Ekológia (Bratislava) Vol. 31, No. 3, p. 341–353, 2012
doi:10.4149/ekol_2012_03_341

DETERMINING THE DAMAGE INFLICTED BY TOURISTS ON THE CURONIAN SPIT NATIONAL PARK AND PREVENTIVE MEASURES IN DUNE CREATION

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Abstract

Morkūnaitė R., Karmaza B., Bauža D.: Determining the damage inflicted by tourists on the Curonian Spit National Park and preventive measures for dune creation. Ekológia (Bratislava), Vol. 31, No. 3, p. 341–353, 2012.

This article contains the results of investigation into the recreational load carried out by a group of researchers in the Nagliai Nature Reserve in the Lithuanian Curonian Spit National Park, and in the blown-out dunes south of Nida. The information concerning the trampled areas and their relative portion in the preserved territory, the definition of preserved areas and decisions related to their use in the "Master Plan of the National park of Curonian spit" (CSNP), and also methods used for calculation of recreational loads is presented herein. Comparison of the obtained results with data reported by other authors provides the conclusion that the recreational load in the CSNP is less than commonly presumed. Although this conclusion is partly predetermined by methodical differences, the presented data provides an important basis for further planning of recreational areas and the preservation of sensitive habitats.

Key words: blown-out dunes, recreational conditions, Curonian spit, adaptation measures, planning documentation, dune preservation

Introduction and research objectives

The "dead" blown-out dunes of the CSNP have mainly been investigated from eolodynamical, stratigraphical and palaeogeographical aspects. Except for the foredune ridge, scientific research on these dunes has mainly concentrated on social or sociographic aspects. As Jungierius pointed out in 2008, theories on dune formation are not always based exclusively on geomorphological research. According to his report, dune management using preserva-

tion and regulation measures is a very complicated task because coastal dunes are currently expected to fulfil many social functions. These include: (1) protection of the shore from wave action, (2) preservation of the natural environment, 3) recreation, 4) construction and industry, 5) agriculture, and 6) military training (Jungierius, 2008).

The results obtained by the group of researchers while investigating the CSNP during 1995–2005, and especially those on the Main dune ridge, have been reported at seminars with representatives from the Klaipėda and Neringa municipalities, and published in transactions of international conferences within the INTERREG III B project.

Bearing in mind the recent climate changes, this project seeks to establish adaptation measures and strategies, and to explain to the wider public that adaptation measures under these changing climate conditions are quite complex, as they encompass legal and financial "tools", organizational skills and development of communication possibilities (www.astra-project.org; Česnulevičius et al., 2007). The included material is considered useful for practical purposes related to the preservation and regulation of dunes, and some of this material has not previously been reported at conferences.

The aims of this study are: (1) to determine the importance of anthropogenic factors in the blow-out processes, (2) to describe the possible management scenario based on the obtained results and (3) to survey the planning document for the CSNP.

The primary task is to determine the role of natural and anthropogenic processes on the dune dynamics in the CSNP. During investigation of the chosen reference areas in the Nagliai Nature Reserve and the dunes south of Nida (Fig. 1), the following processes were determined: (1) the trampled dune area, (2) the dependence of trampled paths on the slope forms, and (3) the "desire" of holiday-makers to reach the sea or Curonian lagoon using the shortest way across the dunes". The recommended measures for preservation of the eroded sand areas are presented.

The detailed analysis of zones distinguished in the CSNP planning documentation ("Management plan of the National park of Curonian spit, 1994") served as a basis for analysis

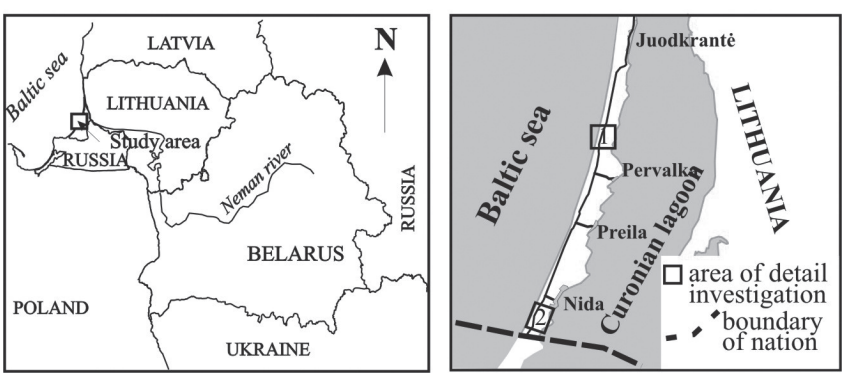

Fig. 1. Investigated areas of eolian or grey dunes.

and comparison of plausibility of legal statements, related to the boundaries of preserved relief areas and the actual current situation. The above aims emanated from the preserved territories, as follows; (status: "National park; nature reserves"): (1) the flow of holiday-makers to the CSNP has intensified since 1990, (2) this increased the anthropogenic load on the Main dune ridge (Česnulevičius et al., 2006). Therefore, requests for development (3), the regulation of recreation (4) and also measures for aeolian sand protection (5) have gained special importance. These are referred to as the socio-geographical factors which affect recent dune degradation. According to Schmidt-Thome, (2006), regulation of environmental problems in planning documentation began in Germany 30 years ago with the advent of relief devastation, while mitigation of environmental effects in most other countries has been regulated in planning documentation since 1980.

There have been many questionnaire-based researches reporting results of surveys of holiday-makers, including holiday-making numbers, their social status, the attractive destinations requested and distances covered. One such research was carried out in the Baltic sea coasts, foredune ridge and beaches by Jarmalavičius and Žilinskas (2007). The character of research of recreational resources was also described by Professor P. Kavaliauskas (1995), together with plans for geo-morphological educational paths (Kavaliauskas et al., 2004).

Foreign researchers have focused on investigations of aeolian relief in other than marine locations. For example aeolian relief has been developing (1) as a result of anthropogenic processes in the eastern part of the Silesian upland; (2) in the Olkusz mining industry locality, and (3) in the Starczynov "desert" which has longitudinal dunes which are not typically found in such climatic conditions (Pelka–Gosciniak, 2000). Blown-out sand areas in the territory between the Chika and Selenga rivers of the Western Trans-Baikal have been described where the species composition of vegetation changed due to intensive animal breeding. Here, the substratum was saturated with nitrogen compounds from animal faeces (Szcypek et al., 2000).

Presentations at the Southport international conference in England discussed damage to coastal sand areas by military detachments and scientifically based feasible practical strategies for their preservation (Baker, 2001). When erosion of the coastal dune system of Scotland was associated with tourist activity, research work was published which showed that dunes are the centre of attraction in all coastal landscapes (Wood, 2001). Efforts to mitigate the damage to the Rømø island of Denmark included recommendations to regulate the flows of visitors by means of fences and signs. The Danish dunes occupy an area of 127,000 ha, and with the population of Denmark at approximately 5 million, the erosion induced by holiday-makers is not currently very intensive (Reimers, 2001). However, recent problems of dune erosion in the West Jutland have become so acute that it is now necessary to regionalize and manage this territory. Discussions are currently continuing, to decide where the "white" dunes should be preserved and where it is necessary to reinforce the dunes and to regulate the flows of visitors (Reimers, 2001).

Anthropogenic transformation of aeolian massifs is determined and assessed in different ways. For example, in the aeolian massifs in the Fore-Urals (Kumak sand fields) this is explained by the increasing numbers of cattle, sheep and goat herds (Čibiliov et al., 2004).

The number of cattle there dramatically increased in 1970–1980 and with the coinciding atmospheric aridity, these two factors caused the movement of sand massifs.

These given examples illustrate the variety of ways in which wind-damage erosion can be determined.

Methods and study area

Methods

Trampled areas were investigated in the environs of Nagliai and Parnidis dunes using the Etrex navigation device. This was utilized during field investigations to fix coordinates of investigated objects. This research is also based on large-scale topographic maps (1:10 000), ortophotographs and other cartographic sources. These were analyzed to determine the boundaries of investigated territories and the dune areas which were most sensitive to treading.

The anthropogenically affected areas were identified between July 26–28, and October 6–8 in 2004. The longitudinal and latitudinal coordinates of localities were converted into the LKS 94 national coordinates system, and areas of anthropogenic impact near the footpaths were marked using graphic SURFER software. Ortophotoplans (1:10 000) were used for determining the density and length of footpaths. The trampled areas were marked using marker-poles.

The results of recreational loads were analyzed from Riepšas (1986).

Study area

As mentioned above, the territories chosen for investigation are the Nagliai Nature Reserve and the environs of Parnidis dune.

The Nagliai Nature Reserve (NNR) occupies an area of 1680 ha, extending for 9 km between Juodkrantė and Pervalka. The most valuable elements of the reserve comprize bare dunes, buried ancient settlements, natural forest plants and buried forest soils (Aukštaitis, 1996). This territory was chosen because strong winds in this terrain form impressive depressions and pothole, and fragments of old soils are exposed in the sand in some parts. The NNR biota is rich forming a habitat for many representatives from the List of Extinct and Endangered Species of Lithuania. All activities unrelated to preservation and regeneration of the natural environment, including recreation are prohibited within this reserve, so its natural environment is perfect for scientific observation.

The area of Parnidis Landscape Reserve (PLR) is 230 ha, and this includes the Parnidis cape complex, the sea "blowaway" plain, lagoon "blowaway" plain, a blown-out remnants area and the slope of Parnidis dune. This reserve forms a barrier zone between Nida settlement and the Grobštas Nature Reserve (Bučas, 2001; Aukštaitis, 1996). The PLR is distinguished by its aesthetically valuable landscape, with a sand ridge forested by mountain pines in its northern part and a blown-out sand ridge in its southern area. This remains the only area in the national park with a preserved chain of blown-out dunes.

Recreational loads as defined in the "Master Plan of Curonian spit"

In the scheme of CSNP ("Management plan of the National park of Curonian spit, 1995") regulating the recreation zones it is stated that (1) "The measures of formation of recreational environment and the trends of recreational development were established taking into consideration the interest to preserve the general environmental equilibrium of landscape and permissible load". The description of the actual situation also includes the statement that (2) "The public request for recreational resources is growing yet poorly organized recreation inflicts damage to natural environment and entails landscape degradation". Another statement related to the economic and social environment is to the following effect: "Priority of recreational activity creates prerequisites for economic development of the

park, improvement of the social welfare, solution of demographic and employment problems and development of infrastructure and settlements. The most promising traditional trades and recreational services are encouraged".

The analysis of the status of and recreational conditions in the CSNP illustrates that the highest concentrations of holiday-makers in the beach zones are characteristic for sunny summer days, with 70–80% of the total of holiday-makers in those times. However during afternoons and evenings, the concentration of holiday-makers in recreational forests in the settlement's environs does not exceed 30%. The main types and forms of recreation are: 1. stationary rest on holiday; 2. tourist recreation, when visitors stay overnight for up to 3 days; 3. excursions, when visitors do not stay overnight; 4. weekend and daily outings for local residents and Klaipėda citizens, and 5. water sports.

The results of sociological investigations carried out in 1988–1991 show that up to 84% of holiday-makers spent two weeks in Neringa. Recently, the number of cultural events, such as music festivals, has increased, and these sporadically attract additional groups of visitors to the CSNP.

The evaluation of loads using different methods is based on calculations of ecological capacity. The researcher E. Riepšas (1985, 1986) recommended a suitable method for calculation of ecological capacity of recreational territories based on determining the physical characteristics and the state of natural recreational resources, such as forests and beaches, the number of visitors and their concentration, together with other parameters ("Management plan of the National park of Curonian spit, 1995").

The habitats in the CSNP which are sensitive to visitations represent a limiting factor. Calculations of ecological capacity showed that open beaches and the area behind the dunes (excluding Smiltynė) are able to comfortably accommodate from 16–18,000 to 27,000 visitors. According to Povilanskas (2004), only 5,000 holiday-makers would spend their summer holiday there on a regular basis, and the tourist flow is controlled by permission to visit the spit. The smaller number of approximately 4,400 to 6,400 visitors would ensure greater isolation and psychological comfort. Appropriate dune management and regular reinforcement, however, remain the most indispensable prerequisites. Calculations of ecological capacity of the CSNP are important in establishing recreation zones. Two types are commonly distinguished: a) zones with landscape designed, or transformed if necessary, to maximize the visitor numbers (Smiltynė zone) ; and b) zones with minimal recreational infrastructure where natural landscape must be maximally preserved. This latter condition covers the remaining zones of the CSNP.

The following derived values were obtained by mathematical computation: the annual recreational capacity of these recreational zones is approximately 300,000 visitors, with a daily capacity of 4,100. In 1991, the number of daily holiday-makers exceeded 12,000. This is a sign that a further increase in recreational load is unacceptable for the preservation of a maximally natural landscape. Analysis of these recreational capacity calculations illustrated that a denser footpath network could increase the recreational capacity of the forested areas to 13–15,000. (Riepšas, 1986). However, weekenders and day-visitors also trample the dunes. Transformation of forests into parks would markedly increase the recreational capacity, but this is inconsistent with national park doctrine, and is therefore not included in the Master Plan.

Character of recreation, and damage to the dunes

The level of damage inflicted by trampling was determined in the Nagliai Nature Reserve and south of Nida, where detailed investigations into wind erosion had previously been carried out (Morkūnaitė, 2004; Morkūnaitė, Karmaza, 2006) (Fig. 2).

This research determined that the trampled area in the environs of Nagliai dune covered 5.8 ha, which accounts for approximately 0.3% of the total area of Nagliai Reserve (Fig. 3). The trampled area extends from east to west along the main path, and the perimeter of the area measures 2014 m. Such areas and indices were previously determined based on large-scale maps and ortophotoplans. In this research, however, a navigator was used for this purpose for the first time.

According to the 2004 data, the flow of visitors thronged to the Nagliai dune over the wooden bridge and along the two main paths to the Curonian lagoon. Two 0.5 m wide paths run along the eastern slope of the dune ridge and across the Lydumas cape towards the Vingiakopė dune. Based on the number of visitors on the path leading to the Nagliai dune between July 28 and October 8, it was determined that the sand layer removed by trampling was from 12 to 35 cm thick. It is our considered opinion that wind erosion and sand compression after atmospheric discharges in October 7–8 (about 7 mm) contributed to this value. Bearing in mind that approximately 1 m thick

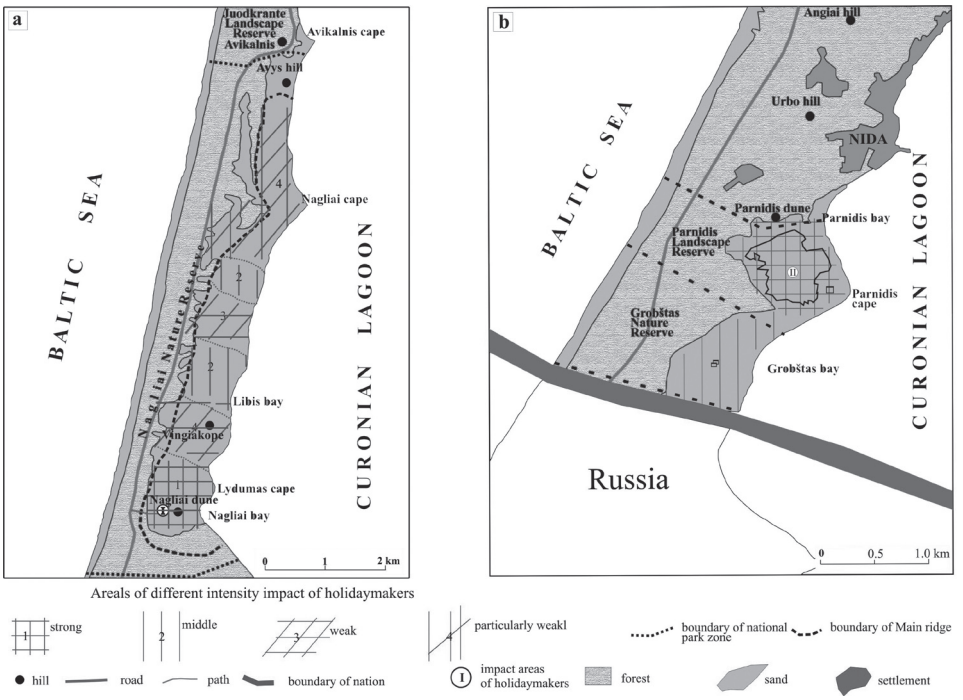

Fig. 2. Evaluation scheme of affected of recreation for Main dune ridge: A – in territory of Nagliai Nature Reserve; B – south part of CSNP: 1. strong impact of holidaymakers, 2. middle impact of holidaymakers, 3. weak impact of holidaymakers, 4. particularly weak impact of holidaymakers; Conventional marks: the boundary of zones Curonian national park, the boundary of Main dune ridge, hill, road, path, boundary of nations, impact areas of holidaymakers, forest, sand, settlement.

wind-eroded sand layers are distinguished, in the levelling profiles, we can make the preliminary assumption that approximately 30% of the sand was trampled and about 70% eroded by wind. This 3/7 proportion defines the roles of anthropogenic and natural factors in this dune degradation.

Based on this method, the highest trampling level was determined at the parting of two paths ascending the slope towards the Curonian lagoon (34 cm), between the former elevation and the 4th oval depression (27 cm) and near the barrier belt towards the Curonian lagoon slope (10.5 cm). Therefore, the most strongly areas affected by trampling are those in the concave slope of the sophisticated configuration to the Curonian lagoon, the slope edge with the view of the Curonian lagoon and near the picturesque natural object – oval depression – on the slopes of which oblique layers of sedimentation and "creeping" grass tussocks can be seen.

According to the Etrex data, the trampled area in the environs of Parnidis dune is up to 25.7 ha (Fig. 4), which is 11.2% of the total area of Parnidis Landscape Reserve and 1.5% of the total area of Nagliai Nature Reserve. This area has a more complicated configuration and structure. A few plots of land overgrown with European beach-grass not visited by holiday-makers are situated in the middle of the area. The flows of visitors are oriented towards the Sklandytojai dune as proven by the shape of the area (Fig. 4). The trampled area of the Parnidis dune was distinguished and measured using Etrex.

Future use of the above-mentioned method, could determine the number of footprints by visual assessment of trampling in different parts of the area. Here, the greater number of footprints indicates stronger effects of

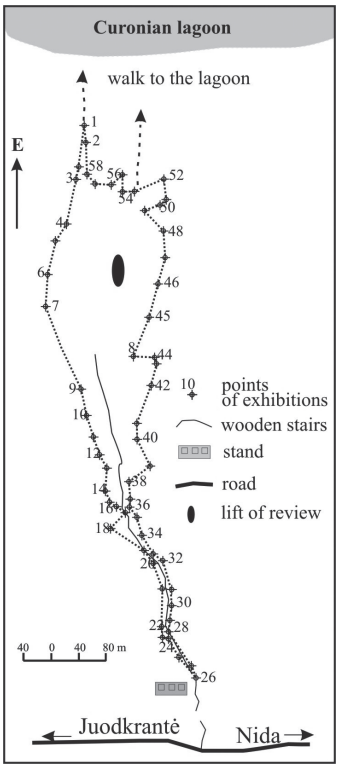

Fig. 3. The trampled the area of Nagliai dune, fixed and measured with Etrex.

trampling. This would show if the flow of visitors is concentrated near the Curonian lagoon slope or near the forest edge, and this would enable prediction of the future transformation of Parnidis dune induced by the visitor flow. This is an important practical aspect of this method. Having determined the most strongly affected areas, it would be possible to replenish them with sand taken from other areas.

Based on field investigations and cartographic material, the length and density of footpaths and the impact of visitor flow on the considered territory were preliminarily determined. The density of footpaths in the territory of Nagliai Nature Reserve is 25.0 m/ha and in the foredune ridge 18.0 m/ha. The width of footpaths ranges from 0.5 to 2.0 m. The footpaths in the upper part of the slope of the Main dune ridge widen to 1.5 m south of the Nagliai cape for example, and then narrow to 0.7 m at the summit of the ridge (Fig. 5). Although the footpaths in the blown out remnants area are very narrow, they then widen to 4.0 m in the upper parts of the slope and between dunes. We recommend that the paths be placed diagonally, and that measures be taken to prevent sand blow-out in the areas between the dunes .

The density of clearings including the foredune ridge, which is rarely used by visitors, is 11.5 ha. The paths usually begin at the parking sites and branch out approaching the dune ridge. The dominant direction of paths is from east to west. Based on the total length of paths and clearings, conditionally taken that their width is 1 m, their calculated area within the Nagliai Nature Reserve accounts for 0.26% of the total area. Since this area is not very large, new paths can be built taking into account the relief resistance to wind erosion.

It should be noted that the remaining part of the reserve (excluding the Nagliai and Parnidis dunes) bears no signs of trampling and littering. The deflation basins north of Vingiakopė dune are rarely visited. Here, the geo-

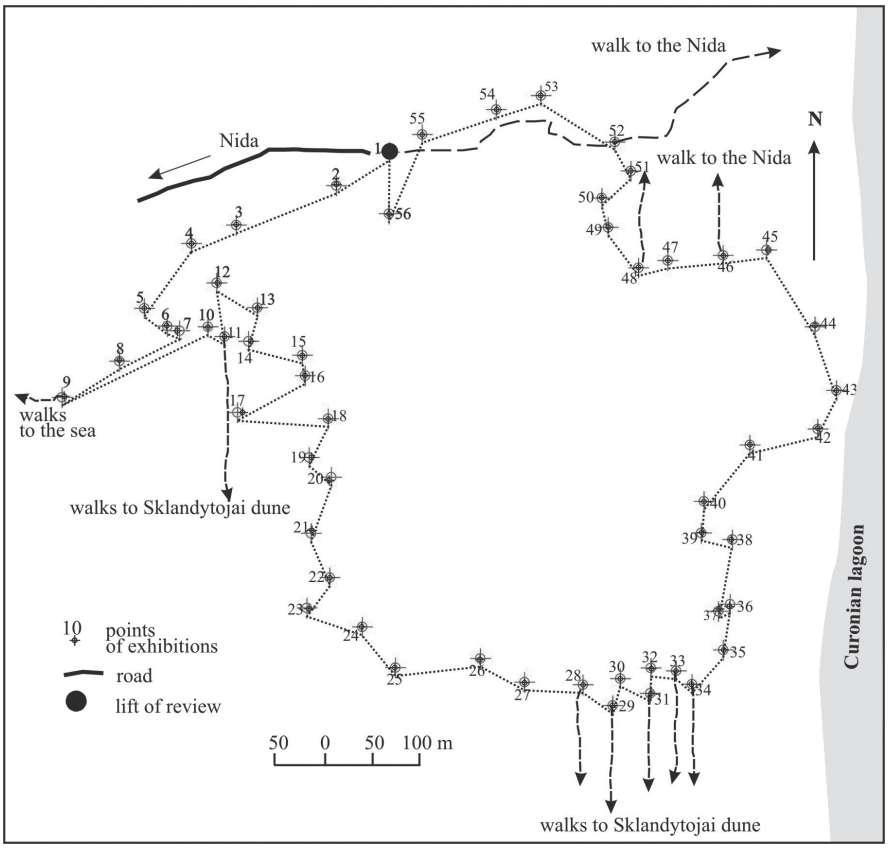

Fig. 4. The trampled the area of Parnidis dune, fixed and measured with Etrex.

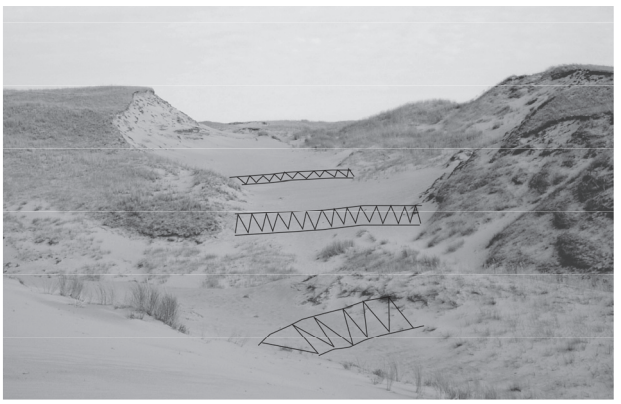

Fig. 5. Places for possible barriers in New Nagliai dune massive. (photos by A. Česnulevičius)

morphological processes are most intensive, and South of Vingiakopė, visitors are also rare, so that the picturesque deflation basins are preserved as a "natural laboratory".

Measuring values presented in this work, and also in previous works (Morkūnaitė, 2004; Morkūnaitė, Karmaza, 2006), enable classification of this investigated territory according to the recreation loads (Fig. 2a, b). Moreover, the scheme of these areas could be detailed.

Recommendations for preservation of intensively trampled areas of the Main dune ridge

Field investigations were carried out in the Nagliai Nature Reserve to optimize the use of the Main dune ridge for tourism. The potentially critical dune areas were determined in the following parts of the reserve: 1. the middle of the educational footpath, 2. Lydumas cape, 3. the environs of Nagliai (Agila) cape.

Although blown-out areas and aeolian forms were also discovered in other places, their scale is small. The present work introduces a system of measures to be taken for preservation of the educational path in the Nagliai Nature Reserve. The terminologies "foredune" and "dune" refer to preliminary morphological parts of the Nagliai dune.

Possible ways to reconstruct the educational path in the Nagliai Nature Reserve:

The educational footpath of Nagliai dune is in the CSNP near the Pervalka settlement. This path was built for visitors to cross the dunes and to observe the Curonian lagoon. The path begins at the 7th parking area and extends 700 m eastwards across the Nagliai dune and towards the Curonian lagoon (Fig. 5).

At present, the educational path consists of five sectors with markedly different aeolian and anthropogenic features. The first sector is between the beginning of the path and the first bend to the north. Here, the foredune slope angle changes so that the slope steepens sharply. The second sector includes the steep part of the dune and the segment to the old path. The third sector extends to the former elevation, the fourth from the elevation to the steepening part of the dune and the fifth sector forms the end of this educational path.

Characteristics of sector I in terms of wind erosion and anthropogenic activity:

This sector is distinguished by a widely eroded belt related to anthropogenic trampling. The wooden footpath serves as a barrier for short-lasting sand transport in certain directions. On the other hand, the smooth wooden

Fig. 6. Common view of path from the beginning towards Nagliai dune. (photo D. Bauža)

surface facilitates wind acceleration when wind and path directions coincide (Fig. 6). Visitors walking along the sides of the wooden footpath inflict damage to this sector. In some places, trampled areas are 10 times wider than the 1.2 m wooden footpath, and human footprints are apparent.

Sector II is distinguished by strong anthropogenic transformation which is mainly related to using wooden steps to extend the footpath. The exposed slope is rather strongly blown-out due to the anthropogenic effects being increased by sand creeping down as a result of wind action.

Sector III shows clear evidence there are few effective measures against wind action. The blown-out corridor in the previous northerly directed path sector is a perfect "runway" for wind to gain momentum. Therefore, the wooden part of the path has been fully covered with sand. Planted shrubs on the dune summit would presumably serve as an obstacle to this blown sand.

Sector IV is the relatively least transformed. It has no wooden pavement and its margins are marked with spikes. This is not the best solution because these can be broken or stuck anywhere by vandalism. These dunes are also damaged by climbing and jumping.

Although Sector V is farthest from the start of the educational path, anthropogenic activity here is very intensive. This has been predetermined by these following objective factors: (1) there is a beautiful view to the Curonian lagoon, (2), blurred margins and (3) the "what next" factor. Little can be done to eliminate the first factor responsible for this dune erosion because most visitors wish to photograph the background of Curonian lagoon following their long trek, and this cannot be done without breaking the rules. The second factor can be eliminated by the clear marking of the margins of the footpath. As to the third factor, there always will be visitors who regard walking across dunes as a commonplace adventure, and there are no "remedies" for this kind of thinking.

It appears that the blurred margins form one of the main causes of negative anthropogenic activity on this educational path. It is evident that most of the visitors use the 1.2 m wide path. Yet it is not typical use of coastal landscape, and even favours wind action. In our opinion, the path should be marked with a wicker fence along the anthropogenically affected perimeter. This would prevent the formation of artificial barriers which facilitate increased wind velocity, and such a fence would also reinforce the dunes. These advantages have also been reported by other researchers (Daujotas, 1958). Finally, it is very important to mark the footpath margins to indicate allowed directions for walking.

Fig. 7. The place and the type of planting recommended. ("big" kanjon near Lydumas cape). (photo by D. Bauža)

The processes of wind erosion occurring in the western slope of the dune massif must be stopped by regulating the number of visitors, and by building artificial barriers which obstruct the movement of sand. In the Naujieji Nagliai dune massif, the barriers should wall in the new deflation basins (Fig. 5).

The construction of the educational path in the Nagliai Nature Reserve could be improved following the German method. The existing footpath here is built close to the sand surface and the planks are fixed side by side. However, in Germany, the wooden pavement is elevated above the sand surface and planks are arranged at intervals so that this openwork construction reduces wind erosion near the footpath. It must be considered, however, that this kind of footpath in Germany is constructed in a sand blow-out basin where processes are different.

The other investigated areas obviously lack vegetation cover, and the open area near the Lydumas cape forms a "runway" for wind. Appropriate vegetation must be planted to obstruct wind action (Fig. 7). As it is, the dominant western and north-western winds have formed a corridor for sand transport into the Curonian lagoon. A few spruce trees and birches obstruct NW winds and vegetation is flourishing behind them (the left side in Fig. 7). Meanwhile, turf has no time to develop in the open areas. This area should be planted to shade the winds, and Mountain pine is perhaps the best species for this purpose.

Conclusion

1. The different kinds of anthropogenic damage inflicted to blown-out dunes were studied in the artificial foredune of the Curonian spit national park (CSNP). The damage in the Nagliai Reserve was described in the Master Plan of CSNP in 1988–1991. This allowed comparison of the data included in the Master Plan with the individual results obtained by investigations of the Main dune ridge and the whole area of the CSNP. The number of visitors indicated in the Master Plan is higher than data obtained during the individual research. According to recreational capacity calculations this figure is up to 27 thousand. This is presumably due to the different methods used. According to the Master Plan, the number of holiday-makers exceeded the permissible recreational load in the territory of the CSNP by 12 thousand.
2. The present investigation has shown that the trampled area in the Nagliai dune is 5.8 ha (3% of the total area of Nagliai Reserve) and 25.7 ha in the Parnidis dune. The sand layer lost by trampling in the Nagliai dune ranges from 12 to 35 cm thick. Wind erosion of 40% and sand compression after rainfalls also contributed to sand loss.
3. Fences should be built in the intensively eroded aeolian basins, since these would at least partly mitigate the consequences of wind action.
4. The density of educational footpaths in the Nagliai Nature Reserve, when the artificial foredune ridge is excluded, reaches 18.0 m/ha, and together with the foredune ridge it makes 25.0 m/ha. The portion of footpaths and clearings form 0.26% of the total area of Nagliai Nature Reserve, and this shows that the recreational load in the Main dune ridge of Nagliai Nature Reserve is not very high.
5. The number and density of educational footpaths are low, and these should be increased for better regulation of the flows of visitors to the blown-out dunes. It is especially important to build more footpaths in the "wild" dunes between Vingiakope dune and Juodkrante.

Translated by the authors
English corrected by R. Marshall

Acknowledgements

The authors are grateful to researcher Dr. Artūras Bautrėnas of the Vilnius university for assistance in digitalising the obtained data and also to Rūta Gruzdytė from The Ministry of Environment for consultations and the opportunity to study the Master Plan. The authors also wish to thank the Administration of CSNP and LSSF for their financial support of this study and preparation of the article.

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