University herbaria are uniquely important

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Abstract: University herbaria play critical roles in biodiversity research and training and provide an interdisciplinary academic environment that fosters innovative uses of natural history collections. Universities have a responsibility to steward these important collections in perpetuity, in alignment with their academic missions and for the good of science and society.

Duke University, a long-standing pillar of Natural History Collections (NHC)-based biological research, has recently announced plans to close its 100-year-old herbarium, citing a reorientation of its funding priorities [1]. This decision has caused an uproar around the world, and for good reason [2,3]. The Duke Herbarium contains nearly one million specimens and is especially rich in records of the southeastern flora of the U.S. and Latin America, capturing important global biodiversity hotspots. Moreover, this decision comes at a moment when herbaria are experiencing a renaissance and becoming increasingly relevant for conservation, climate change, and other larger societal agendas [4]. Herbaria represent a global biodiversity heritage that should be used effectively and ethically and protected for the future [5]. We strongly echo the refrains that Duke's decision is a misguided and irresponsible divestment, especially in the current global biodiversity crisis. And we strongly disagree with the premise that simply relocating the collection to another herbarium will solve the problem. The full value of the Duke herbarium stems not only from the specimens themselves, but from the environment in which they are situated – a leading research university. Specifically, we argue that world class collections at universities like Duke are critically important for advancing science and society (**Figure 1**). They have a distinct role relative to free standing NHCs because they are inherently part of the larger academic vision, resources, and mission of a university.

The immersion of university herbaria within an ecosystem of scholars spanning engineering to art history inspires new research directions that leverage collections in creative new ways, and enables cutting-edge education of scholars at all levels, both inside and outside of the academy. One need look no further than the use of herbaria as precious sources of DNA for reconstructing plant evolutionary history. The extraction of 'antique' DNA from herbaria was pioneered by Doyle and Dickson nearly 40 years ago [6] who were based at the Bailey Hortorium Herbarium at Cornell University. These researchers elegantly demonstrated that large molecules of DNA could be harvested and sequenced from pressed and dried specimens. This was essential to the meteoric rise in the use of herbaria and other natural history collections for largescale phylogenetic investigations, which have rewritten our understanding of the Tree of Life. There are countless other examples of innovation in university herbaria, including: tracing the origin and spread of crop pathogens, such as potato blight [7]; tracking changes in herbivory in the face of global warming [8]; timing the introduction and spread of cryptic invasions [9]; developing phylogenetic algorithms from specimen locality records to assess biodiversity conservation

priorities on the landscape [10]; and illuminating the colonial legacies of these collections [11]. In our own labs in just the last year, we have mentored students utilizing specimens in ways that had never occurred to us before, from analyzing stable carbon isotopes of specimens to track the fingerprint of fossil fuel consumption on atmospheric CO_2 isotopic composition, to sampling pitcher plant specimens for their microbiomes, to a history term paper examining how early U.S. plant collectors collaborated extensively with slaveowners and plantations in Caribbean colonies.

Importantly, it isn't just a diversity of campus scholars who find their way to herbaria; herbaria provide connections to the broader communities that surround universities, including federal and state land managers, scientists, conservation biologists, local naturalists and collaborators worldwide who rely on the critical information that resides in university herbaria. Maintaining a resource that is a true public good, as well as a vital campus resource, should be part of a university's central mission, especially now, as the public mistrust of academia reaches an all-time high.

But perhaps the most salient issue, from our viewpoint as faculty curators of university herbaria, is that Duke's outstanding research and training programs in plant and fungal systematics and evolution will be forever diminished, or even eliminated. Included in Duke's cost-benefit assessment for collection stewardship is the expense of its five faculty lines currently dedicated to herbarium-based research. Closing the herbarium just prior to the retirement of these faculty increases Duke's flexibility in future hires. By removing the foundation on which collections-based research is built, this decision all but ensures the allocation of these faculty lines to other biological disciplines. Moreover, this comes at a time when our collective global taxonomic expertise is already shrinking at an alarming rate [12].

A mistaken attitude we often encounter is that herbaria are storage repositories of work that was all finished many decades ago – i.e., the naming and classification of species. On the contrary, the science of taxonomy and phylogenetic systematics is an ever-evolving discipline that still faces enormous challenges in documenting and understanding the biodiversity of life on Earth - challenges made even more difficult because species are literally disappearing while we work. This research is fundamental to every biological discipline. Every scientist or conservationist who works on a particular plant species starts with the (often unconscious) assumption that their species is a valid taxonomic entity; the person who can figure that out is undoubtedly working in an herbarium.

Duke is exceptionally well-positioned to lead the current renaissance of biodiversity and climate science that is built on herbarium-based research. We urge Duke leaders to reconsider their decision to close the Duke Herbarium. An herbarium is not simply an

expensive storage facility– it is an active laboratory for research and teaching. Having a collection of global importance comes with a responsibility to a community that extends far beyond the college campus. For a century, Duke has been a responsible steward of this global resource, which resulted in the development of a world-renowned training program that has propelled the field forward and produced multiple generations of biodiversity scientists, who are now performing critical work in academic and non-academic institutions around the world. The impending retirement of the core herbarium faculty at Duke should be viewed as an exciting opportunity to *re-invest* in the herbarium and affiliated research programs - to recruit the next generation of brilliant scientists, with fresh ideas and new approaches - and to build on Duke's great legacy.

Figure 1. Fraction of R1 research universities in the United States that also house herbaria. Of the 146 designated R1 universities (last surveyed in 2021 by https://carnegieclassifications.acenet.edu/carnegie-classification/classification-methodology/basic-classification/), 91 have an associated herbarium, according to the data in *Index Herbariorum* (https://sweetgum.nybg.org/science/ih/). However, most of these herbaria are small collections; only 38 R1 institutions – 26% – are home to herbaria containing at least 200,000 specimens. Duke University houses the eighth largest R1 herbarium in the United States, and as such has served as one of the most significant and influential training programs in plant and fungal diversity for many decades.

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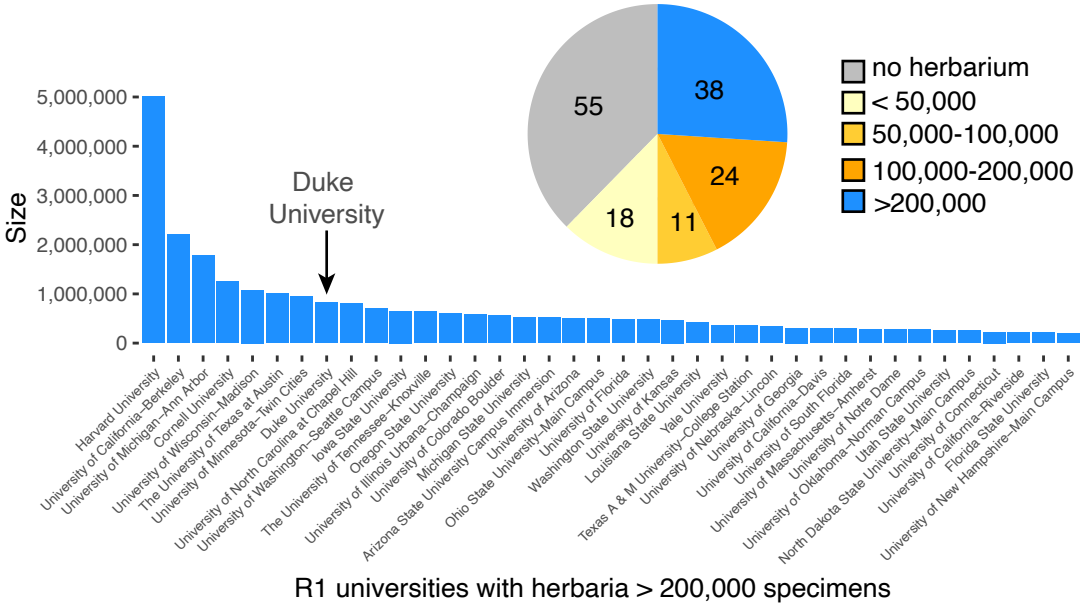
Figure 1



R1 universities with herbaria > 200,000 specimens