IUFRO – 8.01.02 Landscape Ecology

Proceedings of the International Conference

Landscape Ecology and Forest Management
Challenges and Solutions

September 16-22, 2008
Chengdu, Sichuan, P.R. China

Jiquan Chen, Shirong Liu, Richard Lucas,
Pengsen Sun, Raffaele Lafortezza, Lisa Delp

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Northern Research Station
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65 **[S-3]**: HOT SPOTS OF FOREST PATTERN PROCESSES OVER THE LAST DECADE IN EUROPE

Christine Estreguil*, Peter Vogt and Katarzyna Ostapowicz

Joint Research Centre of the European Commission, Institute for Environment and Sustainability, TP261, Via Enrico Fermi 1, 21-027 Ispra (VA) Italy, Phone: +39 0332 785422, Fax: +39 0332 785500

**corresponding author e-mail: christine.estreguil@jrc.it; Web: http://forest.jrc.it/biodiversity/*

A new method based on mathematical morphology and combined with customized measures was applied for European reporting on forest ecosystem goods and services, with special emphasis on forest spatial pattern processes –fragmentation and lack of connectivity- leading to loss of biodiversity. Four pattern processes were informed over a 10 years time frame from the European CORINE Land Cover data at 100m spatial resolution. They capture (1) sample effects (when habitat units are totally lost), (2) area effects (reduction of habitat units in number and size, small/large fragments issue), (3) isolation effects (increased distance between habitat units, reduction of structural/functional connectivity), and (4) edge effects (creation of forest edge habitat, internal and external edge effects).

The computation of each of the four patterns processes is based on combinations of seven forest spatial patterns classes (core, small fragments, edges, perforation, connectors as bridges and loops, branches) identified with 100m edge width in the year 1990 and 2000. European hot spots maps and associated area statistics summarized the processes at country and administrative NUTS3 management levels. The direction and degree of each forest processes is informed: low and high increase and decrease levels. Each management unit was also assigned a forest proportion category (<10%; 10%-30%; 30%-60% ;> 60%) in 1990. The most critical hot spots for the survival of area-sensitive forest interior species were identified for the four processes in the less forested regions (below 30% threshold). This large-scale harmonized assessment identified landscape level hot spots of pattern changes where local surveys are needed and correction measures would probably be necessary for conservation and landscape restoration.

Keywords: Forest spatial pattern processes, European assessment, hot spots maps, landscape indices

67 **[O-5]**: THE ROLE OF URBAN GREEN SPACES IN AIR QUALITY

M. Feliciano[1], A. Fernandes[1], T. Nunes[2], P. Alves[1], A. Gonçalves[1], L. Nunes[1], P. Cortez[1] and L. Dias[1]

[1]Escola Superior Agrária, Instituto Politécnico de Bragança, Apartado 1138, 5301-854 Bragança, Portugal, Campus de Santa Apolónia, +351273303200, +351273325405 , msabenca@ipb.pt, www.esa.ipb.pt

[2]Departamento de Ambiente e Ordenamento, Universidade de Aveiro, 3010-193 Aveiro, Portugal, +351234370200, +351234370309, tnunes@ua.pt, www.ua.pt

Urban green areas such as public open spaces, private planted park areas around buildings, street alignments, and others, provide many environmental services contributing to ameliorate life conditions in our cities by creating high-quality urban environments.

In the framework of the Greenurbe Project (*The Impacts of Green Spaces on Urban Environmental Quality - POCI/AMB/59174/2004*), a study is being developed with the purpose of evaluating the influence of urban green spaces on local air quality in Bragança, Portugal. In order to achieve this objective we have measured several gaseous pollutants (ozone (O_3), nitrogen dioxide (NO_2) and volatile organic compounds (VOC)) in the urban area since 2006. Ambient concentrations of O_3, NO_2 and VOC are currently being measured at various locations at urban and green space scales. Air samples have been collected at approximately 2,5 m height by means of passive sampling devices. Portable ozone monitors have also been used.

Temporal and spatial patterns of the aforementioned pollutants were inferred from measurements, in order to identify and establish potential relationships between air quality and urban land use, with special focus on density, shape and composition of green spaces. Preliminary results showed that NO_2 concentration exhibited a spatial pattern strongly correlated with the distribution and intensity of mobile sources (road traffic). Concerning VOC, top ten abundant volatile organic compounds were identified for each sampling point. The most prevailing VOC species were toluene, benzene, xylene, ethyl benzene, benzene 1,2,4-trimethyl, hexane, naphthalene, and D-limonene. The first seven were generally associated to road traffic and industrial sources. D-Limonene and Naphthalene seemed to be associated to phytosanitary practices, exhibiting a more complex spatial pattern, as this element was detected in both near intense traffic roads and inside green spaces relatively far from mobile sources. Long and short-term ozone concentrations showed a less clear spatial pattern, suggesting a minor contribution of the micro and local scale phenomena on ozone spatial pattern.

Keywords: Urban forest, air quality, gaseous pollutants, passive sampling, spatial pattern

69 **[O-2]**: LANDSCAPE SELECTION BY FOREST-DWELLING CARIBOU VARIES ALONG GEOGRAPHICAL GRADIENTS IN HABITAT ATTRIBUTES

Daniel Fortin[1], Réhaume Courtois[2], Pierre Etcheverry[3], Claude Dussault[4] and André Gingras[5]

[1]*NSERC-Université Laval industrial research chair in silviculture and wildlife, Département de Biologie, Université Laval, Québec, QC G1K 7P4, Canada. Phone: (418) 656-2131 #5971, Fax: (418) 656-2043, email: Daniel.Fortin@bio.ulaval.ca, web-page: http://www.cef-cfr.ca/index.php?n=Membres.DanielFortin*

[2]*Ministère des Ressources naturelles et de la Faune, Direction du développement de la faune, 880, chemin Sainte-Foy, 2e étage, Québec, Québec, G1S 4X4, Canada; and Département de foresterie et de géomatique, Cité Universitaire, Sainte-Foy, Québec, G1K 7P4, Canada*

[3]*NSERC-Université Laval industrial research chair in silviculture and wildlife, Département de Biologie, Université Laval, Québec, QC G1K 7P4, Canada.*

[4]*Ministère des Ressources naturelles et de la faune, Direction de l'aménagement de la faune, 3950 boulevard Harvey, 4e étage, Saguenay, Québec G7X 8L6, Canada*

[5]*Ministère des Ressources naturelles et de la faune, Direction de l'aménagement de la faune, 818, boulevard Laure, Sept-Îles, Québec G4R 1Y8, Canada*

Populations of forest-dwelling woodland caribou (*Rangifer tarandus caribou*) are declining all across North America (Courtois et al. 2003, Schaefer 2003), and important efforts are currently devoted to the conservation of the ecotype and its habitat. Habitat selection often constitutes

The role of urban green spaces in air quality

M. Feliciano[1], A. Fernandes[1], L. Nunes[1], T. Nunes[2]
P. Alves[1], A. Gonçalves[1], P. Cortez[1], L. Dias[1]

[1]Escola Superior Agrária, Instituto Politécnico de Bragança, Apartado 1138, 5301-854 Bragança, Portugal, Campus de Santa Apolónia, +351273303200, +351273325405 , msabenca@ipb.pt, www.esa.ipb.pt

[2]Departamento de Ambiente e Ordenamento, Universidade de Aveiro, 3010-193 Aveiro, Portugal, +351234370200, +351234370309, tnunes@ua.pt, www.ua.pt

INSTITUTO POLITÉCNICO DE BRAGANÇA Escola Superior Agrária

Centro de Investigação de Montanha

Poster presented in the Landscape Ecology and Forest Management Conference, September 16-18, 2008 Chengdu, Sichuan, China

1. Introduction

Despite technological advances, most cities face critical air quality problems, principally with regards to high atmospheric levels of particulate matter (e.g. PM10) and ground-level ozone. Therefore, urban green areas are seen as "a biotechnology" to mitigate air pollution effects (Taha, 1996; Nowak *et al.*, 2000 and 2006).

In fact, vegetation can improve urban air quality in several ways. Urban green spaces increase dispersion of air pollutants, as a result of their influence on solar radiation, temperature and wind characteristics (Givoni *et al.* 2003). Vegetation also absorbs gaseous pollutants from the air by uptake through leaf stomata and can efficiently intercept airborne particles. However, intercepted particles might often be re-suspended in the atmosphere (Shashua-Bar and Hoffman, 2004). Another positive key factor is related to the influence of trees on the energy consumption pattern of buildings, which in many situations might contribute to reducing anthropogenic pollutant emissions (Akbari, 2002).

In spite of all these benefits, urban green spaces can also affect air quality negatively, because some plant species emit volatile organic compounds (VOC), which are precursors to ground-level ozone. Therefore, in nonattainment areas for ground-level ozone, low VOC emitting species should be considered (Nowak *et al.*, 2000).

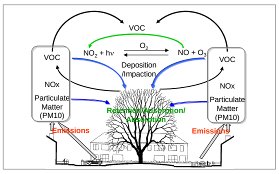

Figure 1. Illustration of how vegetation can improve air quality in an urban system.

The global influence of green spaces on air quality has been studied since 2006, within the framework of the Greenurbe Project (PPCDT/AMB/59174/2004). This project is funded by *Fundação para a Ciência e a Tecnologia* (FCT) and aims at evaluating impacts of green spaces on urban environmental quality and the well-being of the citizens, within a particular spatial context – the city of Bragança.

2. Materials and methods

In order to achieve the objective aforementioned, several gaseous pollutants (ozone (O_3), nitrogen dioxide (NO_2) and volatile organic compounds (VOC)) have been measured, by means of passive sampling devices (diffusion tubes) in 21 urban and peri-urban locations (initially, ozone and NO_2 were evaluated in a 40 points sampling grid). For details concerning passive sampling see e.g. Krupa and Legge (2000). Air samples have been collected at approximately 2.5 m height. Except in some situations, exposure time of sampling devices was 1 week for O_3 and 2 weeks for NO_2 and VOC.

Passive samplers have been protected against bad weather conditions by using PVC shelters easily assembled. Diffusing tubes not exposed to ambient air have also been placed at several points, in more than fifty percent of the total sampling points, in order to perform blank correction.

Samples of ozone and NO_2 have been analysed by visible spectofotometry, while total VOC and the 10 most abundant VOC species, in each place, have been determined with a gas chromatograph/mass selective detector (GCMS) by Gradko International Laboratory.

Measurements of particulate matter (PM10) have also been performed, but their analysis is not addressed in this publication.

Figure 2. Relevant equipment and accessories.

3. Local of study

Bragança is a small city situated in the Northeast of Portugal, having an approximated area of 25 km² and 27000 inhabitants. The topography presents variable forms, with elevation ranging from 560 to 800 meters. Weather conditions vary from cold temperatures in the winter with frequent negative temperatures at night, to very hot summers with temperatures rising up to 40 degrees Celsius.

In the last ten years, the city of Bragança underwent a significant development. Throughout this recent and fast growing process, the urban landscape was transformed, leaving open green spaces and creating some public parks and gardens within the city limit. The figure below shows a classification of identified open spaces in ten categories, each one defining a particular urban element with distinctive vegetation and functionality.

One of the most representative urban vegetation elements is street trees, not considered as area but rather as punctual and linear elements. Bragança has over 4 thousand street trees. Existent database show exotic species as the primary element in this kind of structures. Five species together represent 56% of all the trees, being Acer pseudoplatanus and Platanus orientalis the two foremost representative species. Native species contribute to approximately 9% of the total number of street trees and local native species to just about 4%. Ilex aquifolium and Betula celtibericca are the most representative local native tree species.

Very few specimens of other local native trees such as Olea europea, Quercus rotundifolia, Castanea sativa, Quercus pyrenaica and Ulmus minor can be found.

Additionally, small trees with a shrub like structure as is the case of Taxus baccata, Crataegus monogyna and Juniperus communis are also present in the study area.

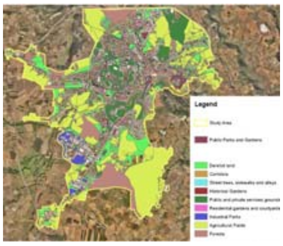

Figure 3. Urban Green Structure

4. Results

Long-term average concentrations of nitrogen dioxide, total VOC, BTEX and ozone, obtained in the Spring/Summer of 2006/07, are shown in figure 4. Total VOC are only depicted for 2007.

In general, air quality in the city of Bragança is reasonably good as a result of its low density of atmospheric pollution sources, either stationary or mobile. Nevertheless, a prominent spatial pattern concerning the air concentrations of NO_2 and some VOC, such as BTEX (acronym that stands for benzene, toluene, ethylbenzene, and xylenes) was clearly identified. Concentrations of these air pollutants are relatively higher along the main urban road axis that crosses the centre of the city of Bragança. The slight difference between total VOC and NO_2 patterns suggests that total VOC concentrations are affected by local factors other than those related to the distribution levels of NO_2. In fact, from the analysis of the ten most abundant volatile organic compounds in each sampling place, more than forty VOC species were identified, the most pervasive being toluene, xylene, ethylbenzene, bezene, benzene 1,2,3-trimethyl, benzene 1,2,4-trimethyl and D-limonene. In addition, other VOC such as naphthalene (in samples collected in 2006), and phenol, acetone and propionic acid (in samples obtained in 2007) were found in the Atmospheric surface layer of Bragança. Ground-level ozone is a secondary pollutant related to NOx and VOC levels, but no clear pattern was found in the spatial distribution of this gaseous pollutant. Long-term ozone concentrations differ from place to place, but its variation is difficult to understand at first glance.

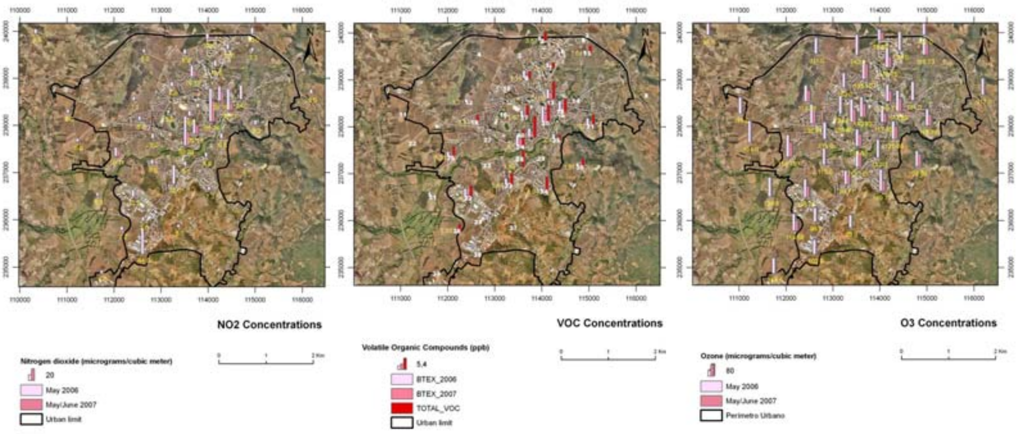

Figure 4. Spatial pattern of long-term concentrations of nitrogen dioxide (µg m⁻³), volatile organic compounds (BTEX and Total VOC) (ppb) and ozone (µg m⁻³), for two different periods in the city of Bragança. In the VOC map, yellow labels represent the concentration of total VOC and the white labels correspond to the ID of the sampling local. Zero values presented for NO_2 and ozone concentration concerning 2007 indicate no measurement available.

With the purpose of helping our analysis to look for potential links between spatial distribution of air pollutants and urban structure elements, such as traffic roads, green spaces, among others, experimental data was submitted to multivariate analysis procedures.

Firstly, principal component analysis (PCA) was applied to the 2007 dataset, comprising concentration values of volatile organic compounds, ozone and NO_2 available to the 21 urban sampling locations. The first four factors explain almost 60% of total variance in the data. Six factors are necessary to explain more than 70% of total variance.

Factor 1 is positively correlated with NO_2, p-Xylene, 1,3,5-trimethylbenzene 1,2,4-trimethylbenzene, Toluene, o-Xylene, and Ethylbenzene. Factor 2 is mainly related to ozone and D-limonene. Acetone and Benzene also present a moderate negative correlation with this axis. Nonanoic acid and pentadecane present the highest contribution in factor 3. Factor 4 shows a contrast between benzene (positive) and N,N-dimethylbenzamide and propanoic acid (negative). To simplify the analysis, our attention is focused only on the first two principal components, which are depicted in figure 5. These two components explain almost 40% of total variance. PCA was performed with JMP® statistical software.

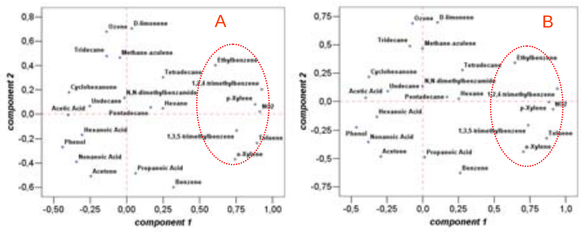

Figure 5. Loading Plots (unrotated pattern (A) and varimax rotation (B)) for the first two components.

Factor 1 seems to represent the contribution of traffic emissions to the atmosphere since all gaseous species are directly associated with vehicle exhaust emissions. NO_2 is mostly a secondary pollutant, however it is chemically produced by oxidation of NO directly emitted by automobiles. The other three factors possibly represent different industrial, commercial, and other sources, such as phyto-sanitary activities. Benzene is mainly used as an intermediate to make other chemicals, being present in several products such as lubricants, dyes, detergents and pesticides. Acetone can be released into atmosphere by vegetation (biogenic VOC), but it is widely used as a solvent. D-Limonene can also be a biogenic VOC. However, the spatial pattern of D-limonene seems to be related in a large extension to its use as a paint stripper or as a botanical insecticide. N,N-dimethylbenzamide is commonly used a solvent, while Naphthalene and propanoic acid are used as pesticides. Biogenic VOC seems to be little relevant in the urban atmosphere of Bragança. In samples collected in 2006, α–pinene was found in the top ten most abundant VOC species in places with conifer trees.

To complement this initial analysis, information on land cover and traffic intensity within a 120 meters buffer circle around each sampling site was projected into the already determined ordination space (represented as environmental variables in figures 6 and 7). This analysis shows that the first principal component is correlated mainly with traffic intensity (increasing from the left to the right side of the diagram). This factor seems to be also negatively correlated with agricultural areas. The second principal component appears to be mainly correlated with conifer trees and, somehow, with grass (lawns) and native vegetation. Nevertheless, the results obtained with Redundancy Analysis (RDA) show that only traffic and conifer trees are relevant in explaining the variance of dependent variables. These two environmental variables explain 23% percent of the total variance associated to pollutant species. These analyses were performed with the CANOCO software.

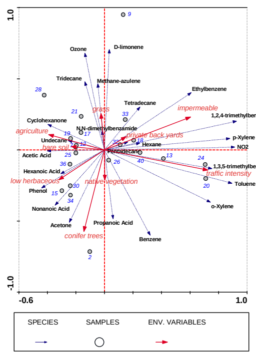

Figure 6. Triplot of PCA with samples, pollutants and environmental variables.

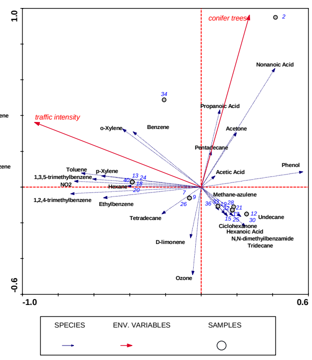

Figure 7. Triplot of RDA with samples, pollutants and environmental variables.

5. Final remarks

➲ This study has enabled us to construct an important database concerning air quality and other environmental variables;

➲ Some possible relationships between air quality and urban land use, with special relevance to the influence of green areas have been identified, but not to the desired extent, despite all efforts. In fact, vegetation is directly related with VOC distribution since it is a source of biogenic VOC; furthermore, vegetation is related indirectly with VOC distribution because it can be subjected to several management practices that might lead to different VOC emissions. As elements of pollutant removal no evidence was found;

➲ Data gathering and analysis will continue, but the experimental methodology followed seems to be inadequate to infer on reliable relationships between air quality and urban green spaces. Local factors are surely relevant in micro-scale atmospheric phenomena and in other processes related to air quality. However, their influence on air concentrations is not being sufficiently captured. Air quality is determined by a complex system of inter-related atmospheric phenomena of different temporal and spatial scales;

➲ Further efforts will be focused on developing procedures of analysis based on multivariate and spatial statistics techniques with the purpose of establishing a set of relationships among green spaces and its impact on local air quality conditions;

➲ Finally, the achievement of this overall objective requires further passive measurements of air pollutants at urban and lower scales, but preferably short-term passive sampling devices should be used. Moreover, more sophisticated experiments involving real time equipment should be integrated in the methodology in order to increase the success of the research.

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Acknowledgments

Funding for this project was provided by the Portuguese Science and Technology Foundation (FCT) and by European Fund for Regional Development (FEDER).

Authors also thank the public institutions and private owners for allowing equipment and sampling devices on their properties.

For further information

Please contact *msabenca@ipb.pt.*
More information on this and related projects can be obtained at *www.esa.ipb.pt/greenurbe*.
PDF-version of the poster will be shortly available for downloading.

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