Received: 12 August 2021 | Revised: 25 May 2022 | Accepted: 10 June 2022

DOI: 10.1111/cobi.13983

Conservation Biology

DIVERSITY

Lessons for conservation from beneath the pavement

Alexis M. Mychajliw[1,2] | Elizabeth R. Ellwood[1,3] | Peter S. Alagona[4] | R. Scott Anderson[5] | Mairin A. Balisi[1,6,7] | Eric Biber[8] | Justin L. Brown[9] | Jessie George[10] | Austin J. W. Hendy[11] | Lila Higgins[12,13] | Courtney A. Hofman[14,15] | Ashley Leger[16] | Miguel A. Ordeñana[12,13] | Gregory B. Pauly[13,17] | Breanna J. Putman[13,18] | John M. Randall[19] | Seth P. D. Riley[9,20] | Allison J. Shultz[21] | M. Allison Stegner[22,23] | Thomas A. Wake[24,25] | Emily L. Lindsey[1,26,27]

[1]La Brea Tar Pits & Museum, Los Angeles, California, USA

[2]Department of Biology and Environmental Studies Program, Middlebury College, Middlebury, Vermont, USA

[3]iDigBio, Florida Museum of Natural History, University of Florida, Gainesville, Florida, USA

[4]Environmental Studies Program, University of California, Santa Barbara, Santa Barbara, California, USA

[5]School of Earth and Sustainability, Northern Arizona University, Flagstaff, Arizona, USA

[6]Department of Life and Environmental Sciences, University of California, Merced, Merced, California, USA

[7]Raymond M. Alf Museum of Paleontology, The Webb Schools, Claremont, California, USA

[8]School of Law, University of California, Berkeley, Berkeley, California, USA

[9]National Park Service, Santa Monica Mountains National Recreation Area, Thousand Oaks, California, USA

[10]Department of Geography, University of California, Los Angeles, Los Angeles, California, USA

[11]Department of Invertebrate Paleontology, Natural History Museum of Los Angeles County, Los Angeles, California, USA

[12]Community Science Program, Natural History Museum of Los Angeles County, Los Angeles, California, USA

[13]Urban Nature Research Center, Natural History Museum of Los Angeles County, Los Angeles, California, USA

[14]Department of Anthropology, University of Oklahoma, Norman, Oklahoma, USA

[15]Laboratories of Molecular Anthropology & Microbiome Research, University of Oklahoma, Norman, Oklahoma, USA

[16]Cogstone Resource Management, Orange, California, USA

[17]Department of Herpetology, Natural History Museum of Los Angeles County, Los Angeles, California, USA

[18]Department of Biology, California State University, San Bernardino, California, USA

[19]The Nature Conservancy, California Chapter, San Diego, California, USA

[20]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, Los Angeles, California, USA

[21]Department of Ornithology, Natural History Museum of Los Angeles County, Los Angeles, California, USA

[22]Jasper Ridge Biological Preserve, Stanford University, California, USA

[23]Department of Biology, Stanford University, Stanford, California, USA

[24]The Cotsen Institute of Archaeology, University of California, Los Angeles, Los Angeles, California, USA

[25]Department of Anthropology, University of California, Los Angeles, Los Angeles, California, USA

[26]Institute of the Environment and Sustainability, University of California, Los Angeles, Los Angeles, California, USA

[27]Department of Earth Sciences, University of Southern California, Los Angeles, California, USA

Correspondence
Alexis M. Mychajliw, Department of Biology and Environmental Studies Program, Middlebury College, 374 McCardell Bicentennial Hall, Middlebury College, Middlebury, VT 05753, USA.
Email: amychajliw@middlebury.edu

Alexis M. Mychajliw and Elizabeth R. Ellwood contributed equally to this work.

Article impact statement: Integrating deep-time records in urban ecology can reframe conservation goals in cities—the places where most people live.

Funding information
University of California Los Angeles Institute of the Environment and Sustainability; Natural History Museum of Los Angeles County

KEYWORDS
archeology, baselines, cities, community science, museums, paleontology, urban ecology, paleoecology

A fundamental challenge for 21st century conservation is to develop goals that are meaningful and attainable in a world shaped by anthropogenic change (Kareiva & Marvier, 2012). In areas that receive high conservation priority (e.g., national parks), goals have traditionally been set using historic baselines, with value placed on restoring or supporting conditions from the relatively recent past (Barnosky et al., 2017). But, these so-called natural configurations invariably reflect some degree of human modification (Ellis et al., 2021) and may be difficult or impossible to maintain (Lynch et al., 2021). Future conservation actions will take place in increasingly complex biological and cultural contexts and be informed by fragmentary—if existing—records of past conditions.

Urban landscapes comprise a patchwork of ecological scenarios that are generally assumed to depart radically from what is natural. Yet, cities can be surprisingly biodiverse, supporting apex predators and undescribed species (e.g., Hartop et al., 2015). Prioritizing conservation attention in cities is urgent because global urban area is projected to expand disproportionately in biodiverse regions and the tropics in the coming decades (Seto et al., 2012). Cities can also be laboratories for conservation goal setting because they are places where historic baselines are often treated as invisible, and because urban areas are used differently than wildlands, people's perceptions of what is natural and what is worthy of conservation often diverge. The process of developing conservation goals in cities may thus generate valuable lessons, strategies, and technologies that can be applied broadly (Figure 1) in an increasingly human-dominated world (Sanderson & Huron, 2011).

Urbanization often occurs so rapidly and in spaces already so altered by human activities that present ecological records are assumed inadequate to determine conditions prior to city formation; many cities are palimpsests of human land use on milennial timescales (Smith et al., 2021). However, it is in fact this deep human history that can facilitate baseline reconstruction, as snapshots of ecological change can be more accessible than in less modified landscapes. Natural history collections contain specimens collected during the urbanization process (Shultz et al., 2021), and recent human history yields photographs, diaries, archives, and city planning maps (Sanderson, 2013). Ongoing construction begets a high probability of encountering subsurface records (e.g., boreholes, archaeological sites) (Figure 1), and paleontological and cultural resource management laws, where they exist, help ensure that these records are documented and preserved (e.g., Scott et al., 2017). Skyrocketing participation in community (citizen) science efforts (e.g., iNaturalist) continues to provide much data on species occupying present day urban habitats (Spear et al., 2017). These separate data sources can be used to understand the deep-time natural history, recent human history, or current ecology of urban landscapes in isolated conservation contexts. But, more powerfully, they can be joined across disciplines and in collaboration with local communities to trace the long-term socioecological pathways of a city and provide blueprints for the future.

PALEOBIOLOGY IN URBAN ECOSYSTEMS

Urban ecology focuses on the formation of no-analog assemblages, but it is usually ahistorical (Ramalho & Hobbs, 2012), and urban evolution studies tend to consider change only over very recent time scales (Lambert & Donihue, 2020). The use of a wider range of temporal perspectives in conservation is gaining traction: conservation paleobiology uses deep-time geohistorical records to assess ecosystem structure and function on millennial scales (Barnosky et al., 2017) and historical ecology examines relatively recent human–environment interactions over decades or centuries, often through an archaeological lens (Balée, 2006). But, such studies are typically conducted in the service of protected areas. We encourage the integration of these approaches and their application in urban environments, where they have not traditionally been employed.

We consider urban conservation paleobiology an approach that leverages past life in the broad sense, including fossil, archaeological, and sedimentological records, in combination with historical specimens, documents, and narratives. These data sources and the human expertise behind them can inform baselines and conservation actions in an overlapping chronological context (examples in Rick & Lockwood [2013]). By focusing on urban environments, one can reconstruct not only how a location has changed over the course of its specific history prior to and following human arrival, but, additionally, how human uses of and interactions with nature have changed over time.

Such deep-time records in cities can articulate with modern ecological data sets generated by community scientists to contextualize geohistorical records and foster public interest in conservation. For example, fossil woodrat (*Neotoma* sp.) nests represent millennial-scale archives of ecological data in the form of aggregated plant macrofossils, and modern nests in urban parks could be used to extend this record in describing ongoing changes with urbanization based on the items stored in them, such as the introduction of a non-native species. Similarly, pollen traps in urban yards and swimming pools could calibrate accumulation rates and biases of fossil pollen in sediment cores by providing an analogous vegetation record of the present. Mass online classification platforms (e.g., Zooniverse) can facilitate community participation in the translation of urban historical records, and community paleoscience projects (Figure 1c,e,h) allow residents to connect with the deeper past of their city in ways not generally considered; rich coral reefs, lush forests, and formidable megafauna lie waiting to be appreciated under the concrete. Fossils provide tangible connections to these past ecosystems and engage local communities in telling the full story of where they live.

THE CASE OF THE LOS ANGELES RIVER

The Los Angeles River, weaving through both a megacity of over 10 million people *and* a global biodiversity hotspot, is so altered that in many places it is barely recognizable as a river

FIGURE 1 (a) Early 1900s CE Los Angeles River showing a point in time temporally recent yet ecologically distant (file P-2.2 162R, Seaver Center for Western History) that can be compared with (b) present day academic scientific surveys of the soft-bottomed and concretized sections of the river (photo courtesy of the Natural History Museum of Los Angeles County) and (c) community surveys highlighting changing river uses and users over time. (d) Ongoing construction of a new subway station that provides a window into the past ∼50,000 years by yielding fossils (white outlined subway plans superimposed onto Wilshire Blvd [rendering by B. Engh, Cogstone Resource Management]) that (e) can be used to inform augmented reality experiences of Pleistocene megafauna (photo copyright La Brea Tar Pits) and (f) are curated for research (photo courtesy of Los Angeles County Metro). (g) Public scat-sorting party in which community scientists generate data on modern coyote diets by dissecting scat (photo courtesy of U.S. National Park Service). (h) Students identifying plants and animals from Rancho La Brea (photo copyright La Brea Tar Pits). Solid lines connect past conditions (a, d) to methods of studying and communicating them through ecological (b, c) and paleontological (e, f) approaches. Dashed lines reflect the iterative nature of how generating new data can provide participatory research opportunities that refine peoples' images of the past and provoke new community-led questions (g, h).

(Figure 1a-c). Though concretized along nearly its entire ∼80-km length, the river is a nexus for recreation and the focus of an ambitious restoration plan because 3 soft-bottom sections of the river still support productive riparian habitats (Los Angeles County Public Works, 2022; TNC, 2016) (Figure 1b). Los Angeles' rich fossil and historical archives present an ideal opportunity to integrate deep-time data in an urban conservation project. The Los Angeles River provides an example of how an urban conservation paleobiological approach can benefit goal setting and expand types of data—and therefore perspectives—that may be considered by local policy makers and stakeholders in their efforts to support biodiversity and diverse ecosystem services in a human-dominated context.

Informing conservation goals

Sedimentological data from before channelization evoke a dynamic, wandering river with seasonal flow variation (Ciolek-Torello et al., 2013). Although few, if any, parcels along the river may be candidates for restoration to a pre-urban state, the spectrum of conditions captured by deep temporal records provides opportunities for creative thinking about what components of past ecosystems could support different conservation priorities. For example, Pleistocene–Holocene paleontological records reveal wetland ecosystems supporting dozens of species, including herons, ducks, and storks. Although some of these species disappeared after the Pleistocene, areas of the river could be restored to their prior function, supporting surviving taxa, along with introduced waterfowl species (e.g., Garrett, 2018) that may fill ecological niches once occupied by extinct and extirpated species.

Supporting biodiversity

Abundant fossil deposits and historical records connect the past and present by providing local histories of environmental conditions, species composition, population connectivity through time, and extinction (Figure 1). These LA-area records highlight that open, sandy habitats were once common along the river, but recent ecological restoration resulted in gentrified green spaces that diverge from past conditions and may not support native species (Aronson et al., 2017). Academic and community scientists have demonstrated that some less restored parcels along the river provide habitat patches for species sensitive to urbanization, such as side-blotched lizards (*Uta stansburiana*) and coachwhip snakes (*Masticophis flagellum*) (TNC, 2016). This time-transgressive record of landscape and species configurations indicates that future restoration efforts should include prioritizing some parcels for the conservation of, or restoration to, these more apparently barren conditions.

Promoting socioecological resilience

The Los Angeles River has been at the center of sustenance, recreation, and culture in the area for nearly 10,000 years (Ciolek-Torello et al., 2013). Zooarchaeological, anthropological, and oral historical records document species thriving in an anthropogenically-modified ecosystem throughout this period. Restoring sections of the river to support species of cultural importance to the Tongva people, who continue to harvest tule (*Schoenoplectus* spp.) and rush (*Juncus textilis*) (Reddy, 2015) in the remaining soft-bottom stretches, represents a step toward environmental justice by centering Indigenous community members in restoration dialogues (Hernandez, 2022; Reeder-Myers et al., 2022) and supports resilient ecological assemblages that have been a feature of the area for millennia.

WHAT THE PAST MEANS FOR THE FUTURE OF CITIES

Some conservation approaches strictly prioritize naturalness, yet, as expounded upon by Cronon (1996), if "the place where we are is the place where nature is not", then cities cannot be valuable places for nature. This narrow view downplays conservation efforts in urban areas and limits the ability of cities to support biodiversity; decreases access to ecosystem services for many people; and facilitates actions that result in environmental injustices. The plurality of past configurations of a landscape provides options for what the future *could* include and fosters a broad vision of what ecological scenarios could exist in urban environments. In cities, there is no going back—neither to a pre-human state nor, usually, to a decade ago, and this recognition enables more inclusive and holistic dialogues. Just as urban ecology has become a mainstay within the broader field of ecology, we hope a new generation of paleontologists and archeologists will explore data hidden beneath the pavement and that historians and social scientists will engage with natural scientists in sharing insight into these evolving spaces.

ACKNOWLEDGMENTS

The Natural History Museum of Los Angeles County and the UCLA Institute of the Environment and Sustainability supported the workshop on Urban Conservation Paleobiology. UCLA acknowledges our presence on the traditional, ancestral, and unceded territory of the Gabrielino/Tongva peoples. This work was enriched by P. Gonzalez, M. Gold, S. Campbell-Staton, N. Garrison, and D. Bevington and the community scientists of Los Angeles.

ORCID

Alexis M. Mychajliw https://orcid.org/0000-0003-4801-7496
Elizabeth R. Ellwood https://orcid.org/0000-0003-1602-1917
Peter S. Alagona https://orcid.org/0000-0002-1030-0029
R. Scott Anderson https://orcid.org/0000-0002-7037-4150
Mairin A. Balisi https://orcid.org/0000-0001-6633-1222
Jessie George https://orcid.org/0000-0002-6518-6235
Austin J. W. Hendy https://orcid.org/0000-0002-9818-1158
Lila Higgins https://orcid.org/0000-0001-8903-8619
Courtney A. Hofman https://orcid.org/0000-0002-6808-3370
Ashley Leger https://orcid.org/0000-0002-3414-2918
Gregory B. Pauly https://orcid.org/0000-0002-2381-2576
Breanna J. Putman https://orcid.org/0000-0002-1079-5519
John M. Randall https://orcid.org/0000-0003-2254-0385
Allison J. Shultz https://orcid.org/0000-0002-2089-4086
M. Allison Stegner https://orcid.org/0000-0002-1412-8203
Thomas A. Wake https://orcid.org/0000-0001-8001-5058
Emily L. Lindsey https://orcid.org/0000-0003-0845-8545

REFERENCES

Aronson, M. F., Lepczyk, C. A., Evans, K. L., Goddard, M. A., Lerman, S. B., MacIvor, J. S., Nilon, C. H., & Vargo, T. (2017). Biodiversity in the city: Key challenges for urban green space management. *Frontiers in Ecology and the Environment*, *15*(4), 189–196.

Balée, W. (2006). The research program of historical ecology. *Annual Review of Anthropology*, *35*, 75–98.

Barnosky, A. D., Hadly, E. A., Gonzalez, P., Head, J., Polly, P. D., Lawing, A. M., Eronen, J. T., Ackerly, D., Alex, K., Biber, E., Blois, B., Brashares, J., Ceballos, G., Davis, C., Dietl, G. P., Dirzo, R., Doremus, H., Fortelius, M., Greene, H. W., … Zhang, Z. (2017). Merging paleobiology with conservation biology to guide the future of terrestrial ecosystems. *Science*, *355*(6325), eaah4787.

Ciolek-Torello, R., Homburg, J. A., Reddy, S. N., Douglass, J. G., & Grenda, D. R. (2013). Living in the Ballona Wetlands of the Southern California coast: Paleoenvironmental reconstruction and human settlement. *Journal of Wetland Archaeology*, *13*(1), 1–28.

Cronon, W. (1996). The trouble with wilderness: Or, getting back to the wrong nature. *Environmental History*, *1*, 7–28.

Ellis, E. C., Gauthier, N., Goldewijk, K. K., Bird, R. B., Boivin, N., Díaz, S., Fuller, D. Q., Gill, J. L., Kaplan, J. O., Kingston, N., & Locke, H. (2021). People have shaped most of terrestrial nature for at least 12,000 years. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(17), e2023483118.

Garrett, K. L. (2018). Introducing change: A current look at naturalized bird species in western North America, in Trends and traditions: Avifaunal change in western North America (W. D. Shuford, R. E. Gill Jr., and C. M. Handel, eds.), pp. 116–130. Studies of Western Birds 3. Western Field Ornithologists, Camarillo, California.

Hartop, E. A., Brown, B. V., & Disney, R. H. L. (2015). Opportunity in our ignorance: Urban biodiversity study reveals 30 new species and one new Nearctic record for Megaselia (Diptera: Phoridae) in Los Angeles (California, USA). *Zootaxa*, *3941*(4), 451–484.

Hernandez, J. (2022). *Fresh Banana Leaves: Healing Indigenous Landscapes Through Indigenous Science*. United States: North Atlantic Books.

Kareiva, P., & Marvier, M. (2012). What is conservation science? *Bioscience*, *62*, 962–969.

Lambert, M. R., & Donihue, C. M. (2020). Urban biodiversity management using evolutionary tools. *Nature Ecology and Evolution*, *4*, 903–910.

Los Angeles County Public Works. (2022). *LA River master plan*. https://pw.lacounty.gov/uploads/swp/LARiverMasterPlan-FINAL-DIGITAL-COMPRESSED.pdf

Lynch, A. J., Thompson, L. M., Beever, E. A., Cole, D. N., Engman, A. C., Hawkins Hoffman, C., Lynch, A. J., Thompson, L. M., Beever, E. A., Cole, D. N., Engman, A. C., Hoffman, C. H., Jackson, S. T., Krabbenhoft, T. J., Lawrence, D. J., Limpinsel, D., Magill, R. T., Melvin, T. A., Morton, J. M., … Wilkening, J. L. (2021). Managing for RADical ecosystem change: Applying the Resist-Accept-Direct (RAD) framework. *Frontiers in Ecology and the Environment*, *19*(8), 461–469.

Ramalho, C. E., & Hobbs, R. J. (2012). Time for a change: Dynamic urban ecology. *Trends in Ecology and Evolution*, *27*, 179–188.

Reddy, S. N. (2015). Feeding family and ancestors: Persistence of traditional Native American lifeways during the Mission Period in coastal Southern California. *Journal of Anthropological Archaeology*, *37*, 48–66.

Reeder-Myers, L., Braje, T. J., Hofman, C. A., Elliott Smith, E. A., Garland, C. J., Grone, M., Hadden, C. S., Hatch, M., Hunt, T., Kelley, A., LeFebvre, M. J., Lockman, M., McKechnie, I., McNiven, I. J., Newsom, B., Pluckhahn, T., Sanchez, G., Schwadron, M., Smith, K. Y., … Rick, T. C. (2022). Indigenous oyster fisheries persisted for millennia and should inform future management. *Nature Communications*, *13*(1), 2383.

Rick, T. C., & Lockwood, R. (2013). Integrating paleobiology, archeology, and history to inform biological conservation. *Conservation Biology*, *27*(1), 45–54.

Sanderson, E. W. (2013). *Mannahatta: A natural history of New York City*. Abrams.

Sanderson, E. W., & Huron, A. (2011). Conservation in the city. *Conservation Biology*, *25*, 421–423.

Scott, E., Leger, A., Scott, K., Harris, J., & Gust, S. (2017). *2017 Paleontological resources progress report for the purple line extension, Section One, Los Angeles, California*. Cogstone.

Seto, K. C., Güneralp, 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 of the United States of America*, *109*(40), 16083–16088.

Shultz, A. J., Adams, B. J., Bell, K. C., Ludt, W. B., Pauly, G. B., & Vendetti, J. E. (2021). Natural history collections are critical resources for contemporary and future studies of urban evolution. *Evolutionary Applications*, *14*(1), 233–247.

Smith, M. E., Lobo, J., Peeples, M. A., York, A. M., Stanley, B. W., Crawford, K. A., Gauthier, N., & Huster, A. C. (2021). The persistence of ancient settlements and urban sustainability. *Proceedings of the National Academy of Sciences of the United States of America*, *118*(20), e2018155118.

Spear, D. M., Pauly, G. B., & Kaiser, K. (2017). Citizen science as a tool for augmenting museum collection data from urban areas. *Frontiers in Ecology and Evolution*, *5*, 86.

The Nature Conservancy (TNC). (2016). *Water supply and habitat resiliency for a future Los Angeles River: Site-specific natural enhancement opportunities informed by river flow and watershed-wide action: Los Feliz to Taylor Yard*. The Nature Conservancy.

How to cite this article: Mychajliw, A. M., Ellwood, E. R., Alagona, P. S., Anderson, R. S., Balisi, M. A., Biber, E., Brown, J. L., George, J., Hendy, A. J. W., Higgins, L., Hofman, C. A., Leger, A., Ordeñana, M. A., Pauly, G. B., Putman, B. J., Randall, J. M., Riley, S. P. D., Shultz, A. J., Stegner, M. A., … Lindsey, E. L. (2022). Lessons for conservation from beneath the pavement. *Conservation Biology*, *36,* e13983. https://doi.org/10.1111/cobi.13983