FORESTRY AND THE 40th ANNIVERSARY OF IALE
GOZDARSTVO IN 40. OBLETNICA ORGANIZACIJE IALE

Janez PIRNAT[1]

(1) University of Ljubljana, Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, janez.pirnat@bf.uni-lj.si

ABSTRACT

In this paper we evaluated key forestry related topics in the journal Landscape Ecology in the period 1987-2021 using keyword analysis to highlight which forestry topics have been relevant for landscape ecologists from the inception of the IALE organisation until present. Our analysis has shown that forests have far too often been just a framework for research focusing on management interventions in the forest. The three key words with the highest frequencies were forest/wood fragmentation, forest management and forest(s). Until now, however, we have not made sufficient use of the opportunity to study the field of forest ecosystem functionning at the landscape level. Suggestions for future reserch are therefore given.

Key words: forest, 40th anniversary of IALE, key word analysis, forest fragmentation

IZVLEČEK

V pričujočem prispevku smo ovrednotili ključne gozdarske teme v reviji Landscape Ecology v obdobju 1987–2021 z analizo ključnih besed, da bi poudarili, katere gozdarske teme so bile pomembne za krajinske ekologe od ustanovitve organizacije IALE do danes. Naša analiza je pokazala, da so bili gozdovi vse prevečkrat le okvir za raziskovanje gospodarskih posegov v gozd. Tri ključne besede z najvišjo frekvenco so bile fragmentacija gozda, gospodarjenje z gozdovi in gozd(ovi). Doslej še nismo dovolj izkoristili možnosti preučevanja področja delovanja gozdnih ekosistemov na krajinski ravni. Zato so podani predlogi za prihodnje raziskave.

Ključne besede: gozd, 40. obletnica IALE, analiza ključnih besed, razdrobljenost gozda

1 AIM OF THE OVERVIEW
1 CILJ PREGLEDA

Landscape ecology falls under the umbrella of the field of "landscape science" (Wu, 2013), as do many other disciplines, such as conservation biology, forestry, geography, landscape architecture and landscape planning. Many authors have analyzed the key research topics of landscape ecology as well as those appearing in the journal Landscape Ecology (Wiens, 1992; Forman, 1995; Hobbs, 1997; Antrop, 2001; Wu and Hobbs, 2002; Wu, 2006; Andersen, 2008; McIntyre et al., 2013; Risser in Iverson, 2013; Wu, 2013; Helfenstein et al., 2014; Wu, 2017; Kienast et al., 2021). However, no studies have analyzed how landscape ecology deals with forest and forestry, despite the fact that forest is one of the key building blocks of both natural and cultural landscapes, and that forestry was organized internationally as a research activity as early as 1890, when IUFRO (International Union of Forestry Research Organizations) was established. On the other hand, IALE (International Association for Landscape Ecology) is a much younger organization, having been founded in 1982 in Bratislava on the basis of an idea presented at the 1981 Landscape Ecology Congress in Veldhoven in the Netherlands.

Wu (2013) has defined important core research topics and concepts in landscape ecology from a spatial point of view, particularly with respect to the pattern-process relationship: connectivity, fragmentation, scale, land use change, ecosystem/landscape history models, spatial analysis models and sustainability. In our research, we wanted to determine the extent to which these key research topics relate to forest and forestry.

2 RESULTS
2 REZULTATI

In order to determine which topics in forest and forestry science have been researched in the journal Landscape Ecology, we chose an analysis based on keywords related to forest and forestry in the period 1987-2021, from the creation of the journal to the end of 2021, in 282 issues of the journal encompassing a total of 3229 articles. For this presentation we have combined different original keyword records (e.g. clear cuts, clear-cutting, clearcut, clearcutting) and replaced them with a single record (e.g. clearcut).

Table 1: Different keyword group frequencies with up to 5 of the most common keywords

Preglednica 1: Različne frekvence skupin ključnih besed z do 5 najpogostejšimi ključnimi besedami

Keyword groups	Frequency	%	Top 5 (or less) keywords
Geographical indication	139	19	Boreal f, Atlantic f, Mediterranean f, temperate f, tropical f
Forest structure	107	14	f patch, f cover, f composition, f configuration, f edge
Forest - general	78	11	forest, woodland, urban f, forestry, agroforestry
Forest changes - loss	70	10	deforestation, f fragmentation, w fragmentation, f loss, subtropical fragmentation
Forest management	69	9	f management, inventory, landscape model, silvicultural management, class
Forest vegetation types	52	7	conifer f, deciduous f, mixed wood, oak f, riparian f
Forest changes - gain	44	6	f expansion, f regeneration, f restoration, f succession, afforestation
Forest species - animals	33	4	f birds, Woodland fauna, f carnivores, f carabid beetles, f avifauna
Forest social dimension	28	4	f history, f service, private f, non-industrial private f, farm woodlands
Forest damage, diseases	26	4	f disturbances, fire, f degradation, f damage, f die-off
Forest technology	26	4	f clear-cutting, f harvesting, timber harvest, timber production, Woody debris
Forest functioning	25	3	f dynamics, f connectivity, f productivity, f biogeochemistry, f dendrochronology
Computer programs	19	3	Random forest, f simulation, Random forest algorithm, Balanced Random Forests
Forest changes - neutral	10	1	f cover change, transition, landscape cover change model
Forest diversity, ecology	10	1	f ecology, conservation, diversity, biodiversity, dendroecology

Note: ƒ denotes the word 'forest'

In total, we have listed 736 keywords that can be linked to forest and forestry. We categorized these keywords into meaningful groups (Table 1) and keywords by frequency of occurrence (Table 2).

3   DISCUSSION AND PERSPECTIVES
3   DISKUSIJA IN PERSPEKTIVA

Although forests have been regarded as one of the most studied landscapes in the journal Landscape Ecology (Wu, 2017), the pattern-process relationship as a key topic in landscape ecology has not been properly addressed. According to the definition of Alma Farina (2010), landscape ecology is an ecological discipline dealing with the spatial distribution of organisms, patterns and processes. In our case, we decided to omit groups of general, geographical and vegetation designations, as well as the broad concept of »management« and other keywords not directly involved in the "pattern-process" relationship. Keywords most closely related to landscape ecological designations include fragmentation, deforestation, forest birds, reforestation, restoration and dynamics (Table 2). It is possible to see that keyword "fragmentation" is well represented; however, keywords from the field of forest functioning (i.e. forest dynamics) are relatively rare.

Forest often represents only a space or framework in which researchers study certain processes that are the result of (in)direct human activities. Examples in-

Table 2: Keywords by frequency of occurrence, taking into account those that appeared at least 10 times

Preglednica 2: Ključne besede po frekvenci pojavljanja ob upoštevanju tistih, zapisanih najmanj 10-krat

Keywords	Frequency
forest / wood fragmentation	45
forest management	41
forest(s)	32
Boreal forest(s)	27
deforestation	18
Random forest	18
forest / woodland birds	17
Tropical forest(s)	16
Atlantic forest(s)	14
Temperate forest(s)	13
afforestation / reforestation	11
forest restoration	10
forest dynamics	10

clude fragmentation and deforestation. A much more demanding step is to study the functioning of the forest, i.e. the forest as an ecosystem itself, which includes keywords such as f dynamics, f connectivity, f productivity and f biogeochemistry.

Why have landscape ecologists appeared to neglect forest functioning issues? One possible answer may be that researchers in the field of forestry have not been particularly interested in the relationship between landscape patterns and processes, or they have published their research in specialized journals in the field of forestry.

There may be another reason, namely the keyword type of analysis. The limitations of this type of analysis are well known (Helfenstein et al., 2014). Authors my not be careful enough when choosing the keywords associated with their research, especially in recent times when it has been more attractive to choose keywords relating to methodology rather than the ecological function itself. "Random forest" represents such a keyword in our case.

According to the idea of ecological civilization (Frazier et al., 2019), three concepts integral to landscape ecology have been recognized as essential: linkages between landscape patterns and biodiversity, the measurement of connectivity and flows across spatially heterogeneous systems, and the study of linkages between disturbances, resilience and recovery. With the help of these guidelines, we propose prioritizing research topics that connect forestry and landscape ecology:

- forest ecosystem services and well-being (Hladnik and Pirnat, 2011; Hladnik et al., 2020)
- urban forests as a source of urban heat island mitigation (Nastran et al., 2019)
- forests as a source of ecosystem disservices mitigation (Nagel et al. 2014, 2016; Žabota and Kobal, 2020, 2021)
- larger persistent forest patches in suburban areas (Pirnat and Hladnik, 2016)
- post-glacial forest spread (Magri et al., 2006)
- ecosystem services of (sub)urban forests and a holistic social-ecological approach (Pirnat and Hladnik, 2018, 2019)

Forty years is not much time compared to the age of a forest, but it represents a substantial period of time for the field of landscape ecology. Congratulations to landscape ecology for a successful 40 years. Now landscape ecology is a mature and well adapted science, with roots well embedded in different disciplines. Just like a well-established tree. Or a forest.

4 SUMMARY
4 POVZETEK

Krajinska ekologija sodi na področje krajinske znanosti kot tudi številnih drugih disciplin, kot so ohranitvena biologija, gozdarstvo, geografija, krajinska arhitektura in krajinsko načrtovanje. Številni avtorji so do sedaj že analizirali ključne raziskovalne teme krajinske ekologije, vključno s tistimi, ki se pojavljajo v reviji Landscape Ecology. S prostorskega vidika so pomembne naslednje temeljne raziskovalne teme in koncepti v krajinski ekologiji, zlasti kar zadeva odnos med vzorcem in procesom: povezljivost, razdrobljenost, merilo, sprememba rabe zemljišč, modeli zgodovine ekosistema / krajine, modeli prostorske analize in trajnost.

Do sedaj niso še v nobeni študiji analizirali, kako se krajinska ekologija ukvarja z gozdom in gozdarstvom, kljub dejstvu, da je gozd eden ključnih gradnikov tako naravnih kot kulturnih krajin, in da je bilo gozdarstvo organizirano na mednarodni ravni kot raziskovalna dejavnost že leta 1890, ko je bila ustanovljena IUFRO (International Union of Forestry Research Organizations). Po drugi strani pa je IALE (International Association for Landscape Ecology) veliko mlajša organizacija, ki je bila ustanovljena leta 1982 v Bratislavi na podlagi ideje, predstavljene na kongresu krajinske ekologije leta 1981 v Veldhovnu na Nizozemskem.

V naši raziskavi smo zato želeli ugotoviti, v kolikšni meri se te ključne raziskovalne teme s področja krajinske ekologije nanašajo na gozd in gozdarstvo. Da bi ugotovili, katere gozdarske teme so doslej obravnavali v reviji Landscape Ecology, smo analizirali ključne besede, povezane z gozdarstvom in gozdarstvom v obdobju 1987–2021, od nastanka revije do konca leta 2021, v 282 številkah te revije. Za večjo preglednost smo združili različne izvirne zapise ključnih besed (npr. clear cuts, clear-cutting, clearcut, clearcutting) in jih zamenjali z enovitim zapisom (npr. clearcut). Skupaj smo našli 736 ključnih besed, ki jih je mogoče povezati z gozdom in gozdarstvom. Te ključne besede smo razvrstili v pomenske skupine (preglednica 1).

Čeprav so gozdovi med najbolj raziskanimi krajinskimi tipi v reviji Landscape Ecology, odnos med vzorci in procesi kot ključna tema v krajinski ekologiji ni bil ustrezno obravnavan. Ob pregledu vseh ključnih besed smo se odločili, da se v drugem delu analize ne ukvarjamo več s ključnimi besedami, ki vsebujejo splošne, geografske in vegetacijske oznake, opustili smo tudi širok pojem »upravljanje«, saj niso neposredno vključene v odnos »vzorec-proces«. Analiza preostalih ključnih besed, ki so najbolj povezane s krajinsko ekološkimi lastnostmi gozdov, kažejo, da so bile najbolj pogoste ključne besede: razdrobljenost, gozdovi, gozdne

ptice, pogozditev in obnova, dinamika (preglednica 2). Mogoče je videti, da je ključna beseda razdrobljenost (fragmentacija) sicer dobro zastopana, druge ključne besede s področja delovanja gozdov (to je dinamika gozdov) pa so razmeroma redke.

Gozdovi so pogosto le prostor ali okvir, v katerem raziskovalci preučujejo druge procese, ki so posledica (ne)posrednih človeških dejavnosti. Ti primeri vključujejo tudi ključne besede razdroblenost, deforestacija. Zahtevnejši korak je preučevanje delovanja gozda, torej gozda kot samega ekosistema, sem sodijo ključne besede, kot so gozdna dinamika, povezljivost gozda, gozdna produktivnost in biogeokemija gozda. Zakaj so krajinski ekologi v dosedanjih objavah zanemarjali vprašanja delovanja gozdov? Eden izmed možnih odgovorov je lahko ta, da raziskovalci na področju gozdarstva niso bili posebej zainteresirani za odnos med krajinskimi vzorci in procesi, ali pa so objavili svoje raziskave v specializiranih revijah na področju gozdarstva. Morda obstaja še en razlog, in sicer površnost pri izbiri ključnih besed. Avtorji morda niso bili dovolj natančni pri izbiri ključnih besed, povezanih z njihovimi raziskavami, še posebej v zadnjem času, ko je bilo bolj privlačno izbrati ključne besede, ki se nanašajo na metodologijo prej kot na ekološke funkcije gozda.

Danes so priznani kot bistveni trije koncepti krajinske ekologije: povezave med krajinskim vzorcem in biotsko raznovrstnostjo; merjenje povezljivosti in tokovi po prostorsko heterogenih sistemih ter povezave med motnjami, odpornostjo in okrevanjem. S pomočjo teh smernic predlagamo prednostno obravnavanje naslednjih raziskovalnih tem, ki povezujejo gozdarstvo in krajinsko ekologijo: storitve gozdnega ekosistema in blaginja, urbani gozdovi kot vir blažitve mestnih toplotnih otokov, gozdovi kot vir blaženja ekosistemskih bremen, večje ohranjene gozdne zaplate na primestnih območjih, postglacialno širjenje gozdov, ekosistemske storitve (pri)mestnih gozdov in celosten socialno-ekološki pristop.

Štirideset let ni veliko v primerjavi s starostjo gozda, je pa precejšnje časovno obdobje za področje krajinske ekologije. Zato čestitamo krajinski ekologiji za uspešnih prvih 40 let. Kljub nekaterim omejitvam in dosedanjim pomanjkljivostim je krajinska ekologija zrela in dobro prilagojena znanost s koreninami, dobro vgrajenimi v različne discipline. Tako kot dobro uveljavljeno drevo. Ali gozd.

REFERENCES
VIRI

Andersen B.J. 2008. Research in the journal Landscape Ecology, 1987–2005. Landscape Ecology, 23, 2: 129-134.

Antrop M. 2001. The language of landscape ecologists and planners a comparative content analysis of concepts used in landscape ecology. Landscape and Urban Planning, 55, 3: 163-173. DOI 10.1016/S0169-2046(01)00151-7

Farina A. 2010. Ecology, cognition and landscape. (Landscape Series). Münich, Springer: 169 str.

Forman R. 1995. Some general principles of landscape and regional ecology. Landscape Ecology, 10, 3:133-142. DOI 10.1007/BF00133027

Frazier A.E., Bryan B.A., Buyantuev A., Chen L., Echeverria C., Jia P., Liu L., Li Q., Ouyang Z., Wu J., Xiang W., Yang J., Yang L., Zhao S. 2019. Ecological civilization: perspectives from landscape ecology and landscape sustainability science. Landscape Ecology, 34, 1: 1-8. DOI 10.1007/s10980-019-00772-4

Helfenstein J., Bauer L., Clalüna A., Bolliger J., Kienast F. 2014. **Landscape ecology meets landscape science.** Landscape Ecology, 29, 7: 1109-1113. DOI 10.1007/s10980-014-0055-6

Hladnik D., Pirnat J. 2011. Urban forestry - linking naturalness and amenity = the case of Ljubljana, Slovenia. Urban Forestry & Urban Greening, 10, 2: 105-112. DOI 10.1016/j.ufug.2011.02.002

Hladnik D., Kobler A., Pirnat J. 2020. Evaluation of forest edge structure and stability in peri-urban forests. Forests, 11, 3, 338: 19 str. DOI 10.3390/f11030338

Hobbs R. 1997. Future landscapes and the future of landscape ecology. Landscape & Urban Planning, 37, 1-2: 1-9. DOI 10.1016/S0169-2046(96)00364-7

Kienast F., Walters G., Bürgi M. 2021. Landscape ecology reaching out. Landscape Ecology, 36, 8: 2189-2198. DOI 10.1007/s10980-021-01301-y

Magri D., Vendramin G. G., Comps B., Dupanloup I., Geburek T., Gömöry D., Latałowa M., Litt T., Paule L., Roure J. M., Tantau I., Van Der Knaap W.O., Rémy J., De Beaulieu J. L. 2006. A new scenario for the Quaternary history of European beech populations: palaeobotanical evidence and genetic consequences. New phytologist, 171, 1: 199-221. DOI 10.1111/j.1469-8137.2006.01740.x

McIntyre N.E., Iverson L.R., Turner M.G. 2013. A 27-year perspective on landscape ecology from the US-IALE annual meeting. Landscape Ecology, 28, 10: 1845-1848. DOI 10.1007/s10980-013-9944-3

Nagel T.A., Svoboda M., Kobal M. 2014. Disturbance, life history traits, and dynamics in an old-growth forest landscape of southeastern Europe. Ecological Applications, 24, 4: 663-679. DOI 10.1890/13-0632.1

Nagel T.A., Firm D., Roženbergar D., Kobal M. 2016. Patterns and drivers of ice storm damage in temperate forests of Central Europe. European Journal for Forest Research, 135, 3: 519-530. DOI 10.1007/s10342-016-0950-2

Nastran M., Kobal M., Eler K. 2019. Urban heat islands in relation to green land use in European cities. Urban Forestry & Urban Greening, 37: 33-41. DOI 10.1016/j.ufug.2018.01.008

Pirnat J., Hladnik D. 2016. Connectivity as a tool in the prioritization and protection of sub-urban forest patches in landscape conservation planning. Landscape & Urban Planning, 153: 129-139. DOI 10.1016/j.landurbplan.2016.05.013

Pirnat J., Hladnik D. 2018. The concept of landscape structure, forest continuum and connectivity as a support in urban forest management and landscape planning. Forests, 9, 10, 584: 14 str. DOI 10.3390/f9100584

Pirnat J., Hladnik D. 2019. A tale of two cities - from separation to common green connectivity for maintaining of biodiversity and well-being. Land Use Policy, 84: 252-259. DOI 10.1016/j.landusepol.2019.03.011

Risser P.G., Iverson L.R. 2013. 30 Years later-landscape ecology: directions and approaches. Landscape Ecology, 28, 3: 367-369. DOI 10.1007/s10980-013-9856-2

Wiens J. 1992. What is landscape ecology, really? Landscape Ecology, 7, 3: 149-150. DOI 10.1007/BF00133306

Wu J. 2006. Landscape ecology, cross-disciplinarity, and sustainability science. Landscape Ecology, 21, 1: 1–4. DOI 10.1007/BF00133306

Wu J. 2013. Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop. Landscape Ecology, 28, 1: 1-11. DOI 10.1007/s10980-012-9836-y

Wu J. 2017. Thirty years of Landscape Ecology (1987-2017): retrospects and prospects. Landscape Ecology 32, 12: 2225-2239. DOI 10.1007/s10980-017-0594-8

Wu J., Hobbs R. 2002. Key issues and research priorities in landscape ecology: an idiosyncratic synthesis. Landscape Ecology, 17, 4: 355-365. DOI 10.1023/A:1020561630963

Žabota B., Kobal M. 2020. A new methodology for mapping past rockfall events: from mobile crowdsourcing to rockfall simulation validation. ISPRS International Journal of Geo-Information, 9, 9, 514: 21 str. DOI 10.3390/ijgi9090514

Žabota B., Kobal M. 2021. Accuracy assessment of UAV-photogrammetric-derived products using PPK and GCPs in challenging terrains: in search of optimized rockfall mapping. Remote Sensing, 13, 3812: 31 str. DOI 10.3390/rs13193812