The Five Factors of Soil Formation and Horizonation vs. Simple Processes

W. Lee Daniels

wdaniels@vt.edu; 540-231-7175

Crop & Soil Environmental Sciences

VirginiaTech

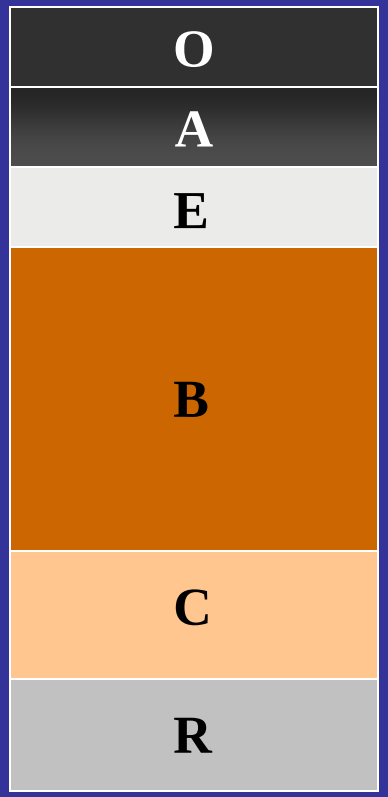
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

http://www.landrehab.org

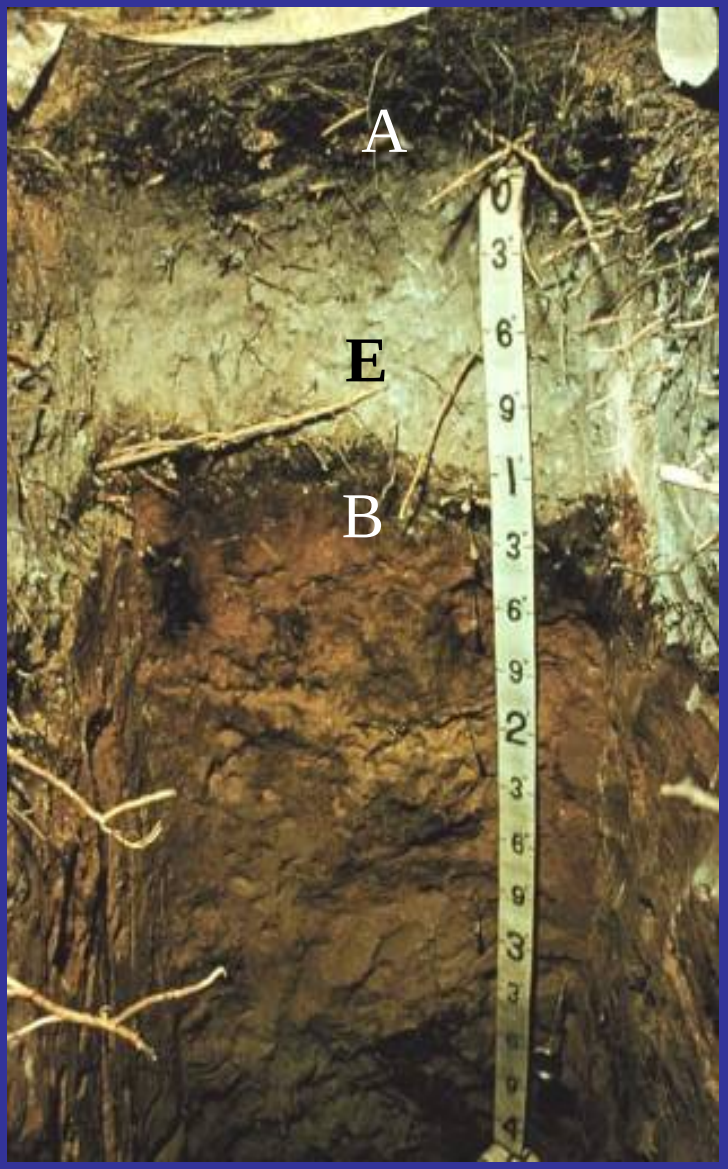
Typical sandy upland soil in the middle Coastal Plain in Virginia. Note layers (horizons) developed by organic matter accumulation and leaching of mobile clay and Fe.

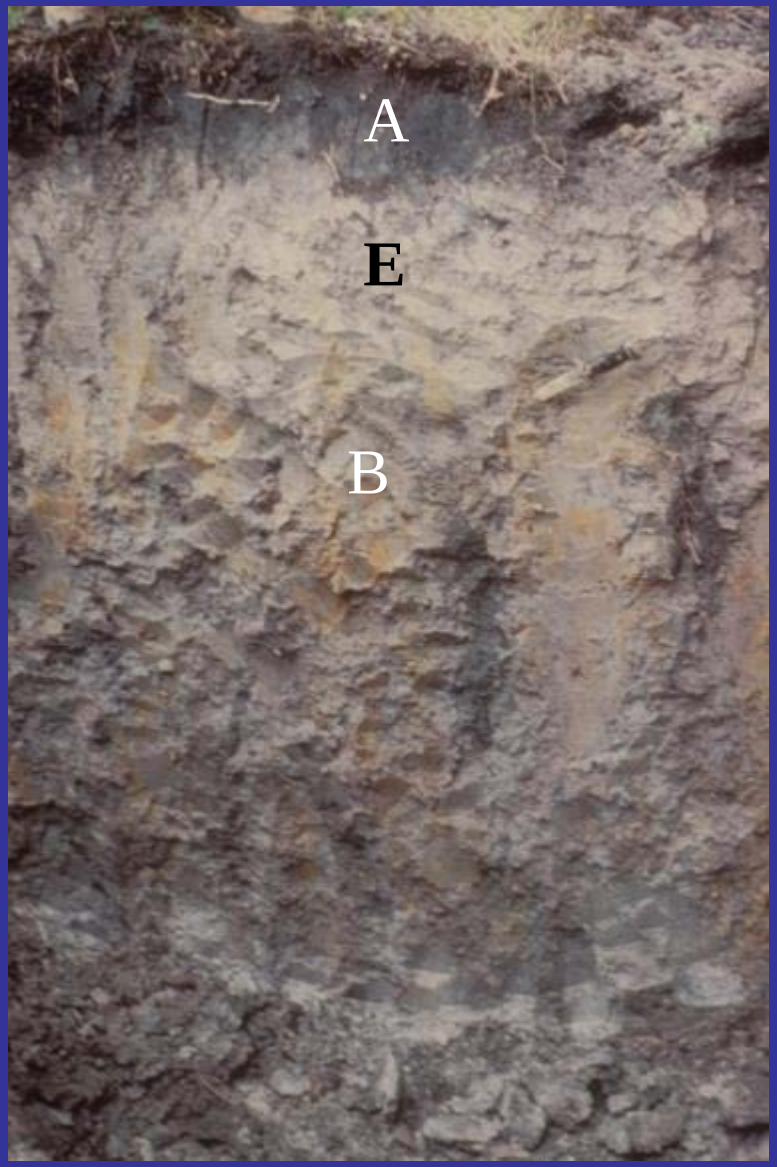
Master Horizons

- O horizon – Litter; organic soil materials
- A horizon – Mineral soil with OM
- E horizon – Leached of clay, Fe, OM
- B horizon – + Illuvial clay, Fe, OM
- C horizon – Weathered parent material
- R Layer – Hard underlying rock



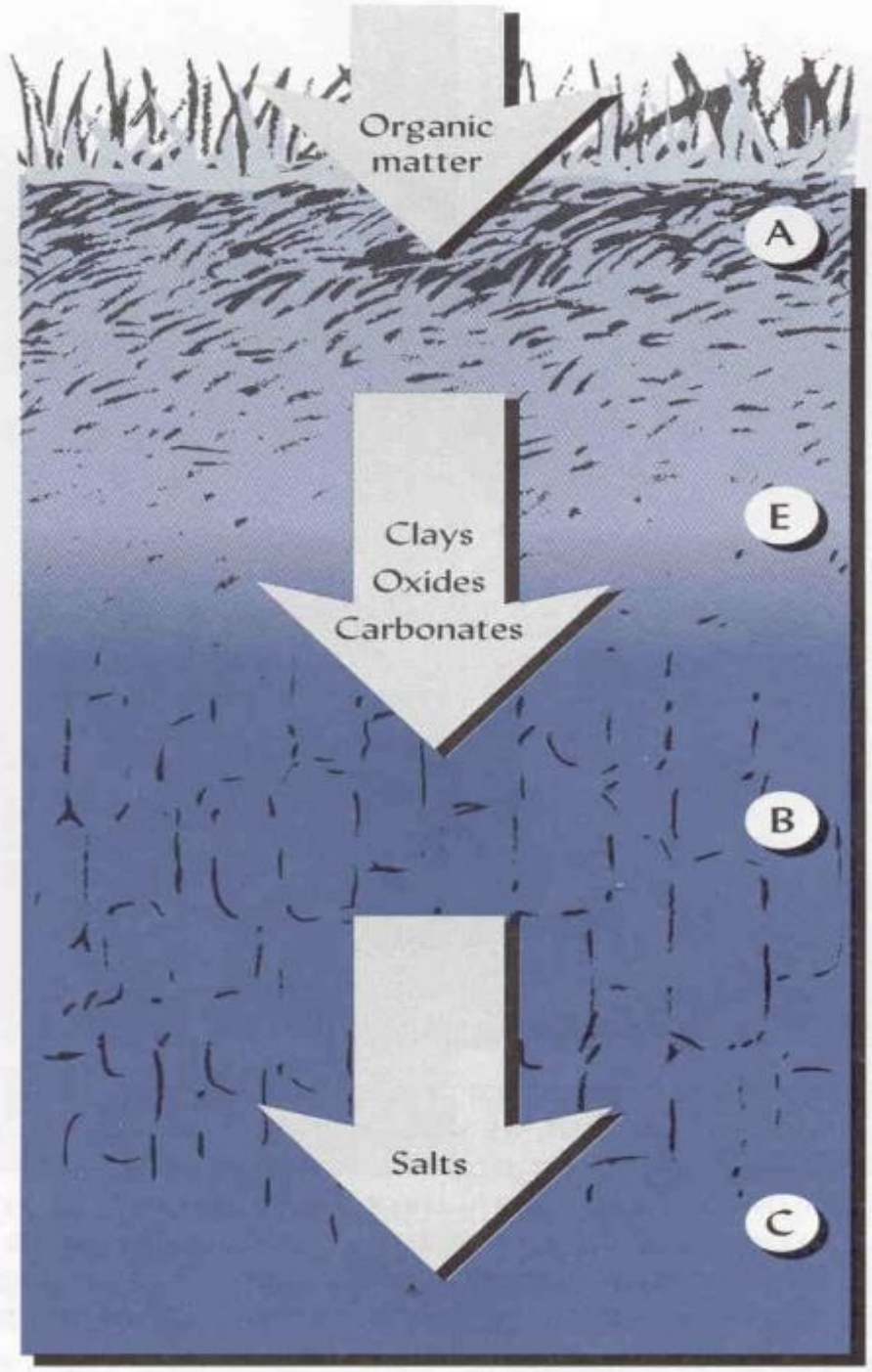
A, E and B horizons





Soils develop horizons due to the combined process of (1) organic matter deposition and decomposition and (2) illuviation of clays, oxides and other mobile compounds downward with the wetting front. In moist environments (e.g. Virginia) free salts (Cl and SO_4) are leached completely out of the profile, but they often accumulate in desert soils.

Fig. from Brady & Weil 2010



Soil Forming Factors

- **Parent Material** – mineral and organic
- **Climate** – rainfall/temp. drive the process
- **Organisms** – plants, animals, microbes, *people*?
- **Topography** – slope, aspect, landscape position
- **Time** – All four of the factors above are strongly interdependent and interact ***via soil forming processes*** over time to form soils.

A Few Soil Forming Processes

- **Organic matter (litter and roots) is added to soils and decomposes (turns over) into humus. This then leads to humus (organic matter) accumulation, but also generates soil acidity, particularly in uplands. *Wetland soils tend to accumulate OM since their saturation limits the rate of OM breakdown*.**

- **Weathering of sand-sized minerals like feldspars and micas produces clays and Fe-oxide coatings on soil surfaces.**

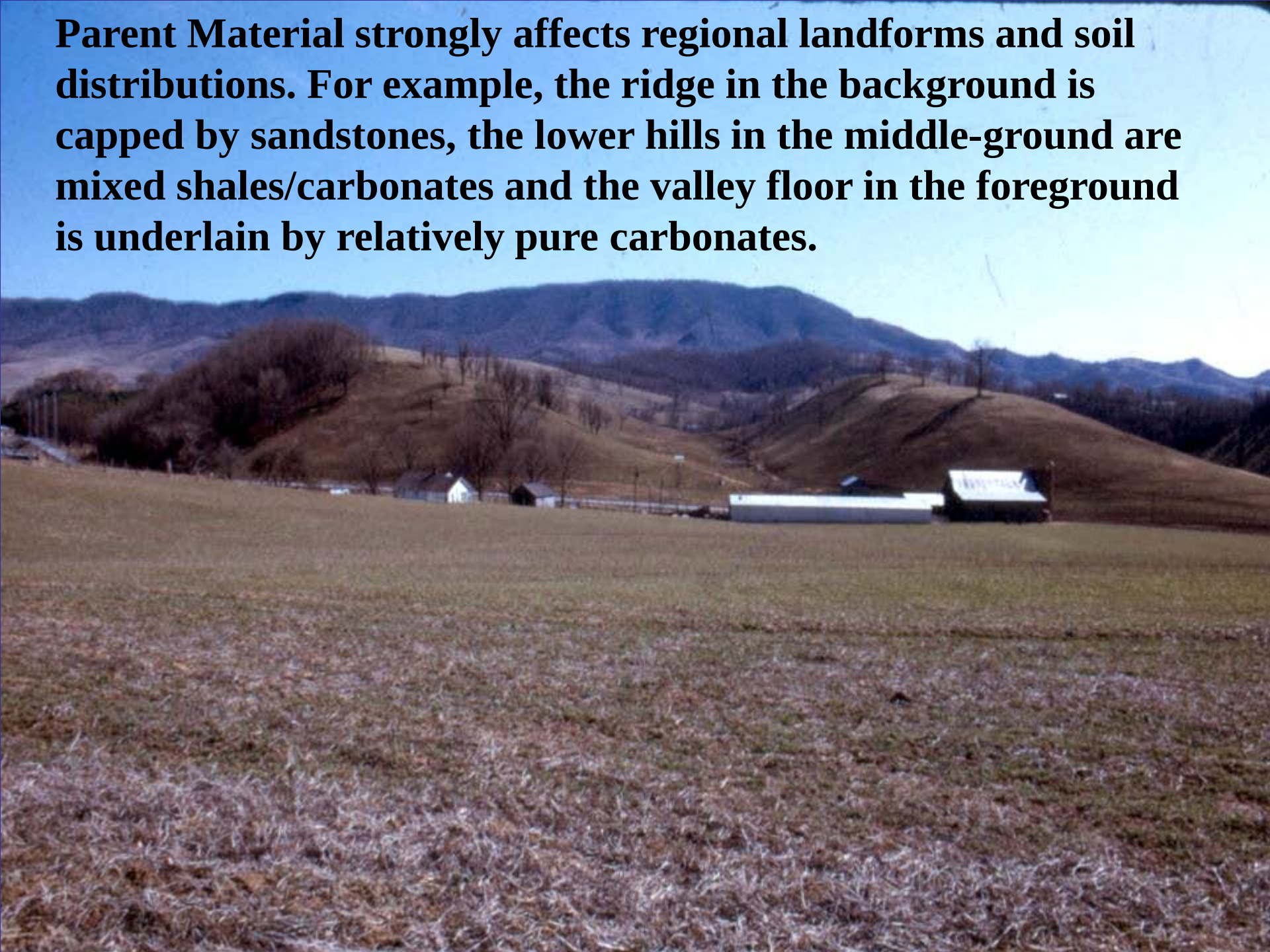
A Few Soil Forming Processes

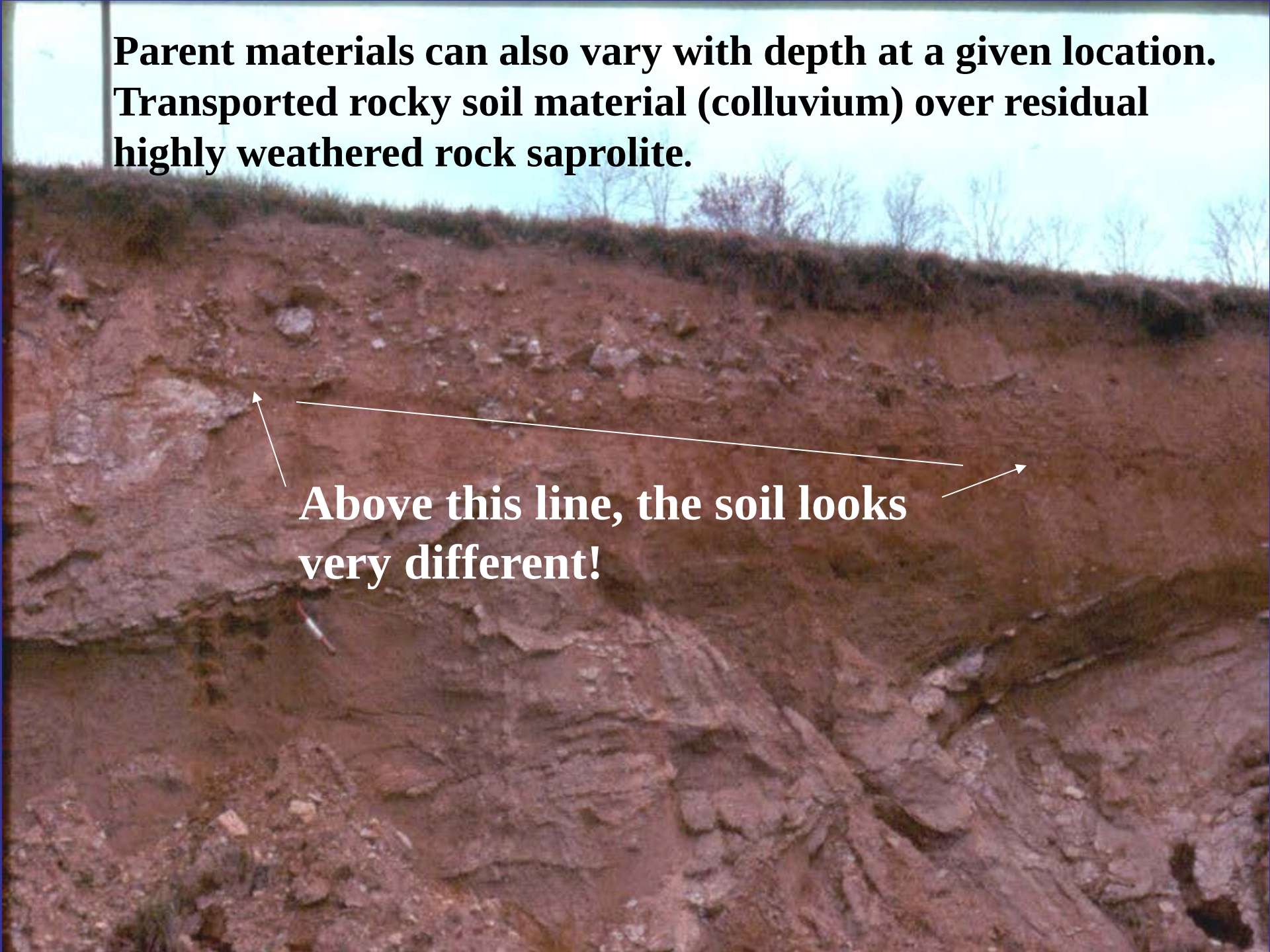
- **Reduction and oxidation (redox) of certain elements like, Fe, Mn and S leads to distinctive coloration patterns. Oxidation generates acidity while reduction generally results in higher pH conditions.**

- **Over time, clay particles and humus are leached (illuviated) downward in soils with periodic wetting fronts. This process generates the E and B horizons.**

Factors vs. Processes vs. Profiles vs. Horizons?

Soil forming factors **integrate and drive** ***soil forming processes*** **to create unique and varied** ***soil profiles*** **and their distinctive** ***horizons*** **across the local landscape and the world.**

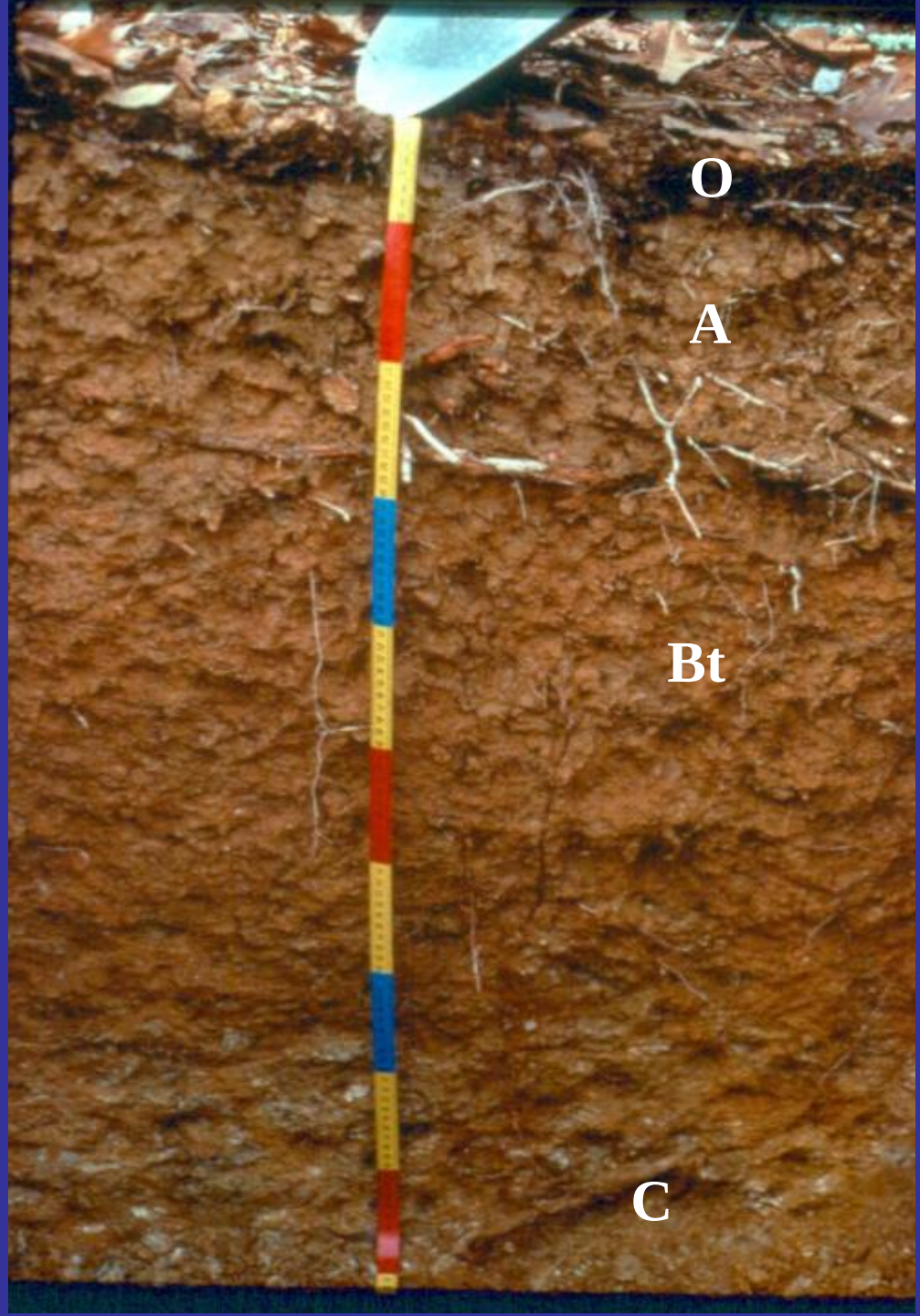

Parent Material strongly affects regional landforms and soil distributions. For example, the ridge in the background is capped by sandstones, the lower hills in the middle-ground are mixed shales/carbonates and the valley floor in the foreground is underlain by relatively pure carbonates.


Parent materials can also vary with depth at a given location. Transported rocky soil material (colluvium) over residual highly weathered rock saprolite.
Above this line, the soil looks very different!

Vegetation and climate co-vary together to influence soil genesis.

Typical forest soil. Acidic, highly weathered with clay accumulation. “t” means clay accum.

Note thin A horizon and litter layer.

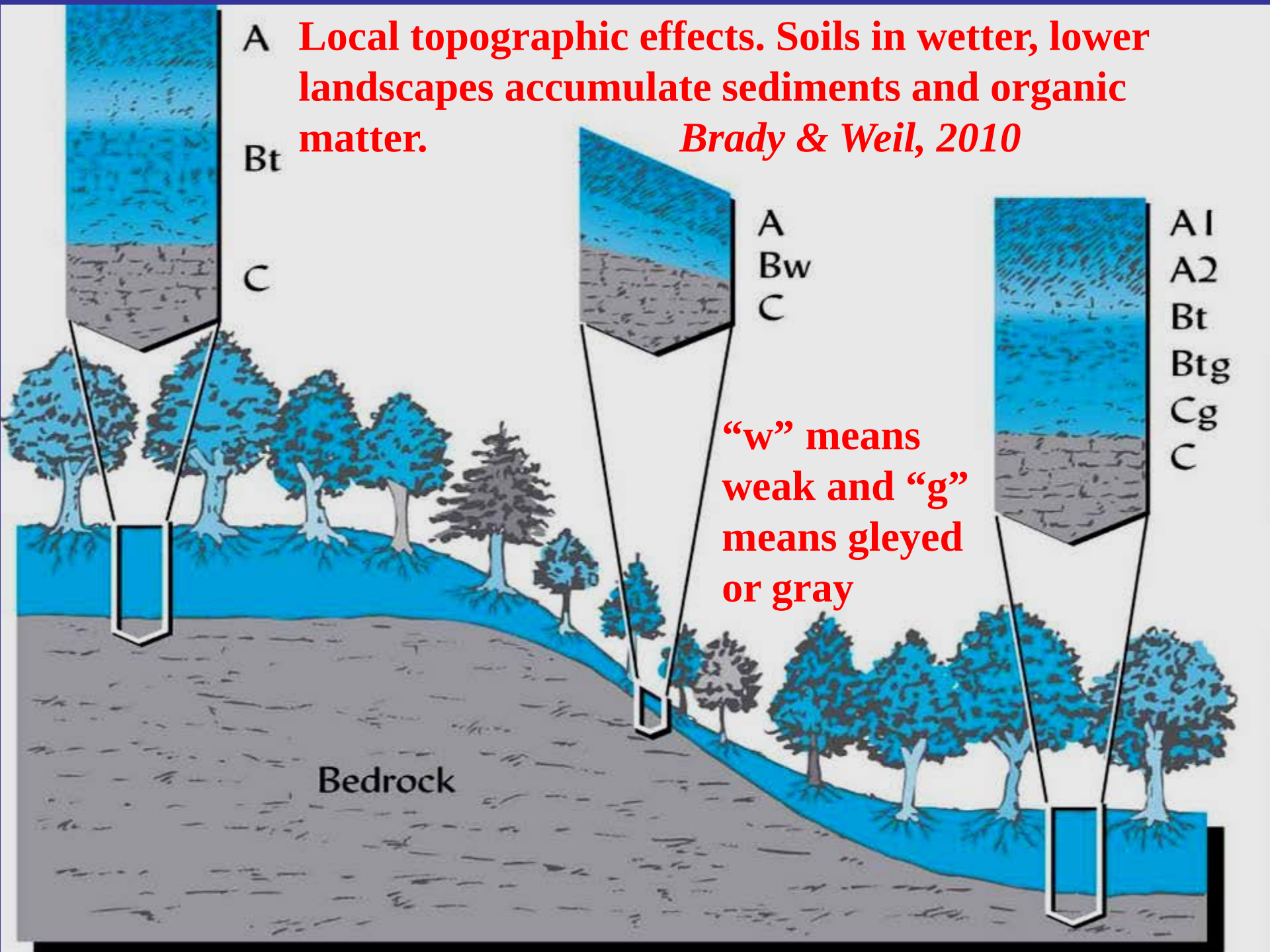


Typical tall grass prairie soil from Iowa. This soil is formed in a much drier environment under tall grass prairie.

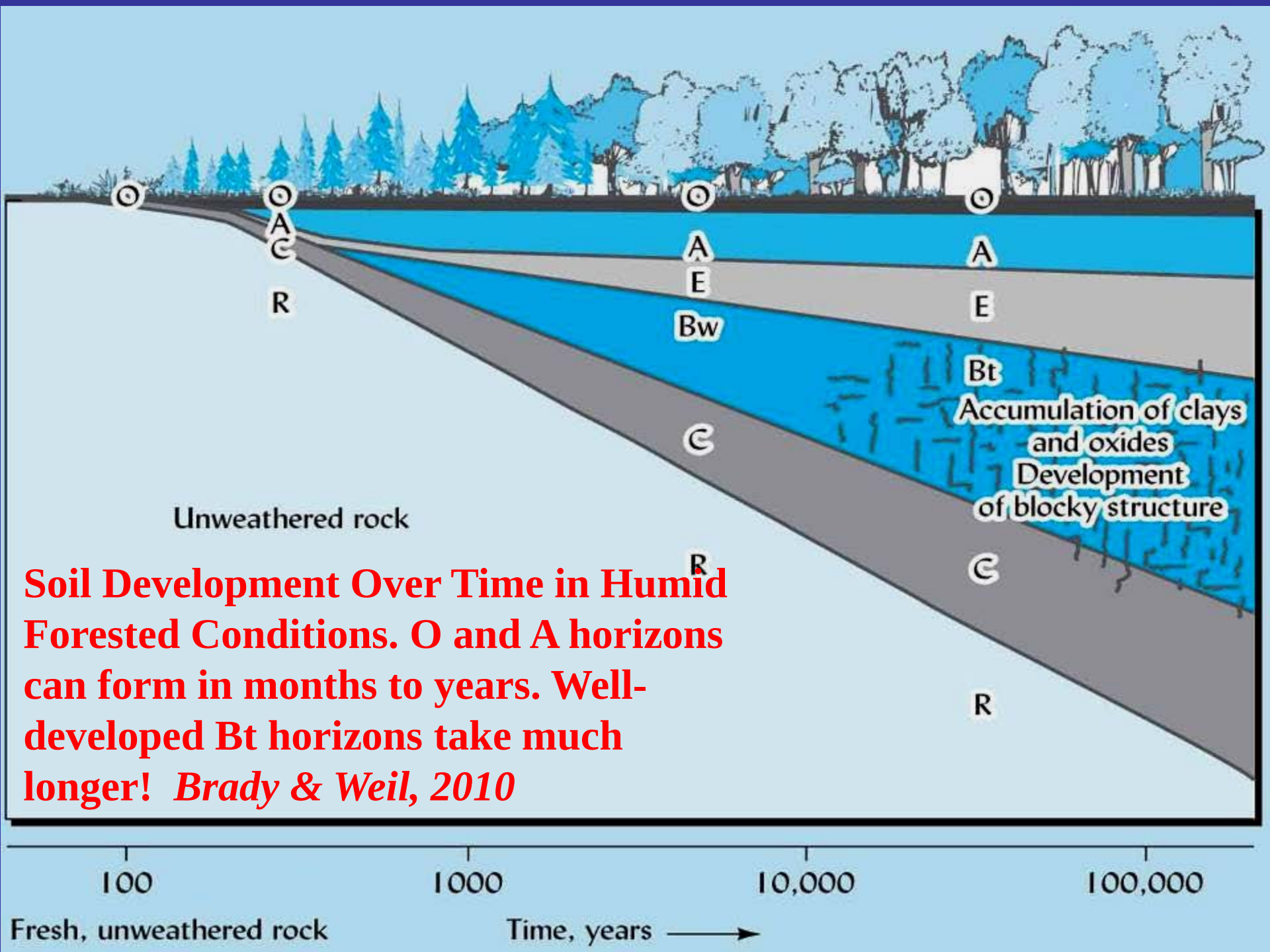
Note the deep thick A horizon and less weathered B horizon as compared to a forest soil.

The white flecks in the lower B horizon are secondary carbonates.

Local topographic effects. Soils in wetter, lower landscapes accumulate sediments and organic matter. *Brady & Weil, 2010*



"w" means weak and "g" means gleyed or gray



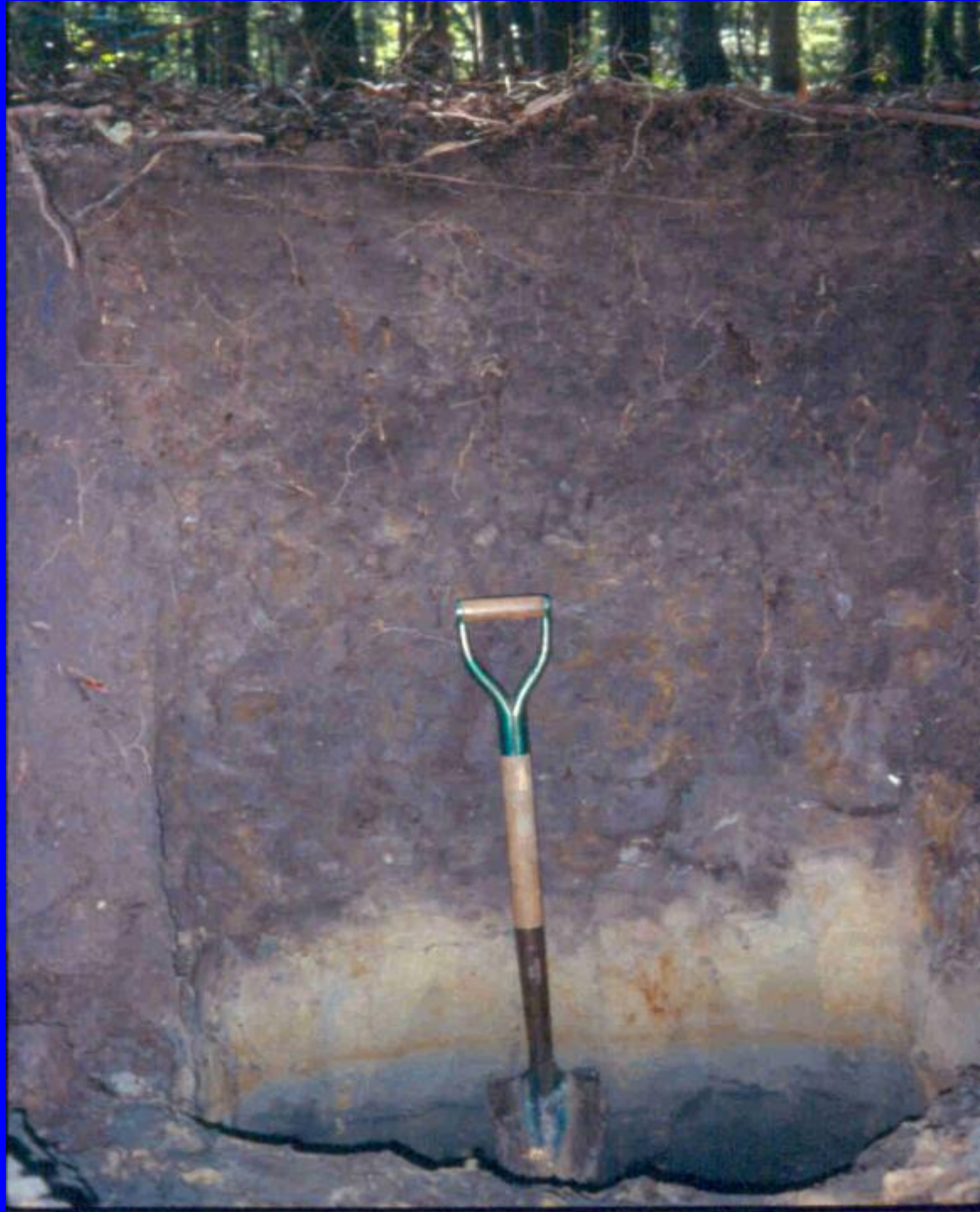
Soil Development Over Time in Humid Forested Conditions. O and A horizons can form in months to years. Well-developed Bt horizons take much longer! ***Brady & Weil, 2010***

What's a Hydric Soil?

A soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

High OM wetland (hydric) soil at Sandy Bottom Nature Park in Hampton VA. The A horizon here is over 30 cm thick.

The annual water table fluctuation (hydroperiod) of this soil is ~ 4 ft. The surface is saturated to < -2 inches in the winter and then drops dramatically in mid- to late April as ET kicks in with full leaf-out.



Hydric soil with relatively low organic matter content due to acidic and clayey near-surface soil conditions which limit rooting and faunal mixing.

Also note the dominance of gray colors in this soil which indicates a lack of oxygen (anaerobic conditions).

We routinely use certain variations in color (redoxymorphic features) as part of the system of *Hydric Soil Indicators* to identify *Hydric Soils* in the field.

<u>Note</u>: This is not a Hydric Soil, but does contain well-developed redox features at depth.

Soil Coloring Agents

- **Reds, oranges, and yellows are due to various types of Fe-oxides.**
- **Browns and overall black hues are due to organic carbon accumulation. The darker the hue, the more OC.**
- **Some black nodules and masses of color may be due to Mn-oxides or charcoal, however.**
- **Gray colors are the background color of soil without any oxidized coatings or pigments masking it. Results from reducing conditions in wet soils and/or leaching conditions in E horizons.**

Factors Leading to Reduction

- **Saturation leads to poor gas exchange and oxygen diffusion from surface.**
- **Palatable/oxidizable organics must be present.**
- **Microbial population must be active; warmth, pH, etc., important**
- **Water must be “stagnant” long enough for oxygen depletion.**

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