# THE INFLUENCE OF LIGHT ON THE SUCCESSION OF CALCAREOUS GRASSLAND USING A GIS AS AN INSTRUMENT FOR ANALYSIS

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**ABSTRACT**
The change of light transmission along a gradient from shrub center to open grassland and its correlation to vegetation composition has been studied in two shrub surroundings on abandoned calcareous grassland. Light measurements were made at soil surface locations in high density and later interpolated to area maps. Low-growing plants were mapped in plots within the shrub area and their shapes subsequently digitized. Using SPANS GIS an overlay of maps representing light transmission, distance to shrub center and apearance of low-growing plants was made by calculating averages in a specified grid to create data sets for a statistical evaluation. The relationship between light and distance to shrub center shows a sigmoidal function with low values at shrub center positions and high values in the open grassland. Most plant species were positively correlated to bright, few to darker areas.

**KEYWORDS**
Abandoned, calcareous grassland, GIS, light, shrub, succession, vegetation

**INTRODUCTION**
The invasion of shrubs to abandoned calcareous grassland influences the vegetation composition of low-growing plants with an increased dominace of Brachypodium pinnatum and a decrease of typical calcareous grassland species within the shrub area. (Bobbink and Willems, 1987; Dierschke, 1993; Hakes, 1987; Hakes, 1992). Among other growth related factors the appearence of shrubs reduces light transmission. Thus the objective of this study was to evaluate the change of light transmission in shrub areas and their surroundings and to find relationships to the appearence of low growing plants.

**METHODS**
Two shrub areas on an abandoned calcareous grassland near Witzenhausen in Northern Hesse, Germany were selected, one in an early succession stage (pioneer stage) and the other in advanced succession (enrichment stage) (Kollmann, 1992). For each successional stage, a study area of 8 x 8 m was marked, placing the shrub area in the center. Relative photosythetically active radiation (PAR) was measured at the soil surface at 119 and 176 systematically selected points. Measurements took place three times one day in June 1995 at 6.00 a.m., 12.00 a.m. and 6.00 p.m. MEZ. Mean values were calculated and interpolated to an area map using the potential mapping feature in SPANS GIS. Additionally a map with 10 cm interval buffers representing distances to the shrub center (distance map) was created within the GIS, based on the digitized outline of the central shrub area. Within each study area 26 rectangular plots (50 x 50 cm) were selected with increased density to the shrub center to determine plant occurence. Inside those plots plant shapes were mapped in spring, summer and autumn 1995 to get the whole plant inventory. Averages of plant species cover and light radiation were calculated for each plot. In the same way averages were calculated for light- and distance maps by overlaying a 10 x 10 cm grid. Light and distance datasets were used for a non-linear-regression analysis in a limited area with a distance of 0 - 200 cm to shrub center in the early succession stage and 0 - 250 cm in the advanced succession stage, depending on where a constant level of light transmission in the open grassland was reached. Vegetation and light datasets were used to calculate Spearmans rank correlation coefficients. In both cases SPSS version 3.2.5 for AIX was used.

**RESULTS AND DISCUSSION**
The change of light along the gradient shrub center to the open grassland follows a sigmoidal function. Figure 1 shows the trend and the mathematical formulation for the advanced succession stage. Starting at nearly total darkness in the shrub center the main increase of light intensity takes place in a distance of 100 to 180 cm. A level of about 60 % light transmission is reached asypmtotically at a distance of 200 cm. For the early successional stage, light intensity is about 20 % in the shrub center and reaches a constant level of 70 % already at a distance of 150 cm. Because of the higher light transmission in the early successional stage, the correlation between light intensity and plant occurence is weaker. The higher amplitude of light transmission in the advanced successional stage leads to a more differentiated relationship between light intensity and plant appearence (Table 1). Most plants were related to bright areas which represent normal conditions for calcareous grassland vegetation. Only Brachypodium pinnatum and Primula veris are positively correlated to dark areas, especially in the advanced succession stage.

**REFERENCES**
**Bobbink, R. & J.H. Willems; 1987:** Increasing dominance of Brachypodium pinnatum (L.) Beauv. in chalk grasslands: a threat to a species-rich ecosystem. Biological Conservation **40**: pp. 301-314.

**Dierschke H. 1993:** Sukzession in einem brachliegenden Kalkmagerrasen. Vergleich von Rasterkartierungen 1971 - 1988. Fragm. Flor. Geobot. Suppl. 2(2): pp. 577-595

**Hakes, W. 1987:** Einfluß von Wiederbewaldungsvorgängen in Kalkmagerrasen auf die floristische Artenvielfalt und Möglichkeiten der Steuerung durch Pflegemaßnahmen. Dissertationes Botanicae **109**: 152 p.

**Hakes, W. 1993:** Was kommt nach dem Halbtrockenrasen? Verhandlungen der Gesellschaft für Ökologie, Band 22, pp. 211- 214

**Kollmann, J. 1992:** Gebüschentwicklung in Halbtrockenrasen des Kaiserstuhls. Natur und Landschaft, **67**: Heft 1, pp. 20-26

**Table 1**
Spearman's rank correlation coefficients representing the relationship between light intensity and plant appearance for some selected plant species in shrub areas of two succession stages on a calcareous grassland in Northern Hesse, Germany. ( * = significant at 5 % level)

| Plant species | Early succession stage | Advanced succession stage |
|---|---|---|
| Brachypodium pinnatum | -0.39* | - 0.69* |
| Primula veris | missing | - 0.56* |
| Anthyllis vulneraria | 0.31 | 0.42* |
| Cirsium acaule | 0.50* | 0.68* |
| Euphrasia rostkoviana | 0.57* | 0.45* |
| Hieracium pilosella | 0.53* | 0.65* |
| Plantago lanceolata | 0.45* | 0.54* |
| Plantago media | 0.09 | 0.39* |
| Potentilla verna | 0.10 | 0.47* |
| Sanguisorba minor | 0.10 | 0.59* |

**Figure 1**
Change of light transmission along a gradient from shrub center to open grassland in an advanced succession stage on a calcareous grassland in Northern Hesse, Germany. Showing a sigmoidal trend of light transmission ( A ), plant species are strongly correlated to dark and bright areas respectively ( B ).