EFFECT OF SOIL USE CHANGE ON SOIL TEMPERATURE REGIME

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Abstract
A main objective today is to protect soils against external aggression. The type of use to which the soil is put plays an important role in that it can help protect or, conversely, accelerate degradation processes. Among the parameters affected are structure, soil moisture regime and soil temperature regime. In this paper we examine the changes in soil temperature regime caused by a modification of vegetation. The study was carried out on the island of Tenerife (Canary Islands, Spain) on a site with Andisols. The site is situated on the north face of the island, at 870 m.a.s.l., in an area with annual rainfall of around 650 mm, and frequently influenced by the trade winds. Three adjacent plots originally covered with cloud forest were put to different uses. The natural, but degraded, vegetation of tree-heath (*Erica arborea, Chamaecytisus proliferus, Cistus symphytifolius*) was maintained in one case, but removed from the other two plots. One of the two was used for cultivation (*Solanum tuberosum*) while the other was abandoned and gradually taken over by herbaceous plants (*Pteridium aquilinum, Cistus symphytifolius, Rumex maderensis, Rubus ulmifolius*). Soil temperature at 50 cm was measured monthly over a period of 4 years (2000-2003). The results obtained show the influence of the type of covering: whereas the soil with natural vegetation has an isomesic temperature regime, the regime in the cultivated soil is thermic, as is the case of the soil with the herbaceous plant cover, albeit bordering on isomesic. The decisive effect of the natural vegetation in capturing atmospheric moisture is therefore evident.

Additional Keywords: soil climate, vegetation cover, soil classification, soil management

Introduction
There is no disputing that soil climate, via its temperature and humidity, influences various soil processes and properties. These parameters are extremely important when defining soil use. For this reason, soil moisture regime and soil temperature regime have been included as classification criteria in different systems, among them the Soil Taxonomy (Soil Survey Staff, 1999). Difficulties in obtaining direct field data to help define these regimes accurately have led extrapolated environmental data to be used, not always successfully. In some systems, these regimes have been excluded as a classification criterion, as is the case of the World Reference Base for Soil Resources (FAO 1998). Studies on climate change and carbon sequestration, which are so common today, need reliable data on soil climate and the effect on this of types of soil use (Brenna *et al*., 2002).

Abundant literature exists on the influence of vegetation on soil temperature (Green *et al*., 1984; Rodskjer *et al*., 1989; Pierson and Wight, 1991; Pradel and Pieri, 2000). Some of this focuses on predictions based on air temperature, while others examine links with various parameters of the vegetation, or address the effect on the crops grown, etc. Less common are papers which, in discussing the soil temperature regimes of a given region for the purposes of classification in the Soil Taxonomy, examine the possible influence of vegetation (Jensen *et al*., 1989; Nullet *et al*., 1990; Mount, 1999; Mount and Paetzold, 2002). Studies on the soil temperature regimes of the island of Tenerife are relatively recent and the bibliography is still limited (Tejedor *et al*., 2002, 2003).

In this paper we present the results of 4 years of measurements of soil temperature in a plot under natural tree-heath woodland vegetation and in two adjacent plots where the covering was altered, in one case with herbaceous plants and in the other by cultivation. The influence on soil temperature regimes is examined.

Materials and Methods
The island of Tenerife (Canary Islands, Spain) is situated near the Tropic of Cancer, and has a highest point of 3,718 metres. It has a wide variety of microclimates which depend on a series of factors, among them altitude, orientation, orography, and the influence of the trade winds and of the sea. For the north side, which is exposed to the humid trade winds, the following soil temperature regime altitudinal sequence has been provisionally described: hyperthermic (0-80 m.a.s.l.), isothermic/thermic (80-800/850 m.a.s.l.), isomesic (800/850-1400 m.a.s.l.), mesic (1400-3200 m.a.s.l.), frigid (>3200 m.a.s.l.).

The study area is situated at 870 m.a.s.l. on the lower limit of the strip defined by an isomesic regime. The natural vegetation is cloud forest in the central part and tree-heath/wax-myrtle (‘fayal-brezal’) in the upper and lower parts.

Annual rainfall is around 650 mm and is supplemented by humidity from condensation, which can at times be greater than the actual rainfall. The natural soils, Hapludands (Soil Survey Staff, 1999), are sandy loam, rich in organic carbon which is fully, and deeply incorporated (still 2% at 50 cm) and with surface stoniness containing around 20-40% of basaltic fragments. The natural vegetation of the study zone, which is located relatively near small rural populations, has gradually been altered to allow cultivation. Depending on the property, one can find plots with natural vegetation, others with crops and others still that were cleared of trees but never entered farming use and subsequently became covered with herbaceous plants. The main species in each community and the degree of cover are as follows. Natural, tree-heath woodland vegetation: *Erica arborea*, *Chamaecytisus proliferus*, *Cystus symphytifolius*, with a covering of 60-80% all years, 3-4 m height. Herbaceous plants: *Pteridium aquilinum*, *Cystus symphytifolius*, *Rumex maderensis*, *Rubus ulmifolius,* with a covering of over 80% in summer and less than 20% in winter, 0.8-1 m height. Cultivated plots: *Solanum tuberosum*, with a covering in excess of 80% during the cropping season and below 10% post-harvest. The cultivated land is not irrigated.

Soil temperature was measured monthly during 2000-2003 in each of the plots at 50 cm depth using thermistors. Between four and six measurements were taken each time and at all three points. The SPSS programme, version 11.0.1 (SPSS Inc. 2001), was used for statistical analysis.

Results and Discussion

Figure 1 shows the evolution of the monthly soil temperature for the three plots throughout the study period. The tendency observed was consistently the same over the four years: the lowest temperatures were found below the natural vegetation and the highest in the cultivated area. The soil covered with herbaceous plants was somewhere in-between, at times near the temperature of the natural vegetation plots while at others closer to the cultivated plot. The biggest differences were seen in July, August and September, with differences of around 2 ºC between the natural vegetation and the herbaceous plots, over 4 ºC between the herbaceous and the cultivated plots, and 5 ºC between the natural vegetation and the cultivated plot. Similarly, considerable differences were observed between the three plots as regards the maximum and minimum temperatures.

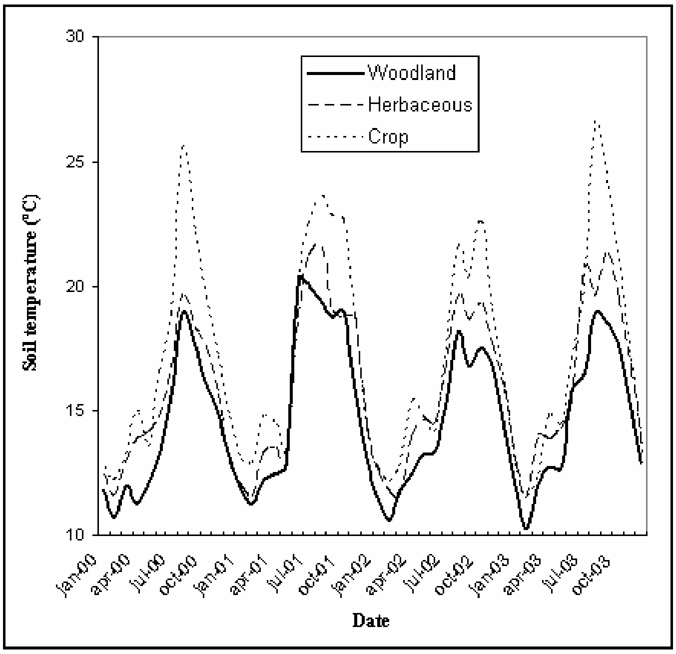

Figure 1. Annual evolution of the soil temperature for the study plots.

Figure 2 illustrates in box diagram form the three cases and accurately reflects the different behaviours. The greatest differences between the maximum and minimum temperatures were found in the cultivated plot, with the smallest seen in the natural vegetation plot. The plot under herbaceous cover lay somewhere in the middle.

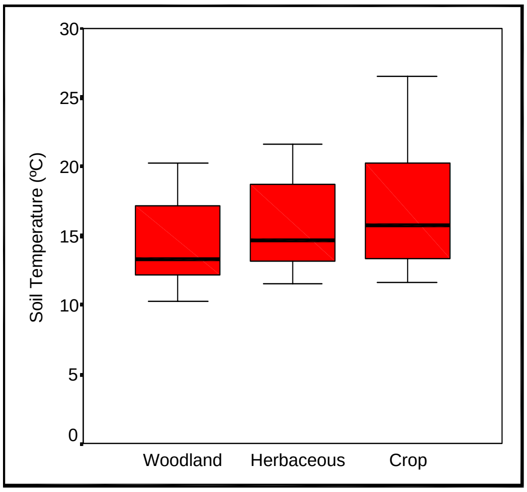

Figure 2. Box diagram for the different land uses.

The set of data is reflected in the average annual temperatures given in Table 1 together with the averages for summer, winter and isotivity value. The lowest annual average was found in the natural soil (14.4 ºC) and the highest in the cultivated soil (16.8 ºC); the plot under the herbaceous cover produced a temperature between the two (15.5 ºC). The observed tendency is also reflected in the statistical analysis carried out using the Mann-Whitney U test: whereas the temperature differences between the soil of the natural vegetation and the cultivated plots are statistically significant, the same is not true when either of the two is compared with the herbaceous plot, although the statistical significance borders on that of the tree-heath population and herbaceous plot.

Table 1. Seasonal and annual soil temperature (ºC) for the study plots.

Land use	Woodland	Herbaceous	Crop
Mean Annual Soil Temperature	14.4	15.5	16.8
Mean Summer Soil Temperature	17.3	18.5	20.8
Mean Winter Soil Temperature	12.0	12.8	13.3
Isotivity	5.3	5.7	7.5

These results have repercussions for the soil temperature regime. In the second version of the Soil Taxonomy (Soil Survey Staff, 1999) soil temperature regime is considered to be "iso" when the difference between summer and winter is less than 6 ºC. This was the case of the natural vegetation plot, but far from true for the cultivated soil. Based on the annual average temperature of the soil at 50 cm and the temperature difference between summer and winter, an isomesic regime for the natural vegetation soil and a thermic regime for the soils of the cultivated and herbaceous plots can be defined. It should be noted, however, that the latter - annual average of 15.5 ºC and an isotivity value of 5.7 ºC - is very close to the isomesic regime (according to Mount and Paetzold, 2002, Soil Taxonomy defines each soil temperature regime and temperature class to the nearest whole unit).

Our study reveals that a change in soil use, with modification of the vegetation cover, leads to an important variation in the soil temperature regime. Given that the study was carried out in a border zone between altitudinal strips with different climates, the results would probably be less marked if more central areas of each strip had been used. Still, the regime changes reflect differences in ecosystems: the system is tropical in the case of the tree-heath, but is no longer thus in the other two plots. What characteristics of the plant communities may have had a bearing on this situation? Almost certainly the combination of the height of the vegetation and the surface area covered. Important as these parameters may be, we believe that a more decisive influence is the role played by the tree-heath vegetation in helping moisture condensation from the trade winds, thereby creating a tropical environment that considerably reduces both seasonal and day-night temperature fluctuations. The gradual nature of the changes is reflected in our study by the results obtained under the intermediate vegetation.

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