4.s23 Biodiversity and Cities: A Perspective in Colombian Cities

Course Information
Course number: 4.s23
Credit hours: 3-3-6 G/U
Meeting times: TU-TH - 2:00 to 3:30 PM
Classroom location: 9-450A
Office location: E38-346
Office hours: MW – 2:00 to 4:00 PM

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Course Description

Biodiversity is declining worldwide, driven foremost by the intensification in land management and the transformation of natural areas for agriculture, industrial-scale forestry production, and human settlements. Urban areas have doubled since 1992 and, in comparison with 2020, are projected to expand between 30% and 180% until 2100, depending on the scenario applied. Notably, most of the urban growth is often located in regions of high biodiversity and affects ecosystems far beyond urban areas, through resource demands, pollution, and climate impacts. Therefore, biodiversity conservation in urban areas needs to be approached in a way that supports global conservation efforts. This course introduces the relationships between urban environments and biodiversity, how urban biodiversity influences ecosystem functions and underlying services that affect human well-being and whether urban habitats are hotspots or ecological traps (or neither) for biodiversity. The course will focus on eight key topics: 1) relationships between biodiversity, climate change and cities, 2) ecosystem services and natural climate solutions, 3) socioeconomic and ecological drivers of urban biodiversity, 4) biodiversity indicators and spatiotemporal scale in urban biodiversity assessment, 5) socio-environmental inequalities, perception and engagement, 6) urban refugia and rewilding, 7) biodiversity response to technological change in building technologies and urban systems, and 8) urban biodiversity evolution. The course will answer several questions such as: which synergies and trade-offs among biodiversity and ecosystem services exist in urban areas, which factors drive the relationships between biodiversity and socioeconomic and environmental drivers at different spatial scales, and how do urbanization-induced changes affect ecosystem functions and ecological networks' complexity and diversity.

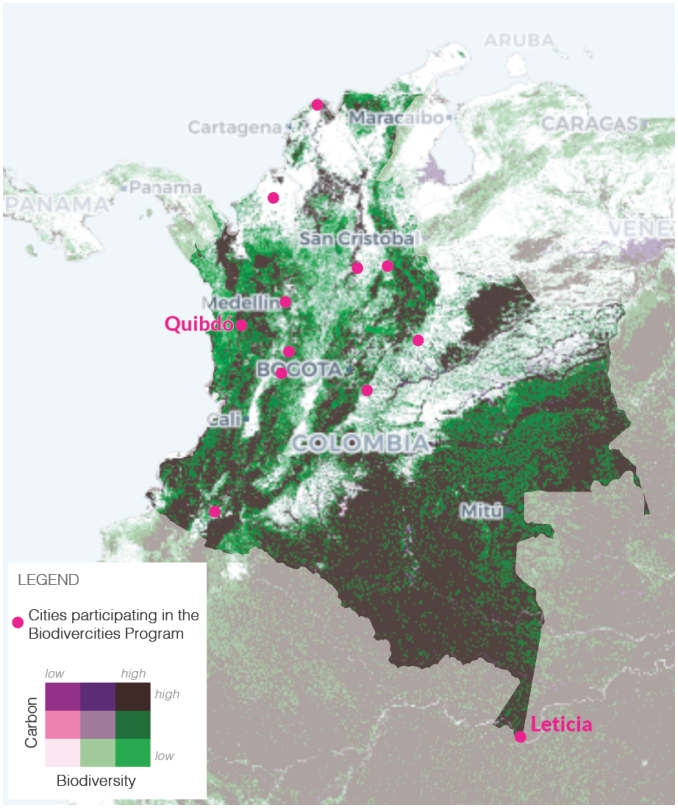
Biodiversity conservation through urban-regional strategies in an emerging field. There are significant gaps in our understanding that are critical to improving biodiversity conservation policies and management in urban areas that need to be analyzed, tested and implemented to improve global biodiversity outcomes. Colombia, the most biodiverse country by square kilometer, has been a leader in this field and in 2021 launched the Biodivercities program to support cities through a combination of the latest research with practical solutions in the service of sustainable, inclusive and nature-positive urban development. The Biodivercities program is led by the Ministry of Environment and Sustainable Development, in coordination with the mayor's and planning offices of over 10 cities in Colombia. This program is informed by the Global Commission on BiodiverCities by 2030, a high-level forum of academics and practitioners convened by the World Economic Forum.

The class will be structured in two parts: 1) Academic discussions and 2) client-based and hands-on urban analysis and design projects. The academic discussions will be framed as a series of guest lectures in the focus areas. The guest lecture series will include international and Colombian guest speakers. The hand-on part of the work will be focused in two Colombian cities, Leticia and Quibdó. These cities are located in some of the most biodiverse and carbon-rich ecosystems in Colombia: the Amazon and Pacific tropical forests.

Leticia is a city in the south of Colombia in the heart of the Amazon forest, located by the Amazon River and at the border with Brazil and Peru, with a population of approximately 50 thousand people and a significant presence of multiple Indigenous communities. The city is currently designing a strategy to develop green public spaces along

the rivers and a botanical garden, improving the tree canopy, as well as developing circular economy and bioeconomy strategies to reduce waste and leverage the sustainable use of natural Amazonian resources.

Quibdó is a city located in the Pacific region, next to the Atrato River in the Pacific-Andean piedmont, in one of the most biodiverse regions of Colombia. The city has a population around 130,000, predominantly Afro-Colombian peoples. Quibdó is currently designing a plan for tree planting along green corridors, developing environmental education and citizen stewardship programs, and circular economy strategies for waste management.



Overlay of irrecoverable carbon reserves and biodiversity and cities in the Biodivercities Program. Basemap source: Resiliency Atlas, CI

Working on these cities in Colombia, students will develop a series of strategies to explore how human and natural systems co-exists in positively reinforcing relationships, particularly through Natural Climate Solutions. Through this process, students will handle various data types to first assess the performance of existing biodiversity strategies, design a methodology for biodiversity assessment in urban areas using novel approaches such as aerial technology and artificial intelligence, and develop a research framework and project to promote biodiversity conservation within and beyond urban areas, and highlight ways forward at the science-policy-design interface. Throughout the class, students will gain skills to understand how to (1) improve urban habitat mapping; (2) integrate multiple urban gradients in the biodiversity assessment framework; (3) use satellite data and AI based methods to improve our mechanistic understanding of the relationships between biodiversity and ecosystem functions and services; and (4) participatory approaches to extend the involvement of multiple stakeholders and citizens in biodiversity management efforts in urban areas. The course is meant to provide a solid framework, broad overview, and a rich set of references for future pursuits involving urban biodiversity, data analysis and visualization, and community-based planning.

It is assumed that enrolled students are interested in learning about and discussing the topic of urban biodiversity. Although the course will generally cover the topic of urban biodiversity and urban ecology, it will be flexible enough to allow for individual student outreach into topics of specific interest with regard to spatial analysis, big data, and AI applications in urbanizing areas.

Intended Learning Outcomes (ILOs)

The students in this class will be able to achieve the following learning outcomes:

- Understand and analyze how humans influence urban biodiversity.
- Understand the principles of landscape ecology in an urban context.
- Understand the evolutionary adaptation of humans and other organisms in an urban environment
- Understand and identify the impacts of climate change on urban biodiversity.
- Understand the relationships among planners/policymakers, developers, and the public and their roles in conserving biodiversity.
- Outline strategies for urban ecosystem services and biodiversity management.

- Outline frameworks to conserve, manage, and restore natural habitat and to promote biodiversity in urban and rural environments.
- Gain familiarity with tools and methods for biodiversity mapping at various urban scales.

Prerequisites/Co-requisites

- *Basic knowledge in python and data visualization platforms such as D3 or tableau.*
- *Prior knowledge of GIS platforms and processing satellite data is preferred.*
- *Students must understand and preferably speak Spanish*
- *Students should feel comfortable working with an iterative work plan, with changes reflecting the priorities of the client and affecting the agenda during the field-trip.*

Opportunities for collaboration

The class has been developed by the MIT Environmental Solutions Initiative ESI in collaboration with Universidad de los Andes' Environmental Engineering Research Center (EERC). Students will have the opportunity to engage with national and municipal authorities in Colombia, who will act as clients while students develop strategies for improving and managing biodiversity, particularly the Ministry of Environment and Sustainable Development of Colombia and the mayor's offices and planning departments of Leticia and Quibdó. Other Colombian institutions engaged in this initiative include the Humboldt Institute for Biological Resources, the SINCHI Institute for Amazonian Research, and the Institute of the Pacific Research IIAP, among other long-term collaborators of ESI.

Impact

Cities selected for this class are small to medium size cities located in remote areas in the heart of the Amazon and the Pacific tropical forest and have a lack of technical capacity to develop strategies aligned with the ambitions objectives of the Biodivercities program. Nonetheless, due to their location within some of the most biodiverse areas and highly valuable natural carbon sinks, they could have significant impacts on adjacent biodiversity and carbon reserves. Moreover, despite being located in regions of enormous natural wealth that provide highly valuable environmental services, a high percentage of the population in these cities lives in poverty and with unsatisfied basic needs. The work of students including research, analysis and the proposed strategies could have a tangible impact helping these Colombian cities incorporate biodiversity and climate change considerations into their climate mitigation and adaptation plans, biodiversity management strategies, and urban development plans that are sensitive to the socio-economic conditions of populations who have historically been marginalized. Ultimately, the work could serve as a model for other cities participating in the Biodivercities Program to create more equitable and research-driven biodiversity management projects and strategies.

Course Materials

There will be a weekly series of readings posted on Course Canvas either as PDFs or as links to external content. The readings (as well as any required films or podcasts) are frontloaded so we can, early on, build a foundation for thinking through these issues together. You are, of course, encouraged to read more widely and suggest your own readings to the class.

What to expect in this course

The core objective of this course is to develop a better understanding of urbanization impacts on biodiversity and ecosystem services and to develop urban strategies for biodiversity assessment and management in two Colombian Cities that aim to strengthen the role that cities play in regional and global climate and biodiversity conservation efforts. The course will investigate four key areas answering the following questions:

1. **Biodiversity and climate challenges in urban areas:** *how to identify factors that affect biodiversity conservation in urban areas and potential climate change risks.*

2. **Mapping approaches for urban ecosystems:** *What are the different methods and data types used in mapping biodiversity and urban ecosystems at various urban spatial levels.*
3. **Biodiversity conservation:** *What policies and urban strategies are considered effective in promoting and managing biodiversity and natural habitats in urban areas.*
4. **Community engagement and biodiversity management:** *how can urban communities play a role in conserving urban ecology and managing biodiversity.*

Evaluation

Discussion Lead and Reading Responses: 15% (Reflections)
The goal of this assignment is to assist you in practicing effective and critical reading through the weekly reading discussions. For each week, 2 or 3 students will prepare a one to three powerpoint slide synopsis of the week´s readings, suggesting specific questions for discussion and reflections for the final project and will lead the discussion on the class readings. (You may present more than twice depending on the number of students enrolled in the class).

Rethinking Biodiversity – Case Study Research: 25% (Research)

In this assignment, you will analyze the city's strategies to promote and manage biodiversity conservation in urban areas. Through this assignment you will be able to:

1) Identify a suite of policies, urban design and management strategies that cities undertake to promote global biodiversity conservation.
2) Examine the indicators and different spatial and temporal dimensions that are considered in urban biodiversity assessments.
3) Outline a set of socio-ecological and socioeconomic factors driving biodiversity in the city.
4) Identify the urban features/technological changes that are likely having unintended consequences on species and ecosystems in the short or long term.

Be prepared to identify the city you will be analyzing by February 8. Your case study research should not exceed 10 pages, including text and any graphics you may wish to include. This assignment is due in class on March 3.

Applied Research Project for Leticia or Quibdó - Group Project: 50% (Analysis and Design)
The main goal of the class is to build your experience in analyzing, interpreting, designing and presenting an urban strategy to promote biodiversity conservation. You will work in two groups to develop a testable hypothesis on urban biodiversity management; design an engagement, data collection, and analysis framework; and then work to develop a plan consisting of a diagnosis and a series of strategies and recommendations for one of the two Colombian cities' case studies. The projects will culminate in presentations to the clients and a concise written class report entailing the research hypothesis, description of the data collection and analysis framework and engagement process, diagnosis and design or policy recommendations. We will distribute a guideline for this assignment as the semester progresses.

In order to expose you to key methods and to give you exposure to options for your research projects, we will do a field trip in Colombia during spring break and visit the two case study cities Leticia and Quibdó. These excursions will lead to short assignments that will involve data analysis and the development of biodiversity management framework. The field-trip will be an immersive experience where students will have the opportunity to share their preliminary findings with local stakeholders, to conduct semi-structured interviews to understand the tradeoffs regarding the development of cities located within biodiversity hotspots and carbon-rich ecosystems, and to collect data and observe first-hand the technical and socio-economic challenges of small cities in the developing world. Depending on COVID-19 developments and travel risk approval by MIT, fieldwork may not be possible in

which case it will be replaced by a series of on-line workshops with local authorities and stakeholders in Colombia.

Finally, you will keep a working document/journal where you critically describe your research findings throughout the whole course. You will share your journal with the teaching team on google drive.

Participation – 10%

Participation in weekly discussions will be essential to the success of this course as it will help you shape and develop the biodiversity framework that will guide the main class project.

Course Outline

Week 1: Course Introduction
February 1 Architecture Showcase
February 3 Course Introduction

Assigned: Exercise 1 - Discussion Lead and Reading Responses, sign-up by February 5

Week 2: Introduction to Biodiversity, Climate Change and Cities

February 8 Lecture: Biodiversity, climate change and cities
February 10 Client presentation - Introduction Biodivercities Program, Leticia and Quibdó

Assigned: Exercise 2a, due by electronic submission before midnight on Tuesday, March 2.

Readings:

- *Seto, K. C., Guneralp, B., & Hutyra, L. R. 2012.* ***Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools.*** *Proceedings of the National Academy of Sciences, 109(40), 16083–16088. https://doi.org/10.1073/pnas.1211658109*
- *Fernández, John E., and Marcela Angel. 2020.* ***Ecological City-States in an Era of Environmental Disaster: Security, Climate Change and Biodiversity.*** *Sustainability 12, no. 14: 5532. https://doi.org/10.3390/su12145532*
- *Pörtner, H.O., et al. 2021.* ***IPBES-IPCC co-sponsored workshop report on biodiversity and climate change****; IPBES and IPCC, DOI:10.5281/zenodo.4782538*
- *Knapp, S., Aronson, M. F. J., Carpenter, E., Herrera-Montes, A., Jung, K., Kotze, D. J., La Sorte, F. A., Lepczyk, C. A., MacGregor-Fors, I., MacIvor, J. S., Moretti, M., Nilon, C. H., Piana, M. R., Rega-Brodsky, C. C., Salisbury, A., Threlfall, C. G., Trisos, C., Williams, N. S. G., & Hahs, A. K.. 2021. A Research Agenda for Urban Biodiversity in the Global Extinction Crisis. BioScience, 71(3), 268–279. https://doi.org/10.1093/biosci/biaa141*
- *Folke, C.; Jansson, A.; Larsson, J.; Costanza, R.* ***Ecosystem Appropriation by Cities****. Ambio 1997, 26, 167–172.*

Week 3: Urban Environment and Ecosystem Services
February 15 Lecture: Urban environment and natural climate solutions
February 17 Workshop - working with data 1

Readings:

- *Bolund, P. and S. Hunhammar. 1999.* ***Ecosystem services in urban areas.*** *Ecological Economics 29(2): 293-301.*
- *Gómez-Baggethun, E. and D.N. Barton. 2013.* ***Classifying and valuing ecosystem services for urban planning.*** *Ecological Economics 86: 235-245.*
- *Barton, J., & Pretty, J. (2010). Urban ecology and human health and wellbeing. Urban Ecology, 202–229. https://doi.org/10.1017/CBO9780511778483.010*
- *Pataki, et al (2011).* ***Coupling biogeochemical cycles in urban environments: Ecosystem services, green solutions, and misconceptions.*** *Frontiers in Ecology and the Environment, 9(1), 27–36. https://doi.org/10.1890/090220*

- *Hubacek, K., & Kronenberg, J. (2013). Synthesizing different perspectives on the value of urban ecosystem services. Landscape and Urban Planning, 109(1), 1–6. https://doi.org/10.1016/j.landurbplan.2012.10.010*

Week 4: Urban Ecology

February 22 Guest Lecture: Socioeconomic and Ecological Drivers of Urban Biodiversity
February 24 Workshop - working with data 2

Readings:

- *Pickett, S.T.A., M.L. Cadenasso, J.M. Grove, C.H. Nilon, R.V.Pouyat, W.C. Zipperer, et al. 2001.* ***Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas****. Annual Review of Ecology, Evolution, and Systematics 32: 127–157.*
- *Grimm, N.B., C.L. Redman, C.G. Boone, D.L. Childers, S.L. Harlan, B.L. Turner II. 2013.* ***Viewing the urban socio-ecological system through a sustainability lens: Lessons and prospects from the central Arizona-Phoenix LTER programme.*** *Chapter in: Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales, Singh S., Haberl H., Chertow M., Mirtl M., Schmid M. (eds). Springer.*
- *Ramalho C.E. and R.J. Hobbs. 2012.* ***Time for a change: dynamic urban ecology.*** *Trends in Ecology & Evolution 27(3): 179–188.*
- *McDonnell, M.J., A.K. Hahs, and S.T.A. Pickett. 2012.* ***Exposing an urban ecology straw man: critique of Ramalho and Hobbs****. Trends in Ecology & Evolution 27(5): 255–256.*
- *Grove, J.M., D.L. Childers, M. Galvin, S. Hines, T. Muñoz-Erickson and E.S. Svendsen. 2016.* ***Linking science and decision making to promote an ecology for the city: practices and opportunities****. Ecosystem Health and Sustainability. 9(2): e01239.*

Week 5: Modelling Urban Ecosystems (part 1)

March 1 Guest Lecture: Biodiversity indicators and spatio-temporal scale in urban biodiversity assessment
March 3 Case Study Research presentations

Readings:

- *Nowak, D.J. S. Hirabayashi, A. Bodine and R. Hoehn. 2013.* ***Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects****. Environmental Pollution 178: 395-402.*
- *Stott, I., Soga, M., Inger, R., & Gaston, K. J. (2015).* ***Land sparing is crucial for urban ecosystem services.*** *Frontiers in Ecology and the Environment, 13(7), 387–393. https://doi.org/10.1890/140286*
- *T. Rötzer, A. Moser-Reischl, M. A. Rahman, R. Grote, S. Pauleit, H. Pretzsch. 2021.* ***Modelling Urban Tree Growth and Ecosystem Services: Review and Perspectives.*** *Available at:https://link.springer.com/chapter/10.1007/124_2020_46*
- *M. Alberti. 2008.* ***Modelling Urban Ecosystems: Conceptual Framework****. Available at: https://link.springer.com/chapter/10.1007/978-0-387-73412-5_41*
- *Patrycia Brzoska and Aiga Spage. 2020.* ***From City- to Site-Dimension: Assessing the Urban Ecosystem Services of Different Types of Green Infrastructure.*** *Land Journal.*
- *Roberts, D.; O'Donoghue, S.* ***Urban environmental challenges and climate change action in Durban, South Africa****. Environ. Urban.* ***2013****, 25, 299–319.*

Week 6: Modelling Urban Ecosystems (part 2)

March 8 Guest Lecture: Frameworks to introduce sustainable urban drainage systems and other nature-based solutions to enhance the health and well-being of citizens
March 10 Fieldwork agenda discussion / Workshop - Qualitative research and engagement methods

Readings:

- *Jiménez Ariza, Martínez, Muñoz, Quijano, Rodríguez, Camacho, & Díaz-Granados.* (2019). **A Multicriteria Planning Framework to Locate and Select Sustainable Urban Drainage Systems (SUDS) in Consolidated Urban Areas.** *Sustainability, 11(8), 2312. https://doi.org/10.3390/su11082312.*
- *Matthew Scowen, Ioannis N. Athanasiadis, James M. Bullock, Felix Eigenbrod, Simon Willcock. 2021.* ***The current and future uses of machine learning in ecosystem service research****, Science of The Total Environment, Volume 799, https://doi.org/10.1016/j.scitotenv.2021.149263*
- *Mallick, J.; AlQadhi, S.; Talukdar, S.; Pradhan, B.; Bindajam, A.A.; Islam, A.R.M.T.; Dajam, A.S.2021.* ***A Novel Technique for Modeling Ecosystem Health Condition: A Case Study in Saudi Arabia****. Remote Sens. 13, 2632. https://doi.org/10.3390/rs13132632*

- *Nhat-Duc Hoang, Xuan-Linh Tran, 2021.* ***"Remote Sensing–Based Urban Green Space Detection Using Marine Predators Algorithm Optimized Machine Learning Approach",*** *Mathematical Problems in Engineering, Article ID 5586913, 22 pages, 2021. https://doi.org/10.1155/2021/5586913 .*
- *Gómez, J.A.; Patiño, J.E.; Duque, J.C.; Passos, S.2020.* ***Spatiotemporal Modeling of Urban Growth Using Machine Learning.*** *Remote Sens. 12, 109. https://doi.org/10.3390/rs12010109*
- *Joan Casanelles-Abella, Yohann Chauvier, Florian Zellweger, Petrissa Villiger, David Frey, Christian Ginzler, Marco Moretti, Loïc Pellissier. 2021.* ***Applying predictive models to study the ecological properties of urban ecosystems: A case study in Zürich, Switzerland****, Landscape and Urban Planning, Volume 214, https://doi.org/10.1016/j.landurbplan.2021.104137*

Week 7: Environmental Equity and Citizen Engagement

March 15 Guest Lecture: Socio-environmental inequalities, perception and engagement of ethnic communities

March 17 Travel prep - travel requirements and logistics / Workshop - Research Design Framework

Reading:

- *Nagendra, H.; Bai, X.; Brondizio, E.S.; Lwasa, S.* ***The urban south and the predicament of global sustainability.*** *Nat. Sustain.* ***2018****, 1, 341–349*
- *Escobedo, F. J., Clerici, N., Staudhammer, C. L., & Corzo, G. T. (2015).* ***Socio-ecological dynamics and inequality in Bogotá, Colombia's public urban forests and their ecosystem services.*** *Urban Forestry & Urban Greening, 14(4), 1040–1053. https://doi.org/10.1016/j.ufug.2015.09.011*
- *Escobedo, F. J., Clerici, N., Staudhammer, C. L., Feged-Rivadeneira, A., Bohorquez, J. C., & Tovar, G. (2018).* ***Trees and Crime in Bogota, Colombia: Is the link an ecosystem disservice or service?*** *Land Use Policy, 78, 583–592. https://doi.org/10.1016/j.landusepol.2018.07.029*
- *Barak, N.* ***Civic Ecologism: Environmental Politics in Cities****. Ethics Policy Environ.* ***2020****, 23, 53–69.*
- *Nassauer, J. I. (2011).* **Care and stewardship: From home to planet.** *Landscape and Urban Planning, 100(4), 321–323. https://doi.org/10.1016/j.landurbplan.2011.02.022*

Week 8: Spring Break (Colombia Field trip)

March 19 to March 27

Week 9: Urban Species and Nature Conservation in Urban Regions

March 29 Guest Lecture: Urban refugia and rewilding

March 31 Fieldwork findings discussion and debrief / Working session - Diagnostic

Readings:

- *Lepczyk, C. A., Aronson, M. F. J., Evans, K. L., Goddard, M. A., Lerman, S. B., & MacIvor, J. S. (2017).* ***Biodiversity in the City: Fundamental Questions for Understanding the Ecology of Urban Green Spaces for Biodiversity Conservation****. BioScience, 67(9), 799–807. https://doi.org/10.1093/biosci/bix079*
- *Hofmeister, S. (2009).* ***Natures Running Wild: A Social-Ecological Perspective on Wilderness.*** *Nature and Culture, 4, 293–315. https://doi.org/10.3167/nc.2009.040305*
- *Kowarik, I. (2013).* ***Cities and wilderness. A new perspective.*** *International Journal of Wilderness, 19, 32–36.*
- *Tredici, P. D. (2010).* ***Spontaneous Urban Vegetation: Reflections of Change in a Globalized World.*** *Nature and Culture, 5(3), 299–315. https://doi.org/10.3167/nc.2010.050305*

Week 10: Biodiversity Response to Technological Changes

April 5 Lecture: Biodiversity response to technological change in building technologies and urban systems

April 7 Client in class - Presentations of diagnostic, goals and workplan for group projects

Readings:

- *White, T. B., Viana, L. R., Campbell, G., Elverum, C., & Bennun, L. A. (2021).* ***Using technology to improve the management of development impacts on biodiversity****. Business Strategy and the Environment, 30(8), 3502– 3516. https://doi.org/10.1002/bse.2816*
- *Gaston KJ, Visser ME, Hölker F. 2015.* ***The biological impacts of artificial light at night: The research challenge.*** *Philosophical Transactions of the Royal Society B 370: 20140133.*

- *Firebaugh A, Haynes KJ. 2018.* ***Light pollution may create demographic traps for nocturnal insects****. Basic and Applied Ecology 34: 118–125.*
- *Filazzola A, Shrestha N, MacIvor JS. 2019.* ***The contribution of constructed green infrastructure to urban biodiversity: A synthesis and meta-analysis****. Journal of Applied Ecology 56: 2131–2143.*
- *Apfelbeck B, Snep RP, Hauck TE, Ferguson J, Holy M, Jakoby C, MacIvor JS, Schär L, Taylor M, Weisser WW. 2020.* ***Designing wildlife-inclusive cities that support human–animal co-existence****. Landscape and Urban Planning 200: 103817.*
- *Ortar N, Ryghaug M. 2019.* ***Should all cars be electric by 2025? The electric car debate in Europe****. Sustainability 11: 1868.*

Week 11: Urban Biodiversity Evolution

April 12 Guest lecture: Species conservation and fragmented and endangered populations in the Amazon and the Pacific

April 14 Working session - Group project

Readings:

- *Ossola Alessandro, Cadenasso Mary L., Meineke Emily K. 2021.* ***Valuing the Role of Time in Urban Ecology****, Frontiers in Ecology and Evolution, Vol. 9, http://doi.org/10.3389/fevo.2021.620620*
- *Swan, C. M., Brown, B., Borowy, D., Cavender-Bares, J., Jeliazkov, A., Knapp, S., Lososová, Z., Padullés Cubino, J., Pavoine, S., Ricotta, C., and Sol, D.. 2021.* ***A framework for understanding how biodiversity patterns unfold across multiple spatial scales in urban ecosystems****. Ecosphere 12(7):e03650. 10.1002/ecs2.3650*
- *Cooper Daniel S., Wood Eric M., Katz Nurit D., Superfisky Kat, Osborn Fiona M., Novoselov Anna, Tarczynski Jo, Bacasen Lara K. 2021.* ***Large Cities Fall Behind in "Neighborhood Biodiversity".*** *Frontiers in Conservation Science, https://doi.org/10.3389/fcosc.2021.734931*
- *Uchida K, Blakey RV, Burger JR, Cooper DS, Niesner CA, Blumstein DT. 2021.* ***Urban Biodiversity and the Importance of Scale****. Trends Ecol Evol. Feb;36(2):123-131. doi: 10.1016/j.tree.2020.10.011. Epub 2020 Nov 6. PMID: 33168154.*
- *Lambert, M.R., Donihue, C.M. 2020.* ***Urban biodiversity management using evolutionary tools****. Nat Ecol Evol 4, 903–910. https://doi.org/10.1038/s41559-020-1193-7****.***
- *Kondratyeva Anna, Knapp Sonja, Durka Walter, Kühn Ingolf, Vallet Jeanne, Machon Nathalie, Martin Gabrielle, Motard Eric, Grandcolas Philippe, Pavoine Sandrine. 2021.* ***Urbanization Effects on Biodiversity Revealed by a Two-Scale Analysis of Species Functional Uniqueness vs. Redundancy.*** *Frontiers in Ecology and Evolution, https://doi.org/10.3389/fevo.2020.00073*

Week 12: Class Project working Session

April 19 Working session - Group project

April 21 Working session - Group project

Week 13: Client Final Presentations

April 26 Working session - Group project

April 28 Final Class Presentation to clients and external reviewers

Week 14: Class project working Session

May 3 Working session - Final Report draft discussed and edits

May 5 Working session - Final Report draft discussed and edits

Week 15: Class Project Report

May 10 Working session - Final Report draft discussed and edits

May 12 Working session - Final Report draft discussed and edits

Due: Final Project Report, by electronic submission on Monday, May 16 by midnight.

Additional Course Materials / Readings

- ***Book:*** *Adler and Tanner (2013)* ***Urban Ecosystems – Ecological principles for the built environment.***
- *Goddard, M. A., Dougill, A. J., & Benton, T. G. (2010). Scaling up from gardens: biodiversity conservation in urban environments. Trends in Ecology & Evolution, 25(2), 90-98.*

- *Turner, W. R., Nakamura, T., & Dinetti, M. (2004). Global urbanization and the separation of humans from nature. Bioscience, 54(6), 585-590.*
- *Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure. Built Environment (1978-), 115-133.*
- *Pörtner, H.O., et al. 2021. Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change; IPBES secretariat, Bonn, Germany, DOI:10.5281/zenodo.4659158.*