Douglas-fir (*Pseudotsuga menziesii*) stands and its herb layer in a Czech commercial forests

***Jiří Viewegh[1], Antonín Martiník[2], Karel Matějka[3], Vilém Podrázský[4]**
[1]Štěpánovice 52, CZ-666 02 p. Předklášteří, Czech Republic
[2]Mendel University in Brno, Faculty of Forestry and Wood Technology, Zemědělská 1, CZ-613 00 Brno, Czech Republic
[3]IDS, Na Komořsku 2175/2a, CZ-143 00 Praha 4 – Komořany, Czech Republic
[4]Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Kamýcká 1176, CZ-165 21 Praha 6 – Suchdol, Czech Republic
*Corresponding author: viewegh-jiri@seznam.cz

Received date:09.05.2014

Abstract

Influence of allochtonous stands introduced Douglas-fir (*Pseudotsuga menziesii*) on understory vegetation was studied on 44 plots in Czechia territory. Stands had to be 60 years old at least. Norway spruce (*Picea abies*), European beech (*Fagus sylvatica*), oaks – Sessile and Pedunculate (*Quercus petraea* and *Q. robur*) and other commercial tree species (*Tilia cordata*, *Acer pseudoplatanus*, *Pinus sylvestris* and *Larix deciduas*) stands were chosen to compare. Compared stands had always the same habitat conditions as Douglas-fir plot.

Results have shown that Douglas-fir stands have not unambiguous characteristic species of the herb layer, but they show higher increase of nitrophilous species.

Key words: Douglas-fir (*Pseudotsuga menziesii*), herb layer

Introduction

Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) is the one of the most forestry commercially used tree species in the world. Its natural distribution covers a wide of the western North America, where it is often planted. This tree species is often introduced in European forests e.g. in France, Germany, but also in New Zealand and Argentina. Douglas-fir grows in different stand conditions making productive and stabile stands (Larson 2010). It became the most used planted tree species in France during the second half of the 20th century. About 5 millions of the seedlings were planted annually there and stands area cover exceeded 400 thousands hectares (Ferron and Douglas 2010). Similar situation is in the other western European countries as Germany, Denmark, Great Britain or Ireland. In Czechia, Douglas-fir grows on area about 5,600 ha only (i.e. 0.22% of the forest cover) (Kouba and Zahradník 2011), but according to high potential of that tree species, it can cover larger area (Podrázský and Remeš 2010, Remeš et al. 2011). From the production point of view, it is tree species on which is necessary to pay more attention and appropriate use its potential respectively (Kantor et al. 2001a-b & 2010, Martiník 2003, Martiník and Kantor 2007, Kantor 2008, Kantor and Mareš 2009, Podrázský et al. 2009, Urban et al. 2009, Remeš et al. 2011). Moreover, Douglas-fir should be more appreciated tree species on forest soils due to its resistance to drought (Urban et al. 2009 & 2010, Eilmann and Rigling 2010) and to the current trends of climate change (Podrázský et al. 2002 & 2009, Podrázská and Remeš 2008, Menšík et al. 2009). This is due to the fact, that in Czechia native Norway spruce is also silvicultured on allochtonous stand conditions, on lower altitudes especially. Although geographically alien species, Douglas-fir could be good alternative on such localities, provided that it is demonstrated, that it is able to co-exist in the ecosystem of the original species communities, corresponding to potential vegetation. However, in Douglas-fir silviculture, as an introduced species, environmental risks are still not fully recognized and cannot be ruled out. These risks are mostly specific to each habitat (Sergent et al. 2010). As an example, pure Douglas-fir stands can provide significant potential for nitrification (Zeller et al. 2010), which corresponds to the growth of this species with a red alder (*Alnus rubra* Bong.) in natural habitats in case of a significant disturbance of the ecosystem, especially in connection with fires (Binkley 1986). The influence of Douglas-fir on plant and animal communities is also noticeable, i.e. on diversity and function of the other forest community components. The aim of this research is to show the first results of the Douglas-fir communities' effects on herb layer vegetation in a wider range of research areas in different climatic and soil conditions of the Czech Republic.

Methods

Data were collected in stands situated at different parts in Czechia – at central and southern Bohemia (denoted: Kostelec nad Černými lesy – Ko; Písek – Pi), northern and southern Moravia (Hranice na Moravě – Hr; Křtiny – Kr). Stands of Norway spruce and other trees species (European beech, small-leaved linden, Sessile oak and Pedunculate oak) have been located in parallel to each test stand of Douglas-fir research areas, in cases where Norway spruce stand have not been near. Stands in at least third age class have been chosen, to examine the effect of impacts on the herb layer. Stands of Douglas-fir and these comparable have had to be situated on similar habitats, ie. similar altitude, exposure, slope, soil type and belong to the same (typological) classification unit (Viewegh 2003, Viewegh et al. 2003). Phytosociological relevés have been made on the plots, which then have been put to DBreleve (Matějka 2009) database.

Then herb layer abundance has been transformed so as the sum of all herb layer species has been equal to all herb layer abundance. DBreleve package (Matějka 2009) has been used to calculate indices elucidating stands heterogeneity (Magurran 2004) – ie. number of species (S), Shannon-Wiener diversity index (H') and equitability index (e). Classification of the phytosociological relevés has been made on herb layer data by Ward (1963) method. Ordination Canonical Correlation Analysis (CCA) has been made by CANOCO package (Ter Braak and Šmilauer 2002). Presence of *Picea abies* and *Pseudotsuga menziesii* in tree layer has been use as the explaining parameters. Significance of the canonical axes has been tested by Monte-Carlo permutation test. Phytosociological relevés have been divided into groups according to the abundance of the tree layer species:

DG – *Pseudotsuga menziesii* abundance ≥ 50% (15 relevés)

SM – *Picea abies* abundance ≥ 50% (11 relevés)

(dg) – *Pseudotsuga menziesii* < 50 % (4 relevés)

(sm) – *Picea abies* < 50 % (4 relevés)

o – relevés on localities with the dominancy of other tree species (10 relevés)

Taxonomical nomenclature has been made according to Kubát (2002).

Results and discussion

Numerical classification of the phytosociologal relevés (Figure 1) has shown a high data heterogeneity, which could be result of the influence of habitats, forest management and regional differences. Any group of phytocoenoses characterizing some of above mentioned tree layer group is not possible to identify on the sourced data. Not so big amount of the older Douglas-fir stands with an enough fully developed herb layer in the Czechia forests is the main problem to assess it influence on it. Douglas-fir is often as an admixture here. So, there is too hard to find higher (and more representative) data set. From the silviculture point of view, it is the right rule. However, this fact makes difficulties to assess some aspects of its silviculture (Matějka and Viewegh 2010).

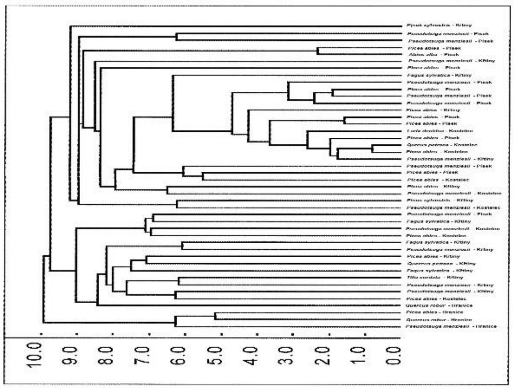

Figure 1. Classification of phytosociological relevés according to herb layer species composition

Ordination analysis, which uses Douglas-fir and Norway spruce in a tree layer as a factors presence, gives statistically significant results (error probability p = 0.002), however first two ordination axes explain 8% of data variance only. The first ordination axis CCA shows stands with the Norway spruce dominance in tree layer (Figure 2).

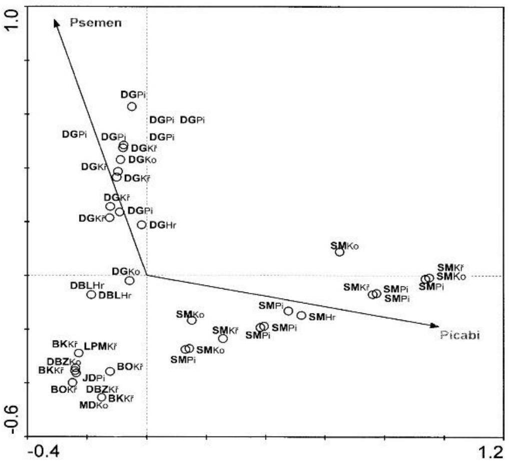

Figure 2: Sample plot position in ordination by CCA with marking of two observed factor direction – dominances of *Picea abies* (Picabi) and *Pseudotsuga menziesii* (Psemen) in tree layer

The highest values of the ordination scores along the first axis are reached eg. by species *Nardus stricta, Avenella flexuosa, Calluna vulgaris, Carex pilulifera, Luzula luzuloides, Calamagrostis arundinacea, Hieracium murorum* and *Molinia arundinacea* (Figure 3), which are typical for communities with a Norway spruce in tree layer. As it is shown, they belong to acidophilous localities, despite the fact that plots of Moravian localities (plots Kř and Hr) are on nutrient rich soils. Similarly it is possible to determine species with the high score values along the second ordination (CCA) axes, which belong to stands with dominating Douglas-fir in tree layer, e.g.: *Viola reichenbachiana, Geum urbanum, Rubus fruticosus* agg., *Paris quadrifolia, Rubus idaeus, Stachys sylvatica, Tilia cordata, Bromus benekenii, Rosa dumetorum, Sambucus nigra, Galeopsis tertrahit, Astragalus glycyphyllos, Festuca gigantea, Urtica dioica, Circaea lutetiana* etc. (Figure 4). These species are typical for nutrient rich habitats, especially by nitrates.

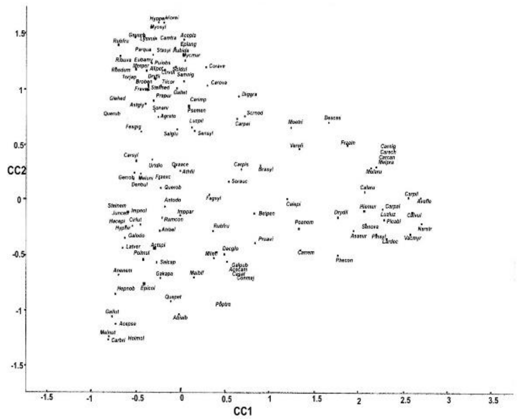

Figure 3: Herb layer species position in the first two axes of CCA ordination. Species abbreviations are in Appendix.

Differences in species richness, diversity and equitability between tested groups of plots according to tree species dominance (Tab. 1) are not statistically significant (tested by one-factor variation analysis):

Species richness (S) : $F_{4, 39} = 1.66$, p = 0.18
Species diversity (H') : $F_{4, 39} = 0.60$, p = 0.67
Species equitability (e): $F_{4, 39} = 0.32$, p = 0.86

A possible small indication of influence could be shown in herb species richness, which is a little bit higher in Douglas-fir stands.

Table 1. Species richness, diversity and equitability in individual groups of plots

group of plots	N	number of species (S)		species diversity (H')		species equitability (e)	
		average	standard deviation	average	standard deviation	average	standard deviation
o	10	12,6	1,5	1,89	0,21	0,51	0,05
(dg)	4	17,3	2,4	1,86	0,34	0,47	0,08
DG	15	16,6	1,3	2,1	0,17	0,52	0,04
(sm)	4	12	2,4	1,64	0,34	0,53	0,08
SM	11	14	1,5	1,75	0,2	0,46	0,05

DG – dominance of *Pseudotsuga menziesii* ≥ 50 %
SM – dominance of *Picea abies* ≥ 50 %
(dg) – dominance of *Pseudotsuga menziesii* < 50 %
(sm) – dominance of *Picea abies* < 50 %

o – relevés with dominace of other tree species (see text above)

Conclusion
Data set is not so much extend, but it is big enough to show the way of the next research. It is possible to say with a high probability that as Norway spruce makes top soil acidification, which results to herb layer change, so Douglas fir also apparently influences dynamics of some carrying capacity elements, which is shaped by quite different ground floor vegetation cover. This cover shows heminitrophilous and nitrophilous species even on nutrient poor parent material. Since Douglas-fir occurs lower sensitivity to drought, it is better species from the point of practical silviculture. It could change Norway spruce in a lower vegetation zones (e.g lowlands, lower and higher hills), where they both are allochtonous there. Moreover, Douglas-fir is also known by the higher production then Norway spruce (Kouba and Zahradník 2011).

Appendix: Species abbreviations
Abialb - *Abies alba*; Acecam - *Acer campestre*; Acepla - *Acer platanoides*; Acepse - *Acer pseudoplatanus*; Actspi - *Actaea spicata*; Agrsto - *Agrostis stolonifera*; Ajurep - *Ajuga reptans*; Allpet - *Alliaria petiolata*; Anenem - *Anemone nemorosa*; Antodo - *Anthoxanthum odoratum*; Asaeur - *Asarum europaeum*; Astgly - *Astragalus glycyphyllos*; Athfil - *Athyrium filix-femina*; Atrbel - *Atropa bella-donna*; Avefle - *Avenella flexuosa*; Betpen - *Betula pendula*; Brasyl - *Brachypodium sylvaticum*; Broben - *Bromus benekenii*; Calaru - *Calamagrostis arundinacea*; Calepi - *Calamagrostis epigejos*; Calvul - *Calluna vulgaris*; Camtra - *Campanula trachelium*; Carbet - *Carpinus betulus*; Carbri - *Carex brizoides*; Carcan - *Carex canescens*; Carech - *Carex echinata*; Carimp - *Cardamine impatiens*; Carnig - *Carex nigra*; Carova - *Carex ovalis*; Carpai - *Carex pairae*; Carpal - *Carex pallescens*; Carpi1 - *Carex pilulifera*; Carpil - *Carex pilosa*; Carrem - *Carex remota*; Carsyl - *Carex sylvatica*; Cassat - *Castanea sativa*; Cirlut - *Circaea lutetiana*; Cirvul - *Cirsium vulgare*; Conmaj - *Convallaria majalis*; Corave - *Corylus avellana*; Dacglo - *Dactylis glomerata*; Denbul - *Dentaria bulbifera*; Desces - *Deschampsia cespitosa*; Diggra - *Digitalis grandiflora*; Drydil - *Dryopteris dilatata*; Dryfil - *Dryopteris filix-mas*; Epiang - *Epilobium angustifolium*; Epicol - *Epilobium collinum*; Eupamy - *Euphorbia amygdaloides*; Fagsyl - *Fagus sylvatica*; Fesgig - *Festuca gigantea*; Fraaln - *Frangula alnus*; Fraexc - *Fraxinus excelsior*; Fraves - *Fragaria vesca*; Galapa - *Galium aparine*; Gallut - *Galeobdolon luteum*; Galodo - *Galium odoratum*; Galpub - *Galeopsis pubescens*; Galtet - *Galeopsis tetrahit*; Gerrob - *Geranium robertianum*; Geuurb - *Geum urbanum*; Glehed - *Glechoma hederacea*; Hacepi - *Hacquetia epipactis*; Hepnob - *Hepatica nobilis*; Hiemur - *Hieracium murorum*; Holmol - *Holcus mollis*; Hyphir - *Hypericum hirsutum*; Hypper - *Hypericum perforatum*; Impnol - *Impatiens noli-tangere*; Imppar - *Impatiens parviflora*; Juneff - *Juncus effusus*; Lardec - *Larix decidua*; Latver - *Lathyrus vernus*; Luzluz - *Luzula luzuloides*; Luzpil - *Luzula pilosa*; Lysvul - *Lysimachia vulgaris*; Maibif - *Maianthemum bifolium*; Melnut - *Melica nutans*; Melpra - *Melampyrum pratense*; Meluni - *Melica uniflora*; Merper - *Mercurialis perennis*; Mileff - *Milium effusum*; Moetri - *Moehringia trinervia*; Molaru - *Molinia arundinacea*; Mycmur - *Mycelis muralis*; Myosyl - *Myosotis sylvatica*; Narstr - *Nardus stricta*; Oxaace - *Oxalis acetosella*; Parqua - *Paris quadrifolia*; Phecon - *Phegopteris connectilis*; Picabi - *Picea abies*; Pinsyl - *Pinus sylvestris*; Poanem - *Poa nemoralis*; Polmul - *Polygonatum multiflorum*; Poptre - *Populus tremula*; Prepur - *Prenanthes purpurea*; Pruavi - *Prunus avium*; Psemen - *Pseudotsuga menziesii*; Pulobs - *Pulmonaria obscura*; Quepet - *Quercus petraea*; Querob - *Quercus robur*; Querub - *Quercus rubra*; Ribuva - *Ribes uva-crispa*; Rosdum - *Rosa dumalis*; Rubfru - *Rubus fruticosus* agg.; Rubida - *Rubus idaeus*; Rumcon - *Rumex conglomeratus*; Salcap - *Salix caprea*; Salglu - *Salvia glutinosa*; Samnig - *Sambucus nigra*; Scrnod - *Scrophularia nodosa*; Senova - *Senecio ovatus*; Sensyl - *Senecio sylvaticus*; Soldul - *Solanum dulcamara*; Sonarv - *Sonchus arvensis*; Sorauc - *Sorbus*

aucuparia; Stasyl - *Stachys sylvatica*; Stemed - *Stellaria media*; Stenem - *Stellaria nemorum*; Tilcor - *Tilia cordata*; Torjap - *Torilis japonica*; Urtdio - *Urtica dioica*; Vacmyr - *Vaccinium myrtillus*; Veroff - *Veronica officinalis*; Viorei - *Viola reichenbachiana*.

Acknowledgements: The research was supported by the NAZV project QI112A172 and the internal IGA project A05/14

References

Binkley D. 1986. Forest nutrition management. J. Wiley , New York, 289 pp.

Eilmann B., Rigling A. 2010. Douglas-fir – a substitute species for Scots pine in dry inner-Alpine valleys? In: Opportunities and risks for Douglas-fir in a changing climate. Oc. 18-20, 2010 Freiburg, Berichte Freiburger Forstliche Forschung, H. 85, Freiburg: 11.

Ferron J.L., Douglas F. 2010. Douglas-fir in Fance: history, recent economic development, overviews for the future. In: Opportunities and risks for Douglas-fir in a changing climate. Oct. 18-20, 2010 Freiburg, Berichte Freiburger Forstliche Forschung, H. 85, Freiburg: 11-13.

Kantor P. 2008. Production potential of Douglas-fir at mesotrophic sites of Křtiny Training Forest Enterprise. Journal of Forest Science 54 (7): 321-332.

Kantor P., Knott R., Martiník A. 2001a. Production capacity of Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) in a mixed stand. Ekológia (Bratislava) 20 (Supplement 1): 5-14.

Kantor P., Knott R., Martiník A. 2001b. Production potential and ecological stability of mixed forest stands in uplands - III. A single tree mixed stand with Douglas-fir on a eutrophic site of the Křtiny Training Forest Enterprise. Journal of Forest Science 47 (2): 45-59.

Kantor P., Bušina F., Knott R. 2010. Postavení douglasky tisolisté (*Pseudotsuga menziesii* /Mirb./ Franco) a její přirozená obnova na Školním polesí Hůrky Středních lesnických škol Písek. [Position of the Douglas-fir (*Pseudotsuga menziesii* /Mirb./ Franco and its natural regeneration on School Training Forest District Hůrky of Secondary Forestry Schools in Písek.] Zprávy lesnického výzkumu [Reports of Forestry Research] 55 (4): 251-263.

Kantor, P., Mareš R. 2009. Production potential of Douglas-fir in acid sites of Hůrky Training Forest District, Secondary Forestry School in Písek. Journal of Forest Science 55 (7): 312-322.

Kouba J., Zahradník D. 2011. Produkce nejdůležitějších introdukovaných dřevin v ČR podle lesnické statistiky. [Production of the most important introduced tree species in CZ, according to forestrz statistics] In: Aktuality v pěstování méně častých dřevin v České republice 2011 [Actualities in silviculture of the less often tree species in Czech Republic]. Sborník referátů konference v Kostelci n. Č.l. 21. 10. 2011 [Proceedings of conference held at Kostelec n.Č.l. on Oct. 21st, 2011] , ČZU, Praha: 52-66.

Kubát K. [red.] 2002. Klíč ke květeně České republiky. [Key to Flora of Czech Republic] ACADEMIA, Praha: 927 pp.

Larson, B. 2010. Thy dynamics of Douglas-fir stands. In: Opportunities and risks for Douglas-fir in a changing climate. Oct. 18-20, 2010 Freiburg, Berichte Freiburger Forstliche Forschung, H. 85, Freiburg: 9-10.

Magurran, A. E. 2004.: Measuring biological diversity. - Blackwell Publishing, Malden etc.: 256 pp.

Martiník A. 2003. Possibilities of growing Douglas-fir (*Pseudotsuga menziesii* /Mirb./ Franco) in the conception of sustainable forest management. Ekológia (Bratislava) 22, (Supplement 3): 136-146.

Martiník A., Kantor P., 2007. Branches and the assimilatory apparatus of full-grown trees of Douglas-fir (*Pseudotsuga menziesii* /Mirb./ Franco) of a different coenotic position. Ekológia (Bratislava) 26, (3): 223--239.

Matějka K. 2009. Nápověda k programu DBreleve / DBreleve program help. - URL: http://www.infodatasys.cz/software/hlp_dbreleve/dbreleve.htm

Matějka, K., Viewegh, J. 2010. Druhová diverzita a bohatost v lesích s různým typem hospodaření. [Species diversity and richness in forests with a different types of management] Zprávy lesnického výzkumu. [Reports of Forestry Research] 55, (Speciál): 28 – 39.

Menšík, L., Kulhavý, J., Kantor, P., Remeš, M. 2009. Humus conditions of stands with the different proportion of Douglas-fir in training forest district Hůrky and the Křtiny Forest Training Enterprise. Journal of Forest Sciences 55, (8): 345-356.

Podrázský, V., Remeš, J., Liao, Ch.Y. 2002. Vliv douglasky tisolisté (*Pseudotsuga menziesii* /Mirb./Franco) na stav humusových forem lesních půd – srovnání se smrkem ztepilým. [Influence of Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) on the stage of forest soils humus forms] Zprávy lesnického výzkumu [Reports of Forestry Research] 46, (2): 86 – 89.

Podrázský, V., Remeš, J., Hart, V., Moser, W.K., 2009. Production and humus form development in forest stands established on agricultural lands – Kostelec nad Černými lesy region. Journal of Forest Science 55 (7): 299-305.

Podrázský, V., Remeš, J. 2008. Půdotvorná role významných introdukovaných jehličnanů – douglasky tisolisté, jedle obrovské a borovice vejmutovky. [Soil-forming role of the significant introduced coniferous – Douglas-fir, Grand fir and Weymouth pine] Zprávy lesnického výzkumu [Reports of Forestry Research] 53 (1): 27 – 33.

Podrázský, V., Remeš, J., 2010. Production and environmental functios of Douglas-fir on the School Training Forest Kostelec nad Černými lesy territory. In: Opportunities and risks for Douglas-fir in a changing climate. Oct. 18-20, 2010 Freiburg, Berichte Freiburger Forstliche Forschung, H. 85, Freiburg: 64.

Remeš, J., Pulkrab, K., Tauchman, P. 2011. Produkce a ekonomický potenciál douglasky tisolisté na některých plochách ŠLP Kostelec n. Č.l.. [Production and ecomic potential of Douglas/fir on some plots of Universitz Forest at Kostelec n. Č.l.] In: Aktuality v pěstování méně častých dřevin v České republice. [Actualities in silviculture of the less often tree species in Czech Republic] Sborník referátů konference v Kostelci n. Č.l. 21. 10. 2011 [Proceedings of conference held at Kostelec n.Č.l. on Oct. 21st, 2011], ČZU, Praha: 68-69.

Sergent, A.S., Rozenberg, P., Marcais, B., Lefevre, Y., Bastien, J.C., Nageleisen, L.M., Breda, N., 2010. Vulnerability of Douglas-fir in a changing climate: study of decline in France after the extreme 2003s drought. In: Opportunities and risks for Douglas-fir in a changing climate. Oc. 18-20, 2010 Freiburg, Berichte Freiburger Forstliche Forschung, H. 85, Freiburg : 21-22.

Ter Braak C.J.F., Šmilauer P. 2002. CANOCO reference manual and CanoDraw for Windows user's guide: Software for canonical community ordination (version 4.5). Microcomputer Power, Ithaca (NY): 500 pp.

Urban J., Čermák J., Nadyezhdina N., Kantor P. 2009. Growth and transpiration of the Norway spruce and Douglas-fir at two contrasting sites. In: Water issues in dryland forestry. 1. vyd. Sede Boqer, Israel: Ben Gurion University: 47.

Urban, J., Čermák, J., Kantor, P., 2011. Srovnání radiálního přírůstu a transpirace douglasky tisolisté a smrku ztepilého. [Douglas-fir and Norway spruce comparison of radial growth and transpiration] In: Aktuality v pěstování méně častých dřevin v České republice. [Actualities in silviculture of the less often tree species in Czech Republic] Sborník referátů konference v Kostelci n. Č.l. 21. 10. 2011 [Proceedings of conference held at Kostelec n.Č.l. on Oct. 21st, 2011], ČZU, Praha: 77-81.

Viewegh J., 2003: Czech Forest (Site) Ecosystem Classification. Czech University of Life Sciences Prague. URL: http://fld.czu.cz/docs/forestry_classification.pdf

Viewegh, J., Kusbach, A, Mikeska, M. 2003. Czech forest ecosystem classification. Journal of Forest Science 49 (2): 74-82.

Ward J. H. 1963. Hierarchical grouping to optimize an objective function. - Journal of the American Statistical Association, 58 (301): 236-244.

Zeller, B., Andrianarisoa, S., Jussy, J.H., 2010. Impact of Douglas-fir on the N cycle: Douglas-fir promote nitrification? In: Opportunities and risks for Douglas-fir in a changing climate. Oc. 18-20, 2010 Freiburg, Berichte Freiburger Forstliche Forschung, H. 85, Freiburg: 11.