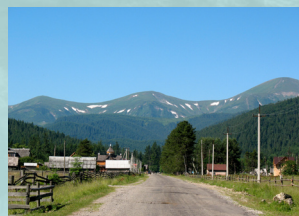




Science for the Carpathians



**Local Responses  
to Global Challenges**

**Proceedings  
of Forum Carpathicum 2014**

[www.forumcarpathicum.org](http://www.forumcarpathicum.org)



Lviv 2014



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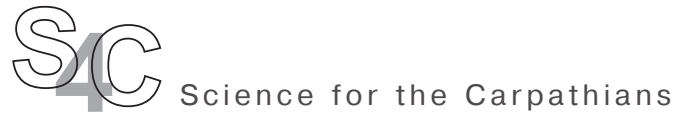
The Forum Carpaticum is a bi-annual open meeting of the Science for the Carpathians (S4C) initiative, which goes back to the initiation of the Carpathian Convention in 2001. The S4C network was formally established in 2008 to foster dialogue between research, policy and practice in the realm of sustainable development of the Carpathian region. It also established strategic partnership with the Interim Secretariat of the Carpathian Convention (UNEP Vienna) to ensure durable basis for collaboration and knowledge transfer. Today, S4C connects more than 400 scientists from Central Europe and other countries. Numerous members actively participate in the Carpathian Convention working groups and meetings of the Conference of the Parties to the Carpathian Convention.

The 1<sup>st</sup> Forum Carpaticum (Forum Carpaticum 2010) in Kraków, Poland identified the need for better data generation, availability, and accessibility to information in the Carpathian Mountain ecological region. The 2<sup>nd</sup> Forum Carpaticum (Forum Carpaticum 2012) in Stará Lesná, Slovakia addressed this need by covering the whole Data-Knowledge-Action cycle, i.e. focusing on how data are generated and transformed into useful knowledge, how the knowledge is transferred to policy and practice, and how it can feed back to research planning.

The 3<sup>rd</sup> Forum Carpaticum – **Forum Carpaticum 2014: Local Responses to Global Challenges** aims to explore ways to address global challenges in the local and regional context. The main themes of the Forum Carpaticum 2014 conference in Lviv, Ukraine are related, but not limited, to the policy priorities of the Europe 2020 Strategy and the Horizon 2020 Programme, focusing on major challenges affecting the Carpathian ecoregion:

1. **Ecosystem services and land use change.** This theme concentrates on the problems of sustainable forest management (SFM), agriculture, agro-ecology, eco-tourism, as well as of control of infrastructure development, urban sprawl, rational utilization of mountain resources, communities and their roles in regulating the access to various ecosystem services.
2. **Climate change, water and extreme events/hazards.** The theme looks into the complex relations between climate change and water resources in the Carpathian area. The focus will be on integrated impact analysis, the resilience of mountain ecosystems as well as their management, conservation and restoration while paying attention to problems of flood protection, water availability and use.
3. **Natural and cultural heritage.** This theme deals with preservation of and threats to various types of natural and cultural heritage of the Carpathians. A critical issue will be assessment, monitoring and forecasting changes in complex Carpathian landscapes both in socio-economic and as well as ecological terms for sustaining biodiversity, traditional economy and human well-being.
4. **Smart mountains.** This theme considers the chances offered to mountain areas by a knowledge-based economy, technology development and green growth including environmental-friendly tourism development, mobility, interrelations between rural mountain areas and urban centres in and outside the Carpathians.

*Science for the Carpathians (S4C)  
Scientific Steering Committee*



**Local Responses to Global Challenges  
Proceedings of Forum Carpaticum 2014**

Edited by Ivan Kruhlov and Bohdan Prots

[www.forumcarpaticum.org](http://www.forumcarpaticum.org)

Lviv 2014

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This publication contains selected extended abstracts of the presentations made at the Forum Carpaticum 2014 (3<sup>rd</sup> Forum Carpaticum), which took place in Lviv, Ukraine during September 16-18, 2014. The 21 abstracts are divided into four sections: (1) Sustainable Governance, (2) Ecosystem Services and Sustainable Forest Management, (3) Land Cover and Climate Change, and (4) Stream Channel Processes.

The publication will be useful for the scientists, authorities, NGOs and general public interested in sustainable development, environmental management and transboundary cooperation of the Carpathian ecoregion.

Available on-line at: [www.forumcarpaticum.org](http://www.forumcarpaticum.org)

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**Місцеві відповіді на глобальні виклики  
Матеріали Форуму Карпатікуму 2014**

Збірник наукових праць

За редакцією Івана Круглова та Богдана Проця

[www.forumcarpaticum.org](http://www.forumcarpaticum.org)

Львів 2014

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Місцеві відповіді на глобальні виклики : матеріали Форуму Карпатікуму 2014. : [зб. наук. пр. / наук. ред. Круглов І., Проць Б. ]. – Львів : Український бестселер, 2014. – 120 с.

Цей науковий збірник містить розширені тези вибраних доповідей, представлених на Форумі Карпатікумі 2014 (Третьому Форумі Карпатікумі), який відбувся у Львові протягом 16-18 вересня 2014. Двадцять одна праця, вміщена у збірнику, розподілена за чотирма секціями: 1. Стале урядування, 2. Екосистемні послуги та стале лісокористування, 3. Зміни наземного покриву та клімату та 4. Руслові процеси.

Видання буде корисним для науковців, управлінців, громадських активістів та інших осіб, які цікавляться питаннями сталого розвитку, екологічного менеджменту та транскордонного співробітництва у Карпатському екорегіоні.

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## Preface

More than 100 international scientists and practitioners met in Lviv, Ukraine at the 3<sup>rd</sup> Forum Carpathicum (Forum Carpathicum 2014) on September 16-18, 2014 to discuss the issues important not only for researchers, but also for other people living in, and dealing with, the mountains. The event was organised by the network Science for the Carpathians (S4C, <http://carpathianscience.org>), which acts as a strategic partner of the Framework Convention on the Protection and Sustainable Development of the Carpathians (<http://www.carpathianconvention.org>).

How to combine the outstanding biodiversity significance and huge tourism development potential of the Carpathians? How to plan spatially in the times of dynamic climate changes and natural hazards caused by them? Are the Carpathians the water towers for the regions around or rather a place where dramatic floods starts? People, who would like to know the answers to these questions are not only those living in the mountains or working at universities. These topics are crucial also for policy makers, people working in business sector or just living in the areas around. That is why the Forum Carpathicum 2014 was a very important point on the map of scientific events this year.

The Forum Carpathicum 2014 is the 3<sup>rd</sup> event of the kind. It was preceded by the 1<sup>st</sup> Forum Carpathicum (FC2010) in Kraków, Poland, which identified the need for better data generation, availability, and accessibility to information in the Carpathian Mountain ecological region. The 2<sup>nd</sup> Forum Carpathicum (FC2012) in Stará Lesná, Slovakia addressed this need by covering the whole Data-Knowledge-Action cycle, i.e. focusing on how data are generated and transformed into useful knowledge, how the knowledge is transferred to policy and practice, and how it can feed back to research planning.

The 3<sup>rd</sup> Forum Carpathicum in Lviv aimed to explore ways to address global challenges in the local and regional context. The main themes of the 3<sup>rd</sup> Forum Carpathicum (FC2014) conference in Lviv, Ukraine were related, but not limited, to the policy priorities of the Europe 2020 Strategy and the Horizon 2020 Programme, focusing on major challenges affecting the Carpathian ecoregion:

1. Ecosystem services and land use change (e.g., rational utilization of mountain resources, role of mountain communities in regulating access to various ecosystem services),
2. Climate change, water and extreme events/hazards (e.g., problems of flood protection, water availability and use under changing climatic conditions),
3. Natural and cultural heritage (e.g., assessment, monitoring and forecasting changes in complex and valuable Carpathian landscapes),
4. Smart mountains (e.g., mountain areas and technology development, or interrelations between rural mountain areas and urban centres in and outside the Carpathians).

The WWF workshops on ecological connectivity and old growth forests as well as a CARPIVIA/Carpathian Convention workshop on ecosystem-based adaptation to climate change were incorporated into the Programme and received a very positive feedback.

More information about the Forum Carpathicum 2014 as well as about the previous forums can be found at a dedicated web-site (<http://www.forumcarpathicum.org>).

The Proceedings are divided into four sections: (1) Sustainable Governance, (2) Ecosystem Services and Sustainable Forest Management, (3) Landcover and Climate Change, and (4) Stream Channel Processes.

The section on Sustainable governance includes seven papers. They discuss prospects of English agri-environmental schemes for the protection of natural and cultural landscapes in the Romanian Carpathians (Mountford et al., pp. 12-17) as well as the implementation of the Carpathian Convention (Vetier, Antypas, pp.18-22) and of Natura 2000 programme (Yakusheva, pp. 23-30; Cent, Grodzińska-Jurczak, pp. 31-34) in the Carpathian countries. Two papers deal with the development of rural tourism (Martins et al., pp. 35-40; Mitrofanenko et al., pp. 41-46), while the paper of Dovbenko (pp. 47-51) gives an overview of the potential for the development of the Ukrainian Carpathians.

The section on the Ecosystem Services and Sustainable Forest Management contains six papers in total related to the values of forests in the Ukrainian Carpathians (Melnikovych et al., pp. 60-64; Zahvoyska et al., pp. 65-69; Stoyko, pp. 70-74) and silvicultural management in the Czech Carpathians (Novák et al., pp. 75-78; Slodičák et al., pp. 79-81). The section opens with the paper of Striamets and Elbakidze (pp. 54-59) on the comparative study of cultural ecosystem services of forests in Northern Russia and Western Ukraine.

The section on Land Cover and Climate Change embraces five thematically rather different papers dealing with the effects of management practices on grassland communities in the Polish Carpathians (Zarycki, Korzeniak, pp. 84-88), the historical study of land cover change in a depopulated municipality of the Ukrainian Carpathians (Smaliychuk, pp. 92-95), GIS modelling of the alpine habitats extent in the central part of the Ukrainian Carpathians (Mkrtehian, Svidzinska, pp. 96-102), dynamics of ozone concentrations at the windthrow site in the High Tatra Mountains (Bičárová et al., pp. 103-106). There is also a paper discussing the possible impact of climate change on the development of pathogenic fungi and fungi-like organisms in the forests of Norway and the Ukrainian Carpathians (Bjoner, pp.89-91).

The section Stream Channel Processes contains three papers on the hydrological studies in the Polish Carpathians – namely of the flood discharges and associated channel parameters of the Biała river (Laszek et al., pp. 108-111), the movement of large tree debris (Mikuś, Wyźga, pp. 112-115) and the dynamics of vegetated islands (Wyźga et al., pp. 116-119) in mountain watercourses.

The editors of the volume would like to acknowledge the support of the International Visegrad Fund, WWF, and Franko University of Lviv in the preparation and realization of the Forum Carpathicum 2014 and of this publication.

Ivan Kruhlov and Bohdan Prots



## Передмова

Понад сто науковців та практиків з різних країн зустрілися у Львові на Форумі Карпатікумі 2014 (Третьюму Карпатському Форумі) протягом 16-18 вересня 2014 року. Вони обговорили питання, цікаві не лише для дослідників, алей для інших людей, які проживають у горах або мають справу з гірськими територіями. Сам захід був організований міжнародною науковою мережею Наука для Карпат (Science for the Carpathians – S4C, <http://carpathianscience.org>), яка є стратегічним партнером Рамкової конвенції щодо охорони та сталого розвитку Карпат (<http://www.carpathianconvention.org>).

Як поєднати важливу роль Карпат у збереженні біотичного різноманіття з величезним туристичним потенціалом цієї території? Як здійснювати тут територіальне планування з урахуванням динамічних змін клімату та пов'язаних з ними екстремальних природних явищ? Чи є Карпати джерелом водопостачання для прилеглих територій, чи вони є просто регіоном, з якого надходять паводки? Коло осіб, які хочуть знати відповідь на ці питання, не обмежується лише тими, хто проживає в горах або працює в університетах. Ці питання також важливі для політиків, а також для тих, хто займається бізнесом та проживає на суміжних територіях. Ось чому Форум Карпатікум 2014 став дуже важливим пунктом на карті наукових заходів цього року.

Форум Карпатікум 2014 є вже третім зібранням такого роду. Перший Форум Карпатікум відбувся у 2010 році в Кракові (Польща) і визначив потребу у кращому забезпеченні даними та доступі до інформації щодо Карпатського екорегіону. Другий Форум Карпатікум, який мав місце у Старій Лесні (Словаччина), стосувався циклу “дані – знання – дії”, тобто розглянув питання генерації даних про довкілля, перетворення їх у корисні знання, які, своєю чергою, повинні бути втілені в політику та практику, а результати практичних дій, замикаючи цикл, покликані знайти відображення у подальших наукових дослідженнях.

Третій Форум Карпатікум, що відбувся у Львові, був націлений на пошук відповідей на глобальні виклики у локальному та регіональному контексті. Головні теми львівського форуму були пов'язані з (але не обмежені) пріоритетними установками Європейської дослідницької стратегії у рамках програми Горизонт 2020 і зосереджувалися на основних викликах, що стосуються Карпатського екорегіону. Серед них були особливо виділені такі питання:

1. Екосистемні послуги та зміни у землекористуванні (напр., раціональне використання ресурсів гір, роль гірських громад у регулюванні доступу до різноманітних екосистемних послуг);

2. Зміни клімату, водні ресурси та екстремальні природні явища (напр., питання запобігання руйнівній дії паводків, вплив змін клімату на водопостачання та водоспоживання);

3. Природна та культурна спадщина (напр., оцінка, моніторинг та прогнозування змін у складних та цінних ландшафтах Карпат);

4. “Розумні гори” (напр., вплив нових технологій на розвиток гірських територій, взаємозв'язки між сільськими гірськими територіями та урбаністичними центрами поза межами Карпат).

Програма конференції містила семінари щодо екологічних мереж та пралісів, які були проведені представниками WWF, а також семінар щодо адаптації до змін клімату на засадах екосистемного підходу, який підготували учасники

проекту CARPIVIA разом із Секретаріатом Карпатської конвенції. Усі ці заходи отримали дуже позитивну оцінку від учасників Форуму.

Більше інформації щодо Форуму Карпатікуму 2014, а також щодо попередніх форумів, можна знайти на спеціальному англomовному сайті (<http://www.forumcarpaticum.org>).

Цей збірник матеріалів Форуму Карпатікуму 2014 поділений на чотири секції: 1) Стале урядування; 2) Екосистемні послуги та стале лісокористування; 3) Зміни наземного покриву та клімату; 4) Руслові процеси. Секція “Стале урядування” містить сім статей. Вони стосуються перспектив застосування англійських агроекологічних схем для охорони природних та культурних ландшафтів Румунських Карпат ((Mountford et al., С. 12-17), а також впровадження Карпатської конвенції (Vetier, Antypas, С.18-22) та програми Натура 2000 (Yakusheva, pp. 23-30; Cent, Grodzińska-Jurczak, pp. 31-34) в країнах Карпатського екорегіону. Дві статі обговорюють розвиток сільського туризму (Martins et al., С. 35-40; Mitrofanenko et al., С. 41-46), а повідомлення В. Довбенка (С. 47-51) містить огляд потенціалу сталого розвитку Українських Карпат.

Секція “Екосистемні послуги та стале лісокористування” охоплює шість статей. Вони стосуються цінності лісів Українських Карпат (Melnykovych et al., С. 60-64; Zahvoyska et al., С. 65-69; Stoyko, С. 70-74) та лісogосподарського менеджменту у Чеських Карпатах (Novák et al., С. 75-78; Slodičák et al., С. 79-81). Відкриває цю секцію публікація Н. Стрямець та М. Елбакідзе (С. 54-59) щодо порівняльного дослідження культурних екосистемних послуг лісів північної Росії та західної України.

Секція “Зміни наземного покриву та клімату” вміщує п’ять публікацій, які є досить різноманітними за тематикою. Вони стосуються дослідження впливу землекористування на лучні фітоценози у Польських Карпатах (Zagucki, Kozeniak, С. 84-88), історичного дослідження змін наземного покриву на території Боберської сільської ради в Українських Карпатах (Smaliychuk, С. 92-95), ГИС-моделювання ареалів альпійських лук у центральній частині Українських Карпат (Mkrtchian, Svidzinska, С. 96-102), а також динаміки концентрації озону на вітровальній ділянці у словацьких Високих Татрах (Vičárová et al., С. 103-106). У цю секцію також вміщене повідомлення щодо можливого впливу кліматичних змін на розвиток патогенних мікроорганізмів у лісах Норвегії та Українських Карпат (Bjoner, С.89-91).

Секція “Руслові процеси” складається з трьох статей щодо гідрологічних досліджень у Польських Карпатах, а саме – щодо паводкових витрат та руслових параметрів річки Бяла (Laszek et al., С. 108-111), а також щодо переміщення великих залишків дерев (Mikuś, Wyźga, С. 112-115) та динаміки островів рослинності (Wyźga et al., С. 116-119) у руслах гірських водотоків.

Редактори збірника висловлюють подяку Міжнародному Вишеградському Фонду (International Visegrad Fund), WWF, а також Львівському університету Франка за підтримку Форуму Карпатікуму 2014 та, зокрема, цієї публікації.

Іван Круглов і Богдан Проць

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## **Sustainable Governance**

## The design of agri-environment schemes in protecting heritage (natural and cultural) and encouraging green growth: does the English experience have relevance for the Carpathians?

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**Key words:** Appraisal panel, EU accession, Higher Level Stewardship, survey, Transylvania

Within the European Network for Rural Development, agri-environment schemes (AES) represent a key tool in achieving “green growth” combined with the conservation of natural and cultural heritage. Such schemes have been encouraged in EU members and accession states, though their efficacy and value-for-money has been occasionally questioned. Agri-environment schemes were first introduced into European Union (EU) agricultural policy during the late 1980s as an option for Member States. From 1992 application of agri-environment programmes became compulsory for Member States, and measures are co-financed by the states, though they remain optional for individual farmers and landowners. From 2007-2013, EU expenditure on agri-environment measures was almost €20 billion or 22% of the total expenditure on rural development. Agri-environment schemes focus on agricultural landscapes which are known to contain some of the most diverse and threatened habitats in Europe (Turtureanu et al., 2013).

With the accession of many Carpathian states to the EU (*e.g.* Romania in 2007), they too were required to implement agri-environment schemes. However, if such schemes are to have a role in the agricultural economy of the Carpathians, their design and implementation must be based on evidence gathered from the widest relevant experience, including other EU states where the schemes have been operational for many years. Evidence arises from monitoring of schemes and testing whether the desired outcomes have been delivered. Early monitoring of the original AES indicated their success in reducing the rate of habitat loss, but provided little evidence of the successful enhancement of nature or the improved condition of high value environmental features. Amongst other issues, in their review of AES Kleijn and Sutherland (2003) observed that there was generally insufficient monitoring and evaluation of progress and that even if AES provided financial benefits, without support and feedback the AES management prescriptions would be viewed as an inconvenience, carried out with the least possible effort. Thus the success of AES depended greatly on the attitudes of farmers.

**Geographical setting.** Within the EU, England (the largest component country of the UK) has used such schemes widely and increasingly developed rigorous monitoring programmes both to test the success of the schemes and to inform revision and enhancement of their design. Thus in 2003, a detailed review recommended that the best elements of the schemes introduced in the late 1980s be combined into a single revised scheme, Environmental Stewardship, of which one component is Higher Level Stewardship (HLS). HLS is targeted on areas and holdings that have potential to deliver the greatest environmental benefit. The work reported here describes how the success of HLS has been evaluated in upland England and discusses the relevant

messages arising from this evaluation for the application of AES in the Carpathian nations, especially within Romania.

**Material and methods.** *Natural England* and the NERC Centre for Ecology and Hydrology collaborated in a programme to develop methods whereby the success of HLS in meeting its goals could be assessed (Mountford et al., 2013). *Natural England* (the English conservation agency) administers the HLS scheme and makes HLS agreements in negotiation with landowners and managers. The project sought to achieve a standard assessment of agreements in their first year from which future progress could be assessed. The project used very detailed field survey and mapping of features, including habitats, vegetation and species, together with their composition and condition. The project also assessed a sample of agreements that had been under way for 2-4 years, as an early indication of scheme success. This portion of the project included a detailed assessment of how appropriate the agreements were in the context of local landscape character.

Importantly, a panel of experts drawn from conservation agencies and research bodies made a rigorous appraisal of the design and development of all the individual agreements, together with a systematic evaluation of the relevant survey results. This appraisal included examination of the accuracy and quality of the *Farm Environment Plan* (“FEP” *i.e.* the site description on which the individual AES agreement was made) as well as whether the agreement fitted with local and regional priorities, whether the right AES prescriptions had been selected and whether there was evidence of progress toward the desired outcomes from the situation described in the FEP.

The vegetation data (quadrats) gathered as part of the programme was compared directly with equivalent data from the wider countryside that was not under HLS. These contextual data were derived from the UK Countryside Survey for 2007 (Carey et al., 2008) and compared with the HLS survey data using methods developed for assessing earlier AES (Carey et al., 2002).

The differing roles and interests of individual agreement holders, conservation NGOs and public sector agencies were assessed through several regional stakeholder workshops. This 4-year research programme included a full year devoted to upland habitats comparable to those found at medium altitudes in the Carpathians and also assessed upland habitats in a regional workshop.

**Results and discussion.** *HLS in England.* The research programme created a database of 174 new agreements and a further 62 that had been under way for several years. Of the overall total of 236 agreements, 60 were located in upland landscapes. These data tested the success of the maintenance, restoration and (where relevant) creation of forest, grasslands (both species-rich and those of importance for birds), upland heath and montane habitats, mires and historic or cultural features. The results also examined boundary features, ancient trees, scrub, traditional orchards, arable land and management to reduce erosion and pollution, as well as control of invasive or pest species. The HLS scheme has a strong focus on public access and education; hence analysis tested how amenity usage and tourism could be integrated within management to protect heritage.

The results of the programme are described in detail by Mountford et al. (2013). The conclusions emerging from this programme gave a largely positive assessment of Higher Level Stewardship (HLS), its potential to deliver desired outcomes and its likely contribution to the Rural Development Programme. The HLS project:

- created a representative and robust baseline from which to assess future progress,

- confirmed that agreement design was generally good, and suggested ways in which developing an agreement could be improved,
- demonstrated that for most habitats HLS had been well targeted and applied to high quality features in representative landscapes that should deliver the desired outcomes,
- showed good evidence of progress toward the desired outcomes in agreements that had been under way for at least two years,
- provided clear evidence of HLS contributing more than “ordinary farmland” toward many ecosystem services, at least in grasslands.

Thus overall, HLS appears to be an effective agri-environment scheme despite some specific problems applying AES to grasslands and wetlands. Nonetheless, the research also indicated issues that would need to be rectified or improved, particularly if HLS were to be employed as a model elsewhere, such as within the Carpathians:

- management approaches must be targeted on appropriate features, where the goals are achievable, rather than implemented indiscriminately,
- management objectives for an agreement should be clear, so that agencies allocating public funds can assess which agreements are likely to succeed,
- the “Indicators of Success” used in measuring progress should be fully measurable and quantifiable,
- decisions made in designing and revising the agreement should be fully documented, and
- management should be based on the best available science and clearly described.

*Agri-environment schemes in Romania and the Carpathians.* The recent situation (2007-2013) with AES in Romania is outlined by Didicescu (2007). At its accession to the EU, 87% of Romania could be defined as rural, with approximately 45% of the Romanian population living in this rural area. Within the rural population, 64% was occupied in the primary (agricultural) sector and there were 4.25 million farms with an average size of 3 hectares. Although most (91%) of these farms were of a subsistence or semi-subsistence type, the 2000s witnessed the growth of big commercial farms that now account for about half the agricultural area.

Prior to accession, Romania adopted the Special Accession Programme for Agriculture and Rural Development (the SAPARD agri-environment measure). However there were very few applications to SAPARD and almost all were from the same region advised by an NGO. Before 2007, it was apparent that Romanian farmers were not familiar with agri-environment measures and that the provision of advisory services was vital. During the accession phase, attempts were made to create information schemes although there was evidence that these were not sufficiently ambitious. Crucially, the state advisory system needed time and training to cover the probable future demand for AES. However the size of the problem in getting advice to over 4 million farmers contrasts with the UK which has only 152,000 full time farmers (plus a further 198,000 part-time farmers) despite a total population of 64.1 million people (compared to slightly less than 20 million in Romania).

Following accession, a phased approach to AES was planned in Romania comprising three main elements (Didicescu, 2007). Firstly organic farming was to be both maintained and also support provided for conversion to organic farming. Secondly, there was to be a focus on grassland conservation, especially for High Nature Value (HNV) grassland (Solovyeva, Nuppenau 2012), including holdings that were >50% under grass with attention to stocking rate, fertiliser usage, wet grassland,



scrub invasion and traditional working practices. The third focus was resource protection (water and soil) with a move to winter cropping and conversion of arable land to grassland. Much of the most successful awareness-raising and coordination of applications to AES continues to be achieved by regional NGOs *e.g.* Fundația ADEPT (Agricultural Development and Environmental Protection in Transylvania) in Târnava Mare since 2003 and the Pogány-havas Association in Bacău county, both in the Carpathian foothills within Transylvania (Babai, Molnár, 2013; Sutcliffe, Larkham, 2011). Although large private consultancies are also involved in rural development, most of these focus on big investment projects rather than the small subsistence farms where much of the biodiversity and cultural richness resides.

**Conclusions.** The nations of the Carpathian Mountains differ both within themselves and in comparison to England in terms of history, habitats and environmental legislation. Within Western Europe AES developed in a highly modified and industrial farming context and it is therefore not a simple task to apply findings and lessons from England to the traditional farming economy of the Carpathians. However, the English experience with agri-environment schemes has some relevance at a number of levels, both as a guide on what to do and also on what not to do.

As applied in the EU, AES require some additional activity or change in practice by the farmer. However, in traditional landscapes, farmers have practised flexible responses and adapt to the prevailing local environmental conditions. The formalisation of management often required through AES can risk disturbing the natural rhythms of agricultural wildlife *e.g.* by changing cutting dates or enabling cutting to occur over a very short period. The structures of typical AES may thus be inappropriate for the Carpathians and indeed there is evidence that the extreme bureaucracy of schemes and overly strict EU regulations on production discourage farmers from involvement. Particular problems of applying AES to the Carpathians include dealing with the apparently conflicting trends of both land abandonment and intensification (Babai, Molnár, 2013) and adapting the AES to deal with small farm sizes.

The special richness of the Carpathians is demonstrated by the abundance of HNV habitats, especially grassland (Solovyeva, Nuppenau, 2012), which survived in both Romania and Ukraine despite the Communist era of intensive land use and many state farms. Romania and Ukraine both retain hotspots of biodiversity, linked locally to cultural diversity and traditions *e.g.* Csángós, Hutsuls, Saxons and Székely, in addition to Romanians and Ukrainians. The situation with biodiversity protection in Romania and Ukraine differ. In Romania, with EU agri-environment schemes, uptake of AES by many small farmers is low and the contribution of such schemes remains localised. In Ukraine, without this policy support, farmers often retain management patterns which have existed for centuries based on cultural traditions. Nonetheless, these trends do not represent an argument against AES payments but rather for better targeting toward preventing abandonment and supporting the preservation of traditional practices.

In conclusion, although there are huge differences between the English uplands and the Carpathians, some of the findings emerging from the HLS project (Mountford et al., 2013) are clearly relevant:

- success requires monitoring and evaluation of progress,
- management prescriptions should be adapted according to the evidence of this monitoring,
- activity should be targeted *e.g.* toward HNV farmland,
- government agencies and NGOs must involve individuals and communities to improve schemes and deliver success.

Stressing local involvement, examples like Fundația ADEPT and the Pogány-havas Association underline how natural heritage can be safeguarded by bringing the many small traditional farmers together for a common benefit. Such partnerships have developed independently in Transylvania. However there is an example of an AES option from England that might be adapted for the Carpathians and could help bring about such partnerships: the HR8 *Supplement for group applications*. This English AES approach supports the cost of facilitating linked agreements which together manage a target feature e.g. areas of shared grazing and areas under more than one ownership. This is precisely the kind of situation that is commonplace through the Carpathians.

The habitat and floristic differences between England and the Carpathians clearly mean all such prescriptions are not directly transferable, though the meticulous design structure of HLS agreements may have relevance. Carpathian agri-environment schemes and their individual agreements need thorough monitoring using a representative baseline from which to judge future progress. There needs to be a consistent process for evaluating the agreement design and, with increasing pressure on funding resources, there should be encouragement for local partnerships to use agri-environment schemes to deliver ecosystem goods and services in the Carpathians.

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## Conflicts and synergies between multilateral biodiversity-related agreements in the Carpathian region

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**Key words:** Carpathian Convention, clustering environmental agreements, policy integration, biodiversity governance

Since the late 1960s over 500 multilateral environmental agreements (MEAs) have been negotiated and adopted by the international community, and out of these at least 150 address some aspect of biological diversity. However, the uncoordinated adoption of such large number of MEAs has led to fragmentation, overlapping functions and inconsistencies in international environmental governance. Despite the large number of legal instruments, and in part because of their uncoordinated development and implementation, environmental regimes have been less effective than expected, and many environmental issues, such as loss of biodiversity, have not been solved. (UNEP-DELC, 2012) This paper seeks to identify opportunities to harmonize the international legal instruments that apply to biodiversity in the Carpathian region, especially through the Carpathian Convention.

**Scope.** Just in the field of biodiversity conservation bearing on the Carpathian Mountains there are six international conventions under the United Nations (UN), two under the Council of Europe and the Carpathian Convention's Biodiversity Protocol. Additionally, numerous soft law instruments exist that aim to protect biodiversity and enable its sustainable use. Table 1 provides an overview of the aims of the conventions and their relevance to the Carpathian region.

**Methodology.** By reviewing the biodiversity-related multilateral agreements' text and the notes of the discussion surrounding the ongoing clustering processes under the UN, it was possible to define the main conflicts among the conventions. Additional interviews have provided the grounds for establishing a role for the Carpathian Convention in the process of harmonizing MEAs.

**Discussion. Origin of conflicts.** The biodiversity conventions have one single unifying aim: the protection of biological diversity. However each of them addresses different aspects of diversity loss. Global biodiversity governance is fragmented. Genetic diversity losses are addressed by the CBD and the Plant Treaty; population decline by CITES, CMS and the Bern Convention; and habitat level changes by the Ramsar Convention, WHC and the Landscape Convention. The treaties also deal with different driving forces of biodiversity loss, such as trade (CITES), threats during migration (CMS, Ramsar), habitat fragmentation and land use change (Ramsar Convention, Bern Convention, Landscape Convention, MAB). The CBD and the Landscape Convention adopts a landscape level ecosystem approach to biodiversity conservation, while other conventions focus on species or localized ecosystems such as wetlands.

**Table 1.** Overview of biodiversity-related MEAs bearing on the Carpathian Region

<i>Title of the convention</i>	<i>The convention's aim(s)</i>	<i>Relevance to the Carpathians</i>
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	To provide the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.	9 designated Ramsar sites
Convention concerning the Protection of the World Cultural and Natural Heritage (WHC) and the Man and Biosphere Programme (MAB)	To ensure that effective and active measures are taken for the protection, conservation and presentation of the cultural and natural heritage.	2 natural heritage sites 13 cultural heritage sites 9 biosphere reserves
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	To ensure that international trade in specimens of wild animals and plants does not threaten their survival.	> 100 species
Convention on Conservation of Migratory Species (CMS)	To conserve terrestrial, aquatic and avian migratory species throughout their range	> 100 species
Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)	To conserve wild flora and fauna and their natural habitats and to promote European co-operation in that field	> 100 species Sites in the Emerald and Natura2000 networks
Convention on Biological Diversity (CBD)	To conserve biological diversity, to enable the sustainable use of the components of biological diversity and to allow for the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.	Carpathians has been proposed as a biodiversity hotspot
European Landscape Convention	To promote landscape protection, management and planning, and to organise European co-operation on landscape issues.	Concerns the whole Carpathian region Several areas with Landscape Award
International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty)	To establish a framework for the conservation, sustainable use of all plant genetic resources for food and agriculture (PGRFA), and for the fair and equitable sharing of benefits that arise from the use of these resources	Rich agro-diversity, traditional varieties
Framework Convention on the Protection and Sustainable Development of the Carpathians	To enhance the conservation, restoration and sustainable use of biological and landscape diversity of the Carpathians	Carpathian region

Due to these differences in targets and driving forces the tools and measures that the MEAs apply are also plentiful. The activities described in the aims of the 9 biodiversity-related MEAs are benefit sharing, conservation, cooperation, education,

promotion and use. Although such a diverse approach in theory could even be beneficial by addressing all drivers and needs; in reality the MEAs do not work synergistically. Conflicts and inconsistencies hinder protection of biodiversity:

- definitions and environmental principles in the MEAs differ,
- decision-making processes are not uniform: whereas parties to the CITES decide by voting, other conventions require consensus,
- compliance regimes are also different,
- access and participation options of stakeholders (NGOs, industry groups, private actors) vary among the conventions,
- reporting requirements, their content, timing and details are different. (Baakman 2011).

*Enhancing synergies.* The global process to enhance synergies among biodiversity-related conventions was started in 2002 by setting up the Biodiversity Liaison Group comprising the executive heads of the six biodiversity-related conventions. The need to address inconsistencies has been reinforced several times, including COP11 of the CBP which “stresses the need to strengthen synergistic processes among the biodiversity-related conventions”. (CBD Secretariat, 2012)

The governing bodies of the conventions have agreed to different levels and forms of cooperation. The CBD has joint work plans with the Ramsar Convention, with the Convention on Migratory Species and with the WHC. There are also formalized liaison groups addressing integration, such as the Environment Management Group’s Issues Management Group on biodiversity, whose members are the secretariats of the MEAs; the Informal Liaison Group on Biological and Cultural Diversity assisting the CBD and the WHC and thematic coordination mechanisms e.g. on forests, plant conservation, invasive alien species. Furthermore, work has been going into harmonizing reporting requirements and knowledge and information management (UNEP, 2012).

*Advantages and disadvantages of integration.* Since the conventions all aim to address biological diversity it seems obvious to follow the principles of integration and harmonize these agreements. However all conventions have a unique history, culture and values; different rules, principles, procedures, obligations and means of implementation; which poses challenges since these aspects should not be weakened or even lost in the process of integration (Nordic Council of Ministers, 2010). UNEP (2010) acknowledges that possibly national level action is most appropriate to achieve synergies: ensuring that people responsible for national implementation coordinate their activities. Additionally to national action international harmonization can help to ease national burdens (e.g., through harmonized reporting, coordinated meeting, streamlined information flow, capacity building). International level integration allows to have more human and financial resources available for concrete national and regional actions on species, habitats and ecosystems. Integration of biodiversity-related conventions does not necessarily lead to immediate cost savings, however it allows to achieve more effects with the same resources (Nordic Council of Ministers, 2010).

*Role of the Carpathian Convention.* The Carpathian Convention acts as a platform on several issues, including biodiversity, in order to bring together stakeholders and harmonize their activities. It is not a prohibitive or normative convention, and does not add extra burdens to its parties; its role is rather to catalyse activities and projects in a proactive manner. Until now the Convention has formalized agreements with some MEAs (e.g., CBD, Ramsar Convention) and regional conventions (e.g. Alpine

Convention, ICPDR). In other cases (e.g., UNESCO World Heritage Convention, European Landscape Convention) the Carpathian Convention fills in gaps by being responsive to regional issues. (Egerer, 2014)

The Protocol on Conservation and Sustainable Use of Biological and Landscape Diversity to the Carpathian Convention recognizes in its preamble the need to integrate its actions with the other global and European biodiversity-related MEAs. Several activities have been undertaken to enhance synergies:

- enhancing cooperation: the Carpathian Network of Protected Areas (CPNA) and the Carpathian Wetland Initiative (CWI) are initiatives to harmonize national activities in relation to certain aspects of biodiversity protection. (ISCC, 2014),
- information and knowledge management: the Carpathian Red List of Habitats and Species, the List of Invasive Alien Species and the Carpathian Integrated Biodiversity Information System (clearing house) are all attempts to synthesize national lists and information in order to make them coherent and accessible to other parties. (Köck et al., 2014 and ISCC, 2014),
- mobilizing funding: it has been possible to mobilize European and international funds for joint activities for example under the CNPA and CWI networks. (ISCC, 2014),
- improved visibility and representation: the Carpathian Convention Interim Secretariat has been active to increase the visibility of the region and ensure its proper representation through involvement in mountains work under the United Nations, such as UN Secretary General Sustainable Mountain Development and the Sustainable Development Goals and mountains (ISCC, 2014).

**Conclusions.** The Carpathian Convention has the potential to enhance the effectiveness of international MEAs by being able to complement them with regionally relevant implementation tools and measures. Further to the valuable approaches listed above there are additional opportunities that can be harvested. Firstly, the establishment of the permanent secretariat for the Convention will hopefully increase human resources and possibly contribute to national ownership of the convention. Secondly, additional resources could be mobilized for the Carpathian region if it was recognized as a macro-region in Europe, such as the Alps. Thirdly, the Convention could promote landscape level ecosystem management through its coordinating functions, and even assess the overall effectiveness of biodiversity conservation in the region. Fourthly, the Convention can also act as a communication channel that enhances communication between scientists and policy-makers, and vice versa. Finally, however the main role of the Convention should be, as it is today, to make sure the policy decisions do not only remain on paper but are implemented through projects.

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## The implementation deficit in the European Union: insights from Natura 2000 policy in the Carpathian countries

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The EU policy for nature conservation aims to assure the long-term survival of Europe's most valuable and threatened species and habitats. At the same time it recognizes that man is an integral part of nature and the two work best in partnership with one another. This is particularly important for ensuring the interests of the local, rural population that lives in close contact with the nature.

The nature conservation agenda emerged in the EU with the adoption of the Directive on the Conservation of Wild Birds 79/409/EEC (The Birds Directive) (EC, 1979), which followed later by the Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora 92/43/EEC (The Habitats Directive) (EC, 1992). Implementation of these Directives is ensured through establishment of European Ecological Network of Protected areas – Natura 2000. Up to date it is the most ambitious supranational initiative for nature conservation world-wide.

However, the policy implementation is recognized as one of the most troublesome stages of the environmental policy cycle in the EU and often defined in term of implementation deficit. There are various reasons to which such deficit might be attributed e.g. discrepancy in policy goals among different levels, insufficient results achieved through implementation, disrupted implementation process etc. Nevertheless the outcome of implementation deficit lies in unfulfilled policy aims.

Multi-Level Governance (MLG) is frequently used to conceptualize the current complex architecture of the EU, thus as a theoretical tool. However, it is also actively promoted as a policy management tool within the EU system aiming to steer complex vertical and horizontal interactions among actors. Consequently it aims to address and offer solutions of the implementation deficit e.g. through involving broader range of stakeholders, which may bring additional resources and visions to the process of decision-making and implementation. However, brings additional challenges for putting policy into practice due to the system's complexity.

The paper provides insights on the implementation of the EU nature conservation policy in the Carpathian countries as a whole with further detailed scrutiny of the Polish and Slovak cases. It aims to identify specific implementation challenges and opportunities of the EU policy system on the example of Natura 2000 policy for these cases. Hence, the following question is sought to be answered: "Which challenges and opportunities are arising from MLG system at intermediate (national) implementation level?"

**Geographical setting.** As it was mentioned above the research is focused on the countries of the Carpathian Mountain Range. The Carpathians is one of the few wilderness spots, with unique areas of preserved primeval beech forest and a substantial population of large carnivores, remained in the European region. Furthermore, it provides an essential ecological corridor for overall connectivity in Europe. Thus

nature conservation in the area has special significance for supporting biodiversity and wildlife richness in Europe.

At the same time the Carpathian countries currently are in the period of rapid socio-economic development, that closely connected with infrastructure development (including tourism) and intensive economic growth that leads to increased pressure on the environment. Thereby, competing interests (socio-economic vs environmental) arise in these natural areas. Furthermore, these cases represent the dynamic restructuring of the policy sector since the EU framework is based on the participatory approach to nature conservation in opposite to the strictly hierarchical (top-down) logic inherited from the communist regime. Nevertheless it is important to stress that the nature conservation policy was fairly well developed compare to other sectors of environmental policy during the communist time, even though it was largely based on the conservative, preservationist approach. Hence it is fruitful to analyze how newly proposed logic and structures interact with existing ones.

The year 2012 was set as a deadline for Natura 2000 sites designation in these countries, therefore certain implementation structures have been already set, but not yet settled. The scrutiny of such cases helps to reveal policy dynamics, as well as identify current challenges and opportunities.

**Material and methods.** The conceptual ground of this paper lays on the elaboration of Multi-level Governance and implementation theories. MLG is a generic concept, which presents a comprehensive conceptualization of the modern political sphere characterized by the dispersed and pluralistic processes changing the nature of organization and management of the political processes. Namely, increasing interconnectedness of actors on the vertical and horizontal axis, the relationships among which is not anymore build in the hierarchical mode, but rather span across, forming a network-like structures. The composition of MLG structures are defined through the following components: jurisdictions (including legal framework), membership (who are the actors involved); jurisdictional levels (which levels/sectors members belong to); design, (particular interactions) (Marks, Hooghe, 2001). Various indicators could be used to describe these structures. Thus, Bache and Flinders distinguish four of them: 1) participation; 2) levels' overlap (network) in particular MLG structure; 3) the role of the governmental institutions; and 4) accountability (Bache, Flinders, 2005). In the particular research the two of them are chosen for the closer scrutiny: 1) participation understood as an actor engagement, and 2) the role of the governmental institutions, namely how much they are open for collaboration with other actors, what are methods and tools used in their work.

The second conceptual component the implementation theory is rather loose and not easy to define. In the broadest sense implementation is the process by which "intent gets translated into action" Specifying, implementation can be defined as "those events and activities that occur after the issuing of authoritative public policy directives, which include the effort to administer and the substantive impacts on people and events" (Victor et. al, 1998). Firstly, this definition brings attention to the important pre-condition of implementation, namely the decision of legislation, policy framework etc should be set and agreed beforehand. Secondly, it points out that implementation is a process based on multiply interactions. Thirdly, it is implementation process rather than legislation (decision) itself determines whether a policy commitment has any practical influence.

The implementation analysis could not be done without defining two key categories, namely outputs and outcomes. Outputs, thus, can be defined as specific policy interventions designed for particular issue. In other words, output analysis

the issues of defining and operationalizing the various choices at stake. In turn outcomes can be defined as actual achievements, whatever the objectives of policy may have been. They are real results, whether intended or unintended. Defining and analyzing outcomes often implies a certain degree of judgment, since it is based on the comparison of what was expected and what was actually achieved. It is frequently observed also that the achieved results do not entirely match the expected ones, thus so-called “implementation gap” emerges. The researcher, however, must be aware that using such type of categories can unintentionally bring normative statements in the analysis (Hill, Hupe, 2002).

As the EU is a focus of this research the number of reasons could be pointed out to which such gap could be attributed. For instance, due to subsidiarity principle the implementation is at hand of the Member States, thus there is a discrepancy between those who adopt the decision and those who implement it, besides implementation is often done unevenly since it is largely rely on the national context and available resources. Moreover, in the EU implementation of each policy has two dimensions: first is a formal transposition of European rules into the national legal and administrative provisions, second is practical implementation of those provisions in the national regulatory practice (Knill and Liefferink, 2007). If the formal transposition of laws can be monitored quiet effectively, the practical implementation is not so easily assessed. Furthermore, number of problems is particularly related to the problem field in focus (environmental). Such as the scope of the problem dispersed across the levels, i.e. the very local problem can have regional, national or even global effects or vice versa. Accordingly, the level of policy making should be adapted to the scale of the problem. Moreover, the nature of environmental problems is highly complex and the expert information is often ambiguous and not complete, so the policy cycle is attributed with high degree of uncertainty.

The attempt to explore the particular challenges and opportunities of the EU MLG system on the example of Natura 2000 policy using the above mentioned conceptual considerations is made in the section below. It is then proceeds with brief comparison of Polish and Slovak cases and provides conclusions. The research is based on the materials of the interviews with broad range of the relevant EU, national, non-governmental and other stakeholders, as well as official documents, project reports, and scholarly literature.

**Results and discussion.** As each complex political process the compliance with the EU nature conservation policy brought certain opportunities and challenges to the Carpathian countries. Opportunities wise the Natura 2000 regulation provides an incentive to change the management structure and more important the general approach of the state institutions towards protected areas and encouraged them to develop participatory model with broader inclusion of NGOs and local activists groups, presenting various interests, so far it has mainly been local tourist firms (Kluvankova-Oravska, Chobotova, 2010).

The EU regulation also provides an alternative channel through which issues related to the nature conservation can be pushed forward. For instance, there is a case of yearly ban on wolf hunting in Slovakia, as a result of the complaint filed by several NGOs from the region, since hunting on the strictly protected wolf species is perceived unsustainable due to the uncertainty of the actual population number (Representative of NGO “Wolf”, 2013). Furthermore, it also provides an opportunity of the capacity building and knowledge sharing through various activities and available funds. In addition to this, an experience from several projects shows that from practitioners and

experts sides there are interests in collaboration and knowledge sharing with countries across the region. Since it is recognized that faced challenges are in many regards common to some extent possible solutions might be also similar. It is hard to evaluate, whether it is related to a particular policy or in general to the shifts of attitudes. However, the EU and other international institutions (i.e. the Carpathian Convention) may act as an umbrella for such collaboration (WWF representative, 2013).

In terms of challenges following ones can be distinguished. The compliance with the Habitats Directive was a part of the accession processes, thus preparation in majority of the Carpathian countries started before the actual accession in 2004. Albeit, the deadline for the designation process has been postponed several times and lists of SACs were finalized only at the end of 2012. The delay in the processes is not an exclusive characteristic of the Carpathian countries. At the current stage countries mainly deal with the adoption of management plans for the designated sites, as well as further incorporation of Natura 2000 network in the structure and activities of existing nature conservation policy. To the problems mentioned above related to designation and present management issues of Natura 2000 in CEE realities several others were added. First of all, various institutional and cultural challenges starting with the legacies of top-down approaches combined with the absent tradition of participation that seriously limited the application of policy component of participation.

Secondly, as have been noticed by various interviewees, at the national level there is a very strong development incentives, thus nature conservation is not highly prioritized. Furthermore, the coordination and communication among different policy sector is rather weak, thus sectors that provide development opportunities and economic benefits obviously have a higher priorities.

Thirdly, the further constraints are laid in the policy financing and undefined responsibility for the coordination of available resources. At the national level in the majority of the countries there were and still is not enough funding available. At the initial stage the experience in acquiring EU funds for program's implementation was very limited, as well as the capacity to use such funds (Grodzinska-Jurczak, Cent, 2011).

Fourthly, above mentioned challenges were combined with the particular local situation, namely, the greater dependency of local communities on natural resources due to the economic hardship. As a consequence local people mainly see PAs as a restriction to their use of natural resources, which comes with no or very limited and hard to access compensation that in turn brings a hostile attitude towards the nature conservation in general and Natura 2000 in particular (Lawrence, 2008). Responding to this challenge, around the region currently number of projects is working with local authorities and citizens raising the awareness about the issue of nature conservation and the added values of the PAs, including the topic of alternative income generation from the PAs (CC representative, 2013).

Furthermore national governments often took an ambiguous position agreeing to the EU requirements, but not providing further necessary actions for its implementation either due to the budget constraints, or to the conflict of interests. In some cases (e.g. Poland), Natura 2000 due to the previous efforts in nature conservation was understood solely as a restrictive measure "additional burden" especially on the municipal level (Klůvankova-Oravska et al., 2009)

Nevertheless the process of site designation is officially finalized with only some minor law transposition and designation issues that most likely will not be pursued forward by the Commission. The total amount of land surface covered by Natura 2000 network in the Carpathian countries is higher than the EU27 average, which

could be attributed to the biodiversity richness of these countries (DG Environment Representative, 2013).

However, it is also important to mention that currently the Carpathian countries entered active practical stage of implementation, since the designation was finalized in 2012. Thus overall long-term outcomes of policy implementation to large extent will depend on the establishment of effective enforcement mechanisms and management structures for this policy area.

Another important characteristic of nature conservation policy in the region is the multi-stakeholder project driven policy development. Namely, due to the limited funds available from the national budgets policy innovations and to some extent implementation is done through international projects (e.g. *Bioregio* <http://www.bioregio-carpathians.eu/> *AKK Centrope* <http://www.centrope.com/en/centrope-project/centrope-initiative>). The funding for such projects often comes from the EU, INGOs, national development agencies (e.g. Swiss, Norwegian), the Carpathian Convention, and private companies. On the one hand, it brings additional resources, knowledge and capacities that sometimes lacking in the region. Furthermore, it allows concentration of the resources on the particular issue (e.g. establishment of regional information and monitoring system; science-policy interactions), which may be excluded or treated marginally in the national-policy due to the various factors. On the other hand, the follow-up of the projects are often not ensured, thus the results despite of all the efforts could be lost easily and rather than contribution it can become a loss of resources.

Despite of the shared common patterns in challenges and opportunities described above there were also significant differences in the countries of the region. The brief summary of the policy implementation in Poland and Slovakia is scrutinized in the table below.

**Table 1.** Implementation in Poland and Slovakia in brief

<i>Variable</i>	<i>Poland</i>	<i>Slovakia</i>
Formal transposition	Completed, only minor issues	Completed, issues with hunting
Attitudes	National authorities saw the policy as an "additional burden" (resulted in infringement)	No expressed opposition (no formal sanctions)
Practical implementation	Adoption of management plans (~25% have plans)	Adoption of management plans (only few sites have plans)
Institutional capacity	Strong institutional capacity	Moderate institutional capacity
Management structure	Clear management structure, designated government authority	Mixed management structure for different type of sites
Financing	Designated secured financial mechanism FEP	Greatly rely on external funds
Participation (site designation)	Expert driven designation with limited participation through non-binding public consultations	Government driven, limited participation through negotiations with land owners, non-binding public consultations, expert consultations
Participation (NGO involvement)	Fairly well-developed NGO sector, state co-financing of projects through FEP, limited capability to set the agenda	Fairly well-developed NGO sector, limited capability to set the agenda, financially more dependant on external funding
Tools	Multi-stakeholder projects as tool for implementation (SWISS, LIFE+)	

*Source:* Author's own elaborations based on the interviews with various national stakeholders

Both in Poland and Slovakia formal transposition of the EU legislation is completed and the current challenges are connected with the practical implementation of the Natura 2000 network, which included the adoption of the management plans and its further implementation, including securing resources, i.e. financing, staff and expertise. The development of the management plans in turn is closely related to the task of collecting or updating available data on the species and habitats. As regards, existing institutional structure and management capacities two countries have rather different approach. Both countries apart of the ministries of the environment have also specially designated management bodies: The General Directorate for Nature Protection in Poland and the State Nature Conservancy in Slovakia, which provides the general management of this policy area through available expertise and resources. However, for Natura 2000 network management responsibilities in Poland is assigned to the Regional Directorates for the Nature Protection, which are relatively independent and have certain amount of funds allocated for it. Whereas in Slovakia, the management of Natura 2000 sites is the responsibility of the land owner, which potentially can get compensation for these activities, but the procedure is rather complex so not everyone can access the funds.

Concerning financing of the nature conservation policy in general there is a key difference between Poland and Slovakia. In Poland the financing is ensured through Funds for environmental protection and water management (FEP), formed from the “green” taxes. It bares the costs related to the nature conservation policy by public entities and even provides co-financing for external projects (e.g. EU) for public and non-governmental organizations covering necessary contribution. In Slovakia the funding available for the nature conservation is mainly coming from the Operational Program for the Environment. i.e. the EU funding.

Last but not least, the participation process has been proven as one of the most challenging element of the implementation process as for the site-designation, as for practical implementation. Formally both countries included public consultation process as a part of designation process, however it did not have any legally-binding force. Thus even when participants expressed opposition in many cases the decision has been put forward, which in turn brought the feeling of distrust and hostility among affected groups. Finally, as regards inclusion of NGOs in the Natura 2000 policy processes. It might be noted that both in Poland and Slovakia the environmental NGO sector is fairly well-developed and as has been acknowledged by several interviewees the availability of the EU funds played a significant role in this capacity-building. However, it has been also noted that this reduced a critical capacity of NGOs to set an agenda, since in most of the cases they have to fit their projects in the frames of the existing funding streams. Also in both countries NGO representatives noted that governmental bodies are fairly easy accessible and it is possible to cooperate on the certain issues. However, in Poland NGOs played an active role in criticizing the site-designation process through development of so-called “Shadow List” (unofficial NGO inventory of the possible Natura sites) that was taken by the Commission for filing an infringement case.

**Conclusions.** Summing-up, the MLG concept is relatively well fit to explore the realities of the modern policy processes. Furthermore, the evidence of such structural changes reflected in all the stages of the policy cycle. In the implementation stage, it is particularly clear in the broader involvement of non-state actors, as well as through interconnectedness among involved stakeholders. As regards, implementation gap on the formal implementation stage it was mainly attributed to the delays in transposition

and site-designation, which however, is not exclusive characteristic of the Carpathian countries. Since above mentioned countries entered fairly recently the stage of the practical implementation it is hard to investigate the long-term consequences and whether such a “gap” will emerge and will influence the outcomes. Therefore, more research is needed in the due time to trace the possible consequences.

Furthermore at the national level in the Carpathian region the EU policy has had multiply effects. Such as it incentivized Member States to adapt the management structure and more important the general approach of the state institutions towards protected areas and encouraged them to work on the development of more inclusive and participatory model with collaboration with NGOs and local activists groups, not least it provided an access to the financial resources partially covering such implementation. However, it also brought about certain challenges, such as ones related to the process of implementation itself, i.e. complication related to the sites’ designation process. On the broader scope the range of challenges is related to the issues of environmental protection vs development and priorities associated to it, including the allocation of finances.

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## **Forum Carpaticum 2014** Local Responses to Global Challenges

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## Evaluation of social development on Natura 2000 sites in Poland with the use of Local Human Development Index (LHDI)

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**Key words:** biodiversity conservation, local development, protected areas, rural development

Challenges of local development at the European Ecological Network Natura 2000 sites and the actual effect of the program on real development opportunities and barriers are issues of interest to various groups: scientific community, policy makers and public institution (Cent et al., 2014). Natura 2000 challenges local development and requires innovating and pro-active attitudes of local governments in order to benefit rather than loose from its designation (Bołtromium, 2012). In order to meet this need, the local development requires support of knowledge-based policy and planning, sensitive to opportunities and obstacles created by Natura 2000 program (Evans, 2012; Grodzińska-Jurczak 2008, Grodzińska-Jurczak et al., 2012). However, systematic measurement of the actual impact of Natura 2000 on local development has been hardly practiced in Poland as well as in other European countries, mainly due to lack of adequate available data. Majority of the research focused on such issues has so far covered only selected regions, voivodships or particular sites, frequently providing only qualitative evidence focused on chosen social groups and institutions engaged in site designation, or using very specific methodology of measuring development, difficult to be replicated in the future on in other areas.

**Geographical setting.** Our work presents a country-wide analysis of local administrative units (powiat) in Poland. Using Local Human Development Index (LHDI) data from Poland (UNDP 2013) we compared social development levels in rural and urban areas with and without designated Natura 2000 sites, as well as explored spatial distribution of powiat's scores of the index, in order to estimate the actual influence of Natura 2000 on local development.

**Material and methods.** Local Human Development Index (LHDI) is a measure of social development, based on UNDP's index of human development (UNDP, 2013) and Amartya Sen's capacities approach to measuring social development (Sen, 2002), adjusted to characteristics of local level units within a certain country. It comprises of three partial indicators:

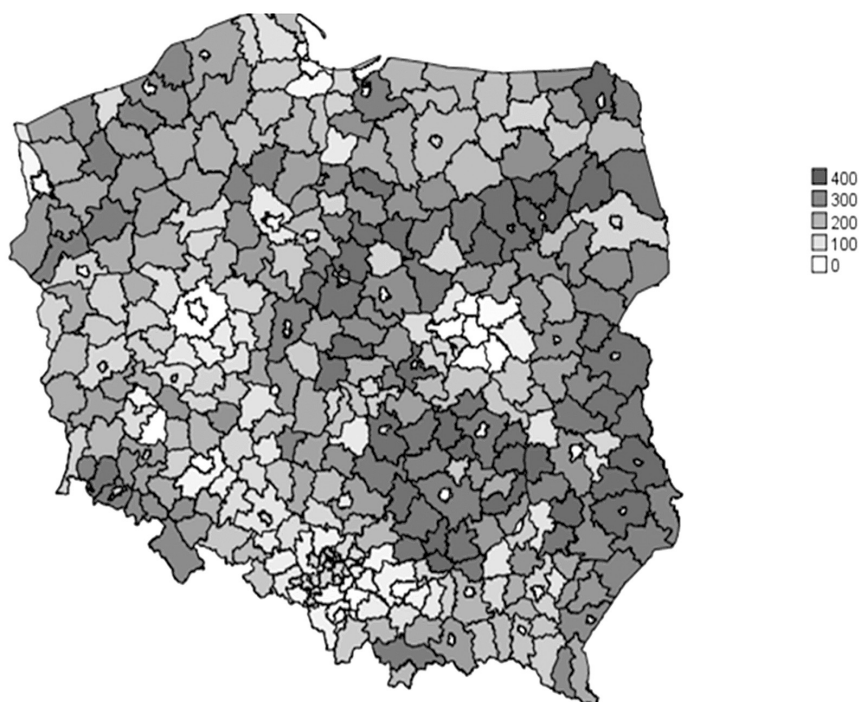
- health (including life expectancy at birth, deaths due to cardio diseases and cancer),
- education (enrollment in pre-school education, average results in the junior high school final exam),
- wealth (average wealth of citizens).

Additionally LHDI includes a measure of policy input into these three areas (LHDIPI), based on information on public expenditures.

The LHDI data for years of 2007-2010 was obtained from the Polish report (UNDP, 2013). Information about designation of Natura 2000 sites and the size of sites was

achieved directly from the Polish Ministry of the Environment and represented the state of Natura 2000 network in 2013.

**Results and discussion.** First of all, trends in social development are mainly linked to central or peripheral location of powiats (Figure 1). Powiats situated close to urbanized areas and bigger cities score better on the index. However, Natura 2000 site designation tend to be larger and more frequently located in peripheral region, which are less urbanized, often include agriculture areas of less intensive use and lesser development pressure on existing ecosystems. Powiats without Natura 2000 spend more resources in the area of health, education and wealth than powiats covered with Natura 2000 (Table 2), which might be due to overall better economic situation of centrally located areas, rather than influence of Natura 2000 designation.



**Fig. 1.** The LHD index positions of powiats related to Natura 2000. The darker color means the lower score of the index

Secondly, urban powiats use development opportunities originated from Natura more effectively than rural powiats (Table 1). Urban powiats with Natura 2000 tend to score better than urban powiats without Natura 2000, while rural powiats with Natura 2000 score significantly worse than the rural powiats without Natura 2000. Also, the LHD index scores of all powiats hardly changed within the analyzed period.

**Table 1.** Mean score of powiats of LHDI ranking in selected years, with distinguished scores for rural and urban powiats, and powiats with and without Natura 2000 sites

<i>Scores of LHDI</i>		<i>LHDI score</i>	<i>LHDI</i>	<i>LHDI score</i>	<i>LHDI</i>	
		<i>in 2010</i>	<i>score in</i>	<i>in 2008</i>	<i>score in</i>	
			<i>2009</i>		<i>2007</i>	
Urban powiats	Powiats with Natura 2000	Mean	53,36	51,55	51,69	52
		N	42	42	42	42
	Powiats without Natura 2000	Mean	64,87	71,7	69,22	71,13
		N	23	23	23	23
	Total urban powiats	Mean	57,43	58,68	57,89	58,77
		N	65	65	65	65
Rural powiats	Powiats with Natura 2000	Mean	219,83*	219,51*	219,84*	219,44*
		N	303	303	303	303
	Powiats without Natura 2000	Mean	151,82*	153,18*	148,64*	154,55*
		N	11	11	11	11
	Total rural powiats	Mean	217,44	217,18	217,35	217,17
		N	314	314	314	314
Total	Powiat with Natura 2000	Mean	199,56	199,06	199,37	199,06
		N	345	345	345	345
	Powiats without Natura 2000	Mean	93	98,06	94,91	98,12
		N	34	34	34	34
	Total (all powiats)	Mean	190	190	190	190
		N	379	379	379	379

\*Differences between powiat with and without Natura 2000 that are statistically significant,  $p < 0,05$

**Table 2.** Mean score of powiats of LHDIPi ranking with distinguished scores of rural and urban powiats with and without Natura 2000 sites

<i>Scores of LHDIPi</i>			
Urban powiats	Powiats with Natura 2000	Mean	53,36
	Powiat without Natura 2000	N	42
	Powiats without Natura 2000	Mean	64,87
	Powiat without Natura 2000	N	23

\*Differences between powiat with and without Natura 2000 that are statistically significant,  $p < 0,05$

Thirdly, the size of Natura 2000 sites doesn't matter for the social development of powiats. There was no correlation between percentage of powiat's area covered by Natura 2000 and its score of the index.

**Conclusions.** The results confirm that the role of Natura 2000 is especially important for planning development in rural areas and in periphery regions. So far, designation of Natura 2000 sites is not a major determinant of local development; however its role might increase in the future. The program can potentially either support or hinder local development (Stanny, 2011).

In general, Polish municipalities and other local units (as powiats) increased their incomes and expenditures in the period 2001-2008; however the dynamics of budget changes differ among units with and without Natura 2000 areas (Pięcek, 2011). Surprisingly, rural units with Natura 2000 sites, despite their peripheral location, tend to have higher income and larger expenditures on social development than similar units without Natura 2000 sites.

The results justify a need for further studies and assessments on these issues in longer time perspective – the analysis revealed some visible and statistically significant trends, however influence of Natura 2000 on local development need to be monitored and analyzed in a longer time period. The presented analysis is to be continued in the future with the use of available public data. Its' application enriches a knowledge-based management of mountain regions and social development in the vicinity of and within protected areas. It also presents important fact in the current discussion on introduction of ecological subventions in Poland.

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## Improving Rural Tourism Training – An approach based on understanding local communities' needs

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**Key words:** rural tourism, community needs' analysis, competencies, e-learning

Diversifying rural livelihoods through rural tourism development is meanwhile targeted intensively in academic research. However, it has also entered the tourism policy discussion of many European countries.

In the framework of InRuTou, a project financed by the European Commission within the Life Long Learning programme, an analysis was conducted that was striving to identify the weaknesses and associated therewith, the needs, which local stakeholders show in terms of rural tourism development.

Literature research, community consultations conducted in the study regions and a standardized questionnaire survey formed the basis for this analysis. The study area thereby comprised regions of the Alps, the Apennines and the Carpathians.

“There exist no destination management organizations or even tour-operators. Their functions are taken on by other tourism actors, such as accommodation owners, people selling food and beverages or people taking care of specific visitor attractions. Thus, everybody is acting separately, no common positioning as a sector exists and there is a lack of coordination or supporting services.” (Community consultation report, Ukraine, 2013)

Results show that – although being from different countries and social, cultural and economic backgrounds – rural mountain communities face similar needs with respect to successful rural tourism development. Moreover, core competencies necessary for empowering local actors of these communities in the field of tourism are overall corresponding thematically to these needs. The findings of this study should be integrated when developing a tourism training approach, which is targeted to peripheral mountain regions.

**Theoretical Background.** Rural tourism is an important economic activity in the European Union, and it has been defined as an alternative form for economic growth and regional development in many rural areas (Buhalis, Deimezi, 2004; Chen, et al., 2013; Iorio, Corsale, 2010; Phillips et al 2013; Ray et al., 2012). Tourism is considered as a powerful means for socio-economic development and regeneration of rural areas, particularly for those affected by the decline of traditional agrarian activities (Chen et al., 2013) and those endorsed with natural beauty (Deller, Lledo, 2007).

Briedenhann and Wickens (2004), argue that rural tourism can be viewed as an answer to a series of difficulties rural areas are experiencing. It can contribute to improving living conditions of rural communities (Clark, Chabrel, 2007) by increasing public interest, which is due to the growing demand to implement leisure and tourism activities in rural territories (Lane, 2009; Sharpley, Roberts, 2004). Rural

tourism provides multiple benefits to local communities including the generation of new businesses, the improvement of infrastructure and services, the sustainability of the natural environment and landscapes, and cultural enrichment to the local people (Cánoves et al., 2004).

Literature about rural tourism competencies and skills is scarce and fragmented: research suggests that there is a gap regarding the framework of competencies needed by rural tourism managers (Kunjiapu, Yasin, 2010; Page, Getz, 1997) to excel in the modern competitive tourism arena. Furthermore, tourism is a very complex domain integrating a wide range of knowledge, skills and attitudes that are needed in order to develop, enhance and sustain (rural) tourism businesses (Tribe, 2002). Thus, working on competencies means the creating competitive advantage for the organizations (Kunjiapu, Yasin, 2010). Already in 1997, Page & Getz highlighted the fact that rural tourism managers, who often lack in previous experience and formal business education, might need formal management training in order to drive their business to success. European Union data reveal that the majority of EU managers have already acquired some training and practical work (EU, 2012).

**Geographical setting.** The study area comprised regions of the Alps, the Apennines and the Carpathians, including the following areas: the 'Nationalpark Kalkalpen Region' (Austria), the 'Parco naturale regionale dell'Aveto' (Italy), the 'Tara Dornelor' (Romania), the 'Beskidy Mountains' (Poland), the 'Kosiv district' (Ukraine) and the Storozhynestky rayon (Ukraine).

**Material and methods.** The study is based on two methodological approaches in order to best address the complexity of the subject. Integrating the results from a quantitative questionnaire survey and community consultations allowed for a more complex assessment of the needs' of the local population and the gaps regarding rural tourism development.

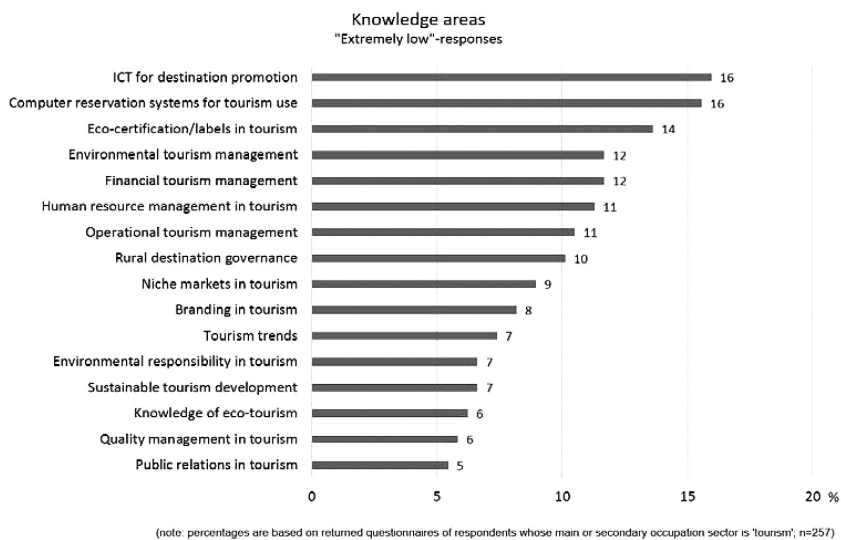
Thus, the needs' assessment is based on community consultations conducted in five countries across the Alps, the Apennines and the Carpathians as well as on a parallel questionnaire survey. The community consultations were carried out from May to October 2013. Various techniques – qualitative interviews, focus groups and workshops – were applied during the community consultations. The results of these meetings, which are outlined in the following section, were recorded based on structured documentation sheets that included the following aspects: social, economic and environmental background, current positioning of the tourism sector, potential for further tourism development and commitment of the local population.

Moreover, results from a needs' analysis, which was implemented on the basis of a standardized questionnaire survey, are shown. This survey was conducted from July to October 2013 among local stakeholders of the above mentioned regions. The total sample consists of 434 questionnaires (convenience sample) and it was collected both, face-to-face and online.

**Results and discussion.** The results of the community consultations reveal a lack of tourism infrastructures across the analyzed rural mountain areas. In most cases there exists a reasonable number of accommodation structures, although these are often showing deficiencies regarding quality. On the other hand, there exist very few tourism infrastructures in addition to accommodation, such as gastronomic facilities, hiring services or mobility solutions. Thus, the lack of infrastructure is strongly interconnected with the low number of services available in rural mountain areas. An aspect that has not only be delineated within the community consultations, but is also reflected through the survey among local stakeholders: only 9% of the respondents

work in the area of food and beverages, 3% in travel services and 2% in the area of culture and visitor attractions, whereas 14% of respondents work in the accommodation sector. Hence, there seems to be a shortage of entrepreneurial initiatives, which needs to be overcome for successful rural tourism development. It is particularly necessary to foster this entrepreneurial spirit among the young generation, which often considers working in the tourism sector unattractive due to low salaries and limited perspectives and consequently migrates away from local villages.

Moreover, there was identified a lack of skills and knowledge regarding the adequate valorization of the local communities' cultural and natural heritage. Rural mountain areas commonly feature unique landscapes and authentic cultural features. They are attractive for visitors because they offer outdoor leisure and sport activities, but also because they enable guests to immerse themselves into the traditions and customs of the local population. However, local actors affirm to have deficiencies regarding knowledge and skills in tourism, which both are needed to take advantage of the regions' assets. This lack of specific knowledge is also shown through the questionnaire survey. Respondents estimate their performance regarding various knowledge areas in tourism to be rather poor. There seems to be existing particularly little knowledge in terms of management aspects, such as environmental tourism management, financial tourism management, human resource management and operational tourism management (Fig.1). Lacking specific knowledge, the inhabitants of rural mountain communities are unlikely to take full economic advantage of their heritage.



**Fig. 1.** Local actors' performance regarding various knowledge areas ('extremely low'-responses)

Moreover, the lack of management skills is related to a scarcity of destination management organisation (DMO), which is confirmed by the local actors. These organizations are fundamental for the successful management and governance of tourism development processes. Tourism associations or DMOs can play an important

role in the context of marketing a destination, however particularly in regions where they do not exist, entrepreneurial activities by single individuals may continue to be elementary. Overall, the scarcity of information about the regions outside of them – including a lack of advertising and clear positioning – is regarded as a problem.

In addition, figure 1 shows the two most significant deficiencies in knowledge, which are both related to modern information and communication technologies. ‘ICT for destination promotion’ and ‘computer reservation systems for tourism use’ are the areas, with the highest percentage of respondents (16%) indicating to have extremely low knowledge. At the same time, local actors consider integrating ICT technologies a crucial aspect in creating an image of a destination and for marketing products and services.

On the other hand, eco- or environmentally related aspects, such as ‘environmental responsibility in tourism’ (7%), ‘sustainable tourism development’ (7%) and ‘knowledge of eco-tourism’ (6%) show fewer “extremely low” responses. This might indicate that respondents are to some extent familiar with the idea of a sustainable or environmentally-conscious tourism development in general, but at the same time feel unacquainted with specific formal issues, such as eco-certification processes (14%) and environmental tourism management (12%). Moreover, local actors of rural mountain regions outline that landscape diversity, which is often ascribed to the existence of a protected area, but especially also cultural heritage - including architectural buildings, historical sites or traditional festivals - are ideal prerequisites for developing a sustainable rural tourism. Typical gastronomic products and traditional handicrafts provide further potential for authentic rural tourism experiences.

The lack of information exchange and coordination among the local actors often poses a significant drawback to the development of successful rural tourism initiatives, thus internal and external cooperations remain fundamental. However, local actors do not only need to generate networks, but it is also necessary to show a long-term commitment to tourism development. This is also reflected in the survey, as respondents overall are more likely to “totally agree” with those items, which are related to the whole community than with those that are related to the individual, e.g. close to half of the respondents (48%; n=434) totally agree that the ‘support of all local stakeholders is needed for the development of sustainable tourism activities’.

**Conclusions.** The present study reveals the following main challenges that seem to be fundamental for empowering local actors in the field of rural tourism:

- lack of entrepreneurial spirit, knowledge and skills in terms of tourism management,
- insufficiency of accommodation structures and services in terms of quality and quantity,
- inadequate valorization of cultural and natural heritage,
- weak national and international marketing of the regions, partly due to a lack of destination management organizations,
- lack of cooperation as well as personal long-term commitment among the local population,
- deficiencies regarding the use of modern information and communication technologies for destination promotion and product distribution,
- need to further benefit from the unique mountainous landscapes as well as traditions in the context of sustainable and ecological tourism development.

Integrating these main challenges into an innovative training approach is important.



Ultimately, based on the research, several policy recommendations have been elaborated: a) Using education, awareness-raising and vocational training as means for tourism development; b) Involvement of a diverse set of individuals and institutions; c) Establishing and ensuring continuous networking and cooperation.

*How general conclusions concern the pilot areas in Ukraine.* The above conclusions and recommendations are generally relevant for the two InRuTou pilot regions of Ukraine: Kosiv and Storozhynets. At the same time, all pilot areas of the project are unique and exhibit their own special aspects; even the two Ukrainian areas have different cultural traditions and natural features, as well as different experiences in organizing rural tourism. Kosiv region, for example, is well known in Ukraine as a destination of cultural heritage and handicrafts; as such, the conclusion “Inadequate valorization of cultural and natural heritage” does not fully apply to this region. At the same time, such conclusion as the “lack of destination management organizations” and the “lack of cooperation among the local population” is most relevant for this area, as well as for Storozhynets. The “use of modern information and communication technologies for destination promotion and product distribution” is very important for both pilots of Ukraine, as well as involving young generation in rural tourism and intergenerational cooperation. Given the above, the Ukrainian partners will adopt the project training materials as relevant for the concrete needs of each region and focus in the training process on the local necessities recognized during the community consultations.

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## Potentials for integrating intergenerational practices into rural tourism development and protected area management in the Carpathians

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**Key words:** Intergenerational practice, intergenerational learning, rural tourism development, protected area management, Carpathian Mountains

Carpathian Mountains is an example of a European mountainous region, a center of natural and cultural diversity. However, its inhabitants are facing a lack of economic opportunities and limited possibilities to participate in the development process. Just as in other rural mountainous regions, this causes outmigration of the population, abandonment of rural settlements, particularly by the younger generations, which could lead to a loss of cultural traditions and degradation of cultural landscape features (Jansky et al., 2002; Jandl et al., 2008; Maselli, 2012). Moreover, the outmigration of the younger generations to the city centers causes the lack of new ideas and skills, such as new media and communications, entrepreneurial skills, useful to develop the rural regions. The remaining population, often of the older generation, is facing a lack of infrastructure and even less economic opportunities.

In order to address such challenges cooperatively, the Carpathian countries have committed to sustainable development and natural protection through their participation in the Framework Convention for the Protection and Sustainable Development of the Carpathian Mountains (Carpathian Convention, 2014). Practices and experience under the Carpathian Convention could be considered as a showcase of the sustainable regional mountain development initiatives on an international level. Three protocols of the Carpathian Convention have been elaborated: the Biodiversity Protocol, the Forestry and Tourism protocols, and the Cultural Heritage protocol is being elaborated. The protocols are implemented through projects.

Sustainable tourism is an important approach to development of rural mountainous regions. Both the traditional knowledge of the older generation and innovative approach of the younger generation are necessary components of rural tourism development initiatives. While the importance of cultural heritage and innovative approaches for tourism development is reflected in sustainable tourism research and policy (Aas et al., 2005; Choi, Sirakaya, 2006; Carpathian Convention, 2013), they are rarely approached from the point of view of younger and older population, holders of these specific knowledge and skills.

Another focus of sustainable regional development efforts, including in the Carpathian region, is protection of biodiversity, natural resources and unique natural landscapes via establishment of protected areas. Literature dealing with landscape policy and protected area management increasingly addresses the need for integration

of local values and perceptions into protected area management, (Zanon, Geneletti, 2011; Conrad et al., 2011a, 2011b). Such vision is especially relevant for the highly populated landscapes of the Carpathians.

In fact, objectives of many protected areas encompass more than nature protection. They include preserving traditional and cultural practices, supporting socio-economic development of the surrounding local communities, such as through tourism development, as well as education and research (Thomas, Middleton, 2003; Wallsten, 2003; Dredge, Thomas, 2009; Getzner et al., 2010). Research on nature conservation and sustainable tourism development acknowledges the importance of participation (Conrad et al., 2011a, 2011b) and co-management by local stakeholders (Armitage et al., 2008; Heeb, Hindenlang, 2008; Berkes, 2009; Brummel et al., 2010). However, community participation poses a number of challenges in itself, such as the lack of interest, skills, time and financial resources among the prospective stakeholders.

This paper aims at proposing an approach, which has been shown as useful in addressing several of the above challenges, including that of the tourism development: intergenerational learning and practice (Mitrofanenko et al. Paper in review).

***Intergenerational learning and practice.*** Intergenerational learning and practice are not new concepts. They have provided an informal way of transferring “knowledge, skills, competencies, norms and values” for centuries within families (Hoff, 2007 in Newman, Hatton-Yeo, 2008), and have become more relevant in a broader “extra-familial” social context to-date (Boström, 2003; Newman, Hatton-Yeo, 2008).

*“Intergenerational learning is a process, through which individuals of all ages acquire skills and knowledge, but also attitudes and values, from daily experience, from all available resources and from all influences in their own ‘life worlds’.”* (EAGLE, 2008).

Intergenerational practice is a more tangible and practicle concept. It *“aims to bring people together in purposeful, mutually beneficial activities, which promote greater understanding and respect between generations and may contribute to building more cohesive communities”* (EAGLE, 2008).

Intergenerational practice has received increasing attention due to demographic changes, such as aging and changing family structures. It usually happens via activities in both formal and informal atmosphere, and aims at benefits to both participants and wider communities. Older participants often share traditional or professional knowledge and the younger ones - technical skills; at the same time, personal stories are also shared. This exchange of values and knowledge can lead to enhanced communication in communities, capacity building and participation in community development – useful both in the context of nature protection and sustainable tourism development.

Its role is recognized in developing sustainable communities (Buffel et al., 2014), and leading to more inclusive and cohesive societies (Newman, Hatton-Yeo, 2008). One of its principles is that younger generations can also provide knowledge and influence views and behavior of their older counterparts (Maddox et al., 2011).

***Intergenerational practice as a factor in protected area management in the context of sustainable tourism development.*** Protected areas, often situated in mountain areas, are supposed to support socio-economic development of the neighboring communities, including through supporting tourism development. Intergenerational activities, organized by the protected areas, can facilitate their role in community development, as well as in implementing other management objectives.

Several studies suggest potential impacts of intergenerational activities on

environmental regeneration and preservation activities (Sanches et al., 2008; Springate et al., 2008; Buffel et al., 2014), and several practical examples exist of environmental organizations using intergenerational activities to safeguard the environment. The US Environmental Protection Agency, for example, organizes and promotes intergenerational activities via its Aging Initiative (US EPA, 2013). The World Conservation Union (IUCN), and the WILD foundation (USA) piloted initiatives explicitly focused on intergenerational cooperation in the context of nature protection, such as the Intergenerational Partnership of the IUCN (Hesselink, 2008; WILD Foundation, 2014).

Another example is that of the pilot project “Big Foot. Crossing Generations, Crossing Mountains”, in which the United Nations Environment Programme, Vienna - Interim Secretariat of the Carpathian Convention (UNEP Vienna - ISCC) acted as a partner. The Project, funded by the European Commission, aimed at testing an intergenerational learning approach to sustainable development, and especially in the context of nature protection and tourism development.

The objectives of the given paper is to examine potentials for integration of intergenerational practice into protected areas management in the context of sustainable tourism development of the rural mountainous communities, on the basis of the Big Foot project (Mitrofanenko et al. Paper in review) and its integration into the practices of the Carpathian Convention.

**Geographical setting.** The Big Foot Project activities took place in three rural mountain communities: Berkovitsa, Bulgaria (43.2333° N, 23.1167° E); Trikala, Greece (39.5500° N, 21.7667° E); and Gubbio, Italy (43.3500° N, 12.5667° E). UNEP Vienna - ISCC was tasked with transferring the project results to the Carpathian countries: Carpathian country: Czech Republic, Hungary, Poland, Romania, Serbia, Slovak Republic, and Ukraine.

**Material and methods.** The empirical basis of the paper is an mixed methodological approach, including literature review, a survey of existing intergenerational initiatives, semi-structured interviews with nine regional development experts and twelve protected area managers from the Carpathian region, and three case studies from the Big Foot Project. The lead author participated in project activities, maintained the website, informed Carpathian Convention stakeholders about the project, conducted semi-structured interactive interviews with the project managers from pilot countries and examined the project documents, such as the Participatory Mapping Guidelines and Intergenerational Approach Handbook, and compiled a Big Foot Transferability Tool Kit (Mitrofanenko et al., 2013).

**Results and discussion.** Interviewed protected area managers at first were mostly surprised by the suggestion that intergenerational activities could be relevant for protected area management and involvement in tourism development. However, throughout the discussion, they provided examples of existing or potentially useful initiatives in their respective protected areas, such as educational activities or preservation of traditional land use practices. However, none of them exhibited a clear understanding of intergenerational practice. Most of the interviewed experts, however, seemed more familiar with the potential of intergenerational practice to strengthen participatory conservation and tourism development initiatives.

The Results indicate that ingergenerational learning could contribute to dealing with the following challenges of protected area management:

- socio-Economic development,
- professional development,

- broader funding opportunities,
- protection of biological and cultural diversity,
- vocational educational training,
- volunteer recruitment,
- awareness raising and participation,
- education,
- research.

With respect to tourism development, in cooperation with protected areas, intergenerational practice could be useful in the following proposed ways: (1) developing offers for the local population and (2) cooperating with the local community on promoting sustainable tourism development.

In the first case, protected areas could develop activities, suitable for people of younger and older ages, and focused on attracting intergenerational groups, for example, via organizing training courses and events, or via volunteer programmes, in cooperation with the local schools and/or retired professionals.

In the second, intergenerational practice can facilitate community-based tourism development, by using traditional knowledge of the older population, while at the same time catering especially to the younger and older tourists, and promoting innovative offers via new media with the help of the younger generations.

**Conclusions.** The potentials of incorporating intergenerational activities into sustainable regional development are not yet fully explored, however, the results suggest possible benefits for nature conservation and tourism development, such as addressing challenges related to community participation, training and knowledge-related processes. The authors recommend incorporating intergenerational practice into community tourism development and protected area management on the local, national, macro-regional, and international levels (Mitrofanenko et al. Paper in review).

With respect to the Carpathian region, integration of intergenerational activities into tourism and nature conservation activities could be facilitated by introducing this approach to the Carpathian Network of Protected Areas, and the working groups on Biodiversity, Sustainable tourism development and Cultural heritage and traditional knowledge. Moreover, funding mechanisms should be used to develop projects, with participation of protected areas, supporting joint actions in the field of awareness raising, public participation, and tourism development.

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## The opportunities for the sustainable development of the Ukrainian Carpathians

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**Key words:** energy efficiency, environmental protection, potential of tourism and recreation, investment policy, socio-economic model

Environmental policy in modern conditions acquires new features. This requires special attention to the development of interdisciplinary research and careful attention not only to the current, but also to possible future problems. Under conditions of globalization, an increasingly important role for the human civilization begins to play the mountainous regions, which preserved the unique “islands” of biodiversity and clean environment. In this paper the question of creation the conditions for formation the sustainable development the Ukrainian Carpathian are considered. It is analyzed the opportunities of increasing the potential of recreation industry and minimization of negative influence the human activity on the environment.

**Material and methods.** In this paper we have used the quantitative and qualitative methods of research, including quantitative methods of diagnosis and modeling of impact the same factors of human and economic activity on the Carpathian ecology. The methods of performance of this paper include analysis of law and scientific literature (Kravtsiv, Zuk, 1993; Körner, 2009; Hamor, 2010; Pomázi, Szabó, 2010; Bjørnsen, 2013; Hämäläinen, 2013; Lessmann, Rauschmayer, 2013), systematization of approaches to the formation the potential of development the Ukrainian Carpathian, and also analysis and synthesis, comparison and modeling the processes of influence same factors on the specific the regional development.

**Results and discussion.** Ukrainian Carpathians have considerable potential of their development. However, it is used unsatisfactorily and in many cases suffers tremendous damage. Similar things occur under the influence various factors. However, in most cases the causes of problems only ascertained and the necessary steps to correct the existing condition are not accepted.

Current Ukrainian legislation recognized that anthropogenic and human impacts on the environment in Ukraine are several times higher than the corresponding rates in developed countries. The root causes of environmental problems in Ukraine are: inherited economic structure, depreciation of fixed assets, the current system of state administration in the field of environmental protection, the lack of clear division of environmental and economic functions and formation of civil society, the lack of understanding in the community priorities for preserving the environment and benefits sustainable development and also non-compliance of laws concerning environment protection. Of the common processes of land degradation the most widely are the erosion (about 57,5 percent of the territory), pollution (20% of the territory), flooding (about 12 % of the territory). Nutrient content of the soil reduces and annual losses of humus make up 0.65 tons per 1 hectare. Forests cover more than 15,7 % of Ukraine (9,58 million hectares), located mainly in the north (Polissia) and west (the Carpathians). To achieve the

optimal rate of forest cover (20 %) is necessary to create more than 2 million hectares of new forests (VR, no date).

Occupying less than 6% of Europe, Ukraine has about 35% of its biodiversity (Biosphere of Ukraine has over 70,000 species of flora and fauna, including flora – more than 27 thousand species of fauna – more than 45 thousand species. Prior to the nature reserve fund of Ukraine includes more than 7608 areas and sites with a total area of 3,2 million hectares (5,4% of the total area of the country) and 402,5 hectares within the Black sea. Much of the biodiversity in Ukraine concentrated in the Carpathians. Nevertheless, the proportion of protected areas in Ukraine is insufficient and remains much lower than in most European countries (VR, no date).

Since 1990, there have been great divergences in GDP growth between the Carpathian countries. In Ukraine, after the collapse of Soviet Union, there has been an almost decade long and very deep economic decline. Ukraine has not even reached its level of economic output in 1990. The economic transition towards market economy has been accompanied by high inflation rate. Since autumn of 2008, Ukraine and Romania were hit by global financing and economic crisis which is now penetrating into the social sphere. All Carpathian countries show marked turn-down in GDP. In 2009 Ukraine represented the highest rate decline (-15,3%), followed by Romania (-8%), Hungary (-6,3%) and Slovakia (-5,8%) (Pomázi, Szabó, 2010).

Over the past decade, the national economies of the Carpathian countries have been significantly restructured. For example, the expansion of the service sector exceeded the growth rate of all the other sectors and in 2008 accounted for over 60% of the GDP in three countries (Table. 1, Pomázi, Szabó, 2010).

**Table 1.** Structural changes in the Carpathian countries, 1990 and 2008 (Value added, % of GDP, Pomázi, Szabó, 2010)

<i>Country</i>	<i>1990</i>			<i>2008</i>		
	<i>Agriculture</i>	<i>Industry</i>	<i>Services</i>	<i>Agriculture</i>	<i>Industry</i>	<i>Services</i>
Czech Republic	6,24	48,75	45,01	2,33	37,56	60,11
Hungary	14,54	39,06	46,40	4,31	29,45	66,25
Poland	8,26	50,11	41,63	4,18	30,35	65,47
Romania	23,74	49,94	26,32	8,05	33,96	57,99
Serbia*	...	...	...	12,96	28,44	58,61
Slovakia	7,41	59,14	33,45	3,61	41,22	55,17
Ukraine	25,57	44,57	29,86	8,33	36,89	54,78

Apparently, Ukraine compared to other countries Carpathian region (except Serbia) has a much larger share of the agricultural sector and lags behind concerning development of services. This involves attracting more attention to the structural changes for the benefit enlargement the provision of services, and therefore for the improvement transport and tourist infrastructure.

Therefore, to ensure the sustainable development of mountain regions of the Carpathians in Ukraine is important to develop new approaches to address the socio-economic and environmental problems. However, the problems of mountain areas in the Carpathians are not only in Ukraine but also in other countries.

Until recently, the significance of the Carpathian mountain research to the global mountain research community has not been adequately reflected. Even though this eco-region offers perfect conditions for a “natural laboratory” for global change research

and has a rich mountain research history of its own with a wealth of local expertise and data, publishing in international journals was relatively low (Körner 2009).

The idea of the Science for the Carpathians initiative goes back to the negotiation process of the Framework Convention on the Protection and Sustainable Development of the Carpathians (Carpathian Convention) in 2001. The Ukrainian Government requested the United Nations Environment Programme – Regional Office for Europe (UNEP/ROE) to facilitate an intergovernmental consultation process among the Carpathian countries with the aim of drafting an international convention on the Carpathian mountains to be adopted at the Fifth Ministerial Conference “Environment for Europe” in 2003 (Bjørnsen, 2013).

The Carpathians are one of the most environmentally sensitive areas of Europe. In many places here goes an excessive exploitation of natural resources, particularly deforestation. Especially threatening situation in this context observed in Ukrainian and Slovak part of the mountain array. For example, in northern slopes highest Ukrainian top of the mountain Goverla annually cut down about 40 thousand m<sup>3</sup> of wood. Only in recent years on the lands projected to generate protected areas are completely cut down more than 300 hectares of forest water regulation. This leads to disruption of the natural balance, leading to the degradation of scenic landscapes, habitats decrease, and sometimes to the extinction of many rare species of plants and animals, a significant gap in socio-economic development of this region and rise to catastrophic natural disasters (Hamor, 2010).

The highest mountain region of Ukraine is the Ukrainian Carpathians. The territory of the region requires special attention for him, given his role in the recreational industry and the need to maintain the diversity of flora and fauna, as it is here preserved some unique forms of plant and animal life.

The potential of tourism and recreation in Ukraine is used not enough. However, this area has some significant advantages in relation to its effective development opportunities as well as the cost of creating jobs is much less than the industry, and the reversibility of investment capital several times higher than in other areas.

The socio-economic model of the Carpathians must be economically profitable for Ukraine and neighbouring countries (Poland, Slovakia, Hungary and Romania). For this it is important to establish closer cooperation with the EU through participation in a number of applications including, Horizon 2020 and the development of relationships within the Carpathian Euroregion (Dovbenko, 2013).

International experience shows that the effective area of the development of mountain regions is the development of various forms of recreation management. The natural base of the resort complex Ukrainian Carpathians are more than 800 springs and wells curative mineral waters, curative mud resources. Area recreational landscapes is 616,7 hectares, and their one-time capacity in an environmentally acceptable load is estimated at 1.434,7 thousand people. At the same time, the Alpine region with 3.5 times smaller recreational areas annually receives 40 million tourists and 60 million tourists and travellers (Kravtsov et al., 1993).

Social dynamics also play a role in understanding how future people conceive of their well-being, i.e. in which contexts and on what resources and conversion factors they rely in order to achieve a capability set deemed worthy of human life. Furthermore, there might be good reasons for assuming that the individual assessment of behavioural consequences over time really is difficult (Lessmann, Rauschmayer, 2013). This demonstrates the need for a detailed study of the motives of actors the economic and environmental activities in order to prevent undesirable character of events.

The increased uncertainty and complexity of the economy underline the importance of exploration and innovation over the efficient and path-dependent exploitation of existing resources. The evolutionary policy model of “experimentation”, “selection” and “growth/diffusion” is more appropriate for the environment protection than top-down planning, path-dependent cluster development, or a pure free-market approach (Hämäläinen, 2013). For this it is important to develop a civilized corporate culture for local business and promote active and a conscious civil society by the government.

Environmental protection has become an important task of the business. New modern business policy in Carpathian should include investments in programs for renewable energy, which creates the possibility of reducing production costs, energy efficiency and environmental protection, which is a response to rising energy prices.

Mountain regions and communities offer a wide variety of high-quality products such as organic food, beverages, handicrafts, herbs and medicinal plants, which's labelled as mountain goods, is an important tool for marketing. Mountain areas also provide raw materials such as timber, minerals and metals (FAO, 2010). Approaches to the use of resources these areas are different from traditional as important to keep in mind the special importance of preserving the unique natural landscapes and resources.

The Ukrainian Carpathians could have much more significant tourism potential, numerous business opportunities that capitalize on the abundant natural resources of this region and the capability of providing various services. Consequently, the Ukrainian Carpathians are one of the best known regions in Ukraine for excellent typical local cuisine. Carpathian trademark for example “Carpathian taste” is a milestone in the valorisation of local agro-food products, cultural heritage and contributes to the sustainable development. A number of similar trademarks is known far beyond the political border of Ukraine.

**Conclusions.** The opportunities for the sustainable development in the Ukrainian Carpathian are still underutilized used. To change the situation it is necessary focused efforts of many parties, which would provide the required inflow of investments in innovative projects aimed at energy saving and environmental protection. Socio-economic model of the development the Ukrainian Carpathians it should motivate potential participants in the formation of a favourable environment for economic activities and simultaneously for recreation and leisure. The use of this model should be based on consideration of not only the urgent tasks, but provide the best selection of approaches to achieving long-term goals of the Ukrainian Carpathians development.

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## Non-wood forest products in Europe's West and Europe's East: provisioning or cultural ecosystem services of forest landscapes?

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**Key words:** livelihoods, forest depended communities, wild food, wild medicine, Roztochya, Småland, Komi Republic

Forest landscapes provide huge variety of goods and services for human wellbeing for ages. After Millennium Ecosystem Assessment (2005) there is growing interest to identify, assess, use and maintain ecosystem services. A number of scientific papers concerning ecosystem services is rapidly increasing (Wallace, 2007; Boa, 2004; Kalle 2012; Schulp et al., 2014). However managing ecosystem services in a certain landscape in a sustainable way is still a big challenge for decision-makers, landscape planners and managers. According to the Millennium Ecosystem Assessment (2005) there are four categories of ecosystem services such as: provisioning, supporting, regulating and cultural (MEA, 2005). Forests deliver a diversity of non-wood forest products (NWFPs) as a resource base for regional and rural development (Stryamets, 2012). NWFPs have been used for food, medicine, fiber, energy and other products that sustain local communities for Millennia (Stryamets et al., 2012). The aim of this study was to analyse the current use of NWFPs by rural stakeholders in Europe's West and Europe's East in order to clarify the category of ecosystem services that NWFPs belong to. Three rural areas have been selected for the in-depth study: Småland (Sweden) that represented Europe's West, and Roztochya (Ukraine)/ Kortkeross (Russia) in Europe's East. These areas had the similar historical use of forest resources, predominating rural residency, a high percentage of forest coverage and free accesses to forest products collection.

**Geographical setting.** Three study areas were selected to perform this study: Småland in Sweden, Roztochya in Ukraine and the Kortkeross Region in the Komi Republic, NW Russia. These three case studies are located in the countries with different political, social, economic conditions and governance systems. Sweden is developed country in Europe's West; Ukraine and Russian Federation are countries in transition from planned to market economy in Europe's East (World Bank, 2014).

The Swedish study area is located in the central part of Småland (56°52' - 57°26' N and 14°43' - 15°04' E). It is an upland region in southern Sweden. The core of the study area forms the southernmost larger island of boreal forest dominated by Scots pine [*Pinus sylvestris* L.] and Norway spruce [*Picea abies* (L.) Karst.]. Towards the south it is a gradual transition to hemi boreal and the northernmost part of the temperate lowland deciduous with beech [*Fagus sylvatica* L.]. Today's forest-dominated landscapes have a very long history of animal husbandry and farming (Lagerås, 2007). During the second half of the 20th century, grazed mixed deciduous and coniferous forests were transformed into production forests by introduction of Norway spruce plantations and gradual development of sustained yield forestry (Bradshaw et al., 2000). Non-industrial private forest owners own 80-85% of the forests in the study



area. The Swedish study area encompassed 22 parishes with a total area of 1.792 sq. km, and an average population density of 53 persons per sq. km, but with only 13 per sq. km in rural parishes without towns (Statistic Sweden, 2011). The population trend is negative, especially in rural areas that host 26% of the population (Statistic Sweden, 2011). Nevertheless, unemployment rates are lower than the Swedish average.

Roztochya (50°06' N - 49°06' N and 23°20' E - 23°54' E) is located in the western part of Ukraine, and forms the watershed between the Baltic and Black Sea catchments. The study area is situated in the temperate lowland forest ecoregion, and covers 992 sq. km. Forests cover about 44% of the total area, and the rest is made up by agricultural land, cultural woodlands and villages. The forest types are very diverse and range from dry sites with Scots pine to mesic sites with beech, and wet sites with ash [*Fraxinus excelsior* L.] and black alder [*Alnus glutinosa* L.] (Stryamets & Ferenc, 1999). It is an important green infrastructure that forms a corridor for biodiversity across the eastern European Union border. Recently, this territory was recognized as a MAB UNESCO Biosphere Reserve (Elbakidze et al, 2013). The villages have a gradient from houses with gardens, in-fields used for growing food or as orchards, agricultural crops and hay production, and out-field pastures and grazed forests (e.g., Elbakidze & Angelstam, 2009). There are 120 settlements in Roztochya with 59.922 inhabitants (Yavorivskiy and Zhovkivskiy rayons). The population density is about 80 persons per sq. km (Anon., 2008). Unemployment is a major problem in the area.

The Kortkeros Region (60°45' N - 62°50' N and 50°45' E - 53°30' E) is located in eastern edge of European part of Russia, bordering to the Ural Mountains in the East. It is situated in the south of the Komi Republic. Total area of the region is 19,7 thousand sq. km. The total forest cover is approximately 90% of the total area of region. The boreal forest is formed by Scots pine and Norway spruce often with supplement of birch [*Betula* sp.] and asp [*Populus tremula* L.]. The population density is low, less than a person per square kilometer, and the rural population is dominating. There are no towns in the Kortkeros region. There are 60 villages; including forest villages, and traditional villages; that are grouped into 18 settlements, with 19.200 inhabitants (Statistic of Kortkeros region, 2013). The households are characterized by natural husbandry. The depopulation is characterized both by low birth rate and by emigration rate. High unemployment is main problem in the region.

**Material and methods.** In total 234 qualitative semi-structured interviews (Kvale, 2007; Kvale & Brinkman, 2008) with local forest stakeholders in the three study areas (60 in Småland, 104 in Roztochya and 70 in Kortkeross) were conducted in 2010 and 2013. We interviewed people how they used forest resources and what benefits they got from the forest landscapes. The interview manual included a mixture of open-ended and closed questions as following: (1) a type of harvested NWFPs; (2) volume of collected NWFPs and methods, (3) traditional uses and practices, and (4) information about the collector (age, gender and community background). Each interviewee was given full freedom to talk about the subject. During interviews additional questions were asked when respondent have additional information or interesting details on the theme of interview. Verbal consent was obtained before each interview.

**Results and discussion.** *Non-wood forest products as ecosystem services in Småland, Europe's West.* The recreational activities were the major type of forest use. Cultural ecosystem services, like recreation by and inspiration from collecting NWFPs were more valuable for respondents than provisioning ones. Many respondents stated that collection of berries and mushrooms for food and to sell was important for

livelihoods in the region 60-70 years ago. Even 20 years ago, it was more common to pick different berries and mushrooms for food. Nowadays respondents pointed that they found the forest experience rejuvenating and energizing.

Use of NWFPs as provisioning ecosystem services was present in the study area as well, approximately 80% of interviewed people collected berries and mushrooms only for personal use. The villagers collected berries mainly for making pies for immediate use (e.g., blueberry pie). Several respondents also made preserves from mushrooms, blueberries and lingonberries for own consumption during winter. Chanterelle and funnel chanterelle were collected once or twice per season for immediate cooking. And several respondents collected up to 90 liters of lingonberries and blueberries for freezing for winter times. Besides berries and mushrooms, people also collected flowers for decoration. In the interviews, respondents often suggested that they did not have enough knowledge about the species of medicinal herbs or mushrooms and their uses. There were no recorded commercial uses of NWFPs in the study area.

*Non-wood forest products as ecosystem services in Roztochya and Kortkeros, in Europe's East.* In Roztochya both provisioning and cultural ecosystem services were important for villagers. Wild food and medicine as well as ornamental resources from NWFPs were used. Spiritual and religious values, inspiration and recreation were mentioned as component of forest resource use. In Ukrainian study area, all interviewees collected wild berries and mushrooms. All respondents mentioned that it was a tradition to cook dishes including NWFPs for religious holidays such as Christmas. About 30% of the respondents mentioned that it was important to pick mushrooms for religious holidays, which included traditional meals prepared with wild mushrooms. Observation of this tradition was important even for respondents for whom collection of mushrooms was not an economic or subsistence activity. Moreover, people collected berries for their kids because they considered it as healthy product. Some people stated that picking berries and mushrooms was like a hobby. Nearly 90% of the respondents said that their parents had taught them to pick berries and mushrooms; however, some stated that nowadays kids would rather spend time with computers instead of going to the forest. The majority of respondents mentioned that the collection of NWFPs had become more intensive compared to 20-25 years ago. One of the reasons was that, during the Soviet period, people had jobs at the collective farms or in the industry and there was no time and need to collect NWFPs to earn money. However, collective farms and many industries were closed in 1990s, when the Soviet Union collapsed. At the time of this study, unemployment was high and the forest provided an opportunity to support often scarce livelihoods in rural areas.

In Kortkeros respondents pointed that provisioning ecosystem services, especially wild food and medicine was very important for their livelihoods. Additional income was mentioned as well. All respondents in Kortkeros region collect wild food, including berries, birch sap and mushrooms. Cultural ecosystem services were mentioned as traditions and not so important, respondents pointed that forests products were "lifesaving" and "only way to survive". The respondents pointed that since the 1990th it has been a high level of unemployment, and NWFPs have been the most important source of wild food and medicine. Since 2006, the reformation of forestry has begun that led to high unemployment in rural areas in the Republic of Komi. Collecting NWFPs became often the only way to earn money in rural areas. There are collecting places in each village, where people sell berries and mushrooms. There are persons that their only income is from selling NWFPs.

Results show that among provisioning ecosystem services vital for rural livelihoods were wild food (berries, mushrooms and birch sap) and wild medicines (plants, mushrooms) and fiber (fire wood). Among cultural ecosystem services, tourism and recreation, religious values, inspiration, and traditional knowledge were mentioned as important. Provisioning ecosystem services were very important for local people in rural areas in Ukrainian and Russian case studies. Berries, mushrooms and medicinal herbs were used for personal consumption and for additional income; and forests were used for cattle grazing. Many of respondents stated that NWFPs were the only source of income. For respondents with high income, the cultural services were important. In the Swedish case study the provisioning ecosystem services were out of minor importance. Game meat, berries, mushrooms were used for personal consumption; at the same time cultural ecosystem services were the most important. The practice of collecting NWFPs has been declining due to urbanization, general changes in land-use patterns and a decreased contact of urban people with nature.

Most respondents in the Swedish study area stated that NWFPs collection had a very positive effect on their mental well-being. By contrast, our case studies from Europe's East show that NWFPs had been important mainly for personal use as provisioning ecosystem services and as additional -and in many cases the only- financial income. We assume that due to social and economic development challenges in countries transitioning from planned to market economies in Europe's East, forest ecosystem services other than wood production have regained local and regional importance.

This study shows that local populations in forested regions continue to use NWFPs for domestic and economic purposes; however, the role of NWFPs for local livelihoods is clearly different in the study areas (i.e. Småland in Sweden, Roztochya in Ukraine and Kortkeros in Russia), which is mainly linked to differences in economic development. In Sweden, NWFPs lost their wide-spread economic importance to local people during the second half of the 20th century, which also happened in many other developed European countries (Kardell, 1980; Schulp et al., 2014). Results show that berries, mushrooms and herbal medicine are used most by local forest stakeholders in the Russian and Ukrainian study areas. The amount of harvested NWFPs is higher per family in Ukraine and Russia than in Sweden. The traditional ecological knowledge about the species of NWFPs and how they are collected, consumed and stored, which have been passed through generations, are deeper and more extensive among Ukrainian and Russian, than Swedish villagers. By contrast, hunting was more popular and accepted by Swedish people as a traditional recreational activity, while in Ukraine it was of minor importance for economic reasons.

Fast urbanization in Europe's West is one of the reasons that people have become more disconnected from nature, which amongst other trends, causes more stress (Selhub & Logan 2012). By promoting collection of NWFPs, two goals will be achieved, first more physical activity and second reducing stress through restoring the human-nature connection (Sempik et al., 2010). Collection of NWFPs is accompanied by physical activity, fresh air, relaxation and enjoyment of nature

The promotion of value-added products from NWFPs, such as jam, preserved mushrooms and herbal teas have a potential to enhance livelihoods of local people in Europe's East, by aggregating more of the products value in the local community (Stryamets et al., 2012).

**Conclusions.** Nowadays forest ecosystem services, other than wood, have considered attention. NWFPs are both provisioning and cultural ecosystem services.

Provisioning ecosystem services, like wild food and medicine, play important role in rural livelihoods in Europe's East and cultural ecosystem services like recreation, inspiration and aesthetic values are more valuable for locals in Europe's West.

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## Components of forest-dependent communities' well-being in the Ukrainian Carpathians

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**Key words:** forest ecosystem services, local communities, access to forest resources, sustainable forest management (SFM)

Well-being is a term used for describing the general conditions of an individual or group, for example their social, economic, ecological, psychological, spiritual or medical state. High well-being means that, in some sense, the individual or group's experience is positive. The concept of "community well-being" is one of the frameworks for community state assessment along with other concepts such as local community quality-of-life, community health, community resilience or community capacity.

Human well-being and progress toward sustainable development are vitally dependent upon Earth's ecosystems. In the 2003 Millennium Ecosystem Assessment, well-being includes basic material needs for a good life, the experience of freedom, health, personal security, and good social relations. Together, these provide the conditions for physical, social, psychological, and spiritual fulfilment. Well-being in forest-dependent communities has long been discussed in the context of community sustainability, a term that includes the more general notion of forest community well-being. This includes not only economic indicators (i.e., per capita income, employment) but environmental quality and socio-cultural indicators that characterize community well-being. The level of education, parenting, recreation and leisure, social relationships between members of the community and intangibles such as the spiritual level of development affect the well-being of the community.

**Geographical setting.** With up to 50% of the land cover, forests dominate the landscapes of the four *oblasts* (Lviv, Ivano-Frankivs'k, Chernivtsi and Zakarpats'ka oblast (Transcarpathia) that make up the Ukraine's Carpathian Mountains. Saryi Sambir district (population 78.331) of Lviv Region is characterized by high forest cover (46,1 %) and relatively high volume of products and services relying on forest-based economic development. This was the main criterion for selecting this territory for this specific survey. The district takes an extremely advantageous geographical location as the "gateway" to the Ukrainian Carpathians, as well as a territory bordering the European Union (Poland). Forestry in this area provides a broad range of forest functions, wood and no-wood products, jobs in state forest enterprises and small wood-processing enterprises. The tourist industry is growing but still is not well developed neither is the market for multiple ecosystem services.

**Materials and methods.** The data analysed in this study, was selectively and collected within the framework of the ENPI FLEG program "Improving Forest Law Enforcement and Governance in the European Neighbourhood Policy East Countries and Russia."

The methodology of the research was based on "face-to-face" questionnaire survey of respondents by place of residence (representatives of local communities).

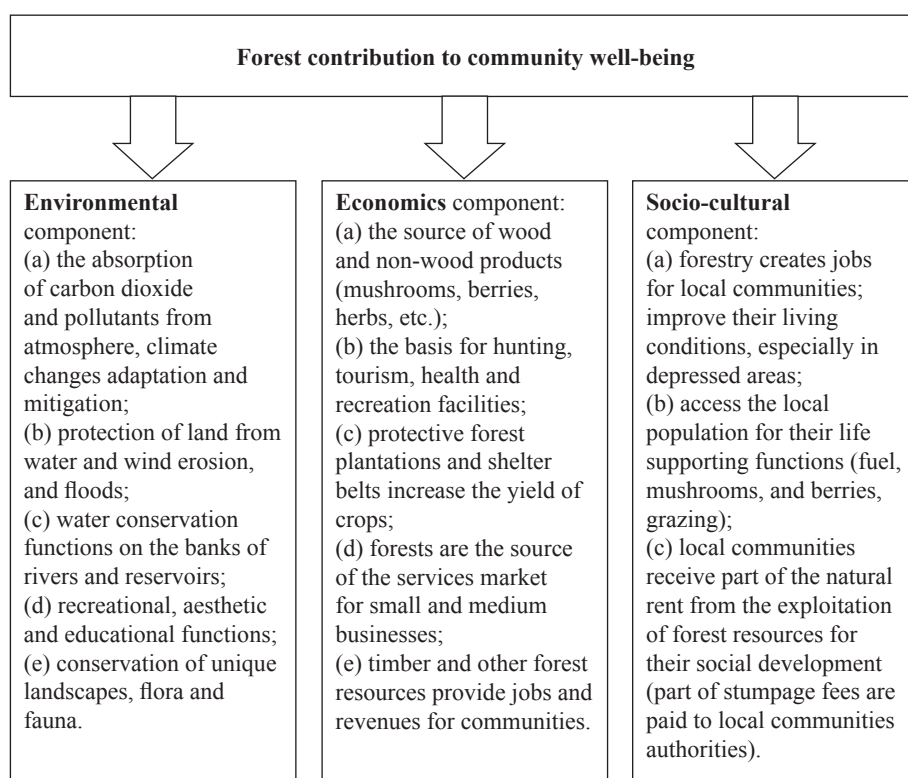
## Ecosystem Services and Sustainable Forest Management

In-depth study was held with forest-dependent communities in a mountain region of the Ukrainian Carpathians (Staryi Sambir district, n=50).

Sufficient levels of competence in the problems of the study were used as criteria for selection of respondents. It has been evaluated by the following parameters: 1) residence and work on the territories of local communities (district capitals, towns, villages) in the regions where the research was carried out and 2) social activities. Participants were selected by one of the methods: identified by the researcher or identified by an interviewee (snowball sampling).

The data was processed using the Statistical Package for the Social Sciences (SPSS).

**Results and discussion.** Forests provide a wide range of natural assets, including household goods, cultural values, physical and biological products, and other services that are vital to the livelihood and well-being of many people (Panta et al., 2009). The results of the study show that in a broad sense, economic, environmental, social, cultural and aesthetic functions of forests contribute considerably to the well-being of forest-dependent communities' in the Ukrainian Carpathians (Fig.1).



**Fig.1.** Environmental, economics and socio-cultural components of forest contribution to community well-being

Although the analysis highlighted the environmental and spiritual aspects of well-being, it also noted that these communities have a number of drawbacks including: low incomes, poor levels of entrepreneurship in rural areas, low employment, illegal labour migration and a natural decline in population.

Community members reported that forest is very important for them as a natural phenomenon or protected area (69,4% of respondents), area for gathering non-timber forest products (NTFPs) such as mushrooms, berries, medicinal plants, etc. (41,7% of respondents), recreation area (32,6% of respondents), source for commercial timber and firewood (29,4% and 18,0% of respondents). More than two-thirds of the respondents said that it is very important to protect forests and survey results confirmed the hypothesis about the importance the role of forest resources and forest ecosystem services for forest-dependent communities (Fig.2).

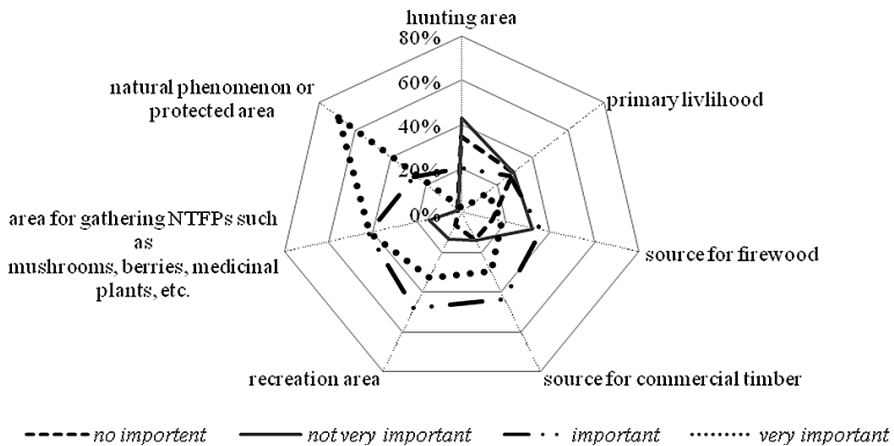


Fig.2. Meanings of forest for local community

An important factor in ensuring the well-being of those communities is their access to forest resources (Melnikovych et al., 2011). The research team also analysed the ease for local communities to get legal access to obtaining forest products including wood and non-timber forest products, hunting and grazing rights.

When asked how easy is it to get legal access to commercial timber in their community, 56% community members responded that it is difficult but possible to get wood in a legal manner and 34% responded that they do not face significant problems with legal access. Community members reported that they obtained commercial wood for construction and household needs (they needed to select no more than three responses) through forest enterprises (official) – 45,1%; bought from local villagers (willingly produced) – 15,7%; through intermediaries (enterprises and individuals) – 15,7%; through forest manager (unofficial) – 13,7%; independent – 5,9% and through village council – 3,9%.

Forest-dependent communities’ members report that they do not face significant problems with legal access to firewood in their area (56,9%) and 39,2% of respondent said that it is difficult but possible to get wood in legal manner. Only for 2% of community members responded it is impossible to get wood in legal manner. The highest part of respondents obtains a firewood through obtain a permit from forest authorities (75,9%). Some interview participants bought firewood from other local community members (15,7% and 13,7% independently harvested firewood in a forest.



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Only 2% of respondents receive firewood from the as a social service from state forest enterprises.

Community members report that they have no significant problems with legal access to gather mushrooms, berries, fruits, medicinal raw materials in the forests (90,2% of respondents). The 7,8% of participants interviewed have some restrictions to access and one respondent said that he hasn't had legal access to gather these products in the forest.

When how much free access to hunting was analysed, the local forest-dependent community present the following picture: 66% of respondents have some restrictions to access, 20% haven't any significant problems with legal access and 8% had no legal access.

Free access of local forest-dependent community members to recreation and tourism as an important factor in ensuring the well-being of those communities. 70.6% community members said that they had not faced any significant problems with legal access and 21,6% replied that there are some restrictions.

A very important factor for community well-being is a free access to grazing (because many people in forest depend on adjacent areas and have their own household farms with Livestock (cows, sheep, horses, etc.). Community members report that they had not faced significant problems with legal access (54,9%) but sometimes there are some restrictions (39,2%). Only 2% of respondents always had restrictions.

International agreements, resolutions, conventions, declarations and laws of Ukraine currently do not offer the desired result in ensuring a legal mechanism for transparent process of communities (as well as other stakeholders) participation in of forest resource management for improving well-being of the communities of place. This circumstance contributes to poor awareness of forestry-dependent communities to their rights on resource management, an absence of mutually fruitful cooperation between communities and forestry managers and, in most cases, a deficit of local residents (communities' involvement) into forest resource decision-making processes.

**Conclusions.** Forest ecosystems and their provisioning services are still very important component of well-being for many communities in the Ukrainian Carpathians even though these communities cannot be treated as fully forest-dependent communities. The well-being of rural local communities in mountain regions is directly dependent on the sustainable development of forest ecosystems and their resources. There is a potential to improve current forest policy and law towards increasing the role of communities in the decision-making process in the field of SFM, conservation and restoration. Smart development of forest-dependent mountain territories and communities requires new and innovative strategies based on green growth innovations that would integrate scientific and local/traditional knowledge around the array of forest ecosystem goods and services. Such strategies should allow for increasing of human well-being without destroying the sustainability of fragile mountain forest ecosystems.

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## Stakeholders' perceptions of treeline ecosystem services and their governance: Focus on the Ukrainian Carpathians

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**Key words:** CICES trinomial classification of ecosystem services, governance landscape, environmental decision-making

In recent ecological-economic scientific discourse ecosystem decline and deforestation are considered as global megatrends which significantly undermine human wellbeing (MA, 2005; TEEB, 2010; KPMG, 2012). Being strongly impacted by natural and anthropogenic factors like unsustainable resource use, unbalanced utilisation of ecosystem services, climate and land use changes ecosystems need holistic governance based on a humans' perception of their value and fragility. Holistic governance is also needed because environmental governance and policy is often sector-based undermining cumulative effects of various sectors on single locations, such as treeline areas. We examine perceptions of local experts who have on the ground view on treelines and can thus provide holistic view on the pressures and potential solutions treeline areas encounter. Treeline ecosystems are highly dynamic, integrative and relatively easy traceable indicator of these changes and therefore quality of ecosystem governance. In this context value of treeline ecosystem services and perception of their role for human wellbeing becomes crucial input to environmentally-sound decision-making also elsewhere.

**Geographical setting.** Treeline areas under investigation are located in the Ukrainian Carpathians and Transcarpathian (Table 1), namely Pokutski Karpaty, Hutzulschyna National Park and Uzhansky National Park. Their territory is above 30 tha ha. Territories below the treelines mainly are covered by mixed forests. Climate is moderate in this region.

**Table 1.** Characteristics of the treeline areas under investigation

<i>Area (name)</i>	<i>Size [ha]</i>	<i>Main ecological features (Vegetation cover)</i>	<i>ClimateType</i>
Pokutski Karpaty	32270	Beech, spruce	Moderate-continental
Hutzulschyna National Park	32271	Beech, spruce mixed with oak and fir	Moderate-continental
Uzhanskyi National Park	39159 (incl. 1000 of treeline area)	Beech, sycamore and beech and fir-beech forests	Moderate

**Material and methods.** Mainstreaming concept of ecosystem services, which is basic for this research, is identified according to CICES'2013 report as a „contributions that ecosystems make to human well-being“ (Haines-Young, Potschin 2012). Trinomial classification of ecosystem services (Provisioning; Regulation and

Maintenance; Cultural), proposed by this report, was chosen in the questionnaire as the most comprehensive and scientifically widely agreed approach for ecosystem services identification and (e)valuation.

We consider treeline ecosystem services (TES) as a contribution of ecosystems, located in a treeline zone, to human well being. In this research, which is based on findings of the COST Action ES1203: Enhancing the resilience capacity of sensitive mountain forest ecosystems under environmental change, treelines are treated as “treeline-related administrative areas and associated landscapes and ecosystems” (Sarkki et al., 2013). This broader definition than simply ecological idea of treeline ecotone was here chosen because it is more likely to be relevant for stakeholders whose interests include treeline areas and adjacent areas and also because governance does not often specifically address treeline areas, but treeline areas are part of various administrative areas governed by different instruments. Hence this definition is especially suited for analyzing social and political issues related to governance.

Notion of environmental governance is widely used in modern environmental scientific literature to emphasize common impact and responsibility of a state, civil society, private sector and science for a quality of environmental decision-making (Lemos, Agrawal 2006). Five principles of good governance: participation, openness, accountability, effectiveness and coherence (European Commission, 2001) were examined with a particular focus on a stakeholders’ engagement and governance landscape and transparency (Sarkki et al., 2013).

The research database was obtained as experts’ assessment of items listed in the questionnaire, designed by the working group 3 participants of the COST Action ES1203 on the background of modern ecosystem discourse and participants’ own experience. The questionnaire included mainly closed-ended questions. A 5-point Likert scale was used to quantify experts’ attitudes and evaluations. Open-ended questions served as a room for examples, own explanations etc. The questionnaire was mailed to national mountain parks and other relevant institutions’ administrations whose territories located in treeline zones. More than 10 employees answered it. The questionnaire-based investigations were conducted in the Ukrainian Carpathians.

**Results and discussion.** Results will be described in three points. The first part of findings focuses on experts’ perceptions of TES. Our respondents state that services from sections Cultural and Regulation & Maintenance are more important comparing to Provisioning services in terms of CICES trinomial classification (Haines-Young, Potschin 2013). The most important classes of TES are Flood protection (4,89 according to Likert scale), Hydrological cycle and water flow maintenance, Scientific and Aesthetic services (4,75) and Global climate regulation (4,67). In section Provision services 8 of the 16 classes of TES were estimated between 3 and 4 and only class Ground water for drinking got 4,33 (Table 2). In section Regulation & Maintenance services 9 of the 21 classes got estimation higher than 4 and only two classes got estimation less than 3. In section Cultural services 6 of the 11 classes got estimation higher than 4 and only one is less than 3. The estimation of 1 was not applied.

The next part of findings is dedicated to beneficiaries of and threats to TES. According to our experts’ estimations Science and education (4,43), Tourism and Water users (4,14) and Nature conservation (3,89) derive the highest benefits from TES. The highest threats for TES go from forestry (3,1), Residents (2,7) and some kinds of Recreation and subsistence activity (2,5).

As it comes from Fig. 1, such stakeholders as State forestry institutions, Recreationists (outdoor activities such as mountain bike cycling), Skiing resort businesses and

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workers derive the highest benefits from TES and in the same time threaten them a lot. Conflicts between stakeholders arises because of weakly defined property rights, contradiction between private economic profit and public environmental integrity and the very nature of significant part of TES as non-excludable but rival public goods.

**Table 2.** The most important treeline ecosystem services according to stakeholders' perceptions (more than 4 estimation using 5-point Likert scale)

Division	Group	Class	Importance			
			Min	Max	Mean	Mode
<b>Section: Provisioning</b>						
Nutrition	Water	Ground water for drinking	3	5	4,33	4
<b>Section: Regulation &amp; Maintenance</b>						
Mediation of flows	Liquid flows	Flood protection	4	5	4,89	5
		Hydrological cycle and water flow maintenance	4	5	4,75	5
Maintenance of physical, chemical, biological conditions	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	4	5	4,67	5
		Micro- and regional climate regulation	4	5	4,63	5
	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	3	5	4,50	5
		Maintaining nursery populations and habitats	1	5	4,11	5
	Water conditions	Chemical condition of freshwaters	3	5	4,25	4
Mediation of waste, toxics and other nuisances	Mediation by biota	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	3	5	4,44	5
		Bio-remediation by micro-organisms, algae, plants, and animals	2	5	4,33	5
<b>Section: Cultural</b>						
Physical and intellectual interactions with biota, ecosystems, landscapes	Intellectual and representative interactions	Scientific	4	5	4,75	5
		Aesthetic	4	5	4,75	5
		Educational	4	5	4,63	5
		Heritage, cultural	3	5	4,38	5
Spiritual, symbolic and other interactions	Spiritual / emblematic	Sacred and/or religious	3	5	4,63	5
	Other cultural outputs	Bequest	3	5	4,25	5

Final set of findings deals with quality of treeline governance. In governance landscape Ukrainian experts pointed the most common use of such instruments as land use and protected area management planning. In the group of policy and legislation

instruments the most effective are national legislation, the EU policies play role to some extent. Governance instruments have gaps and led to biased incentives to use treeline areas in unsustainable manner (this statement was supported and got rather high score of 3.9). Among economic instruments of environmental governance the most applied is forestry certification. Eco-labels for tourism entrepreneurs and for agriculture (e.g. for organic farming) are already used in some cases. Thus the statement “Market based instruments are popular regarding the treeline areas” got 3.4 score.

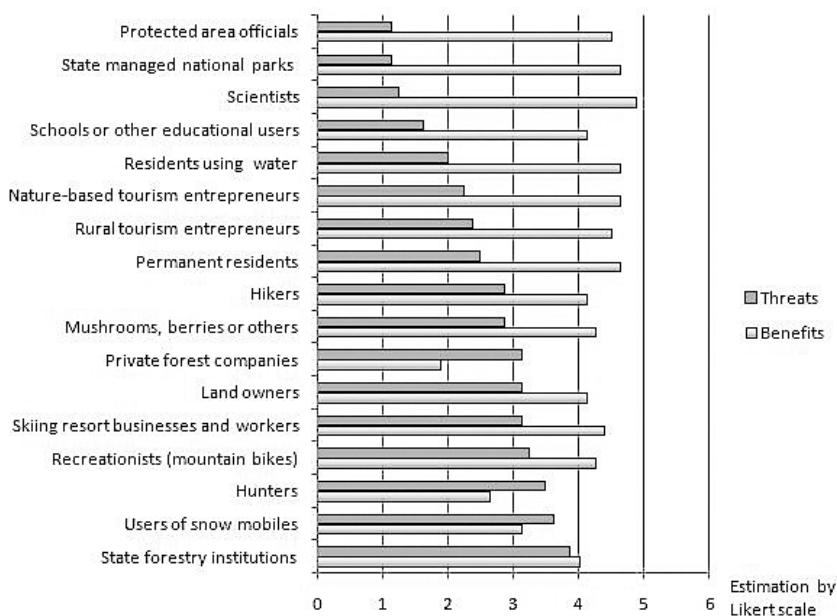


Fig.1. TES stakeholders with highest benefits or / and strongest threatens

Respondents have the impression that research on treeline areas has been engaging stakeholders (3,9) but were conducted for pure scientific interest and stakeholders or decision makers’ needs have not been acknowledged (3,9), were not properly disseminated and research plans do not include collaboration between researchers and stakeholders.

**Conclusions.** This questionnaire-based research let us make some conclusions concerning perceptions of TES, their governance.

Identified set of experts’ perceptions concerning TES highlighted the higher value of Regulation & Maintenance and Cultural services comparing to provisioning ones (with exception of ground water provision for drinking. This finding should be acknowledged by environmental policy and decision-making keeping in mind that all respondents are employees of national parks or other relevant institutions. Broader representation of stakeholders (e.g. local people) could bring stronger focus on provisioning ones (Zahvoyska, Bas, 2013).

Benefits of some stakeholders (like State forestry institutions, Skiing resort businesses, Recreationalists etc.) are highly predetermined by quality of TES,

they decline by own activities. Therefore these beneficiaries have to recognize this feedback and use it for own and whole society benefits. Relevant economic and political instruments should drive environmental behavior of TES beneficiaries towards sustainable patterns.

There are serious gaps in treeline governance: it does not focus on specific needs of fragile and dynamic treeline areas in the face of a threat of climate change anthropogenic pressure. The whole set of governance instruments should be put in place to promote sustainable resource use and stakeholders' wellbeing.

*Acknowledgements.* This questionnaire based research was performed in the framework of the COST Action ES1203: Enhancing the resilience capacity of sensitive mountain forest ecosystems under environmental change (<http://www.sensfor-cost.eu/>).

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## Primeval forests of the Ukrainian Carpathians as a unique natural heritage and their multifunctional significance

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**Key words:** monoculture, sylvagenesis, homeostasis, floods, ecological model, natural forestry

WWF has included the Carpathians into the list of 200 world regions that are most important from the ecological, biogeographical, and economical point of view. The Ukrainian Carpathians are located in the central part of the Carpathian mountain arc. There live 5.5 million people of five ethnic origins. Thus, the region has an important ethno-cultural and economic significance. There are 2.040 vascular plant species known within the area (16 % of all floristic wealth of the continent), and 260 of them are included into the Red Book of Ukraine. The species list of animal world is also very rich there.

The area of state forest fund of the Ukrainian Carpathians is 1.465,3 thousand hectares (forests cover 1.331,2 thousand hectares). Seven rivers – the Sian (the Baltic See basin), the Dnister, the Prut, the Seret, the Uzh, the Latorica, and the Tysa (the Black See basin) have their sources in the Ukrainian Carpathians. Therefore, the mountain forest ecosystems have important water protection role in Central Europe. The forest fund has big economic significance for Ukraine, in which forests cover only 17,6 % of the territory. Thus, natural environment conservation in the region and the support of its economic development are important tasks under such ecological situation.

***Anthropogenic transformation in forest fund and its ecological consequences.*** Forests covered 95% of the Ukrainian Carpathians during the pre-agricultural period. In 1870-1900, Uzhok (889 m above sea level), Veretsky (841 m a.s.l.), Yablunetsky (931 m a.s.l.) passes were crossed by a network of railways that were built in order to bring that area closer to the European timber market, as well as to begin intensive cutting of the forests. This led to considerable quantitative and qualitative changes in natural coenotic structure of forests. Under the influence of forestry concept of “coniferization”, monoculture spruce stands have been created in the natural beech forest habitats. At present, their area is 184 thousand hectares. It should be stressed that water protection role of secondary spruce forests is two times less than that of the beech forests.

During the economically difficult after-war period of soviet regime, annual cuts in the forests of the Ukrainian Carpathians were two times higher than the calculated norm. As a result of different kinds of the anthropogenic influence, the forests area significantly decreased reaching 42% of region territory. The area of state forest fund is 1.465 thousand hectares. Drastic territorial and coenotic changes disturbed ecological balance of the region, particularly the hydrological regime of water arteries.

The Ukrainian Carpathians are located in a humid climate zone with precipitation ranging from 805 mm (Uzhgorod weather station, 128 m above sea level) to 1.491 mm (Pozhezhevskya weather station, 1,429 m above sea level). Annual precipitation may



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exceed 2.000 mm, and dangerous flash floods may take place. The archive data of historian I. Kripyakevych (1928) demonstrate that such floods were observed in 1164, 1230, 1649, 1656, 1688, 1690, 1700, 1730, 1735, 1744, 1867, 1888 (*average: one event in 60 years*). Owing to clear-cuts, monocultural spruce forestry, and decrease of natural forests area in the last century, dangerous floods happen more frequently, and were observed in 1911, 1913, 1926, 1927, 1930, 1941, 1947, 1955, 1957, 1962, 1965, 1969, 1970, 1977, 1980, 1982, 1983, 1998, 2001, 2008, 2009, 2010 (*average: one event in five years*). The studies indicate that water accumulating capacity of mature beech forest is 140-160 mm of precipitation, and of the spruce forests – 70-90 mm (Oliynik, 2008). In order to keep normal hydrological regime in the basins of the Tysa, Dnister, Prut and other rivers, it is necessary to increase the forest cover to 60 % of their basins, restrict the area of clear cuts, conduct the re-naturalization of secondary spruce forest stands and other biologically unstable stands whose water protection role is insignificant.

The primeval forests are ecological models for close-to-natural forestry. In such ecosystems, capability to self-regeneration, self-regulation, self-protection against biological pests, self-development have been formed during a long process of phylocoenogenesis (Stoyko, 2012). Primeval ecosystems possess homeostasis and high water protection potential. Thus, forestry strategy in the Carpathians should be based on the ecological principles of natural forestry, capable of supporting sustainable development of the forest ecosystems and also the ecological balance.

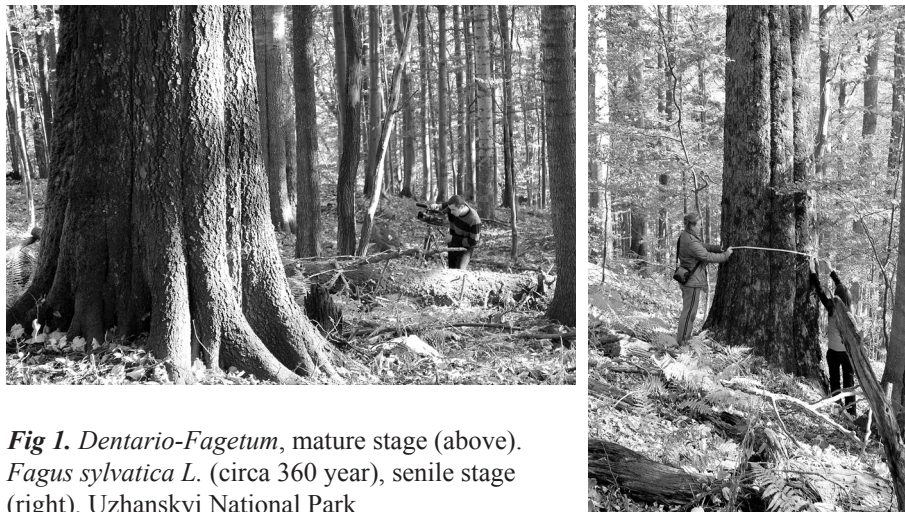
***Ecological/coenotical criteria for identification of the primeval and quasi-primeval forest ecosystems.*** Based on the results of comparative studies of ecological and coenotical state of primeval and partly changed forests (quasi-primeval), we have chosen eight most characteristic ecological-coenotic criteria according to which one can set the degree of forest ecosystems naturalness (Table 1).

**Table 1.** Criteria of forest ecosystem naturalness

<i>No</i>	<i>Criterion</i>	<i>Natural forests categories</i>	
		<i>Primeval forests</i>	<i>Quasi primeval forests</i>
1	Conformity of natural dendroflora with certain environment, habitat	absolute	absolute
2	Different age stage of dendroflora – juvenile, virgin, premature, mature, sub-senile, senile	explicit	explicit
3	Multilayer vertical forest structure	not changed	locally changed
4	Natural condition of soil and underlay	not disturbed	locally disturbed
5	Natural trunks decomposition (presence of deadwood)	normal	locally disturbed
6	Presence of aboriginal fauna	aboriginal fauna	introduced species possible
7	Presence of aboriginal flora species	aboriginal flora	allochtone species possible
8	Capability to re-naturalisation of phytocoenosis (duration)	–	after 20-40 years

The ecosystems of primeval forests should possess aboriginal flora and fauna and represent different age stages of dendroflora – juvenile, virgin, premature, mature,

sub-senile, senile, self-disintegration. They should demonstrate undisturbed direct and indirect relations between autotrophic, heterotrophic and soil blocks; which function as a homeostasis system (Fig. 1).



**Fig 1.** *Dentario-Fagetum*, mature stage (above). *Fagus sylvatica* L. (circa 360 year), senile stage (right). Uzhanskyi National Park

**Preservation of primeval forest ecosystems.** At the beginning of XX century, forward thinking naturalists of Hungary, Poland and Czechoslovakia created several forest reserves (Szafer, 1913; Földvary, 1933; Zlatnik et al. 1938). After the World War Two, the Ukrainian scientists increased this network and also created new protected objects with larger area (e.g., Stoyko, 2005). At present, the Carpathian Biosphere Reserve as well as nine national parks and more than 100 forests reserves have been created. The area of all objects of the Nature Protection Fund equals to 15% of the region's area. The Table 2 contains some data on primeval and quasi-primeval forest and shrub land formations and sub-formations of the Nature Protection Fund.

In Ukraine, as well as in the European countries, during the agricultural period natural oak and beech forests were subjected to the most considerable territorial changes. Presently, in the Ukrainian Carpathians primeval beech forests have been preserved on 23.582 hectares, and in the Slovakian Carpathians – on 5.696 hectares. Around primeval forests determined buffer zone on 48.693 hectares. In 2007 the UNESCO COMMITTEE of World Natural Heritage has included “Primary Beech forests of the Carpathians on 77.971 hectares” to the World Natural Heritage Site. The foresters of Germany and other countries also conduct the measures for including to the above mentioned list the primary forests preserved on their territory.

In Ukraine, as well as in European countries, during the agricultural period natural oak and beech forests were subjected to the most considerable spatial changes. Presently, in the Ukrainian Carpathians primeval beech forests have been preserved on 23.582 hectares, and in the Slovakian Carpathians – on 5.696 hectares. The buffer zone around primeval forests equals to 48.693 hectares. In 2007, the UNESCO Committee of World Natural Heritage has included “primary beech forests of the Carpathians on 77.971 hectares” to the World Natural Heritage Site. The foresters of Germany and other countries also took measures to include to the above mentioned list the primary forests preserved on their territory.

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**Table 2.** Primeval and quasi-primeval forests of the Nature Protection Fund in the Ukrainian Carpathian Mts.

No	<i>Name of the protected area; creation year; area</i>	<i>Primeval and quasi-primeval forests</i>
<i>Zakarpattia Oblast</i>		
1	Carpathian Biosphere Reserve; 1992; 57.880 ha	<i>Querceta petraeae</i> (relict), <i>Fageto-Quercetum petraeae</i> , <i>Junipereta sabinae</i> (relict, fragm.), <i>Betuleta pendulae</i> (relict), <i>Fageta sylvaticae</i> , <i>Carpineto-Fagetum</i> , <i>Fagetum taxosum</i> (relict), <i>Fageto-Abietum</i> , <i>Fageto-Abieto-Piceetum</i> , <i>Piceeta abietis</i> , <i>Pineta mugi</i> , <i>Alneta viridis</i>
2	Uzhanskyi National Nature Park; 1999; 39.159 ha	<i>Querceta petraeae</i> (relict), <i>Fageta sylvaticae</i> , <i>Alnetum syringosum</i> (endemic), <i>Acereto-Fagetum</i> , <i>Fageto-Abietum</i> , <i>Alneta viridis</i>
3	National Nature Park «Synevyr»; 1980; 40.400 ha	<i>Fageta sylvaticae</i> , <i>Fageto-Abieto-Piceetum</i> , <i>Piceeta abietis</i> , <i>Alneta viridis</i>
4	National Nature Park «Zacharovanyi Krai»; 2009; 6.101 ha	<i>Fageta sylvaticae</i> , <i>Acereto-Fagetum</i> , <i>Abieto-Fagetum</i>
5	Forest Reserve «Kedryn»; 1974; 197 ha	<i>Lariceto polonicae-Piceetum</i> (endemic), <i>Pineto cembrae-Piceetum</i> (relict)
6	Forest Reserve «Tavpishyrka»; 1974; 248 ha	<i>Pineto cembrae-Piceetum</i> (relict)
7	Forest Reserve «Popadia»; 1974; 926 ha	<i>Pineto cembrae-Piceetum</i> (relict), <i>Piceeta abietis</i> , <i>Pineta mugi</i>
8	Forest Reserve «Kleva»; 1974; 41,8 ha	<i>Pineta sylvestris</i> (relict)
<i>Ivano-Frankivsk Oblast</i>		
9	Karpatskyi National Nature Park; 1980; 50.303 ha	<i>Fageta sylvaticae</i> , <i>Acereto-Fagetum</i> , <i>Abieto-Fagetum</i> , <i>Fageto-Abieto-Piceetum</i> , <i>Piceeta abietis</i> , <i>Piceeto-Pinetum cembrae</i> , <i>Pineta mugi</i> , <i>Alneta viridis</i>
10	National Nature Park «Hutsulshchyna»; 2002; 32.271 ha	<i>Fageta sylvaticae</i> , <i>Acereto-Fagetum</i> , <i>Fageto-Abietum</i> , <i>Fageto-Abieto-Piceetum</i> , <i>Piceeta abietis</i>
11	National Nature Park «Syniohora»; 2009; 10.866 ha	<i>Fageto-Abietum</i>
12	Verkhovynskyi National Nature Park; 2012; 12.022 ha	<i>Fageta sylvaticae</i> , <i>Abieto-Fagetum</i> , <i>Piceta abietis</i>
13	Natural Reserve «Gorgany»; 1996; 5.344 ha	<i>Fageto-Abieto-Piceetum</i> , <i>Piceeta abietis</i> , <i>Cembreto-Piceetum</i> (relict), <i>Pineta mugi</i>
14	Forest Reserve «Yaitse»; 1935; 263 ha	<i>Piceeta abietis</i> , <i>Piceeto-Pinetum cembrae</i> (relict)
15	Forest Reserve «Maniava-Skyt»; 1937; 2 ha	<i>Lariceta polonicae</i> (endemic)
<i>Lviv Oblast</i>		
16	National Nature Park «Skolivski Beskydy»; 1999; 24.202 ha	<i>Fageta sylvaticae</i> , <i>Acereto-Fagetum</i> , <i>Abieto-Fagetum</i> , <i>Fageto-Abieto-Piceetum</i>
17	Landscape Reserve «Pikui»; 1984; 711 ha	<i>Fageta sylvaticae</i> , <i>Acereto-Fagetum</i>
<i>Chernivtsi Oblast</i>		
18	Vyzhnytskyi National Nature Park; 1995; 11.238 ha	<i>Piceeto-Quercetum petraeae</i> (relict), <i>Fageta sylvaticae</i> , <i>Acereto-Fagetum</i> , <i>Abieto-Fagetum</i>

**Scientific and applied values of primeval forest ecosystems.** Primeval forests retain information about the geographic extent and vitality of the forest cover in Holocene. They are specific natural laboratory for integrated ecological research on forest formations.

**Cognitive value.** Primeval forest ecosystems afford studying silvogenesis process

in various geographical and ecological conditions. In the primeval forest ecosystems, interesting scientific information about their coenotic structure, the relationship between phytocenosis, zoocenosis, microbiota, pedosphere has accumulated. That is why they are relevant to the various branches of phytocoenology.

*Value for conservation of biotic diversity.* In the artificial forest monoculture stands, biological and phytocoenological diversity of pauperization that adversely affects their ecological stability is observed. Primeval forests support the diversity of the aboriginal flora, fauna, microbiota and natural phytocoenosis pool.

*Value for studying of dynamic trends caused by climate change.* The timberline primeval beech and spruce ecosystems of the Uzhanskyi National Park and the Carpathian Biosphere Reserve are suitable for long-term monitoring.

*Genetic significance.* In oak, beech, spruce and fir primeval forests in different edaphic conditions and altitudinal belts, phenotypes of interesting genotypes were formed. Such ecosystems are natural reservoirs of genetic resources, and they should be conserved and used in silvicultural practices. Primeval oak and beech forests keep the gene pool of wild relatives of cultivated fruit plants – *Sorbus torminalis*, *Cerasus avium*, *Malus sylvestris*, etc. They are important for improvement of the genetic structure of such species.

*Ecological model value for forest science and practice.* Foresters develop an approach to manage close-to-natural forests and methods of selective logging to ensure ecological stability. Primeval forests have a value as an ecological model for this system.

*Biodiversity value.* The areas of natural forests may be enriched by a spontaneous migration of biological species and their genetic resources adjacent to commercial forests, and thus, improve their biological stability.

*Educational significance for forestry expertise.* Primeval forest ecosystems are the “natural laboratory” where one can watch the silvogenesis process. Rich ecological information about their functioning should be used in order to create ecologically stable culture phytocoenoses.

*Landscape and esthetic value.* In the denaturalized environment, it is needed to conserve natural forests from the landscapes and esthetic considerations. In these forests, the harmony and beauty of everlasting nature preserved, which meets spiritual and emotional human needs.

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## Concept of silvicultural management in the Western Carpathians

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**Key words:** species composition, conversion and regeneration techniques, Norway spruce decline, site amelioration

In last decade, forest owners and managers are faced with a new situation in forest stands in the Czech part of the Western Carpathians (the Moravsko-Slezské Beskydy Mts.). The traditional silviculture management focused on Norway spruce (*Picea abies* (L.) Karst.) monocultures has failed in current stands (Голуља, 2004, Brodzski, 2010), since they exhibit decline symptoms such as drying and yellowing due to lack of nutrients (Fabiánek et al., 2004, Sitková et al., 2010, Jbránek et al., 2013), change of climatic conditions, especially higher temperature and lower precipitation during the vegetation period (Allen et al., 2010, Hlásny et al., 2014) and massive occurrence of fungi and bark beetle (Жакуљ, 2001, Голуља, Ліљка, 2002, Longauerová et al., 2010, Hlásny et al., 2010). Basically, current cause of spruce decline lies in complicated complex of factors.

On the basis of long-term observations and other studies, new silviculture concept is proposed for use within the area of interest. Firstly, thinning programs to be applied in spruce stands on nutrient-rich and nutrient-poor sites were formulated (Slodičák et al., 2013). Analyses of possible soil-improving function of some tree species, which may be used to restore nutrient supply, were presented subsequently (Novák et al., 2012).

Nowadays, conversion and regeneration techniques (incl. target species compositions) are added and introduced in this contribution.

**Material and methods.** New silviculture concept is based: (1) on analyses which were realised in model Jablunkov region, the Beskydy Mts. (Jbránek et al., 2008) and (2) on knowledge from other regions with comparable conditions. Study about climate development (Bağár, 2007) and forest management (Plíva, 2000) were also included. Main interest is focused on two forest vegetation zones, where beech or beech+fir naturally dominate.

The term “Target tree species composition” (TTSC) was used in our study. TTSC is composition at the end of rotation optimized from the viewpoint of economy, biology and ability to fulfil all requested forest functions and provide services with respect to particular natural conditions. As for above mentioned process of forest conversion, TTSC was proposed in two variants: Basic TTSC and Transient (Ameliorative) TTSC.

Basic TTSC proceeds from the present information on spruce decline and increased drought stress on the sites unsuitable for spruce. It can be achieved over a longer time span (one or two rotations).

Transient Ameliorative TTSC is based on ability of some mostly broadleaved species to ameliorate the site, to take the nutrients from deeper horizons and to mitigate the throughfall acid deposition. The main aim of this composition is to ameliorate the site and to prepare it to gradual implementation of Basic TTSC.

**Results and discussion.** *Species composition.* The basic strategy for new silviculture concept is based on following principles (Table 1):

- to omit Norway spruce in lower (naturally dominated by beech) vegetation zone while maintaining an admixture of Norway spruce for future natural regeneration in higher vegetation zone dominated by beech with fir,
- share of European beech (*Fagus sylvatica* L.) would not be increased because beech is not the best species from the viewpoint of amelioration and production (e.g. Rothe et al., 2002),
- proposed species composition should include the species, which exhibit experimentally documented positive soil-improving and production effects - wild cherry, elm, aspen, birch, lime and introduced Douglas-fir (Vesterdal, Raulund-Rasmussen, 1998, Hagen-Thorn et al., 2004, Podrázský, Ремељ, 2006, Kacálek et al., 2010a, 2010b and others).

**Table 1.** Species composition on fertile sites in vegetation zone naturally dominated by beech and fir. Comparison of common practice to new silviculture concept

<i>Source</i>		<i>Species composition</i>											
		NS	EB	SF	La	Li	Ma	A	Dg	WCH	Asp	E	BR
Present management plan	NS dominated sites	6-7	2-1	1-2			0-1		+				
	EB dominated sites	0-2	7-5	2-1	+		0-1		+	+	+		+
	Natural (Plíva, 2000)	+	5-7	3-5			+						
New concept	<i>Basic TTSC</i>	1-3	2	2	1-2	0+	+2	0-1	0-1	+	+		0+
	<i>Ameliorative TTSC</i>	0-1	1-2	2-3	0+		1-3		+	0-1	1	0+	0-2

NS – Norway spruce, EB – European beech, SF – silver fir, La – larch, Li – linden, Ma – sycamore maple, A – ash, Dg – Douglas-fir, WCH – wild cherry, Asp – aspen, E – elm, BR – birch, numerals denote decimal proportion of individual species sharing the management unit, + means proportion less than 10%.

*Techniques of conversion.* Under-planting and inter-planting are the most common conversion techniques in forests (Balcar et al., 2007). Main reason for planting seedlings into the existing stands (remnants of stands) is to take advantage of their ability to soften the climate extremes, to protect the forest soil from erosion and drought or from risen water table during the conversion.

Under-planting is used in older stands. This technique is recommended in broken-canopy stands (canopy 40–60% due to mortality or deliberate preparatory cut). Regeneration should be managed using relatively small (0,03 – 0,08 ha) canopy gaps, which are (1) not shadowed by crowns and (2) not in drip zones of the shelter trees.

In younger stands (to the top height of ca 4 m), inter-planting should be used for integrating the present stand into the newly created structures. We can use regeneration

elements such as strips or round openings (with or without shelter) according to interplanted tree species or local conditions.

**Conclusions.** On the basis of long-term observations and other studies, concept of silvicultural management in the Western Carpathians was defined. New principles use an approach of „Target tree species composition“ (TTSC), which is divided into: (1) Basic TTSC achievable over a longer time and (2) Ameliorative TTSC aiming mainly to amelioration of the site and to prepare it to gradual implementation of Basic TTSC.

Classical conversion techniques (underplanting in older stands and interplanting in younger stands) are also included in the concept. This is a direct transfer of scientific knowledge and experience to forestry practitioners.

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## Douglas-fir as possible alternative for declining Norway spruce in managed forests of the Western Carpathians

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**Key words:** spruce decline, silviculture, species composition, douglas-fir, soil, roots

Norway spruce (*Picea abies* (L.) Karst.) was widely cultivated in the 4<sup>th</sup> (beech) and 5<sup>th</sup> (beech with fir) forest vegetation zones in the Western Carpathians. These stands show symptoms of health decline over the last decades. The main reasons of spruce decline are nutrient disturbances (low values of base saturation), change of climatic conditions (higher temperature and lower precipitation during the vegetation period) and massive occurrence of fungi and bark beetle. Inevitable measure in declining stands is stand conversion and the change of species composition with orientation on soil-improving forest tree species.

One of the species suitable in conditions of water stress and disturbed forest soils is, at least in managed forests, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Douglas-fir (DG) is a most-frequently used introduced conifer in the West and Middle Europe, being appreciated especially for its high quality wood and ability to take water from deeper soil more efficiently than spruce.

DG is known to be able to overcome many difficulties accompanying global warming. It grows better on some sites and is less vulnerable to the drought than Norway spruce (Bartoš, Kacálek, 2011; Kantor, 2008). DG grows well in the lower rainfall areas if they are not much exposed. It is usually regarded as a species suitable for middle valley slopes and bottoms of at least moderate fertility. It can develop good root systems on deep, well-drained soils. Clayey soils are acceptable if on slopes and the tree species grows well on sandy soils; similarly like spruce is unsuitable to calcareous soils. Urban et al. (2013) found, that DG is less sensitive than spruce to the unfavourable weather and soil nutrient conditions. It can withstand higher temperatures than spruce, but does not grow well at higher altitudes, where spruce dominates.

It belongs to the group of the tallest tree species on frequently occurring volcanic soil in western parts of North America (Domec et al., 2008), where its relatively large water stem storage can help to satisfy higher transpiration demands (Čermák et al., 2007; Phillips et al., 2003). DG can develop root systems much deeper than Norway spruce and numerous studies conducted in the USA indicate, that it can take water from deep soil horizons (Brooks et al., 2006; Meinzer et al., 2007).

Since 2011, Czech National Agency for Agricultural Research has been financing the project Silvicultural approaches applied to use Douglas-fir in mixed stands in the Czech Republic. The main objectives are to develop and propose the silvicultural techniques for wider introduction of DF in to the Czech forests including the economical evaluation and risk minimization. The main objective of the article is to present several results received in the framework of this project.

**Selected results and conclusions.** Deeper root system makes it also more resistant

to wind throw. Investigation of adjacent trees DF and European beech, Norway Spruce, Scots Pine, European large and Silver Fir (Mauer, Palátová 2012) showed, that:

- roots DF the same as its crown diameter and do not penetrate to the space of neighbour species,
- DF creates deeper root system than other neighbour species,
- DF on slope has more geotropic positive roots – more stable,
- DF on sites with normal water regime builds uniform deep root system,
- on normal soils (water and stoniness) all provenances have the same system,
- on waterlogged soils DG creates shallow rot system (50% smaller),
- root system on stony soils is as big as on normal soils but instead of vertical roots sloping roots prevail.

DG soil-forming function has also been widely analysed; negative influence of DG on pedochemical structure of humus forms and mineral horizons was ruled-out, even in case of less advisable monocultures (Kupka et al. 2013, Podrázský, Ремељ 2008).

The soil analysis proved favourable effects of this species on soil chemistry, organic matter as well as nutrient dynamics (Podrázský, 2013). Compared with domestic coniferous species DF:

- have lower acidifying effects on upper soil layers,
- contributes to better humus forms,
- recycles nutrients more effectively,
- produces litter which could be easily decomposed.

As DG, compared to spruce, is more drought-resistant (Nadezhdina et al., 2014; Urban et al., 2013), it might help to substitute spruce at lower altitudes, while not only compensating but even substantially raising the production function of forest stands (Podrázský et al., 2013).

Possible environmental risks have not been ruled out nor quantified yet, though preliminary results indicate that native fytocenoses are influenced less than in case of spruce (Podrázský et al. 2011; Augusto et al. 2003).

On the basis of investigation on 44 research plots in the Czech Republic (Podrázský, 2011) it can be concluded, that:

- presence of DF increased the species richness especially in spruce dominated stands,
- at the same time, increased canopy in DF mixtures resulted in decreased presence of less shade tolerant species.

As for silvicultural prescriptions, thinning seems to be an efficient method to get both stabilized and intensively growing DG stands (Steele 1955, Omule 1985, Novák et al. 2014). Initial thinning is recommended to begin in 10- to 15-year-old stands with 3 to 5 metres mean height (Reukema 1975). Another important silvicultural measure to get the best DG wood quality is pruning (Hofman 1964, Šindelář, Beran 2004, Bartoš, Kacálek 2011).

Based on the DG thinning experimental series established in 2011 – 2012, it can be concluded, that:

- Douglas-fir is both readily and quickly responding species to thinning, increased increment was also observed. First signs of individual stability (lowering h/d ratio) occurred even in first post-treatment period,
- excessively dense DG thickets of natural regeneration origin were also positively affected by thinning,
- as for mixed stands, the tree species accompanying the DG responded to thinning even greatly compared to DG. It seems that released DG individuals do not threaten the admixture of local trees in future.

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# **Land Cover and Climate Change**

## Changes in grassland vegetation in the Polish Carpathians as an effect of abandonment

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**Key words:** meadows management, phytosociological database

Semi-natural mountain meadows in the Carpathians have been important part of mountains landscape and local culture for centuries. Some of mountain grasslands of Europe are among the most species rich phytocoenoses (Wilson et al., 2012). However, their main role was to provide fodder for livestock. Their origin and reach plant species composition is closely associated with the traditional, extensive use. At present, two contradictory trends can be observed in agriculture. In favourable conditions agricultural production is intensified. In term of grassland it means high fertilization level and more frequent cuts. In less favourable conditions socio-economic changes taking place in Central and East Europe during the last decades caused a decrease in the profitability of animal husbandry and, consequently, the abandonment of meadows and pastures. In both cases a significant loss of species and plant communities takes place.

In undertaking protecting measures, the first stage is an inventory of the existing resources. In the Polish Carpathians, apart from some protected areas, this type of inventory is incomplete. It was the reason to create a regional database covering the data concerning the grassland vegetation of the Polish Carpathians. The database is registered in Global Index of Vegetation Databases as „Grasslands in the Polish Carpathians” EU-PL-002 (<http://www.givd.info/ID/EU-PL-002>). Until January 2013, 4.620 relevés recorded by 57 authors have been archived in the base (Korzeniak, 2013). Within the project more than 1000 relevés were made in years 2009-2013 to complete vegetation data from the areas not yet sufficiently investigated to date, in particular the area of the foothill. The data will serve multiple analyzes of state and dynamic of meadows communities. One of the most important problems is transformation of plant species composition caused by abandonment of farming practices (Zarzycki, Korzeniak, 2013). The aim of the study was to compare the species composition of managed and unmanaged grasslands in the Polish Carpathians.

**Material and methods.** Altogether 1476 phytosociological relevés were used (1.102 for managed and 361 for unmanaged grasslands) made after the year 2000 and collected in a database (Fig. 1). They represented semi-natural mesic meadows of *Arrhenatherion elatioris* (*Molinio-Arrhenateretea* class) and mat-grass swards of the order *Nardetalia* (*Nardo-Calunetea* class). The association of species to managed and unmanaged group was done with Juice software and the strength of association was shown by the Phi coefficient, what is the positive fidelity value between a particular vegetation unit and a species (Tichy 2002).

**Results and discussion.** Grasslands in the Polish Carpathians show high diversity in terms of species composition caused by the historical and economical land-use pattern and environmental conditions. The reaction of grassland communities on changing management varies substantially so the comparison between managed



**Table 1.** Species associated with unmanaged and managed variants of false oat-grass meadows. The strength of association is shown by the Phi coefficient - fidelity value between a particular vegetation variant and a species (Tichy 2002)

<i>Species</i>	<i>Unmanaged variant</i>	<i>Managed variant</i>
<i>Holcus lanatus</i>	27,6	---
<i>Luzula campestris</i>	25,9	---
<i>Arrhenatherum elatius</i>	23,8	---
<i>Sanguisorba officinalis</i>	22,2	---
<i>Cirsium arvense</i>	20,4	---
<i>Heracleum sphondylium</i>	19,0	---
<i>Trifolium campestre</i>	18,6	---
<i>Galium mollugo</i>	17,6	---
<i>Taraxacum officinale</i>	---	19,3
<i>Cardamine pratensis</i>	---	19,4
<i>Holcus mollis</i>	---	20,7
<i>Centaurea jacea</i>	---	20,8
<i>Rhinanthus minor</i>	---	20,8
<i>Veronica arvensis</i>	---	23,3
<i>Cynosurus cristatus</i>	---	24,4
<i>Luzula multiflora</i>	---	24,6
<i>Poa trivialis</i>	---	24,7
<i>Alchemilla acutiloba</i>	---	28,1
<i>Agrostis capilaris</i>	---	32,1
<i>Phleum pratense</i>	---	35,5
<i>Cerastium holosteoides</i>	---	38,7
<i>Prunella vulgaris</i>	---	39,3
<i>Trifolium repens</i>	---	45,3

**Table 2.** Species associated with unmanaged and managed variants of mat-grass swards. The strength of association is shown by the Phi coefficient - fidelity value between a particular vegetation variant and a species (Tichy 2002)

<i>Species</i>	<i>Unmanaged variant</i>	<i>Managed variant</i>
<i>Vaccinium myrtillus</i>	45,5	---
<i>Betula pendula</i>	35,4	---
<i>Nardus stricta</i>	34,5	---
<i>Carex pilulifera</i>	33,7	---
<i>Salix caprea</i>	32,4	---
<i>Gentiana asclepiadea</i>	29,9	---
<i>Poa chaixi</i>	29,4	---
<i>Campanula serata</i>	29,1	---
<i>Juniperus communis</i>	28,1	---
<i>Carlina acaulis</i>	27,6	---
<i>Rubus idaeus</i>	27,4	---
<i>Phleum pratense</i>	---	22,7
<i>Rhinanthus alectorolophus</i>	---	24,9
<i>Rhinanthus minor</i>	---	29,8
<i>Festuca pratensis</i>	---	31,0
<i>Cerastium holosteoides</i>	---	32,0
<i>Cynosurus cristatus</i>	---	32,1
<i>Prunella vulgaris</i>	---	33,5
<i>Trifolium repens</i>	---	34,5
<i>Dactylis glomerata</i>	---	36,0
<i>Trifolium pratense</i>	---	39,0



## Land Cover and Climate Change

**Table 3.** Species associated with unmanaged and managed variants of mat-grass swards. The strength of association is shown by the Phi coefficient - fidelity value between a particular vegetation variant and a species (Tichy 2002)

<i>Species</i>	<i>Unmanaged variant</i>	<i>Managed variant</i>
<i>Solidago virg-aurea</i>	48,2	---
<i>Gentiana ascepiadea</i>	42,9	---
<i>Deschampsia flexuosa</i>	37,1	---
<i>Hypochoeris uniflora</i>	33,0	---
<i>Festuca airoides</i>	31,5	---
<i>Sorbus aucuparia</i>	29,4	---
<i>Luzula luzuloides</i>	28,8	---
<i>Antenaria dioica</i>	28,2	---
<i>Salix caprea</i>	26,5	---
<i>Polygala vulgaris</i>	26,5	---
<i>Populus tremula</i>	26,5	---
<i>Carlina acaulis</i>	26,5	---
<i>Crepis conyzifolia</i>	26,5	---
<i>Veronica officinalis</i>	---	25,3
<i>Leontodon hispidus</i>	---	26,6
<i>Poa pratensis</i>	---	27,1
<i>Senetio subalpinus</i>	---	27,1
<i>Trifolium repens</i>	---	27,1
<i>Stelaria graminea</i>	---	27,4
<i>Potentilla erecta</i>	---	28,2
<i>Picea abbies</i>	---	30,9
<i>Luzula multiflora</i>	---	32,9
<i>Potentilla aurea</i>	---	32,9
<i>Anthoxanthum odoratum</i>	---	33,0
<i>Agrostis capilaris</i>	---	41,6
<i>Festuca ovina</i>	---	43,0

**Conclusions.** The abandonment of mowing and grazing gives rise to secondary succession. The influence of abandonment on species composition is significant; however it depends on plant community and habitat conditions. The direction and pace of change depends on many factors. The biomass, which is not removed or degraded, caused accumulation of nutrients and increases habitat fertility, often leading to domination of nitrophilous species (Marrs 1993). This is especially the case of false oat-grass meadows. Bent-grass meadows were often located at the same places as mat-grass swards but they were fertilised with manure. The ceasing of fertilisation allows mat-grass species to appear. If not afforested, the plant species changes within mat-grass swards are relatively slow and some species can survive long time after abandonment. However, increasing number of woody species can be observed. In all communities the accumulated biomass of dead plants inhibits sprouting and growth of small plants.

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## Climate change – The Rise of the Pathogens

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**Key words:** *Phytophthora*, *Asteroma*, *Linospora*

Climate change has brought with it a new era for plant pathogens<sup>1</sup>, with varying degrees of virulence<sup>2</sup>. In this paper, one genus and one species which can both be called climate change winners are presented.

Forest pathology is the research of any factor, biotic or abiotic, that can cause disease on forest trees. This includes all microbiological infections, but whereas plant pathologists work with fungi, bacteria and viruses, most pathogens in forestry are fungal.

Forest trees live their life in symbiosis with mycorrhiza<sup>3</sup> fungi, and most forest trees have saprophytes<sup>4</sup>. Some of the saprophytes are pathogens and wait for the right moment to attack, but most of them do no harm until the tree is dead or dying. There are a number of fungi that cause cosmetic damage to forest trees (yellow spots/stripes on spruce needles), or decrease leaf area and thereby decreasing photosynthesis and growth (rust fungi order Pucciniales, powdery mildews order Erysiphales), or create extra-ordinary organs on the tree (witch's brooms, leaf and catkin curls caused by e.g. *Taphrina* spp.) (Holliday, 1998). However, these are not generally considered a major problem.

Forest owners worldwide are also acquainted with fungi that cause great damage – e.g. root rot by *Heterobasidion* spp. and *Armillaria* spp., bluestain fungi associated with bark beetles (eg *Ceratocystis polonica*), more aggressive rust fungi eg *Chrysomyxa weirii* which attacks spruce needles. These are all diseases that have been well-documented for decades.

But there is a new breed of forest pathogens. *Ophiostoma nova-ulmi*, Dutch elm disease, has been killing off elm trees in Europe since the 1960s. Ash dieback *Hymenoscyphus pseudoalbidus* has been ravaging ash trees all over Europe since the 1990s – the first case is thought to be from Poland in 1992 – but it was first scientifically described in 2006 (Kowalski, Holdenrieder 2009). Last but not least, *Phytophthora* spp. – *P. infestans* has been known since the 1840s and was the cause of the Great Potato Famine in Ireland – but in forestry, *Phytophthoras* have only recently become major pathogens.

With increasing international trade, we also transport unwanted elements – stowaways that are near-invisible. Increasing trade also means that the value of import/export increases to the point where quarantining organisms under “fear of dangerous pathogens” is extremely difficult.

In Norway, some shipments of imported timber from the Baltics and Russia have been checked for plants, insects and fungi, and from 5 shipments they found

<sup>1</sup> Pathogen: Organism which can create disease in another organism

<sup>2</sup> Virulence: The severity of the disease the pathogen can create

<sup>3</sup> Mycorrhiza: Fungi that live on the fine roots of trees, and help supply the tree with nutrients and water whilst getting carbohydrates from the tree

<sup>4</sup> Saprophyte: A fungus that lives inside the tree without causing disease

179 different plants, 77 different fungi and 19 species of bark beetles (Økland, 2004).

**The aspen spot fungus (*Asteroma frondicola*)** is a leaf pathogen which attacks *Populus* spp. and has been observed sporadically throughout Europe and Northern Asia since the 1800s. Rarely seen in Norway before 2000, it has since spread rapidly following the natural dispersal of *P. tremula*. *A. frondicola* is not considered to be an important pathogen, but there is a concern that this rapid advancement may be followed by other, more virulent pathogens (Solheim, Bjoner, 2013).

The aspen leaf spot fungus *A. frondicola* produces lesions on aspen leaves in July/August and may cause premature defoliation of the tree. On overwintered leaves the teleomorph<sup>5</sup> *L. ceuthocarpa* develops in the lesions. The fungus is most common on *Populus* spp. in section *Populus*, and is most commonly found on *Populus tremula* L. In North America, the closely-related fungus *L. tetraspora* attacks *P. tremuloides* Michx.

*L. ceuthocarpa* has been registered in several countries, but *A. frondicola* seems to have been more sporadic, implying that there may have been unfavourable conditions for the development of the anamorph<sup>6</sup>. *A. frondicola* was recorded a few times in Norway prior to the year 2000, when it attacked a great number of trees in the Oslo area. Field trips to determine the spread have been taken at regular intervals along the southern, eastern and central parts of Norway. It has since spread both along the coast and into the country (unpublished data). The methods of dispersal are as yet still unknown, but Pinon and Morelet (1975) found a correlation between the precipitation in August and how much of the foliage was attacked. It will be interesting to see how the fungus reacts to this years' extraordinary weather.

*A. frondicola* is not an important pathogen, but if the environmental triggers that facilitate dispersal and development from teleomorph to anamorph can be found, the knowledge may be used on other, more harmful leaf pathogens.

***Phytophthora* spp.** is a genus of pathogenic oomycetes which can attack all types of plants, the most infamous species being *P. infestans* which causes dry rot in potato (Sinclair, Lyon 2005). There is an increasing number of species that attack and kill healthy trees, due to two main factors: an efficient worldwide dispersal and a large degree of hybridisation between species, creating ever more virulent species. They spread via soil water and plant remains (both compost and via international trade) and are becoming an increasing problem worldwide. Many *Phytophthora* sp. are thought to be saprophytes in indigenous plants in the Far East, and that they become pathogenic when they are moved to different climates and host plants.

Many *Phytophthora* spp. are thought to originally be saprophytes in indigenous plants in the Far East, and that they become pathogenic only when they are moved to different climates and invade other host plants. The rate at which they find new, susceptible hosts, increase their virulence, and kill off seemingly healthy plants “qualifies [them] as one of the worst plant-destroying pathogens of all time” (Agrios, 2005, p. 418).

Climate change is increasing the spread in several ways: increased amounts of precipitation lead to more soil water and a faster spread of the fungi's motile oospores. A warmer climate is doubly beneficial to *Phytophthora* spp.: the fungi prefer warmer temperatures and a warmer climate would encourage more use of oriental, ornamental plants where *Phytophthora* may be undetected.

<sup>5</sup> Teleomorph: Sexual stage of a fungus

<sup>6</sup> Anamorph: The asexual stage of a fungus

The first records of *Phytophthora* in Ukraine are from 2011, when *Phytophthora gonapodyides* and *P. lacustris* were found in the rivers Stryj and Yasenytsya and in a lake in Skolivs'ki Beskydy National Park (Matsiakh et al., 2012).

Sudden oak death has killed millions of oak trees (*Quercus* spp.) since the mid-1990s, and is caused by *P. ramorum* (Sudden Oak Death, 2014). The primary spread of *P. ramorum* is believed to be infected Rhododendron plants from nurseries. When the plants die, their remains are thrown into forests or used for compost – and the pathogen spreads into soil water. In Europe, the common name is ramorum dieback and other preferential host trees are beech *Fagus sylvatica*, Japanese larch *Larix kaempferi* and European larch *Larix decidua*.

In Norway, it was introduced with German Rhododendron plants and has spread to *Larix* sp. and *Vaccinium myrtillus*.

*P. plurivora* and *P. cambivora* are killing off the legendary beech (*Fagus sylvatica*) forest in Larvik, Norway. It was the first public area in Norway (from 1884) and has been a protected area since 1984. Unfortunately, it's also popular as a dumping site for garden litter and the fungus has most likely spread from diseased rhododendron plants.

*P. alni* causes root and collar rot in alder *Alnus* spp. In Norway, alder trees can be found along most streams and rivers and *P. alni* has been found in all water systems that have been tested. The zoospores travel easily in water and infect trees rapidly.

**Conclusions.** In regards to the Phytophthoras that are currently threatening our forest trees there is little or nothing that can be done. There is currently no way to remove it from soil water or other water systems, and *P. alni* is excelling in hybridising and making subspecies thereby increasing the potential host range.

A major problem is the import and sales of tropical and ornamental plants which may/not be carriers of new Phytophthoras. An easy kit to examine plant materials and soils for traces of *Phytophthora* leading to quarantine, destruction of infected plant material and a ban would be a good weapon against more Phytophthoras entering into any given country.

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## Political and economic drivers of land cover changes in mountain regions: an example from low Ukrainian Carpathians

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**Key words:** land cover dynamics, populated landscape, depopulated landscape, low mountains, 20<sup>th</sup> century

Mountain regions are much more vulnerable to fast economic, cultural and environmental changes. That is why dynamics of landscapes, both natural and cultural have to be one of the main issues in scientific agenda in Carpathian region.

Twentieth century and, especially, its ending has been marked by significant political and socio-economic transformations in the Carpathian countries, including Ukraine. Especially drastic changes have happened in pattern of land cover as a consequence of large extended land use dynamics. Such dynamics is caused mainly by large scale political and economic drivers, but proximate drivers of these transformations in the landscapes. The main objective of this study is to detect pattern of cultural low mountain landscape pattern and its dynamics during 20<sup>th</sup> century, caused mainly by both forced and gradual depopulation in the region.

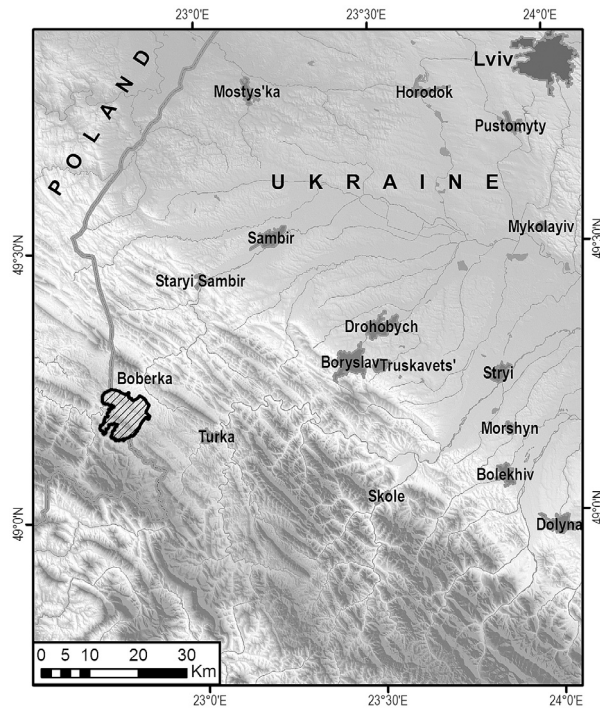
**Geographical setting.** Boberka rural municipality in low mountain part of Ukrainian Carpathians within Lviv region was selected as a study area (Fig. 1). It has an area of 6,819 ha and total population (villages Boberka and Dnistryk Dubovyi) of 1,654 inhabitants. The elevation varies from 536 to 826 m a.s.l., climate conditions change from moderately cool in valleys to cool on the top of mountain ridges. The natural vegetation of Boberka is represented by mixed forests with domination of European beech (*Fagus sylvatica*) and silver fir (*Abies alba*) on brown mountain soils, sometimes with admixture of Norway spruce (*Picea abies*) (Kruhlov et al., 2008).

Area has a long history of agricultural development – low elevation and gentle slopes afforded vast expansion of grasslands and cultivated fields around the villages. Location of Boberka can be described as a true *cul-de-sac* – at the non-permeable European Union (Polish) border with the distance of 26 km to the district town Turka.

After the World War II local population was forced to re-settle from San River valley (western and southern part of study area) by Soviet regime because of closeness to new state border. In 1950-th a fairly large collective farm (2,139 ha) was created in Boberka with 1,050 ha of arable land (about 50%) (Yaremchuk et al., 1978). In 1991, after the Soviet Union collapse, large socio-economic changes have happened in the region. The disintegration of agricultural enterprises took place and its land was distributed between former workers, e. g. in Boberka it has happened in the middle of 1990<sup>th</sup>. Former agricultural lands partly are used individually by local people as a household-scale natural economy but some due to a lack of investment sources and low soil fertility lands became abandoned. Thus processes of secondary succession have started here. Also within last 30 years (1979-2011) Boberka demonstrates the high depopulation index – 7,2 % per year (SSCU, 2002).

The area is known for the preserved ethnical architecture, clothes, and customs. The traditional economies were forestry and agriculture, and in some places the land

is still traditionally cultivated on artificially terraced slopes. Boberka is included to Nadsianskyi Regional Landscape Park, which is a part of the Polish-Ukrainian-Slovak East Carpathian Biosphere Reserve (Maryskevych, Niewiadomski, 2005).



**Fig.1.** Location of the study area

**Material and methods.** Spatial data of three historical periods were used to map the land cover pattern – 1937 (Poland before WW II), 1983 (Soviet Union) and 2008 (independent Ukraine). For two first it was topographic maps on scale 1:100 000 and 1:50 000 respectively created for military purposes by Polish WIG and Soviet Generalnyi Shtab. To explore present state of land cover the satellite images of high spatial resolution were used from Google Earth™. The land cover pattern for all three period was manually delineated using as axillary data for the last time period forest census data. Also it was collected a field data during summer campaigns in 2007-2011.

The study area was divided on two parts – populated and unpopulated. As it usual, particular for mountain region, topography is one of the main obstacles of land use for local population. Therefore we assumed that boundary between these two parts the most probably lays on watershed line, which was manually delineated from topographic maps. Then an analysis of land cover change for three study period was performed for study area in general and for two separate part in particular.

**Results and discussion.** Our results show that the share of forested landscapes in Boberka for last seven decades increase from 26,5 in 1937 to 41,6 % in 1983 and 50 % in 2008. In return, portion of open landscapes (arable land, grassland) declines from 66,2 to 48,2 % between 1937 and 2008. The share of settlements also decreased from 7,3 to 1,8 % of overall area. But it should be mentioned that built-up area for the year 2008 was delineated from satellite image which has much more spatial resolution

than topographic maps, therefore the fraction of built-up area for Polish time (1937) probably is overestimated.

Recent land cover changes (from 1983 to 2008) is equal 718 ha (10,6 % overall area) and about 90 % of them indicates the replacement of arable land and pasture with shrubland or young forest. Among shrub encroachment dominates juniper (*Juniperus communis L.*), among forest recovery – Norway spruce. Important remark is that 21 % of study area is situated in buffer zone near the state border (Fig. 1), existing from Soviet time, which is controlled by Ukrainian border guard service and access to this area for local people is restricted.

Substantial differences between populated and depopulated landscapes in respect to land cover dynamics were distinguished on study area (Fig. 2). Actually, on year 2008, in populated part of Boberka dominates grassland land cover – 53 %, less frequent are coniferous (32 %) and deciduous (8 %) forests, and the least are portions of built-up and shrub lands – 3 and 1 % respectively. But in depopulated landscapes of Boberka forest covers 59 %, with almost equal share of deciduous and coniferous stands, grassland – 39 %, and shrubland – 2 %. Rather different state was explored on the study area before depopulation had happened. In 1937 the ratio of forest–grassland–built-up areas in populated and depopulated parts of Boberka was almost the same: 25–67–8 and 28–66–6 % respectively.

Land cover change during entire study period was observed in 12,2 % of populated landscapes and 19,5 % on depopulated ones. Therefore an average speed of landscapes dynamics ranges from 11,7 to 18,7 ha per year.

Emergence of depopulated landscapes on 46,4 % of study area after WW II is a major reason of land cover change within entire study period. Another driver – establishing and strong restriction for land use in buffer border zone for local population. Rapid depopulation accompanying with socio-economic transformation were major driving forces during last two decades. In addition, Boberka and other municipalities became a part of Nadsianskyi Regional Landscape Park, which is incorporated to East Carpathian Biosphere Reserve. All above mentioned could significantly decrease an anthropogenic pressure on the landscapes and facilitate nature conservation and improve ecological connectivity for migration of mammal species.

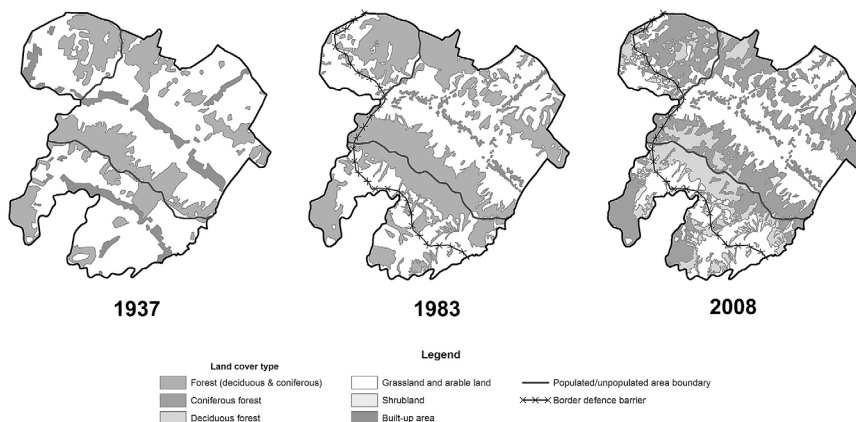


Fig2. Land cover pattern of the village of Boberka for three study periods



However, a big challenge in this respect may be new border crossing “Boberka-Zhuravyn” (TDC, 2012). It is the only opportunities for economic development of study area and improvement of tourist and traffic infrastructure. First, its opening was planned in 2009, then – postponed to the European football championship in 2012, but now the prospect of this project is very unclear. Intensive migration of people and increasing economic attractiveness of the land parcels in Boberka could cause very fast land cover change including depopulated landscapes of study area.

**Conclusions.** Low mountain landscapes with high portion of agricultural land demonstrate widespread land cover dynamics during last seven decades (1937-2008). The main reason of land cover and land use change in Boberka is population decline in the middle and end of 20<sup>th</sup> century cause by significant political and socio-economic transformation in the region. The general direction of these changes is increasing portion of landscapes covered by forest or shrub owing to degradation of former agricultural lands. During the last decades (1983-2008) the increase of forest areas was estimated for Boberka at 0,31 % a year. Depopulated landscapes demonstrate much more land cover changes that populated ones.

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## Modeling the location of natural cold-limited treeline and alpine meadow habitats in the Ukrainian Carpathians

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**Key words:** timberline, climate change, supervised classification, Landsat, CMIP5

Alpine zone, covering the top of the highest ridges and mountains in the Ukrainian Carpathians, represents a unique and valuable biotope of alpine grasslands. As only the highest parts of these mountains rise above treeline, an alpine zone in Ukrainian Carpathians mostly consists of rather small and isolated patches.

The extent and connectivity of these biotopes are defined by the position of the timberline as their natural boundary. The timberline is defined as the upper elevational limit of forest and tree growth and survival on high mountains due to environmental constraints (Wieser G., Tausz M., 2007). While timberline is usually not an abrupt boundary, but a more or less wide transition zone (ecotone), some other related terms are the forest line (i.e. the upper limit of closed-canopy conditions) and the tree line, above which tree life form disappears (Wieser, Matyssek, Luzian, 2009). Global warming is supposed to cause an upward advancement of trees beyond the present tree limit (Walther, 2003). This could have significant implications for the alpine meadow ecosystems in Ukrainian Carpathians, probably shrinking the alpine meadow biotopes and causing the loss of habitats. The amount of prospective loss of alpine meadow biotopes is unknown and merits further researches. It could be estimated by revealing a climatic variable that most strongly correlates with the positions of forest/alpine meadow divide, determining the critical values of this variable that correspond to this divide, and finding the prospective locations of these critical values based on future climate projections.

Humboldt as early as in the beginning of 19<sup>th</sup> century saw the treeline as a global phenomenon, a life form boundary that he used as a common bioclimatological reference (Humboldt, Bonpland, 1816). A century later Däniker (Däniker, 1923) was the first who clearly brought forward the notion of the lack of warmth being a main factor limiting tree growth at the treeline (known thereupon as Däniker's paradigm). Starting the middle of the last century a plenty of field and experimental studies have emerged based on the factors determining the position of treelines at certain regions and locations. The Tranquillini (1979) provided the general synthesis of known experimental data for the temperate zone, largely the Austrian Alps. The focus have shifted from the descriptive studies and speculative hypothesizings to inquiries into the functional relations between environmental constraints and physiological and reproductive processes.

Two main schools of thought presently dominate the discourse on the functional explanation of the position of treelines. The first one, while recognizing its general relation to the thermal-deficiency, asserts the great ecological variety of treelines in different regions that implies the different role of different factors in defining their positions and spatial properties and the need to inquire into the particular interplay of these factors in any particular case (Wieser, Tausz, 2007; Holtmeier, 2009). Still, the second school of thought attributes the position of treelines to a single "fundamental"

(global) forcing driver, on which different secondary regional-specific factors can have “modulative” effect (Körner, Riedl, 2012). The discussion is under the way as to the nature of the “ultimate cause” of altitudinal treeline (and the very existence of such).

One of the hypotheses promoted in (Körner, Riedl, 2012) explains global treeline positions by restrictions of meristematic activity in both shoot and root apices at temperatures below certain limit, which would only moderately constrain photosynthesis. The tree life-form causes self-shading of its root zone screening solar radiation so that its own roots may not receive sufficient warmth to continue cell division and differentiation. Trees also have their shoot apices exposed to the fully convective atmosphere and thus are experiencing lower temperatures than prostrate vegetation. The low-stature vegetation, on the contrary, either has meristems embedded in the surface-soil, it could get profit from the heat stored during the day, or is favored by the well-known higher temperatures within a narrow prostrate canopy as the result of reduced atmospheric coupling.

**Geographical setting.** The study area embraces the central part of the Ukrainian Carpathians, where all of the highest ridges and peaks are situated, with the total area of 3.136 km<sup>2</sup>.

**Material and methods.** The data used in the research included SRTM 90m Digital Elevation Database v4.1; Landsat 5 TM imagery; WorldClim dataset containing current climatic data (1960 – 2000) and projections of global climate model (GCM) data from CMIP5 (IPCC Fifth Assessment) (Hijmans et al., 2005).

To calculate the presumable present and future positions of climatic treeline, we assumed the general “lack of warmth” hypothesis, which connects these positions with it would be possible to associate this position with the critical values of some climatic variable. Among the putative climatic variables associates with the “lack of warmth” are the extreme minimal temperatures probably causing frost damages to tree plants, the duration of the growing period, during which the temperatures are high enough to sustain photosynthetic activity, and the temperatures of the warmest period of the year during which the vegetation processes are active.

The steps of the research included: 1) digital classification of satellite image dataset for the aim of the identification of forest boundary locations (the borders between forest and non-forest pixels); 2) calculation of the statistical relationships between forest boundaries locations and climatic variables and selecting the variable with the highest degree of correspondence; 3) determining the critical value of the selected climatic variable that serves as a proxy to a boundary between the forest and alpine meadow biotopes; 3) calculation of the positions of climatic treeline and the extent of alpine meadow biotopes, based on the current and prospective distribution of the selected climatic variable

The first step involved using Landsat Surface Reflectance Climate Data Record (CDR) products (Masek et al., 2006) for Landsat 5 TM scenes from 17th of July 2007 (path/row 185/026 and 185/027) for the landcover analysis and subsequent extraction of forest boundary locations. Water vapor, ozone, geopotential height, aerosol optical thickness, and digital elevation have been inputted together with Landsat data into a Second Simulation of a Satellite Signal in the Solar Spectrum (6S) radiative transfer models to generate Top of Atmosphere (TOA) reflectance, surface reflectance, brightness temperature, and masks for clouds, cloud shadows, adjacent clouds, land, and water. Thus, the procedure of digital numbers conversion to TOA and surface reflectance was omitted.

However, the images are affected by the geometric distortion and shadowing due to topography. In order to interpret the satellite images effectively, these effects need to be minimized. Prior to classification the band layers were topographically corrected

using normalization method (after Civco, 1989; modified by Law, Nichol, 2004). The normalization method used here consisted of two stages. In the first stage, shaded relief models, corresponding to the solar illumination conditions at the time of the satellite survey, were computed using the SRTM DEM data. In the second stage, a transformation of each of the original bands of the satellite image was performed to derive the topographically normalized images using a correction coefficient. The correction coefficient was calculated from the spectral responses from large samples falling on the slope facing to and away from the sun.

After topographic normalization and elimination of illumination effects the quality assurance masks from the original Landsat Surface Reflectance CDR were used to exclude water and cloud cover. Supervised classification with Maximum Likelihood algorithm has been performed for bands 1-4 (visible and NIR) using Semi-Automatic Classification Plugin v. 3.0 for QGIS (Congedo et al., 2013). There were 9 spectral classes distinguished according to their spectral signatures separability, that afterwards were merged into 3 generic thematic classes that represent forest, grassland and crops, and other surfaces (water, artificial cloud cover etc.).

The boundaries between the class “forest” and the class “grassland and crops” at elevations above 1 200 m a.s.l. were supposed to contain some elements of true climatic timberline, as well as boundaries caused by anthropogenic and other natural processes and factors. Still, statistical analyses could be able to detect the increased frequencies of forest boundaries in areas with critical values of governing climatic variables. One of such analyses rests on the assumption that the variance of such a variable should be smaller when calculated for places that correspond to forest boundaries than those calculated for total areas. Thus the ratios of variances of climatic variables calculated for only the “boundary” pixels and for the total area have been calculated: the smaller the value – the more relevant and indicative the climatic variable is. Another method involved using the analysis of variance (ANOVA) technique to determine the differences between means for climatic variable calculated inside forest and non-forest classes: the bigger this difference the stronger is the relationship between this climatic variable and the location of climatic timberline. Still another method consists in the visual analysis of the histogram of the distribution of values of the climatic variable, calculated for pixels that correspond to forest/ non-forest divide: the critical values of this variable should reveal themselves as the noticeable peaks on this histogram.

Data on actual climatic conditions were taken from WorldClim dataset, composed of the series of global maps of various climatic variables, based on records during 1960-90. Meteorological data have been interpolated using ANUSPLIN software applicable for interpolating noisy multi-variate data through thin plate smoothing splines, using latitude, longitude, and elevation as independent variables (Hijmans et al., 2005). The most spatially detailed data have 30 arc-seconds resolution (roughly equivalent to 1 km), which can be refined using SRTM DEM data with 70 m resolution. For this purpose, geographically weighted regression method has been applied (Lloyd, 2010). The elevation values served as independent variables, with local search range up to 10 km and Inverse distance to a power 2 weighting function. Thus, the grids of climatic variables were obtained with 70 m resolution, which allows discrimination of the main terrain forms.

The same method has been applied for the acquisition of grids of future climatic conditions from WorldClim dataset. The dataset includes the projections from the four global climate models belonging to a set of coordinated climate model experiments comprising the fifth phase of the Coupled Model Intercomparison Project (CMIP5)

(Hijmans et al., 2005). The Community Climate System Model (CCSM) is a coupled climate model for simulating the earth's climate system, composed of four separate models simultaneously simulating the earth's atmosphere, ocean, land surface and sea-ice, and one central coupler component (Shields et al., 2012). HadGEM2 is a coupled Earth system model being used by the UK Met Office Hadley Centre. An Earth-system configuration of this model has been used which includes dynamic vegetation, ocean biology and atmospheric chemistry (Martin et al., 2011). MIROC-ESM model is based on the global climate model MIROC (Model for Interdisciplinary Research on Climate) which has been cooperatively developed by the University of Tokyo, NIES, and JAMSTEC (Watanabe, Hajima, Sudo, 2011). IPSL-CM5 is the global general circulation model developed by Institute Pierre Simon Laplace Climate modeling center (France) to study the long-term response of the climate system to natural and anthropogenic forcings (Dufresne, Foujols, Denvil, 2013). Each of the models produced predictions for 2050 and 2070 periods for different Representative Concentration Pathways (RPC) – greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report.

When the most relevant climatic variable had been detected and its critical value (threshold) connected with the position of climatic treeline had been determined, this value was used to reclassify the study area into parts with the values of the climatic variable below and above this threshold, corresponding to biotopes below and above the climatic treeline. Thus, the locations and the total area of the alpine meadow biotopes could be determined. In the same way, the study area can be reclassified based on the prospective values of the climatic variable. Using projections of different models, calculated for different time periods and different rpc assumptions, a set of estimated future locations of the alpine meadow biotopes can be obtained and compared with each other and with the estimated present locations.

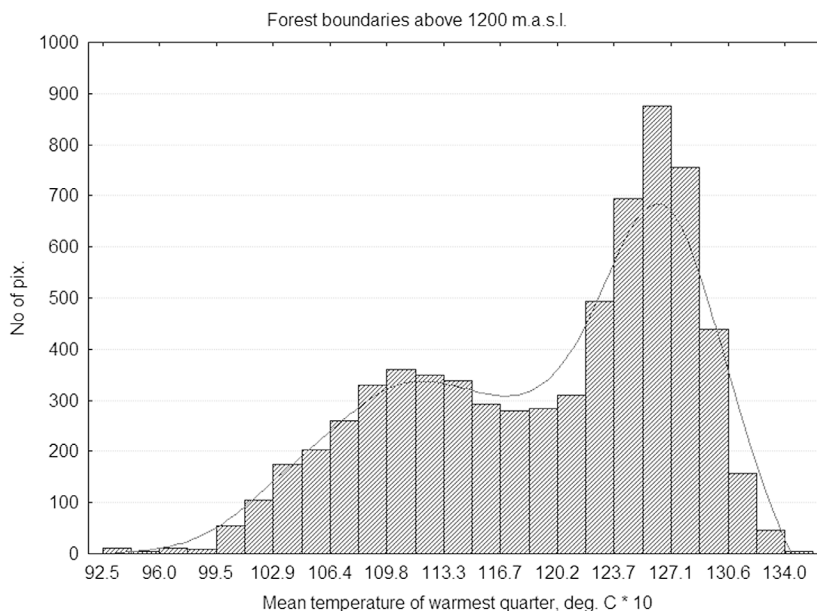
**Results and discussion.** The Table 1 shows the results of the statistical analyses aimed at determining the climatic variable most relevant as an indicator of climatic treeline locations. The warmest quarter mean temperature has revealed the strongest degree of relation among the tested variables. This result is in line with the findings of Körner and Riedl, who suggested the mean growing season temperature to be the best indicator of the natural climatic treelines locations (Körner, Riedl, 2012). The exact variable was not present in the WorldClim dataset, yet the warmest quarter mean temperature could be considered as its close approximation. At the same time, the minimal temperature of the coldest month doesn't show a big significance as an indicator of the natural climatic treelines locations, as well in line with the assertion that there are no indications that the treeline is controlled by frost tolerance (Larcher W., 1985).

To determine the threshold value of the warmest quarter mean temperature, corresponding to climatic treeline locations, the histogram of their values calculated for pixels referring to forest boundaries has been created and visually analyzed (Fig. 1). The threshold value of the warmest quarter mean temperature has been determined to be around 11.1°C. Thus areas with present or prospective future temperatures below this value could be supposed to lie above the climatic treeline, belonging to alpine meadow biotopes.

The Fig. 2 shows the map of the assumed current locations of alpine meadow biotopes. They mostly occupy the highest parts of Chornohora, Svydovets, Horhany, and Marmarosh ranges and massifs, with the total area 19.319 ha. Then the assumed future locations have been calculated based on the climatic models projections, and the supposed future areas of alpine meadow biotopes have been determined. The results are shown in the Table 2.

**Table 1.** The results of statistical analyses of spatial relationships between the climatic variables and the forest boundaries locations in the Ukrainian Carpathian Mts.

<i>Climatic variable</i>	<i>ANOVA on land cover classes</i>	<i>Forest boundaries / total area variance ratio</i>
January minimal temperature	19.423	0,93
July mean temperature	26.728	0,89
Warmest quarter mean temperature	27.985	0,85

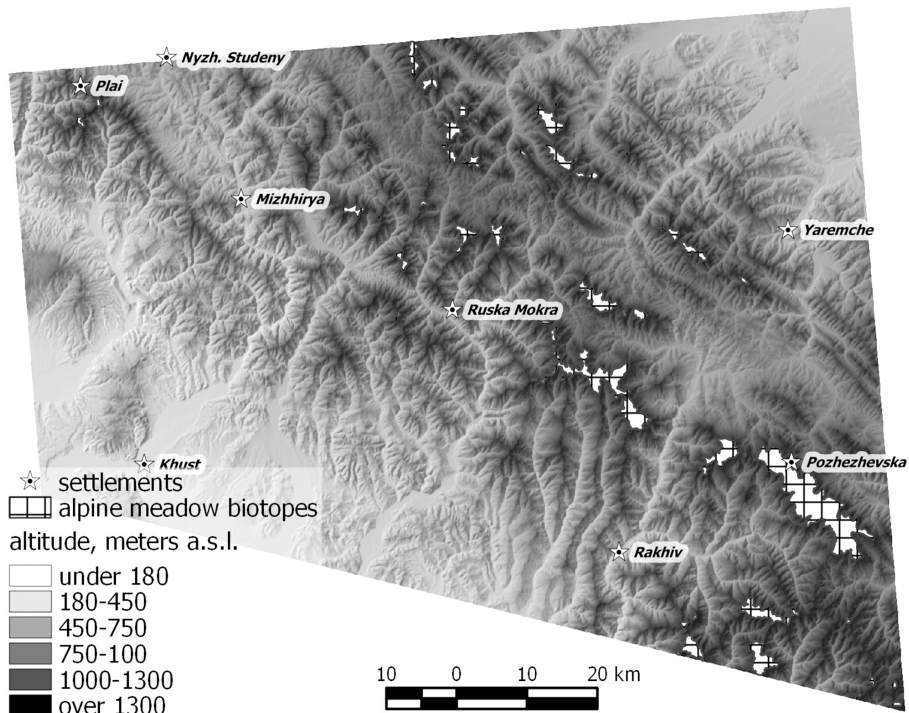


**Fig. 1.** Histogram of the distribution of warmest quarter mean temperatures for the areas corresponding to forest boundaries above 1.200 m a.s.l. in the Ukrainian Carpathian Mts.

**Table 2.** The prospective area of alpine meadow biotopes in the Ukrainian Carpathians based on global climate models predictions, ha

<i>Prediction model</i>	<i>2050: rcp 26</i>	<i>2050: rcp 45</i>	<i>2050: rcp60, rcp85, 2070: any rcp</i>
CCSM4	126	9.8	0
HadGEM2-ES	0	0	0
MIROC-ESM	0	0	0
IPSL-CM5	0	0	0

From the four model predictions used, three predict total disappearance of alpine meadow biotopes in Ukrainian Carpathians for year 2050 even under the most conservative greenhouse gas concentration trajectory (rcp 26). The prediction of the fourth model, the Community Climate System Model (CCSM) shows the decrease in area of alpine meadow biotopes in Ukrainian Carpathians from current 19.319 ha to 12,6 ha in 2050 under the rcp 26 trajectory and to 9,8 ha in 2050 under the rcp 45 trajectory.



**Fig. 2.** Locations with warmest quarter mean temperature under  $11^{\circ}\text{C}$  (assumed current alpine meadow biotopes)

Our previous study that was based on the same methodology but had been using the less sophisticated method of the Landsat image classification, has produced somewhat different results. According to it, natural alpine meadow biotopes in Ukrainian Carpathians will totally disappear by 2050 even when CCSM4 projections under the low carbon emissions scenarios were considered (Mkrtchian, Svidzinska, 2014). The present study, applying the more sophisticated image classification method, has obtained the higher threshold value for warmest quarter mean temperatures indicative of climatic treelines. This has led to the prediction that some alpine meadow biotopes in Ukrainian Carpathians could still hold out till 2050 if the CCSM4 climate projections come true, though their spatial extent will be reduced by an order of 2.

**Conclusions.** The method employed in our research uses several connected techniques to isolate the climatic treelines in the area of the strong anthropogenic disturbances, enabling the mapping of alpine meadow biotopes and the predictions of their future locations and extent, based on climate change projections. According to results, till the middle of the century alpine meadow habitats in Ukrainian Carpathians will either totally disappear or shrink dramatically, dependent on the realized greenhouse gas concentration trajectory and the veracity of the climate model used for the prediction.

It should be noted that what we have determined are the potential biotopes due to climatic constrains. The actual distribution of ecosystems will also be influenced by other factors: as noted by Holtmeier, timberline is not a line that will advance or retreat

parallel to an altitudinal shift of some isotherm, but rather a more or less wide ecotone that will not respond linearly to changing temperatures or other environmental factors (Holtmeier, 2009).

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## Variability of surface ozone in the context of land cover change

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**Key words:** secondary air pollution, extreme wind, forest vegetation, High Tatra Mountains

In November 2004, extraordinary windstorm caused considerable damages in the region of High Tatra Mts. The windstorm strongly damaged almost one third of forested area - approximately 12.600 ha from total 46.000 ha of forest vegetation of the Tatra National Park (Fleischer, 2011). Forest vegetation is important natural source of Biogenic Volatile Organic Compounds (BVOC) such as isoprene and monoterpenes that play a significant role in the tropospheric photochemistry, especially in suburban and rural locations (Chameides et al., 1992).

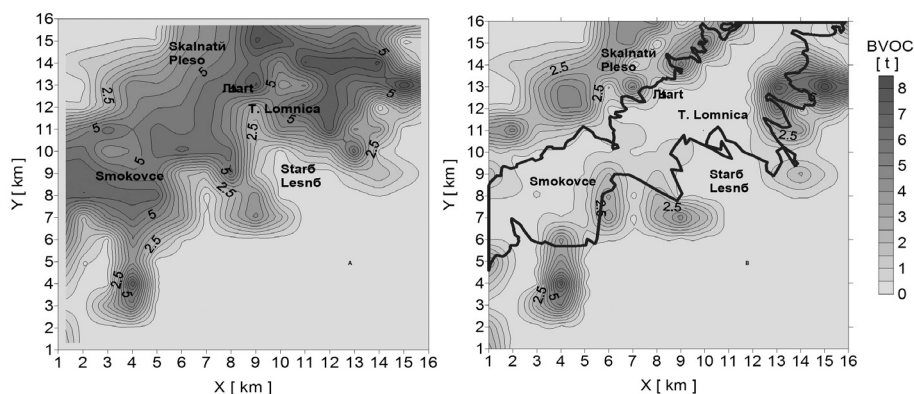
The aims of this paper is to evaluate variability of O<sub>3</sub> concentrations monitored at EMEP station Stará Lesná for period of 1992-2013 and investigate O<sub>3</sub> course in association with the decreasing amount of local BVOC precursors from forest vegetation after extreme windstorm in 2004.

**Geographical setting.** EMEP monitoring station Stará Lesná is situated in foothill of the High Tatra Mts. (49°09' N, 20°17' E, 810 m a.s.l.), near the Slovak-Polish border (Figure 1). It is the background area without industrial sources, surrounded mostly by forests and pastures. From the north-western site is enclosed by main mountain ridge with dominant peak of Lomnický štít (2635 m a.s.l.) and Skalnatá dolina valley. At the south-eastern site is open to the Popradská kotlina basin. Location Stará Lesná lies on lower border of mountain forest belt. Forest is dominant vegetation type in the lower (supramontane) part of Skalnatá dolina (up to 1500 m a.s.l) and according to forest altitudinal classification is part of the Norway spruce vegetation zone. Spruce (*Picea abies*) is absolutely dominant tree species. Higher percentage reaches European larch (*Larix deciduas*) either on extremely rocky sites or, conversely, on deep, loamy soils which are often affected by windstorms (Jbkvarenina, Fleischer, 2013).



**Fig. 1.** Position of EMEP air quality monitoring station at background site Stará Lesná

Changes of BVOC after forest destruction in 2004. The measurement and modeling of BVOC are essential for understanding regional and global atmospheric chemistry, carbon cycles, and climate. Emissions modeling systems (GLOBEIS, ENVIRON) and other global models of tropospheric chemistry (GEOS-CHEM) incorporate the algorithm developed by Guenther et al. (1993). Emission rates are a function of landcover and environmental conditions, which are characterized from user-supplied data using the most updated emissions algorithms. Estimations of BVOC emissions for the High Tatras region before and after devastating windstorm using BEIS2 series of GLOBEIS model (Fig. 2) show decrease of BVOC emissions in range 53 – 59% that is adequate to 59% reduction of forest vegetation area (Bičárová, Fleischer, 2006).



**Fig. 2.** Spatial distribution of total BVOC emissions (isoprene, total monoterpenes and other VOC) for the High Tatras model domain of periods: A – before windstorm, B – after windstorm (solid grey line – border of damaged forest area)

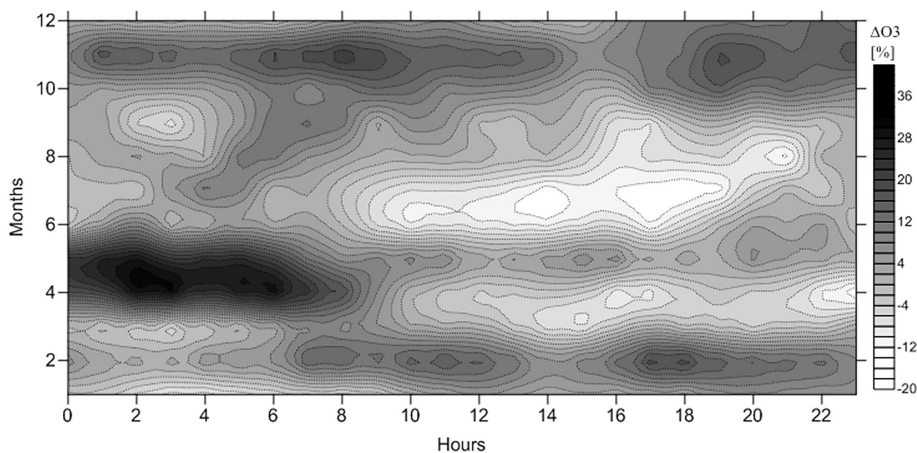
**Material and methods.** Measurement of  $O_3$  concentration is provided by Slovak Hydrometeorological Institute (SHMI) that is national participating institute in EMEP project. Continuously operating air monitoring station measures  $O_3$  concentration by analyzer Horiba APOA360 and mean hourly  $O_3$  are registered in EMEP database under code SK04 ([www.emep.int](http://www.emep.int)). Automatic  $O_3$  analyser is regularly calibrated and data are validated in data centre of SHMI. Experimental workplace of the Geophysical Institute of the Slovak Academy of Sciences (GPI SAS) at Stará Lesná carries out meteorological observations since 1988. Evaluation of meteorological measurement for period 1988-2013 indicate that climate of this location is moderately cool with average annual air temperature  $5,9^{\circ}C$  that seasonally varies from  $-3,5^{\circ}C$  (DJF) to  $15,2^{\circ}C$  (JJA). Wind blows mostly from the more open southern side. Although average wind speed is low (2,1 m/s), occurrence of strong wind gusts above 40 m/s can cause such spatial destruction of natural environment such as in November 2004.

**Results and discussion.** Multiple variable analysis of validated  $O_3$  data (Tab. 1) shows that mean annual values fluctuate around long-term  $O_3$  mean of  $64,1 \pm 3,6 \mu g m^{-3}$ . Changes of annual means during period 1992-2013 are statistically not significant. However, mean values for period before (1992-2004) and after windstorm (2005-2013) increased from  $62,5$  to  $67,6 \mu g m^{-3}$ . Coefficients of variation document higher variability (22%) of annual means for period 1992-2004 than for period 2005-2013 (5%). It corresponds with wider range of mean values ( $50 - 72 \mu g m^{-3}$ ) until 2005 than for following years.

**Table 1.** Summary statistics of O<sub>3</sub> time series data, Stará Lesná (1992-2013)

Year	Annual mean O <sub>3</sub> [mg m <sup>-3</sup> ]	Standard deviation	Coefficient of variation %
1992	65,3	17,5	26,8%
1993	63,6	11,3	17,8%
1994	64,3	13,6	21,2%
1995	69,6	14,9	21,4%
1996	71,8	26,6	37,1%
1997	50,6	13,1	26,0%
1998	50,8	13,6	26,8%
1999	66,0	20,1	30,4%
2000	60,1	14,7	24,5%
2001	55,3	22,1	40,0%
2002	55,6	13,7	24,7%
2003	66,6	15,3	22,9%
2004	61,7	13,8	22,4%
2005	70,4	15,7	22,3%
2006	70,6	20,0	28,3%
2007	68,0	16,4	24,1%
2008	70,3	14,8	21,1%
2009	61,5	16,7	27,1%
2010	67,6	12,0	17,7%
2011	65,3	15,4	23,5%
2012	63,3	12,4	19,6%
2013	71,1	13,1	18,4%
1992-2013	62,5	7,5	9,9%

Changes of O<sub>3</sub> concentration were investigated using hourly O<sub>3</sub> data averaged over period before (1992-2004) and after (2004-2013) extreme windstorm. Temporal distribution of differences  $\Delta O_3$  between the considered periods shows contrast, especially for night and daylight hours. The larger, more than 30% increase for night and early morning hours (0-7h) from April to May (Fig. 3) after 2004 was identified. On the other hand, decrease down to -16% in spring and summer seasons indicate lower photochemical O<sub>3</sub> production during daylight hours.



**Fig. 3.** Temporal distribution of differences  $\Delta O_3$  [%] between hourly O<sub>3</sub> concentrations [ $\mu\text{g m}^{-3}$ ] averaged for periods before (1992-2004) and after (2005-2013) windstorm

**Conclusions.** In the past decade, the High Tatras were affected by several natural disasters (strong windstorms, forest fires, flooding, insect invasions, etc.) as well as by an extensive construction of tourist centres and development of ski resorts. These events contributed to several visible landscape changes in the area including large deforestation of uphill slopes. Spacious destruction of forested area caused reduction of natural emissions from forest vegetation that play important role in surface ozone chemistry. Analysis of long-term O<sub>3</sub> series data for foothill station Stará Lesná suggest association between BVOC and O<sub>3</sub> concentrations in the context of land cover changes. Both, decrease of daylight and increase of nightly O<sub>3</sub> concentrations for selected time period is linked to changes of BVOC after windstorm in 2004. *Further* research is needed to take account of climate factor as well as effect of long-range transport.

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## **Stream Channel Processes**

## Modelling hydraulic parameters of flood flows for a Polish Carpathian river

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**Key words:** river channelization, channel incision, flood flow hydraulics, erodible river corridor, river restoration

During the 20th century many sections of Polish Carpathian rivers were heavily modified by channelization and channel incision (Wyżga, 2008; Zawiejska, Wyżga, 2010). Recent research demonstrated negative effects of these changes on the components of river biocoenoses such as fish fauna (Wyżga et al., 2009) and benthic macroinvertebrates (Wyżga et al., 2012). However, negative consequences of river channelization and channel incision are not limited to their impacts on river ecosystems, but they are also manifested in increased flood hazard to valley sections downstream of the modified river reaches (Wyżga, 1997).

Erodible river corridor is a restoration measure aimed to mitigate the negative effects to river ecosystems and the conditions of flood-water storage. It consists in a part of the valley floor, within which the river is allowed to develop its channel freely, while migrating within the corridor (Piégay et al, 2005). A few years ago such an erodible corridor was delimited in two reaches of the Biała, a gravel-bed river in the Polish Carpathians, that was heavily affected by channelization and channel incision in past decades. In these reaches, short channelized sections located in the vicinity of bridges alternate with longer unmanaged channel sections which either avoided channelization or in which the channel has widened after maintenance of the channelization scheme was abandoned. Effects of these alternating channel morphologies on the conditions for flood flows were investigated in a study of 10 pairs of closely located river cross-sections with constrained and freely developed morphology.

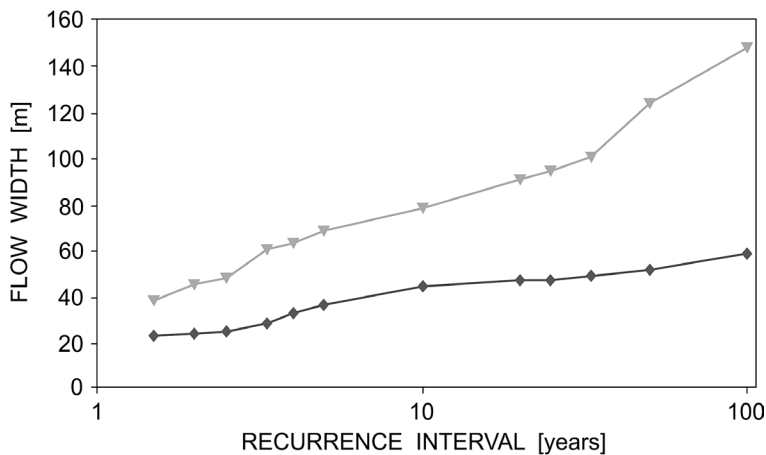
**Geographical setting.** The Biała is a 102-km-long gravel-bed river flowing north across the Outer Western Carpathians in southern Poland. The catchment, with an area of 983 km<sup>2</sup>, is almost entirely underlain by flysch bedrock. The erodible corridor was established along 14,5 km of the upper river course and in the 5,9-km-long reach in the middle river course. Despite the substantial impact of channelization works performed in past decades, both reaches of the erodible river corridor consist of 1–3 km-long channel sections with freely developed morphology alternating with 0,1–0,3 km-long, channelized sections located in the vicinity of bridges. Each study site consisted of a pair of cross-sections running across the adjacent unmanaged and channelized river sections located between significant tributaries. Each pair of the cross-sections thus represented similar hydrological conditions.

**Material and methods.** Discharges of particular probabilities were determined for each cross-section using an empirical formula. The morphology of the cross-sections

together with data about channel slope and roughness of particular parts of the cross-sections were used as input data to the numerical modelling performed with the Hec-ras software.

In the study, average values of particular hydraulic parameters typifying the studied channelized and unmanaged cross-sections at flood flows of given magnitude were compared and statistical significance of their differences between both cross-section types was determined by means of a Wilcoxon test. Principal component analysis was used to establish patterns of the differences in all studied hydraulic parameters apparent at a given flood magnitude between both types of river cross-sections. The potential of particular cross-sections for the retention of flood water in the floodplain area was calculated and compared between both cross-section types.

**Results.** The study indicated that freely developed cross-sections, usually with multi-thread morphology, are characterized by significantly lower water stage (water depth) but larger width (Fig. 1) and cross-sectional area of flow at particular flood discharges than single-thread, channelized cross-sections. They also exhibit significantly lower values of average flow velocity, unit stream power and bed shear stress, especially in the channel zone (Fig. 2).

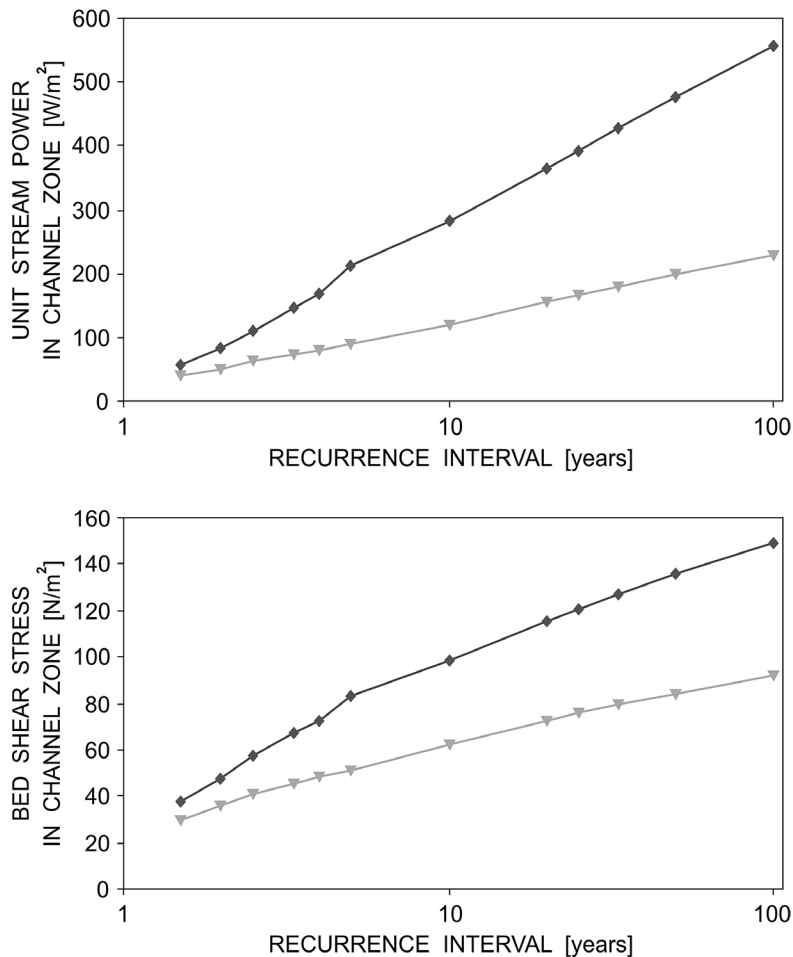


**Fig. 1.** Average values of flow width at flood discharges of given recurrence interval in the 10 channelized (black) and the 10 unmanaged (grey) cross-sections of the Biała River

Principal component analysis of the hydraulic conditions at flood flows demonstrated that the majority of unmanaged and channelized cross-sections of the river differ markedly in the values of hydraulic parameters. The pattern of these differences among the cross-sections varies with changing flood magnitude. At low-magnitude floods, the pattern of hydraulic parameters in the studied cross-sections reflects both the differences between channelized and unmanaged cross-sections and the differences occurring along the river course. At high-magnitude floods, differences between both types of river cross-sections are the main factor responsible for the observed variation of the values of hydraulic parameters among the studied cross-sections.

The retention potential of a river cross-section indicates proportion of the total cross-sectional area of flow, where water can be considered motionless and thus

temporarily retained in the floodplain zone. In channelized cross-sections of the Biała, the potential varies between 0.4% of the total flow area at a 2-year flood to 13.5% of the total flow area at a 100-year discharge. The respective values for the unmanaged cross-sections range from 0.2% of the total flow area at a 2-year discharge to 12.8% of the total flow area at a 100-year flood. These results indicate that due to the deep incision of the river in the past decades, both cross-section types currently exhibit a similar, low potential for the retention of flood water in the floodplain areas.



**Fig. 2.** Average values of unit stream power and bed shear stress in the channel zone associated with flood discharges of given recurrence interval in the 10 channelized (black) and the 10 unmanaged (grey) cross-sections of the Biała River

**Conclusions.** The study indicated that even though the river restoration here has only begun, it already brings beneficial effects for the flood risk management on the river, reducing flow energy and shear forces exerted on the bed and banks of the river in poorly managed valley sections. Only within wide, multi-thread channel sections



can the flows of high-magnitude floods be conveyed with reasonably low shear forces exerted on the banks and bed of the channel. In contrast, in constrained, single-thread channel sections, flow velocity and shear forces are much higher, inevitably causing bank erosion and channel incision.

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## Methods for long-term monitoring of large wood recruitment and mobility in two Polish Carpathian watercourses

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**Key words:** large woody debris, mountain river, wood dynamics, flood risk

In watercourses draining forested river corridors, fluvial processes are determined not only by the amount and character of mineral sediments but also in-channel woody debris (Gurnell et al., 2002; Montgomery et al., 2003). Regular monitoring of the recruitment of trees to mountain river channels and their downstream transport plays an important role in the assessment of flood risk and the interpretation of its causes (Ruiz-Villanueva et al., 2014). Large wood-related flood risk in mountain streams and rivers may result from the kinetic energy of floated wood colliding with in-channel and bank structures, scour of bridge piers and abutments by the water jets caused by wood accumulations, and the elevation of flood water level by wood jams, especially those formed at bridge cross-sections. In a research project on flood risk in the Tatra Mountains foreland, Polish Carpathians (Kundzewicz et al., 2014), several methods are used in the long-term monitoring of large wood recruitment and dynamics in exemplary watercourses of different size.

**Geographical setting.** Our investigations were conducted in two Polish Carpathian watercourses:

- the second- to fourth-order reach of Kamienica Stream in the Gorce Mountains National Park. For more than 30 years this stream reach has nearly lacked human impact on the channel and riparian zone. In the last few years bark beetle infestation greatly increased forest dieback that considerably intensified the delivery of fallen trees to the channel. As a result, a large number of trees can be delivered downstream of this 7 km-long reach,
- the fifth-order Czarny Dunajec River, along which a pronounced development of riparian forest took place in the 20th century. Particular sections of the river differ considerably in morphology and the style of channel management. Wood inventory in the river was performed after the 7-year flood of 2001 in a 17 km-long reach without tributaries (Wyźga, Zawiejska, 2005).

**Material and methods.** In October 2009, 429 trees growing along three sections of Kamienica Stream were tagged with numbered metal plates to allow monitoring of their recruitment to the channel, transport and storage (Fig. 1). Different metals (aluminium, copper or steel) were used in particular stream sections to allow use of a metal detector to distinguish between trees delivered to the stream in its different sections in the case when the plate is invisible or inaccessible. The positions of standing and fallen trees are repeatedly monitored to determine the causes and timing of wood delivery to the stream and the lengths of its transport during particular flood events. Wood dynamics in the stream is also inferred from the inventory of large wood deposits performed on 7 km of stream length. The examined section was divided into segments of 100 m length, in which we measured channel width and gradient

and performed large wood inventory. During the inventory parameters indicating the potential for piece mobilization or the residence time of wood in the stream were recorded.



**Fig. 1.** Installation of metal plates (in Kamienica Stream) and radio transmitters (in the Czarny Dunajec River) in the trees growing along the studied watercourses

As the Czarny Dunajec has substantially greater channel width, 50 trees growing near to undercut banks or fallen to the channel were tagged with radio transmitters of unique signal frequency. Trees were tagged in two river reaches running through a forested corridor, where channel banks are not reinforced and thus prone to erosion. During the flood of May 2014, 30 logs tagged with radio transmitters were placed into the river in its reaches of different morphology and width. After the flood the relocated trees/logs were searched with use of antennas and signal receivers. This experiment allowed determining the transport distance and the locations of deposition of wood pieces transported by the flood.

**Results and discussion.** No significant flood occurred on Kamienica Stream during the 5 years of observations. Various processes may deliver large wood to watercourses (Benda et al., 2003), and to date 20 trees (6% of the tagged sample) have fallen to the channel as a result of windthrow, bank erosion and overloading with snowfall. A considerable proportion of spruce trees in the riparian area are affected by bark beetle infestation. The weakened trees are more susceptible to breakage by wind and this type of delivery is characteristic of the conifers growing along the stream. Trees of deciduous species mostly get into the channel as a result of windthrows, bank erosion by flood flows, landslides and overloading by snow. Based on the number on the metal plate fixed to a fallen tree, it is possible to determine the distance of tree transfer, from its initial position on the banks or the former position within the stream (Fig. 2). As the study period lacked major flood events, the majority of fallen trees were not transported by the stream and some were moved short distances, not exceeding 100 m. It is particularly important to reduce the travel distance of fallen trees are wood dams (Kaczka, 2003) that can retain bed material and wood pieces transported from upstream.

Radio transmitters were installed only in the trees considered as the most prone to erosion during next flood. However, the complexity of erosional and depositional processes in unmanaged, multi-thread reaches of the mountain river caused that

banks were often eroded in unexpected locations. As a result, most of the tagged trees survived the flood of May 2014 of moderate magnitude. In contrast, the experiment with tagged logs placed into the river during the passage of the flood wave has yielded interesting results. The average distance of log transport reached ca. 3 km and was significantly greater for logs that were supplied to the river in single-thread reaches. In turn, logs were mostly deposited in a wide, multi-thread section of the river.



*Fig. 2.* An example of beech tree fallen to the channel of Kamiénica Stream. The white arrow indicates a metal plate with a number allowing to identify the original location of the tree and the length of its transport in the stream

Wood inventory performed in Kamiénica Stream indicated similar total amounts of wood stored in the stream segments of different width. However, the amounts of wood stored per unit channel area decrease considerably as channel width increases (Wyżga et al., in press). Results of the wood inventory performed in the Czarny Dunajec River demonstrated markedly different amounts of large wood retained in the channel sections of different morphology (Wyżga, Zawiejska, 2005; Wyżga et al., 2014). In narrow, single-thread, channelized or incised river sections, only small amounts of large wood are retained. Very small number of wood deposits of relatively low mass was observed in the single-thread section with a regulated channel. In wide, unmanaged sections, wood deposits are numerous and have relatively high mass. This indicates that considerable variability exists among the sections with respect to their potential for either passing or retention of large wood.

**Conclusions.** The experiment with the trees and logs tracked in the Czarny Dunajec after the flood of May 2014 demonstrated: (i) significant differences in the transport distance between the logs delivered to the river at the beginning of narrow, single-thread channel sections and a wide, multi-thread section; and (ii) unpredictable nature of the river dynamics during the flood. The channel of the Czarny Dunajec River is too wide to be spanned by fallen trees and thus woody debris can be transported long distances during floods. In Kamiénica Stream the period without major floods was reflected in minor intensity of wood recruitment, mobility and deposition.

The collisions of floated wood pieces with in-channel or bank structures and wood jamming in bridge cross-sections can result in considerable flood damage. Our

investigations of woody debris conducted with use of the above described methods will help to better recognize the flood risk caused by wood delivery to the channels of mountain watercourses of different size and will be useful in the formulation of management recommendations that will allow to maximize environmental benefits resulting from the presence of in-channel large wood and to minimize the flood risk it causes.

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## Formation, persistence and environmental role of vegetated islands in a mountain river

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**Key words:** large wood, flood disturbance, tree-ring dating, plant diversity, river restoration

Vegetated islands seem to have been a common feature of mountain rivers under natural conditions (Gurnell, Petts, 2002). However, during the last two centuries island formation in Polish Carpathian rivers was inhibited due to considerable human impacts. In the 19th century and the first half of the 20th century, high sediment supply to the rivers favoured development of bar-braided channel pattern. In the second half of the 20th century, intense channelization works led to widespread formation of single-thread channels, precluding the occurrence of islands (Zawiejska, Krzemień, 2004). The Czarny Dunajec is a river that still supports reaches with numerous vegetated islands, hence allowing observations on the origin, development and environmental significance of such features. Understanding these aspects of island occurrence in mountain rivers may be useful for developing fast and cost-effective methods of river restoration in mountain areas.

**Geographical setting.** Islands were surveyed in a 4-km-long, unmanaged channel section in the middle course of the Czarny Dunajec. Here, the river still maintains a geomorphic dynamic equilibrium and a multi-thread channel pattern (Wyżga et al., 2010, 2012), and the width of its active zone varies from about 60 m at both ends of the section to 180 m in its middle part. The Czarny Dunajec is one of two headwater watercourses of the Dunajec, the second largest river of the Polish Carpathians. The Czarny Dunajec originates at about 1500 m a.s.l. in the high-mountain Tatra massif (with elevations in the catchment up to 2176 m a.s.l.), and in the Tatra Mountains foreland it flows for about 38 km, joining with the Biały Dunajec River at an altitude of 578 m.

**Material and methods.** The study focuses on three aspects related to the occurrence of vegetated islands in the Czarny Dunajec River. First, observations of 23 pioneer islands, 1-3 years old, were performed aiming to determine the process responsible for their origin. Second, using a sample of 16 established islands, we performed dendrochronological dating of trees growing in their particular zones (island centre, left and right marginal zones, distal and proximal zones, island head). Age structure of the trees growing in different zones of the islands was subsequently used as a proxy of island development pattern. Third, an inventory of vascular plant taxa on 50 islands was made and compared with that performed on 10 plots of riparian forest. The investigated islands ranged from 1 to 35 years in age and their area varied between 2 and 20370 m<sup>2</sup>. This part of the study was intended to recognise the significance of vegetated islands in the overall biodiversity of terrestrial habitats in the mountain

river, with the plants used as a proxy of all terrestrial biota inhabiting the ecosystem.

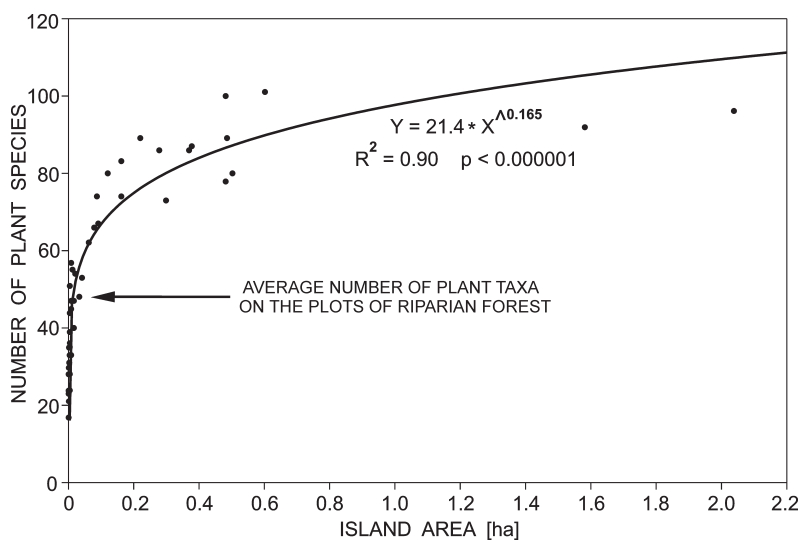
**Results and discussion.** Observations of pioneer islands in the Czarny Dunajec indicated that all of them originated in connection with the deposition of large vegetative particles on exposed river sediments. The most common were willow shrubs and trees that sprouted dense shoots from the canopy and trunk. Less frequently the accumulations of large wood, especially tree root wads and wood jams, induced the deposition of fine sediments and propagules in the lee of the obstacles, subsequently providing shelter for the developing seedlings of herbaceous plants and trees. Finally, there also occurred clods of turf delivered by bank failures, subsequently transported and deposited on gravel bars together with the soil and numerous herbaceous plants.

Dendrochronological dating of trees growing on the established islands in the river indicated that the oldest trees grow in the central, best protected part of the islands. The decrease in tree age from the island centre is more pronounced in the upstream than in the downstream direction. As a result of riparian forest and river management, wood debris in the river is highly mobile and at successive floods accumulates in jams formed at the head of islands (Wyżga, Zawiejska, 2010). Trapping wood and mineral sediment at the island head and successive sprouting of the wood adds new segments to the existing islands, resulting in their upstream growth. That pattern of island formation contrasts with the downstream growth of the islands developing along stable, large fallen trees, that was reported from the rivers of the Pacific Northwest, USA (Fetherston et al., 1995). Upstream island growth seems characteristic of European mountain rivers from which large wood pieces are typically removed and where the resultant lack of key-member fallen trees prevents island development in their hydraulic shadow.

The inventory of vascular plant taxa growing on islands and in the riparian forest indicated that islands are hot spots of terrestrial plant diversity in the river corridor, with many islands supporting richer plant communities than the riparian forest (Fig. 1). The taxa richness increased non-linearly with increasing area (see Fig. 1) and age of the islands. With the rapid increase of the number of plant taxa in the early stage of island development, islands larger than 120 m<sup>2</sup> and older than 4 years supported greater number of taxa than the average found on the plots of riparian forest. Moreover, the total number of taxa found on the islands was greater than that recorded in the riparian forest. All this seems to reflect the availability of propagules delivered to the islands by flood waters and wind, and frequent flood disturbance of the relatively low-elevated surfaces, resulting in the formation of numerous niches with diverse habitat characteristics.

**Conclusions.** Vegetated islands originate and develop in close connection with the delivery of large wood from the riparian forest (Gurnell, 2007; Kollmann et al., 1999). Islands exhibit especially high diversity of plant communities as they are located directly on the way of propagule transport by flood waters and are subjected to frequent flood disturbance.

Vegetated islands are highly dynamic elements of the mountain river ecosystem (Schnauder, Moggridge, 2009). With absent or considerably limited human interventions in the environment of mountain rivers, islands can originate and attain a highly biodiverse stage of development within a few years (Bertoldi et al., 2009). Given the relatively fast development of vegetated islands in mountain rivers and their high biodiversity, allowing the spontaneous development of island-braided morphology can be seen as a rapid and cost-effective method of the restoration of rivers draining the Polish Carpathians and other mountain areas.



**Fig. 1.** Scatter plot and estimated regression relationship between the number of vascular plant taxa growing on islands in the Czarny Dunajec and island area. The diversity of plant communities of the islands is shown on the background of the average number of plant taxa found on the plots of riparian forest

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Наукове видання

**Місцеві відповіді на глобальні виклики  
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