Methodological paper

Methodological overview to hemispherical photography, demonstrated on an example of the software GLA

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Abstract

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This contribution provides a literature overview concerning minimising the two main error sources at shooting and evaluating hemispherical photographs with the aid of the software Gap Light Analyser 2.0. It deals with materialisation of the process in which these phenomena arise. The point is at determining the exposure time and thresholding (determining the optimum brightness value for the pixel as the threshold for distinguishing between the foliage and the sky patches on a hemispherical photograph).

Keywords

hemispherical photography, Gap Light Analyser, SideLook, thresholding, exposure time

Introduction

Assessment of light conditions in forest stands results in important information about growth conditions for the plants (both woody plants and herbs) in the understorey. Even small changes in structure of an almost compact crown layer can result in pronounced changes not only in amount of the penetrating sun radiation but also to the site microclimate regime, which has an important influence on growth and survival of the involved plant species (Whitmore et al., 1993; Brown, 1993, 2000; Hale and Brown, 2005).

Quantitative evaluation of light regime in forest environment by direct measurement is both time and money consuming, due to considerable time and spatial variability of this environmental factor. For this reason, there have been developed numerous indirect methods targeting at determining of amount of accessible sun radiation, based on assessment of the crown layer structure of the stand. One of them is the method providing with evaluation of photographs made at 180° "fisheye" lenses (Jennings et al., 1999). A hemispherical photograph (Fig 1) maps the size, magnitude and distribution of gaps in the crown layer in relation to the spot at which the photograph was taken (Jelaska et al., 2006). The result is that, apart from indirect assessment of under-canopy light environment, the method can also be used for assessing characteristics of the crown layer's structure (canopy openness, effective leaf area index). The first hemispherical objective was manufactured by Hill (1924 in Jelaska et al., 2006) with the purpose to study cloudiness. In the biological research, the approach was used for the first time by Evans and Coombe (1959 in Jelaska et al., 2006). The fundamental of the method is in thresholding – selection (finding) an optimum brightness value for the imaging point (pixel) as the threshold for distinguishing between the vegetation and sky patches (Jonckheere et al., 2004).

Fig 1. Hemisperical image

Recently, there have been developed numerous commercial software packages, as well as freeware programmes that were consequently used in a broad range of applications: Winscanopy (Regent Instruments, Quebec, Canada), Solarcalc, Winphot (Steege, 1997), HemiView (Delta-T Device, Cambridge, UK), Gap Light Analyser (Frazer et al., 1997) and CIMES (Walter et al., 2003) (all in Jonckheere et al., 2005).

The aim of this contribution is to inform the reader about the possible use of this method for indirect assessment of light conditions in the stand. We present a literature review of the published data on use (taking and processing) of hemispherical photographs, illustrated with an example of the freeware programme Gap Light Analyser (GLA), version 2.0 (Frazer et al., 1999).

Gap Light Analyser

This software transforms the colours from the photos to black and white, in order to quantify the pixels before calculation of canopy openness. The programme is freely downloadable from the site http://www.rem.sfu.ca/forestry/index.htm.

The programme has already been used by several authors: Shine et al. (2002), Simoni et al. (2003); Schnitzler and Closset (2003); Jelaska (2004); Morsdorf (2006); Janišová et al. (2007); Glončák (2007); Crane and Shearer (2007); Dauzat et al. (2008); Montero et al. (2008) and others.

Tresholding and its objectivization

The most considerable drawback of this software package is that it performs based on a manually, interactively determined, virtually chosen threshold value for the entire picture – which is, according to Englund et al. (2005) an indisputable source of controversies, con-tradictions and errors with the variance dependent on the measuring subject. The sensitivity of this programme to the variable threshold value was evaluated by Hardy et al. (2004) (on example of total solar transmissivity). They tested the sensitivity of the predicted transmission value based on close-to-realistic high and low threshold values, each affecting the predicted transmissivity by about 10%. This drawback can be (the authors seek) eliminated in various ways – by using blue channel, proved to be the best for separation of the pixels into the sky and non-sky classes (Jelaska et al., 2006, also noted by Frazer et al., 1999; Zhang et al., 2005), by using pixel histograms (chosen is the value with the lowest abundance) with following visual control (Barthod and Epron, 2005), by direct measuring transmissivity and subsequent determining the equivalent transmissivity value in GLA, together with its associated threshold value (Hardy et al., 2004), by evaluating all the images by the same person (Beaudet and Messier, 2002), or three independent persons subsequently determining the mean threshold value (Ramos and Santos, 2006). The manual thresholding is also much time consuming, and, consequently, not suitable for implementation in processing of large numbers of photographs (Koller et al., 1994 in Jonckheere et al., 2005).

Objective, reproducible, comprehensible and to a large number of images easy-to-implement method for defining the threshold value has been developed and into the shareware programme SideLook ver. 1.1 (Nobis 2005) embedded by Nobis and Hunziker (2005). The authors show that the automatic threshold algorithm for separating canopy and sky by edge detection is appropriate to replace the widely used manual interactive processing. It also improves the accuracy of results, especially in comparison with single manual thresholding. These conclusions were also confirmed by Monte et al. (2007).

Exposure time

Another possible and important source of errors is exposure (exposure time; Rich, 1988, 1993 in Jonckheere et al., 2004). The results of Zhang et al. (2005) demonstrate that digital hemispherical photographs taken with automatic exposure are not reliable, because they cause effective leaf area index underestimations for medium and high density canopies and corresponding gap fraction overestimations. While in case of open canopies the opposite holds. Beaudet and Messier (2002) and Glončák (personal communication) ensure sufficient contrast between the sky and foliage thanks to bracketing the exposure time indicated by a built-in light meter, or resulting from under-exposing the photographs, respectively. Zhang et al. (2005) have determined the optimum exposure time and developed a protocol for acquiring digital hemispherical photographs. The protocol requires first measuring reference exposure for the open sky with using a built-in camera light meter, and then taking photographs inside the canopy with using the same camera with two stops of more exposure than the reference exposure in order to make the sky appear white and consequently also maximize the contrast between the sky and foliage. For example, if the sky reference is F5.3 (aperture) and shutter speed is 1/1000 s, the correct exposure inside the stand is F5.3 and shutter speed 1/250 s.

Conclusion

In spite of all limitations associated with this indirect method for assessment of forest canopies and understorey illumination (Roxburgh and Kelly, 1995; Jennings et al., 1999), the hemispherical photography provides an important and useful tool in ecological studies. Unification and objectivization of methodical techniques at shooting and evaluating hemispherical photographs is important in term of improvement of outputs accuracy and at comparasion outcomes from different sources too.

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Metodologický prehľad k hemisferickej fotografickej technike na príklade počítačového softvéru GLA

Súhrn

Príspevok uvádza literárne poznatky o minimalizovaní dvoch hlavných zdrojov chýb pri zachytávaní a vyhodnocovaní hemisférických snímok využitím počítačového softvéru Gap Light Analyser 2.0, respektíve o zobjektivizovaní procesu, pri ktorom vznikajú. Jedná sa o určenie expozičného času a „tresholding” (stanovení optimálnej hodnoty jasu obrazového bodu – pixelu ako hranice za účelom odlíšenia olistenia od častí oblohy na hemisférickej fotografii). Objektívny spôsob určenia hodnoty „treshold” ponúka program SideLook 1.1. Za najvhodnejší spôsob na určenie hodnoty expozičného času, ktorá maximalizuje kontrast medzi oblohou a olistením je jeho zvýšenie oproti hodnote zmeranej z nezakrytej oblohy o dva kroky (pri nezmenenej hodnote clony).

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