7. The first results of light pollution measurements in the Transcarpathian Dark-Sky Park

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Transcarpathian Dark-Sky Park

On 11 June 2016, founding memorandum of the Transcarpathian Dark-Sky Park was signed in the Chorni Mlaky tract (Kniahynia village, Uzhhorod district).

The Transcarpathian Dark-Sky Park (with an area of 46,302 ha) includes the territory of the Uzhansky National Nature Park (39,159 ha) and selected areas in the cadastral area of the villages of Sukhyi, Tykhyi, Husnyi, Lyuta, Ruskyi Mochar and part of the village of Velykyi Bereznyi (see Ill. 7.1).

The Transcarpathian Dark-Sky Park was created in order to inform the general public and experts in the field of astronomy about the problems of light pollution of the night environment and environmental protection. The park area allows everyone to conduct astronomical observations on its territory, due to significantly lowered skyglow levels, promotes astronomy among children and the youth, and promotes the development of astrotourism in the Transcarpathian region.

On the occasion of the 150th anniversary of the fall of the Knyahynia meteorite in 2016, the East Carpathian Dark-Sky Tripark was proclaimed, which became the first in the world to be located on the territory of three states. The East Carpathian Dark-Sky Tripark (area 208,667 ha) includes the territory of the Dark-Sky Park Poloniny in Slovakia (48,519 ha), Bieszczady Starry Sky Park in Poland (113,846 ha) and the Transcarpathian Dark-Sky Park in Ukraine (46,302 ha).

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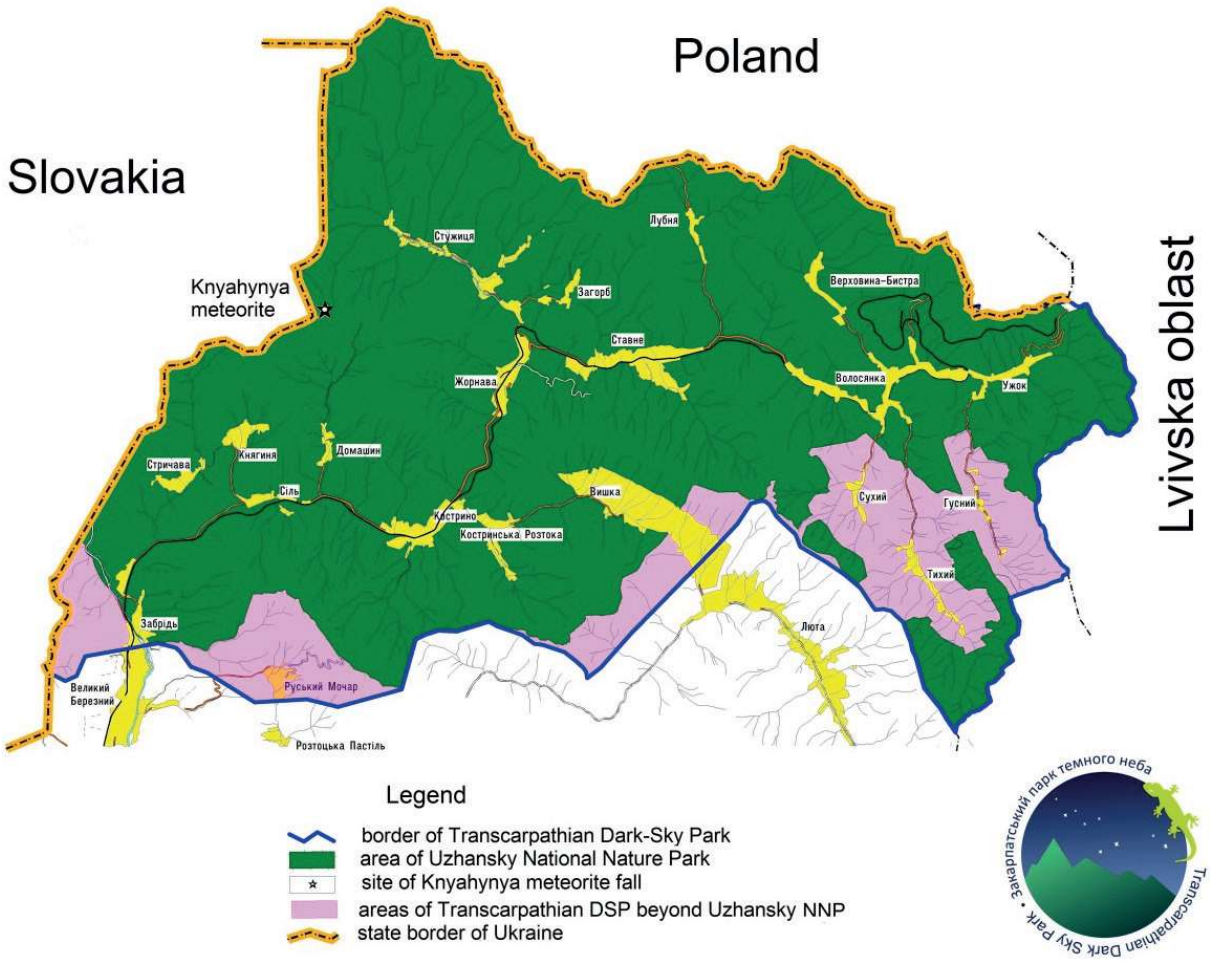
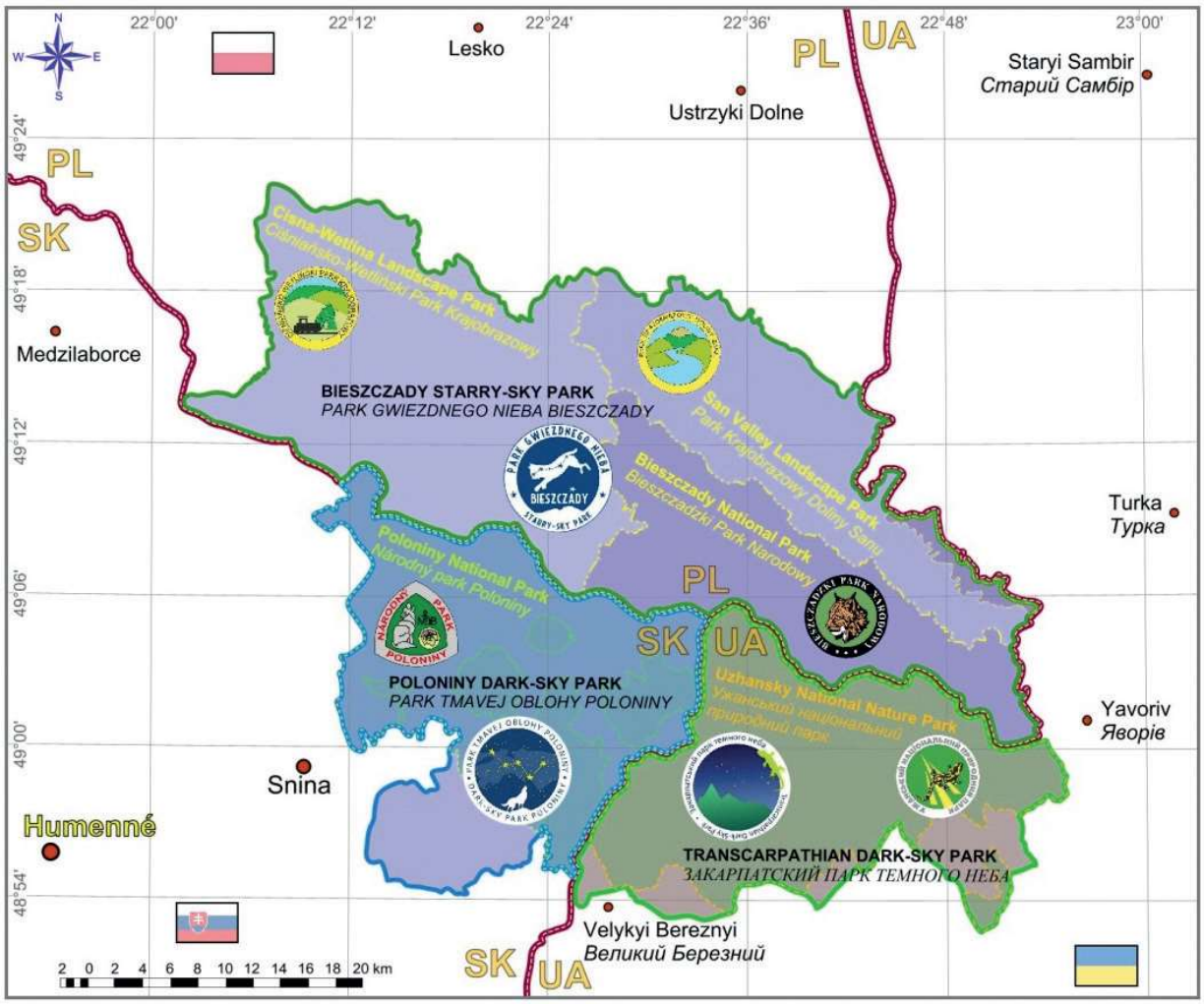


Ill. 7.1. Transcarpathian Dark-Sky Park. Flags – places where measurements of night sky brightness were performed (CSS 2021)

Due to the unique natural and cultural heritage sites included in the UNESCO international lists, the convenient location near the borders of the European Union and the lack of sources of environmental pollution (due to low population density, lack of production and industries), the border region is extremely attractive for eco-tourism. The creation of the Transcarpathian Dark-Sky Park has provided an opportunity to offer a new direction of tourism, bringing novelty to the tourist market.

In addition to good infrastructure, one of the most important factors for the development of astrotourism in the region is the quality of the night sky. The natural night sky is our common and universal heritage, but it is quickly becoming unknown to new generations. An important part of solving the problem of light pollution and understanding the quality of the night sky is to measure the brightness of the night sky (Nazarenko & Chernets 2014). Such measurements were performed at various points in the Transcarpathian Dark-Sky Park, resulting in the selection of locations, which combine rich natural heritage, historical past and most importantly, excellent night sky quality.



Ill. 7.2. East Carpathian Dark-Sky Tripark (CSS 2021)

Analysis of light pollution of the night sky in the Transcarpathian Dark-Sky Park

All measurements were performed using a SQM-LU-DL (Unihedron n.d.) device (Sky Quality Meter with narrow Field-of-View – lens, USB connectivity – data-logging). The main task for which SQM-LU-DL was purchased was measuring the night sky brightness in the Transcarpathian Dark-Sky Park.

One of the goals of the project was to start the process of registration of the Transcarpathian Dark-Sky Park in the International Dark-Sky Association (IDA). For this reason, measurements of the night sky brightness within the Transcarpathian Dark-Sky Park were performed according to the instructions provided by IDA. All measurements were conducted on nights around the new moon.

We conducted measurements in different places of the Transcarpathian Dark-Sky Park. In order to ensure that our values were not false, we conducted at least three

nights (from evening to morning) of measurements in all these places and chose the average of the maximum achieved values in each night. All measurements was made at the zenith, and were taken in months when the Milky Way is near the zenith, this means that the obtained values are brighter than the real darkest conditions. All measurements are listed in Table 7.1.

Measured places:

1. Village Lubnya (coordinates where measurements were made: 49°02′09.2″N 22°43′05.9″E, maximum value of the night sky brightness – 21.91 mag·arcsec^{-2}, measurement dates: August 9–15, 2021) – is a village in Uzhhorod district of the Zakarpattia region. The population is 212 people. The village is located in the valley of the Lubnya river. The village is located in the northern most mountainous part of the district. It is located 42 km from the district centre, near the border with Poland, 7 km from the Stavne railway station.
2. Village Knyahynya (coordinates where measurements were made: 48°58′28.9″N 22°30′47.5″E, maximum value of the night sky brightness – 21.62 mag·arcsec^{-2}, measurement dates: August 9–15, 2021) – is a village in Uzhhorod district of the Zakarpattia region. The population is 319 people (2001).
3. Village Uzhok (coordinates where measurements were made: 49°00′07.4″N 22°53′14.96″E, maximum night sky brightness value – 21.68 mag·arcsec^{-2}, measurement dates: September 8–10, 2021) – is the village located under the Uzhotsky Pass, where the river Uzh originates and where the Transcarpathian region begins. The population of Uzhok as of 2011 is 722 people.
4. Village Vyshka (coordinates where measurements were made: 48°55′29.7″N 22°40′14.9″E, maximum value of night sky brightness – 21.50 mag·arcsec^{-2}, dates of measurements: October 8–11, 2021) – is the village located in a mountainous area in the valley of the Uzh river, 25 km from the district centre – Velykyi Bereznyi, 70 km from the regional centre – Uzhhorod and 7 km from the Kostryno railway station on the Chop–Sambir line. The Vyshka River, a left tributary of the Uzh, originates in the village.
5. Mount Yavirnyk (coordinates where measurements were made: 48°54′56.7″N 22°32′27.6″E, maximum value of night sky brightness – 21.50 mag·arcsec^{-2}, measurement dates: June 17, 2021) – is a 1017-metre peak of the Ukrainian Carpathians, which is located within the Polonyn Beskids. It is located in the Uzhhorod district of the Zakarpattia region, in the eastern direction from the Velykyi Bereznyi village.

Analysis of light pollution of the night sky in the city of Uzhgorod and in the village of Nizhny Solotvino (Derenivka) from 1983–2021

In March 2005, at the Uzhhorod Astronomical Observation Point (Uzhhorod Observatory on Mount Calvary), measurements of the brightness of the night sky were made at the zenith using a photometer that covered an area of the sky with s field of view of about 9°. Observations were performed with a yellow-green filter, the effective transmission wavelength of which was 556 nm. The bandwidth of the filter was 80 nm. The brightness measurement error was 0.08 mag·arcsec^{-2}. Research was conducted on clear, moonless nights. Cloudiness did not exceed two points on a 10-point scale. Snow cover was absent, as well as the solar component in illumination because during all observations, the height of the sun above the horizon reached more than minus 18° (Yepishev et al. 2005).

The average value of the brightness of the night sky was 20.2 mag·arcsec^{-2}, and the average square deviation of the brightness values from the average value was $\sigma = 0.60$ mag·arcsec^{-2}. The obtained data was compared with the results of similar observations of the brightness of the night sky in Uzhgorod, which were performed in 1983 on the same device, when the average value of the brightness of the night sky was 20.7 mag·arcsec^{-2}.

The increase in the brightness of the night sky (Δm at the zenith) over twenty-two years above Calvary, is approximately equal to 0.5 mag·arcsec^{-2} or 1.6 times. Large cities at a great distance cause almost the entire sky to glow. Due to the bad astroclimate, a new observation point was created in Nizhny Solotvino village (Derenivka observation point) at a distance of 15 km from Uzhgorod city, where the brightness of the night sky at the zenith is 21.5 mag·arcsec^{-2} and is almost 3.5 to 5.0 times better than in the Calvary region. However, in recent years, the astroclimate has also worsened there due to the creation of resort complexes, the lighting of highways, etc.

In June–October 2021, we also measured the brightness of the night sky at the Uzhgorod astronomical observation point (Laboratory of space research UzhNU on Mount Calvary) with the SQM device. The average value was 19.72 mag·arcsec^{-2}. At the same time, the brightness of the night sky brightness was also measured at the Derenivka observation point with SQM device; the average value there was 21.18 mag·arcsec^{-2}. As we can see from the measurement results, the closer to the city, the brighter the sky.

The maximum values of the passband effective transmission are almost the same as those reported in the paper by Bará et al. (2019), 556 nm with the photometer used in 1983-2005 and ~510 nm with the SQM device. This enables the carefully comparison of the obtained data.

Conclusions

From June to November 2021, the night sky brightness was measured on the territory of the Transcarpathian Dark-Sky Park. We performed all measurements at night, when the moon was in the new moon or crescent moon phases. We conducted measurements along the perimeter of the Transcarpathian Dark-Sky Park, namely on Mount Yavirnyk (near the village of Velikiy Berezny) as well as near the settlements of Lubnya village, Knyahynya village, Uzhok village and Vishka village. For comparison, we also conducted measurements in the city of Uzhhorod and in the village of Nizhne Solotvino (Derenivka observation point) because we had archival results of measurements from 1983 and 2005.

In all locations of the Transcarpathian Dark-Sky Park where we performed measurements, the average value of the night sky brightness was equal to or greater than 21.50 mag·arcsec^{-2}.

Continuous monitoring of the brightness of the night sky allows recording the specific light pollution in each location, taking into account the difference in weather conditions, climate and different phases of the moon, as well as the ability to study long-term trends.

The modal value of the brightness of the night sky varied from 19.73 to 21.92 mag·arcsec^{-2}, which confirms the great variability of light pollution depending on the position of the site, in particular, the height of the site and its distance from the main sources of pollution, as well as various climatic changes, which play an important role.

Tab. 7.1. Average measurements on night sky brightness in Transcarpathian Dark-Sky Park and surrounding areas

№	Measurement locations	Date yyyy-mm-dd	Max value mag·arcsec^{-2}	Coordinates latitude, longitude, height (meters)		
1	Uzhhorod	2021-06-17	19.73	48°38′01.8″N	22°17′55.4″E	182
2	Uzhhorod	2021-10-16	19.75	48°38′01.8″N	22°17′55.4″E	182
3	Uzhok	2021-09-08	21.67	49°00′07.4″N	22°53′14.96″E	889
4	Uzhok	2021-09-09	21.66	49°00′07.4″N	22°53′14.96″E	889
5	Lubnya	2021-08-09	21.80	49°02′09.2″N	22°43′05.9″E	583
6	Lubnya	2021-08-10	21.71	49°02′09.2″N	22°43′05.9″E	583
7	Lubnya	2021-08-11	21.80	49°02′09.2″N	22°43′05.9″E	583
8	Lubnya	2021-08-12	21.70	49°02′09.2″N	22°43′05.9″E	583
9	Lubnya	2021-08-13	21.92	49°02′09.2″N	22°43′05.9″E	583
10	Lubnya	2021-08-14	21.71	49°02′09.2″N	22°43′05.9″E	583
11	Vishka	2021-10-08	21.46	48°56′34.0″N	22°39′57.0″E	635

12	Vishka	2021-10-09	21.49	48°56′34.0″N	22°39′57.0″E	635
13	Vishka	2021-10-10	21.47	48°56′34.0″N	22°39′57.0″E	635
14	Knyahynya	2021-08-09	21.60	48°58′28.9″N	22°30′47.5″E	512
15	Knyahynya	2021-08-10	21.55	48°58′28.9″N	22°30′47.5″E	512
16	Knyahynya	2021-08-11	21.62	48°58′28.9″N	22°30′47.5″E	512
17	Knyahynya	2021-08-12	21.53	48°58′28.9″N	22°30′47.5″E	512
18	Knyahynya	2021-08-13	21.55	48°58′28.9″N	22°30′47.5″E	512
19	Knyahynya	2021-08-14	21.54	48°58′28.9″N	22°30′47.5″E	512
20	Derenivka	2021-07-13	20.80	48°33′48.4″N	22°27′13.1″E	238
21	Derenivka	2021-07-17	20.87	48°33′48.4″N	22°27′13.1″E	238
22	Derenivka	2021-08-04	21.18	48°33′48.4″N	22°27′13.1″E	238
23	Yavirnyk	2021-06-17	21.50	48°54′56.7″N	22°32′27.6″E	985

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