Identifying significant determinants for canopy development on an Alpine test site by means of artificial neural networks

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Abstract

Detailed studies of canopy development (biomass, leaf area) can only be conduced at a limited number of locations. If we want to assess the dynamics and spatial differences at a larger regional scale (as this is important for land and water resource management), we will have to use spatial technologies such as remote sensing. Such approaches have been already tested (Milton et al. 1989, Carter 1993, Shroder et al. 1995), canopy development of forests were investigated mostly (Peddle et al. 1999, Goetz and Prince 1996). But this in turn is limited in its temporal frequency. The spatio-temporal quantification of ecosystem processes is therefore a big challenge (Ostendorf et al. 2001).

Our study area is situated in the upper Passeier Valley (South Tyrol, Italy) in the central eastern Alps. It is a narrow, v-shaped valley with fairly steep slopes. It extends over approximately 3 km² and ranges from 1200-2350 m in altitude. The area of interest is located on the south exposed hill slope, comprising the alpine meadows of the farmers of the village Walten and the adjoining forest below. A great part of the meadows, especially on steeper slopes, has been abandoned, whereas other parts have been managed to a greater degree. This has led to a high diversity of vegetation (on the study area 21 vegetation units have been determined, Tasser et al. 2002a). From the scientific point of view, the differences in colour distribution and canopy phytomass, which are connected with the patchy vegetation and land-use distribution, are the most interesting aspect of this landscape.

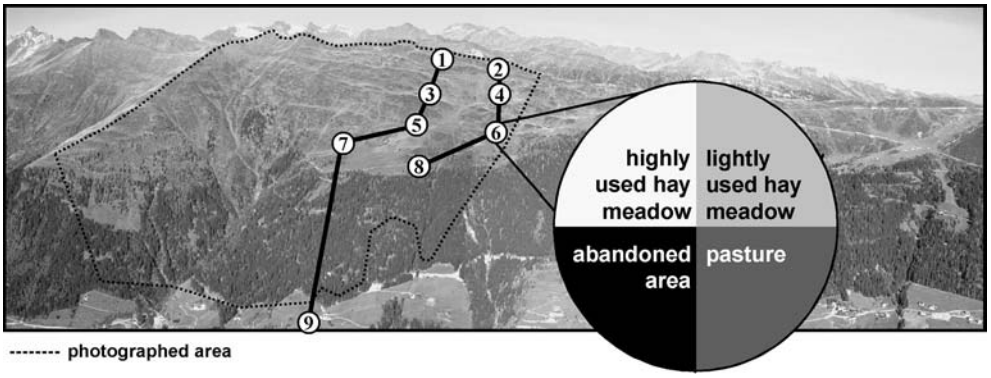

Fig. 1: Experimental design: along two transects from the valley till the ridge were collected date from biomass and leaf area. At each point canopy development was raised from the most important management types.

Structural development (photosyntetically active phytomass and total phytomass) of typical stands were analysed at 9 times during the vegetation period along of two altitudinal transects (1240 – 2200 m a.s.l.) with 21 permanently marked location (8 transect points and 1-4 different management types, see Fig. 1) of the study area that were registered with the GIS database. Altogether 185 observations were available. These investigations were accompanied by rough phytosociological assessment of the vegetation and estimation of the amount of cover deriving from grasses, herbs and dwarf shrubs. All important vegetation types were entered by this selection, so that a representative predicate about the canopy development of the entire area is possible.

The spatial-temporal heterogeneity of stand development in the study area was captured. Photographs were taken from the opposing hill slope at the same time as the canopy development was analysed. These photographs according to the harvest dates were georectifed with the JUKE method (Aschenwald et al. 2001) and divided in RGB-colour values. Topographic parameters of the study site were derived from a digital terrain model with a 5m pixel resolution (see Ostendorf at al. 1999).

The RGB-colours as well as the horizontal distance from the camera position to the single pixels on the opposite hill slope, and land-use indices were used as independent variables in order to explain phytomass and leaf area values measured on the site (see also Guisan et al. 2000). Three ordinal land-use indices were derived from land use types: a hay utilization, a pasture utilization index and a dummy variable for “cutted” or “not cutted” (for details see Tappeiner et al. 1998). As a first experiment we (Tasser et al. 2002b) used multiple linear regression and gave empirical evidence for the possibility to model spatial-temporal pattern of

canopy structure with the help of the quoted inputs. Furthermore we could model the biomass and leaf area distribution in a non-linear way with a limited amount of variables by combining temporal remote sensing (geo-registered and ortho-rectified colour images from the opposing hillslope) with classical field methods from plant physiology (Tasser et al. 2002c). Artificial neural networks and Geographical Information System were used.

With the help of White's test for neglected nonlinearity and the neural network test we show that our model is correctly specified. Unsignificant parameters are identified by statistical tests and consequently eliminated. We demonstrate that this procedure leads to an improvement of the model and to reliable results. As the gained relationship is non-linear the importance of the input variables is not simple measurable as the corresponding coefficient like for example in linear regression analysis, but we provide both graphical and statistical measures to identify form and importance of influence factors on canopy development. Hence, consequences of future agricultural development (lay fallow, intensification) can be precalculated and judged much better. Agrarian policy would be more focused and therefore more purposeful and efficient.

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