

The Plitvice Lakes: World's Natural Heritage

There are waters, lakes, waterfalls, and forests in other places, but there are only one Plitvice Lakes in the entire world.

(Ivo Pevalek)

Sixteen lakes linked by waterfalls located between the mountains of Mala Kapela and Lička Plješivica in central Croatia are known as the Plitvice Lakes (Figure 1). This area, also marked as *Vražji vrt* (Devil's Garden) on some 17th-century maps, was proclaimed a national park of nature in 1928 (1) and thus became the first officially protected natural site in the country. United Nations Educational, Scientific, and Cultural Organization (UNESCO) also recognized its esthetic, cultural, biological, and ecological values and included it in the World Heritage List in 1979.

The Plitvice Lakes are a combination of biological, ecological, and esthetic uniqueness that changes through permanent biodynamics. Abundant water, rich forest, *karst* hydrogeology, various types of mosses and algae, and microclimate conditions in the park differ from those of the surrounding areas. The particularities of Plitvice Lakes are lakes and waterfalls, divided into two systems – the upper lakes and the lower lakes. Each lake and waterfall have a name. The waterfall between the lakes of Milan and Gavan was named after Milka Trnina (1863-1911), one of the best Croatian opera singers, whose voice was

symbolically honored by being compared to the powerful relentless thunder of the water.

The highest waterfall of Plitvice Lakes is between 68 and 78 m tall (2). The waterfall width depends on the water inflow from the four kilometers long Plitvice brook that pours in beneath the fall of the lowest lake, Novakovića Brod. Because of this, the fall does not belong morphologically to the hydrological system of the Lakes, but nevertheless together with other lakes makes an esthetic unit of the water world. It powerfully erodes the rock and forms a semicircular amphitheater, which is an impressive audiovisual experience and makes it one of the most visited falls.

The fundamental phenomenon of the Plitvice Lakes is *sedra* or travertine. Running through rocks, karst water dissolves calcium carbonate that settles and sticks to everything in the water like a silver layer. Deposits of calcium carbonate build dams and that is how lakes, cascades, and waterfalls are created. Where there is more oxygen, there is more abundant deposition. Calcium carbonate crystals also stick to the mucus secreted by bacteria and blue-green algae living on the threads and leaves of mosses of *Bryum* and *Cratoneurum* genus. That is plant-formed travertine. Scientific research proved that higher temperature promotes the creation of travertine, implying that the Plitvice Lakes could not have been created in the ice age.

Travertine is the soul of Plitvice Lakes, making them a fragile structural complex. The barriers are very sensitive to draining, changes in water chemical composition, and physical influences. Wooden bridges and paths above the travertine barriers make sure that travertine formations remain protected from possible mechanical damage. During the Homeland War (1991-1995), the Plitvice Lakes were occupied by the paramilitary Serbian army, whose presence and behavior posed a serious threat to the Lakes' existence.

Although the first written data on the flora and vegetation in the Plitvice Lakes date back to the beginning of the 19th century, systematic scientific research started not earlier than 50 years later (3). Among the most interesting and valuable forms of vegetation are dry and damp grassland surfaces and peat bogs, which make rare and endangered habitats today. Of plants in grassland habitats, *Lingularia sibirica* has the greatest value. It was discovered in the Plitvice Lakes in 1989 (4). There are 18 unique plant species in the Plitvice Lakes, which belong to protected species in Croatia, such as *Cypripedium calceolus* of the orchid family and *Trollius europaeus*.

The forests around the Plitvice Lakes have significant ecological value because they prevent erosion and balance water relations in the ground. The virgin forest of beech and fir in Čorkova uvala (Čorak basin) is unusual to the forest ecosystem. It grows along the hillsides of Mala Kapela, covering the area of 80 hectares (5). Among the three virgin forests in Croatia, Devčića Tavani in Senjsko Bilo and those in Lička Plješivica, Čorkova Uvala is considered the most beautiful. These virgin forests are the very last remains of virgin forests that once covered the European continent. They represent all grades of forest growth and development: forestation, its optimal condition, aging and decomposition. Tall trees of fir, spruce, and beech may grow over 50 m in height. The diameter of such trees is larger than 1.5 m. Čorkova Uvala carries the status of a special reserve of forestry vegetation and is closed to visitors. The variety of life in a virgin forest is vast. Dead trees create soil on otherwise poor karst surface. The soil provides a shelter and food to the living beings such as bacteria, fungi, insects, and various plants. The forests also provide home to wolf and bear.



Figure 1. The map of the Plitvice Lakes, the first national park of nature in Croatia.

A special indicator of diversity of biotopes is the presence of birds. There are over 150 different bird species in the Plitvice Lakes (6), including cuckoos, tits, warblers, woodpeckers, and owls. All these are nesting birds of the Plitvice Lakes, whose species amounted to a total of 70 according to the list made by 1954 (7), ie, 90 according to later research (6). There are 29 bird species that migrate via the Plitvice Lakes or spend the winter there. Many rare and endangered bird species dwell there, such as a forest species black stork (6) and capercaillie and pygmy owl, which nest in mixed forests. As water habitats, lakes are not very rich in life because they are too small (surface area up to 200 hectares). However, there are mallard, great-crested grebe, dipper, little grebe, common kingfisher, common sandpiper, moorhen, coot, and gray wagtail. In fall and winter, it is possible to spot some water-related bird species, such as white-tailed eagle, heron, red-breasted merganser, black-throated diver, pochard, golden-eye, and cormorant (6).

Over 700 000 tourists visit the Plitvice Lakes every year. There are seven electric boats for lake cruises and five trains that transport visitors through the park via forest railroads. Wooden rowing boats can be rented on the Kozjak Lake. Swimming is prohibited, but the usage of water from the Kozjak Lake is so immense that it jeopardizes the fundamental biological features of the Plitvice Lakes. Wastewaters also represent a problem as they are not managed outside the protected area of the park. Increased speed of eutrophication of the Plitvice Lakes is evident in the increased number of plankton algae in the lakes, more noticeable in the Prošćansko Lake than in the Kozjak Lake (8). This points to the saturation by substances entering the Prošćansko Lake. Water transparency decreases, while blue-green thread algae grow excessively. Underwater tall plants, such as *Myriophyllum* and *Potamogeton*,

develop intensely and cover the bottom, making the white bottom zones (*bjelari*) in some places hardly visible.

The need to enhance economy through Croatian tourism-related potentials may at times be in direct collision with the need to preserve the nature, as already experienced by both economists and naturalists (9). Even though no objections can be made to the logic trying to bring as many tourists as possible to an interesting place, it is clear that an enormous traffic may directly endanger the existence of what makes the place attractive.

That is the reason why the Plitvice Lakes more than ever depend on the fine art of keeping the balance between wishes and possibilities.

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