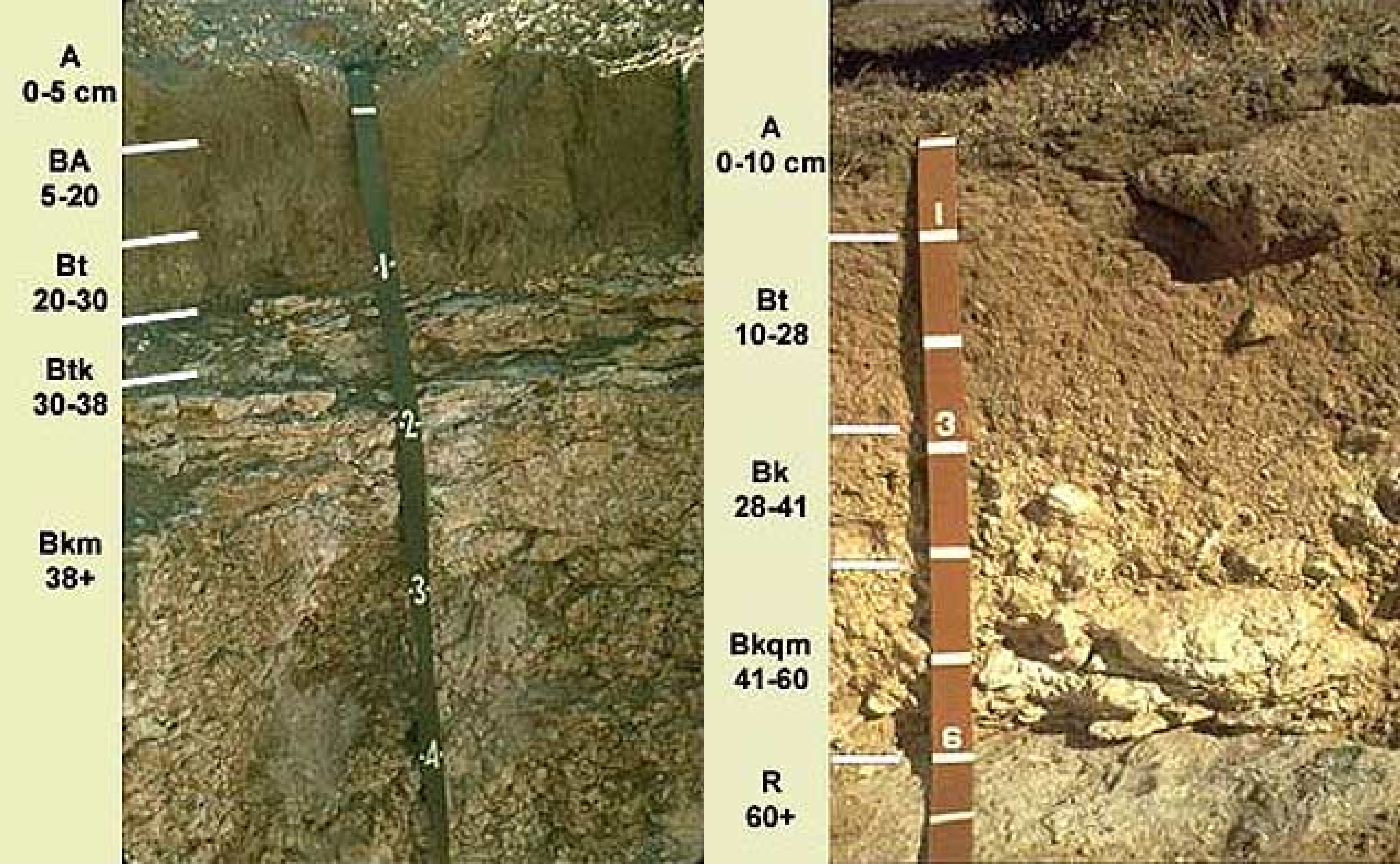



No
Soils with an aridic soil moisture regime and some B horizon development or a salic horizon
Yes
Aridisols
No


Percent of Land Area in Aridisols
Percent
Less than 1
1 to 10
10 to 25
25 to 50
50 to 75
75 or more
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska
Puerto Rico / U.S. Virgin Islands
Aridisols are soils that are too dry to grow mesophytic plants. They may have a clay-enriched subsoil and/or cemented to noncemented deposits of salts or carbonates. These soils are commonly in the deserts of Western states.
Technical definition: Aridisols are mineral soils that have an aridic moisture regime, an ochric epipedon, and other pedogenic horizons but no oxic horizon.
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC June 1999
Map ID: m4030
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDASOTL" to locate our map index.
Data Source: Soil Survey Staff. 1998 Dominant Soil Orders and Suborders-Soil Taxonomy 1998. United States of America. Maps and Soil Photographs, USDA NRCS. National Soil Survey Center, Lincoln, NE. NSSC 5502-698-01



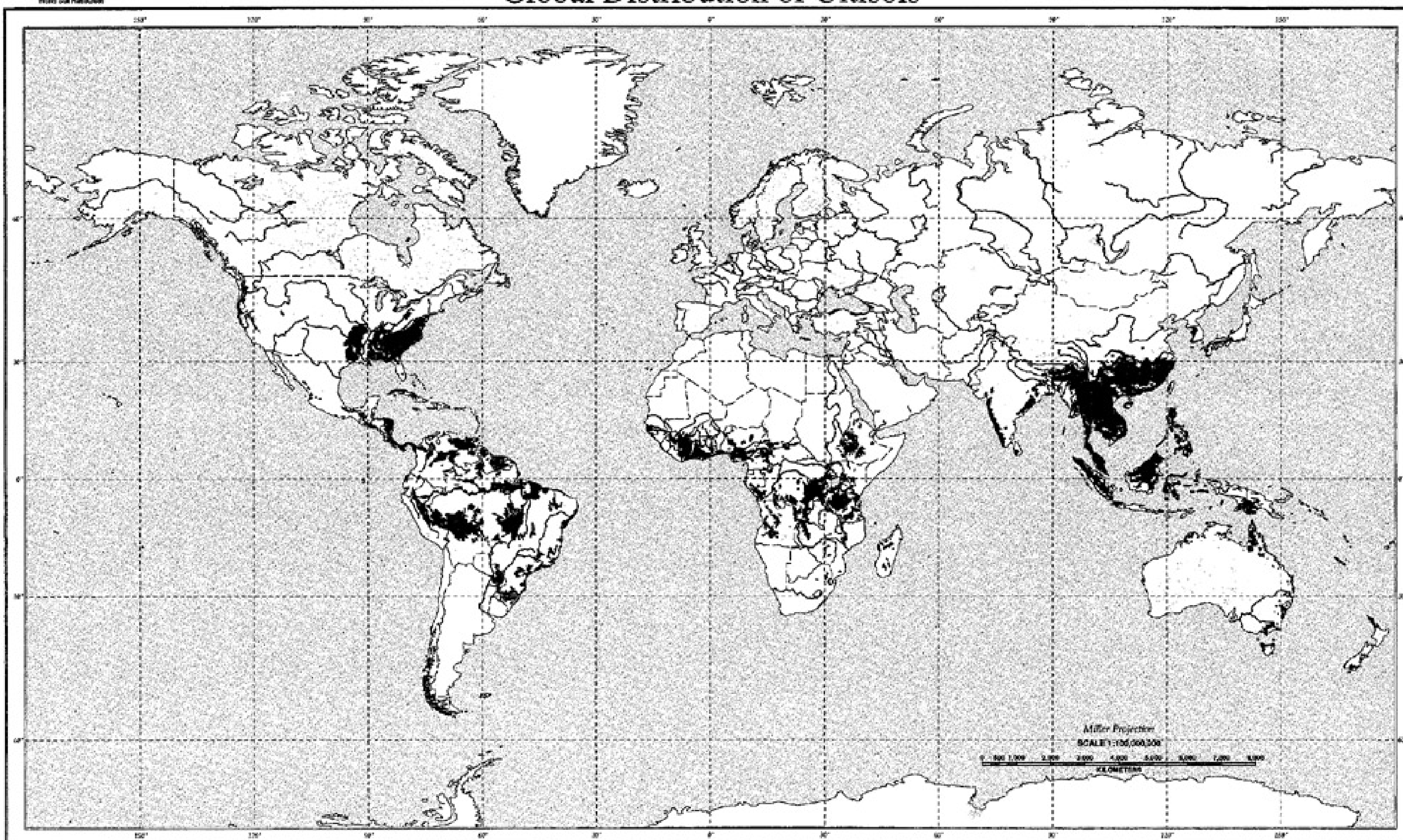

Az
0-8 cm
Bz
8-13
C1
13-51
2C2
51-89
3C3
89-152


A
0-5 cm
BA
5-20
Bt
20-30
Btk
30-38
Bkm
38+
A
0-10 cm
Bt
10-28
Bk
28-41
Bkqm
41-60
R
60+

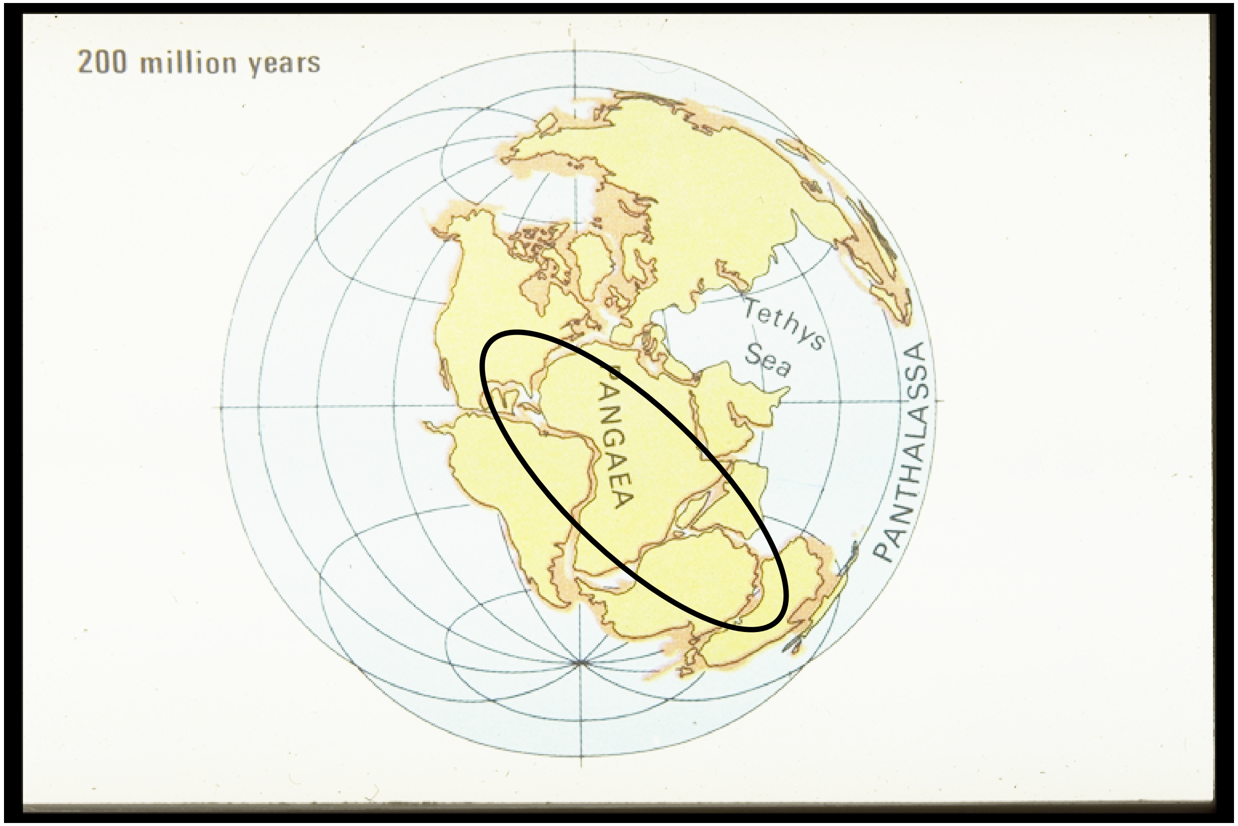
ULTISOLS

Similar to Alfisol, but <35% base saturation
Result of more intense weathering & leaching, or weathering over a longer time.
Often redder in color than Alfisol due to oxides.

Global Distribution of Ultisols



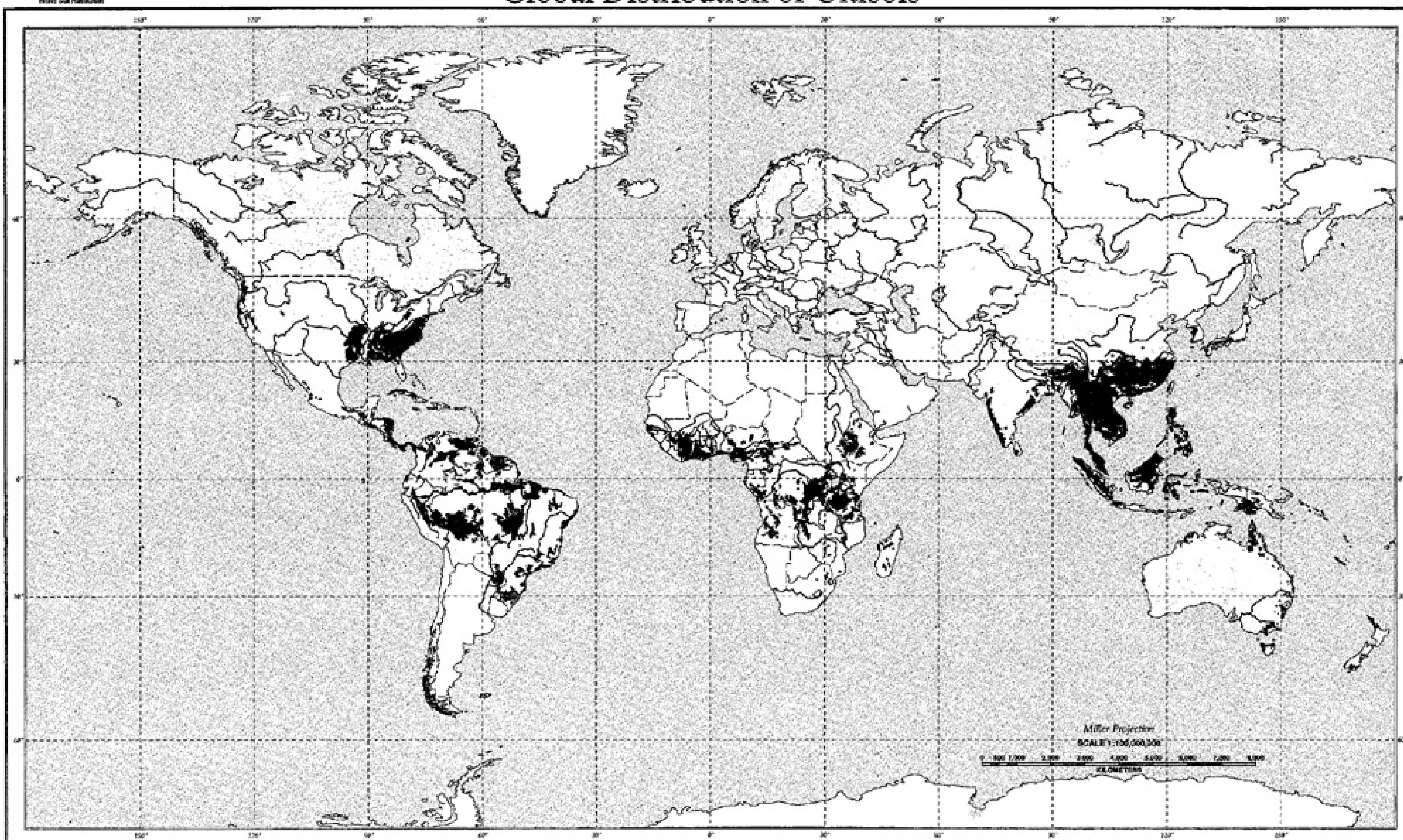
The region inside the black oval was the continental interior of Pangaea 200 million years ago



ULTISOLS

Similar to Alfisol, but <35% base saturation
Result of more intense weathering & leaching, or weathering over a longer time.
Often redder in color than Alfisol due to oxides.

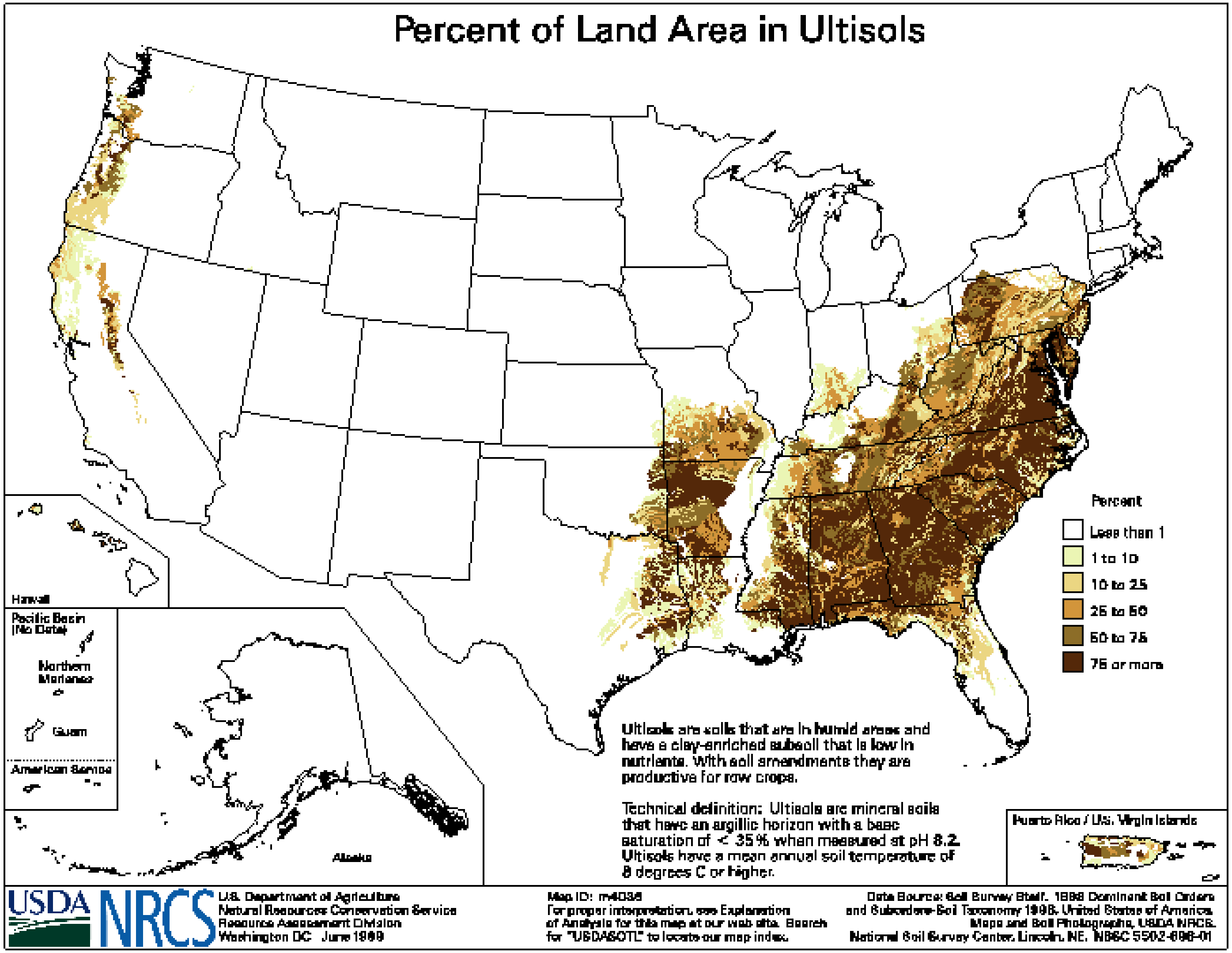
Global Distribution of Ultisols

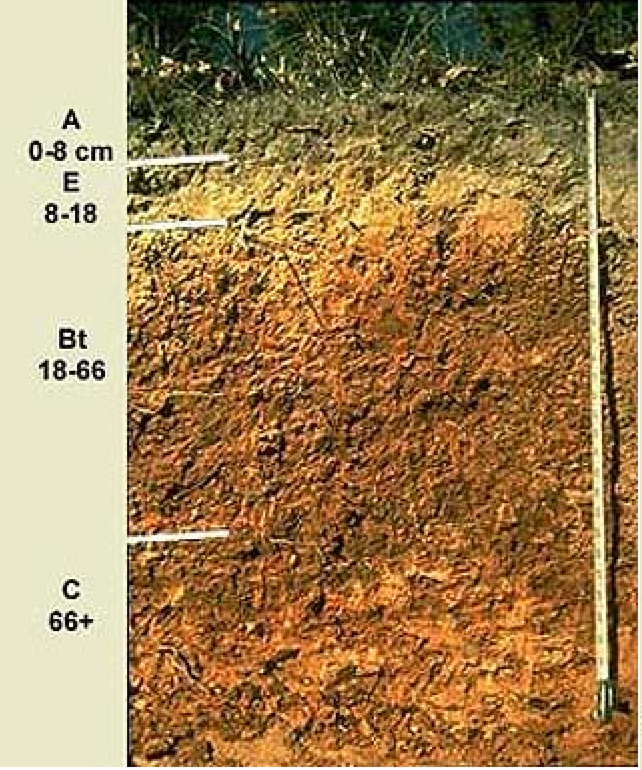


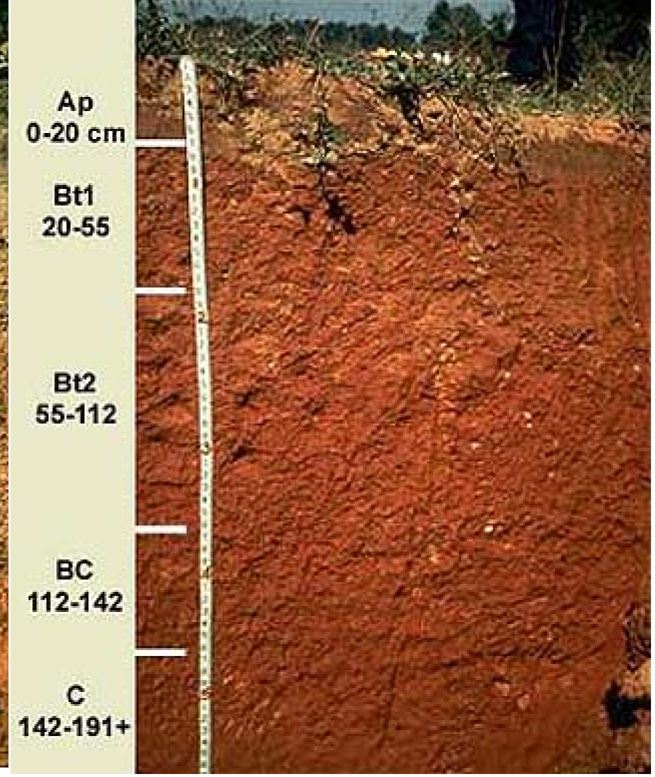
No

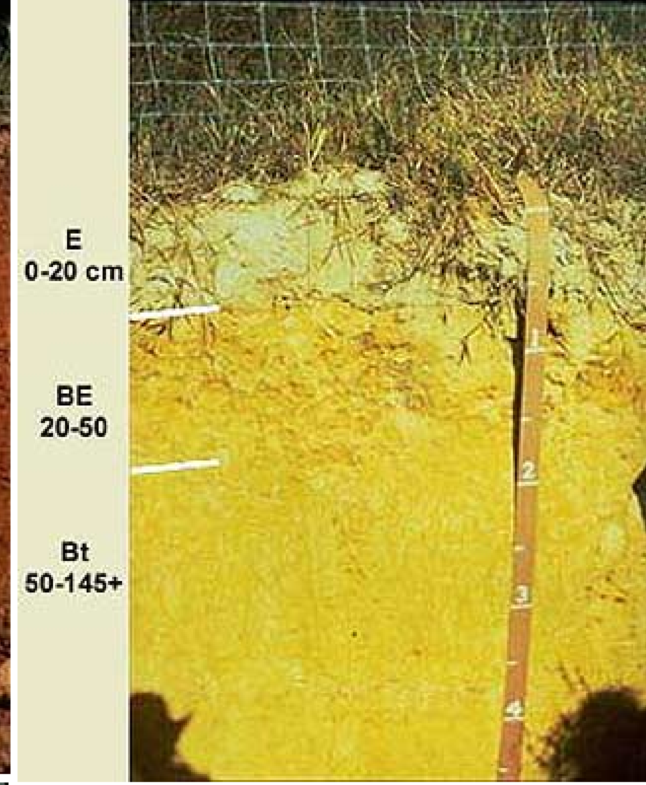
Soils with an argillic or kandic horizon or fragipan and a base saturation of <35% at 2 m depth or 75 cm below a fragipan — Yes → Ultisols

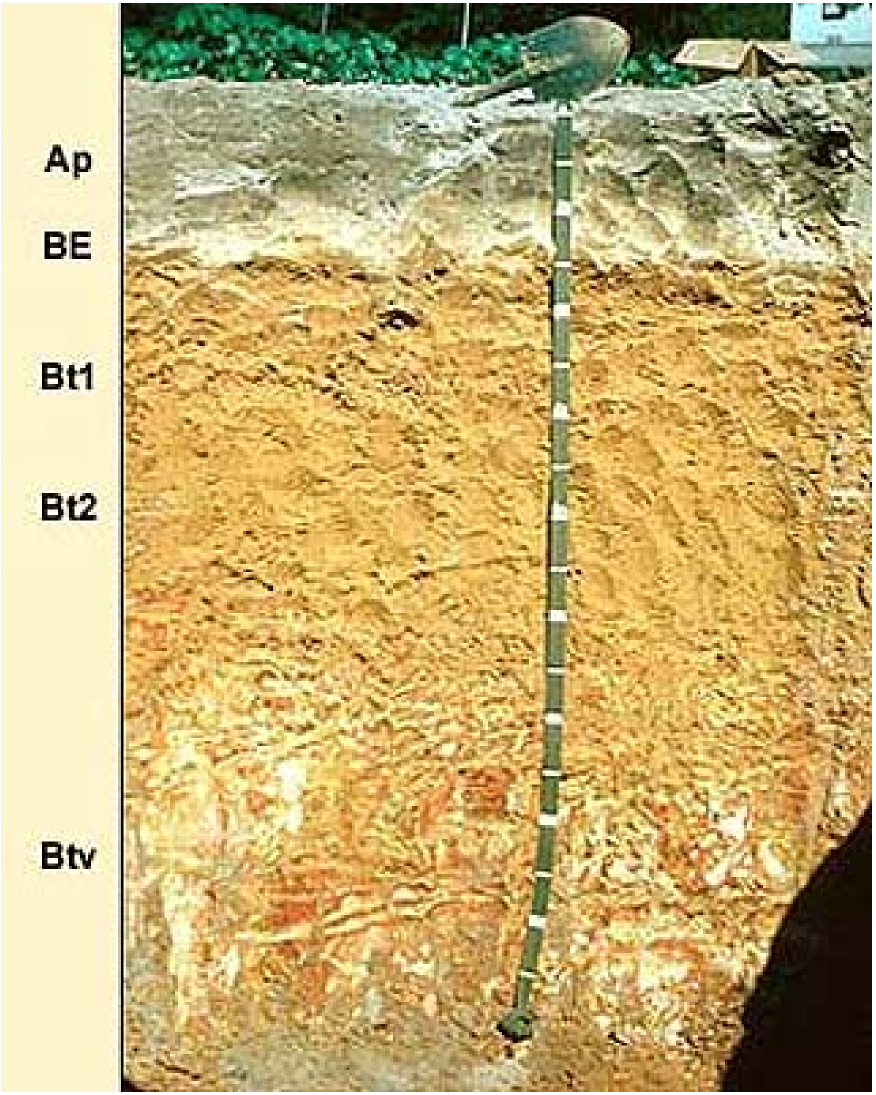
No




A
0-8 cm
E
8-18
Bt
18-66
C
66+


Ap
0-20 cm
Bt1
20-55
Bt2
55-112
BC
112-142
C
142-191+


E
0-20 cm
BE
20-50
Bt
50-145+

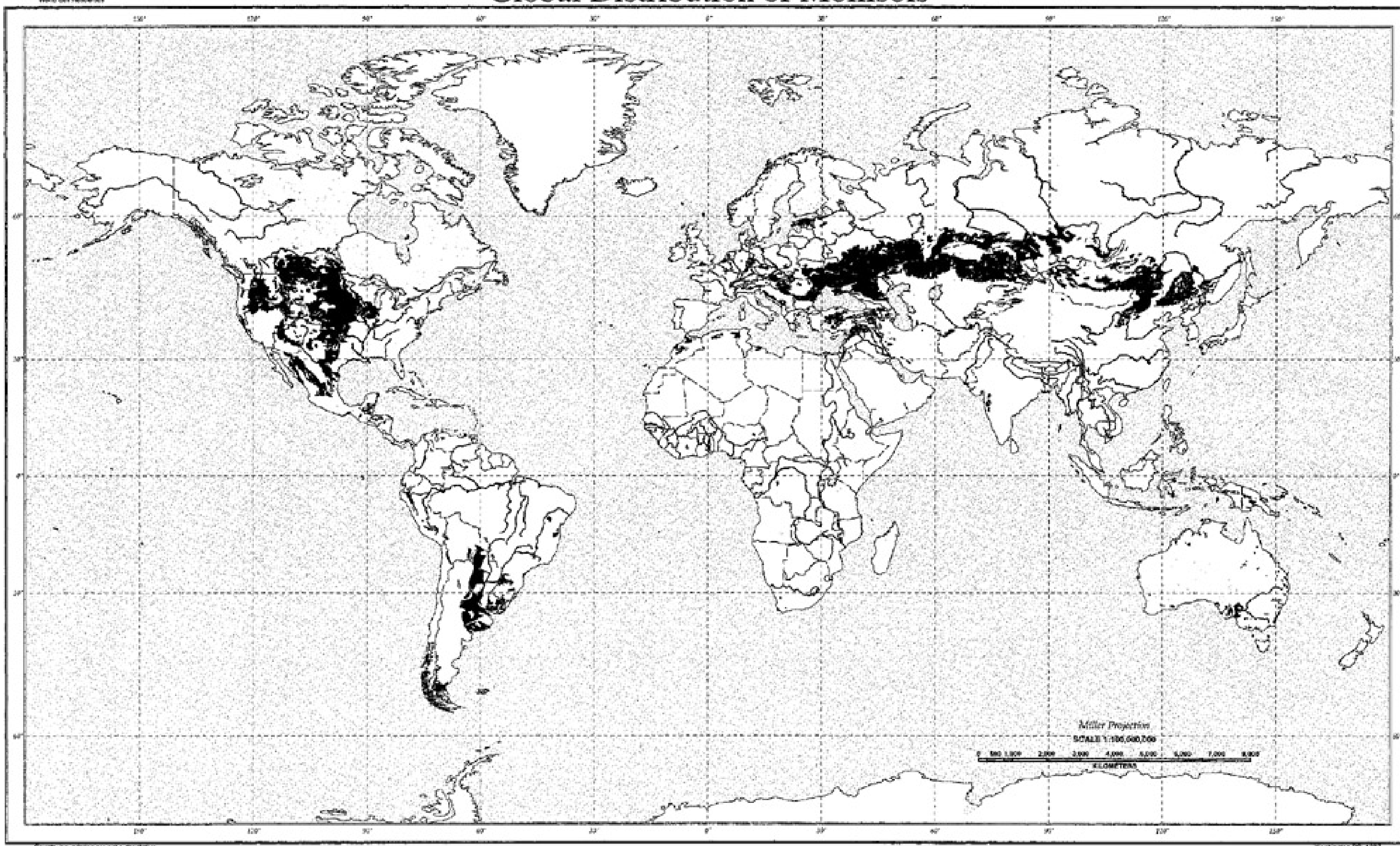

Ap
BE
Bt1
Bt2
Btv

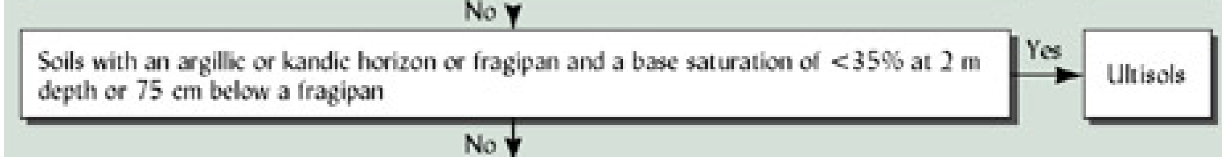
MOLLISOLS

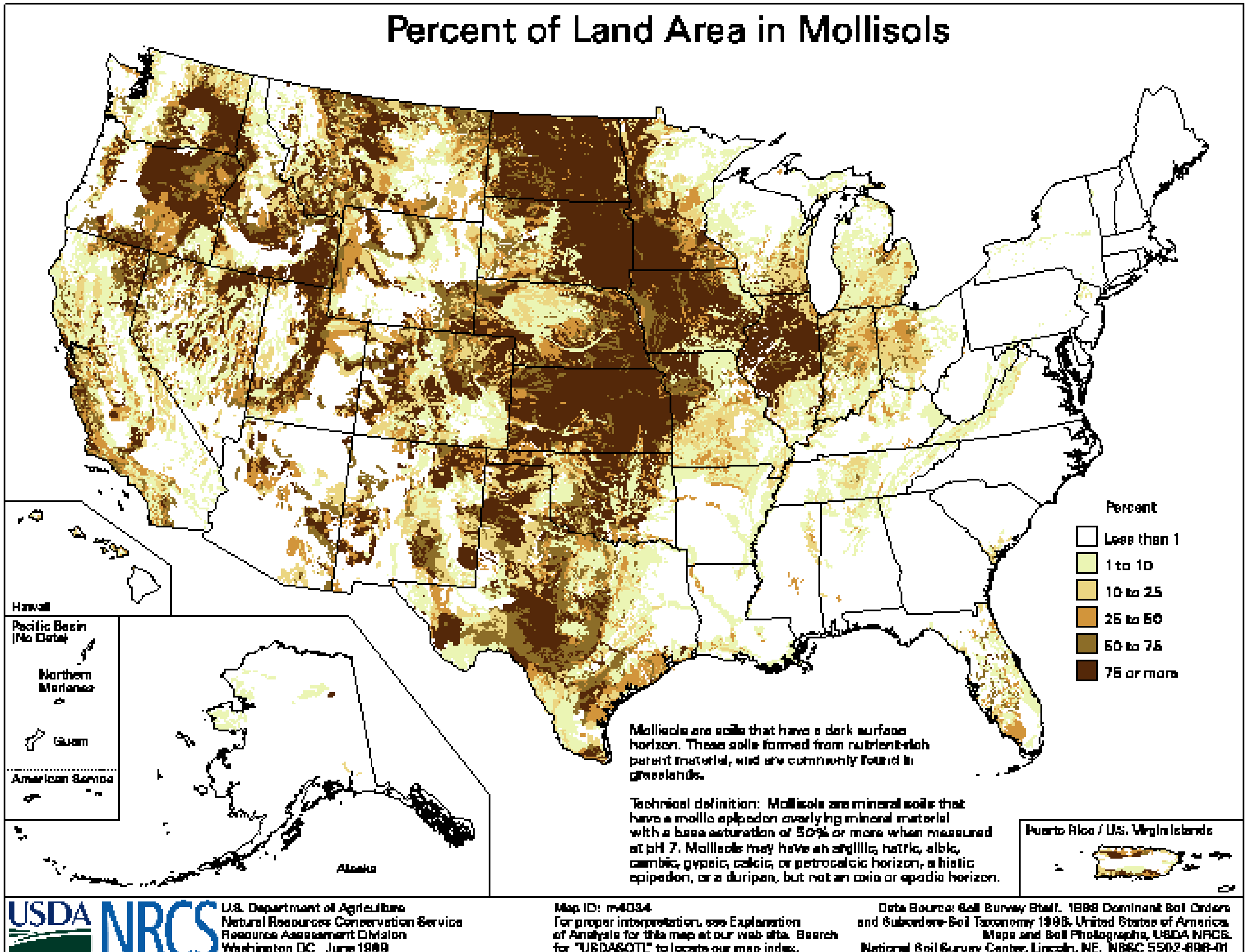
High surface accumulation of organic matter
Surface horizon is dark, high in bases, well-structured
Dominant natural vegetation is prairie grasses

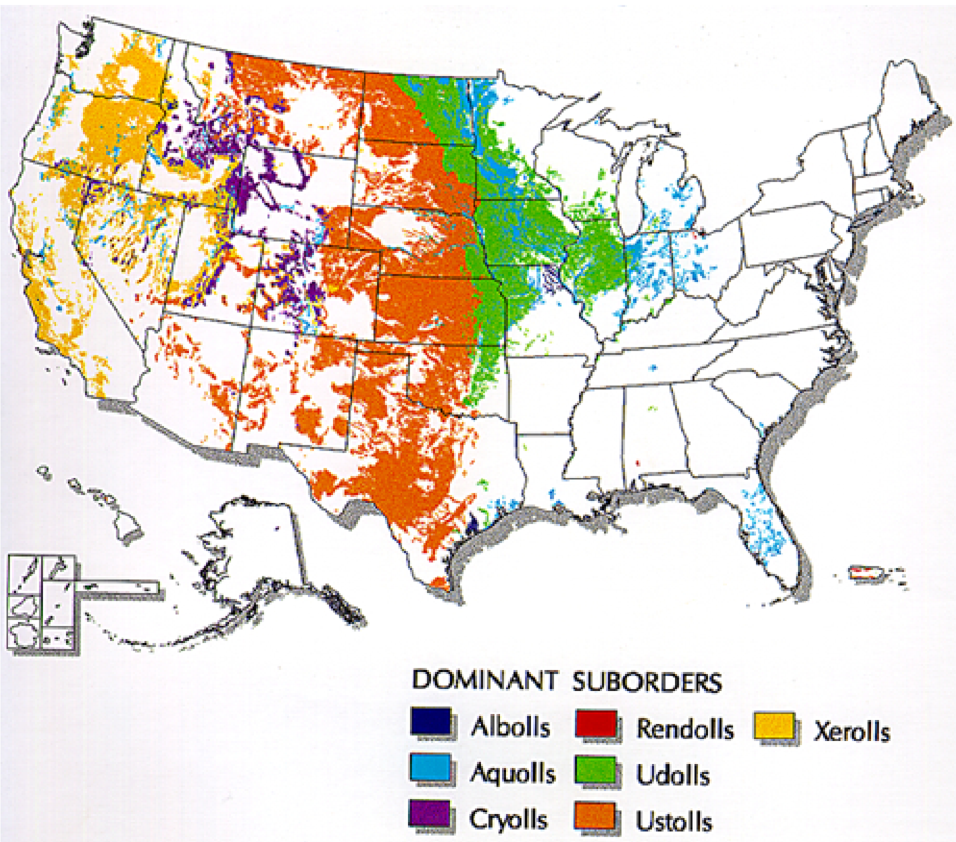
U.S. Dept. of Agriculture

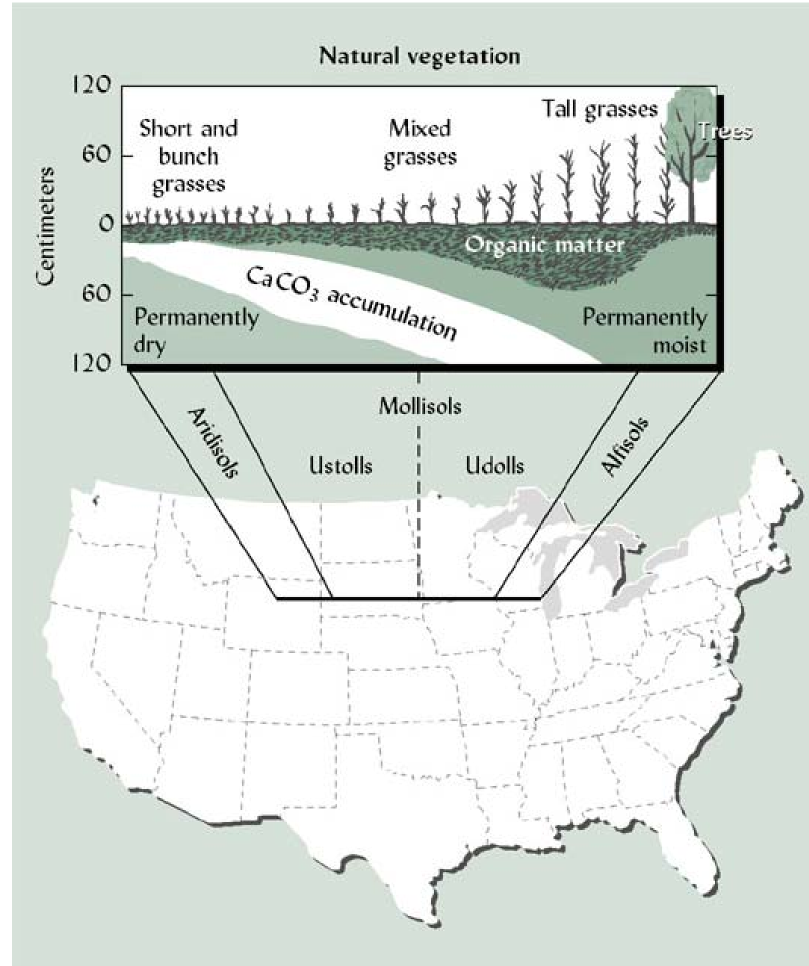
Global Distribution of Mollisols



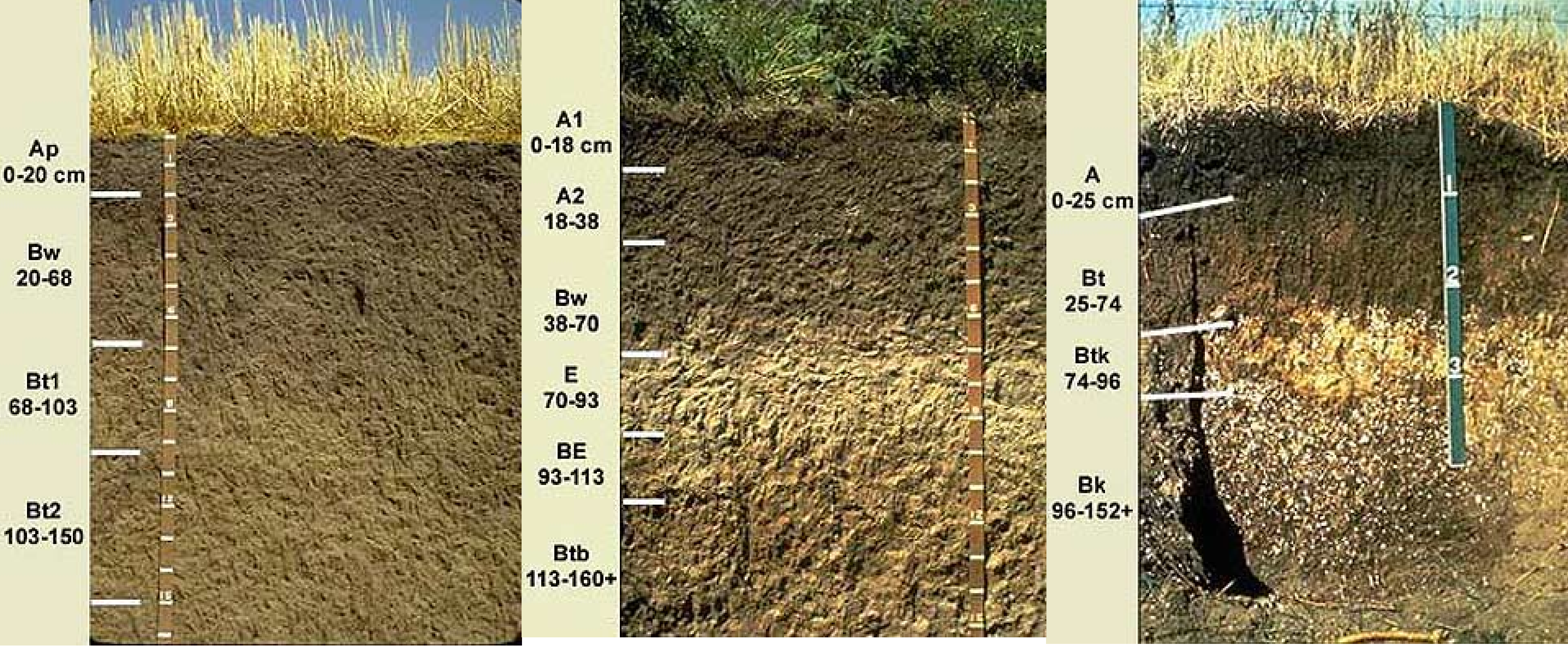

No
Soils with an argillic or kandic horizon or fragipan and a base saturation of <35% at 2 m depth or 75 cm below a fragipan
Yes
Ultisols
No


Percent of Land Area in Mollisols
Percent
Less than 1
1 to 10
10 to 25
25 to 50
50 to 75
75 or more
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska
Puerto Rico / U.S. Virgin Islands
Mollisols are soils that have a dark surface horizon. These soils formed from nutrient-rich parent material, and are commonly found in grasslands.
Technical definition: Mollisols are mineral soils that have a mollic epipedon overlying mineral material with a base saturation of 50% or more when measured at pH 7. Mollisols may have an argillic, natric, albic, cambic, gypsic, calcic, or petrocalcic horizon, a histic epipedon, or a duripan, but not an oxic or spodic horizon.
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC June 1999
Map ID: m4034
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDASOTL" to locate our map index.
Data Source: Soil Survey Staff. 1998 Dominant Soil Orders and Suborders-Soil Taxonomy 1998. United States of America. Maps and Soil Photographs, USDA NRCS. National Soil Survey Center, Lincoln, NE. NSSC 5502-698-01


DOMINANT SUBORDERS
Albolls
Aquolls
Cryolls
Rendolls
Udolls
Ustolls
Xerolls

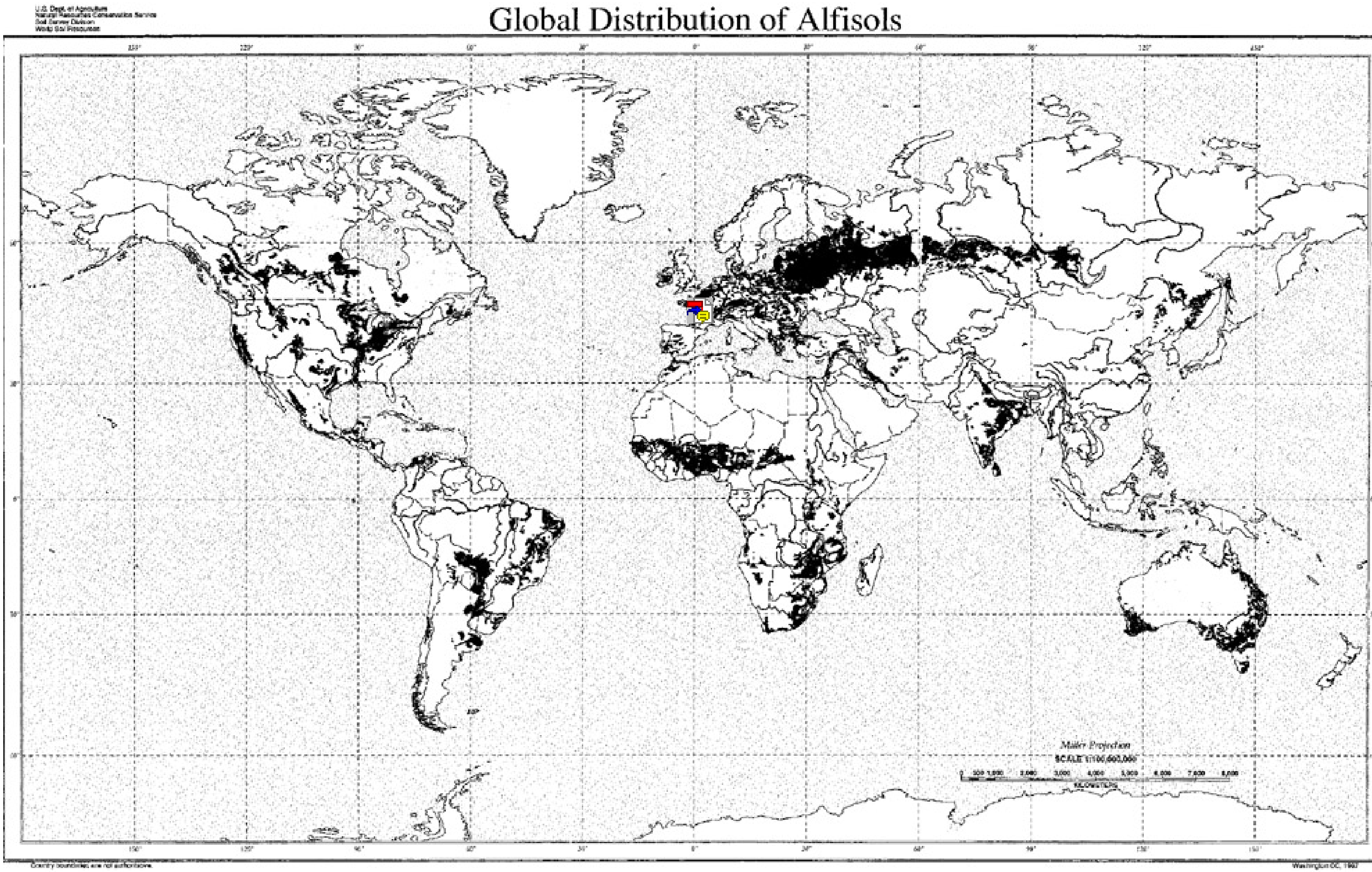

Natural vegetation
120
60
0
60
120
Centimeters
Short and bunch grasses
Mixed grasses
Tall grasses
Trees
Organic matter
$CaCO_3$ accumulation
Permanently dry
Permanently moist
Aridisols
Mollisols
Ustolls
Udolls
Alfisols


C
F
0
2
1
4
6
2
8
3
10
12
4
14
5

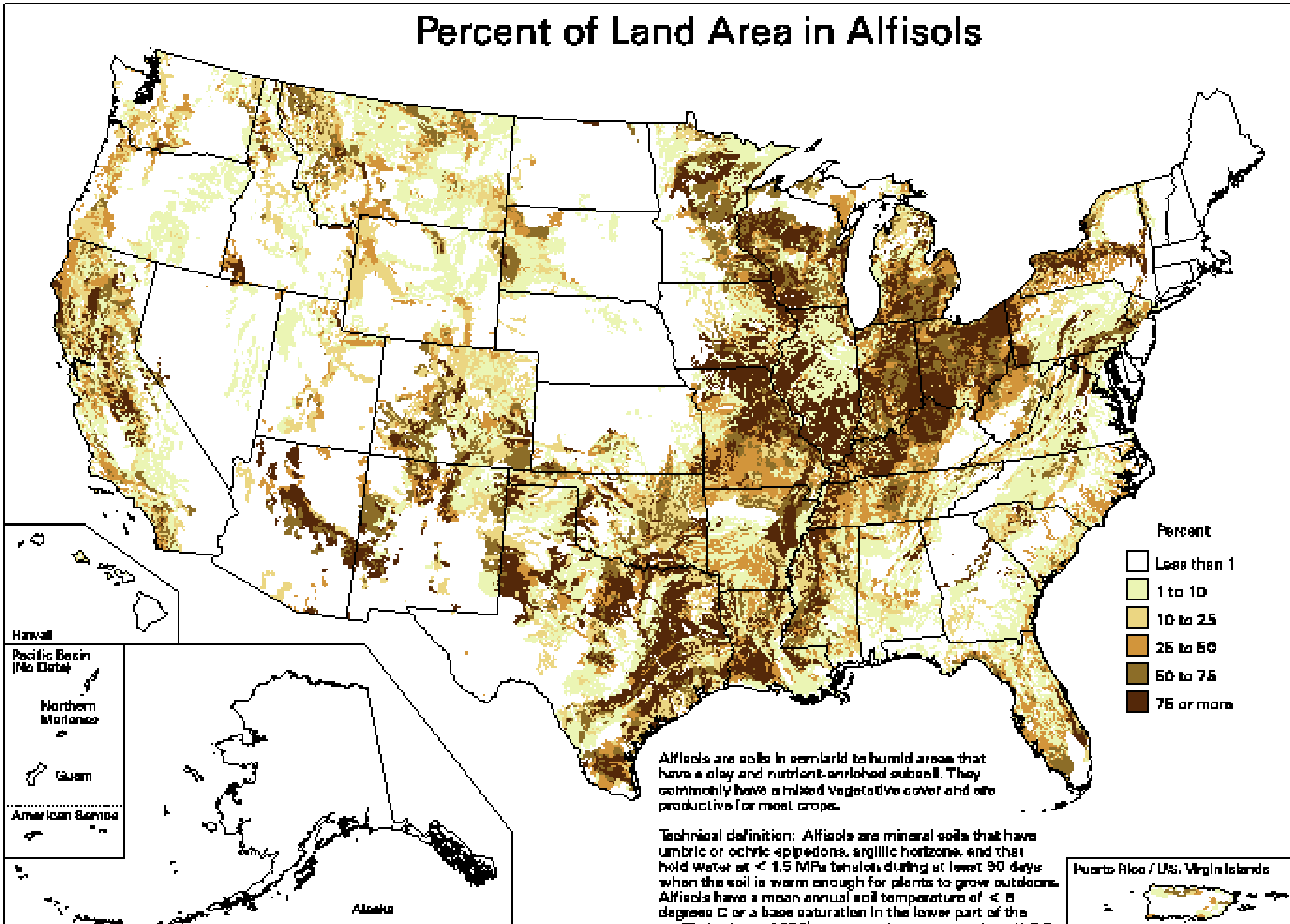


Ap
0-20 cm
Bw
20-68
Bt1
68-103
Bt2
103-150
A1
0-18 cm
A2
18-38
Bw
38-70
E
70-93
BE
93-113
Btb
113-160+
A
0-25 cm
Bt
25-74
Btk
74-96
Bk
96-152+

ALFISOLS

Accumulations of translocated clay in subsoil (B_t)
At least 35% base saturation
Little organic matter accumulation in surface

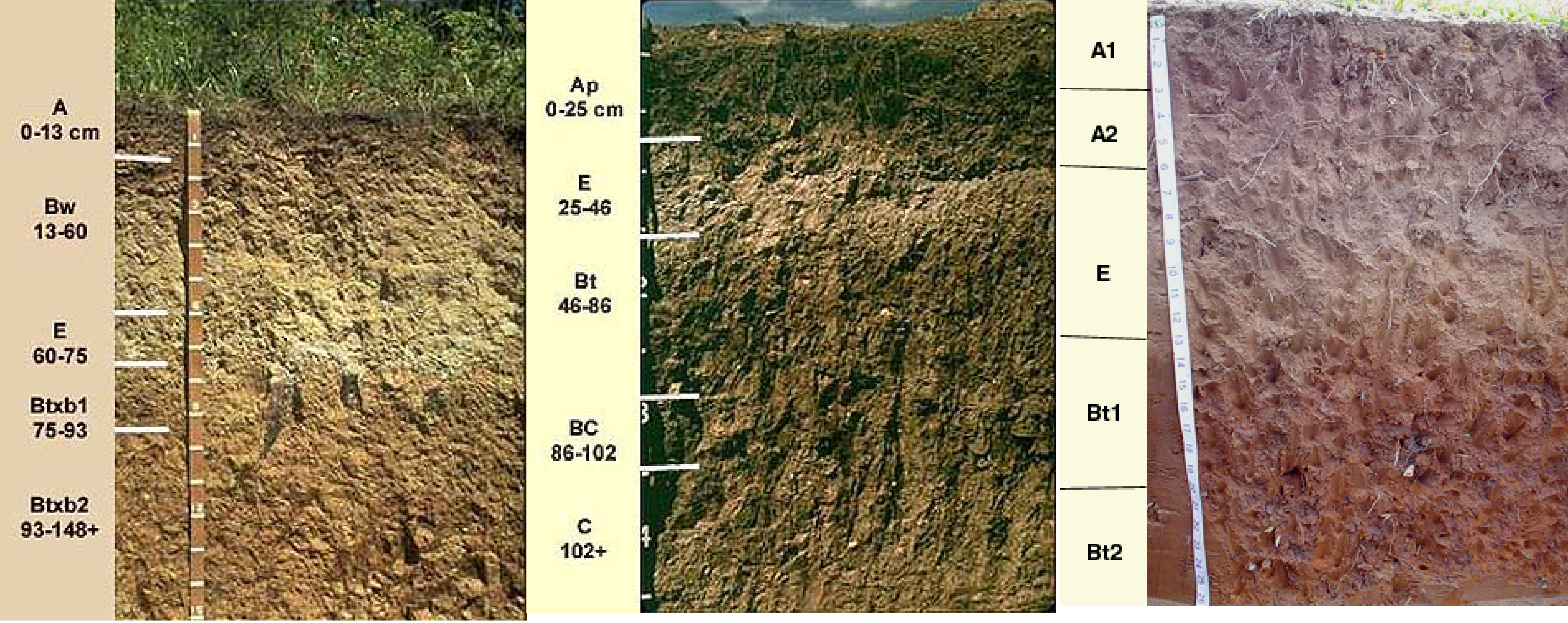



No
Soils with an argillic, kandic or natric horizon or a fragipan with clay skins
Yes
Alfisols
No


Percent of Land Area in Alfisols
Percent
Less than 1
1 to 10
10 to 25
25 to 50
50 to 75
75 or more
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska
Puerto Rico / U.S. Virgin Islands
Alfisols are soils in semiarid to humid areas that have a clay and nutrient-enriched subsoil. They commonly have a mixed vegetative cover and are productive for most crops.
Technical definition: Alfisols are mineral soils that have umbric or ochric epipedons, argillic horizons, and that hold water at < 1.5 MPa tension during at least 90 days when the soil is warm enough for plants to grow outdoors. Alfisols have a mean annual soil temperature of < 8 degrees C or a base saturation in the lower part of the argillic horizon of 35% or more when measured at pH 8.2.



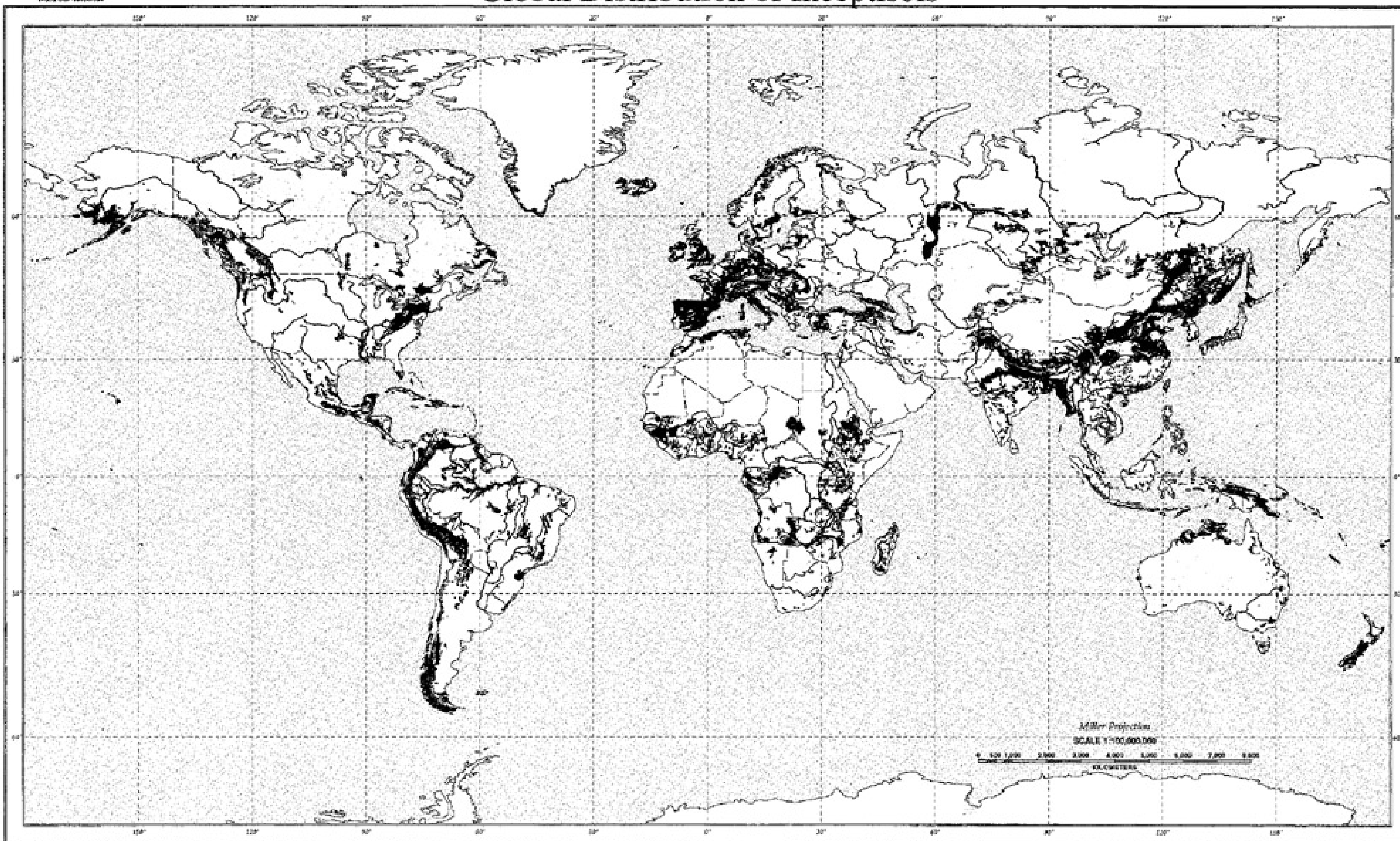

M
F
.2
1
.4
.6
2
.8
3
1
.2
4
.4
5
.6


A
0-13 cm
Bw
13-60
E
60-75
Btxb1
75-93
Btxb2
93-148+
Ap
0-25 cm
E
25-46
Bt
46-86
BC
86-102
C
102+
A1
A2
E
Bt1
Bt2

INCEPTISOLS

Horizons of alteration (<u>cambic</u> = structure or color)
Insufficient eluviation/illuviation to have an argillic horizon.

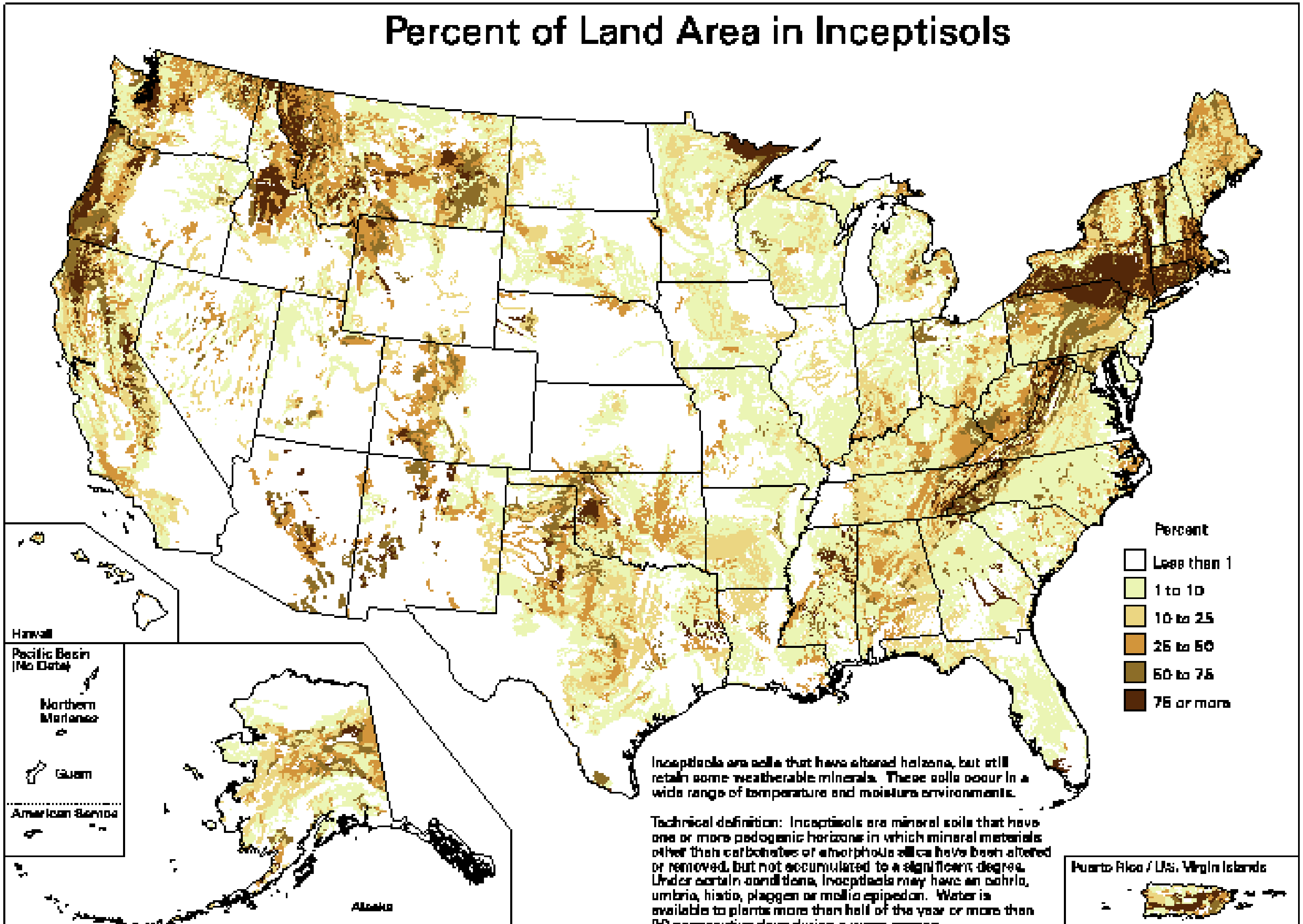
Global Distribution of Inceptisols



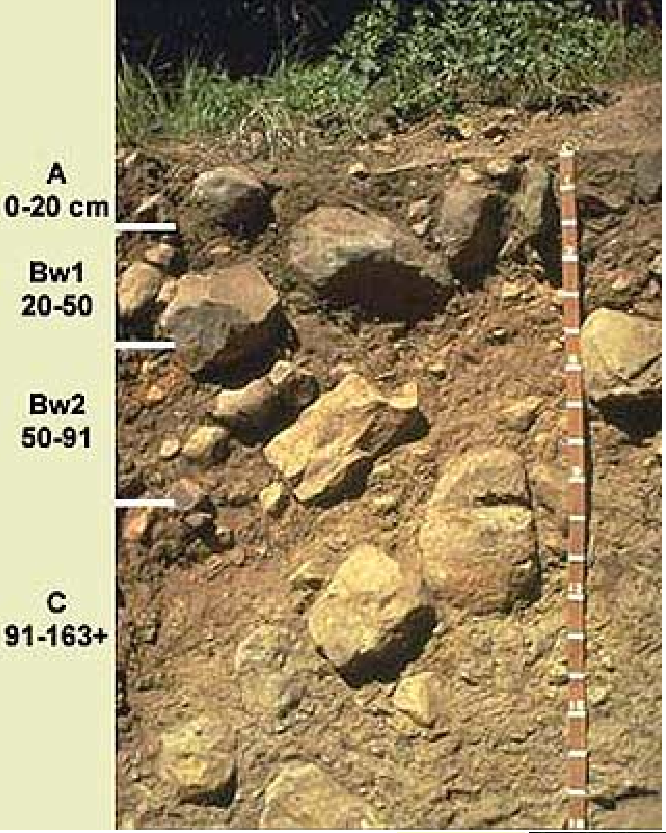
No

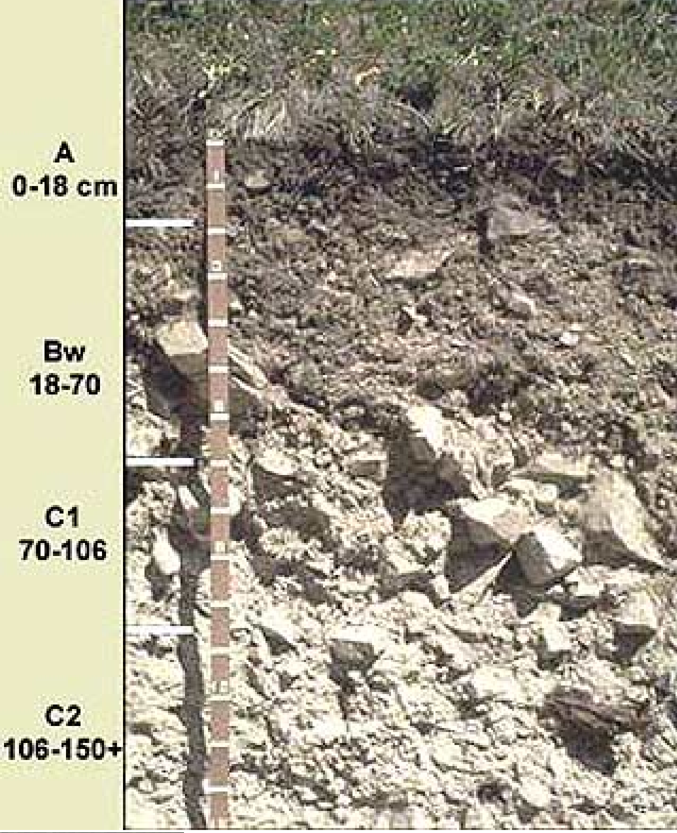
Soils with a cambic, sulfuric, calcic, gypsic, petrocalcic, or petrogypsic horizon, or with a mollic, umbric, or histic epipedon, or with an exchangeable sodium percentage (ESP) of >15%, or a fragipan → Yes → Inceptisols

No




UNION USA
UnionTools


A
0-20 cm
Bw1
20-50
Bw2
50-91
C
91-163+

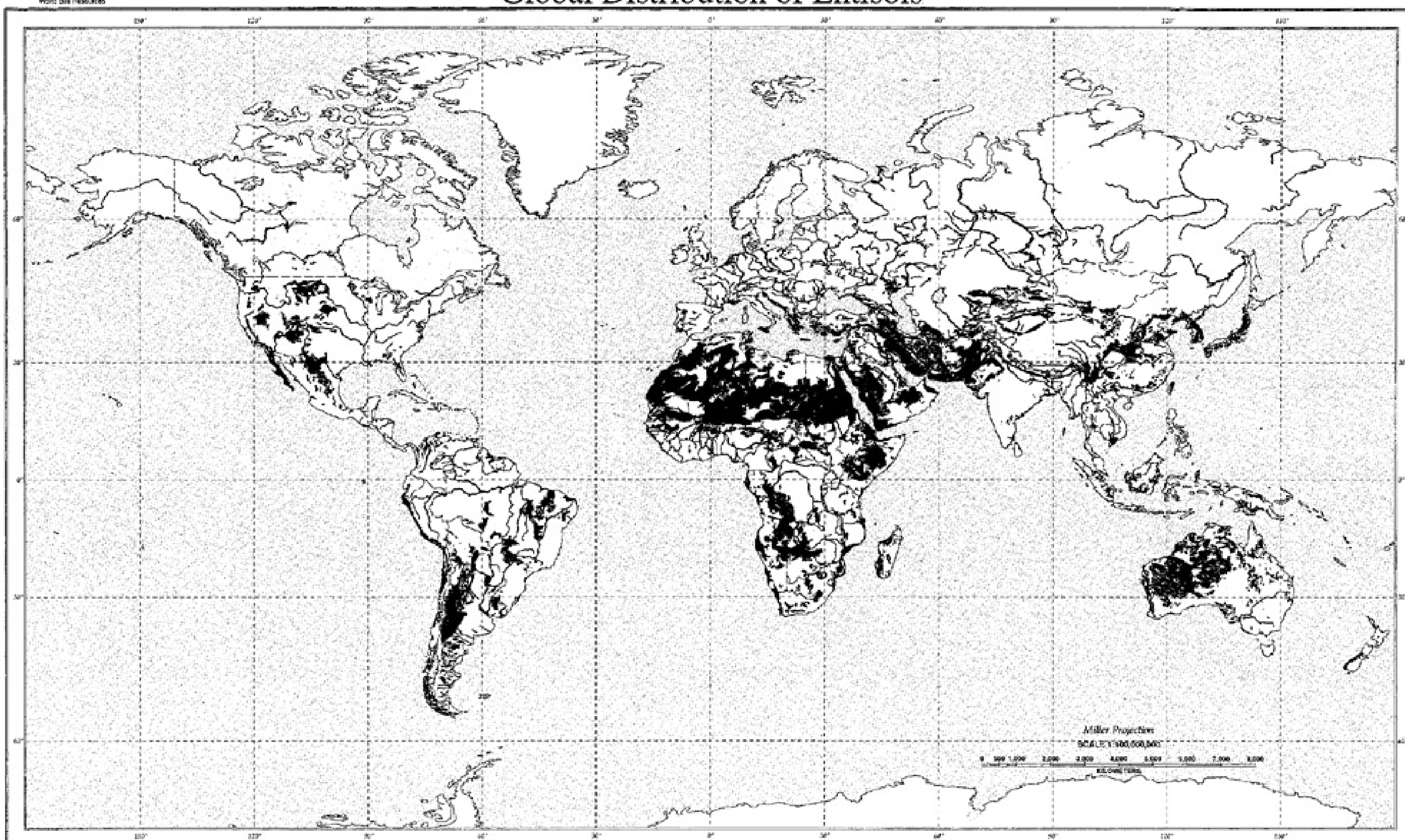

A
0-18 cm
Bw
18-70
C1
70-106
C2
106-150+

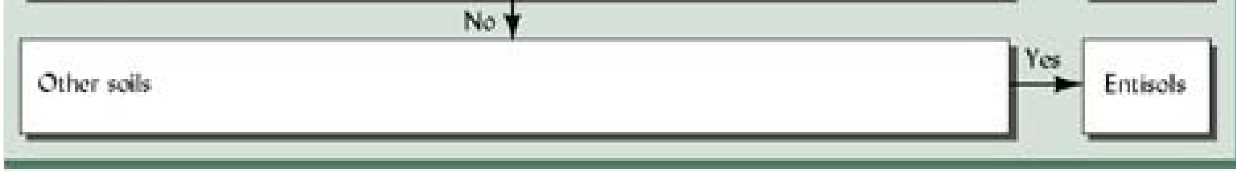

A
0-28 cm
Bw
18-31
R
31+

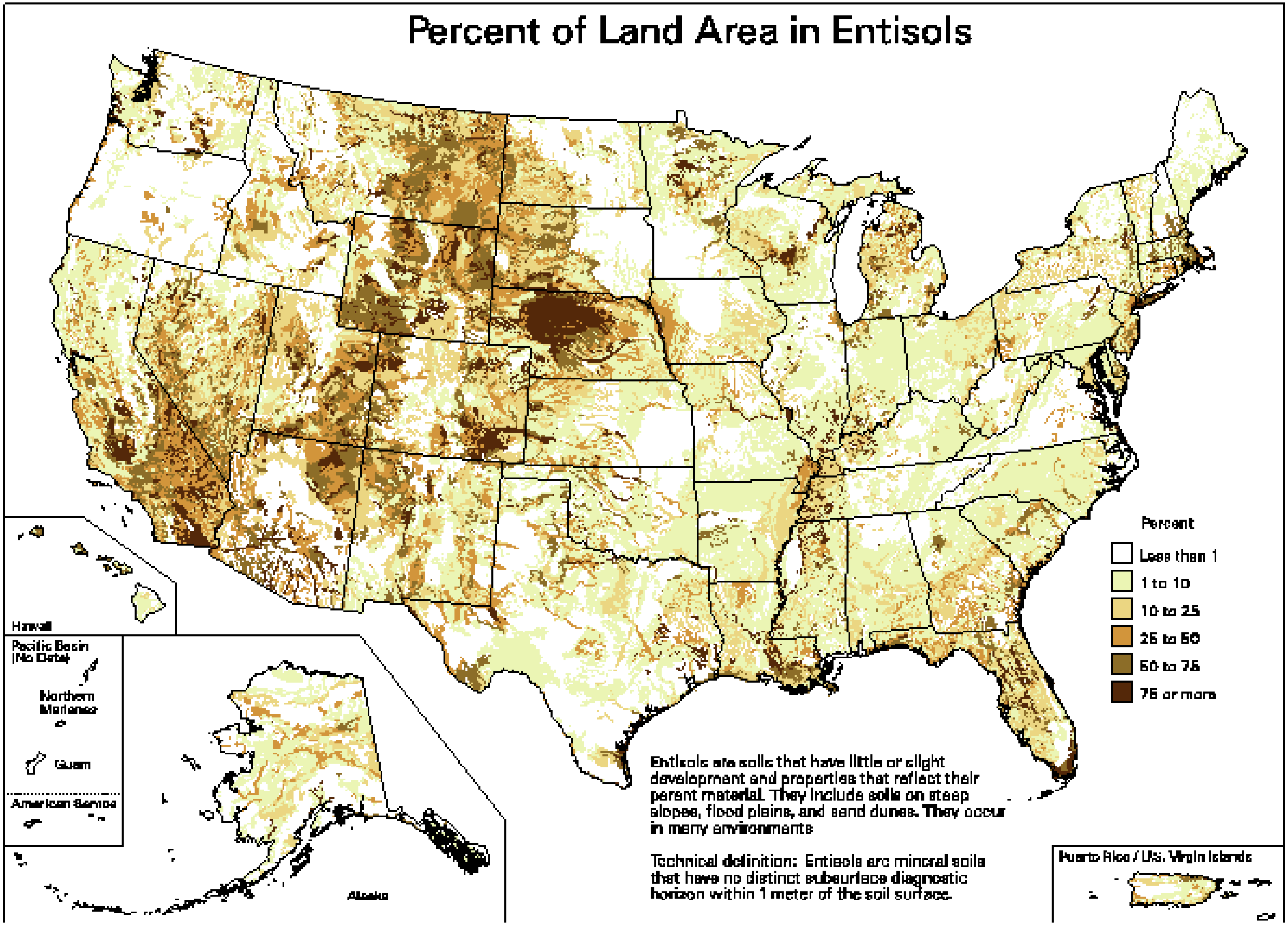
ENTISOLS

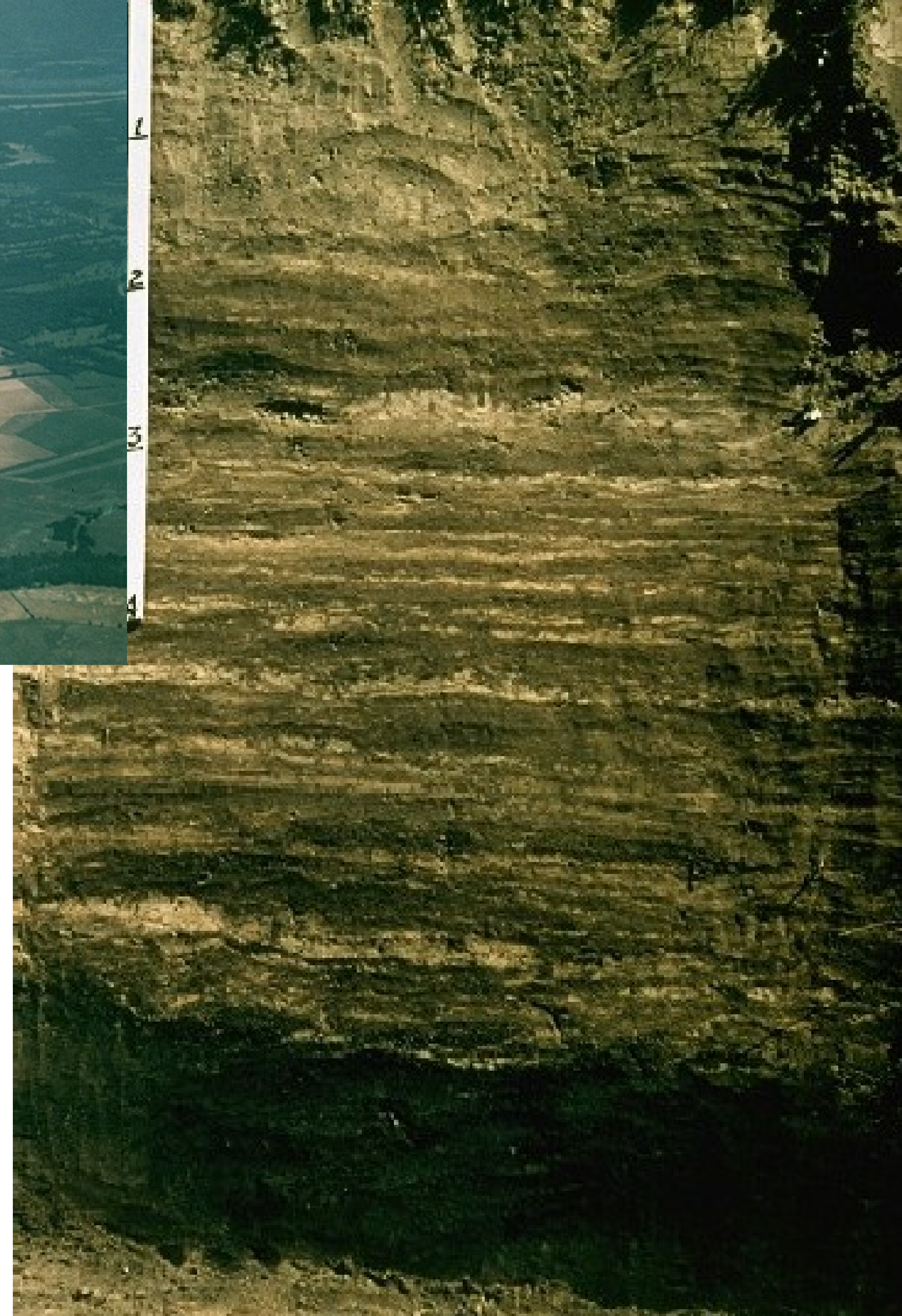
Do not shrink-swell
Not well-developed, young soils
Found in all climates, vegetation

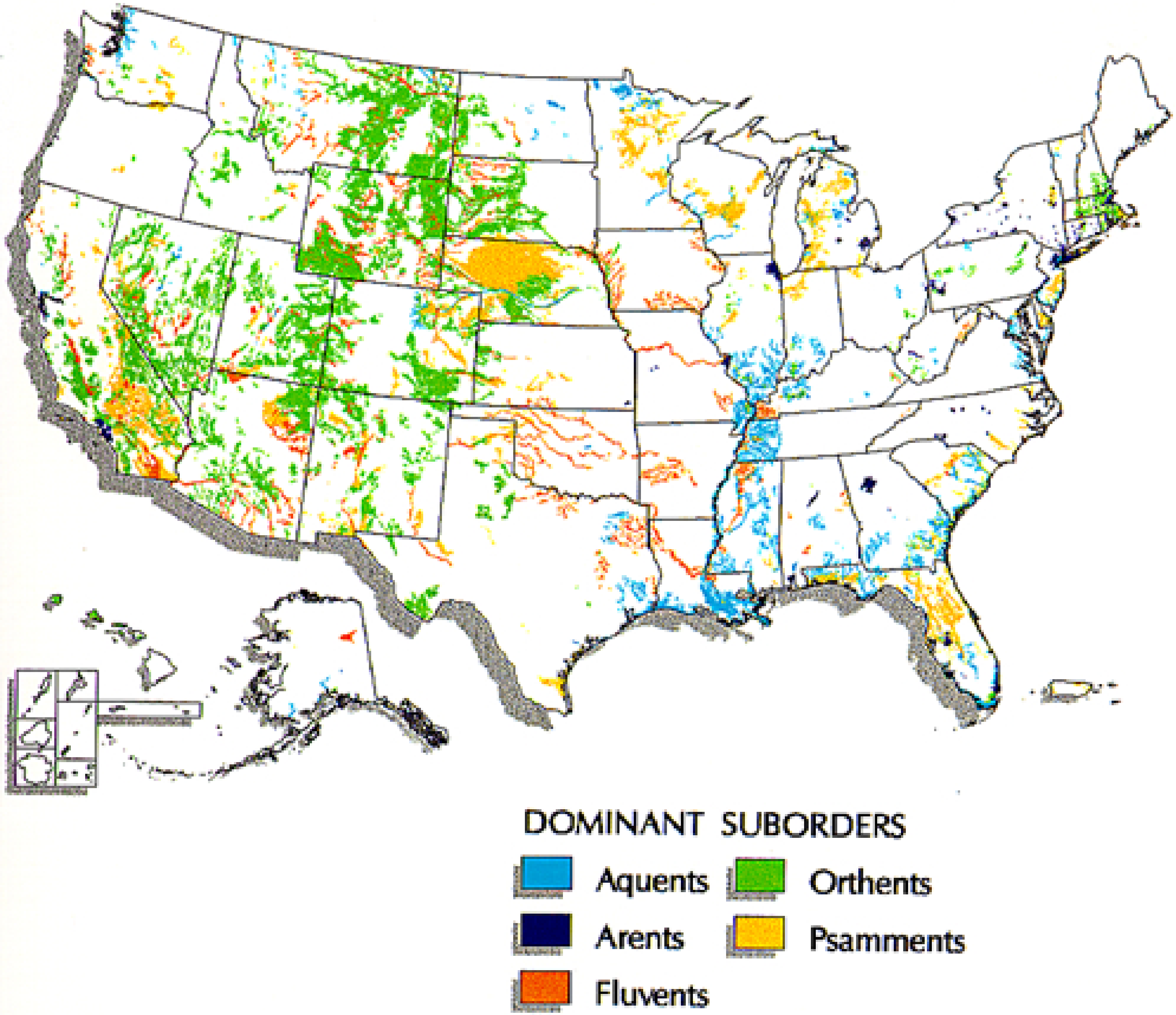
Global Distribution of Entisols




No
Other soils
Yes
Entisols


Percent of Land Area in Entisols
Percent
Less than 1
1 to 10
10 to 25
25 to 50
50 to 75
75 or more
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska
Puerto Rico / U.S. Virgin Islands
Entisols are soils that have little or slight development and properties that reflect their parent material. They include soils on steep slopes, flood plains, and sand dunes. They occur in many environments.
Technical definition: Entisols are mineral soils that have no distinct subsurface diagnostic horizon within 1 meter of the soil surface.


1
2
3
4


DOMINANT SUBORDERS
Aquents
Orthents
Arents
Psamments
Fluvents

A
0-10 cm

R
10-86

Ap
0-15 cm

C1
15-90

C2
90-150

TABLE 3.4 Approximate Land Areas of Different Soil Orders as Percentages of the Ice-Free Land in the World and in the United States

The major land use and natural fertility status of these soils are also given.

	Percent of ice-free land[a]			
Soil order	Global[b]	United States[c]	Major land uses	Natural fertility
Alfisols	9.65	14.51	Crops, forests, range	High
Andisols	0.70	1.74	Tundra, forests, crops	Moderate to high
Aridisols	12.10	8.78	Range, crops	Low to moderate
Entisols	16.29	12.16	Range, forest, crops, wetlands	Low to moderate
Gelisols	8.61	7.50	Tundra, bogs	Moderate
Histosols	1.18	1.28	Wetlands, crops	Moderate to high
Inceptisols	9.91	9.11	Forests, range, crops	Low to High
Mollisols	6.94	22.40	Crops, range, wetlands	High
Oxisols	7.56	<0.01	Forests, crops	Low
Spodosols	2.58	3.27	Forests, crops	Low
Ultisols	8.52	9.61	Forests, crops	Low to moderate
Vertisols	2.44	1.72	Crops, range, wetlands	High
Shifting sands or rock	14.07	7.81		

[a] Total global ice-free land area = 129,788,231 km^2. Total U.S. land area estimated from STATSGO as 8,739,275 km^2.
[b] Global areas calculated from FAO world database by USDA/NRCS Soil Survey Division, World Soils Resources, Washington, D.C.
[c] U.S. areas calculated from State Soil Geographic Data Base (STATSGO) taxonomically amended in 1997 by USDA/NRCS Soil Survey Division, National Soil Survey Center, Lincoln, Nebraska.

TABLE 3.2 Comparison of the Classification of a Common Cultivated Plant, White Clover (*Trifolium repens*), and a Soil, Miami Series

Plant classification			*Soil classification*	
Phylum	Pterophyta	Increase specificity ↓	Order	Alfisols
Class	Angiospermae		Suborder	Udalfs
Subclass	Dicotyledoneae		Great Group	Hapludalfs
Order	Rosales		Subgroup	Oxyaquic Hapludalfs
Family	Leguminosae		Family	Fine loamy, mixed, mesic, active
Genus	*Trifolium*		Series	Miami
Species	*repens*		Phase[a]	Miami silt loam

[a] Technically not a category in *Soil Taxonomy* but used in field surveying. *Silt loam* refers to the texture of the A horizon.

Name	*Formative element*	*Derivation*	*Pronunciation*	*Major characteristics*
Alfisols	alf	Nonsense symbol	Ped*alf*er	Argillic, natric, or kandic horizon; high to medium base saturation
Andisols	and	Jap. *ando,* blacksoil	*And*esite	From volcanic ejecta, dominated by allophane or Al-humic complexes
Aridisols	id	L. *aridus,* dry	A*rid*	Dry soil, ochric epipedon, sometimes argillic or natric horizon
Entisols	ent	Nonsense symbol	Rec*ent*	Little profile development, ochric epipedon common
Gelisols	el	Gk. *gelid,* very cold	*Jel*ly	Permafrost, often with cryoturbation (frost churning)
Histosols	ist	Gk. *histos,* tissue	*Hist*ology	Peat or bog; >20% organic matter
Inceptisols	ept	L. *inceptum,* beginning	Inc*ept*ion	Embryonic soils with few diagnostic features, ochric or umbric epipedon, cambic horizon
Mollisols	oll	L. *mollis,* soft	M*olli*fy	Mollic epipedon, high base saturation, dark soils, some with argillic or natric horizons
Oxisols	ox	Fr. *oxide,* oxide	O*xi*de	Oxic horizon, no argillic horizon, highly weathered
Spodosols	od	Gk. *spodos,* wood ash	*Pod*zol; odd	Spodic horizon commonly with Fe, Al oxides and humus accumulation
Ultisols	ult	L. *ultimus,* last	*Ult*imate	Argillic or kandic horizon, low base saturation
Vertisols	ert	L. *verto,* turn	In*vert*	High in swelling clays; deep cracks when soil dry

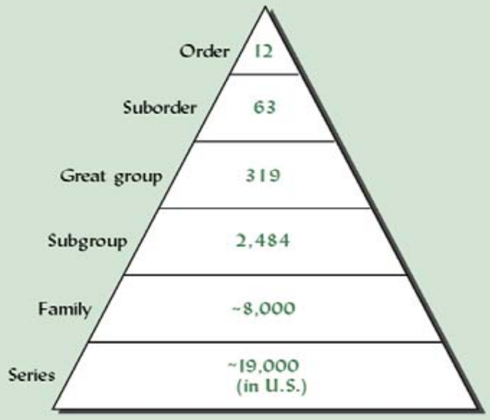


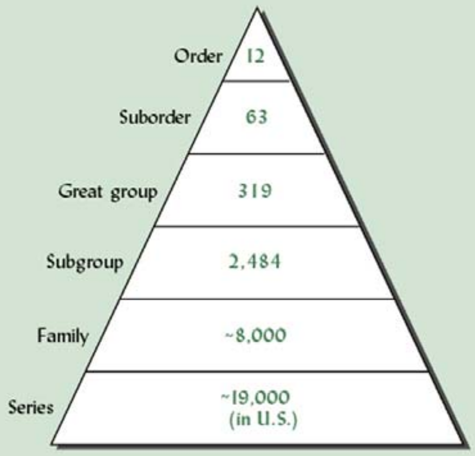
TABLE 3.5 Soil Orders and Suborders in *Soil Taxonomy*

Note that the ending of the suborder name identifies the order in which the soils are found.

Order	*Suborder*	*Order*	*Suborder*	*Order*	*Suborder*
Alfisols	Aqualfs Cryalfs Udalfs Ustalfs Xeralfs	Andisols	Aquands Cryands Torrands Udands Ustands Vitrands Xerands	Aridisols	Argids Calcids Cambids Cryids Durids Gypsids Salids
Entisols	Aquents Arents Fluvents Orthents Psamments	Gelisols	Histels Orthels Turbels	Histosols	Fibrists Folists Hemists Saprists
Inceptisols	Anthrepts Aquepts Cryepts Udepts Ustepts Xerepts	Mollisols	Albolls Aquolls Cryolls Rendolls Udolls Ustolls Xerolls	Oxisols	Aquox Perox Torrox Udox Ustox
Spodosols	Aquods Cryods Humods Orthods	Ultisols	Aquults Humults Udults Ustults Xerults	Vertisols	Aquerts Cryerts Uderts Usterts Xererts

TABLE 3.6 Formative Elements in Names of Suborders in *Soil Taxonomy*

Formative element	*Derivation*	*Connotation of formative element*
alb	L. *albus*, white	Presence of albic horizon (a bleached eluvial horizon)
anthr	Gk. *anthropos*, human	Presence of anthropic or plaggen epipedon
aqu	L. *aqua*, water	Characteristics associated with wetness
ar	L. *arare*, to plow	Mixed horizons
arg	L. *argilla*, white clay	Presence of argillic horizon (a horizon with illuvial clay)
calc	L. *calcis*, lime	Presence of calcic horizon
camb	L. *cambriare*, to change	Presence of cambric horizon
cry	Gk. *kryos*, icy cold	Cold
dur	L. *durus*, hard	Presence of a duripan
fibr	L. *fibra*, fiber	Least decomposed stage
fluv	L. *fluvius*, river	Floodplains
fol	L. *folia*, leaf	Mass of leaves
gyps	L. *gypsum*, gypsum	Presence of gypsic horizon
hem	Gk. *hemi*, half	Intermediate stage of decomposition
hist	Gk. *histos*, tissue	Presence of histic epipedon
hum	L. *humus*, earth	Presence of organic matter
orth	Gk. *orthos*, true	The common ones
per	L. *per*, throughout time	Of year-round humid climates, perudic moisture regime
psamm	Gk. *psammos*, sand	Sand textures
rend	Modified from Rendzina	Rendzinalike—high in carbonates
sal	L. *sal*, salt	Presence of salic (saline) horizon
sapr	Gk. *sapros*, rotten	Most decomposed stage
torr	L. *torridus*, hot and dry	Usually dry
turb	L. *turbidus*, disturbed	Cryoturbation
ud	L. *udus*, humid	Of humid climates
ust	L. *ustus*, burnt	Of dry climates, usually hot in summer
vitr	L. *vitreus*, glass	Resembling glass
xer	Gk. *xeros*, dry	Dry summers, moist winters



	Dominant feature of great group		
	Argillic horizon	*Archetypical with no distinguishing features*	*Old land surfaces*
Mollisols			
1. Aquolls (wet)	Argi*aquolls*	Hapl*aquolls*	—
2. Udolls (moist)	Argi*udolls*	Hapl*udolls*	Pale*udolls*
3. Ustolls (dry)	Argi*ustolls*	Hapl*ustolls*	Pale*ustolls*
4. Xerolls (Med.)[a]	Argi*xerolls*	Haplo*xerolls*	Pale*xerolls*
Alfisols			
1. Aqualfs (wet)	—	—	—
2. Udalfs (moist)	—	Hapl*udalfs*	Pale*udalfs*
3. Ustalfs (dry)	—	Hapl*ustalfs*	Pale*ustalfs*
4. Xeralfs (Med.)[a]	—	Haplo*xeralfs*	Pale*xeralfs*
Ultisols			
1. Aquults (wet)	—	—	Pale*aqults*
2. Udults (moist)	—	Hapl*udults*	Pale*udults*
3. Ustults (dry)	—	Hapl*ustults*	Pale*ustults*
4. Xerults (Med.)[a]	—	Haplo*xerults*	Pale*xerults*

[a] Med. = Mediterranean climate; distinct dry period in summer.

TABLE 3.7 Formative Elements for Names of Great Groups and Their Connotation

These formative elements combined with the appropriate suborder names give the great group names.

Formative element	*Connotation*	*Formative element*	*Connotation*	*Formative element*	*Connotation*
acr	Extreme weathering	fol	Mass of leaves	petr	Cemented horizon
agr	Agric horizon	fragi	Fragipan	plac	Thin pan
al	High aluminum, low iron	fragloss	See *frag* and *gloss*	plagg	Plaggen horizon
alb	Albic horizon	fulv	light-colored melanic horizon	plinth	Plinthite
and	Ando-like	gyps	Gypsic horizon	psamm	Sand texture
anhy	Anhydrous	gloss	Tongued	quartz	High quartz
aqu	Water saturated	hal	Salty	rhod	Dark red colors
argi	Argillic horizon	hapl	Minimum horizon	sal	Salic horizon
calc, calci	Calcic horizon	hem	Intermediate decomposition	sapr	Most decomposed
camb	Cambic horizon	hist	Presence of organic materials	somb	Dark horizon
chrom	High chroma	hum	Humus	sphagn	Sphagnum moss
cry	Cold	hydr	Water	sulf	Sulfur
dur	Duripan	kand	Low-activity 1:1 silicate clay	torr	Usually dry and hot
dystr, dys	Low base saturation	lithic	Near stone	ud	Humid climates
endo	Fully water saturated	luv, lu	Illuvial	umbr	Umbric epipedon
epi	Perched water table	melan	Melanic epipedon	ust	Dry climate, usually hot in summer
eutr	High base saturation	molli	With a mollic epipedon	verm	Wormy, or mixed by animals
ferr	Iron	natr	Presence of a natric horizon	vitr	Glass
fibr	Least decomposed	pale	Old development	xer	Dry summers, moist winters
fluv	Floodplain				

TABLE 3.9 Some Commonly Used Particle-Size, Mineralogy, Cation Exchange Activity, and Temperature Classes Used to Differentiate Soil Families.

The characteristics generally apply to the subsoil or 50 cm depth. Other criteria used to differentiate soil families (but not shown here) include the presence of calcareous or highly aluminum toxic (allic) properties, extremely shallow depth (shallow or micro), degree of cementation, coatings on sand grains, and the presence of permanent cracks.

		Cation exchange activity class[b]		*Soil temperature regime class*		
Particle-size class	*Mineralogy class*	*Term*	*CEC / % clay*	*Mean annual temperature, °C*	*>6°C difference between summer and winter*	*<6°C difference between summer and winter*
Ashy	Mixed	Superactive	0.60	<–10	Hypergelic[c]	—
Fragmental	Micaceous	Active	0.4 to 0.6	–4 to –10	Pergelic[c]	—
Sandy-skeletal[a]	Siliceous	Semiactive	0.24 to 0.4	+1 to –4	Subgelic[c]	—
Sandy	Kaolinitic	Subactive	<0.24	<+8	Cryic	—
Loamy	Smectitic			<+8	Frigid[d]	Isofrigid
Clayey	Gibbsitic			+8 to +15	Mesic	Isomesic
Fine-silty	Gypsic			+15 to +22	Thermic	Isothermic
Fine-loamy	Carbonic			>+22	Hyperthermic	Isohyperthermic
Etc.	Etc.					

[a] Skeletal refers to presence of up to 35% rock fragments by volume.

[b] Cation exchange activity class is not used for taxa already defined by low CEC (e.g., kandic or oxic groups).

[c] Permafrost present.

[d] Frigid is warmer in summer than Cryic.

Honeoye: New York State Soil

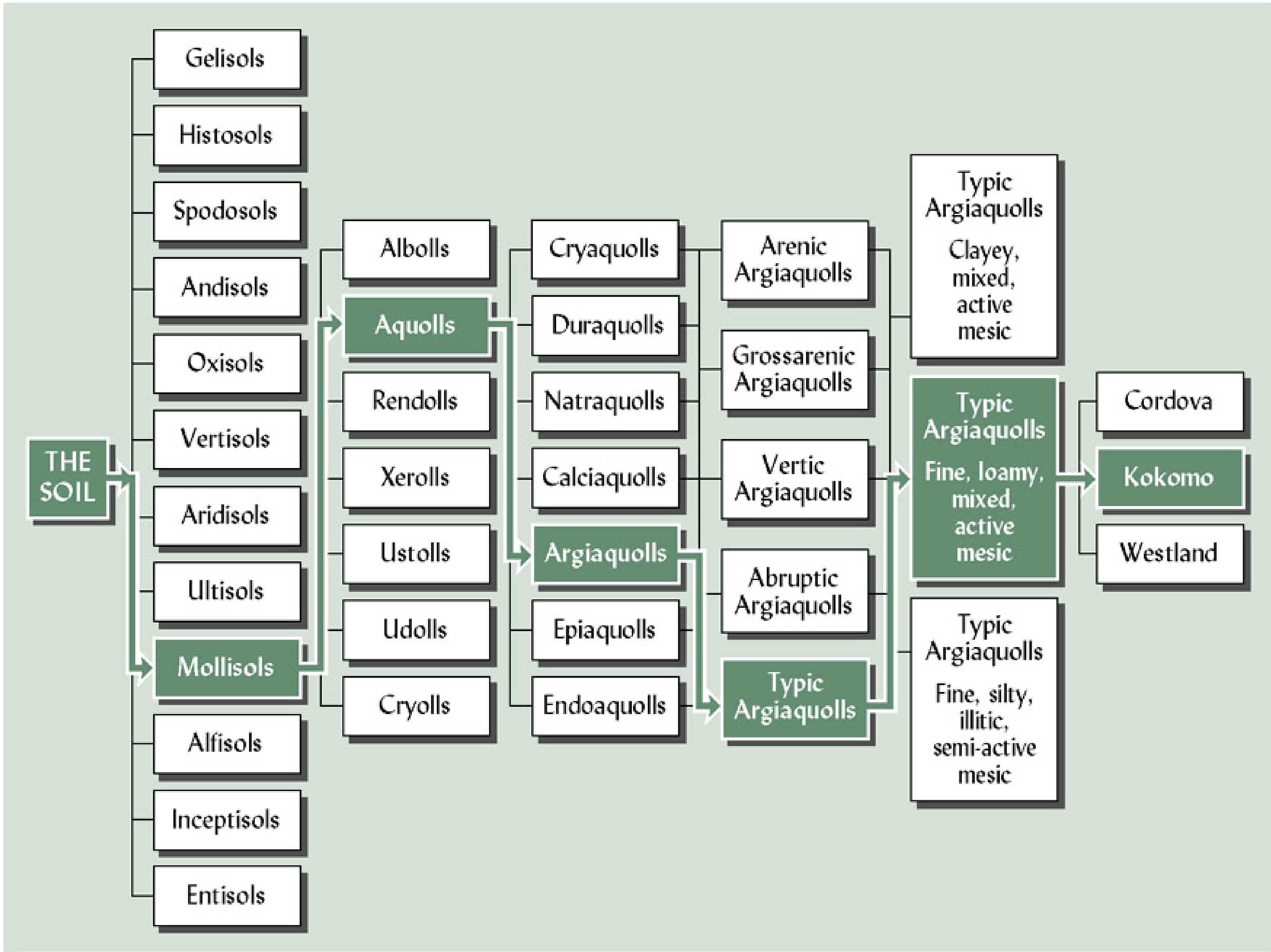
fine-loamy, mixed, active, mesic glossic Hapludalf

TABLE 3.9 Some Commonly Used Particle-Size, Mineralogy, Cation Exchange Activity, and Temperature Classes Used to Differentiate Soil Families.

The characteristics generally apply to the subsoil or 50 cm depth. Other criteria used to differentiate soil families (but not shown here) include the presence of calcareous or highly aluminum toxic (allic) properties, extremely shallow depth (shallow or micro), degree of cementation, coatings on sand grains, and the presence of permanent cracks.

		Cation exchange activity class[b]		*Soil temperature regime class*		
Particle-size class	*Mineralogy class*	*Term*	*CEC / % clay*	*Mean annual temperature, °C*	*>6°C difference between summer and winter*	*<6°C difference between summer and winter*
Ashy	Mixed	Superactive	0.60	<−10	Hypergelic[c]	—
Fragmental	Micaceous	Active	0.4 to 0.6	−4 to −10	Pergelic[c]	—
Sandy-skeletal[a]	Siliceous	Semiactive	0.24 to 0.4	+1 to −4	Subgelic[c]	—
Sandy	Kaolinitic	Subactive	<0.24	<+8	Cryic	—
Loamy	Smectitic			<+8	Frigid[d]	Isofrigid
Clayey	Gibbsitic			+8 to +15	Mesic	Isomesic
Fine-silty	Gypsic			+15 to +22	Thermic	Isothermic
Fine-loamy	Carbonic			>+22	Hyperthermic	Isohyperthermic
Etc.	Etc.					

[a] Skeletal refers to presence of up to 35% rock fragments by volume.
[b] Cation exchange activity class is not used for taxa already defined by low CEC (e.g., kandic or oxic groups).
[c] Permafrost present.
[d] Frigid is warmer in summer than Cryic.


THE SOIL
Gelisols
Histosols
Spodosols
Andisols
Oxisols
Vertisols
Aridisols
Ultisols
Mollisols
Alfisols
Inceptisols
Entisols
Albolls
Aquolls
Rendolls
Xerolls
Ustolls
Udolls
Cryolls
Cryaquolls
Duraquolls
Natraquolls
Calciaquolls
Argiaquolls
Epiaquolls
Endoaquolls
Arenic Argiaquolls
Grossarenic Argiaquolls
Vertic Argiaquolls
Abruptic Argiaquolls
Typic Argiaquolls
Typic Argiaquolls Clayey, mixed, active mesic
Typic Argiaquolls Fine, loamy, mixed, active mesic
Typic Argiaquolls Fine, silty, illitic, semi-active mesic
Cordova
Kokomo
Westland

Description of a Soil Series

- Arkport: Coarse-loamy, mixed, active, mesic Lamellic Hapludalfs
- Mardin: Coarse-loamy, mixed, active, mesic Typic Fragiudepts
- Bath: Coarse-loamy, mixed, active, mesic Typic Fragiudepts
- Collamer: Fine-silty, mixed, active, mesic Glossaquic Hapludalfs
- Hudson: Fine, illitic, mesic Glossaquic Hapludalfs