Soil Taxonomy and Land Evaluation for Forest Establishment[1]

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Abstract: Soil Taxonomy, the United States system of soil classification, can be used for land evaluation for selected purposes. One use is forest establishment in the tropics, and the soil family category is especially functional for this purpose. The soil family is a bionomial name with descriptions usually of soil texture, mineralogy, and soil temperature classes. If the growth requirements of the tree species are known, they can be matched with the soil and land characteristics that are inherent in the taxonomic name.

In rating soils for specific uses or in land evaluation, land use requirements must be matched with the land characteristics. Examples of land use requirements are environmental conditions, soil moisture and nutrient status, soil depth, various management practices, and even socio-economic considerations. Land characteristics, on the other hand, include not only the various soil properties but also the slope of the land, the amount of rainfall, the amount and kinds of vegetation, and other factors which are normally a part of soil formation.

Because land characteristics actually show interactions, the Food and Agriculture Organization of the United Nations (FAO) (1976) has proposed the use of the term "land quality" in land evaluation. The concepts and principles of land evaluation as well as the various definitions associated with land evaluation are presented in the FAO publication "A Framework for Land Evaluation" (1976). Land quality is an interaction of different land characteristics. For example, the land quality of erosion resistance would include the interaction of characteristics such as slope angle and length, permeability, and soil structure, and rainfall intensity.

This paper describes the taxonomy and system for classifying soils and their requirements for forest establishment.

Soil Classification and Soil Taxonomy

There are many kinds of soils. Some are fertile while others are infertile; some are highly suited for a specified use while others are better suited for other uses. These soils are different because of some differences in properties and behavior. At the same time, similar soils have similar properties and behavior. With so many kinds of soils, it becomes a tremendous task to determine which of these soils behave similarly for a given use.

A classification scheme, however, can be used to group similar objects. Soil classification, furthermore, can be used not only to group similar soils but also to organize knowledge, so that the properties and behavior of these soils and their relationships to other properties and behavior can be easily remembered or understood for some specific purpose.

There are many systems of soil classification worldwide. Some are based on similar colors, while others are associated with similar parent materials, climate, or mode of formation. Still others, such as Soil Taxonomy, the United States system of classification, are based on properties (Soil Survey Staff 1975). Although developed by the U.S. Department of Agriculture Soil Survey Staff, Soil Taxonomy is a contribution of soil scientists from many different countries and agencies. Soil Taxonomy, therefore, is used almost worldwide, commonly together with the national classification system of a country.

Like the plant classification system, Soil Taxonomy is made up of several categories (Soil Survey Staff 1975). There are six categories in Soil Taxonomy: Order, suborder, great group, subgroup, family, and series. The soil order, the highest category, is based mainly on properties which are the result of soil-forming processes and is associated with general description of the soil. The lower categories, on the other hand, carry information not only of the higher categories but also of others which are more specific. For example, the soil family taxa is a bionomial name with descriptions usually of soil texture, mineralogy, and soil temperature classes with additional information on soil moisture status. If the land use requirements are known, they can be matched with the group of land characteristics or the land quality that is inherently contained in the taxonomic name.

Land characteristics can be determined without regard for soil classification, but such a practice would be site-specific without concern for information or technology transfer between similar soils.

Soil Taxonomy and Land Evaluation for Forest Establishment

Soil characterization and soil classification using Soil Taxonomy serve as efficient tools in land evaluation. The taxonomic names denote the various properties and behavior or land characteristics that are needed in the matching process with the land use requirements. Again, the soil family category with its capability of information transfer between similar soils is best suited for this matching process.

Forests require radiation, suitable temperatures, moisture, aeration, nutrients, suitable rooting conditions, and an absence of conditions that negatively affect tree growth or survival. For example, if *Acacia koa,* an endemic species in Hawaii, is selected for forest establishment, two growth requirements can be emphasized: the need for the plant nutrient phosphorus and moisture. These requirements are emphasized because of a preliminary nutrient study and the common habitat of the koa.

If the Wahiawa soil, an Oxisol, is considered as a site for koa forest establishment, the following land qualities may be used in the matching process: phosphorus availability and moisture availability. The interacting land (soil) characteristics associated with phosphorus availability are soil pH and mineralogy,

[1]An abbreviated version of this paper was presented at the Session on Tropical Forestry for People of the Pacific, XVII Pacific Science Congress, May 27-28, 1991, Honolulu, Hawaii.

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while those of moisture availability are soil moisture regime, mean annual rainfall and distribution, evapotranspiration, and vegetation indicators. An additional land quality could be seedling transplanting conditions, with the land (soil) characteristics of mineralogy, structure, and soil depth.

The Wahiawa soil is classified as Rhodic Eutrustox, clayey, kaolinitic, isohyperthermic family (Soil Survey Staff 1990). In relation to phosphorus availability, the taxonomic name suggests that the clayey texture and kaolinitic mineralogy, together with the iron content expressed in Rhodic Eutrustox, indicate that there will be at least moderate phosphorus fixation. Such behaviors are established relationships.

For moisture availability, the ustic soil moisture regime expressed in Eutrustox may be a limiting factor, especially during plant establishment and during the summer months when evapotranspiration is high and rainfall may be low.

For seedling transplanting conditions, the clayey texture and kaolinitic (and oxidic) mineralogy can also be related with the hard consistence (when dry) which would make seedling transplant time-consuming. For example, transplanting 1,000 koa seedlings may require as much as 54 person-hours in this soil, in contrast to only about 18 person-hours in a loamy soil. In the aggregated kaolinitic and oxidic (Rhodic) clayey soils, the cloddy structure also reduces plant survival after transplanting because of low moisture retention.

On the basis of matching of the koa establishment requirements with the land qualities mentioned above, the Wahiawa soil would be at best only moderately suited for koa forest establishment without further management input. Suitability is expected to improve with management inputs such as phosphorus fertilizer application and land preparation for transplanting the seedlings.

Land evaluation for a specified use can be accomplished by matching the land use requirements with the land characteristics. For koa tree establishment in a soil such as the Wahiawa soil, an Oxisol, tree growth requirements for phosphorus nutrient and soil moisture are matched with land qualities of phosphorus availability, moisture availability, and seedling transplant conditions that are influenced by characteristics such as soil pH, texture, mineralogy, soil moisture status, and so on. According to Soil Taxonomy, the Wahiawa soil is classified as Rhodic Eutrustox, clayey, kaolinitic, isohyperthermic family, and this soil is at best only moderately suited for koa establishment without additional management input. With management input such as fertilizer application and adequate land preparation, suitability is expected to improve. The use of Soil Taxonomy and its taxonomic names in land evaluation assures information transfer when dealing with similar soils.

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