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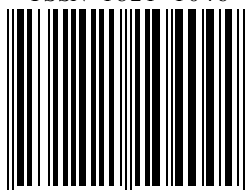
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ADAPTATION OF FOREST ECOSYSTEMS ON NEGATIVE CLIMATE CHANGE IMPACTS IN SERBIA

Ljiljana BRASANAC-BOSANAC¹, Tatjana CIRKOVIC-MITROVIC¹,
Nevena CULE¹

Abstract: *The environmental pollution causes many ecological problems, climate changes and global warming, with adverse effect on forest ecosystems in the whole world, and Serbia also. Global warming and the potential changes of temperature and humidity, point out to a very wide range of the effects, both on the forest system in general and on the individual trees. Since the effects of global warming can be so intense in some regions that they can cause the changes in the forest productivity in composition of the plant and animal species in them, the forest cover would become unsustainable. Such reactions to the climate change would lead to numerous consequences and adverse effects on the preservation of biodiversity and water integrity, environmental protection, protection of the natural areas from erosion, as well as on the commercial forestry, wood processing industry, tourism, recreation, etc. This paper analyzes a significance, problems and challenges in forest ecosystems in Serbia caused by climate change and the impacts of the climate change on the forests and forest management. In order to predict new changes and adaptability of the forest ecosystems, it is necessary to initiate scientific researches, modernize forest policies, and apply more adaptive forest management practices in Serbia.*

Key words: The impact of climate change /Forest ecosystems /Adaptive measures /Sustainability.

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ADAPTACIJA ŠUMSKIH EKOSISTEMA NA NEGATIVAN UTICAJ KLIMATSKIH PROMENA U SRBIJI

Izvod: *Zagađivanje životne sredine dovodi do brojnih ekoloških problema, klimatskih promena i globalnog zagrevanja, koji negativno utiču na šumske ekosisteme u celom svetu, pa i u Srbiji. Globalno zagrevanje i potencijalne promene temperature i vlažnosti ukazuju na vrlo širok spektar efekata kako na šumske ekosisteme u celini tako i na pojedinačna stabla. Efekti globalnog zagrevanja mogli bi da budu toliko jaki u pojedinim regionima da bi došlo do promena produktivnosti šuma i sastava biljnih i životinjskih zajednica u njima, pa održavanje šumskog pokrivača ne bi bilo moguće. Ovakve reakcije na promenu klimatskih prilika uslovile bi niz posledica i negativnih uticaja na očuvanje biodiverziteta i integriteta voda, zaštitu životne sredine, zaštitu prirodnih predela i zemljišta od erozije, zatim na komercijalno šumarstvo, drvnu industriju, turizam, rekreaciju i drugo. U radu će se analizirati značaj, problemi i izazovi sa kojima se suočavaju šumski ekosistemi u Srbiji usled klimatskih promena, kao i posledice uticaja promene klime na šume i gazdovanje šumama. U cilju predviđanja novonastalih promena i prilagođavanja šumskih ekosistema neophodno je započeti nova naučna istraživanja, inovirati šumarsku politiku i primenjivati adaptivnu praksu gazdovanja šumama u Srbiji.*

Ključne reči: *Šumski ekosistemi /Klimatske promene /Adaptivne mere /Održivost.*

1. INTRODUCTION

It has been foreseen that the global temperature in the World increase from 1.1°C to 6.4°C and humidity increase from 7.1% to 15.8% in 21st century will lead to serious and rapid changes in forest ecosystems [1-3].

Based on the analysis of the air temperature trend in Serbia over the period 1950-2008 it can be concluded that the trend of increase of mean air temperature (by about 1.2 °C in the twentieth century) is present in the greatest part of the territory, except in southeast Serbia, where the trend of the decrease of mean air temperature was reported. In Serbia over the period 1950-2008, the greatest reduction in annual precipitation (120 mm) was recorded in Negotinska Krajina, whereas in Vojvodina the decrease in the rainfall was considerably smaller. It is expected that these trends of climate change in Serbia will continue in the future, which will significantly alter the structure and function of forest ecosystems, thereby imposing the need for the change of the previous forest management.

This paper is aimed at pointing out to the possible conditions of the forest ecosystems in Serbia due to global warming and the type of actions which can be taken, based on the study of the trend of the changes of air temperatures in Serbia.

2. MATERIALS AND METHODS

The multi-decade data obtained by the systematic meteorological measurements are the only way in which the valid assessment of the current condition and the comparison of it with the previous periods can be made. In order to analyze the climate characteristics and climate change in Serbia, the arithmetic means of the numerous available data related to time and area are used.

Based on the data provided by the Republic Hydrometeorological Service of Serbia, the thermal conditions in Serbia in period 1950-2008. were assessed by using the normalized deviations from the annual air temperatures. The deviations were determined based on the climate standards over the period 1961-1990. The period was analyzed as a whole.

The normalized deviations, which point how many standard deviations the individual value is above or below the normal level, are used for the presentation of the deviation from the normal level.

The analytical method, which implied the use of the results of the previous researches on the climate parameters, their change and effects on the condition of forest ecosystems in Serbia, was applied. The data provided by the Republic Hydrometeorological Service of Serbia, Public Enterprise „Srbijasume”, The Ministry of Agriculture, Forestry and Water Management - Forest Directorate, Republic Agency for Spatial Planning, Spatial Development Strategy of Serbia from 2009 to 2020, Spatial Plan of the Republic of Serbia until 2020, as well as the suitable scientific papers, studies, projects and monographs dealing with this problem, were analyzed and processed.

The proposed measures are based on the previous works and experiences that have proved effective.

3. THE CLIMATE CHARACTERISTICS AND CLIMATE CHANGE IN SERBIA

It is known that the occurrence and survival of vegetation in certain area, its distribution and altitudinal differentiation, along with the other ecological conditions, to a great extent also depends on the climate characteristics of the area. The numerous researches point out to this fact: Kolic [4,5], Jovanovic and Kolic [6], Krstic [7], Krstic et al. [8], Smailagic et al. [9], Krstic and Cirkovic [10] etc.

According to Rakicevic [11], three climate regions are singled out in Serbia: continental, moderate-continental and alternated continental. The greatest part of Central Serbia is characterized by the moderate-continental climate.

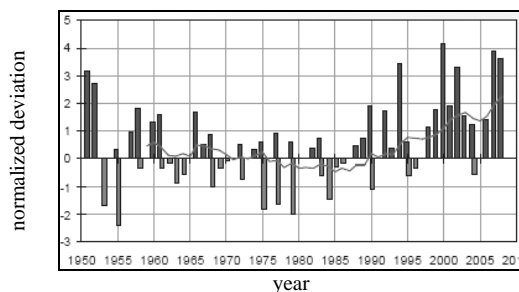
Over the period 1950-2008 the following climate parameters were reported in Serbia:

- trend of the increase of the mean annual air temperature (about 1.2 °C in the 20th century) in most parts of the territory, except for southeast Serbia, where the less negative trend of air temperature was reported;
- decrease of the annual amount of precipitation (the highest decrease – about 120 mm was reported in Negotinska Krajina);
- occurrence of the extreme precipitation,
- increase of soil erodibility,
- deterioration of the physical soil characteristics,
- decrease of the protective role of vegetation cover
- less favourable conditions for natural and artificial regeneration of mainly forest vegetation.

The scenario of partial application of measures aimed at decrease of emission of greenhouse gases (*A1B*, *SRES/IPCC*) implies that the mean air temperature in Serbia would increase by 3-4°C compared to the reference period

1961-1990, and the amount of precipitation would decrease by about 12% per a year, compared to the reference period, i.e. by about 24% in summer. However, if no measures are taken (Scenario A2, SRES/IPCC), considerably higher increase of air temperature is anticipated, particularly in summer (by 4-5 °C), as well as the greater decrease of precipitation, which would be equal to -30%, particularly in spring.

The normalized deviation of mean annual air temperature in Serbia over the period 1951-2008 is presented on the Graph 1.



Graph 1. *The normalized deviations, with ten-year average relative variability over the period 1950-2008 (data from RHMS of Serbia)*

The normalized deviation of the mean annual air temperature in 2008 is positive and higher than 3, which points out to the fact that it was extreme warmer than the normal value. It is visible that from 1998 to 2008 each year was warmer than the average (except for 2004-2005), so based on the results it can be concluded that in the Republic of Serbia the trend of increase of mean air temperatures will continue.

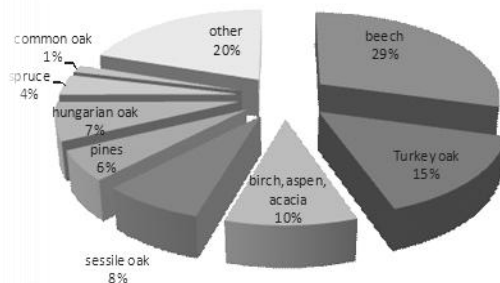
4. FOREST AREAS AND PERCENT OF SOME TREE SPECIES IN SERBIA

Serbia is considered to be a medium forested country. Forests account for 29.1% of the total area of Serbia (7.1% in Vojvodina, 37.6% in central Serbia). The other forest land, which by the international definition also includes bushes and scrubs, accounts for 4.9% of the territory, which in total accounts for 34.0% or 36.3% of the productive soil of Serbia [12].

Table 1. *The structure of areas (the way of use) by type of land in Serbia [12]*

Type of land	Area	
	ha	%
Forest	2,252,400.0	29.1
Other forest land	382,400.0	4.9
Unfertile soil	92,000.0	1.2
Agricultural land	3,594,800.0	46.4
Meadows and pastures	1,029,600.0	13.3
Urban land	312,000.0	4.0
Water areas	85,200.0	1.1
TOTAL AREA	7,748,400.0	100.0

By Bankovic et al. [12], 40 broadleaf and 9 conifer tree species were reported, as well as the uneven presence of the reported tree species in the total growing stock.



Graph 2. *The percent of some tree species in the total forest area in Serbia*

The beech is dominant, since it accounts for 29.0% of the total area, for 40.5% of the total volume, and it accounts for 30.6% of the total volume increment, the second dominant species is Turkey oak, which accounts for 15.0% of the total area, for 13.0% of the total volume, and for 11.4% of the volume increment. The most dominant conifer trees are Scots and Austrian pine, accounting for 6.0% of the total area. The pines account for 4.5% of the total volume, and 9.8% of the volume increment. Spruce accounts for 4.0% of the total forest areas, for 5.2% of the volume and for 6.7% of the volume increment.

In the forests of the primary natural origin, the beech, which accounts for 56.5% of the total area, is the most dominant species, whereas the percent of other categories ranges from 0.7% (ash and maple forests) to 8.7% (spruce forests). In coppice forests of Serbia, the most dominant category of forest are the Turkey oak forests, accounting for 22.4%, beech forests, accounting for 21.3%, black locust forests (aspen and birch forests), accounting for 13.5%, Hungarian oak forests, accounting for 9.7%, sessile oak forests, accounting for 8.8%, and hornbeam oak forests, accounting for 7.8% of the total forest area.

The beech, as the most dominant broadleaf species in Serbia, is a mesothermal species, well-adapted to the moderate temperatures, quantities of moisture, and shady conditions (sciophytes). In contrast to the beech, most oaks in Serbia are xerothermic (they grow at dry and warm sites) and light-loving species (heliophytes). Regarding conifers, pines are light-loving species, adaptable to the ecological condition of temperature, moisture and soil. The spruce and fir are sciophilic, i.e. shade-loving species.

Based on the calculations and analysis, it can be concluded that the Serbian forests are characterized by the relatively high potential carbon-dioxide absorption from the atmosphere and thereby they significantly contribute to the alleviation of the adverse effects of the climate change. Based on the preliminary calculation, there are around 120,237.000 tonnes of carbon-dioxide in the Serbian forests, and around 5,000.000 tonnes of CO₂ is absorbed annually (NFI). Given the flexible mechanisms of Kyoto Protocol, above all the Emissions Trading, it is clear that this potential is important, particularly when the fact that the price of tonne of CO₂ continuously increases at the world market is taken into account. Since the price

per ton of CO₂ is around 29 Euros, in the financial sense, it is easy to demonstrate the importance of forests regarding the absorption of CO₂ from the atmosphere in this way.

5. ADAPTIVE MEASURES OF FOREST MANAGEMENT

Environmental pollution leads to numerous ecological problems, climate changes and global warming, creating negative impact on forest ecosystems: rapid deforestation and forest degradation, biodiversity loss, occupation of habitats by allochthonous species, change in pollination system, change in plant dispersion and regeneration, change in forest growth and ecosystem biomass, change in relation between species/habitat, change in ecosystem nitrogen cycle, increased mortality due to climatic stress and reduced forest ecosystem vitality and health due to cumulative impact of different stresses [13].

Roberts et al. [14] provide survey of current forest management trends which are promoting forest and forestry adaptation to new climate changes. The proposed management measures are mainly oriented to creation of stable, resistant to negative climate changes, forests. The management model which aims at preserving forests in their most natural form, avoiding mono-cultures and creating mixed forests, both in the structure of species and age, is supported. Furthermore, it aims at maintaining natural or nature appropriate regeneration, as methods of maintaining genetic diversity, and consequently, forest ecosystems sensitivity reduction.

There is a large number of potential methods, related to resolving issues that have arisen in forestry owing to global climate change and forest adaptation to new environmental conditions [15-27].

Surveys of potential strategic and operational methods of adaptation, which can be implemented as adaptive measures of forest management are:

- strictly comply with legal provisions concerning prevention of unlimited and unrestrained wood felling;
- protect climate refugia by different measures;
- minimise habitat fragmentation and maintain connectivity;
- protect high forests;
- strategically increase the size and number of protected areas, particularly in exceptionally valuable habitats;
- protect most endangered ex-situ species;
- create artificial forest reservations or arboreta for the purpose of rare species preservation;
- improve regional co-operation concerning species management and protection;
- support changes in distribution of endangered and sensitive species by means of their introduction to new areas;
- in artificially planted woods and mixed cultures, encourage natural genetic diversity, imitate the structure of neighbouring forests and avoid direct substitute of natural ecosystem;
- maintain seed sources (seed banks and seed facilities);
- allow forest regeneration through natural succession after large disturbances wherever possible;

- plant and sow genotypes resistant to draught and other climate extremes, insects and diseases;
- increase genetic diversity of trees used in setting up plantations;
- reduce stress factors not linked to climate conditions, in particular air pollution, in order to increase ecosystem ability to respond to climate change;
- re-cultivate degraded area in order to preserve genetic diversity and improve ecosystem health;
- carry out monitoring of all forests by means of establishing and improving national, regional and operational network for monitoring forest health condition, and subsequently, diagnostic – forecast services, as well as services for invasive species distribution monitoring;
- actively implement control measures against pests and diseases;
- improve plantation stability by means of increasing species and structure diversity;
- increase use of commercial thinning in draught areas in order to increase tolerance of remaining trees and to introduce species tolerant of draught, where possible;
- increase people's awareness in regard to potential impact of climate changes on fire regime and promote proactive actions in regard to fuel management and community protection.
- include climate parameters in forest growth and production models;
- apply thinning or selective removal of suppressed, damaged trees of poor quality;
- adapt the time of annual wood felling in such a way that forest processes remain in a state of most possible balance.

It is certain that implementation of number of measures aiming at adapting forests to climatic changes conveys a degree of uncertainty. Essentially, adaptive forest management can be understood as a systematic process aiming at constant improving of management policy and practice itself by monitoring, and later, learning by means of analyses of operative programmes results [28].

6. CONCLUSION

Given the fact that the previous global warming of the atmosphere equal to about 1°C caused the significant global, regional and global climate change, and taking into account the anticipations and effects of climate change, it can be concluded that Serbia is one of the world regions which are very susceptible to the climate change.

The above climate parameters point out to the increased risk of the desiccation of forest plantations and natural forest occupying great areas. Given the possible irreversible processes in the climate system with the immeasurable consequences to the living world, it is necessary to take the preventive measures aimed at alleviation of the effects of the climate change and adaptation to the altered climate conditions. All activities regarding the monitoring and studying of the climate change and its influence should be designed in order to provide the long-term systematic, comprehensive and continuous monitoring and forecasting of the conditions of the local and regional climate. The suitable anticipations of the

climate change and update of the database will point out to the needs and application of the sector strategies and action plans for the adaptation and measures aimed at alleviation.

The fact that the climate change occurs much more rapidly than it was anticipated has pointed out to the need to incorporate the problems regarding the adverse climate change on the natural resources in the priorities of the National Strategy of Scientific and Technological Development of Serbia. It is needed to conduct the continuous researches and monitor the influence of the climate change on the vertical and horizontal zoning of vegetation, alternations in the current forest ecosystems and effects of this change during the establishment of new forests.

The previous activities aimed at reforestation, tending and regeneration of forest ecosystems were based on the climate parameters from the previous multi-annual period and did not take into account the recent climate change which was reported in Serbia as well.

The complexity of forest ecosystems and numerous ways in which the society use and misuse them, as well as the fact that the forest ecosystems in Serbia are endangered by different factors, requires the application of the range of different protective measures. These measures, above all, include the suitable normative-legal and organizational-institutional mechanisms, suitable standards and practice in the domains of forestry. By integrating all these measures it is possible to achieve the higher degree of the environmental protection and sustainable forest management, even under the altered climate conditions, which are the results of the global warming.

The concept of the spatial development of the Republic, aimed at the alleviation of the effects of global warming and climate change on the forest ecosystems in Serbia, should include the determination of the effects of climate change on the availability of the natural resources, above all forest ecosystems and biodiversity aimed at planning sustainable development and ecologically acceptable activities in the domains susceptible to the climate change. It implies the adoption and application of new measures aimed at preservation and protection of forest land in accord with international conventions, national plans and sector strategies, as well as legal regulations from the domain of spatial planning.

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REFERENCES

- Andrasko, K. (1990): *Global warming and forests: An overview of current knowledge*. UnASYLVA - No. 163 - Forestry and environment, Vol. 41 - 1990/4, 3-11.
- Botkin, D.B., R.A. Nisbet, L.G. Simpson (1992) *Forests and Global Climate Change*. In: S.K. Majumdar, L.S. Kalkstein, B.M. Yarnal, E.W. Miller, and L.M. Rosenfeld (eds.),

- Global Climate Change: Implications, Challenges and Mitigation Measures, Philadelphia, Pennsylvania Academy of Sciences, Chapter 19, 274- 290.
- Biringer, J. (2003) *Forest ecosystems threatened by climate change: promoting long-term forest resilience*. In: Hansen, L.J., Biringer, J., Hoffman, J.R. (eds.), *Buying time: A user's manual for building resistance and resilience to climate change in natural systems*. World Wide Fund for Nature, 43–71.
- Kolic, B. (1975) *The relation of the beech-fir forests and climate factors in Serbia*. *Ecology*, Vol. 10, No. 2, Belgrade, 155-164.
- Kolic, B. (1988) *Forest ecoclimatology*, Class book, Faculty of Forestry, Scientific Book, Belgrade, 1-397.
- Jovanovic, B, Kolic, B. (1980) *Climate-vegetation (oroclimatogenic) regionalization of Suva mountain*, Bulletin of the Faculty of Forestry - University of Belgrade, No. 54, Belgrade, 19-62.
- Krstic, M. (1998) *Climatic characteristics of the sessile forest belt (Quercetum montanum serbicum Cer et Jov.) on Stara mountain*, Jubilee Scientific Conference: 70 Anniversary of the Forest Research Institute of the Bulgarian Academy of Sciences, Proceedings, Sofia, 76-79.
- Krstic, M., Smailagic, J., Nikolic, J. (2001) *Climatic characteristics of the Sessile oak forests (Quercetum montanum serbicum Cer et Jov.) belt in Serbia*. 3rd Balcan Scientific Conference „Study, conservation and utilisation of the forest resources“, Proceedings, Sofia, 200-209.
- Smailagic, J., Krstic, M., Cvjeticanin, R. (2002) *Climate and vegetation characteristics of the mountain Deli Jovan in East Serbia*. 18th International Conference on Carpatian Meteorology, Proceedings (printed as CD version), Belgrade.
- Krstic, M., Cirkovic, T. (2005) *Climate-vegetation characteristics of Cemernik region*, Conference „8th Symposium on Flora of Southeast Serbia and Neighbouring Regions“, Proceedings, Nis, 195-200.
- Rakicevic, T. (1980) *Climate zoning of Republic of Serbia*, Proceedings of Institute of Geography, University of Belgrade, Belgrade, Vol. 27, 29-42.
- Bankovic, S., Medarevic, M., Pantic, D., Petrovic, N. (2009) *National Inventory of Forests of the Republic of Serbia, Growing Stock of the Republic of Serbia*. Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia – Forest Directorate, Belgrade, 43-91.
- Innes, J., Joyce, L.A., Kellomaki, S., Louman, B., Ogden, A., Parrotta, J. and Thompson, I. (2009): *Management for Adaptation*. In: Risto Seppälä, Alexander Buck and Pia Katila. (eds.). *Adaptation of Forests and People to Climate Change - A Global Assessment Report*. IUFRO World Series Volume 22. Helsinki. 153-185.
- Roberts, G., Parrotta, J. and Wreford, A. (2009): *Current Adaptation Measures and Policies*. In: Risto Seppälä, Alexander Buck and Pia Katila. (eds.). *Adaptation of Forests and People to Climate Change - A Global Assessment Report*. IUFRO World Series Volume 22. Helsinki. 123-133.
- Ogden, A.E. and Innes, J.L. (2007): *Incorporating climate change adaptation considerations into forest management planning in the boreal forest*. *International Forestry Review* 9, 713–733.

- Aragao, L.E.O.C., Malhi, Y., Barbier, N., Lima, A., Shimabukuro, Y., Anderson, L. & Saatchi, S. (2008): *Interactions between rainfall, deforestation and fires during recent years in the Brazilian Amazonia*. Philosophical Transactions of the Royal Society of London Series B Biological Sciences 363, 1779–1785.
- Barlow, J. & Peres, C.A. (2008): *Fire-mediated dieback and compositional cascade in an Amazonian forest*. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 363, 1787–1794.
- Betts, R.A., Malhi, Y. & Roberts, J.T. (2008): *The future of the Amazon: new perspectives from climate, ecosystem and social sciences*. Philosophical Transactions of the Royal Society of London Series B, Biological Sciences 363, 1729–1735.
- Biringer, J. (2003): *Forest ecosystems threatened by climate change: promoting long-term forest resilience*. In: Hansen, L.J., Biringer, J. and Hoffman, J.R. (eds.), *Buying time: A user's manual for building resistance and resilience to climate change in natural systems*. World Wide Fund for Nature, 43–71.
- Carey, A.B. (2003): *Restoration of landscape function: reserves or active management* Forestry 76, 221–230.
- Drever, C.R., Peterson, G., Messier, C., Bergeron, Y. & Flannigan, M. (2006): *Can forest management based on natural disturbances maintain ecological resilience?* Canadian Journal of Forest Research 36, 2285–2299.
- Schroeder, L.M. (2007): *Escape in space from enemies: a comparison between stands with and without enhanced densities of the spruce bark beetle*. Agricultural and Forest Entomology 9, 85–91.
- Koski, V. and Rousi, M. (2005): *A review of the promises and constraints of breeding silver birch (Betula pendula Roth) in Finland*. Forestry 78, 187–198.
- Gitay, H., Brown, S., Easterling, W. & Jallow, B. (2001): *Ecosystems and their goods and services*. In: McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. & White, K.S. (eds.). *Climate change 2001: Impacts, adaptation, and vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, Chapter 5, 235-247.
- Spittlehouse, D.L. and Stewart, R.B. (2003): *Adaptation to climate change in forest management*. BC Journal of Ecosystems and Management, Volume 4, Number 1, 1-11.
- Ogden, A.E. (2007): *Forest management in a changing climate: building the environmental information base for southwest Yukon*. Forestry Chronicle Volume 83, Number 6, 806–809.
- IPCC (2000): *Land Use, Land-Use Change and Forestry*. Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N.H., Verardo, D.J. and Dokken, D.J. (eds.). Cambridge University Press, UK., 375.
- Innes, J., Joyce, L.A., Kellomaki, S., Louman, B., Ogden, A., Parrotta, J. and Thompson, I. (2009): *Management for Adaptation*. In: Risto Seppälä, Alexander Buck and Pia Katila. (eds.). *Adaptation of Forests and People to Climate Change - A Global Assessment Report*. IUFRO World Series Volume 22. Helsinki. 153-185.

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