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Dark Sky Parks – new impulse for nature tourism development in protected areas (National Park Muranska Planina, Slovakia)

Dark Sky Parks are one of important measures to support nature tourism in the protected areas. In this paper, we introduce the concept of astro-tourism on the model area of National Park Muranska Planina (Slovakia), which should lead to the establishment of Dark Sky Park and the implementation of measures focused on dark sky protection, i.e. the elimination of light pollution over model area. The concept includes the measurement of night sky brightness, the selection of suitable observational sites and lighting plan. It is very important from the view of ecology, e.g. by the protection of night animal species. On the other hand, these characteristics can be fully used in new tourism concept in that protected area.

Keywords: National Park Muranska planina, light pollution, Dark Sky Parks

Martin Labuda studied Nature Conservation and the Protection of Nature Resources at Comenius University (CU) in Bratislava. He defended his dissertation thesis at the same university. He spent several years at foreign workplaces in Germany, Austria and Italy during his PhD. and post-doctoral study. He attends to nature conservation in cultural landscape and collision between land use and nature conservation with the emphasis on tourism. He has worked as research assistant at the Department of Landscape Ecology at CU in Bratislava for several years.

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Introduction

Nature tourism should be developed not only in protected areas, but also in other regions, where it is possible to apply this form of tourism. Dark Sky Parks are important, modern and fully applicable tool of nature tourism in praxis. Their number and importance increase progressively in many countries of the world. In this paper, we point out a possibility to establish Dark Sky Park on the model area of National Park Muranska Planina. Another goal is to introduce astro-tourism as a tool for the conservation and the development of nature landscape, as well as the recovery of traditional cultural landscape ant its biodiversity. Dark Sky Park in the model area is proposed according to Dark Sky Park Poloniny and prepared Dark Sky Park Nossentiner/Schwinzer Heide.

One of the most progressive environmental changes is the decrease of natural darkness caused by the excessive emission of artificial light. The study of global environmental change has to take into consideration this phenomenon of light pollution (Cinzano et al. 2001). The lack of darkness in night disturbs circadian rhythm, which has negative impacts on flora and fauna.

Duriscoe (2001) formulated optimistic appeal: „Unlike losing a species to extinction, topsoil to erosion, or virgin lands to development, the night sky is 100% recoverable".

There are only few areas in Europe, where night sky is not polluted by artificial light sources. Therefore, it is important to preserve the quality of dark sky in these areas and to improve it using various measures. One of them is the establishment of Dark Sky Park in such regions. The first condition for that is dark sky and the restriction of disturbing artificial light factors using effective measures (Held et al. 2013).

Areas with dark sky can be established as Dark Sky Park by several organisations (Figure 1):

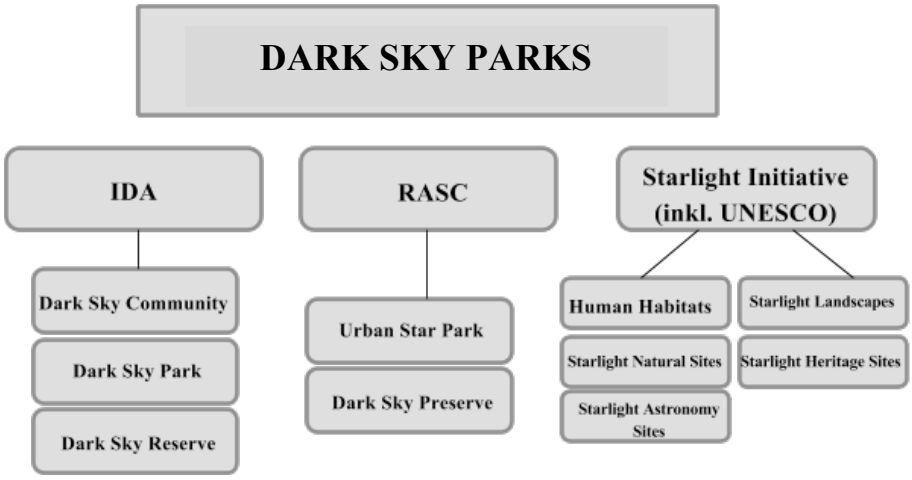

Fig. 1: The graphical description of dark sky parks categories

- **Royal Astronomical Society of Canada** (RASC)
- **International Dark Sky Association** (IDA) establishes: Dark Sky Community, Dark Sky Reserves , Dark Sky Parks
- **Starlight Initiative** establishes: Star Parks**,** Starlight Reserves

Nature tourism

Nature tourism is a responsible travel to natural areas, which conserves the environment. It is tourism based on the natural attractions of an area. Examples include birdwatching, photography, stargazing, hiking, fishing, and visiting parks (Nature Tourism Programme, 2014).

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Model area of National Park Muranska Planina

Within Slovakia the Muranska Planina (Murain Plain) is one of the most well-preserved area. In 1976 year it was announced as the Landscape Protected Are and in 1977 year the National Park Muran Plain was declared (Figure 2). Own territory of the National Park represents 203,2 sq. km, protected zone is spreaded on 217 sq. km. 10 national nature reservations a 11 nature reservations are situated in the National Park.

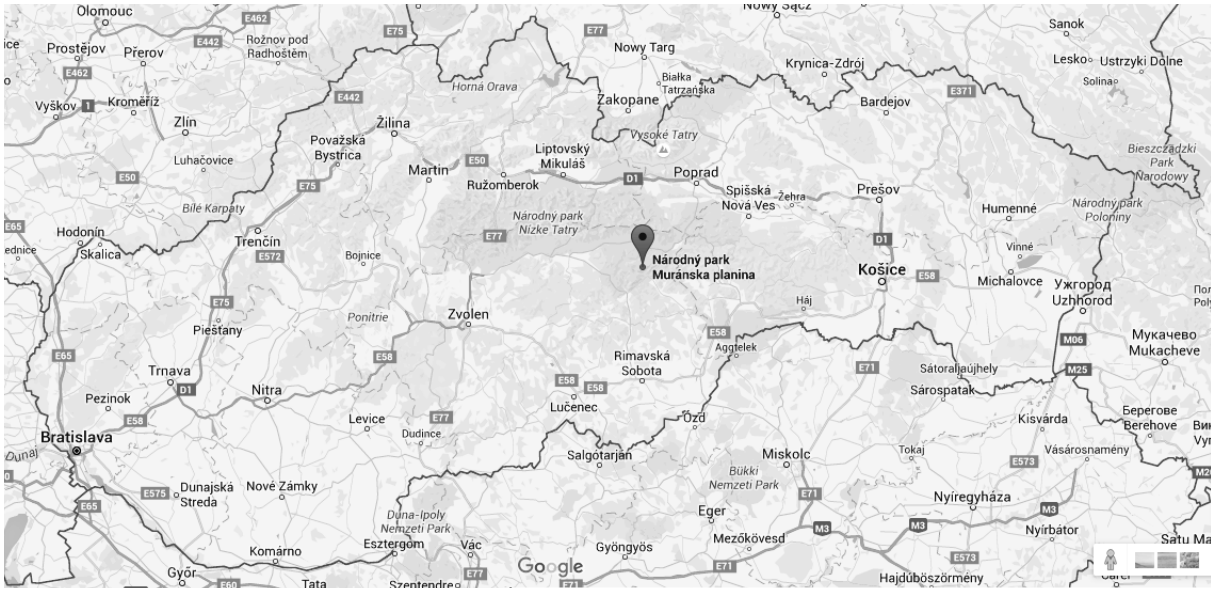


Fig. 2: Geographical location of the model in Slovak Republic (maps.google.sk)

Muranska planina is located in the western part Slovenske Rudohorie Mountains. 4 geomorphological units - Veporske vrchy, Stolicke vrchy, Spissko-gemersky kras, Horehronske podolie - meet there. The highest point is Fabolova hola (1439 meters above see level).

Considerable part of the National Park is created by karstic relief on triasoc limestones. Nonkarstic relief, river relief, is formed mainly on palozoic schists, granitoids and neogene sediments of Breznianska kotlina. Total length of karstic zone ic app. 25 km, whereby the width does not exceed 6 km. More than 150 caves, more than 50 dives and exsurgences, 15 abysses and many other surface karstic phenomena's as scarps, karst pits, sinkholes, rock towers, gaps, rock gates, etc. are registered in the National Park.

The vegetation of the Muranska planina is diversiform a belongs to the most interesting within the orographic units of Slovakia. Around 1150 species of higher plans are occured here. Many of them belong to our endemic and subendemic. The most important high plain is endemic - cainozoic relict - (Daphne arbuscula). On the territory of the National Park are abundantly represented xerotherm, mountain, alpine and subalpine species.

Forest coverage reaches more than 87 %. Vegetation zones from beech-oaken to pine-wood are represented here. In inverse position is also scrub presented.

From the faunistic point of view the south boundary of Slovak division of Carpathians is very interesting. Brown bear (Ursus arctos), bob cat (Lynx lynx), grey wolf (Canis lupus) not only occurred here, but also regularly reproduce here as their population is stabile here. Up to now app. 1500 species of invertebrate are identified in the National Park.

A great deal of the territory creates Bird Protected Area Muranska Planina. In the affected area was recorded the appearance of 113 bird species, within them 94 species are notifying here.

Material and Methods

Methodological progress can be characterised as integrated and logical flow of following steps: the reconnaissance of terrain, the study and the analysis of documents and scientific literature, the mapping of external lighting, the measurement of night sky brightness. The geographical location of model area is shown on Figure 2. At present, the proposal of Dark Sky Park Muranska Planina is almost finished. The selected aspects of this concept (night sky brightness measurements, involved persons and lighting plan) are introduced in this paper.

The population density is very important aspect from the point of view of our aims within the contribution. The degree of light pollution is connected with this character very strongly. The National Park Muranska planina does not include any settlement, what was the basic starting point for our choice of model territory (Figure 3).

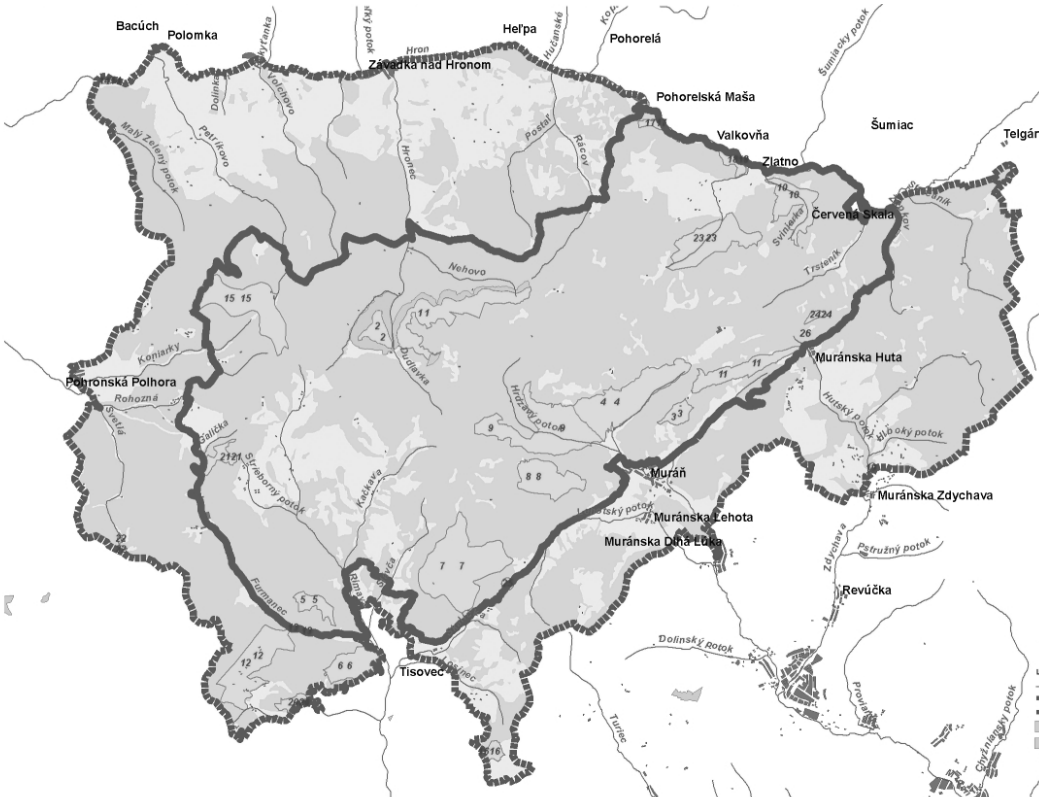


Fig. 3: Map of National Park Muranska Planina (Source: http://www.npmp.sk/)

At the present, the concept of Dark Sky Park Muranska Planina will be soon finished. Selected aspects such as the measurement of night sky brightness, the selection of involved partners and their tasks, or the preparing of lighting plan, are presented in this paper.

The measurements of night sky brightness were done in National Park Muranska Planina (NP MP) at many sites in months: July 2015 and August 2015. The selection of suitable sites for measurements was done according to knowledge about region. Only sites, which allow the measurement of free sky without its covering or eclipse, were accepted.

Another criterion was the spatial distribution of sites within NP MP and the transport accessibility of each site. Only sites, which enabled free measurement of night sky brightness without its covering, were accepted. Another criterion was the spatial distribution of sites over whole area of Nation Park Muranska Planina their transport accessibility and suitability in the nature and landscape protection point of view. We considered only sites, which do not have a tighter regime according to national and international law in the field of nature protection.

Sky Quality Meter L (SQM-L, Figure 3) by Canadian company Unihedron was used to measure night sky brightness in astronomic units magnitudes per square arcsecond (mag/arcsec^2). Scale is inverse, where high values mean dark sky:

21.7 truly dark sky, Milky way is visible up to horizon, black clouds

21.4 zodiacal light (in the evening in spring and in the morning in autumn) is well visible; Milky way is well visible; clouds above town are bright on horizon

20.5 Milky way is visible with low contrast, clouds are bright

19.5 Milky way is hardly discernible

18.5 few stars, very bright sky

The measurement of night sky brightness took important part in the concept preparing of Dark Sky Park Muranska Planina.

Fig. 4: Sky Quality Meter L (Source: Company Unihedron)

Results

The concept of Dark Sky Park Muranska Planina was prepared using knowledge and experiences from implemented project Dark Sky Park Poloniny in Slovakia (DSP P) as well as from prepared project Darky Sky Park Nossentiner/Schwinzer Heide. DSP P is located within area of National Park Poloniny on the borders with Poland and Ukraine (Figure 5). It was established on the occasion of International year of biodiversity in 2010 as the first dark sky area in Slovakia and the 20th in the world with the total area of 48 519 ha. It is characterised by extraordinary low population density (9 inhabitants per 1 km^2). DSP P has the lowest light pollution in Slovakia. Average night sky brightness reaches 21.5 mag/arcsec^2. It is possible to observe objects and phenomena such as zodiacal light, or gegenschein (from German, established term in English).

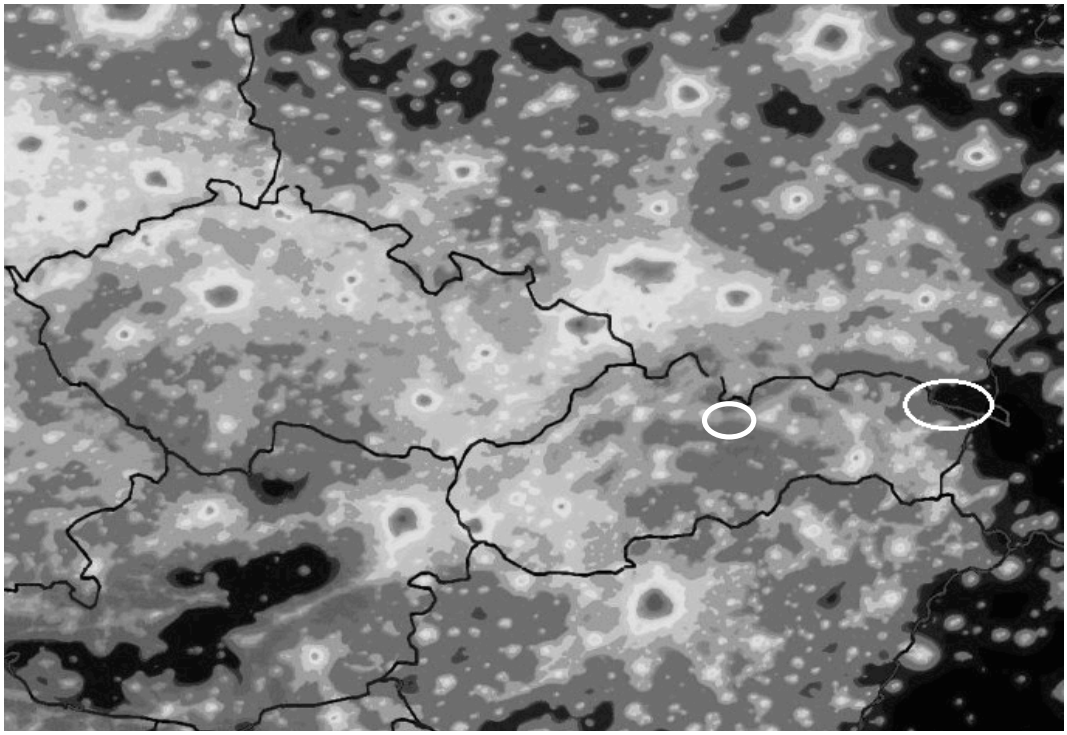


Fig. 5: Map of light pollution in Slovakia with the location of Dark Sky Park Poloniny (right) and proposed Dark Sky Muranska Planina (left). (Source: http://fjfi.cce.cz/astro/celp.jpg)

The measurement of dark sky brightness at selected sites was the base step for the concept of Dark Sky Park Muranska Planina:

1. Locality: Zlatno
Altitude: 766 m
GPS coordinates: N 48°49.154' ; E 20°03.981'
The highest dark sky brightness: 21.40 mag/arcsec^2
Fulfils the criterion for astronomic observational site: yes

2. Locality: Sedlo Burda
Altitude: 1033 m
GPS coordinates: N 48°45.705' ; E 19°54.214'
The highest dark sky brightness: 21,45 mag/arcsec^2
Fulfils the criterion for astronomic observational site: yes

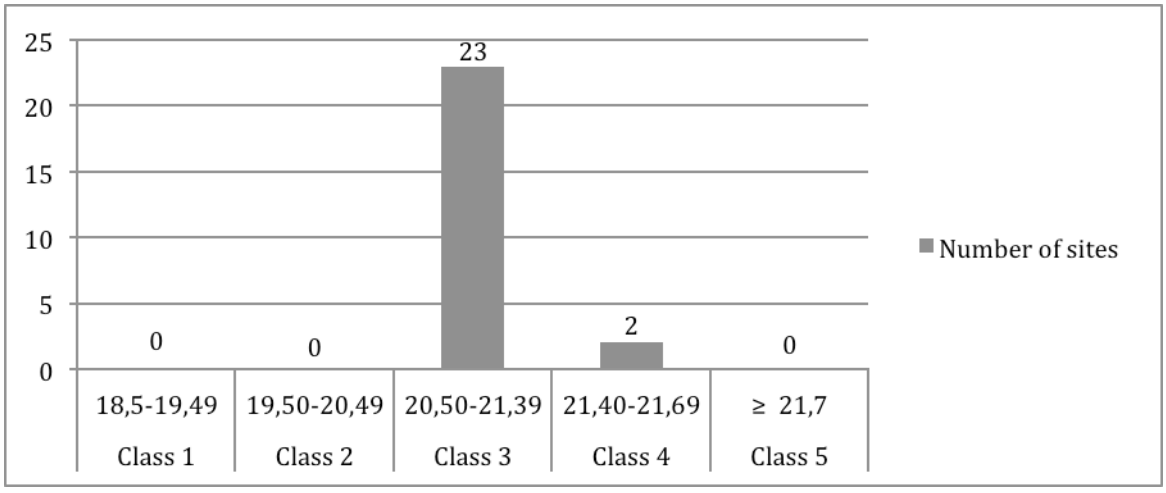
3. Locality: Srokov kút
Altitude: 771 m
GPS coordinates: N 48°4.445' ; E 19°50.947'
The highest dark sky brightness: 21,34 mag/arcsec^2
Fulfils the criterion for astronomic observational site: yes

4. Locality: Hrdzavá dolina
Altitude: 432 m
GPS coordinates: N 48°44.693' ; E 20°01.956'
Fulfils the criterion for astronomic observational site: yes

5. Locality: Javorníkova dolina
Altitude: 375 m
GPS coordinates: N 48°43.526' ; E 20°01.497'
The highest dark sky brightness: 21,26 mag/arcsec^2
Fulfils the criterion for astronomic observational site: no

The measurements of night sky brightness run frequently at localities mentioned above in July and August 2015. From 5 localities, where the measurement was realized, were 4 (locality 1-4) sustainable for the localization of astronomical observatories. Basic condition is measured level of the night sky brightness, which has to reach the value above 21,30 mag/arcsec^2.

Following graph (graph 1) shows brief overview of night sky brightness measurements at selected sites in NP MP.



Graph 1 Distribution of sites into categories

The sites, which belong to class 3, 4 and 5, are the most important from the view of concept and realisation of Dark Sky Park MP. They are ideal sites for astronomical observations as they reach values greater or equal to 21.30 mag/arcsec^2.
The important part of concept was the selection of sites, which are suitable for astronomical observations. Selected sites had to fulfil following criterion:

- no light pollution sources in visual field (360°), ideally near water level
- well transport accessibility – existing infrastructure (parking places, roads, tourist paths)

- suitability for tourism from species and area protection viewpoint (exclusion of sites, which are the part of NR and FFH)

The cooperation of several involved persons is needed during the preparation process of the Dark Sky Park Muranska Planina concept (Figure 6). On the one side, it is important to gather knowledge and experiences within topic from various aspects. On the other side, scientists from existing Dark Sky Parks and other multipliers should spread information.

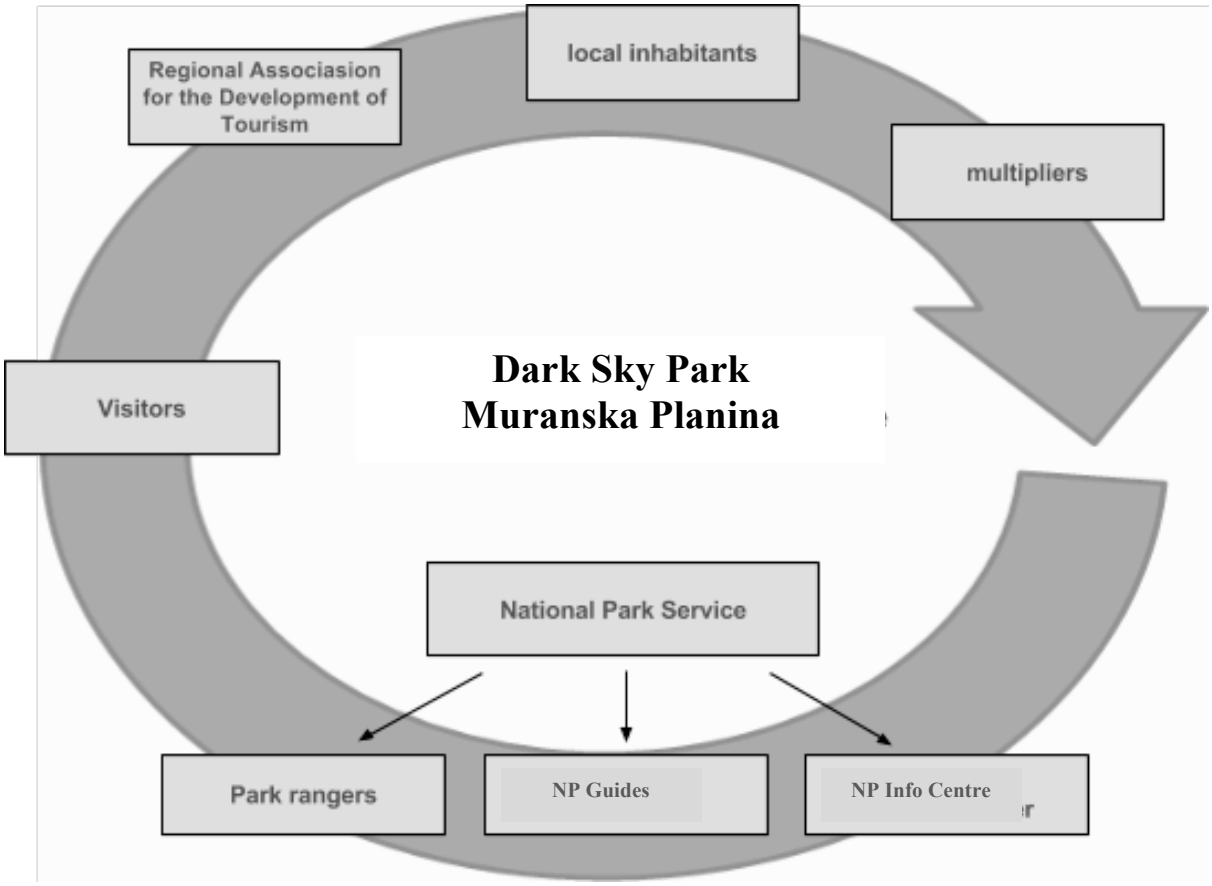


Figure 6 Involved persons in prepared Dark Sky Park Muranska Planina

Regional associations of tourism bear the highest responsibility for the marketing of concept through the creating and the support of attractive activities for visitors. The National Park Service could be the main coordinator in all processes. The participation of inhabitants is necessary to achieve acceptation. The building of network among those involved persons may achieve that Dark Sky Park will be a tool for the support of economically weak regions. The attractiveness of region increases through the creating of image and progressive increase of visitors in this tourism segment. It results in better utilization of regional added value.

Lighting plan

The goal of lighting plan is to set stable rules and directives for external lighting in proposed Dark Sky Park MP. Essentially, there should be no inappropriate external lighting in NP MP in the future. As Figure 7 shows, the best lights are those, which's the ratio of effectively used light is the highest (two most right lights in Figure 7). Important parameter by the assessment of unused emitted light is Upward Light Ratio. It describes how many percent's of light are emitted into atmosphere in imaginary circle above lighting. Optimum value is equal to 0. In this way, it is one of criterion valid for Dark Sky Park (Luginbuhl et al. 2006).

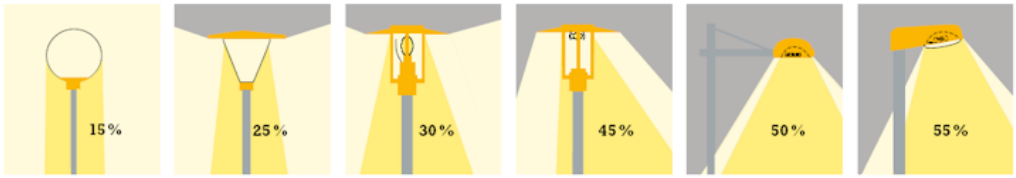


Fig. 7: Ratio of effectively used light by different lighting types (© S.A.F.E.)

Ecological aspect

From entomological aspect, high-pressure sodium lamp is the most suitable form of lighting. This statement is derived from the emission spectrum of different lighting types. E.g. mercury lamps emit light with wave length in ultraviolet spectrum (< 400 nm), as well as in range from 400 to 450 nm. (Weickelt, 2010). According to Eisenbeins (2009), mercury lamp was 2.33-times more often attacked by insect than high-pressure sodium lamp. This lamp emits less light and light wave length is equal to 600 nm. Therefore, it is more suitable from entomological aspect than mercury lamp.

Discussion

The concept of Dark Sky Park Muranska Planina is not the first planed dark sky park in Slovakia. Naturally dark sky is rare phenomenon in developed countries. Therefore, it is necessary to protect it. Naturally dark sky is the base condition for the establishment of Dark Sky Park, which is basis for the increase of area attractiveness from astro-tourism viewpoint. The topic of dark sky parks was discussed by several authors (Nagyová, 2014; Kossack 2013, Held et al. 2013, Marín et al. 2010). E.g. Kossack (2013) lists the tourism advantages of such parks on the example of Nature Park Westhavelland. The author came to conclusion that this form of tourism is not only sustainable, but it also prolong tourist season and enlarge the

attractiveness of Nature Park. The concept of dark sky park enables to enlarge added value of region and its economical utilization within sustainable development in margin regions.
Nagyová (2014) assesses recent state of tourism in Nature Park Nossentiner/Schwinzer Heide and focuses on new trends in tourism, e.g. astro-tourism, at the same time. Her study includes also the first concept of Dark Sky Park establishment in NP NSH. The assessment concludes that the Nature Park fulfils serious conditions for the establishment of Dark Sky Park.

Conclusion

Dark sky protection and light pollution elimination belong to important environmental problems in developed countries, i.e. Slovakia, too.
The establishment of Dark Sky Park is one of useful nature tourism tools, which is basis for astro-tourism. Measurements confirmed that National Park Muranska Planina fulfil difficult requests for night sky quality, as well as other requests for the establishment of Dark Sky Park. At the same time, the basis of regional partners was created, which will develop the concept further. It is assumed that it will increase added value of this margin region and it will improve its position from the viewpoint of sustainable tourism implementation.

Acknowledgement

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