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EU Green Week Partner Event

A Nexus Approach to Assessing Anthropogenic Impact: Integrating Soil Invertebrate Diversity and Space Syntax in Urban Parks

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THE WATER-ENERGY-FOOD NEXUS: BUILDING RESILIENCE TO GLOBAL CHALLENGES







INTEGRATING SOIL BIODIVERSITY AND SPACE SYNTAX TO EVALUATE ANTHROPOGENIC PRESSURE IN URBAN GREEN SPACES

OBJECTIVES AND HYPOTESIS

(O1) analyze the **composition of soil invertebrate communities at varying distances** from the main pedestrian corridors in urban parks;



(H1) The abundance and diversity of soil invertebrates vary with distance from major human movement corridors, with greater diversity expected at increased distances from these corridors.

(O2) compare the representation of individual soil invertebrate families with spatial configuration parameters (space syntax metrics) derived from syntactical model of Zagreb city;



(H2) The distribution of individual soil invertebrate families is associated with space syntax parameters that reflect urbanization intensity, with **higher integration** (**urbanization**) levels corresponding to **reduced family-level diversity**.

(O3) explore the potential for using soil invertebrate community structure, together with space syntax parameters, as **indicators** of **urbanization intensity** and its impact on the structural and functional biodiversity of urban ecosystems.



(H3) Soil invertebrate community structure, in combination with space syntax metrics, can serve as an indicator of urbanization levels and their ecological impact on urban biodiversity.

How it started... Synergy of Biology and Urbanism in Teaching

GUIDED FIELD TOURS WITH LOCAL COMMUNITIES AND EXPERTS

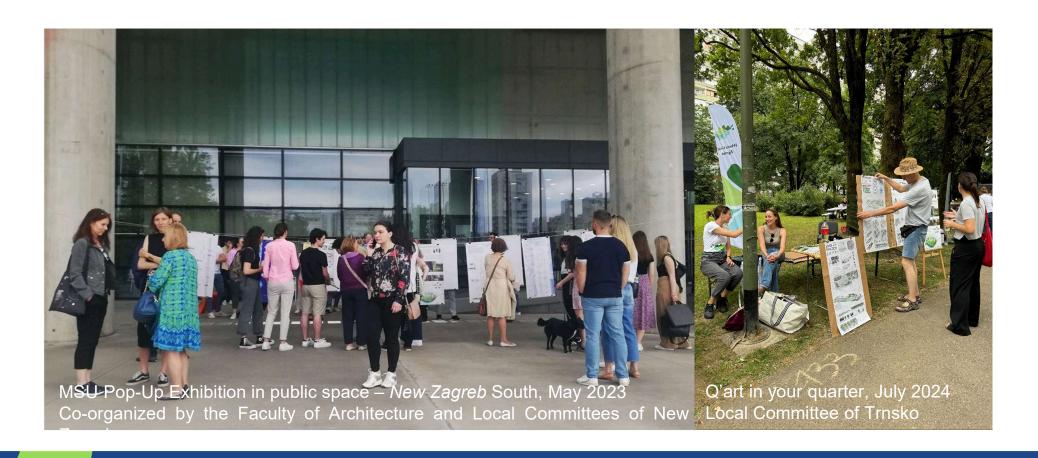
New Zagreb East 2021



How it started... Synergy of Biology and Urbanism in Teaching



How it started... Synergy of Biology and Urbanism in Teaching



ČAROBNI SVIJET BIOLOŠKE RAZNOLIKOSTI BIORAZNOLIKOST TLA U PARKU MLADENACA

Ekoloki i društveni znadaj tla, posebice u urbanim područjima, malo je poznat široj zajednici. Projekt Bioraznolitost ti o Portru Malemora naglasals stavlja na važnost tla za opatanak kosustava te urbanih sustava gospodarstva i društva. Cilj projekta je povećanje kolektivne svijesti o važnosti tla kao resursa u urbanim podruje.

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Specifični ciljevi projekta Bioraznolikost tla u Parku Mladenaca su:

- CILI 1 Povećanje kolektivne svijesti o važnosti tla kao iznimno značajnog prostornog resursa CILI 2 Průzanje svida u nevdljívni mikrosvijet javníh urbanih prostora (bioraznoškosti tla u Parku mladenaca) kroz postavljanje interaktivne tematske izložbe (muzeja tla) i održavanje radionica za zainteresirane pradane.
- konzervacijske vrijednosti tla CILJ 4 Pružanje uvida u geološku strukturu tla unutar Parka mladenaca
 - CILI 4. Pružanje uvida u geološku strukturu tla unutar Parka mladenaca CILI 5. Uspostava edukativna ektivnosti na temu biovaznolikosti, obliježja i uloge tla u funkcioniranju u banih ekosustava za sve zainteresirane građane, djecu i mlade, volontere i sve posjetitelje Parka koji žel pridonjetje zaštiti i održivosti svog bliskog oktivalna i urbanog okoliša







edloženi položaj Muzeja tla u Parku Mladenaca





Resulting projects in comparison

NEW ZAGREB SOUTH 2022./2023.

PARK MLADENACA

FoS poster (left) student: Marija Dadić

mentors: M. Sertić Perić et. al.

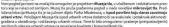
FoA poster (right)

students: Tea Koritar, Lucija Kovačević

mentor: M. Duić

ČAROBNI SVIJET BIOLOŠKE RAZNOLIKOSTI BIORAZNOLIKOST TLA U PARKU MLADENACA

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- naca) kroz postavljanje interaktivne tematske izložbe (muzeja tla) i održavanje radionica za zainteresirane građane
- CILJ 4 Pružanje uvida u geološku strukturu tla unutar Parka mladenaca
- CILL 5 Uspostava edukativne aktivnost ina ternu bioraznolikosti, obilječja i uloge tla u funkcioniranju urbanih ekosustava za sve zainteresirane građane, djecu i mlade, volontere i sve posjetitelje Parka koji žele ardoništiri i indribusti u obi biora obioraznolikosti, obilječja i uloge tla u funkcioniranju urbanih ekosustava za sve zainteresirane građane, djecu i mlade, volontere i sve posjetitelje Parka koji žele ardoništiri i indribusti u obi biora obioraznoli i bioraznolikosti.

riBON Essential Brodiversity Variables framework (Guerra et al., 2021)



Margati

edloženi položaj Muzeja tla u Parku Mladenaca





How it started...

Marija Dadić

WORLD OF BIODIVERSITY

BIODIVERSITY OF SOIL IN PARK MLADENACA IN ZAGREB

INTEGRATING SOIL
BIODIVERSITY AND SPACE
SYNTAX TO EVALUATE
ANTHROPOGENIC
PRESSURE IN URBAN GREEN
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What is Space Syntax?

Definition:

Space Syntax is an analytical approach for studying **how spatial configurations influence human behavior and movement**.

Key concept:

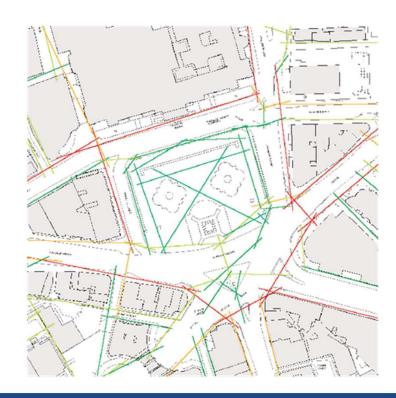
- Spatial layout shapes social interaction, movement, and organization and *vice versa* social needs influence spatial networks.
- Space has an underlying social logic of connectivity.

Origins:

Developed in the 1980s at University College London by Hillier & Hanson (1984).

Application scale:

From individual buildings to entire cities and regions.



What is Space Syntax?

Uses quantitative metrics like *Integration* and *Choice* to assess spatial accessibility.

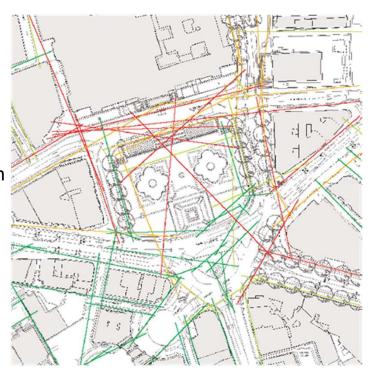
Benefits

- identifies central vs. marginalized areas
- supports planning for mobility, public space, and safety
- aids in designing functionally and socially responsive environments

Broader impact:

Applied in architecture, urban planning, transport, archaeology, and increasingly in environmental studies.

This thesis applies Space Syntax to study human impact on urban biodiversity – - a novel and growing area of research.



SPATIAL CONTEXT

SELECTED URBAN PARKS IN ZAGREB

ALLÉE MAIN PEDESTRIAN CORRIDORS LANDSCAPE AVENUES



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SELECTED URBAN PARKS IN ZAGREB

ALLÉE MAIN PEDESTRIAN CORRIDORS LANDSCAPE AVENUES



MAKSIMIR

(historical urban park, one of the oldest in Europe)

1637 HYDE PARK (LONDON)

1755 AUGARTEN (VIENNA)

1766 PRATER (VIENNA)

1787 MAKSIMIR (ZAGREB / baroque phase)

1806 ENGLISCHER GARTEN (MÜNCHEN)

1812 REGENT'S PARK (LONDON)

1843 MAKSIMIR (ZAGREB / romantic phase)

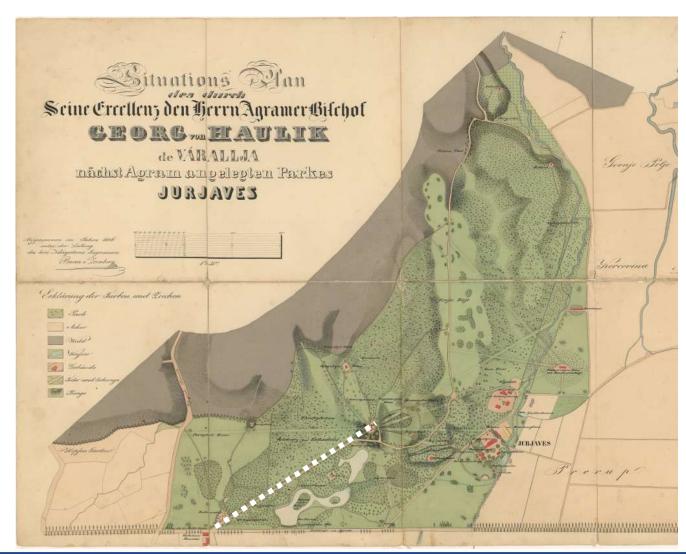
1852 BOIS DE BOULOGNE (PARIZ / romantic adaptation)

1857 CENTRAL PARK (NEW YORK)

1863 STADTPARK (VIENNA)

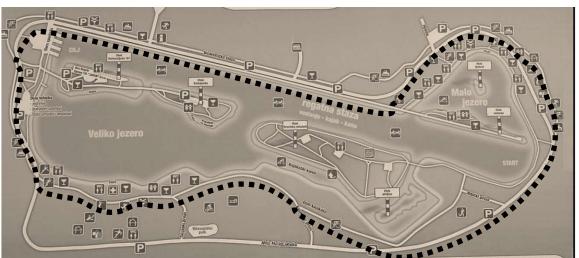
1863 PARC DES BUTTES-CHAUMONT (PARIZ)

1867 SEFTON PARK (LIVERPOOL)

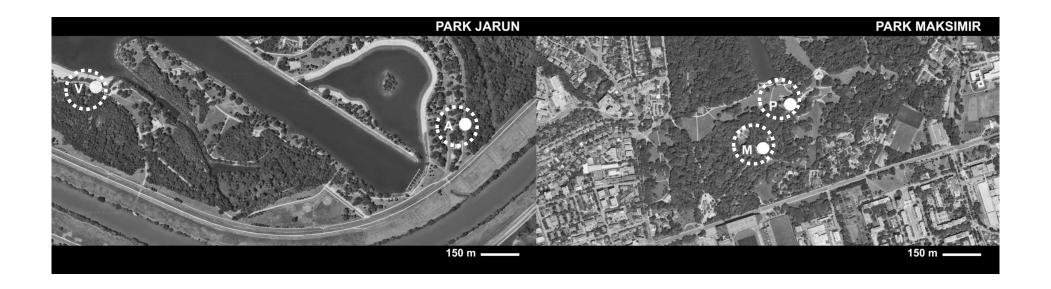


JARUN

- originally a meander and floodplain of the Sava River
- area used for agriculture; prone to seasonal flooding
- severe flood in 1964 led to major flood-control projects
- gravel excavation for embankment construction created artificial lake basins
- selected site for 1987 Summer Universiade → transformation into sports and recreation center
- built rowing course, artificial islands, pedestrian bridges, and sports infrastructure







4 sites (two in each park) were selected for the study → the criteria for choosing sites:

- 1. Near the main pedestrian corridors
- 2. Near the human additional functions in parks such as pavillions in Maksimir and beach and clubs in Jarun
- 3. Where there are both meadows and forest in perpendicular line from the human corridors

MAKSIMIR





At each site, three microhabitats were defined based on distance from the main pedestrian corridor:

- Microhabitat A (directly adjacent to the main pedestrian corridor)
- Microhabitat B (10–15 m into the mowed narrow green zone)
- **Microhabitat C** (30–40 m into the successional zone where green zone transitions into forest)



JARUN

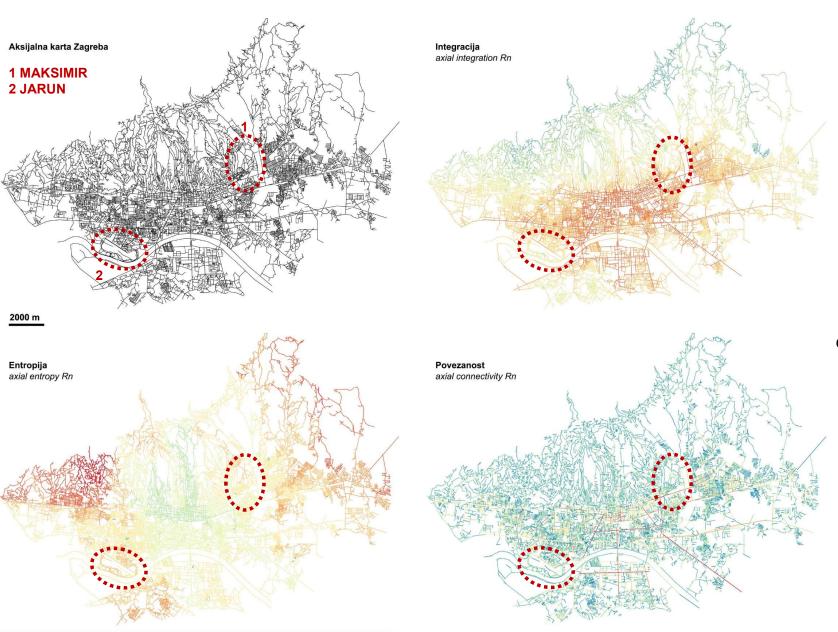




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Space Syntax revealed a significant difference between the two parks.

Paths that are straighter and serve as main entrances or corridors tend to have higher integration values, while more natural, organic paths in forested areas of both parks show lower integration.

SEGMENT ANALYSIS											
	Grad Zagreb			F	erivoj Maks	imir	Park Jarun				
	min. max. a		average	min.	max.	average	min.	max.	average		
NACH	0,0	1,8100	0,7979	0,0	1,3374	0,8663	0,0	1,2139	0,8617		
NAIN	0,2438	2,4137	0,7268	0,5332	0,9933	0,7692	0,5306	0,9375	0,7149		
Segment Length	0,0006	2086,3921	81,0585	0,0428	621,0396	53,2410	0,1547	504,0948	99,0425		

AXISAL ANALYSIS											
	Grad Zagreb			1	Perivoj Maks	imir	Park Jarun				
	min.	max.	average	min.	max.	average	min.	max.	average		
Connectivity	0,0	47,0	2,6434	0,0	15,0	2,8893	1,0	10,0	2,8880		
Entropy	-1,0	5,6159	5,1891	-1,0	5,2453	5,1421	5,1324	5,2548	5,2106		
Integration	-1,0	3,4479	0,4774	-1,0	0,6957	0,5462	0,3662	0,6084	0,4748		
Line Length	2,0378	5885,0171	171,0598	2,0378	911,8413	122,5814	27,9204	2185,8267	233,3121		





Photos by Mirela Sertić Perić, 2024

June 20,

2024

Methods & sampling dynamics

- ➤ Pitfall traps → installed May 3, 2024
- ➤ Trap contents collected and replaced at 2-week intervals:
 - May 20, 2024
 - June 10, 2024
 - June 20, 2024
- > Traps active throughout vegetation season
- > Spring chosen for peak soil invertebrate activity
- > Seasonal factors considered:
 - Summer: reduced activity (heat/drought)
 - Winter: hibernation/frost adaptation











Photos by Marija Dadić, 2024

Sample preservation & processing

- Invertebrates sieved (0.5 mm mesh) and rinsed with water
- Specimens cleaned of antifreeze, soil, detritus
- Preserved in 75% ethanol in labeled
 200 mL containers

Taxonomic identification

- Conducted in lab using stereomicroscope
- Specimens identified to family level (Chinery 1993, Iowa State University 2023, Nentwig et al. 2023, Shultz 2023, Nordsieck 2023)

Additional details

- > Research permits obtained from park authorities
- ➤ Soil physico-chemical data for all sites

		Coordinates		t _{10cm}	t _{surface}	p _{H2O}	p _{KCI}	organic matter (%)	descriptive organic matter content	humus (%)	descriptive humus content	descriptive soil texture
Jarun	Α	N45°46'40.87''	AVG	18.8	18.5	7.65	7.06	10.79	Very high organic	5.67	Very humus-rich soil	Loam
	^	E15°56'18.8''	SD	3.37 x 10 ⁻⁷	0.0	1.19 x 10 ⁻⁷	0.00	2.38 x 10 ⁷	matter content	0.00		
,	V	N45°46'45"	AVG	19.63	19.25	7.70	7.23	8.51	High organic	5.49	Very humus-rich soil	Sandy loam / clay-
	V	E15°55'15''	SD	0.0	3.37 x 10 ⁻⁷	0.00	0.00	0.00	matter content	0.00		sandy loam
Maksimir	M	N45°49'20.2"	AVG	18.5	18.6	7.30	6.74	7.14	High organic	5.90	Very humus-rich soil	Loam
	IVI	E16°01'08.2''	SD	4.13 x 10 ⁻⁷	2.38 x 10 ⁻⁷	0.00	0.00	0.00	matter content	1.19 x 10 ⁻⁷		
	Þ	N45°49'25.2"	AVG	19.2	19.6	7.22	6.62	13.88	Very high organic	8.84	Very humus-rich soil	Loam
	F	E16°01'12.7''	SD	2.38 x 10 ⁻⁷	2.38 x 10 ⁻⁷	0.00	2.06 x 10 ⁻⁷	0.00	matter content	0.00	very numus-nem som	

Statistical analysis

- Performed using TIBCO Statistica™ 14.0.0
- Non-parametric tests used (non-normal distribution)
- Key comparisons: Mann-Whitney U test between parks
- Kruskal-Wallis test between sites and microhabitats
- Post-hoc comparisons
- Statistically significant results at p < 0.05

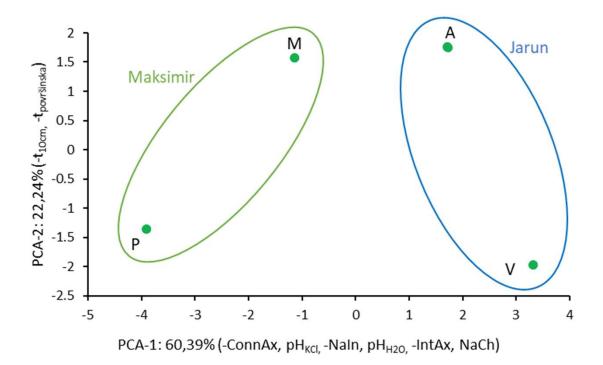
Correlation & multivariate analysis

- Spearman's Rs used to assess: Abiotic soil factors & space syntax vs. invertebrate abundance/diversity
- Visualized with tables and graphs to highlight trends

Principal Component Analysis (PCA)

- PCA performed to identify key differentiating variables
- Combined physico-chemical & spatial syntax data
- Helped visualize variance and clustering by park type

RESULTSmicrohabitats' physico-chemical and space syntax parametres



- 13 soil physico-chemical parameters + Space Syntax metrics
- Horizontal axis (PCA-1):
 - Driven by space syntax measures
 - Jarun sites = Lower spatial integration and connectivity, higher soil pH
 - Maksimir sites = Higher spatial integration, lower soil pH
- Vertical axis (PCA-2):
 - Reflects soil temperature differences
 - M & A sites = Lower temperatures (shaded/covered)
 - P & V sites = Higher temperatures (open/exposed)
- Spatial and environmental factors jointly shape ecological conditions, affecting invertebrate distribution

RESULTS

biodiversity in relation to microhabitat distance from the main pedestrian corridor

- Site M → highest invertebrate abundance, accounting for 43% of all collected individuals, but differences in total abundance and number of families between sites were not statistically significant.
- No significant difference in number of individuals between microhabitats at different distances from pedestrian corridors, but familylevel diversity did vary significantly.
- Microhabitat B → significantly less families than microhabitat C, indicating a potential influence of human disturbance on biodiversity.



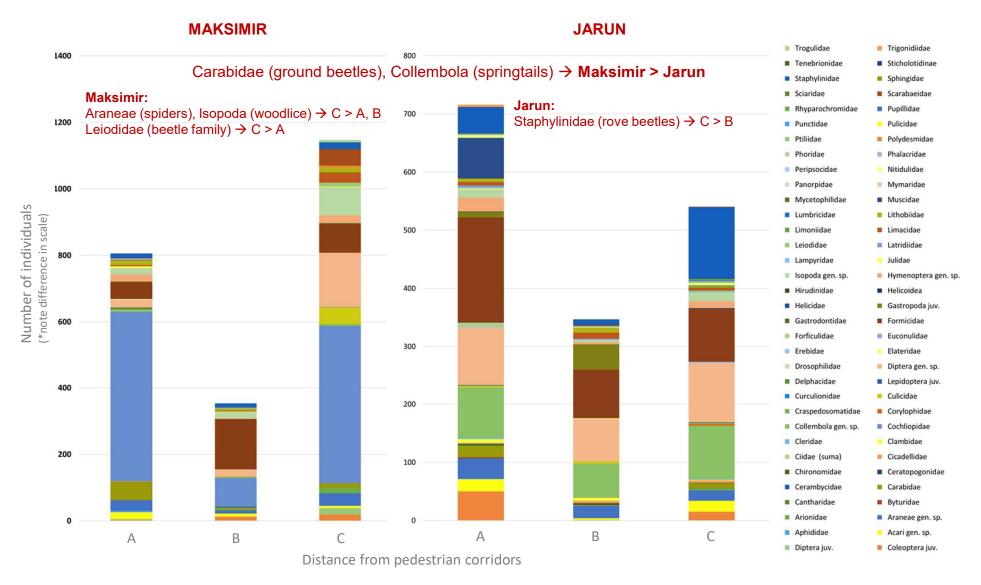


A = directly adjacent to the main pedestrian corridor

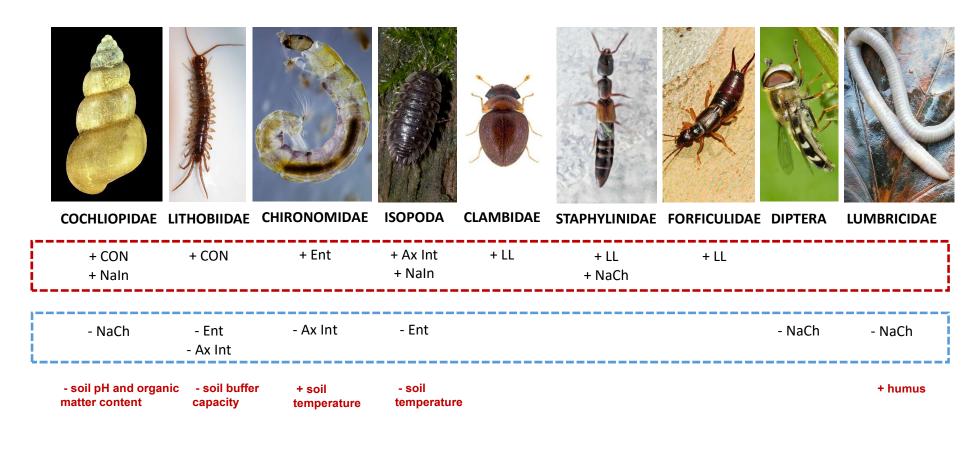
B = 10-15 m into the narrow green zone

C = 30-40 m into the successional zone where green zone transitions into forest

RESULTS biodiversity in relation to microhabitat distance from the main pedestrian corridor



RESULTS biodiversity in relation to space syntax and physico-chemical parametres



CON = (axial) connectivity
Ax Int = axial integration

NaIn = normalised (segment) integration NaCh = normalised (segment) choice

Ent = entropy LL = line length Spatial and environmental factors jointly shape ecological conditions, affecting invertebrate distribution

CONCLUSIONS

- **H1 was confirmed:** Our results showed that soil invertebrate abundance and diversity increase with distance from major human movement corridors.
- H2 was partially supported: While we observed associations between invertebrate distribution and space syntax parameters, we did not find consistent evidence that higher integration (i.e., urbanization) levels correspond to reduced family-level diversity.
- H3 was confirmed: The structure of soil invertebrate communities, combined with space syntax metrics, proved to be a useful indicator of urbanization intensity and its ecological effects on biodiversity.

CONCLUSIONS

- We consider that these preliminary results linking space syntax and biological methods can be a direction in better understanding of urban environments.
- Syntactical model and metrics enable quantitative description and comparison of urban spaces and may serve as a proxy of antropogenic (human movement) influence on biodiversity patterns in urban parks.
- Through interdisciplinary collaboration in teaching Urban Ecology we are inspired and motivated for collaborative research practice.





BEETLES AND TERRESTRIAL ISOPOD CRUSTACEANS WERE FOUND IN HIGHER NUMBERS FURTHER FROM THE WALKWAYS IN MAKSIMIR AND JARUN PARKS