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Contextualizing Science Learning through Agricultural Free-Choice Learning Opportunities in Your Backyard

Abstract

Contextualizing science and STEM learning through agriculture can bring both science and agriculture to new audiences, and improve understanding of both fields. Such agriscience education benefits from informal education resources to support classroom work, but teachers may struggle to locate cost-effective free-choice learning resources in their area. This case study categorizes the various agriscience nonformal education resources that Gainesville, Florida, has to offer within the city limits and open to the general public. We found destinations and events through web searches, brochures, and ideas from local residents. Using constant comparative methods, we categorized 90 resources in 11 categories. While our study took place in a well-resourced part of the world, many resources we identified could exist with minimal infrastructure. This categorization will serve as a guide for teachers looking for local field trip destinations and informal agriscience education resources and for researchers interested in the spectrum of informal agricultural education or science education resources in their area.

It is paramount for all learners to understand the connections among agricultural and science, technology, engineering, and math (STEM) topics in order to establish a deeper connection between applied and basic science principles and promote meaningful learning about all of the associated disciplines. Everyone needs to eat, yet many Americans today are far removed from food production (Environmental Protection Agency, 2013). Even if people do not enter these career fields, global crises such as the need to feed 9 billion people in the year 2050 will impact choices of a wide range of public institutions. Public literacy about the food and fiber industry and its scientific underpinnings will support more informed political, economic, and social decisions. Traditionally, researchers and practitioners separate science and agriculture in formal education (Thoron & Myers, 2008), nonformal or informal education (Stofer, 2015a, 2015b), and studies of public perceptions of the two (e.g. Lundy, Ruth, Telg, & Irani, 2006; Miller, 2010). This lack of overlap reflects a general disconnect between learning opportunities and practices of the so-called basic STEM and applied agricultural domains (Barrick, Heinert, Myers, Thoron, & Stofer, in press), which manifests in a public disconnect of these fields (Stofer & Newberry III, 2017). This article will highlight community resources that can be used to reintegrate these areas to foster both basic and applied science learning.

Keywords: Agriscience education Science literacy Agricultural literacy Education resources Informal education Nonformal education Free-choice science learning

Literature Review

As technology advanced and agricultural production became more efficient over the course of the 20th century, the need increased for the agricultural workforce to become more highly educated in both science and agricultural applications (Carnevale, Smith, & Melton, 2011; Drache, 1996; National Commission on Excellence in Education, 1983). This demand increased pressure on high schools to offer more openings in agricultural education programs. However, in American schools, agricultural education often is separated from the study of the basic scientific and technological principles applied to food production today (Chumbley, Haynes, & Stofer, 2015; Thoron & Myers, 2008).

Integrating science into agricultural education programs assists students in understanding both science concepts and their application to agriculture better (Thompson & Balschweid, 2000). Improved science self-efficacy that can result from agriscience courses may be a motivator to studying these combined courses in upper-level secondary school for students enrolled in applied agricultural courses (Chumbley et al., 2015). On the other hand, core science education benefits from having a context of agriculture, to which people can relate abstract scientific principles (Rivet & Krajcik, 2008). Offering science through agriculture curriculum allows incorporation of more agricultural concepts into school curriculum as well as more efficient science teaching (Committee on Agricultural Education in Secondary Schools, 1988; Shoulders & Myers, 2011).

To emphasize the connections, educators may use the term agriscience or ag-STEM. Here we will use agriscience, with the understanding that science in this case is a shorthand for all the STEM disciplines. In order to understand better the term agriscience, it is helpful to understand the definitions of the words science as well as agriculture. Science is the "intellectual and practical activity encompassing those branches of study that relate to the phenomena of the physical universe and their laws, sometimes with the implied exclusion of pure mathematics" (Simpson, 1989). Agriculture can be thought of as "the practice of growing crops, rearing livestock, and producing animal products, regarded as a single sphere of activity" (Simpson, 1989). Modern agriculture encompasses natural resources in many contexts and considers whole ecosystems as part of its purview as well ("Topics | USDA," n.d.). Finally, Buriak (1989) defined agriscience as, "agriculture emphasizing the principles, concepts, and laws of science and their mathematical relationships, supporting, describing, and explaining agriculture" (p. 18). Agriculture would not be possible without the scientific principles that assist in such cultivation. At the same time, without agriculture, many fields of science would have fewer real-world applications, and it is illogical to separate these topics completely (Conroy, Dailey, & Shelley-Tolbert, 2000; Hillison, 1996).

Learning about these topics must take place across the spectrum of education contexts, including particularly those characterized as free-choice learning environments, also known as informal or non(-)formal environments (Stofer, 2015b). Despite this nascent re-emphasis on the connectedness of agriculture and science in schools, especially within agriculture classes (Thoron & Myers, 2008), there may be less emphasis on these connections in everyday learning situations. People spend most of their lives outside of school (R. C. Anderson, Wilson, & Fielding, 1988; Falk & Dierking, 2010) and typically learn best in situations conductive to social, multisensory active learning (Behrendt & Franklin, 2014). In particular, students often generate this active learning from field trips, as fourth-graders, eighth-graders, and even adults are able to recall field trips from their elementary school days (Falk & Dierking, 1997). Field trips offer individualized learning (D. Anderson, Piscitelli, Weier, Everett, & Tayler, 2002), can allow students to explore what is meaningful to them (Kelner & Sanders, 2009; Tunnicliffe, 1996), and can offer fieldwork that integrates science literacy and environmental preservation (Lima, Vasconcelos, Félix, Barros, & Mendonça, 2010). The greatest value of field trips above other methods of learning lies in the provision of hands-on experience complementary to subject theory via the use of data processing and analysis (Fuller, 2006). Students, particularly those from historically underserved populations, sometimes demonstrate gains on science standardized testing after field trips (Whitesell, 2016). Therefore, field trips that inspire curiosity about a subject can facilitate active learning in those contexts, generating opportunities for scientific inquiry and knowledge acquisition through direct exploration.

Agriscience is a broad multidisciplinary field that can allow such interesting hands-on learning experiences through the various agriscience programs listed, such as trips to libraries, natural parks, museums, and public farms. Although field trips can be effective, they are not often well-used (DeWitt & Storksdieck, 2008), especially for agriscience. Field trip rates are declining (Courtney, Caniglia, & Singh, 2014; Mehta, 2008); teachers lack support for planning and funding field trips (D. Anderson, Kisiel, & Storksdieck, 2006; Michie, 1998), and often use a limited number of familiar venues (Falk & Dierking, 1992; Ramey-Gassert, Walberg, & Walberg, 1994; D. L. Rennie & McClafferty, 1995; L. J. Rennie & McClafferty, 1996). Field trips are also less effective for learning when they are in settings without optimal novelty (D. Anderson & Lucas, 1997; Orion & Hofstein, 1994; Pauw, Hoof, & Petegem, 2018); environments – cognitive, geographic, and psychological (Orion & Hofstein, 1994) – with too much novelty can distract students, while too little novelty may induce boredom (Pauw et al., 2018). Novelty effects may be mediated if the setting is relevant to the learning at hand (DeWitt & Storksdieck, 2008; Falk & Balling, 1979).

This study is an attempt to categorize and collect the agriscience resources that are available in the city, resources that might often be separately categorized as agricultural or scientific (Stofer, 2015a). The resources we present may not themselves explicitly identify as both agricultural and scientific, but we list them as sources where a facilitator could make the connections obvious through a program or through discussion with visitors. For example, a farm may advertise experiences with farming operations but not the science behind the choice of irrigation system or fertilizer use. This scientific underpinning may be made clear by a presentation by the farmer or by a parent discussing with their family and friends.

This article will emphasize the diversity of resources as well as the vast number of resources that can be used to learn about agriculture and science in a community. In particular, we offer a categorization scheme which may help other researchers, for example, examine their own communities or compare communities on the number of resources per category type, and which may help teachers find field trip sites that are lower-cost and closer to their campus or connected to a wider variety of topics, potentially making field trips more accessible. While the absolute number of resources may vary from community to community, considering an array of types of resources makes it more likely that any individual resource can be identified in even the smallest communities. Using community resources that may be familiar and found close to schools, such as school gardens, fields, bordering forests, and local neighborhoods can reduce field trip novelty effects.

Many websites (such as those hosted by a municipality) may not contain a completely exhaustive list of all resources a city may have, including hidden spots that are familiar mostly to locals. City websites also have different purposes for promotion than teachers and other members of the public have for visiting. Throughout the duration of our research, we looked for out-of-school agriscience resources, especially those that allow the general public to learn by means of multisensory, active-learning experiences. Therefore, the goal of this paper is to provide a listing of representative categories of agriscience resources that are available for the public's educational benefit, especially for local teachers and students, so that they may find creative ways to learn about agriculture and science in context.

Method

We present a case study (Yin, 2009) of a medium-sized university city in the Southeastern United States. We limited our search to resources that relate to agriculture and science that are open to the public within the city limits. Broadening the search to a wider geographic area would certainly reveal further sources. However, school-based groups in particular may only be able to travel to certain destinations within a geographic limit such as the city limits, for example, so we restricted our search to the city limits to illustrate the variety and number of resources available even in a relatively small but well-defined area. We limited the search to resources located outside of school grounds, so school-based afterschool programs and school gardens were not included, though afterschool programs held by other non-profit groups were included. We imposed this limitation presuming that teachers and parents would be aware of resources associated with their own schools, and that resources at other schools were not available to members of the public beyond the school community.

To build our set of resources for categorization, we first discussed common types of locations where one may learn about agriscience, such as museums, farms, and libraries, and places where programs about agriscience may occur, forming an initial set of categories as well as internet search terms. To build the list of specific resources, we next generated a list of all programs, venues, and other resources that related to the field of agriscience within the city limits of which we were aware from having lived in the area. The first author lived in the area for one and a half years as a faculty member and the second for one and a half years as an undergraduate at the time of compiling the list in Fall 2015.

We then completed our list using numerous sources, such as tourist brochures, local web sites of event and program offerings, magazine listings, and information provided by local professionals or residents whom we encountered in the process of creating the inventory. We did not seek these sources deliberately or systematically but rather took advantage of the opportunities presented when friends or colleagues mentioned resources that we had not considered, usually offered in the context of other conversations. We used the city's independent tourism board website, which listed a great deal of the libraries as well as museums listed that are affiliated with the University of Florida, and the city's government website that lists many of the tourist attractions and events the city has to offer. Brochures included those the researchers possessed as well as those picked up at local grocery markets, drugstores, museums, and tourist information centers. These brochures typically catalogued local tourist destinations and recent events. When using local residents as informants, we used their input to perform web searches, allowing us to make informed decisions about whether the resources met the search criteria. Once we decided on our initial specific categories, we used Google.com to search terms such as "farms in Gainesville, Florida," that reflected our categories. We repeated these searches of physical and internet resources until we found no more unique resources.

When determining appropriateness of content of the offerings, agriculture and science were considered broad terms encompassing topics covered in formal school standards (National Council for Agricultural Education, 2009; NGSS Lead States, 2013); as previously mentioned, science was used as a generic term to include science, technology, engineering, and math (STEM). Events, such as performances and festivals, qualified for our list if they had agriscience content. For example, the play "Proof," about the life of a mathematician, would be counted in our list as related to agriscience, while the play "Wicked," about the fictional Land of Oz and its Wicked Witch, would not. However, fictional content alone would not exclude an item from our list. In general, resources that offered content related to either agriculture or one or more STEM disciplines qualified for our list; the resources did not have to themselves explicitly discuss integrated agriscience to provide an opportunity for learning about both STEM and agriculture and natural resources. Those that did not address both might require facilitation from a teacher, docent, parent, or the like to make the connections obvious for learners.

As the search progressed and the inventory list of specific resources started, we used constant comparative coding (Glaser, 1965) to group the resources, refine our codebook, and continue our search for resources. Our initial codebook included museums, gardens, zoos, farms, parks, ongoing programs, and festivals. Once we developed the initial codebook, while we continued searching for resources, the authors worked together to group the resources into broad categories as the list was relatively short (Auerbach & Silverstein, 2003). We resolved discrepancies through discussion. While we conducted this constant comparison, we revised our codes when we grouped resources differently, as when museums and farms were grouped into the final category Structures. We also developed additional emergent (Bogdan & Biklen, 2007) categories based on our searches, including Nature Trails and Performances. As new categories emerged, the authors reviewed previously categorized resources to determine whether they warranted a new or additional categorization. This iterative process continued until we categorized all resources and the authors had applied all the categories to all the resources, no new categories emerged, and searches turned up no new resources. Finally, the second author determined frequencies of categories. The final search criteria encompassed these general locations and organizations: libraries, extension programs, after-school programs, farmer's markets, nature trails, parks, agricultural/horticultural festivals, museums, farms open to the public, botanical gardens, zoos, bodies of water, public outdoor recreational areas, and performance centers where learning about agriculture or science may take place.

Results

We identified a total of 90 resources located in the area that fulfilled our criteria. There does not appear to be a centralized resource for the city that encompassed all of our identified resources, including the city's web site, which was the most comprehensive and varied listing of resources. The majority of the resources (n = 57) were found through Internet keyword searches, leaving 41 resources originally located elsewhere. Word of mouth from local residents informed us of four resources included in the list. There were 30 entries for resources that we found through brochures of events and locations to visit. For the full list of resources identified and their sources, please see the supplementary material.

We grouped these into 11 categories. See Table 1 for category names, descriptions, and examples. The most common resources identified were Nature Trails (n = 31), followed by Structures (n = 28) and Events (n = 24). Nature Trails and Recreational areas represented the natural resources side of agriscience. Some results were included in two categories. For example, a park which has nature trails as a component amongst others, was coded under both the Recreational Area category and the Nature Trails category. Twenty-two of the 90 resources (24%) fell into more than one category. The most commonly overlapping categorization was Structure and Event, as museums and farms often hosted special events at their permanent locations.

Discussion

Ultimately, the purpose of this research was to help learners and educators locate events, programs and locations that relate to agriculture and science for academic and recreational purposes. This resource list and the categories we identified demonstrates that there are a large number, 91 in our city of approximately 150,000 residents, and variety of locations that provide opportunities for people to learn about agriculture and science in our medium-sized university city. Nature Trails represented the most commonly-identified category of informal agriscience education resource available in the community, with over a third (31) of our results fitting this classification. Yet this type of resource is not one that may immediately come to mind when thinking of informal education resources and sites. In addition, we identified performances at venues not typically associated with agriculture or science, such as theaters, as a separate category of resource in addition to a more-traditional event that may be held at a museum or historical site. Performance venues (10) represented over one-tenth of our results. This work therefore revealed several hidden gems that may be overlooked by teachers, researchers, and the general public seeking these resources in their communities.

Although we attempted to locate every location in Gainesville that matched the defined criteria, pragmatically, it is not possible for a researcher to spend indefinite amounts of time and to identify everything, and inevitably, such lists do not remain current. Human development may remove or even add locations on this list. However, the larger point was

Table 1. Categories Used to Classify Resources

Category	Definition	Example	Resources per Category[a]
After-School Program	An educational program that teaches students about agriculture or science that does not occur during school hours	4-H Youth Program	5
Certification	A training program in a specific field for the public	Florida “Master Gardener Program”	1
Event	An occasion in which the public can learn about science or agriculture	Florida Museum Science Café	28
Farm	An area of land devoted primarily to agricultural practices but open to public	Brave Harvest Farm	3
Garden	An outdoor, planned space set aside for display, cultivation, and enjoyment of plants and other forms of nature	Wilmot Garden	3
Nature Trails	A natural park where signage is used to classify the flora in the park	Loblolly Woods	31
Ongoing Project	An endeavor in progress that relates to agriscience	Florida Program for Shark Research	1
Partner Organization	An organization that seeks to advance public knowledge in science or agriculture	University of Florida/IFAS Extension	2
Performance	A presentation space that involves agriculture or science	Santa Fe College Kika Silva Pla Planetarium	10
Recreational Area	A park that exists purely for the public to enjoy sporting events, playgrounds, skate parks, swimming pools, etc.	Green Acres Park	4
Structure	A physical building or structure, often with educational exhibits or artifacts on display, but not in which only performances occur	Matheson History Museum	24

Note. a. Due to dual-coding, numbers in the categories total more than the 90 unique resources identified.

to create categories that any educator or free-choice learner could consult when seeking to learn about agriscience. We identified categories outside the traditional realm of science field trips, such as farms, and outside the traditional realm of agriculture field trips, such as planetariums, to guide educators and learners when seeking such resources. Our categorization may also aid researchers in comparing the extent of types of resources in multiple communities or comparing the extent of explicit agriscience integration in these resources, among other questions. While we expect that educators and researchers will see the transferability to their own contexts, our results are not generalizable as they are the result of a single case study.

The agriscience resources provided here can serve as a guide for teachers to identify desirable, cost-effective destinations for field trips in their area by suggesting types of resources they may not normally consider. The variety of resources identified, 11 categories in all, creates a guide for individuals looking for effective locations to visit for agriscience learning, which may be particularly true for teachers planning field trips. Teachers generally take their students on field trips that relate to a specific subject that they are presenting in class. In other words, teachers may need a broad list of agriscience locations in order to find a particular field trip that matches their lesson plans or to reinforce academic standards. Due to our cityscape, the locations of the majority of the agriscience resources are categorized as Nature Trails, a category not traditionally used by teachers on field trips (Falk & Dierking, 1992). Our city also has numerous libraries as well as museums (Structures). We also found that performance venues throughout the city may offer plays with content related to agriculture or science.

This list is also one of a very few, if any, that list specifically resources that could be used for integrated Ag-STEM learning, at least with facilitation if the resource does not explicitly itself address both. Attempts are underway to describe both the entire ecosystem of lifelong STEM education resources (including informal/free-choice and formal) in a smaller underresourced urban neighborhood focusing on a middle school population (Falk et al., 2015), and on a global scale but without explicitly considering agriculture (Falk, 2015). Neither of these efforts has produced an explicit categorization of the resources of an entire city or with the integration of agricultural resources such as we present here. While these eventually may overlap with our lists, they have not taken an approach of describing specifically resources related to integrated agriculture and science. Typically, these may be thought of and even advertised separately, as gardens, farms, aquariums, and science museums all have separate professional organizations with no overarching "informal education" group. Science museums, in particular, often do not use the word agriculture in particular as an explicit frame or label for their exhibits and programs (Stofer, 2015a). This could be reflective of the formal education divide between agricultural education as vocational preparation and STEM topics as core courses (Hillison, 1996).

Beyond the identification of resources for learning, it is important that the learners use the resources listed in meaningful ways. Although field trips are particularly stimulating for students, teachers may not use them to their full advantage (DeWitt & Storksdieck, 2008), especially for agriscience (e.g. Sigmon, 2014), and overall, field trip rates are declining (Courtney et al., 2014; Mehta, 2008). Teachers do not always receive support for planning field trips and they express frustration with hassles with having to get appropriate-sized buses (Michie, 1998) and decreased funding for field trips. Teachers typically plan and organize field trips to a limited number of familiar venues, such as museum and science centers, rather than planetariums, zoos, aquariums, or nature centers (Falk & Dierking, 1992; Ramey-Gassert et al., 1994; D. L. Rennie & McClafferty, 1995; L. J. Rennie & McClafferty, 1996). Therefore, due to the funding and familiarity concerns, we deliberately included sources that may be found close to schools, such as gardens, fields, bordering forests, and local neighborhoods.

Teachers are often not able to prepare to use even well-supported locations such as museums, planetariums, and zoos (Michie, 1988); our list provides familiar locations that may be highly customizable for teachers when planning field trips. The most striking aspect of students' self-report of field trips such as these is a diverse, highly individualistic, and idiosyncratic nature of each child's recollections, interests and learning (D. Anderson et al., 2002). While many of these locations may offer guided tours, structured programs, or worksheets for students to complete, other research suggests creative ways to use these spaces. For example, providing students with brochure-like itineraries instead of syllabi and having them record their visits using photography rather than note-taking helps engross students in the role of a tourist and explore what is meaningful and relevant to them (Kelner & Sanders, 2009).

First, teachers must be able to match the activities and content in these resources to their standards. Standards for agriculture, food, and natural resources are structured around performance expectations within particular disciplinary content areas (National Council for Agricultural Education, 2009), and the Next Generation Science Standards are structured around both content and practices, previously known as skills (NGSS Lead States, 2013). A recent study asked experts to identify disciplinary core ideas for agriscience and provide links between the two sets of standards (Barrick, Heinert, Myers, Thoron, & Stofer, in press). Therefore, teachers can look for or design activities to take advantage of these resources based on practices they want their students to demonstrate within given content areas. By giving the students something to do when they visit these resources, the focus becomes student rehearsal of authentic practices of agriscience, for example by visiting a natural history museum and looking for evidence of food and fiber technological developments.

Resources in categories such as Nature Trails may be even less obvious or easy to use due to a lack of signs depicting the park's history or signs that classify all of the plants in the natural park. However, teachers can exploit this "disadvantage" for the students' educational benefit. For example, teachers may allow students to study a number of the local flora in class and direct them to create signs of the scientific and common names for a number of the common plants for STEM content while discussing the plants' role in food or fiber production as part of agricultural content. As a field trip or homework assignment, students may then visit a nearby park and locate matching plants. Teachers may go so far as to secure the assistance of the park managers to actually place signs in front of the matching plants as a service learning project. This may be a type of fieldwork related to agriculture and science that enhances students' scientific literacy as well as environmental education and the preservation of geological history (Lima et al., 2010).

This list will not only benefit those individuals who visit these attractions but also those who become inspired by this list and decide to create a more exhaustive list. This may start a chain reaction of creating such lists in all cities, which could result in greater demand for these agriscience locations by the overall public. Lists such as these may prove to be useful for every city, and eventually become adopted for every community to choose as a valuable way to highlight existing educational and recreational investments in new ways, or assess differently for their increased value to the community. These lists could also provide a starting point for collaborations with researchers to examine the effectiveness of use of these communities, or professional development coordinators to build programs for teachers to increase their use of such resources in their communities.

Conclusion

Through our iterative search and categorization process, the extent and diversity of these agriscience education resources within a community grew even in the minds of the experienced researchers who sat down to undertake this study. We discovered resources previously unknown to us. While we identified a significant number of the entries on the resource list from Internet searches, referrals from local residents and through brochures uncovered other resources.

Thinking about the resources has also generated a mindset in the researchers to be on the lookout for other potential resources. Since our initial analysis was completed, two other types of resources came to our attention: two mobile educational spaces, the Physics bus and the WaterVentures bus; and Maker-style spaces, including the Freewheel Project, and a regular meeting for computer coding and collaboration, the city's Hackerspace. Neither of the Maker-style spaces fit our original definition of Structures, as indeed there exist other maker spaces within some of our Structures, such as the public libraries and the new Cade Museum, which was only planned at the time of our analysis. Both of these would be other categories of spaces that could be consulted for opportunities for informal agriscience education, perhaps a category of "pop-up space." A final informal education program resource that is not necessarily place-based but can be used to highlight the connections between agriculture and science is citizen science or public participation in research projects. Many of these projects concern topics such as weather and climate, soil and water monitoring, or wildlife and plant observation, topics that definitively involve both applied and basic research aspects. These can be done almost anywhere, on or off school grounds.

Even though the list is current and as comprehensive as we could make it, it is already out of date, given the new resources identified after our categorization, and locations that have, unfortunately, closed. With the decentralization of these resources' advertising through Facebook, the internet, smartphone apps and a variety of other free and inexpensive tools for building awareness, it is difficult for educators to have a single place to go to when planning field trips or suggesting to their students new places to explore. We suggest creating individual community-driven and community-maintained online resources that can be kept up-to-date, making the best of centralization and decentralization frameworks. Therefore, we are building and advertising a web page through Cooperative Extension to host these resources, and we encourage others to use our example to do the same for their community.

Lists of this type which highlight previously non-explicit connections between agriculture and science will allow residents and tourists alike to visit these attractions and learn about both, potentially motivating many people of all ages to explore and investigate spots previously unknown to them, or re-visit old favorites with new agendas. We hope this list can also help teachers encourage their students to seek out these experiences in their out-of-school time, with their families and friends. Although our study used a well-resourced university city in the United States, many of the types of resources we identified can be found in a vast number of places with minimal physical infrastructure support, though the distribution and frequency of each type may vary.

When using this as a resource, it is important that readers understand that these resources are related to agriscience (science and agriculture), whether the resource itself explicitly outlines the connections or not. These two disciplines do not exist without each other. There is a need to be explicit in terms of the relationship between science and agriculture when communicating with general audiences; their interconnection often is overlooked in formal and informal education programs and settings. It is increasingly necessary to develop an operational definition of both of these concepts as well as engage the general public about these definitions and their interrelatedness. Using informal education resources that address agriscience will allow a deeper instructional value and impact.

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