



Woody and Grassy Vegetation Development in Different Landscape Elements of the Curonian Spit

Algimantas M. Olšauskas

Klaipėda University

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The species of woody and grassy vegetation grow on the seashore sands and wastes. These plants are adapted for less favorable existence conditions, some of them growing in littoral habitats of excessive moisture and salinity, the others tolerate infertile and dry sand. The aim of this study has been to analyze the dispersion of vegetation in different relief elements of the coastal protective dunes, to search for relation between woody and grassy plant species, and to foresee the tendencies of further seashore landscape development. It has been established that in the locations of an intensive flow of visitors a net of trodden paths is formed where the plants cover is disappearing very fast as there are suitable conditions for the spring and autumn winds to erode the coastal protective dune of the seashore of the Curonian spit. In a couple of years a trodden path turns into sand drifting corridors of 2 – 3 m. wide, and the trodden and lain places by holiday makers extend to 4 – 5 m. wide pits and hollows. After interconnection of these formations they shape different size deflations. The drifting sand carried by the prevailing western direction winds swamp the plains beyond coastal dunes and the outskirts of the forest and sandy meadows. The statistical analysis of the plant projection cover shows that during the last 27 years (from 1982) the conditions for vegetation survival on the Curonian spit seashore sand dunes are gradually deteriorating.

Key words: *Curonian spit seashore, dune woody and grassy plant species, landscape change.*

1. Introduction

Coastal landscapes of the European maritime countries are highly valued and cherished. The landscape value is determined by the structure of the seashore: sandy with dunes or without, plane wet surface, moraine and rocky (Nordstrom et al. 1990). Whatever structure they might have, their value and stability are significantly increased by the presence of woody and grassy plants - as it weakens the rate of the winds erosion and seashore abrasion, heightens the aesthetical worth of the surroundings, improves the microclimate, etc (Wondergem 2005). On the shores of the Baltic and North seas there grow the same species of plants, (Davidson et al. 1991; Lundberg 1987; Ericson et al. 1979; Heikkinen et al. 1987; Piotrowska 1988). The seashore of the Atlantic Ocean is characteristic of the other plant species (Houston 1983; Dijkema et al. 1983; Doing 1989; Bassett et al. 1985). On the seashore of the Black and

Mediterranean seas the flora of more southerly latitudes vegetates (Rivas – Martinez et al. 1990; Escarra 1984; Palladino 1990; Georgiadis et al. 1990; Mishew et al. 1997). The landscape of the European seashore is immensely enjoyed by visitors (Ratas et al. 1997; Rove 2006; Ulsts 1998; Piotrowska 1995; Dudzinska – Nowak et al. 2006).

In the 17th century the Curonian spit seashore was overgrown by forests, therefore the sand drift processes there had not clearly manifested. In the period of the Thirty Years War (1618 – 1648) and the Seven Years War (1756 – 1763) the forest of the Curonian spit seashore was intensively hewn and that was the main reason why the prevailing winds of western directions could evoke sand erosion (Gudelis 1998). At the turn of the 18th and 19th centuries, due to the windborne sands the Curonian lagoon waterway

canal was sand barred causing the closure of the Klaipėda seaport (Daujotas 1958).

At the end of the 18th and the beginning of the 19th centuries dunes used to break through the settlements engulfing not only trees but houses as well. The 14 villages have been buried under the shifting Curonian spit sand. The 19th century is one of the most dynamic times on the Curonian spit which hastened the process of strengthening the moving dunes. The most important events were that people learned how to cope with the catastrophic erosion of the dunes (Abromeit 1903).

In 1807, under the initiative of Bjorn the work of forming and planting of the protective dune was commenced at a settlement of Kranc (present Zelenogradsk), a section of the Curonian spit seashore to curb the sand drift and the seas reaching the plains beyond the dunes (Bezzberger 1889). The forestation of the drifting sand of Nida and its approaches were started in 1825 under the initiative of G.D.Kuvert. Pine – trees (*Pinus mugo* Turra) were planted on the moving sand dunes. Maritime willow (*Salix daphnoides* Vill) was planted on the new formed coastal protective dune (Mager 1938). That work of forming and planting the protective dune was finished in the Curonian spit in 1904. The protective dune supervision was continued by cultivators of woods up to 2004. Afterwards, the care of the protective dune was, unfortunately, passed over to casual inexperienced organizations.

For that reason the woody and grassy plants began to dwindle (Olšauskas et al. 2004). In December 1999, the hurricane “Anatoly” totally annihilated the plant cover on the western slope of the protective dune and thinned it heavily on its top (Olšauskaitė – Urbonienė et al. 2005). Later on, it was not undertaken promptly enough to promote vegetation by sowing or planting, and the bare sand areas were not covered with branches (Olšauskas et al. 2007). The aim of this study has been to determine an optimum of the projection cover of the composition of woody and grassy plants species on the protective dune of the Curonian spit seashore.

2. Characteristic of an object

The Curonian spit of Lithuania borders on the south – eastern Baltic. The length of the seashore is about 52 km. (see Fig. 1).

More than 5000 years ago waves and winds of the Baltic Sea formed this unique unusual place. At first, a barren strip of sand was formed, which separated the lagoon from the sea. The waves and currents of the sea brought more and more sand and the strip broadened. The dry sand was blown away by the wind. This is how the dunes were formed. They

became bigger, joined each other and made the dune ridges.

The sand traveled towards the sea, fell into the Curonian lagoon and the strip widened. In the places where the wind blew most sand capes were formed.



Fig 1. Lithuanian Curonian spit seashore – study area.

The Curonian spit of Lithuania as a geographical marine division belongs to the south – eastern sector of the mid Baltic. On the protective dune of the Curonian spit seashore several floral zones were shaped: fore dune, western slope, top, eastern slope and plain beyond the coastal dune (see Fig. 2).

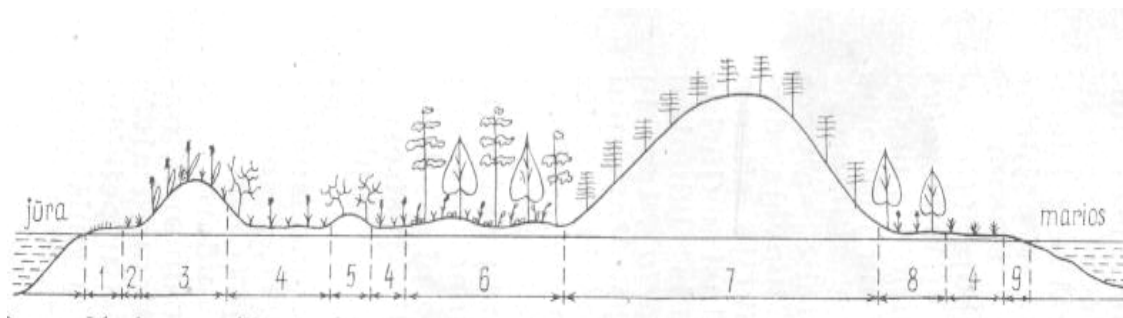


Fig 2. Ideal transverse profile of protective dune on the Curonian spit seashore (Bandžiulienė R.).
1. Sea beach; 2 – fore dune; 3 – coastal protective dune; 4 – plain beyond coastal dune; 5 – 6 hummock;
7 – biggest dunes; 8 – at the foot of biggest dune; 9 – beach of the Curonian lagoon.

In these zones only the plants characteristic of the Curonian spit seashore have grown. On the fore dune, *Cakile baltica* Jord. Ex Pobed, *Honckenia peploides* (L) Ehrh as well as *Salsola kali* L., etc. grow in small groups. On the western slope there is a thin growth of *Leymus arenarin* (L) Hochst, *Ammophila arenaria* L., *Petasites spurius* (Retz.) Rchb. *Lathyrus maritimus* (L.) Bigelow, etc., as well *Salix daphnoides* Vill and *Rosa rugosa* Thunb, etc. vegetate. On the dune top there is an average growth of *Gypsophila paniculata* L., *Festuca arenaria* Osbeck, *Calamagrostis epigeios* (L.) Roth, *Linaria loeselii* Schweigg., *Viola littoralis* Spreng., *Tragopogon heterospermus* Schweigg., *Corynephorum canescens* (L.) P.Beauv., *Hieracium umbellatum* L., *Carex arenaria* L., *Eryngium maritimum* L., etc., as well as *Salix daphnoides* Vill., *Pinus mugo* Turra, *Juniperus communis* L., *Rosa rugosa* Thunb., *Padus avium* Mill., *Betula pendula* Roth., etc. On the eastern slope one can meet *Pinus sylvestris* L., *Pinus mugo* Turra, *Pinus banksiana* Lamb, *Pinus nigra* Arnold J.F., *Juniperus communis* L., *Picea abies* (L.) H.Karst., *Frangula alnum* Mill., *Hippophae rhamnoides* L., *Salix repens* ssp. *arenaria* (L.) Hittonen, *Alnus incana* (L.) Moenoh, *Alnus glutinosa* (L) Goertn., *Sambucus nigra* L., *Sambucus racemosa* L., *Rosa majalis* Hermm., *Rosa canina* L., *Salix caprea* L., *Sorbus aucuparia* L., *Crataegum monogyna* Jacq., *Ribes rubrum* L., *Pyrus pyraister* (L.)Burgsd., *Padus avium* Mill., *Prunus cerasifera* Ehrh., *Populus tremula* L., *Betula pendula* Roth., *Carpinus betulus* L., *Euonymus europaeus* L., *Rubus caesius* L., *Ulmus minor* Mill., *Jasione montana* L., *Artemisia campestris* L., *Carex arenaria* L. and the others.

3. Research methods

The vegetation structure and projection cover of the Curonian spit seashore protective dune by woody and grassy plants have been evaluated by means of 86 cross profiles in all elements of the relief: western slope, dune top, eastern slope. The evaluation process proceeded from the west to east direction. The first study was carried out at the foot of a western slope and the last on the eastern slope. The vegetation density of woody and grassy growth was measured

according to the projection cover. The study was launched at the beginning of summer, 1982, and completed at the end of spring 2009. During that period the vegetation was checked 13 times. All check-ups were carried out at the same places en route to the orienting points (a quarter stamp of the forest) of the location. The projection cover of woody and grassy vegetation was measured by gradation (0, 10, 20...100% of the study area). The following vegetation parameters of the coastal protective dune were taken into account:

1. Projection cover of vegetation;
2. Projection cover of woody plants;
3. Projection cover of grassy plants;
4. Species composition of woody plants;
5. Species composition of grassy plants;

4. Study results and analysis

The coastal protective dune of the Curonian spit seashore is obviously dwindling due to the natural elements and human activities – mainly economical and social. Due to the impact of the sea the western slope of the protective dune has come to a dangerous point of disappearance. Its vegetation growth encompassing grassy species has become noticeably scarcer and has reached the critical point on the top. The prevailing western winds constantly blow through different size dune corridors and through which sand is carried out. By way of these corridors the sand is freely borne onto the meadows of the plains beyond the coastal dune and the outskirts of forests. The walkers' incessant treading it in summer makes good conditions for the sea in autumn and for the winds in spring to intensively destroy the protective dune. In a few years the trampled and lodged places turn into hollows and pits of various sizes. Recreational activities of people inhibit a natural cycle of woody and grassy vegetation quite evidently. At the beginning of June 1982, when the long-term studies of woody and grassy vegetation began, its projection covers on the coastal protective dune were on the average 62%. One third of them were woody plants and two thirds - grassy plants. In 27 years the projection cover of vegetation decreased 0.4 times and at the beginning of 2009 the figure was 37%. The woody projection cover diminished only by

4%, but the grassy cover decreased by half during that period.

In the last decades the Lithuanian seashore suffered from five strong storms and one hurricane. During their boisterous work, the rise of water on the eastern sea part was sharp and the sea reached and undermined the western (windward) slope of the protective dune. The hurricane “Anatoly” should be noted in particular. It swept at the beginning of December, 1999. Then the waves carried away from

the coastal protective dune of the Curonian spit a thick layer of sand into the sea together with the growing woody and grassy vegetation. As a result, the projection cover decreased from 50% to 39%.

The eastern slope of the coastal protective dune is not directly affected by the sea and only slightly by the western winds and on an average by visitors. In 27 years the projection cover of vegetation has decreased 14% (see Fig. 3).

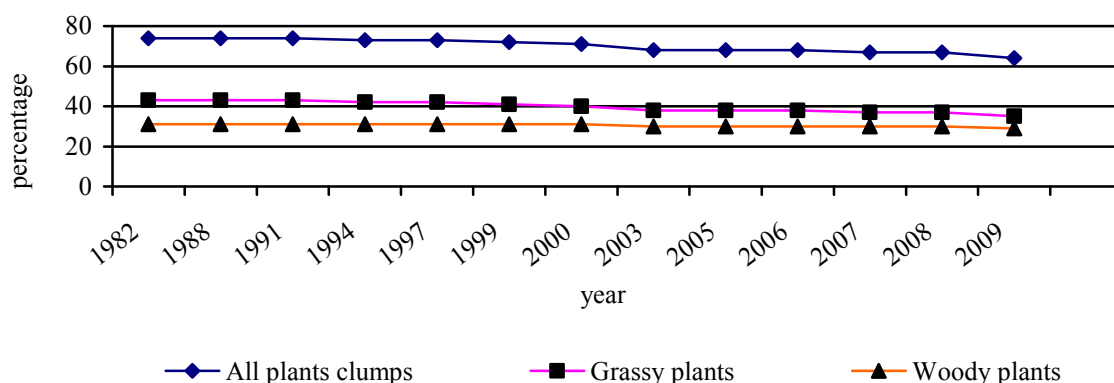


Fig. 3. Dynamics of the projection cover of vegetation of the eastern slope of the coastal dune on the Curonian spit seashore.

Dominating woody plants growing on the eastern slope of the protective dune are the *Pinus sylvestris* L., as well as *Pinus mugo* Turra, *Salix daphnoides* Vill. *Frangula alnus* Mill., *Padus avium* Mill., *Juniperus communis* L., *Picea abies* (L.) H.Karst., *Alnus incana* (L.) Moench. *Alnus glutinosa* (L.) Gaertn., *Sambucus racemosa* L., *Populus tremula* L., *Rosa canina* L., etc. It is worth mentioning that within the range of Nida beach not so rare *Pinus banksiana* Lamb., *Pinus nigra* Arnold J.F., *Hippophae rhamnoides* L., *Sambucus nigra* L., *Pyrus pyraister* (L.), Burgsd., *Prunus cerastifera* Ehrh. grow, while within Smiltynė beach on the same eastern slope of the coastal dune *Sambucus nigra* L., *Rosa majalis* Hermm., *Carpinus betulus* L., *Euonymus europaeus* L., *Ulmus minor* Mill., *Sorbus aucuparia* L., *Crataegus monogyna* Jacq., *Hippophae rhamnoides* L., *Robinia pseudoacacia* L., *Rubus idaeus* L., *Rubus caesius* L., *Carex arenaria* L., *Jasione mantona* L., *Artemisia campestris* are found.

At the beginning of the study period the projection cover of vegetation on the top of the protective dune made 71%. The grassy plants covered 54% of the surface, whereas the woody plants - 17%. In the 27 years period the projection cover of grassy plants decreased about three times, while the woody plants cover decreased up to 10%. The vegetation growth noticeably diminished on the top of the protective dune during the hurricane “Anatoly“. The projection cover of all plant clumps was reduced from 46% to 36%, while grassy vegetation was reduced from 32% to 24%. Woody plants suffered less and their cover lessened from 14% to 12% (see Fig. 4).

During the hurricane the vegetation roots and the dune sand were carried by the waves to the sea. In

addition to *Gypsophila paniculata* L., *Eryngium maritimum* L., *Lathyrus maritimus* (L.) Bigelow., *Linaria loeselii* Schoweigg., *Viola littoralis* Spreng. other grassy plants species such as *Rosa rugosa* Thunb., and *Salix daphnoides* Vill had suffered severely. While the grassy growth is diminishing it has been noticed that the reproduction of *Salix daphnoides* Vill. is increasing. Nowadays, together with the aforementioned species on the top of the protective dune one can find solitary *Pinus mugo* Turra., *Juniperus communis* L., *Frangula alnus* Mill., *Betula pendula* Roth., *Rosa rugosa* Thunb, but in Smiltynė there are several saplings of *Rhamnus cathartica* L., and *Sorbus aucuparia* L.

The western (windward) slope of the protective dune of the Curonian spit seashore suffers the greatest losses from heavy storms and hurricanes. At the beginning of the studding period the western slope of the protective dune was overgrown by woody and grassy vegetation whose projections cover reached 42%. The area covered by grassy species outstripped the woody vegetation cover five times. In the study period the grassy plants of the western slope became much thinner and its projection cover decreased twice – from 35% to 17%. The projection cover by woody plants did not undergo significant changes and remained at 5%. The projection cover of vegetation, especially grassy suffered a great deal from the hurricane “Anatoly“. Before that event the projection cover of the western slope of the protective dune made 29%, but during the heavy storm the grassy vegetation was destroyed significantly – fourfold. The projection cover of the woody plants decreased twice – from 6% to 3% (see Fig. 5).

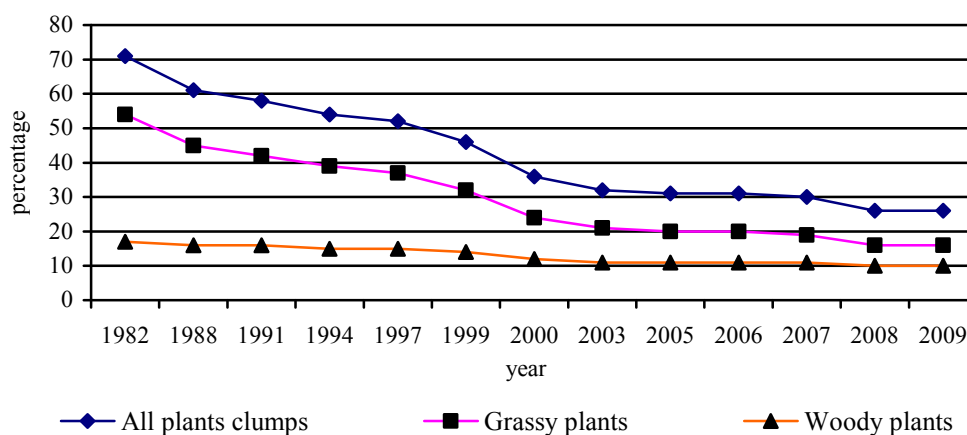


Fig. 4. Dynamics of the projection cover of vegetation of coastal dune on the Curonian spit seashore

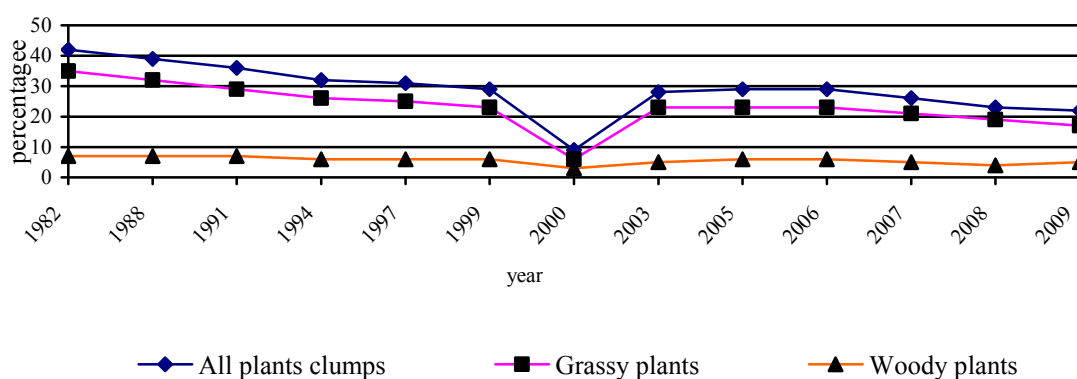


Fig. 5. Dynamics of projection cover of vegetation of the western slope of the coastal dune on the Curonian spit seashore

The growth of woody plants, primarily *Salix daphnoides* Vill., was partly recovered from live roots when in spring of 2000 the first shoots sprung up and comprised 5% of the plant cover. The grassy growth of the western slope is dominated by rootstock specific grass like *Ammophila arenaria* (L.) Link, *Leymus arenarius* L. that has an opportunity to overwhelm the area because of their specific features. More flexible among coastal woody species – *Salix daphnoides* Vill. is very vital and adapted to the extremely hard conditions dominating in the western slope of the coastal protective dune.

The invasive woody species like *Robinia pseudoacacia* L., *Hippophae rhamnoides* L., *Cerasus mahaleb* (L.) Mill., *Rosa rugosa* Thunb., etc. are fixed in the soil and grow poorly therefore there is no danger that they might oust the best dune protector – *Salix daphnoides* Vill. The other woody species met on the eastern slope and the top of the protective dune are not aggressive towards *Salix daphnoides* Vill., though they are inclined to move slowly over to the western slope. The grassy species found on the mentioned dune relief are becoming from year to year thinner or dwindle due to intensifying recreational activities and the onslaught of the woody plants species. The grassy species are suitable for curbing sand erosion despite the foot that they make a species of completion to the shoots of woody plants. The

natural self-forestation of the relief of the coastal protective dune should not be impendent. On the contrary, in certain places it should be promoted for its better projection cover.

5. Conclusion

1. The vegetation covers of woody and grassy communities of the protective dune of the Curonian spit seashore are gradually decreasing because of three negative factors: the impact of the sea, western winds and human activities.
2. Open sand on the top of the protective dune may not exceed 20% of the area, whereas on the eastern slope - 10% and on the eastern slope - 30%. The protective dune may be optimally planted by woody and grassy vegetation so that the inborn sand does not drift on to the plain beyond the dune, thus covering the meadows and recreational forests.
3. The woody species variegates the seashore landscape; their deep roots strengthen the dune sand thus impeding the erosion raised by the winds and water, improve the microclimate for visitors and make better conditions for nesting birds.

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Dr.T.Sc. Algimantas M. Olšauskas – prof. at the Department of Recreational and Landscape Architecture., Klaipėda University.
Main research areas: anthropogenic influence of the vegetation in Lithuanian seaside (protective dune, fore dune).
Address: Klaipeda University, H. Manto str. 84, LT – 92294, Klaipeda, Lithuania.
Tel.: +370–63–98830
Fax.: +370-63-98835
E-mail: rpc.gmmf@ku.lt

Sumedėjusios ir žolinės augalijos plėtojimosi aspektai skirtinguose Kuršių Nerijos pajūrio kraštovaizdžio elementuose

Algimantas Olšauskas

Klaipėdos universitetas

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Sumedėjusios ir žolinės augalų rūšys yra išikūrusios Kuršių Nerijos pakrančių smėlynuose ir dykynėse. Vienos iš jų pamėgo drėgnus ar druskingus dirvožemius, kitos – nederlingą ir sausą smėlį.

Tyrimų tikslas – išanalizuoti pajūrio kraštovaizdžio plėtojimosi raidą skirtingomis reljefo elementų sąlygomis, rasti sąsajas tarp sumedėjusių ir žolinių augalų rūšių, numatyti kraštovaizdžio plėtojimosi ateities tendencijas.

Dėl blogėjančių aplinkos sąlygų Kuršių Nerijoje – klimato kaitos, vandens lygio jūroje kilimo, dažnų audrų ar net uraganų, žmogaus ūkinės veiklos – retėja sumedėjusi ir žolinė augalija, mažėja jos projekcinis padengimas, didėja vėjo erozijos ir bangų abrazijos rizika. Dėl viso šito sparčiai nyksta žmogaus rankų sukurtas pajūrio apsauginių smėlio kopų kraštovaizdis.

Nustatyta, kad ten, kur intensyvūs poilsiautojų srautai, sparčiai nyksta augalija, pastebimai formuojasi takų tinklas, o dėl šios priežasties susidaro geros sąlygos rudeniniams ir pavasariniam vėjams ardyti pajūrio kopas. Išminti iki podirvio takai per kelis metus tampa 2–3 metų pločio smėlio pernašos koridoriais, o poilsiautojų ištryptos ir išgulėtos kopų vietos – 4–5 metrų skersmens lomomis ir duburiais. Jiems susijungus susidaro įvairaus dydžio defliacinės daubos. Vyraujančių vakarų krypties vėjų pernešamas smėlis nuolat užpila užkopės lygumos pievas ir rekreacinius miškų pakraščius.

Statistinė sumedėjusios ir žolinės augalijos projekcinio padengimo ir rūšinės sudėties analizė rodo, kad per pastaruosius 27 metus (nuo 1982 m.) sąlygos, kad išliktų augalija Kuršių Nerijos pajūrio apsauginėje kopoje, metai iš metų blogėja.