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THE REACTION OF SCOTS PINE *PINUS SYLVESTRIS* L. FOREST GROUND COVER VEGETATION TO ORIENTEERING COMPETITIONS IN THE SEASIDE, LATVIA

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Abstract
Orienteering is one of the most popular folk sports in Latvia, it involves a very large number of participants, and this number is growing every year. While participating in the competition and running through the forest, the competitors are trampling the forest floor. In Latvia, the impact of orienteering competitions has not been studied a lot; therefore, when organizing competitions, disagreements arise when choosing the competition area – there are groundless suspicions that orienteering sport has a significant negative long-term impact on the forest floor. The aim of research is to assess the impact of orienteering competitions on ground vegetation in pine forests at the seaside, Latvia. The research was carried out in the orienteering competition 'World Masters Orienteering Championships 2019' area, which was located in Scots pine forests in the seaside territory – in the vicinity of Bumbukalns and Garezeri. The study describes orienteering competitions and their process in forest lands; analyzes the vegetation at orienteering competition checkpoints before and after the competition; compares and evaluates vegetation changes in hilly areas on hill tops and in depressions. The study has found that orienteering competitions do not significantly affect the forest layers. It is concluded that as the distance from the control point increases, the trampling intensity decreases. The intensity of trampling does not depend only on the shape of the terrain. The effect of trampling is best seen on the moss layer.
Key words: Scots pine forests, forest layers, orienteering, trampling, projective coverage.

Introduction

Orienteering is very popular folk sport in Latvia. The number of participants increases year by year - from 50 to 700 participants, while international competitions gather more than one and a half thousand participants. Orienteering competitions take place all over Latvia, and in the year 2019 competitions gathered more than 16 thousand participants who took part in competitions 121.040 times (Orientēšanās sacensību rezultāti, 2020).

The origins of orienteering sport can be traced back to Scandinavia in the 19th century. Initially, orienteering was part of soldiers' military training. The first known public competition took place in 1897 in Norway, near Oslo. In 1918, cooperating with the Stockholm Amateur Athletics Association Ernst Killander organized a distance running competition, searching for and finding certain control points. After this event E. Killander developed rules for orienteering sport, relating to the choice of route, the creation of age groups and the organization of competitions. E. Killander in history is referred as the father of orienteering sport (History and Facts…, 2020).

In the 20th century, orienteering sport spread throughout the whole Europe (Orienteering, 2020). Orienteering sport also gained popularity in Latvia. Since 1933, orienteering competitions for beginners had been organized under the control of the Latvian Army Sports Club, and training had been organized under the guidance of specialists. In 1936, the first official orienteering competition took place (Senā vēsture, 2020).

Orienteering is a complex sport in which the athlete must be fast-thinking and at the same time physically strong in order to achieve the best results. In the orienteering distance, the athlete, using the orienteering map and compass, must find and check in the control points marked on the map and placed in the vicinity in the shortest time possible. When choosing a place where to organize orienteering competitions in Latvia, one must follow the guidelines of the organization process jointly prepared by the Nature Protection Board (DAP) and the Latvian Orienteering Federation (LOF) (DAP & LOF, 2014c).

The organization of orienteering competitions in one of the specially protected nature territories (SPNT) is regulated by several regulations of the Republic of Latvia (DAP & LOF, 2014a):

- Law On the Conservation of Species and Biotopes. Adopted on March 16, 2000;
- Cabinet Regulations No. 264 'General Regulations on Protection and Use of Specially Protected Nature Territories' adopted by the Cabinet of Ministers on March 16, 2010;
- Cabinet Regulations No. 940 'Regulations Regarding the Establishment and Management of Micro-reserves, Their Conservation, as well as Determination of Micro-reserves and Their Buffer Zones' adopted by the Cabinet of Ministers on 18 December 2012;
- Individual Regulations on Protection and Use of SPNT (for instance, Gauja National Park Law, Teiči Nature Reserve Law, etc.).

Any activity is prohibited, and residence is restricted or prohibited in the strict regime zone and regulated regime zone of nature reserves and specially protected nature territories. Without the written permission of the Nature Protection Board,

it is prohibited to organize public events in nature reserves and in nature reserves zone of specially protected nature territories in the open air, as well as camps with more than 60 people but in nature reserves zone of Gauja National Park and Ķemeri National Park no more than 50 people. In micro-reserves, it is prohibited to do any activity that is contrary to the objectives and tasks of the establishment of the micro-reserve, that destroys or disturbs the given specially protected species or habitat, including the organization and conduct of outdoor recreational and sports events.

The deliberate disturbance of animals of specially protected species, including birds, is prohibited. Individual protection and use regulations may be developed for each specially protected nature territory. They set out different requirements which must be followed while in them. In the nature park zone of Rāzna National Park, it is prohibited to organize public events in the open air with more than 100 people participating outside the designated or specially arranged places, without the written permission of the Nature Protection Board. In the nature reserve zone of Gauja National Park, it is prohibited to organize public events in nature from 15 March to 31 July, while from 1 August to 31 October it is allowed but no more than twice in the same territory (DAP & LOF, 2014a).

Orienteering has an impact on nature and its values. International Orienteering Federation has conducted various studies and produced reports on the impact of competitions. The results show that disturbance of mammals, wastewater and trampling of vegetation are considered to be very important factors during orienteering competitions. In relation to the ecological load, the most important factors are the trampling of vegetation and the disturbance of mammals. Laininen (2012) emphasizes that edaphic changes in the soil, such as changes in soil moisture, erosion and structure, can also occur in connection with trampling of vegetation. As a result of compaction, the soil pores are closed, interfering with the exchange of water and gases in the soil, resulting in a lack of water and oxygen, or the exact opposite process takes place – soil leaching. Similar processes are particularly sensitive in forest habitats, while in dunes edaphic changes in the soil are even necessary because they overgrow rapidly.

Orienteering competitions, with their positive impact on dune habitats, serve in the Braunton Burrow Nature Reserve in the south-west of England. This competition is a good example, because with the help of this competition the overgrowth of the dunes is prevented and the typical dunes plants return. After calculations it is concluded that 15,000 athletes, being in dune habitats for average 1.25 hours each, are equivalent to one cattle grazing in this type of habitat per year. With the competition the result is achieved much faster – overgrowth of the dunes is stopped and sand fields appear. It should be noted that an entire herd of, say, 200 cattle affects an area as much as 3 million athletes, leading to the conclusion that athletes are not the ones with the most significant impact on the environment (Parker, 2009).

Athletes are interested in getting from one control point to the next one trough the most efficient route, so their impact is linear, especially near control points where trails are particularly noticeable as vegetation is more trampled. Such trails are temporary and disappear during one to three vegetation seasons, depending on the nature of the vegetation affected (Mendoza, 2008).

In the south of England (The New Forest), an orienteering competition was held in 1988, with 1,200 participants in an area of 11 km^2. A study (Douglas, 1989) was conducted in connection with this event, in which it was found out that most of the surveyed sites recovered within two weeks. The most used as well as the most sensitive areas had not recovered at all after six months; however, they had fully recovered within a year, with the exception of two sample plots where moss and lichens grew on sandy soil. It is noted that trampling of vegetation depends on the intensity, duration and frequency of the disturbance, together with plant species, soil type and depth, slopes and moisture.

The main factors influencing the resilience of nature complexes in flat areas where the slope gradient does not exceed three degrees, are the bedrock, the degree of humidity, the main tree species in the forest stand and the origin of the forest. Nature complexes with light mechanical bedrock (sand, clay sand) are less resistant to recreational loads than natural complexes with heavy mechanical bedrock (loam, clay). As a result of trampling, the first mentioned will suffer more, mainly will suffer soil and biocenoses (Чижова, 1977).

In Finland (Sipoonkorpi National Park, near Helsinki) after the competition, monitoring started to assess the impact of the event on biodiversity. The greatest effect was observed in bog and wet forest habitats, as well as in the pioneering communities of dry and warm habitats. Dry habitats recover very slowly, especially those dominated by lichens, which can be explained by the fact that they were broken into smaller pieces and washed away during the rainy season. It will probably take decades for these habitats to fully recover. Vegetation damage in bogs and herbaceous plant covered forests recovered very quickly, but wet forests were still in very poor biological condition after one year (DAP & LOF, 2014b).

In Denmark, studies have been carried out (Andersen *et al*., 1986) in several forests with a

network of roads and trails about the proportions of trail running in the orienteering distance. It was concluded that, on average, 50% of the distance done by the participants is on forest roads, tracks or paths, and 50% is off-track, off-road, and only less than 0.5% of the distance passes through a very dense forest.

Dartmoor National Park in the south-west of England is a popular destination for a variety of activities, including orienteering sport. The number of bans in the park has been increasing on orienteering activities, so a comparative study of the environmental and ecological impacts on the national park was conducted, including 12 off-road activities (Parker, 2005a). It was found out that in comparison with other types of recreation in the mentioned park, the negative impact of orienteering on the park is very minimal. It has been studied that people spend many more hours off-tracks in other forms of recreation than in orienteering, which shows that they have a greater impact on the forest and forest floor. For instance, people spend one and a half million hours a year hiking off the trails, but for orienteering, it is only 800 hours a year. Of the mentioned activities in the study, hiking, bird watching and mountain biking can be referred to Latvia. Assuming that the number of hours is proportionally similar in Latvia as well, all three mentioned activities have a greater ecological impact than orienteering.

Among the Latvian researches related to the trampling of forest vegetation in recent years, the research of Laura Liepiņa (Vārpiņa) (2016) and Ralfs Čākurs (2019) can be mentioned. In her study, Liepiņa (2016) assessed the impact of orienteering competitions on the forest ground vegetation. The study confirms the hypothesis that the effect of trampling does not have a significant effect on the forest ground vegetation, except for the moss layer on the seaside. There it has also been observed that trampling has the greatest impact on vegetation on the hill tops and slopes of inland dunes and hills, and it has the least impact on micro-depressions and in *Vacciniosa*. Čākurs (2019) concluded that significant impact of trampling was observed only in a short period of time. Vegetation recovered very quickly - a month after the competition. The biggest impact of trampling was observed on the moss layer and on the slopes of dunes and hills. According to these studies, it can be concluded that the impact of orienteering competitions in the territory of Latvia is observed in the most sensitive places; however, the vegetation is restoring relatively quickly.

After analysis of several studies (Parker, 2005b), Parker believes that orienteering events with around 2,000 participants have very minimal impact on vegetation, while very large events require at least a season for vegetation to recover. Given that long-term damage is defined as lasting for at least ten years, it cannot be said that orienteering has a significant effect on vegetation, as no study has shown such a long-term damage, even in those with more than 10,000 participants.

Kardel (1974) considers that the biological damage to vegetation is mostly just theoretical. The main assumptions that vegetation is destroyed and erosion effects occur as a result of orienteering competitions and other forest recreational activities are often subjective and inconsistent. Vegetation damage can be observed immediately after orienteering competitions and may seem significant, but the resilience and capacity of different types of vegetation are so good that the damage is almost invisible after one or two seasons. Considering that, there is no significant reason to restrict or prohibit the organization of orienteering competitions.

The aim of the research is to assess the impact of orienteering competitions on ground vegetation at the seaside, Latvia. In order to achieve the aim, the following research tasks have been set: to analyse the vegetation around the orienteering control points before and after the competition and to compare and evaluate the changes of vegetation in the terrain on the hill tops and in depressions.

Materials and Methods

In order to assess the impact of orienteering competitions on ground vegetation, two research objects have been selected from orienteering competition 'World Masters Orienteering Championships 2019' or 'WMOC 2019' competition area which was situated in the seaside near Bumbukalns and Garezeri (Figure 1). The competition took place from July 5, 2019 to July 12, 2019 and gathered more than 3 thousand participants, which was the largest competition in Latvia that year. In these areas applies Cabinet Regulation No. 86. 'Methodology for determining the Coastal Protection Zone of the Baltic Sea and the Gulf of Riga' (adopted on 17 February, 2004).

Bumbukalns, where the competition in the middle distance took place, is located in the northwest of Riga near Buļļupe - the tributary of the old Lielupe in river Daugava. Bumbukalns is included in the green zone of Riga. Dunes covered with pine forests are typical for the competition area. It has a dune relief with various hill shapes. In some places the terrain is flat, but in other places dune ridges and hills reach a height of 20 meters. In several places, openings can be found as well as thick undergrowth. It is easy to run through the pine forests although the area is technically complex (LOF & IOF, 2019). In the competition area two forest types were recognized – *Cladinoso-callunosa* and *Vacciniosa*, where a small number of species and poor soils are common. The territory of

Figure 1. WMOC 2019 competition areas.

Bumbukalns is included in the SPNT 'Buļļu kāpas' and belongs to the nature reserve zone of this SPNT. In the competition area the European Union protected habitat *2180 Wooded seaside dunes* can be found (Dabas aizsardzības pārvalde, 2020).

Garezeri, where the competition in the long distance took place, is located northeast of Riga, on the Baltic Sea coast, near the village of Lilaste in Carnikava region. The competition area is characterized by sand dunes covered with pine forests. The area is filled with distinct hills and dune ridges of various sizes, but swampy places can also be found there. In the area, there is an extensive network of trails – both large and small trails run through the entire coastline. Garezeri is included in the Seaside Nature Park, most of it is the nature reserve area, but some areas are included in the nature park area as well (LOF & IOF, 2019). In this competition area two forest types were recognized too – *Cladinoso-callunosa* and *Vacciniosa*, which are characterized by a small number of species and poor soils. In the competition area, there is the European Union protected habitat *2180 Wooded seaside dunes* (Dabas aizsardzības pārvalde, 2020).

The collection of data required for the study took place in July 2019 before and after the competition. A total of 10 control point locations were selected at the sites (5 in Bumbukalns, 5 in Garezeri), of which 4 were located on hill tops, 4 in depressions and 2 were finish checkpoints. Vegetation was counted in each sample plot using the Braun-Blanquet method (Pakalne & Znotiņa, 1992). In each sample plot the total projected cover (%) of vegetation was determined in each layer at a distance of 7 m and 14 m from the control point. The intensity of the trampling depends on the number of participants crossing the sample plots to check in the required control point. Using the data published about 'WMOC 2019' concerning the results of the competition, the number of participants that have been at each control point has been calculated. Two-factor analysis of variance was used for mathematical data processing (Arhipova & Bāliņa, 1999).

Results and Discussion

The creation of control points is individual at each location of competition. Control points have been inspected both before and after the competition,

Table 1

The projective cover of forest stand layers in Bumbukalns sample plot before and after the competition

Relief	Control points									
	1		2		3		4		5	
	Depression				Hill top				Finish check-point	
Vegetation layer	Before	After	Before	After	Before	After	Before	After	Before	After
Tree layer	5.3	5.3	3.4	3.4	1.1	1.1	2.3	2.3	0.1	0.1
Scrub layer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Herb layer	0.0	0.0	0.0	0.0	17.7	17.7	17.7	17.7	20.2	20.2
Moss layer	94.3	92.6	95.3	90.2	61.1	57.8	82.9	80.2	41.1	40.0

and a photo has been taken of the sample plot. The repetition of data collection is possible using maps of competitions. The intensity of trampling varies in the sample plots. The projective cover of forest stand layers in Bumbukalns and Garezeri sample plots is shown in Table 1 and 2, respectively.

The first five sample plots – control points were located in Bumbukalns competition area (Table 1). Two of the control points were situated in depressions with the forest type – *Cladinoso-callunosa*. In the sample plot, the land in the centre is visibly trampled and the moss layer is flattened. In some places, both at a distance of 7 m and 14 m, some separate pieces of moss were trampled. This control point was visited by 335 participants. They went to the control point from different sides, hence there was a new path visible in the northern direction. The projective coverage of the moss layer has decreased by 1.7% ($p>0.05$).

A similar situation is observed in the second sample plot – the centre is trampled and several trajectories are visible from which the participants have come. At 7 m distance traces of trampling can still be seen - to the west the moss is trampled intensively, to the east the trampling is observed directly towards the centre, but not so intensively, while to the north the trampling volume is decreasing. At a distance of 14 m, no visual effect in the moss layer is observed. This control point was visited by twice as many participants as before – 742 in total. The projective coverage of the moss layer has decreased by 5.1% ($p>0.05$).

Two control points were located on the slopes, forest type *Cladinoso-callunosa*. In the first sample plot, open soil was already visible before the competition, there was not a lot of vegetation; however, after the competition it was recognized that the whole centre around the control point was trampled, only behind the tree in the northern direction the moss remained intact. This control point was visited by 848 participants. The influence of the participants can be seen in the centre; however, further away (at a distance of 7 m and 14 m) there are practically no visual changes. The projective coverage of the moss layer has decreased by 3.3% ($p>0.05$).

In the second sample plot, the control point is clearly visible from afar, and the participants came from the bottom of the hill, hence the slope to the control point is trampled; however, at the hill top the effect of trampling has not been observed. This control point was visited by 211 participants. A small impact is observed at a distance of 14 m in the northern direction, where the moss layer is trampled a little. The projective coverage of the moss layer has decreased by 2.7% ($p>0.05$).

At the finish, which was located at the crossroads of the trails, the terrain is flat, the forest type there is *Vacciniosa*, and 3,679 participants ran by this point. A flattened path has formed from the south direction. The projective coverage of the moss layer has decreased by 1.1% ($p>0.05$).

Five sample plots were located at Garezeri area competition control points (Table 2). The first two control points were located in depressions. In the first sample plot, the forest type is *Cladinoso-callunosa*. The ground vegetation has been trampled in the centre, the moss layer has been trampled a little at a distance of 7 m, but no other changes have been observed. This control point was visited by 603 participants. The projective coverage of the moss layer has decreased by 2.0% ($p>0.05$).

The second sample plot in the depression was with the forest type *Vacciniosa*. The centre there was slightly flattened, but further no visual changes were observed. This can be explained by the fact that the plot is dominated by herbaceous species which tolerate trampling better (Emsis, 1980). This control point was visited by 149 participants. The projective coverage of the moss layer has decreased by 0.1% ($p>0.05$).

Two control points were located on the hills, the forest type was *Vacciniosa*. After the competition, in the centre of the sample plot moss layer was trampled and a path had formed on the northern slope, which also stretches through 7 m sample plot and till 14 m from the centre. The control point was visited by 143 participants. The projective coverage of the moss layer has decreased by 3.2% ($p>0.05$).

Moss is trampled in a few places around centre of the second sample plot, visual changes further from the centre are minimal. It can be seen that the participants have visited the control point from the west - the moss has slightly flattened and is regaining its original shape. Only 28 participants visited this control point; therefore, the change is very small. The projective coverage of the moss layer has decreased by 0.6% ($p>0.05$).

The finish control point is located on a sandy road with flat terrain, the forest type is *Cladinoso-callunosa*. 1,412 people visited this place. No visual changes were observed in this sample plot, and the projective cover of the moss layer did not change.

It is characteristic of all control points that the ground is trampled in the centre. For the sample plots in the hills, the centre (average moss layer decreased by 2.5%) is more affected than in the depressions (average moss layer decreased by 2.2%), but the effect of trampling on flat terrain is small or practically non-existent (average moss layer decreased by 0.6%) and the differences are not significant ($p>0.05$) (Liepina, 2016). The participants visited the control points in the hills from one side of the hill - one slope of the hill is more trampled, but in the depressions, there are several trajectories from which the control was visited. The intensity of trampling varies depending on the

number of participants, but there are no regularities. The impact does not only depend on the number of participants - both the diversity of ground cover plants and the characteristics of the terrain and soil must be taken into account.

Conclusions

The effect of trampling is observed only in the moss layer. At control points, the projective coverage of the moss layer has decreased by 1.8% on average ($p>0.05$). On other layers of the forest stand there has been observed no impact of trampling. The most pronounced damage to the forest floor can be detected at the control point itself in the centre. As the distance from the control point increases, the trampling intensity decreases. There was no correlation among the terrain form at the checkpoint, the amount of participants and the intensity of the trampling. The impact depends on both the diversity of ground cover plants and the terrain as well as soil properties.

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References

Andersen, E.B., Børsting, B., Køhler, M., Neilsen, I., Rasmussen, J., & Sandgreen, F. (1986). *Vejvalgsundersøgelse af 3 orienteringsløb* (Route choice at 3 orienteering events). Danish Orienteering Federation. (in Danish).

Arhipova, I., & Bāliņa, S. (1999). *Statistika ar Microsoft Excel ikvienam* (Statistics with Microsoft Excel for everyone). Rīga: Datorzinību Centrs. (in Latvian).

Čākurs, R. (2019). *Orientēšanās sporta ietekme uz veģetāciju: bakalaura darbs* (The impact of orientieering sport to vegetation: Bachelour thesis). Rīga: LU Vides zinātnes nodaļa, 52 lpp. (in Latvian).

Dabas aizsardzības pārvalde (2020). *OZOLS – Dabas datu pārvaldības sistēma* (OZOLS – The system of nature data management). Retrieved March 31, 2020, from https://ozols.gov.lv/pub. (in Latvian).

DAP & LOF darba grupas rekomendācijas (The recommendations of DAP and LOF working group). (2014). *Kopsavilkums. Normatīvie akti orientēšanās sacensību organizēšanai ĪADT, sugu un biotopu dzīvotnēs* (Abstract. Normative acts of orienteering competitions in especially protected nature territories, species and habitat biotopes). Retrieved March 28, 2020, from https://lof.lv/uploads/Admin/DAP/Kopsavilkums_NA.DOCX. (in Latvian).

DAP & LOF darba grupas rekomendācijas (The recommendations of DAP and LOF working group). (2014). *Orientēšanās sacensību ietekme uz aizsargājamām dabas teritorijām* (The impact of orienteering competitions on especially protected nature territories). Retrieved March 28, 2020, from https://lof.lv/uploads/Admin/DAP/OS_ietekme_uz_vidi_apkopojums.doc. (in Latvian).

DAP & LOF darba grupas rekomendācijas (The recommendations of DAP and LOF working group). (2014). *Orientēšanās sporta sacensību organizēšanas PROCESS ietekmes uz vidi mazināšanai* (The process of organizing of orienteering sport competitions to reduce the impact on the environment). Retrieved March 28, 2020, from https://lof.lv/uploads/Admin/DAP/DAP_LOF_procedura_gala_20_05_2014.xlsx. (in Latvian).

Douglas, E.A. (1989). *Assessment of the impact of the November Classic Badge Event 1988 on the New Forest*. British Orienteering Federation, Matlock.

Emsis, I. (1980). Rīgas pilsētas mežu apsaimniekošana (The management of Riga city forests). Riga: LatZTIZPI. 63 lpp. (in Latvian).

History and Facts About Orienteering (2020). Retrieved April 4, 2020, from https://www.athleticscholarships.net/other-sports-orienteering.htm.

Kardell, L. (1974). *Vegetation damage in connection with orienteering events*. Research Notes 4. Royal College of Forestry, Stockholm.

Laininen, E. (2012). *IOF Survey – Orienteering and the Environment*. Retrieved March 31, 2020, from https://orienteering.sport/iof/environment-and-sustainability/.

Liepiņa, L. (2016). *Orientēšanās sacensību ietekme uz meža zemsedzi mainīgā reljefā*: *maģistra darbs* (The impact of Orienteering competitions on forest ground cover in variable relief: Master thesis). Jelgava: LLU Mežkopības katedra, 77 lpp. (in Latvian).

LOF & IOF. (2019). *WMOC_2019_Bulletin2*. Retrieved March 28, 2020, from https://www.wmoc2019.lv/augsuplades/files/WMOC_2019_Bulletin2.pdf.

Mendoza, A. (2008). Effects of an orienteering competition at Bow Valley Wildland Park, Alberta, 2002-2008, Alberta Orienteering Association.

Orienteering (2020). Encyclopaedia Britannica. Retrieved April 4, 2020, from https://www.britannica.com/sports/orienteering.

Orientēšanās sacensību rezultāti (The results of orienteering competitions). (2020). Latvijas Orientēšanās Federācija. Retrieved April 24, 2020, from https://lof.lv/seriali_rez/stati. (in Latvian).

Pakalne, M., & Znotiņa, V. (1992). *Veģetācijas klasifikācija: Brauna-Blankē metode* (The classification of vegetation: the method of Braun-Blanke). Rīga: Latvijas Universitāte, 36 lpp. (in Latvian).

Parker, B.H. (2005a). *Comparison of the environmental impact of orienteering and other off-track recreations in the Dartmoor National Park, UK*. IOF Environment Commission.

Parker, B.H. (2005b). Review of research into the ecological impact of orienteering. IOF Environment Commission.

Parker, B.H. (2009). *A physical model for comparing the trampling impact of large grazing mammals and off-track recreational activities*. Scientific Journal of Orienteering, Vol. 17, Issue 1, 21–24.

Senā vēsture (Old history). (2020). Retrieved April 4, 2020, from https://sites.google.com/view/os-karte/senie-laiki/senā-vēsture?authuser=0. (in Latvian).

Чижова, В.П.М. (1977). *Рекреационные нагрузки в зонах отдыха* (The recreational loads in recreational areas). Москва: Лесная промышленность, 48 с. (in Russian).