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# PLANT IDENTIFICATION AND MAPPING IN THE DIGITAL AGE: HISTORICAL AND CONTEMPORARY PERSPECTIVES

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## ABSTRACT

This paper discusses the variety of recent digital media available for the identification and mapping of plants in cities in relation to the history of plant guides and maps. It raises the question: how has our focus on plants- especially their identification and mapping- evolved over the centuries and how might new digital media extend and/or limit our relationships with plants? The paper begins with an historical perspective on the processes of identifying and mapping plants and describes the development of plant books and their changing purposes within the general development of Western culture through a scientific lens. It touches on Theophrastus' Enquiry into Plants, Dioscorides' De Materia Medica, Linneaus' Systema Naturae, and Tansley's work in ecology. Next, the paper discusses the recent proliferation of locative media for identifying and mapping plants, which use face recognition software, crowd-sourcing, and location-based-services through GIS. These include *Leafsnap* for plant identification and *i-Tree* for ecological investigations of vegetation in cities. The paper concludes that in every era, human interests in plants and the media we've devised to investigate plants have been knit together. The 21st century is no different and the new digital media will be of great use in addressing issues as complex as climate change and as basic as identifying fresh fruit in cities. Overall, the new media have the potential to deliver knowledge to people about plants that was formerly hard to get, which may lead to an increase in plant literacy, especially in cities.

## INTRODUCTION

The lives of humans and plants are woven together tightly. New digital media, discoveries in plant science, and changes to the social and physical contexts of our lives may alter the particulars of our relationships with plants, but our connections to them remain and may strengthen through such media in the 21st century. From a biological and evolutionary perspective we share many of the same genes with plants[1]. Culturally, most of our crops are products of artificial selection. Opportunistically, some plants we call weeds have adapted to thrive in the conditions we prepare for other plants and purposes. For most of our history, our focus on plants has centered on survival, and it still does, even if the burning questions have shifted from which plants are poisonous to how much carbon a typical tree sequesters to offset climate change. No matter when and where we find ourselves on the planet, searching for, identifying, and sharing plants are basic human activities. Most of us find ourselves wondering at some point, which plant this is? What are its names? Where did it come from? How did it get to be where it is? What properties does it have? There is often some practical reason for this typical line of questioning, but it may also be out of sheer curiosity.

How we answer these and other questions about plants has a lot to do with our time and place and the particular media available to us to investigate. And so, while this paper is about new digital media designed to investigate the identity and locations of plants, it presents these in relation to the history of Western plant knowledge up until now. The focus of the history is on Europe and North America, and the perspective is largely scientific. The discussion of the new digital media that follows, while rooted in various ways to the history of Western culture, isn't presented here as a logical next step in its development. If anything, the new media seem to make information about plants that was once

difficult to access, widely available across cultures and continents, while using similar conceptual devices to organize it.

## AN HISTORICAL PERSPECTIVE

Identifying and mapping plants is not a new activity. In the Western tradition, Theophrastus (371-287 BC), a student of Aristotle, identified about 500 distinctive plants and categorized them by their observable characteristics and properties[2] and also noted where they grew. This compilation of plant knowledge, his Enquiry into Plants, is the oldest book of this type to survive in the Western tradition. Others in antiquity, assembled texts devoted to plants, but Dioscorides's work is perhaps the most remarkable[3]. A physician in the Roman army, he traveled widely and recorded all of the plants he encountered, their properties and lore. His book, De Materia Medica, became the primary plant text in the literate world for about 1500 years, copied and re-copied over centuries. Texts like Enquiry into Plants and De Materica Medica represent the plant knowledge of the literate world before the Renaissance. But this was not the only way that people knew plants. The plane tree (Platanus orientalis), for instance, is a common entry in these historical texts, but would also have been commonly known through oral tradition and use.

The Western world of plants expanded greatly during the European Renaissance. This was in part through the re-reading of texts like that of Theophrastus, but also through exploration, particularly to the Americas. The number and variety of plants available grew ten-fold, as did the number of volumes it took to complete an herbal. Trees like the American sycamore (Platanus occidentalis), a New World cousin of the plane-tree, crossed the Atlantic and became key features of new botanical gardens and herbaria (dried specimen collections), often associated with universities, such as the first one in Padua, Italy (1545)[4]. Plants in these gardens were organized by types, using the notion of the Great Chain of Being or scala naturae, which combined Aristotle's way of ordering substances (including life forms) with the Christian notion of the fixed nature of species as created by God[5].

This perspective that plant species are fixed entities carried all the way through the Enlightenment and into the late 19th century. Carolus Linneaus, the great systematician who invented binomial nomenclature, structured his work or flora (the term to replace herbal) around Orders, which still related to the *scala naturae* in his Systema Naturae of 1735. Even as Linneaus worked to fit the known species into his system, the plane-tree and the American sycamore naturally hybridized where they were planted side by side at the Oxford Botanic Garden, producing the now famous urban street tree, the London plane. Hybridization and artificial selection were the starting points for Darwin's evolutionary theory in On the Origins of Species (1859). But despite the long history of crossing and breeding plants, which Darwin argued attested to their mutability, those concerned with plant identification, Bentham and Hooker in Genera plantarum (1862-1883) still based their classification scheme on plant morphology rather than evolutionary relationships. Only late in his career did Bentham concede that plant species were the products of the ongoing process of evolution[6]. However, despite Bentham and Hooker's resistance the evolutionary concept, their taxonomy is still useful today for the key structure it developed. And though we may understand the evolutionary relationships between plant species more now and have the ability to map their genes, plant identification is still most feasible with keys that focus on plant morphology, the plant's phenotype rather than its genotype.

At the same time as the great botanical developments of the 19th century in the realm of evolutionary biology and taxonomy, another great wave of plant exploration occurred. This was the age of the bio-geographers such as Alexander Von Humboldt, who explored the high peaks of the Andes, for example, and found relationships there between where plant species grow and the climates they experience. Subsequent studies in the relationships between plants and their environments brought about the field of ecological science, especially, in the work of Arthur Tansley, whose projects included mapping the vegetation of the British Isles and later the introduction of the ecosystem concept in a 1935 publication, "The use and abuse of vegetational terms and concepts". And now,

though much of the heterogeneous surface of the earth has been mapped and only a handful of novel plant species are discovered each year, experts and novices often still face the seemingly simple questions posed earlier, what is this plant and where does it grow?

The issues of identifying and locating plants are equally pressing for an ecologist in the field, a farmer behind the plow, or, in the author's case, a landscape architecture educator concerned with planting in cities. And because of the great exchanges that have occurred with plants between continents and among people, historical bio-geographical limits have been blurred, particularly in cities. This has as much to do with the cultures of the people who have migrated with their plants as any particular plant's tendency to disperse, germinate, and grow in the novel conditions we create in urban environments. Knowing plants in this 21st century context, in which a plant one encounters might be one of 130,000 globally (not to mention cultivars), rather than say 1,300 locally (in a typical temperate region) suggests that the map and matrix of species has shifted and the media through which we know and locate them must change too.

## IDENTIFICATION

Not until the late 20th century was the body of knowledge described above easily accessible. Up until about 20 years ago, the primary means of identifying a plant would have been to find a hard copy field guide or to ask an expert. Field guides became especially popular in the 20th century in the United States[7]. Examples range from Wherry's Wildflower Guide[8] first published in 1948 to Fernald and Kinsey's 1943 book, Edible Wild Plants[9]. Increasingly, guides like the Peterson field guide series, which began with some color illustrations, now include color photographs and key maps for the range or distribution of plants. Printed in the millions of copies, there seems to be no shortage of guides available to identify plants today, all the descendants of the generations of plant books, herbals and flora that have preceded them. Most guides lead the reader through a dichotomous key that helps narrow in on the identity of the plant in question through a decision tree with leads based on the plant's characteristics. The leads are usually quite straightforward features of plants. For instance, in Wherry's guide he uses "floral structure, significant features of leaves, stems, roots, et cetera"[10] to organize the key. Of course, in parallel, and supporting the richness of botanical inquiry at the level of the novice field guide, has been the work of scientific botanists, (such as Gleason and Cronquist at the New York Botanical Garden) who developed an exhaustive key in technical language that covers the flora of Northeastern North America, drawing out the hairline distinctions between species[11].

So what's happened with identifying plants recently? A great deal of field-guide type information has been transferred onto the web, especially through the work of botanical gardens. The NYBG, for example, has scanned several million specimens in its herbarium. Searching for plants has become even faster with computer aided multi-access keys, which can sort through multiple plant characteristics simultaneously to find an identity. Interestingly, this type of key search now common on the Internet had its origins in the great taxonomic keys of the 18th and 19th centuries. Now, not only can a knowledgeable person conduct a key search on the Internet, a relative novice can use the equivalent of face-recognition software for plant identification, as well as crowdsourcing to identify plants. In applications like Leafsnap[12], a joint effort of Columbia University, the University of Maryland, and the Smithsonian, anyone with a mobile device can take a photograph of a tree leaf, and have it identified from among several hundred possible tree species, as well as geo-locate it. Using an algorithm that analyzes the leaf morphology, the app performs the same function that our brains formerly did when we learned plants or the faces of our neighbors visually. Other apps, such as Plantifier[13], allow users to upload photographs of plants they are trying to identify and other users of the app are free to comment on and attempt to identify the plants (crowdsourcing). In both cases the digital media are making available the identities of plants through new means, somewhat like the mental processing required to recognize plants after we have studied them, perhaps after having been told their identity by a teacher or elder. The apps may short circuit learning to identify plants through their morphology and eliminate some of the social processes that were once in place to learn about plants, but, as will be discussed, they may provide other social functions and open up the world of

plants to individuals and cultures, which no longer retain close ties with their ecological community, including plants.

## MAPPING

Knowing where plants are located can be of great value. In terms of the fields associated with economic botany (agriculture, horticulture, forestry) the importance of mapping plants can have obvious consequences to the livelihoods of individuals, communities, and nations. Bio-geographers since the late 19th century have had economies in mind, but also have been genuinely curious about the distribution of plants and their interactions within ecosystems, as were Tansley's and his colleagues in the first half of the 20th century[14]. Today the ecosystem approach seems almost second nature to many and increasingly informs environmental, economic, and social planning and decisions. Through most of the 20th century there was a rich tradition of making analog maps of vegetation, which is nicely described in its European form by Franco Pedrotti[15]. Currently, the media of choice for mapping vegetation is Geographic Information Systems (GIS), which captures, stores, and manipulates all sorts of geographical data. GIS, when Roger Tomlinson developed the first version in 1968, was designed for forestry mapping in Canada[16]. This digital media and the satellite systems it now uses, coupled with aerial photographs, have extended the possibilities for knowing the vegetation of the planet, and especially its distribution and health, as well as being useful in numerous other arenas. An example of its application is Digital Aerial Sketch Mapping[17]. This process of the U.S. Forest Service is used to map the distribution of pest outbreaks with a combination of aerial surveys that are transformed into GIS data. Ground surveys act as quality control. On the ground is where most users of new digital media find themselves in the position of wanting to locate plants or map plants they have found and where using the location-based-services of GIS or basic web searches can help locate a great variety of specific information on plants very easily.

Recently I was curious about the northern extent of the pawpaw (*Asimina triloba*) on the east coast of the United States. I found myself quickly reading notes on specific populations with addresses in New Jersey, providing an approximate range. This I could corroborate with Little's Atlas of United States Trees[18] from 1977, which showed a spotty distribution in the areas described online. Increasingly, the question of the range of certain species will be raised as our climate shifts. The mapping that is possible with location-based-services on mobile devices and with every hit on apps (such as Leafsnap) has a great deal of potential for better understanding the populations and distributions of our flora.

Other applications, designed specifically to map vegetation, such as i-Tree[19], are popular with a wide range of users for mapping tree populations. Data-gathering, which formerly was limited to specialized scientists, is now in the hands of citizens from school children to retired persons, who are able to satisfy some of their interests and curiosity with plants and make a contribution to ecological science. Their work with this application goes beyond naming, sizing, and pinning trees to estimating their ecological contributions to urban environments. Through this type of application, cities can begin to answer questions about the role of trees in the health of urban areas and how climate change might affect the distribution of species. The possibility of pooling data that is collected with abundant hand-held devices will likely be quite useful in the coming decades, as our cities grow and the expectations we have of their vegetation increase around the concepts of ecosystem services and the need for resilient plants. On the other hand, as advanced as the technology is, sometimes its beauty is that it allows us to come back to basics with projects like Fallen Fruit[20]. This initiative began with online postings of analog maps of fruit trees in Los Angeles. It has turned into an online cooperative to steer pick-it-yourselfers to free, ripe crops.

## CONCLUSION

So what are some of the possibilities for the new digital technology mentioned, some of which come out of botanical science, like the multi-access key, or forestry, as in GIS? There are the rather obvious ways that identifying and mapping plants through new media will prove useful to people on small and

large scales, which have given rise to the applications already discussed. Generally, they're of use in ecological planning and design with the pressing issues of how to manage forests and agriculture across the globe. The new media will also be useful dealing with the difficulty of invasive plant species, which disrupt functioning ecological systems, leading to losses in biodiversity. And there are economic questions to which these tools can be applies, such as how we can bring ecosystem services into the marketplace and make ourselves responsible citizens by marrying our wallets to the health of our forests and waterways. In addition to these clearly important causes, it seems that one of the wonderful effects of tools like the crowd-sourced Plantifier or i-Tree is how online communities can lead to live, in the flesh, interactions. The virtual media bring people together around a living medium central to humans: plants. A possible outcome here is that in cities, where people are sometimes estranged from the vegetable world, may now engage in new dialogues between plants and people. Currently, urban people in Western culture encounter most plants as products, at the delivery end, severed from the plant that bore it, making it less obvious to ask the questions, which began this piece. But this situation doesn't seem to be out of a lack of interest, as a visit to the US Botanic Garden or any other urban vegetated plot clearly suggests: they abound with people. There is a significant and diverse population of people with interests in a wide-range of plants in any urban area. Matching people with plants and finding the people-plant relationships that matter in our lives is not an easy task, but it's being made easier with new media. Identifying, locating, and sharing plants through media that engage us immediately and virtually will connect us eventually through live experience and will help us plant and cultivate our cities. Having the herbarium-like Internet, available to all, as opposed to cloistered away, is wholly appropriate in the 21st century. As we pursue life in a global culture, the notion that we have particular local interests, greatly appeals to people. Digital media can facilitate the connections and transmission of knowledge around plants to foster such interests, working to redefine a contemporary idea of a plant community may be.

In conclusion, there seem to be three main benefits to the use of digital applications for plant identification, mapping of vegetation, and sharing of plant information. The first is that knowledge about plants is now freely accessible near and far from where plants of interest grow. Details on the characteristics and properties of plants and the stories associated with them are no longer bound to the institutions and people that hold rare volumes. Rather, the pages of old tomes can be flipped virtually, while standing next to living specimens of the plants described therein. Second, when designed to source information from users, plant apps can gather data that can aid in the modeling of ecosystems and the plant communities that are critical to them. This aspect of new media, that gives most data a geo-spatial character, is already having a profound influence on the interactions we have with each other and our environment. It is changing the global ecosystem, so that we can make more informed decisions, in this case, about how to plant and cultivate designed places in the 21st century. Of course, locative media have many more applications than this, but to point out one more in this vein, our ability now to use GIS and sensor technology to guide crop production is in many ways the kind of innovation that is leading to the growth of cities today. Third, the communities that can form through the sharing of information about plants online and the growing archive, which is essentially a record of the oral traditions of the way people interact with plants, are beginning to be built. Finally, it is interesting to think about ways that virtual interactions with plants may lead to live plant-people interactions and if virtual interactions can ultimately lead to increased community involvement with living plants, even as many of the larger global plant populations are managed remotely.

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