1500001/53
PD-AAN-752
ISN-33180

PURDUE UNIVERSITY
International Education and Research
International Programs in Agriculture

PORTUGAL UNIVERSITY INSTITUTES DEVELOPMENT PROJECT

(Contract AID/NE-C-1701)

REPORT ON
SHORT-TERM STAFF ASSIGNMENT

Submitted by
DR. D. P. FRANZMEIER
Department of Agronomy
Purdue University
West Lafayette, Indiana

September 22 through October 21, 1983

PDAAN 752

PORTUGAL UNIVERSITY INSTITUTES DEVELOPMENT PROJECT
(Contract AID/NE-C-1701)

REPORT ON
SHORT-TERM STAFF ASSIGNMENT

at the

UNIVERSIDADE DE TRAS-OS-MONTES E ALTO DOURO
VILA REAL, PORTUGAL

September 22 to October 21, 1983

Submitted by

DR. D. P. FRANZMEIER
Department of Agronomy
Purdue University
West Lafayette, Indiana

plant growth. This is discussed in Part C.

As a secondary objective, we consulted with other scientists. We visited, in the field and/or the office, the research projects of Eng. Fortunato and Eng. Aloisio of the Forestry Department, and offered some comments on their studies. These comments emphasized that landscape position and available water holding capacity should receive more consideration in studies of tree growth. On the return trip Afonso and I met with Prof. Ed Monke, from Purdue, and Prof. Santos-Junior and Eng. Ricardo at the University of Evora. We examined the soils at a drainage research site near Evora and an irrigation project near Odemira. These scientists seem to have a good appreciation of the properties of the soils at these locations and how they interact with the research objectives. At Lisbon, we visited with Prof. Refega who will be the local advisor of Afonso's research. He indicated that he was very pleased with the study we initiated. He will be able to give Afonso good advice in carrying out his research. These secondary objectives are not discussed further in this report.

Part A: Initiation of Afonso Martins' Research Project.

According to theories of soil genesis, the properties of any soil depend on five major factors, climate, organisms, relief, parent material, and time. The effect of any one of these factors can be studied by allowing that factor to vary while keeping the other four as uniform as possible. Studies of this kind are called a climosequence, biosequence, toposequence, lithosequence, or chronosequence depending on which factor is allowed to vary.

In northern Portugal precipitation varies from about 2800 mm in the area north of Ponte de Barca to less than 500 mm near Mirandela. This provides an excellent opportunity to study a climosequence of soils to determine the effect of rainfall on soil formation.

Symbolically, any soil property can be represented as a function of five factors by the expression

$$s = f(cl, o, r, p, t)$$

which means that any soil property, s, is a function (f) of climate, cl; organisms, o; relief, r; parent material, p; and time, t. A climosequence is represented

$$s = f(cl)_{o, r, p, t}$$

if factors other than climate are held constant or

$$s = f(\underline{cl}, o, r, p, t)$$

if all the factors vary somewhat but the effect of cl is much more important than the effect of the other factors. A precipitation climosequence can be expressed more specifically as

$$s = f(\underline{map}, mat, o, r, p, t)$$

which indicates that mean annual precipitation, map, is the major

variable and mean annual temprature, mat, and the other factors are relatively constant. This is the kind of study we initiated in northern Portugal.

We superimposed the precipitation map on the geology map to find potential sampling areas where the rock type was the same but precipitation varied. This area of Portugal has two main kinds of parent rock, granite and schist, so we were able to lay out two climosequences, one on each kind of rock. Within the various precipitation zones, we attempted to hold some of the other factors constant by selecting sampling sites on stable landscape surfaces, those where very little erosion or deposition has occurred. They are nearly level summit hillslope positions or plateaus. In such locations material cannot be added to the site because there is no higher land not separated from the site by a drainageway, and erosion is minimized because the slope gradient is very small and slope length, the distance from the very summit to the site, is also very small. Minimizing the chance of addition or loss of material helps to keep the parent material factor constant and to minimize the variability of the age factor because if material has moved, some points on the land surface might be very young and others might be much older.

The organism factor can be considered to be constant if all sites had access to the same kinds of seeds (according to H. Jenny). Probably, various kinds of seeds were distributed all around the area and some grew in some locations and others grew in other locations because of non-biotic factors such as relief (including water table effects), parent material, or other factors. The distribution of plants that actually grew, then, is due to factors other than organisms.

According to this analysis, the organisms factor in our study is relatively constant. However, man is also considered an organism and his influence has been important, but we tried to minimize it. Most of the sites were in a natural vegetation when they were sampled.

It is difficult or impossible to determine the age of the land surface in this area but we assume the stable land surfaces of the transect sites are about the same age or that possible age differences do not have a major effect on the soil properties studied.

We selected potential sampling sites from 1:50,000 topographic maps and then used 1:25,000 topographic maps to locate the sites more specifically. Often these summit positions were remote and not easily accessible from a village so the influence of man was minimized. At a potential site we made several soil observations and selected the most highly developed (deepest) spot in the general area to write a soil profile description from a small hole. We located eight sites on granite and seven on schist. We then sampled one site, except for bulk denisty samples, to determine how we should sample the soils by horizons and represent coarse fragments, which are an important component of these soils. We also observed that the upper horizons of some soils were hydrophobic. Water dropped on samples formed beads and ran off without wetting the soil. This property might be investigated further.

We then outlined the kinds of laboratory analysis that should be done on all samples and those that should be done on some samples. On all samples (< 2 mm), particle-size distribution, pH, organic C, total N, extractable Ca, Mg, Na, K, and acidity, and available P and K should be determined. Fulvic and humic acid should be determined on some samples to help characterize the organic component which is very

important in those soils. Bulk density, hydraulic conductivity, and water retention at various suctions should be determined on major horizons where natural fabric samples can be obtained. If they cannot be taken these parameters can be estimated from the most similar soils in order to make the necessary calculations.

On selected samples, perhaps the surface horizon and an important subsoil horizon of each soil, the sample will be dispersed and separated into coarse sand, fine sand, silt, and clay separates. Clay mineralogy will be determined by X-ray diffraction and DTA (especially for kaolinite) and by chemical analysis for K (to determine mica or illite).

Samples of relatively fresh rock will be collected from the bottom of each pit for possible mineral and/or chemical analysis. Further chemical analysis of the clay fractions and of the whole soil and the parent rock will be explored after analyzing the results of some of the other analyses.

Because the amount of coarse fragments in the soil and the bulk density of the fine earth (< 2 mm) varies considerably within these soils, results expressed as a weight percentage of the fine earth might not be representative of what a plant "sees". Therefore, many of the determinations will be expressed on a volume basis, such as 1 m^2 on the surface to a depth of 20 cm or to the depth of rooting of the natural vegetation.

For each site a water balance diagram, as used in Soil Taxonomy and other publications, will be plotted. This requires a knowledge of the available water holding capacity which can be calculated from the results of analyses mentioned earlier and some climatic parameters. Other analyses might also be fruitful. They will become apparent from

reviewing the literature and examining preliminary laboratory results.

Many of the results will be presented by plotting a soil property, such as Kg of carbon per m^2 of soil surface, on the y-axis and precipitation, or an index based on precipitation and temperature, on the x-axis. Various kinds of indexes have been used and they were well summarized by H. Jenny in his two books.

It is impossible to obtain laboratory characterization of all the points in the landscape where soil information is needed but the results of this study will allow the existing information to be extended to other areas. The sampling points were selected according to known points for the factors parent material and precipitation, so one can use his knowledge of parent material and precipitation to estimate the properties of the soil at a certain location. This will allow a relatively small amount of laboratory data to cover a large area.

These sites can also be used to design soil map units for a soil survey. They will point to the morphological features that relate to important differences among soils.

This research project will require much of Afonso's time during the next several years and this should be considered in planning his schedule and assignments. At the same time, he must plan to spend extra time to complete his research as do graduate students everywhere. The research project can be used to help train students. For example, students can assist in sampling the soils and learn about soil morphology, geomorphology, land-use and the use of topographic maps, air photos, altimeters and compasses. Through this work it might also be very productive to develop a standard system that students can use to depict the landscapes and soil profile characteristics for the areas in

which they do their research projects. These projects could be coordinated to provide helpful background information for soil surveys and land-use decisions.

In summary, the objectives of the study are (1) to determine the effects of precipitation in a xeric (Mediterranean) climate on soil properties in a sequence of soils developed from granite and in a sequence developed from schist, (2) to compare properties of soils developed from granite with those developed from schist where the other factors are relatively constant, and (3) to use this information to predict the properties of soils at other locations and to help define map units for a soil survey.

Part B: Recommendations on the Soil Surveying Project.

This project is outlined on page 1 to 12 of Portugal, Trás-os-Montes Rural Development Project Research Plan, March, 1983. My comments are based on only a short visit to the area, so the plan needs to be examined critically by those more familiar with the land and the people.

1. The soil surveying program should be initiated only after a person is hired by the Institute whose main responsibility is the coordination of the soil surveying project. The project needs capable leadership and no one currently at the Institute has time to provide this leadership.
2. The soil survey should be conducted primarily by a public agency or jointly by several public agencies for these reasons:
   a. A soil survey is not a standard product like an automobile.

Instead, it must be designed to fit the physical conditions of the area to be surveyed and to meet the needs of the anticipated users of the survey. Therefore, people closely involved with the area and its people must plan and design the survey. A survey does not meet the needs of the users, it will probably not be used even though it is technically correct.

b. The quality of a soil survey depends greatly on the scientific integrity of the people making the survey and their thorough understanding of the objectives and specifications of the survey. It is a simple matter to draw lines on a map and write something about the units. One could do this without going to the field, but the product would be worthless. Any survey, whether done by a public agency or a private company, must be inspected regularly by the coordinator to make sure the survey is being conducted correctly. However, the inspection can cover only a very small percentage of the work and for this reason one must depend greatly on the integrity of the surveyor. People with high standards of scientific integrity can be in public or private agencies. If, however, a person is not doing high quality work, it might be possible to detect the problem earlier if the coordinator has closer contact with the surveyor, as he usually does in a public agency.

c. Perhaps the most important reason to conduct a survey in a public agency is to retain in the region the experience gained by the surveyors. A soil survey is an art as well as a science and the product depends on the background and attitude of the surveyor. The written report represents only a small portion of

what the surveyor knows. Much of the other information is transmitted verbally by the soil scientist to the person who has need for the information, often at the location under consideration. If the survey is conducted by an outside contractor, this information leaves with the soil scientists. In the U.S., where we have had much experience with making and using soil surveys, much information is communicated by land users talking with the soil scientist who made the survey or one who is familiar with the area through similar experience.

3. While the major part of the project should be done by public agencies, private consultants might provide a valuable service in advising on the design of the survey and helping organize and manage it. Experience gained in other areas could be applied in northern Portugal through a private contractor.

4. The Land System approach, as used in Australia should be investigated to learn if it might be useful in the more mountainous regions. This approach considers the geology, geomorphology and vegetation in addition to soils in an integrated system. It might have application where land use is less intensive. A standard soil survey might be more applicable in the river valleys where land-use is more intensive.

5. The ancestral farmers seemed to have a good appreciation of the relation of soils and land use. They built rock terraces to hold the soil on the steep slopes and to decrease slope length and slope gradient. They also built villages mainly on valley side slopes, leaving the flat valley bottom for farming. Now, we sometimes see steep slopes with no cover, and people are building factories,

homes, and public buildings on nearly-level soils. We seem to have lost some of wisdom of the early farmers. Many of the pertinent land use decisions depend mostly on slope gradient which can be determined from topographic maps. Thus, policies to encourage soil conservation practices on sloping lands and discouraging development of nearly level farm lands need not wait for the soil survey to be completed. If public agencies decided that the best farmland should not be diverted to other uses, this land could be fairly well identified using existing information such as topographic maps and land-use history. For example, public agencies could make it difficult to take land out of production if the topographic maps showed it to be nearly level and the land had a history of being farmed, according to records and/or the observations of local people.

6. People more familiar with the area and the needs of the users will be able to provide more pertinent comments on the plan than I can. However, I will offer these more specific comments on the soil survey plan:

   a. Presumably, the base map for the 1:100,000 map will be the 1:50,000 topographic maps. If these are used, they should be revised, using the latest aerial photographs, maps of municipality, and other sources, to update the maps, especially to show new roads.

   b. Some examples of the taxonomic unit descriptions (e.g., series, families, etc.), of mapping unit descriptions in terms of taxonomic units and other kinds of information, and of actual mapping patterns should be developed to serve as a guideline for

those who will conduct the survey. In developing the examples the coordinator will probably be able to write more specific instructions and specifications for the work.

c. The number of observations per unit area should be a general guideline only. Usually, in conducting a survey, the soil scientist will initially make many observations in a small area to become familiar with the pattern of soils and how they relate to geology, geomorphology, natural vegetation, aerial photo appearance, etc. and after he has this pattern in mind he will predict ahead what soils he will find and then check the observations in a less dense pattern of observations.

d. The plan to map different areas at different scales is wise. Possibly more than two scales should be considered in order to match the soil survey to the size of areas that are farmed. Where fields are small, a larger-scale soil survey is needed than where they are large. In order to maintain credibility of the survey, the units farmed should be shown on a soil map. For example, if a farmer knows that his favorite pasture has especially good soils, he will have much confidence in the survey if it is of large enough scale to show the field and it identifies this soil area correctly.

e. The time to complete the survey probably will be much more than 30 months.

Part C: Purchase and Maintenance of Neutron Moisture Meters.

In this area of low summertime precipitation, available water

during the summer seems to be the factor that often limits plant growth. Therefore, periodic measurements of the water content in the soil profile are very significant in comparing different soils and landscape positions, evaluating irrigation systems, studying efficiency of water use by various species of trees or crops or varieties of crops, and other studies. A convenient method for making these measurements is with neutron probe instruments. Therefore, I suggest that some of these instruments should be purchased and training for their use should be provided. One staff member should be identified who will be responsible for determining the number and kind to order and will be responsible for coordinating their use, calibrating and maintaining them, training people to use them, monitoring radiological safety standards, etc. The staff member should have a technician's assistance for this work. A back-up instrument should be available at all times so that an experiment that requires periodic measurements to be made will not be ruined if an instrument is being repaired.

Itinerary

Sept. 22	Leave from Indianapolis
Sept. 23	Arrive Lisbon, met with Mr. Pinheiro, US AID, at the US Embassy
Sept. 24	Arrive Vila Real
Sept. 26 to Oct. 17	Work with Afonso Martins and others at the Instituto Universitario de Trás-os-Montes e Alto Douro
Oct. 17	Travel to Evora
Oct. 18 to 19	Confer with Prof. Santos-Junior and Ed Monke and visit drainage project near Evora and irrigation project near Odemira
Oct. 20	Confer with Prof. Refega, Lisbon
Oct. 21	Return to U.S.