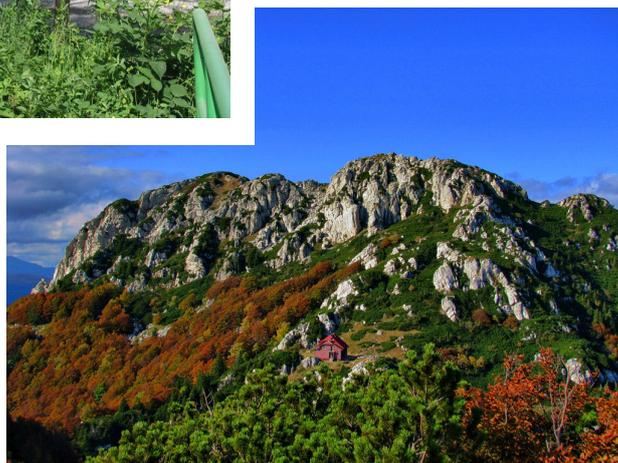
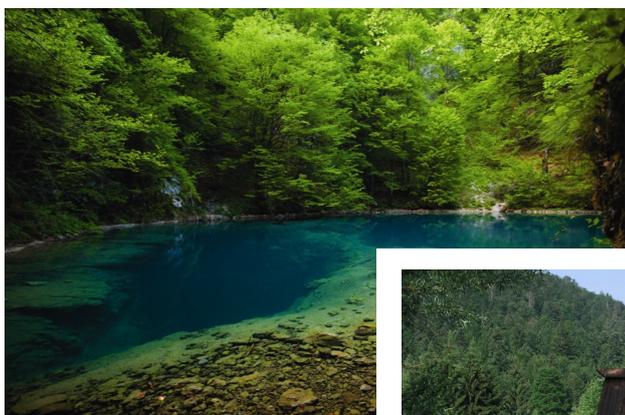


ACTION PLAN FOR CLIMATE CHANGE ADAPTATION

NATIONAL PARK RISNJAK



RISNJAK
Nacionalni park
National Park

IRMO
Institut za razvoj i međunarodne odnose
Institute for Development and International Relations



FOND ZA ZAŠTITU OKOLIŠA I
ENERGETSKU UČINKOVITOST

Action Plan for Climate Change Adaptation National Park Risnjak

Zagreb, September 1, 2017

Project: Climate Change in National Parks and Nature Parks of the Republic of Croatia: Management and Development Options

Environmental Protection and Energy Efficiency Fund (FZOIEU)

Institute for Development and International Relations (IRMO)

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Institute for Development and International Relations, Zagreb

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National Park Risnjak is a pilot area on the project “Climate Change in National Parks and Nature Parks of the Republic of Croatia: Management and Development Options” developed in cooperation with the Institute for Development and International Relations from Zagreb with the financial support of the Environmental Protection and Energy Efficiency Fund.

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1. SITUATION ANALYSIS

1.1. Introduction

At the suggestion of a botanist prof. Ivo Horvat, Ph.D., on September 15, 1953, the Risnjak forest was declared a national park. The park is located in Gorski kotar on a surface of 3,014 ha. The base of the park was the massive Risnjak Mountain, with a peak of 1,528 meters. In 1997 the area of the Park was expanded to an area of 6,350 ha and, besides the central part of the Risnjak Mountain, it also included the Snježnik Mountain and the hydro geomorphologic nature monument - the source of the Kupa River along with its upper course. Thus, the desire of prof. Horvat for the need to protect and valorise these areas was fulfilled.

The National Park is managed by the Public Institution, under the authority of the Ministry of Environmental Protection and Energy. Legal basis for the designation of a protected area management includes two laws: the Nature Protection Act

(Official Gazette 70/05 and 139/08) and the Law on Public Institutions (Official Gazette 76/93, Official Gazette No. 22/79, 47/99 and No. 35/08).

Public institution National Park Risnjak (PINPR) is a public institution. The organizing units are the Office of the Director, the Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the National Park, the Ranger Service, the Department for Promotional Activities, Catering and Tourist Activity, the Technical and Maintenance Department and the General and Joint Services Department. The Statute and the Rulebook on Internal Structure and Operating Rules of the Public Institution determine the organizational structure, tasks and responsibilities of different departments of the Public Institution. The Governing Board of the Public Institution is the body that links the Ministry of Environmental Protection and Energy, administration and shareholders.

In its daily management of the protected area the Public Institution cooperates with local residents, experts and scientists, other public institutions at local, regional and national level, and civil society.

1.2. The establishment of the process

Legal acts and regulations related to the area of nature protection define responsibilities for individual processes, different responsibilities, dynamics for the adoption of new and revision of old documents and strategic plans. The Management Plan has been the fundamental strategic document for NP Risnjak management over ten years (with an audit after five years). The National Park Risnjak Management Plan was developed in 2007 and a new document is expected soon. The specific requirements and needs of the National Park are defined through specific action plans. The timeframe for an individual action plan covers a period of one to several years and is reviewed on the basis of documented monitoring plans. The Management Plan identified the long-term vision of the National Park Risnjak, defined development goals and objectives of protection as well as measures for their realization, and the action plans

represent concrete tasks and are subject to change.

The vision of the National Park Risnjak connects all interesting groups and stakeholders in ensuring better future to the National Park and local community, and all stakeholders. All the management activities in the National Park must therefore be in full agreement with this vision as it reflects the purpose of the National Park and its management goals. The Public Institution of the National Park, in cooperation with all stakeholders, has defined the following vision:

“The National Park Risnjak remains a special and important wilderness area where the local population, landowners, visitors and the National Park authority work together to assure the preservation and restoration of natural processes, and the conservation and enhancement of cultural values.”¹

The vision of the National Park Risnjak emphasizes the need and intentions of the Public Institution to include the local community, landowners and visitors in the process of protection, ensuring long-term protection of the National Park, its natural and cultural values.

Long-term objectives of development and protection of the National Parka Risnjak are:

- *The unique karst biodiversity is preserved and improved by allowing and restoring natural processes and cultural activities.*
- *Local communities have the opportunity to cooperate in an important and useful way with the Park authority and the visitors can realistically experience, understand and evaluate the natural values of the Park.*
- *The National Park assures safe and clean water supply for the Kupa River through conservation of the upper watershed of the river.*

1 National Park Risnjak Management Plan, 2007., p.15

Specific objectives, measures, activities and indicators stated in the NP Risnjak Management Plan are:

a. Biodiversity conservation

Objective:

→ *Maintain existing, and restore where indicated biodiversity and ensure adequate protection of threatened, endangered, rare and endemic species as well as important endangered and rare habitats.*

Measures and activities:

- Undertake necessary activities for the maintenance of all types of meadows and for the restoration of abandoned meadows in succession. Action plans will be developed for specific sites.
- Promote grazing of domestic livestock within the park under control of the park authority
- All activities that influence the water balance will be prohibited to assure preservation of wetland vegetation.
- Locations of high conservation importance will be regularly monitored to make sure their floristic value is maintained. These include:
 - Below Dolari and Podgrić on the left side of the Kupa, the only location inside the Park with *Blechno-Fagetum*, (Beech forest on acid silicate soil) as well as the location of *Picetum montanum* in Lazac and wet meadows in the Kupa valley, habitat for *Matteucia struthiopteris*
 - Location for *Pinguicula alpina*, *Tofieldia calyculata*, Police,
 - Location Leska with various types of meadows and one bog
 - Peak parts of V. Risnjak, Guslica, Snježnik and Planina with poor mountain meadows
 - Location Šegine with meadow vegetation and basophile bogs
 - Kupa source (location for *Pinguicula alpina*)
 - Risnjak peak with calcareous rocky slopes with chasmophytic vegetation.

- Forests under strict nature protection (zone 1) will be managed through protection of natural processes and without human interference, unless extraordinary events occur that endanger the existence of these forests.
- Forests in the active conservation zone (zone 2) are maintained in a sustainable way that the overall characteristics of the forest are not changed. Fuel-wood collection so is allowed only for owners of land in the Park.
- Establish a system of cooperation and agreements with other state and international authorities to conserve birds and mammals that move in and out of park boundaries.
- Promote of the enlargement of the buffer zone to 500m to improve the conservation of large mammals
- Harmonize biodiversity conservation efforts across the border to Slovenia through regular meetings with Slovenian counterparts.
- Monitor continuously characteristic fauna species and undertake the necessary measures to ensure their conservation. Details of species, monitoring methodology and measures will be defined in action plans.

Indicators:

- Systematic monitoring of indicator types does not show significant negative development

b. Water quality conservation

Objective:

→ *Ensure the protection of the catchment of the Kupa River and in the conservation of the unique water habitat in and around the Park*

Measures and activities:

- The park will protect the tributaries of the Kupa River in the park and actively promote their protection outside the park for the conservation

of fish fauna by carefully managing and minimizing human impacts in the watershed

- The park will protect typical karst geomorphological features in the park and ensure through partnerships with other authorities and local stakeholders information and promotion of protection of the geomorphological features in the immediate surroundings.
- The sinkholes are regularly maintained and cleaned.

Indicators:

- The water quality level of the Kupa source remains constant at all times.

c. Socio-economic development

Objective:

→ *Create economic opportunities for the area in and around the park through activities compatible with the park vision and conservation policies of the protected area.*

Measures and activities:

- Participate in creating an enabling environment for the development, production and marketing of local products to tourists and public institutions
- Reserve in each visitor facility space for display and sell of local products
- Promote the local economy helping the owners of tourist facilities (private rooms, restaurants, etc.) to publicise and promote their businesses by preparing contact lists of the facilities and making them available to visitors at all park premises.

Indicators:

- The depopulation trend stopped the cooperation of the Public Institution with the local community established.

d. Participation of the local community

Objective:

→ *Encourage local community to participate in the management and conservation of the Risnjak NP through consultation, partnership and cooperation at all levels. Participative management is a long-term commitment of the park.*

Measures and activities:

- The park will hold yearly stakeholder meetings where problems and issues are openly discussed and follow-up is reported
- The park will inform the communities on all activities and plans with a regular newsletter
- The park will ensure that benefits from tourism are shared with the local communities.

Indicators:

- Annual meetings held; contributions in local media conducted.

e. Research

Objective:

→ *The park will serve as an area for scientific research in accordance with conservation policies.*

Measures and activities:

- The Park will promote research activities relevant for the management of the park in following fields:
 - inventory of old varieties of agricultural crops and fruit trees
 - socio-economic activities in and around the park
 - forest ecosystem and conservation of meadows
 - geomorphology, hydrology, speleology and conservation of the water fauna

- fauna monitoring and conservation measures
- All data collected during research activities are to be registered in the park's GIS and database as a matter of course. The data will be used to take and support management decisions as well as for the improvement of education and interpretation activities.
- All research activities will have to be carried out under supervision of the park management and in respect of the management policies.

Indicators:

- Increased knowledge about the Park area that directly helps manage the area.

f. Education and interpretation

Objective:

→ *Improve knowledge and understanding of the natural and cultural values of the park and thus increase the environmental awareness of the visitors and local residents.*

Measures and activities:

- The Park will develop within one year an interpretive management plan for education and interpretation in National Park Risnjak that identifies park themes and general strategies.
- Two new educational paths will be developed in the area around mountain Snježnik, Međuvrh and Lazačka glava, as well as in the Kupa valley from the source of the Kupa to Kupari. With these two additional educational paths, the National Park Risnjak will interpret all important ecosystems and elevation layers.
- Develop a visitor centre for school groups in Razloge in order to expand the schoolchildren's perception of Risnjak and the Karst phenomena. The visitor centre will be located at the old school in Razloge and the former village pub will be developed as an information centre and

simple accommodation for groups of schoolchildren (about 40).

- The area around the Leska Educational trail will be upgraded by a small information spot with ethnological data in the village of Leska and a recreational area in the vicinity. The concept of the educational trail will be revised and new interpretation methods and approaches used.
- The building of the Park Authority in Crni Lug and the area around will be developed as an educational and interpretative area with a special emphasis on families with children and an interpretative playground for children of different ages constructed.
- The National Park Risnjak will become one of the key locations in the planned international trans frontier Karst trail leading from Italy over Slovenia to Croatia. The most important Karst features to visitors will be interpreted in a variety of ways.
- The park will regularly contact schools of the Primorsko-goransko County in order to inform on educational activities in and around the park.
- In the future, an additional interpretative trail is foreseen at Viljske ponikve, which will inform visitors about the special phenomenon of temperature inversion that is specific for this area.

Indicators:

- Developed education plan, constructed planned educational paths, surveys show increased visitor awareness.

g. Visitor management

Objective:

→ *Provide quality visitor management, visitor recreation program, ticket charging, emergency services, and good information with the aim to preserve the natural beauty of the Park.*

Measures and activities:

- Assess the carrying capacity for Mt. Risnjak, Mt. Snježnik, Leska and the

Kupa source and assure that it is respected within one year.

- An action plan will be developed within one year to make the park restaurant in Bijela Vodica and a part of the Leska trail accessible for people with special needs.
- Improve and properly mark and maintain the existing network of footpaths within the park in order to spread the tourist visits over a larger area.
- Cooperate with tourism organisations in order to ensure that park visitors receive information on the values and possibilities of the Park and in order to attract other interested visitors to the area.
- Develop information spots in Platak and Hrvatsko.
- Visitors to the park pay an entrance fee with the revenues used for conservation purposes.
- Increase the points where entrance tickets are sold in accordance with the extension of the tourist offers.
- Local inhabitants, landowners and people who have legal rights in the park area do not pay entrance fees.
- Appropriate security and rescue services are assured in cooperation with the responsible mountain rescue team. The emergency numbers will be applied on the entrance tickets and on all entry points and facilities of the park.
- Sport fishing permits in the Kupa Valley will be sold according to the estimated carrying capacity in order not to threaten the conservation of the fish fauna and water quality.
- Mountain hut in Risnjak and Snježnik will be improved using renewable energy sources and ecological toilets in order to minimize the impact on the environment.
- The park will ensure proper training of tourist guides for the Risnjak park area through specific training activities.
- In cooperation with other stakeholders, the Park will support the development of two camping facilities in Crni Lug and Plesce.
- The park will support the local administration in the development of the planned recreational zone Velike Vode.

Indicators:

- Increased satisfaction of Park visitors by the offer, planned contents built.

h. Cultural heritage**Objective:**

→ *Cultural values and sustainable traditional economic activities, which reflect the history and integrity of the area, will be maintained and promoted in the Park.*

Measures and activities:

- The park will support and promote activities towards the conservation of the local agriculture and traditional crafts in and around the park.
- Agricultural activities inside the park boundaries are allowed in designated areas using indigenous agricultural varieties and traditional tools and practices.
- The park will carry out an inventory of old fruit varieties in cooperation with Primorsko-goranska County Centre for Mountain Agriculture
- The park will promote the marketing of the products of traditional agriculture among its visitors
- The park will educate its visitors on the traditional agriculture and crafts of the area.
- The park will use for all infrastructure development local crafts and material and will ensure traditional building skills are applied.

Indicators:

- Preserved traditional use of area in the Kupa valley and its presentation to visitors.

In addition to management plans, spatial plans for protected areas are the basic legal management document. The Spatial Plan of the National Park

Risnjak² was created by the Department for Sustainable Development and Physical Planning of the County of Primorje-Gorski kotar in 2001. It describes the features of this area, measures of protection and permitted activities.

Climate change is not addressed in the Spatial Plan or in the Risnjak Management Plan. However, in the next plan there will be a need to establish processes that will further support, encourage research on climate change impacts on NP Risnjak, and ensure flexibility in decision-making and planning activities related to this topic.

1.3. Assessment of human and financial resources and funding opportunities

1.3.1. Human resources

NP Risnjak employs 23 people. Along with experts on nature conservation and rangers, some of the employees are caterers and tourism workers.³ Within the Public Institution, expert services and rangers are concerned with the preservation of nature. The Director of the Public Institution is appointed by the Government of the Republic of Croatia for a period of four years. The Ordinance on the internal organization of the Park 57 employees are envisaged, and the majority of them are missing from the Department of Professional Affairs for the protection, maintenance, conservation, promotion and use of the National Park.

1.3.2. Financial resources and funding opportunities

The annual budget of the National Park Risnjak is about 4 million kunas (2016), and the amounts vary from year to year. The state budget contributes

2 National Park Risnjak Spatial Plan (NN 23/2001).

3 NP Risnjak: Management. Available at: <http://np-risnjak.hr/o-parku/upravljanje/>, Accessed on 10.05.2017.

to the financing of the Park in the amount of approximately 2 million kunas (2016) and the rest of the funds are own revenues from activities that are not exclusively related to nature protection, such as income from the sale of goods and services provided (e.g. souvenir sale, concession authorizations, educational and tourism programs).

Funds collected through domestic and foreign donations, international organizations and institutions (WB, UNDP) and EU tenders (EU programs and funds), assistance from extrabudgetary users, income from property and financial assets have increasingly risen. Such activities require the additional engagement of Park employees by finding opportunities and preparing applications for specific projects, which is often based on the enthusiasm of individuals.

1.4. Collecting data on the National Park

One of the reasons for establishing national parks and other types of protected areas is to preserve the particular values of biodiversity within these areas. Biodiversity research in the Park is continually being carried out within the framework of regular employee work and in cooperation with a number of relevant scientific and professional institutions and organizations.

Activities in the Park include the population. According to the 2011 census, there were 17 people living in NP Risnjak⁴. In the past, the population has traditionally been engaged in forestry in the area, and in the Kupa valley the economy has been more focused on treating small plots with crops and breeding domestic animals. Today, there are only a few remaining farms where fruit, vegetables and small livestock are grown. These small farms are built in the traditional way and represent the cultural heritage of this area. Their restoration and the introduction of old ways of farming are very rare, and there is also rare offer of local products. All this could in the future be the driver of the revitalization of the whole area. The law prohibits hunting and fishing in the NPR area.

4 Detaljniji prikaz dan je u Tablici 13. Prikaz broja stanovnika na području Nacionalnog parka Risnjak.

1.4.1. Biodiversity

Risnjak represents the climatic and vegetative partition between the Croatian coast and the mainland parts of Croatia and is the most significant example of the height vegetation breakdown of Croatia. In the Park there is a prominent phenomenon of seagrass vegetation, a natural connection between the Alps and the Balkan mountains and the natural habitat of three large European beasts - brown bear (*Ursus arctos*), wolf (*Canis lupus*) and Euroasian lynx (*Lynx lynx*), as well as 1,148 species and subspecies of flora.

The Lynx is most probably the shiest carnivore to be found in Europe. Risnjak remains one of the key areas in Croatia for the survival of the lynx and its surroundings are one of the last retreats for this large carnivore of Europe. Furthermore, wolves can also be found in the Park and they are listed as an endangered species on the International Union for Conservation of Nature (IUCN) Red List and generally protected from hunting by law. The park is also the habitat of brown bears⁵. The best habitat of bears is found in the Risnjak - Snježnik massif at altitudes of 500 to 1,100 m, and the population is stable. The number of chamois (*Rupicapra rupicapra*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) populations are present below the carrying capacity of the habitat. Wild boar (*Sus scrofa*) is also present and its population is stable.

Massive Risnjak has been the area of scientific research for more than 150 years. From old research by prof. dr. Ivo Horvat, based on which Risnjak was included in the group of protected areas, various vegetation, fauna and other researches was carried out:

- dr. Paula Durbešić: Entomofauna NP Risnjak
- V. Kušan, Z. Kalafadžić, R. Pernar, Z. Horvatić: Forest damage in NP Risnjak
- Ž. Rauš, Ž Španjol, T. Đrinić: Vegetation research on experimental plots

⁵ NP Risnjak: Mammals. Available at: <http://np-risnjak.hr/fauna/sisavci/>, Accessed on 10.05.2017.

in NP Risnjak

- M. Tortić: Mushrooms in NP Risnjak
- P. Durbešić, S. Vujčić-Karlo: Fauna – ecological research arthropods
- Ž. Huber, H. U. Roth: The movement of brown bears
- M. Kučinić, K. Ilgalfy, M. Šašić, S. Balen: Exploration of butterfly fauna

Continuous monitoring of the status of selected taxa is performed: counting traces of large mammals on the transect; monitor the status of birds in the transect and monitoring the condition of caves and sinkholes.

1.4.2. Ecological Network of the Republic of Croatia

By preserving nature, Croatia is one of the richest countries in Europe. One third of Croatia's territory is part of the Natura 2000 ecological network including NP Risnjak⁶. Natura 2000 marks areas of importance for the conservation and exploitation of favourable conditions of other wild species and their habitats as well as natural habitat types of interest for the European Union. The Natura 2000 network is also aligned with the National Ecological Network of the Republic of Croatia. One of the obligations of the Republic of Croatia towards the European Commission is regular reporting on the status of Natura 2000 sites. It is therefore the task of NP Risnjak to carry out the monitoring of the target species according to the planned dynamics, which is in accordance with the financial possibilities. The current monitoring done in the Park did not include the topic of climate change.

1.4.3. Forests

Almost 96% of the area or 6 101 ha of the National Park Risnjak is covered by forests. Out of the total forest area of the Park, 5,616 ha or 92% are owned

6 NP Risnjak: Natura 2000. Available at: <http://np-risnjak.hr/natura-2000-cuvamo-sto-je-priroda-stvarala-stoljecima/> Accessed on 10.05.2017.

by the state and 485 ha or 8% are private.⁷ The main forest vegetation types are beech forests, fir-tree forests, spruce forests with moss, mountain spruce forests with gavel, sub-mountain juniper forests, sub-mountain beech forests, prefabricated spruce forests with snow moss, snowdrifts with gooseberries, shrubbery hornbeam, beech forest with dead shrubbery, black hornbeam forest, hornbeam and beech forest, beech forest with fern, floodplain grey willow forest and black and white alder forest.⁸ The acidophilus illyrian beech forest and the acidophilus illyrian fir forests represent rare forest associations in the Croatian karst region.

The forests of the NP Risnjak represent the typical potential vegetation of the area and are comparatively little influenced by forest management. In general, the forests of the National Park Risnjak are not managed. In unpredicted and extraordinary events (fire, gradation of insects, forest dieback etc.) certain “ad hoc” actions are undertaken in cooperation with the Croatian Environment and Nature Agency (HAOP) and the Nature Protection Directorate within the Ministry of Environmental Protection and Energy. The use of secondary forest products is prohibited in the whole Park area.⁹

1.4.4. Other habitats

In National Park Risnjak, besides forests, there are grasslands, meadows, moors, high green, mires, wetland habitats, rocks, rivers, and ruderal habitats. Grasslands occupy a smaller part of the Park’s surface, while most of them occupy mountain ridges on the peaks of Risnjak, Snježnik and Guslice.

Meadows with narrow-leaved moor grass and sharp sedge, mountain turfs of evergreen sedge and narrow-leaved moor grass and mountain grasslands

7 Zaštita prirode na području Nacionalnog parka Risnjak. Available at: www.sabor.hr/fgs.axd?id=1738 Accessed on 22.05.2017., PDF file:///C:/Users/mjurisic/Desktop/Downloads/61_ZASTITA__PRIRODE__NA__PODRUCJU__NACIONALOG__PARKA__RISNJAK%20(2).pdf

8 National Park Risnjak Management Plan, 2007., p.27

9 National Park Risnjak Management Plan, 2007., p.28

of sedge and alpine sunflower are settled on most exposed positions of the peaks, where, due to strong winds in winter snow is often blown away. Plants are exposed to extreme climate extremities, low temperature and physiological drought due to permanently frozen substrates. One-year species are not present in the Park area because vegetation season is too short for their complete development.¹⁰

Meadows with sharp anemone and lawns of longhair lilies and violet anemone are found in sheltered positions within the juniper pine and are probably created by anthropogenic activity, grazing and mowing. Mowing as an activity for the last ten years ceases to exist, so the degradation of these lawns can be expected and the conversion to the mountaineering moors can be expected. The lawn of the upright sheep and the middle ground is a very picturesque meadow with a multitude of flowering plants. Lawn grasses occupy small areas in the National Park Risnjak, above acidic, washed substrates. The most beautiful stands are of moravka with their yellow heads. Meadow of red anemone and plain roaches is also found locally on acidic, deep soils. The meadow of oat grass is rare in this area. It is the best mowing meadow created by grassing, but the Park has very little population and there is no need for quality fodder, and the surface does not suffer and does not allow two to three cuts per year, which is a feature of this meadow.

Lawns in the Park are significant habitats for butterflies and birds, but they are not in good condition because of the lack of domestic animals and the lack of mowing, so the forest areas are spreading. Lawns are also an important part of the diversity of landscapes and the preconditions of far-sightedness, which is a very important segment for Park visitors. Meadow habitats develop along settlements and paths in beech forests. The areas around Snježnik and Risnjak peaks are characterized by rocky outcrops of typical karst formations, surrounded by woody vegetation dominated by subalpine calcareous grasslands.

¹⁰ National Park Risnjak Management Plan, 2007., p.29

1.4.5. Protection zones in NPR

National Park Risnjak is divided into three different zones according to natural values, distribution and needs of the local population, as well as management needs. Areas with a high natural value and a low management need are declared as strict protection zones. Areas of low natural value and high management requirements are declared use zones. Zones of active conservation are areas that require a particular type of management in order to preserve their conservation values.¹¹ The overview of protection and management zones in the National Park Risnjak is as follows:

Table 1. Area of the different management zones in NPR

Zone		Area (ha)	Total (ha)	Percentage %
Zone 1 – Strict protection zone				
a) Areas with minimal human intervention	1 – Bijele stijene	116,6	1.229,9	19,4
	2 – Risnjak	441,5		
	3 – Lazačka Glavica - Planina	455,5		
	4 – Kupa source - Sušica	216,3		
b) Areas where scientific research and limited visitor access are allowed	5 – Risnjaka massif and Javornica	2.559,9	3.061,6	48,3
	6 – Kupa valley	429,3		
	7 – Police	37,9		
	16 – Blechno-fagetum forest	34,5		
Zone 2 – Active conservation zone				
a) Areas with impact on the habitat (conservation, rehabilitation)	8 - Mountain grasslands	173,4	387,4	6,1
	9 - Mountain meadows	118,9		
	11 - Wet meadows in Kupa Valley	39,3		
	12 - Forest monoculture	22,7		

¹¹ National Park Risnjak Management Plan, 2007., p.53

Zone		Area (ha)	Total (ha)	Percentage %
b) Areas with impact on the habitat (conservation, rehabilitation)	10 – Kaličak – Leska forest	948,8	966,9	15,2
	13 - Natural mountain spruce forest (Lazac)	18,1		
Zone 3 – Use zone				
a) Settlement, traditional agriculture and forestry zone	14 – Kupa valley	675,8	675,8	10,7
b) Recreational zone, Touristic infrastructure zone, etc.	15 – Areas around mountain hut Risnjak and Snježnik, military zone Guslica, around information spot Leska, recreation zone Španov Laz	21,4	21,4	0,3
TOTAL			6.343,0	100

Source: National Park Risnjak Management Plan, 2007, p. 55

Figure 1. Share of individual zones in the total area of NP Risnjak

Zone 1a – Strict protection zone - Areas with minimal human intervention

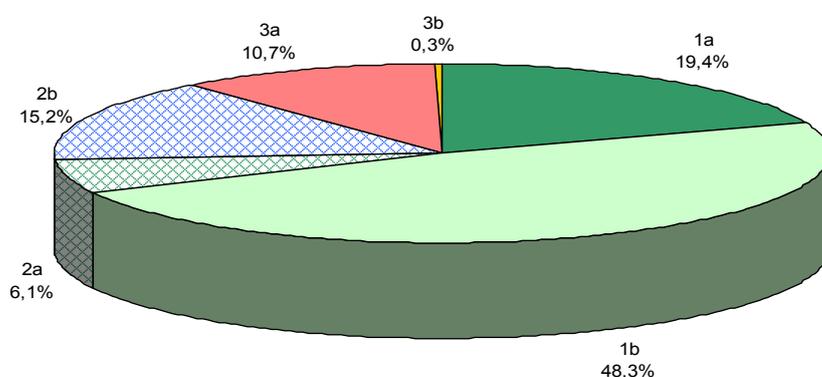
Zone 1b – Strict protection zone - Areas where scientific research and limited visitor access are allowed

Zone 2a – Active conservation zone - Areas with impact on habitats

Zone 2b – Active conservation zone - Areas with impact on habitats

Zone 3a – Use zone - Settlement, traditional agriculture and forestry zone

Zone 3b – Use zone - Recreational zone, Tourist infrastructure zone



■	1a Zona stroge zaštite - Područje uz minimalnu intervenciju
□	1b Zona stroge zaštite - Područje u kojima su dozvoljena znanstvena istraživanja i gdje je ograničen pristup posjetitelja
▨	2a Zona aktivne zaštite - Područje s utjecajem na staništa
▩	2b Zona aktivne zaštite - Područja s utjecajem na staništa
■	3a Zona korištenja - Zona naselja, tradicionalne poljoprivrede i šumarstva
■	3b Zona korištenja - Zona rekreacije i turističke infrastrukture

Source: National Park Risnjak Management Plan, 2017.

1.5. Communication and dissemination of data

The National Park Risnjak is known as the habitat of lynx, wolves and brown bears and many other species of protected flora. NP Risnjak, therefore, with its rich flora and fauna and the diversity of landscapes, attracts numerous tourists, hikers, researchers and other interested visitors. The Risnjak National Park has an edited website (<http://np-risnjak.hr/>) to which data and information related to events in the National Park, projects, marking of important dates,

advertisements and the like are regularly placed. The park is also active on social networks through its Facebook page (<https://hr-hr.facebook.com/np.risnjak/>).

1.6. Tourist valorization of the area

The Risnjak National Park is annually visited by approximately 40.000 visitors, from which approximately 16.000 visitors buy entrance tickets. Almost one half of the visitors are groups of schoolchildren that visit the Park during excursions in the springtime and early summer. The other half of the visitors are coming for mainly one-day trips from their holiday destination on the nearby sea or are mountaineers and hikers that come for a few days and stay mainly in the mountain huts.¹²

Entrance fees for the Risnjak National Park are so far collected only at four locations: The headquarter of the Park authority in Crni Lug, Risnjak mountain hut, Kupari and Razloge. No entrance fees are charged at other entrances to the Park area. For accommodation they use the hotel of the Park (with a very limited capacity), private accommodation in the villages or the mountain huts. The camp does not exist in the Park. Individual visitors mainly make tours in the Park area on their own, using the marked trails and mountain paths. Mountaineers use the area of the Park traditionally and are used to hiking and trekking in the area over the whole year, even in the winter months. The strengthening of eco-tourism based on preserved natural heritage is one of the major challenges for the future development of the National Park in close cooperation with the local population and communities.¹³

12 National Park Risnjak Management Plan, 2007., p. 45

13 Assessment of tourism structure and proposals for sustainable tourism development in the KEC project area, Ministry of Culture, Agriconsulting S.P.A., 2005.



2. RISK ASSESSMENT AND VULNERABILITY OF NP RISNJAK

The results of the Sixth National Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC) are an important source of general data for the Republic of Croatia by which trends and their relative influence and strength can be located in different regions. However, for local impact clarification, a particularly important source of data are local measurements by which more accurate data can be obtained, which can be applied to the development of further climate change strategies. According to estimates of future impacts of climate change on the National Park Risnjak, it is possible to identify the following key risks: temperature changes, rainfall and wind changes and air pollution.

2.1. Current knowledge about risks and vulnerabilities in the area of the National Park Risnjak

There is an automatic meteorological station at the headquarters of National Park Risnjak in Crni lug since 2004. Although meteorological data from the area of National Park exist since then, they have not been subjected to systematic research related to climate change. Meteorological data on air temperature and precipitation in the observed area are therefore presented according to the available data from the NP Risnjak Programme 1991-1992 and the NP Risnjak Protection, Conservation and Maintenance Programme, 2001.

Air temperature

The Lividraga and Platak meteorological stations were used to illustrate the climate in the area of National Park Risnjak. The data from the Lividraga Meteorological Station refer to the period from 1971 to 1980, and the data from the Platak Meteorological Station refer to the period from 1950 to 1961. More recent data are not available, because at these stations the temperature has not been measured since.

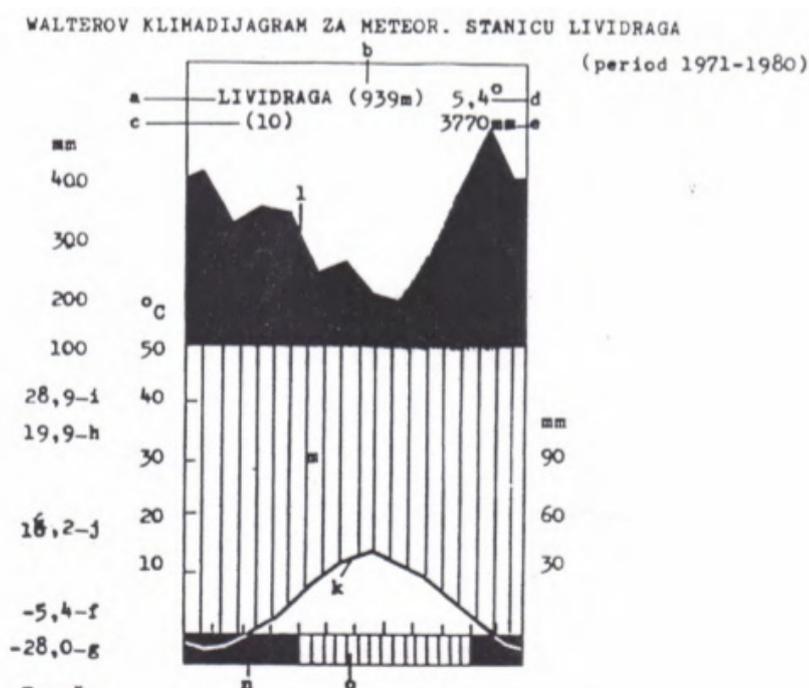
Meteorological Station Lividraga is located at an altitude of 939 m and is about 5 km from the central part of Risnjak Massif. The mean annual temperature measured at the Lividraga Meteorological Station in the period 1971-1980 was 5.4 °C (Table 2). The highest monthly average temperature was in July 14.2 °C, and the lowest in January was -2 °C. The average annual temperature fluctuation was 16.2 °C. The highest increase in average monthly temperatures was recorded between April and May at 5.4 °C (3.4 ° to 8.8 °C). The absolute minimum in the observed period was -28 °C, measured in March 1976, and the absolute maximum 28.9 °C measured in July 1972 and September 1975. July was the hottest month with a mean maximum temperature of 19.9 °C, and December coldest with a mean minimum temperature of -5.4 °C. The absolute minimum air temperature at the Platak Meteorological Station was measured

in 1956 and was -25.3°C , and the absolute maximum was 29.6°C and was measured on July 5, 1950. The average annual air temperature measured at the Platak Metrological Station in the period 1950 to 1961 was 5.5°C .

Table 2. Temperature ($^{\circ}\text{C}$) for the meteorological station Lividraga (1971 to 1980) and Platak (1950 to 1961)

PLACE	MONTHS												Mean annual values
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	
PLATAK	-3.0	-2.0	-0.2	3.6	8.4	12.4	14.3	13.8	10.9	6.3	2.0	-0.1	5.5
LIVIDRAGA	-2.0	-1.4	0.7	3.4	8.8	12.5	14.2	13.3	10.0	5.7	1.6	-0.5	5.4

The average temperature of the vegetation period at the Lividraga meteorological station was 12°C . During the monitoring period, there was no month in which the absolute minimum temperature was below 0°C . This is important because of the appearance of frost. As can be seen from Walter's climatic diagram (Figure 2), there was no period of frosting in the vegetation period (Vukelić, J., 1984).



Tumač:	n	o
a	- meteorološka stanica	
b	- nadmorska visina stanice	
c	- broj godina motrenja	
d	- srednja godišnja temperatura zraka (°C)	
e	- srednja godišnja količina oborina (mm)	
f	- srednji minimum temperature zraka najhladnijeg mjeseca	
g	- apsolutni minimum temperature zraka	
h	- srednji maksimum temperature zraka najtoplijeg mjeseca	
i	- apsolutni maksimum temperature zraka	
j	- srednje kolebanje (amplituda) temperature zraka	
k	- srednje mjesečne temperature zraka	
l	- srednje mjesečne količine oborina	
m	- vlažno razdoblje	
n	- mjeseci sa srednjim minimumom temper. zraka ispod 0°C	
o	- mjeseci s apsolutnim minimumom temper. zraka ispod 0°C	

Figure 2. Walter's climatic diagram for the Lividraga meteorological station (period 1971-1980)

Source: Vukelić, J., 1984. Contribution of photointerpretation analysis to vegetation research of forest communities of Risnjak National Park. Master's thesis, Faculty of Forestry in Zagreb.

Precipitation

The researches of Ivo Penzara (1959) showed that Gorski kotar has the highest amount of precipitation in the Republic of Croatia and precisely on the Risnjak massive. Average annual precipitation measured at Lividraga meteorological station in the period 1971-1980 amounted to 3770 mm (Table 3). By months, the highest precipitation was in November at 488 mm and the lowest in August at 166 mm. There is normally much more precipitation during the colder part of the year, but the summer minimum is sufficient for the development of very lush vegetation. The absolute maximum rainfall during the monitoring period was December 1976, even 1219 mm, and the absolute minimum in August 1973, 31 mm. Of the climatic events, 129 days are recorded annually with rain and 54 days with snow. Snow falls on the ground for an average of 139 days. The number of days with fog is 31 and with thunderstorms 12. The maximum snow depth was 270 cm, which was measured in March 1976.

Table 3. Average values of particular climatic elements and phenomena; climatic factors and indices for the Lividraga meteorological station, period 1971-1980.

Climatic elements and phenomena, factors and indices	Months												Annually
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	
Average air temperature (°C)	-2,0	-1,4	0,7	3,4	8,8	12,5	14,2	13,3	10,0	5,7	1,6	-1,5	5,4
Average relative humidity of air (%)	93	93	93	94	95	93	93	94	95	95	94	93	94
Average amount of precipitation (mm)	409	317	347	338	229	249	190	166	268	374	488	395	3770
Average number of days with rain (>0.1 mm)	9	8	8	11	14	14	13	12	16	12	10	8	129
Average number of days with snow (>0.1 mm)	10	10	10	8	1	-	-	-	1	2	6	6	54
Average number of days with thunderstorm	-	-	-	-	2	3	3	1	1	1	1	-	12
Average number of days with fog	5	4	2	2	1	1	2	1	1	4	3	4	31
Average number of days with clouds	7,5	7	6,3	5,9	5,4	5,4	4,5	4,4	5	6,1	6,7	5,9	5,6
Monthly rain factor	-	-	496	99	26	20	13	12	27	66	305	-	644

Table 4 shows data from 10 rain gauge stations and three totalizers in the wider area of the National Park Risnjak for the period 1961-1990.

Table 4. *Precipitation (mm) for the monitored period 1961-1990*

RAIN GAUGE STATION	MONTHS												ANNUAL		
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	MAX.	MIN.	AVER.
CRNI LUG	243	211	219	210	179	166	133	166	212	255	335	296	3635	1967	2624
DELNICE	190	170	182	202	172	161	128	163	194	215	288	240	3012	1639	2303
LOKVE	243	216	219	218	189	168	132	167	218	247	354	321	3534	1940	2692
M. VODICA	280	223	234	229	195	167	129	166	221	265	210	166	2095	1200	1753
B. N. KUPI	124	127	133	147	136	136	119	148	152	155	210	166	2095	1200	1753
GEROVO	197	174	194	200	171	184	141	176	221	261	332	246	3172	1875	2496
KUŽELJ	137	137	148	160	134	140	114	150	162	168	228	183	2240	1526	1861
LIVIDRAGA	354	315	329	309	238	216	162	191	300	389	528	476	5113	2786	3806
ZAMOST	141	127	144	154	141	152	124	148	175	191	246	175	2389	1499	1918
PLATAK	358	350	206	297	225	266	199	169	325	403	422	437	5784	2281	3657

The duration and amount of snow cover are especially important for the Risnjak area. The snowy winter or the interval between the first and the last day with snow cover in this part of Gorski kotar lasts for more than 5 months, in Mrzla vodica 166 days, and on Platak even 185 days. The highest measured snow cover was 320 cm high and the maximum snow level at Lividraga was measured in March 1976 in the amount of 270 cm. The length and height of the snow cover varies greatly with the altitude and exposure.

Table 5 shows data on mean precipitation rates according to decades for the 30-year period from 1960 to 1990 in the National Park Risnjak and its immediate surroundings measured in totalizers.

Table 5. Average precipitation

DECADE	RISNJAK	SNJEŽNIK	LIVIDRAGA
	mean precipitation rates (mm)		
1960/61 – 1969/70	3944	3722	4034
1970/71 – 1979/80	3354	3199	3704
1980/81 – 1989/90	3112	3054	3535
30-year mean precipitation rates	3470	3325	3758

One of the most significant events related to weather extremes and the impact on climate and the environment at the National Park Risnjak is certainly in the ice of 2014, which has affected parts of Gorski kotar and has caused great damage to the forests.

2.2. Risk and vulnerability assessment for species and habitats in the context of climate change

The general impact of climate change on living organisms is difficult to imagine, but any organism can in some ways be influenced by climate change. Ecosystem disorders increase the risk of spreading invasive species. The risk and vulnerability assessment in the context of climate change predicts which species and habitats could be affected by climate change. The estimates are presented by components of forest stands, non-forest stands and anthropogenic modified habitats, aquatic habitats (springs, streams, ponds), surface and underground karst habitats, soils, hydrology and climates.

2.2.1. Forest stands

Forest vegetation in the area of National Park Risnjak consists of diverse forest communities, mostly mixed with stands of beech and fir. Beech is represented by 59.97%, fir with 35.23%, spruce with 1.80%, and other species, willow, pine

cones, black grape, black and white birch, with 3.00%.¹⁴

In the winter of 2014, parts of the Gorski kotar area were caught by ice that also affected the forests of National Park Risnjak. As one of the consequences of the ice, there was an escalation of beetles, pests that stuck under a tree bark and capable of destroying it in just a few weeks. Most of the spruce woods were attacked, which in some areas were even destroyed by up to 50%¹⁵.

Vegetative shift. Forest stands in the National Park Risnjak are divided by zones.

Zone 1a - Strict protection zone is primary forest area belonging to the old part of the park, characterised by white rocks and undisturbed forest communities. It includes the top part of the Risnjak massif with mountain beach forest, dwarf pine woodlands and rock formations and the upper part of the Kupa River and the whole canyon of the Sušica. It is characterised by thermophile forest and karst-water formations of outstanding beauty. In this area the forests were not managed and there was no cutting. It is relatively large, untouched, inaccessible and is a stable habitat of high natural value for the wildlife. It is the habitat to a black grouse, shrubbery, woodpeckers and owls, as well as brown bear area.

Zone 1b - Strict protection zone, includes the old area of the Park, which is a typical karst landscape with dolinas, caves and pit holes with a vegetation characterised by a mixed beach and fir forest. It also includes the Valley of the Kupa River characterised by steep slopes with mixed white fir and beech forest vegetation interrupted by a mosaic of meadows and orchards. The forest has a high importance in the protection of the catchment and prevention of erosion. Zona 1b is a habitat of a carnivore plant.

14 NP Risnjak: šuma i šumske zajednice. Available at: <http://np-risnjak.hr/flora/suma-i-sumske-zajednice/> Accessed on 11.05.2017.

15 Novi list: Mrvoš Pavić, Bojana: Potkornjak jači od države: Šumama Gorskog kotara prijete kataklizma zbog najezde štetočine, Available at: http://www.novolist.hr/Vijesti/Regija/node_1588/Potkornjak-jaci-od-drzave-Sumama-Gorskog-kotara-prijeti-kataklizma-zbog-najezde-stetocine?meta_refresh=true Accessed on 19.06.2017.

Zone 2a – Active conservation zone consists mainly of mountain grasslands ranging from an altitude of 1300 to 1500 m with minor patches of dwarf pine and mountain beach woodlands. These areas have a high biodiversity and host rare species of butterflies and birds. Roe and red deer feed on them. This area represents the physical link between the new and old area of the park. It has been intensively managed in the past and is characterised by typical karst mixed forest of beach and fir. The area around Leska hosts the existing educational trail, while the central and northern area of Kaličak is characterised by typical karst formations like pit holes and caves. Mosaic of small patches of wet meadows originally created by grazing, with typical flora and fauna. Some characteristic and rare butterfly species have been recorded in this area. Active management is required to prevent forest succession and thus disappearance of this habitat. The area is characterised by late frost and cold long winters and low regeneration rate.

Zone 3a – The use zone is characterised by human activities including settlements, agriculture and forestry. Local varieties of fruit trees characterise the orchards and surrounding of houses.¹⁶ Degree of risk: medium.

Changes in species composition. As a result of ice and the invasion of bark beetles in 2014, some 50% of the trees have been destroyed in some parts of the spruce forest. Thus comes to the change in composition of species. Degree of risk: high.

Areal animals. The Risnjak area is the living space of brown bear, wolf and lynx. These types depend on large, quiet spaces that are not disturbed by people, as well as on many animals that represent their typical hunting. The number of chamois as well as the population of ordinary deer is too small for the habitat capacity. There is a stable population of wild pigs. All climatic changes occurring in this area may have a negative effect on these species and the rate of change in their areal. Degree of risk: high.

Pollution from the atmosphere. Based on the recent research on the occurrence

¹⁶ National Park Risnjak Management Plan, 2007., p.72

of damage and drying of forests, especially fir forests, and the introduction of pollutants into the forests of Gorski kotar, as well as the causes of changes in the structure of forests, the conclusion is that permanent acidification and pollution of soil and water is the result of the acid precipitations caused by the pollution from the industries of northern Italy. The wind coming from the west carries sulphur oxides and nitrogen oxides expelled by the industries in Veneto and Friuli Venetia Giulia Region in Northeastern Italy. Degree of risk: high

Forest pests, phytopathogens (mushrooms, bacteria, viruses), infestation plants. The spruce beetle attacks the physiologically weakened spruce trees, which are still abundant in Gorski kotar even after the ice disaster in 2014. In such a situation, the beetle quickly moves to healthy trees in the environment, lives under the bark, and in the corridors the females lay the eggs. During the summer months, several “generations” of parasites multiply under the bark and stay there during winter months. Within just two to three weeks, the beetle can destroy dozens of trees that were to reach their full height for decades. The way in which beetles can be removed is to harvest weak trees, remove them from the ground in the woods, and burn wood residues. That is why it is important for the tree destroyed by ice to get out of the woods as soon as possible.¹⁷ Degree of risk: high.

Small forest rodents. Small forest rodents are sensitive to temperature changes. In the absence of an optimal number of days with low temperatures, their populations are growing rapidly, reflecting on other chains of nutrition chains. Degree of risk: medium.

Invasive organisms. Invasive organisms most easily establish their populations in natural habitats that are degraded, exposed to stress or are anthropogenically altered. An example are bark beetles that devastated mountain forests after the ice disaster in 2014. Degree of risk: high.

Time Extremes (storms and heavy rainfall). During the year of monitoring of

¹⁷ Protection of nature in the area of National Park Risnjak. Available at: www.sabor.hr/fgs.axd?id=1738, Accessed on 22.05.2017.

the situation in the National Park, weather changes were also noted. In the last ten years, increased damage has been recorded in the Risnjak forest complex as a result of frequent bad weather conditions and extreme climatic events. Powerful winds, with the lethal ice and snow impacts, in damaged stands for a lighter assembly, reduce the biological resistance. Soils are more drought, natural regeneration of forests is absent, growth decreases, and conditions for mass propagation of harmful insects are all more favourable. In addition to these phenomena, the adverse effect of the substances from the atmosphere is suppressed, which with the precipitation and dry deposition reaches the forest soil¹⁸. Degree of risk: high.

Ice, glaziers and snow. Ice resulting from ice rains, especially if it is present in a larger amount and remains for more days, creates devastating consequences on forest stands. Ice creates multiple damage to the trees (icebreakers), and due to static changes, the trees can fall as a result of heavy ice. The consequences of icebreaks have a long-term impact on forest stands. Snowdrifts occur if static stability of trees is damaged due to large amounts of snow cover. Degree of risk: high

Table 6. *Types and levels of risk for forest stands*

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Vegetative shift	Changes in the vegetation zone due to an increase in mean annual temperatures	medium
Changes in species composition	Increase in number and type of pests	high
Areal of animals	Faster changes in animal areal due to changes in microclimatic conditions	high
Pollution of the atmosphere	Stress conditions due to air pollution	high
Presence of forest pests	Reduction of forest stands	high
Small forest rodents	Increase in species and number of rodents	medium

18 Proceedings 40 years of the National Park Risnjak (1953-1993), Headquarters of the National Park Risnjak, Crni Lug, 1994.

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Invasive organisms	Stressed conditions provide faster and more successful expansion	high
Time Extremes	Damage to forest stands	high
Ice, glaziers and snow	Damage to forest stands caused by snow and ice	high

2.2.2. Non-forest stands and anthropogenic modified habitats

An important part of the biodiversity of the National Park Risnjak are the non-forest areas inhabited by various species of flora and fauna.

Grassland habitats. Within the National Park Risnjak there are small grassland surfaces. Of these, the largest areas occupy mountain rudine on the peaks of Risnjak, Snježnik and Guslice, while the grasslands of the mountain belt are rare and embedded within the forests. Three communities of mountain rudine (various types of huts) inhabit the most exposed peaks, where snow is often blown by heavy winds in winter, and plants are exposed to extreme climatic extremes: low temperature and physiological drought due to permanently frozen substrates. Mainly, low perennial species grow there, and there are no one-year species in this area because the vegetation season is too short for their complete development. The grasslands are particularly under threat due to the decline in domestic animals grazing in the Park. One visible effect is the succession developing of natural-potential vegetation for this area which are woods, and the consequent loss of herbaceous species richness and the related fauna. These grasslands and meadows are a very important habitat for several fauna groups including butterflies, passerine birds, and ungulates.¹⁹ Degree of risk: medium.

Fields, orchards, vineyards. Signs of human interventions are characteristic of the Kupa Valley, where agricultural activities have been carried out over centuries. The typical land-use pattern of the area are scattered small villages

¹⁹ National Park Risnjak Management Plan, 2007., B3

or hamlets, with small patches of arable land in the immediate surrounding of the houses, relatively large orchards (with mainly apple and pear, some plums) surrounded by meadows used for grazing. Larger meadows, more distant from the villages were used to produce hay for winter feeding of cattle. The orchards around the villages are rich in old fruit varieties and therefore valuable for the national park. Only in recent years, the rural population has declined and therefore also the agricultural crops have been given up. Production of local products such as honey, rakija, vinegar, etc. did not have a good market in recent years.²⁰ Degree of risk: low

Table 7. Types and levels of risk for non-forest stands

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Grassland habitats	Lack of regular mowing and grazing	medium
Fields, orchards, vineyards	The need for irrigation	low

2.2.3. Aquatic habitats (springs, streams, ponds, puddles)

The main water habitats in Risnjak are the Kupa river karst spring area, periodical stream in the canyon of the Sušica River, the temporary creek in Leska and springs in Sova, other temporary karst springs and very short creeks (Krašicevica, Šegine etc.) and mood-pool and temporary pools. This area of the Kupa River Valley is considered to be of utmost faunistic significance. All water habitats, except for the river Kupa source, are very important for amphibians, especially for *Bombina variegata* (flying insects whose larva live in the water). An autochthonous population of the fish species *Thymallus thymallus* exists in the Kupa spring. In the Kupa spring, the dominant water species are snails and insects. The findings of two species of Trichoptera are especially valuable because they represent endemic Dinaride species. The endangered salmonide fish *Hucho hucho* lives in Kupa, Diptera, Chironomidae and Trichoptera.²¹ Risk level: medium.

²⁰ National Park Risnjak Management Plan, 2007.

²¹ National Park Risnjak Management Plan, 2007.

Table 8. Types and levels of risk for aquatic habitats

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Aquatic habitats	Changes in water regimes	medium

2.2.4. Surface and underground karst habitats

The National Park Risnjak is a karst area with all the karst phenomena and with distinctly embedded relief. The karst habitats due to extreme hydrological and meteorological conditions may be subject to additional drying, which may adversely affect the vegetation cover and the accompanying fauna. Reducing flow, extreme flow rates and uneven bursts of rainfall can disrupt the natural hydrological cycle in karst subterranean habitats. Degree of risk: medium.

Table 9. Types and levels of risk for karst habitats

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Disturbed hydrologic cycles	Droughts / floods	medium

2.3. Soil

Erosion of the soil, sands and landslides. The composition and structure of the soil in the National Park Risnjak are determined by geological background and climate. The geological base consists of limestone and dolomite and clayey slate, sandstone and quartz conglomerate.²² The stability of soil layers within the Park is affected by the slope of terrain, anthropogenic modification (roads, mountain roads, infrastructure buildings), and a particularly important factor determining the stability of the soil is the forest cover.

The National Park is dominated by the type of soil - black soil on limestone and dolomite. This type of soil develops predominantly in the mountainous area, on

²² Program for protection, conservation and maintenance of forests N.P. Risnjak, Crni Lug, 2001.

hard and clean limestone, dolomite and relief, which strongly favours erosion. It is most often found in the mountain range from 900 m above sea level to up to 1500 m above sea level of Risnjak limestone-dolomitic mountains, but it can also be found in lower terrain especially on steep slopes and cliffs.²³

Potential climatic changes will affect this component of space through hydrological and meteorological extremes. In the case of extreme weather disasters, there will be significant damage to forest vegetation and negative impacts on soil stability. Degree of risk: medium.

Table 10. *Types and levels of risk regarding the erosion of the soil*

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Erosion of the soil, sands and landslides	Negative impact on soil stability due to damage to forest vegetation and changes in hydrological conditions	medium

2.4. Hydrology

Due to the relatively high amount of precipitation and long-lasting snow cover in the National Park Risnjak, the precipitation of rain is fairly uniform and therefore the leakage of the most important karst springs is constant. The area is characterized by typical karst features: numerous rocks, pits, abutments and cracks. The terrain is mostly without surface flows and all water falling in the form of rainfall is lost underground. Due to the overcoming of clay-sandstone and conglomerate, the whole complex is highly waterproof, while its surface relief is characterized by a number of spotted dumps that run off precipitation.²⁴

Within the boundaries of the National Park, constant springs and intermittent water flows occur in the south-eastern part, in Leska, Bijela Vodica and Crni

²³ NP Risnjak: Types of soil. Available at: <http://np-risnjak.hr/prirodna-obiljezja-risnjaka/reljef/> Accessed on 24.05.2017.

²⁴ NP Risnjak: hydrology. Available at: <http://np-risnjak.hr/prirodna-obiljezja-risnjaka/orografske-i-hidrografske-prilike/hidrologija/> Accessed on 24.05.2017.

Lug, with the base of the Trias clastic and carbonate deposits. Permanent and occasional flows are not registered in the higher areas, except for a very short flow in the area of Japetove Šegine, with springs and abyss at about twenty meters distance. The only weakest permanent source in the higher area is Studenac in the area of Javorova kala, and there are occasional springs after heavy rains only on certain stone arches or on planks along existing forest paths or on rocky mountains. The snow around the peaks of Risnjak retains more than 150 days a year. All precipitation runs through numerous cracks in limestone and thus create a spacious underground reservoir that feeds downstream springs. In the area of the Snježnik massif there is a watershed between the Black Sea and Adriatic Sea. The source of river Kupa has very karstic springs and is the hydrogeological specificity of this area. The source is related to the defective contact between the well-permeable limestone from the Jura age on the north-eastern slopes of Risnjak, the weakly permeable Trias dolomites and the impenetrable Paleozoic slivers. The karst source of Kupa has the appearance of an oval pond retracted below a hundred meters high vertical rocks at 321 m above sea level. According to current research, water flows from two vertical channels, one of which has a measured depth of 156 m, which is still not a final figure. The minimum leakage capacity is approximately 1100 l/s, while maximum quantities are not measurable. Climate change can cause a decrease in flow, i.e. extreme flow and an uneven distribution of rainfall, and thus disrupt the natural hydrological cycle and create problems in local community water supply. Degree of risk: medium.

Table 11. *Types and levels of risk related to hydrology*

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Hydrotechnical procedures	Extremes of dry periods and torrents	medium
Water supply	Problems in local community water supply	medium

2.5. Climate

The Risnjak massive is steeply rising above Kvarner Bay and makes the rampart exposed to the influence of the maritime and continental climate. Maritime climate is characterized by a considerable amount of precipitation and precipitation regime, where two peaks are exposed, while the valley of the Kupa River penetrates the influence of the lower warm plains all the way to the foot of Risnjak.

Temperature. The basic characteristics are colder months, which is less than -3°C , the average monthly temperature of the hottest month reaches above 10°C and is lower than 22°C . The driest part of the year is during the summer, and the maximum rainfall occurs early in the year and in the late fall. The average annual temperature fluctuation for the National Park Risnjak is between $16-17^{\circ}\text{C}$. Degree of risk: medium.

Rain and wind. The most important winds in the area of the National Park are jugo and bura. Jugo most commonly blows in spring and autumn and its appearance coincides with the maximum rainfall. The bora usually blows in winter; it is cold and brings beautiful weather and good visibility.²⁵ The impact of climate change on rainfall and wind is manifested through an uneven distribution of rainfall, extreme abundance of short-term, severe precipitation and extreme, stormy winds. Degree of risk: high.

Snow cover. For the Risnjak area, the duration and amount of snow cover is of particular importance, since it lasts a very long time. The snowy winter i.e. the interval between the first and the last day with snow cover in this part of Gorski kotar lasts for more than 5 months. Adverse climate factors for forest stands are snow, frost and fog. Snow presents a problem for the rejuvenation of stands, especially on steep terrain, where young and old trees fracture. Heavy and wet snow causes tree breaks also on the treetops. Late spring frost

²⁵ Program for protection, conservation and maintenance of forests N.P. Risnjak, Crni Lug, 2001.

adversely affects young plants in the fertilized phase, in terms of freezing peak buds and even whole plants.²⁶ Degree of risk: medium.

Table 12. *Types and levels of risk related to climate*

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Temperature	Increase in mean summer temperatures	medium
Rain and wind	An uneven distribution of precipitation and extremes	high
Snow cover	Reduction of the number of days under a snow cover	medium

2.6. Risk and vulnerability assessment for other constituents

In addition to nature protection, the National Park Risnjak also has a scientific, cultural, educational and tourist-recreational function. Favourable traffic and geographic position with emphasized aesthetic, tourist and recreational value represents the potential for tourist visits and hiking tours. Up to the Risnjak top there are several hiking trails, and the Risnjak forests offers an interesting ambience for mountain biking.²⁷ Guided walks are organised for visitors, and especially for schoolchildren.²⁸ There are also special areas for the observation of large game, and for sport fishing enthusiasts it is possible to fish in the waters of the Kupa River.²⁹

Accommodation of the visitors of the Risnjak Massif is possible in the log cabin on Lazac and in the mountain hut “Dr. Josip Schlosser Klekovski”. The mountain

²⁶ Program for protection, conservation and maintenance of forests N.P. Risnjak, Crni Lug, 2001.

²⁷ NP Risnjak: Visiting. Available at: <http://np-risnjak.hr/posjecivanje/> Accessed on 30.05.2017.

²⁸ Assessment of tourism structure and proposals for sustainable development of tourism in the KEC project area, Agriconsulting S.P.A., Ministry of Culture, 2005.

²⁹ NP Risnjak: Visiting. Available at: <http://np-risnjak.hr/posjecivanje/> Accessed on 30.05.2017.

hut was managed by hiking organizations until 1991, when it went under the administration of the National Park Risnjak, under which it still resides. Visitors can also stay at the “NP Risnjak” boarding house, which is located directly next to the Park Management in Crni Lug. In the Risnjak boarding house, there is also a conference hall with 70-80 seats suitable for organizing congresses, seminars, workshops, scientific or professional gatherings.³⁰

The National Park Risnjak can be reached by car. Public transport is provided only once a day in both directions to Crni Lug. Other entrances to the National Park are dislocated from major roads.

2.6.1. Visitors

Risk and vulnerability assessment related to visitors may be reflected in changes in the dynamics of visiting the National Park with regard to, for example, visitor safety related to extreme weather changes such as the 2014 ice that affected the National Park area. Due to the ice the forest the forests can be jammed which increases the unsafety of the infrastructure. Degree of risk: low.

2.6.2. Infrastructure

The ice from 2014 affected the infrastructure within the Park, particularly the roads, the passage of roads and access roads. The most endangered are the paths leading to the top of Risnjak and the source of Kupa. Both routes towards Risnjak from the direction of the Crni Lug were impassable. The path to the source of the Kupa from the settlement Razloge was unpredictable and even dangerous. The sanation of the breaks caused by ice lasted for several months. Furthermore, a number of forest roads were cleaned.³¹ Degree of risk: medium.

30 NP Risnjak: Visiting. Available at: <http://np-risnjak.hr/posjecivanje/> Accessed on 30.05.2017.

31 Novi list: Krmpotić, Marinko: The Risnjak National Park is drenched and difficult to walk. Available at: http://www.novolist.hr/Vijesti/Regija/node_1588/Nacionalni-park-Risnjak-poharan-i-tesko-prohodan?meta_refresh=true Accessed on 30.05.2017.

2.6.3. Agriculture

The population in the National Park engaged in agriculture represents an important component of biodiversity conservation since the agricultural areas support a part of the non-human species. These activities are carried out in the zone 3a - zone of use of the National Park Risnjak. The number of inhabitants of this area has decreased considerably over the last few decades. Consequences of climate change could increase pressure on the agricultural population in the National Park in the direction of halting further agricultural production or reducing its current size, which is still small. Today, only a few remaining farms can be found in Risnjak where fruit, vegetables and small livestock are grown. These small farms are built in the traditional way and represent the cultural heritage of this area. Degree of risk: low.

2.6.4. Population

In the area of the National Park Risnjak according to the 2011 census, there were 17 residents³², while in 2001 there were 59 , and in 1991 82³³ (Table 13). Some of the villages are completely abandoned, while other villages and hamlets are inhabited by a smaller number of old people. There is a real danger that over time the remaining hamlets will be abandoned. The local population takes care of the entire space and recognizes the need to preserve natural values as one of the prerequisites for continuing life in this area.³⁴ Degree of risk: low.

32 Central Bureau of Statistics: Population by age and sex by settlements, 2011 census. Available at: https://www.dzs.hr/Hrv/censuses/census2011/results/htm/H01_01_01/h01_01_01_zup08.html. Accessed on 30.05.2017.

33 NP Risnjak: Population. Available at: <http://np-risnjak.hr/kulturna-bastina/naselja/>. Accessed on 30.05.2017.

34 National Park Risnjak Management Plan, 2007., p.44

Table 13. Overview of the number of inhabitants in the National Park Risnjak

Settlement	Status	1991	2001	2011
Grad Čabar				
Hrib**	BS			
Dolari		3	3*	
Podgrič		20	20*	
Donji Kupari		4	4*	
Srednji Kupari	BS			
Gornji Kupari	BS			
Konjci		1	1*	
Grad Delnice				
Leska			2	3
Plajzi	BS			
Razloški Okrug		8	9	
Donji Okrug		7	3	2
Gornji Okrug		5	4	2
Donja Krašićevica	BS			
Gornja Krašićevica		5	5	2
Srednja Krašićevica		1		
Razloge		28	10	8
TOTAL		82	61	17
* according to the NP Risnjak management				
** in the area of the Park there are parts of hamlets without permanent residents (BS)				

Source: National Park Risnjak Management Plan, 2007, p. 43 and the Central Bureau of Statistics: Population by age and gender by settlements, 2011 census. Available at: https://www.dzs.hr/Hrv/censuses/census2011/results/htm/H01_01_01/h01_01_01_zup08.html

2.6.5. Protection and rescue

Public institution The National Park Risnjak monitors the protected area through the work of the Ranger Service. In the area of the Park, rescue operations are intervened by the Delnice and Rijeka Mountain Rescue Service. In the past

five years, no visitor has been injured in the area of the National Park Risnjak.
Degree of risk: low.

Table 14. *Types and levels of other risks*

RISK AREA	DESCRIPTION OF RISK	DEGREE OF RISK
Visitors	Reduced visitors' security due to adverse weather conditions caused by climate change	low
Infrastructure	Destruction of infrastructure due to icebreaking	medium
Agriculture	Discontinuation of agricultural activity in the Park due to climate change	low
Population	Decrease in population	low
Protection and rescue	Harsh weather and terrain conditions for protection and rescue	low



3. IDENTIFICATION AND ANALYSIS OF OPTIONS FOR ADAPTATION

Identification and analysis of adaptation options should enable the National Park Risnjak to allow the adverse effects of climate change to fall to an acceptable level. Key activities are capacity building of the National Park Risnjak for adaptation to climate change, including concrete technical solutions for the preliminary action to alleviate the consequences of climate change. Adaptation options and main actors in their implementation are defined for each identified problem. Analysis of options (such as increased area resistance, reduction of mitigation costs, etc.) includes ranking and the selection of priorities based on previously defined criteria.

3.1. The basic goals of adaptation in the National Park Risnjak to climate change

The basic goals of adaptation to climate change in the NP Risnjak are to reduce the negative impacts of climate change. The emphasis at this stage is on the

education of employees and visitors, and the inclusion of the topic of climate change into new annual work plans and strategic documents of the National Park. Key areas for future steps are:

1. Scientific and professional research
2. Education
3. Planning and Adaptive Management
4. Lobbying, creating and strengthening partnerships.

3.1.1. Scientific and professional research

Scientific and professional research is the basis of all activities related to climate change adaptation since they can give us an insight into the current situation and projections of the future state of all environmental and socio-economic aspects as well as climate change implications. Most studies require long-term monitoring and often substantial financial investment. Sometimes knowledge gaps can be compensated by using available scientific data on directions and impacts of climate change in similar conditions in wider regional areas.

In the National Park Risnjak the following priority scientific research has been identified that will help to increase knowledge about the current and future impacts of climate change:

- a. meteorological research
- b. hydrological research
- c. biological research
 - i. forests
 - ii. aquatic habitats
 - iii. grassland habitats
 - iv. endangered species and habitat types
 - v. target species and habitat types of the ecological network of the Republic of Croatia
 - vi. exploration of underground habitats (caves and pits)
- g. other applied research

3.1.2. Education

Continuous education of the National Park Risnjak employees on climate change is a significant step forward in monitoring and adapting the Park to climate change. The acquired knowledge should enable the identification of changes caused by climate change and the definition and implementation of measures to mitigate them. The role of the Park employees is further education of interested visitors who come to the National Park Risnjak either alone or in organised groups and participate in various events, visiting some of the localities or participate in programs taking place in the Park.

3.1.3. Planning and Adaptive Management

The National Park Risnjak Management Plan is a key long-term framework for the work of the Public Institution, which should include a part devoted to climate change. Identifying challenges, measures and activities are part of the separate action plans. In line with the financial capabilities, it is necessary to include elements related to climate change monitoring in the National Park. Based on the monitoring of the implementation of strategic documents, it is possible to influence the changes of goals and measures through the so called flexible planning or adaptive management that enables the rapid implementation of new measures to adapt to climate change in all planning processes and their efficient and timely realization. When developing management plans it is necessary to involve all interested groups in the design of the plan itself and in the creation and implementation of climate change adjustment measures.

3.1.4. Lobbying, creating and strengthening partnerships

National Park Risnjak is committed to implement new models in nature conservation and protection and to raising public awareness of contemporary environmental challenges, including climate change. In the context of climate change, the Park can be profiled as a significant institution that will,

by presenting its very impressive examples of damage caused by climate change, have a significant and influential role in the lobbying process for timely implementation of adjustment measures. The key role is to create partnerships and invest in the further development of existing partnerships, and networking is an excellent tool for sharing information on climate change, identifying possible adjustment measures, and solving individual challenges.

Key identified activities of the National Park Risnjak contributing to the achievement of the set goals in combating climate change are as follows:

ACTION PLAN FOR THE PERIOD 2017-2019

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
A. Protection and conservation of natural values							
1.	Analysis of all existing data on the impact of climate change in the area of NP Risnjak (e.g. various publications, damage records in the Park etc.)	Insufficient availability of existing data on NP Risnjak	Annual plan	2018	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Public institution NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; External associates	List of publications and their easy availability Analysis of existing data
2.	Ensuring the implementation of applied research and monitoring of changing environmental conditions with the aim of assessing vulnerability of habitats and species	Insufficient applied environmental research	Management Plan	2018 - Continuous	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; External associates	Number of research Number of species covered, habitat types and other environmental constituents
3.	Analysis and risk assessment in NP Risnjak due to the increased incidence of extreme events	Lack of flexibility	Management Plan	2018	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Ranger Service; Technical and Maintenance Department; External associates	Targeted risk assessment developed of the frequency of extreme events

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
4.	Creating a space-time chart of increased risk of climate change impacts and its regular updating	Insufficient knowledge of climate change most intense points Inability to direct activities to the most important zones	Management Plan Annual Plan	2019, and thereafter every three years	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Ranger Service; Technical and Maintenance Department; External associates	Created map Updated map depending on new data
	Development of the climate change adaptation measures	Non-adaptability	Annual Plan	Every year	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Management of the Public institution NP Risnjak; External associates	Realized revision of climate change adjustment measures
	Implementation of the topic of climate change impacts and adaptations to climate change in the NP Risnjak Spatial Plan	Insufficient affirmation of climate change topics	Spatial Plan of the NP Risnjak	Whenever any change or adoption of a new spatial plan occurs	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Management of the Public institution NP Risnjak	Satisfactory implemented measures in the Spatial Plan

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
B. Collaboration with the local community							
	Establishing an interdisciplinary team for climate change	Insufficient staff in NP Risnjak for expert work in the field of climate change	Management Plan Annual Plan	2018	NP Risnjak Management	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Management of the Public institution NP Risnjak	The representation of members from different professional and scientific fields
	Involvement of the local population and the wider community in solving the issue of adaptation to climate change	Ignorance of the topic of climate change Not knowing the attitudes of stakeholders Unwillingness to implement adjustment measures	Annual Plan	Continuous	NP Risnjak Management	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Ranger Service; Technical and Maintenance Department; Management of the Public institution NP Risnjak; External associates	Analysis of population attitudes on the impact of climate change A minimum one-year meeting with local stakeholders held with topics of climate change

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
C. Education and interpretation							
	Education of the local population on climate change	Ignorance of the topic of climate change	Annual Plan	Continuous	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Public institution NP Risnjak	Department for Promotional Activities, Catering and Tourist Activity; Ranger Service; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; External associates; Public institution NP Risnjak	A special program on climate change developed Continuous education of the local population
	Visitor education on climate change	Ignorance of the topic of climate change	Annual Plan	Continuous	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Public institution NP Risnjak	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; External associates	Implemented themes of climate change into existing programs for the visitors of NP Risnjak

No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
	Lobbying on the importance of implementing adaptation measures in areas beyond NP Risnjak	Ignorance of the topic of climate change	Management Plan Annual Plan	Continuous	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Public institution NP Risnjak	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Management of the Public institution NP Risnjak; External associates	The number of held meetings, press releases and similar events mentioning adaptation to climate change

D. Visiting and promotion

Analyse the impact of climate change on the dynamics of visits and develop adaptation measures related to visiting and promotion	Not knowing the climate change real influence on visiting Inability to make mitigation measures	Management Plan Annual Plan	2019.	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Department for Promotional Activities, Catering and Tourist Activity; Technical and Maintenance Department; Management of the Public institution NP Risnjak	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; External associates; Management of the Public institution NP Risnjak	Developed analysis and adjustment and mitigation measures
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No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
	Include the topic of climate change in promotional materials of the NP Risnjak	Inability to spread reliable information on climate change	Annual Plan	2020.	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Department for Promotional Activities, Catering and Tourist Activity; Management of the Public institution NP Risnjak	Department for Promotional Activities, Catering and Tourist Activity; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; External associates	Developed promotional materials and made available to visitors of the NP Risnjak and other interested groups

E. Fire protection

	Adapt action plans for crisis situations with local governments and self-government units	Inconsistency and ineffective implementation due to insufficient information exchange	Annual Plan	2019	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Technical and Maintenance Department; Management of the Public institution NP Risnjak	Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Management of the Public institution NP Risnjak; Technical and Maintenance Department	Harmonized plans Revised plans
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No.	Activity	Response to risk	Related planning document	Deadline	Responsibility	Realization	Implementation indicators
F. Development of institution's capacity							
	Education of NP Risnjak staff on climate change	Ignorance of the topic of climate change	Management Plan	2018 -2020	Management of the Public institution NP Risnjak	Management of the Public institution NP Risnjak; External associates	Training conducted
	Introducing climate change themes into the strategic planning documents of NP Risnjak	Impossibility of rapid and effective implementation of climate change adaptation measures due to formal obstacles	Spatial Plan Management Plan	2018-2020	Management of the Public institution NP Risnjak	Management of the Public institution NP Risnjak; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak	The topics of climate change introduced into strategic documents of NP Risnjak
	Implementation of green principle in relation to transport, buildings, lighting and green infrastructure	Promotion of adaptation measures to climate change	Management Plan Annual Plans	Continuous	Management of the Public institution NP Risnjak	Management of the Public institution NP Risnjak; Department of Professional Affairs for the Protection, Maintenance, Conservation, Promotion and Use of the NP Risnjak; Department for Promotional Activities, Catering and Tourist Activity	Implemented Green Principles

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