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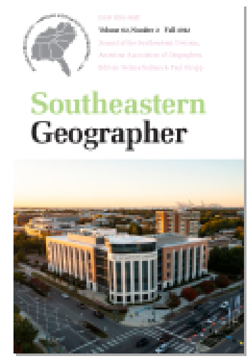

Evaluating Informal Science Education Centers in the Southern Appalachians

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HIGHLIGHTS

- An online survey of informal science education centers in the southern Appalachians revealed 166 active centers.
- We noted geographic gaps in informal science education center locations, and these gaps were often in areas of low population.
- Most informal science education centers offered multiple program types, with public programs and field trips being the most common.
- We offer recommendations for future practice and research related to informal science education in the region.

ABSTRACT: *The southern Appalachian region is a hotspot of ecological biodiversity that is under increasing threat from climate change and rapid population growth. We posit that informal science education is uniquely adapted to foster environmental stewardship in the region, but the current state of informal science education within the southern Appalachians is poorly understood. We reviewed current informal science education centers (ISECs), which we define as centers for science learning outside of structured curriculum (*n *= 166). For each of these centers, we compiled information on geographical location, programs offered, and funding sources. We found large geographic gaps in ISEC coverage that often aligned with low-population, low-income counties. The most common program type in our dataset was field trips, followed by public programming, while research and virtual programming were the least often offered. ISECs that had funding from multiple organizations generally had the most diverse and robust programming.*

KEYWORDS: Environmental education, Southern Appalachians, Meta-analysis, Funding, Programming

INTRODUCTION

The southern region of the Appalachian Mountains, which we define as the region between West Virginia and Mississippi, is united by its natural wealth (Boettner 2014, Hoyle 2016), similar cultural heritage (Tice and Billings 1991, Eller 2012), and growing population (Pollard and Jacobsen 2021). For example, Stein et al. (2000) called the southern Appalachian region one of the most biodiverse ecosystems in the world in terms of aquatic biodiversity. The southern Appalachians provide freshwater for approximately 48.7 million people and via coal and natural gas, provides more than a third of the country's electricity generation (Hoyle 2016, Muyskenes et al. 2017). However, this economic, cultural, and natural wealth is increasingly under threat. Threats to the region include ecological impacts from climate change (e.g., increased rainfall [Hoomehr et al. 2016], range contractions [Buckwalter et al. 2017]), exploitative resource extraction (Lampe and Stolz 2015), introduction of non-native species (Vose et al. 2013), land use change (Caretta et al. 2021), and increasing population growth (Appalachian Regional Commission 2011). Population growth is a less commonly mentioned threat to the region, but its scale and rapidity portend major impacts. Parts of the southern Appalachians have seen population increases of up to 78 percent in the past ten years (Boettner 2014, U.S. Census Bureau 2020), with marked increase at the wildland–urban interface (Radeloff et al. 2018). One of the outcomes of this population expansion is increased human–nature interactions (Soga and Gaston 2020). These interactions can lead to increased disturbance, wildfire risk, pollution, and zoonotic vector transmission; especially if the general population has little to no knowledge about safe interactions with wildlife or wild spaces (Calviño-Cancela et al. 2016, Soga and Gaston 2020, Hubert 2022). However, the increasing population of the southern Appalachians can be a positive force that can help foster protection of regional ecosystems if people are positively oriented toward nature. Thus, one avenue to preserve the biological integrity of the Appalachian region may be to strengthen science education in the region that promotes a positive view of natural environments, biological diversity, and conservation.

Science education happens in many places: schools, museums, botanical gardens, and even via television programs and social media. Most Americans engage with science primarily through primary education and media consumption (Guston 2014). However, recent ideological movements within science education have begun to emphasize the importance of learning at zoos, aquariums, museums, and other "informal" venues (Center for Advancement of Informal Science Education 2020). Informal science education (ISE) is defined by the Center for Advancement of Informal Science Education as "lifelong learning in science, technology, engineering, and math (STEM) that takes place across a multitude of designed settings and experiences outside of the formal classroom" (Center for Advancement of Informal Science Education 2020). ISE provides learners of all ages with opportunities to engage with science in ways that are personally relevant, convenient, and highly engaging (Adams 2007). Because ISE often takes place outside of a classroom, it can connect with those who have little affiliation with academic institutions, which may include disadvantaged populations, geographically isolated communities, and communities with a distrust of outsiders. For example, Streicher et al. (2014) created ISE centers called "knowledge rooms" that functioned as pop-up science centers in "socially disadvantaged," urban areas of Austria. These knowledge rooms were located in empty shop buildings and had no entrance fee, so any passerby was able to stop in and engage in science exploration (e.g., using a microscope, building a paper rocket, taking apart a computer). The researchers attributed the success of the project to the flexibility, informality, and engagement that the centers provided (Streicher et al. 2014). Beyond the practical benefit to the learner, ISE has the unique ability to disrupt social advantages and the reproduction of cultural hegemony that often act as barriers in both formal and informal education — that is, ISE meets people where they are and provides a decentralized avenue towards science education for all people (Streicher et al. 2014, Shein et al. 2019). Overall, ISE is a highly flexible and relevant way to engage with learners and has important implications for education equity.

ISE is ideally suited to the southern Appalachian region as it defies the deeply ingrained wariness of elites and outsiders common in the region and can be designed to build upon the region's history of land stewardship. Culturally, some in the southern Appalachians are suspicious of outsiders, forged from the region's history of exploitative extraction, broken promises, and unfounded stereotyping (Drake 2003, Hirschman 2021). This culturally ingrained wariness can make it difficult for outsiders or those in presumed positions of power such as professors, doctors, or government officials, to make inroads in the region (Schiller et al. 1982, Peine and Schafft 2012). Informal education programs are often led by local scientists and naturalists and don't necessitate an advanced degree to teach, which may make ISE more welcome and more likely to be adopted. Inhabitants of the Appalachian region are often negatively stereotyped based on income and cultural background; however, as with most stereotypes, this does not capture the complexity, history, or cultural depth of the region (Cunningham 2010, Hirschman 2021). Indeed, common Appalachian stereotypes almost completely mischaracterize the rich land ethic held by many in the region, which is the belief that the human and natural world are intertwined and that humans hold a moral responsibility to care for the land (Leopold 1949, Tice and Billings 1991, Cunningham 2010). There have been many examples of the strength of this land ethic over the past century, including Cherokee resistance to European settlers' mistreatment of the land (Greene 2022), the abundance of folk tales related to nature and natural magic (Cunningham 2010), the success of the Civilian Conservation Corps in the region (Biggers 2007), and more recent resistance against mountaintop removal (Witt 2016). Thus, ISE is well suited for the Appalachians because of its ability to counter the warranted wariness of those in the region, as well as its ability to build upon the rich and deeply ingrained love of the land to facilitate protection and environmental stewardship.

While ISE may be key to preserving the richness of the southern Appalachians, the current state of ISE in the southern Appalachians — which provides the necessary context to make informed decisions about growth — is unclear. In this research, we set out to examine the number and diversity of informal science education centers (ISECs) in the southern Appalachian region, with a focus on three factors that strongly influence ISEC attendance and impact: location, funding, and programs offered. We focus on the southern Appalachians as this is the region in which we live and work, and where we see opportunities to work to increase informal science education. While location, funding, and programs offered affect attendance and impact for all ISECs, we began this research with the idea that these factors may be affected by the unique history and culture of the southern Appalachians. Previous research has indicated that rural population distributions often lead to inequitable access to public services such as health care and other government services (Buzza et al. 2011); 107 of the 420 counties in the Appalachian region are considered rural, with a higher concentration of rural counties in southern Appalachian states like Mississippi, Kentucky, Virginia, and West Virginia (Pollard and Jacobsen 2021). Thus, information about the spatial and geographic locations of ISECs in the Appalachians may be integral to understanding who has access to this type of education. In terms of funding, public schools in the southern Appalachian region spend an average of $10,000 per pupil, compared to the national average of approximately $12,000 (Southern Appalachian Vitality Index 2016, Hanson 2022). While states in this region have a lower cost of living, on average compared to the national average, lower spending on formal education may be paired with a similar disparity in informal education resources in the region. Finally, exploring what types of programs are offered gives insight into what topics, audiences, and activities are valuable to a given community and thus, may act as a foundation for future programmatic decisions.

METHODS

Data Collection

Here we defined informal science education centers as centers that held programs or educational lessons related to environmental education, or science generally, that took place outside of a formal education setting (i.e., a formal primary, secondary, or college classroom). We define the region of the southern Appalachians as the section of the Appalachian Mountain Range and surrounding ecological region stretching from Mississippi to West Virginia (i.e., including Mississippi, Alabama, Georgia, Tennessee, North Carolina, Kentucky, Virginia, and West Virginia). We used the counties served by the Appalachian Regional Commission (ARC) to define county-based inclusion criteria within the states chosen. We identified ISECs using an adapted Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocol (Moher et al. 2009). On March 30th, 2022, and on February 1st, 2023, we performed an online search of Google search engine and Google Maps for the following search terms: "informal education center," "nature center," "environmental education," "science center," "educational forest," "discovery center," "nature park," "outdoor programming," and "museum."

We used the following criteria to determine which ISECs to include in the final dataset:

1) Centers were located in the southern Appalachians, as defined above.
2) Centers had at least one type of education program described on their website. This eliminated centers that did not have an online presence.
3) Centers were currently open (as of the search date); this excluded centers that had closed and centers that were under construction.

Table 1. Program categories, definitions, and frequency within the dataset.

Program Category	Definition	Number found
Field Trips	ISEC hosts school groups that are visiting the center. Often guided tours, materials, or other interpretation are included.	110
Public Programs	Programs aimed at audiences of all ages that take place at the ISEC and discuss environmental education or science generally.	115
School Outreach	Programs related to environmental education or science generally that are held at a school site.	85
Teacher Resources	Resources, such as lesson plans or materials, provided for K–12 teachers to incorporate into their school programming.	79
Exhibits	Plaques, signs, or other public display related to environmental education or science generally.	84
Youth Camps	Multi-day, day-long programs for school-aged children. Often held during spring, summer, or fall break.	51
Continuing Education Workshops	Workshops for adult learners.	43
Homeschool Programs	Programs related to environmental education or science generally aimed at a homeschool audience.	49
Research	ISEC facilitates scientific research via citizen science efforts or formal academic research.	15
Internships	Opportunities for students (usually high school–aged and older) to participate in the ISEC, often as educators or naturalists.	17
Virtual Programs	Programs related to environmental education or science generally that are conducted synchronously over teleconferencing software or asynchronously.	19
After-School Programs	Programs related to environmental education or science generally held at the ISEC during school days after normal school hours.	9

Our initial search returned 418 results. After removing duplicate entries and applying our inclusion criteria, we were left with 166 ISECs. From each ISEC, we collected the following data: funding sources, types of programs offered, and location. We also determined twelve program categories into which to sort the programs we discovered in our search (Table 1).

Data Analysis

Data were analyzed and visualized in RStudio statistical software (v. 1.2.5, RStudio Team, Boston, MA, USA) using the base and ggplot2 packages (Wickham 2016, RStudio Team 2019). After loading data into RStudio software, we calculated descriptive statistics (i.e., mean, median, mode) for types and the number of programs offered by the state. Specific variables including funding sources, number, and types of programs offered per state were visualized using bar charts.

RESULTS

ISEC Locations

Of the 166 ISECs we evaluated, 26.5 percent were located in North Carolina, followed by 23.5 percent in Tennessee, 15 percent in West Virginia, 12.1 percent in Alabama, 7.8 percent in Virginia, 6.6 percent in Kentucky, 4.8 percent in Georgia, and 3.6 percent in Mississippi (Supplemental Table 1). Our results show that the ISECs we evaluated were concentrated in North Carolina and Tennessee, with fewer ISECs from southeastern Kentucky through southern West Virginia, and Mississippi (Figure 1).

Funding Sources

Of the ISECs analyzed, 48 percent were funded by state governmental organizations, such as state departments of natural resources, or state parks (Figure 2). After state funding, 24 percent of the ISECs in our study were funded and run by non-profit organizations (i.e., NGOs), and thus were supported mainly by donations and fundraising. Fewer centers were funded by city governments, institutions of higher education (i.e., colleges or universities), or the National Park Service (Figure 2). Only three ISECs in our study were funded at the county level, while several ISECs were funded and run jointly, by combinations of NGO, university, and state sources (Supplemental Table 1).

Programs Offered

Our breakdown of programs offered by category shows high diversity in programming. The most common type of program offered was public programs, offered by the majority of ISECs (69 percent) (Table 2). These programs were most often intended for an all-ages audience, usually taking the form of guided hikes or outdoor interpretation. After public programs, school field trips were the second most common program type, offered by 66 percent of ISECs. Most ISECs offered these programs for grades K–12 and often included a guided hike or interpretive walk. Notably, these were most often programmed for public school pupils, with fewer ISECs advertising homeschool programming (29.5 percent). Overall, programs aimed at school-aged children or teachers were the most common (e.g., field trips, school outreach, teacher resources), while programs for adults and learners outside of the public school system were less common (e.g., continuing education workshops, citizen science programs). Across states, public programs were the most common program category followed by field trips (Table 2). However, there were notable exceptions; for example, ISECs in Kentucky offered a larger proportion of homeschool and youth camp programs than any other state, and the proportion of virtual programs offered by ISECs in Georgia was much higher than those offered in the other states evaluated (Table 2).

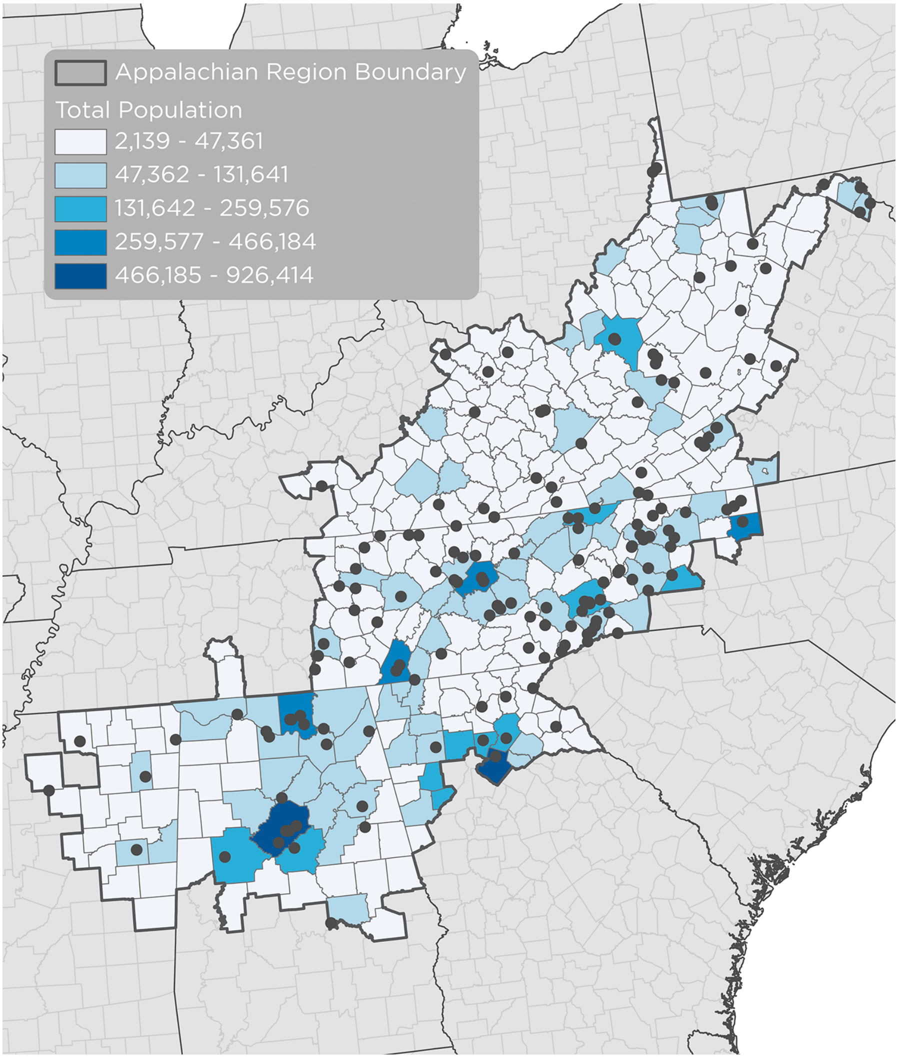

Figure 1. Map of ISECs evaluated in this study by population density from the 2020 US Population Census. Black circles indicate ISECs in this study.

DISCUSSION

The region of the southern Appalachians, which has seen a rise in population growth over the past decade, is both highly biodiverse and threatened (Hoyle 2016, Pollard and Jacobsen 2021). Given the region's history of environmental stewardship and its strong land ethic, we propose that there is likely a cultural willingness to preserve and protect this integral ecological region, which can be strengthened with culturally appropriate

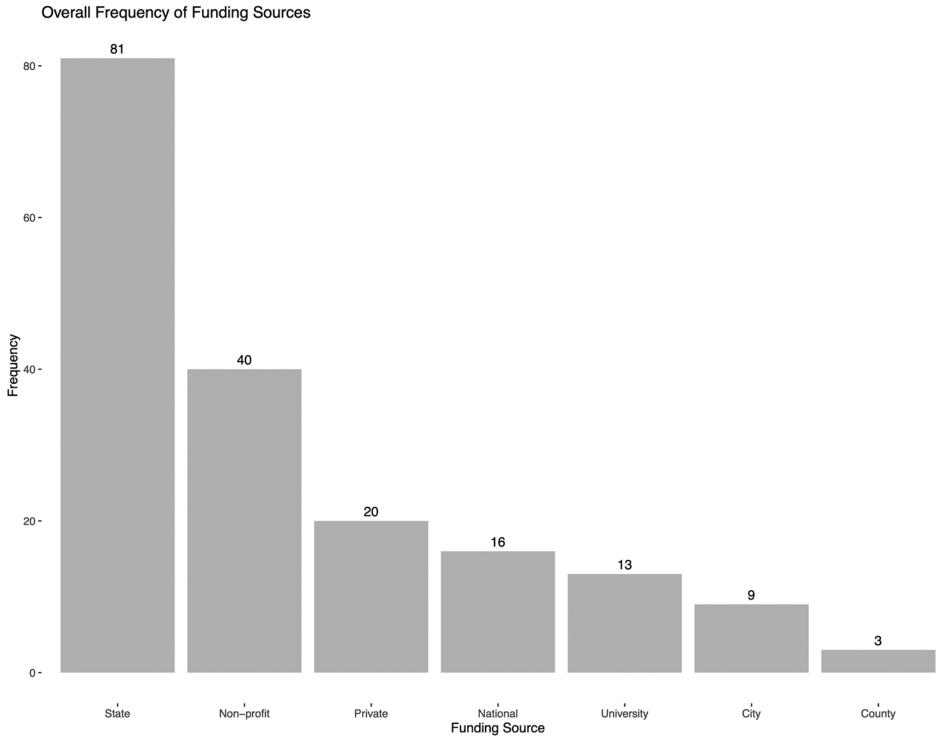

Figure 2. The overall frequency of funding sources for the 166 ISECs evaluated.

approaches to STEM education and locally relevant, engaging education programs. We believe that informal science education is uniquely suited to serve those within the Appalachians, due to its dispersed, flexible, and informal nature (Adams 2007, Streicher et al. 2014, Shein et al. 2019). Thus, this paper aimed to explore the current state of informal science education in the southern Appalachians to collect information relevant to future policy, programmatic, and funding decisions that we hope can help grow ISECs in the region.

The majority of the ISECs we evaluated were in North Carolina and Tennessee, with large gaps in ISEC coverage in Kentucky and Mississippi, and parts of West Virginia. We found more ISECs located in regions with large populations; for example, we found more ISECs near population centers like the Birmingham and Atlanta metro areas (Figure 1). Many of the areas in North Carolina and Tennessee where we found many ISECs were not large population centers, though we hypothesize that there are more ISECs here due to the presence of a large natural area, Great Smoky Mountains National Park. However, being near a natural area did not guarantee the presence of an ISEC; for example, Clay County in southeastern Kentucky did not have an ISEC in our dataset despite its location near a national forest. Clay County was also one of the least populated

Table 2. Number of programs, separated by program type and state.

Program Type	AL (n=20)	GA (n=8)	KY (n=11)	MS (n=6)	NC (n=45)	TN (n=40)	VA (n=20)	WV (n=26)
Continuing Education	2	2	0	1	10	15	5	8
Exhibits	16	4	3	1	21	13	9	17
Youth Camps	7	3	6	0	15	6	4	10
School Programs	9	5	7	1	26	30	1	6
Virtual Programs	6	2	0	0	3	3	1	4
Teacher Resources	7	5	3	1	17	33	4	9
Homeschool Programs	7	2	7	1	15	8	2	7
After School	1	1	0	1	3	1	2	0
Internships	4	0	0	1	5	5	0	2
Field Trips	11	5	10	2	28	36	6	12
Citizen Science	1	0	1	0	4	1	3	5
Public Programs	18	5	7	5	21	31	12	16

and lowest-income counties in the region we evaluated. Populations without close access to an ISEC are likely to rely on other forms of education to learn about STEM and environmental issues, like public school or media (Dawson 2014). However, as public schools in the United States are primarily funded by local property taxes, we can assume that population density and funding for public education are related and thus that rural areas with low population densities are likely underserved in terms of public science education resources (Carrington 1973, Bayer et al. 2020). One study found direct relationships between the wealth of students' counties, their families' socioeconomic status, their access to educational resources, and their science achievement scores (Gándara and Randall 2015). The geographic gaps in ISECs that exist in rural areas of low population in the southern Appalachians, such as eastern Kentucky, northern West Virginia, and northern Mississippi, combined with the underfunding of public education in these areas necessitate future work to establish ISECs to address these geographic gaps. One strategy to establish ISECs in low-income or funding-sparse areas is partnering across organization types. Many of the most program-diverse ISECs in our sample were those that were supported by multiple organizations. For example, the Highlands Nature Center in North Carolina is run and funded by Western Carolina University, a non-profit, and the State of North Carolina. These joint partnerships can help supplement population-based funding in rural areas and combine expertise across domains.

The most frequent program categories evaluated in our study — field trips, public programs, and school programs — meet the call by Gursoy (2020) for science centers to emphasize interactive programs to increase visitor engagement and knowledge retention. Leaders in the field of ISE have long suggested that interactive programs (e.g., workshops, interactive exhibits) should be at the forefront of programmatic offerings by ISECs (Rennie and McClafferty 1995, Eshach 2007). The high prevalence of these interactive programs in our dataset suggests that ISECs in the southern Appalachians are equipped for engaging with visitors of all ages. However, the lack of research-based programs in the ISECs we studied suggests that there are areas for improvement. It may be that ISECs in the region are not located or affiliated closely with research institutions, and thus cannot offer research-based programs. However, research-based programs, like citizen science projects and research internships, can have large benefits for both research organizations and community members. Researchers with projects that lend themselves to citizen science efforts can benefit from low-to-no-cost data collection that may encompass a far larger geographical or temporal range than a single research team could achieve, and citizen participants can benefit from increases in science identity and academic social capital (Conrad and Hilchey 2011), as well as new scientific knowledge and experiences. We believe that citizen science and other research-based programming have untapped potential in the southern Appalachians and thus, we recommend that informal educators and program leaders should seek to partner with research institutions in the future.

Similarly, the low number of virtual programs offered by the ISECs evaluated shows an opportunity for growth. Given the rural population common throughout the southern Appalachians, virtual programs could help close the geographic gaps in ISEC coverage in the region and expand the populations that ISECs can serve. Previous work has shown that virtual programming can increase learners' engagement and lead to overall higher science achievement and enjoyment (Brinson 2015, Samosa 2021). One explanation for a lack of virtual programming may be due to the relative lack of households with computers in the region (84 percent, compared to 90 percent nationwide [Pollard and Jacobsen 2021]). Several governmental and non-governmental programs are currently working to increase the technological capabilities of households in the region (e.g., Jonas 2022), and as these programs continue, more virtual programming may help bridge geographic gaps in informal science education. ISECs in the region may benefit from an increase in both research-based and virtual programs, which represent important components of a diverse approach to informal science education. However, we recognize that much more research is needed to survey the unique populations of this region and their needs.

Beyond the types of programs offered at the ISECs surveyed, there were interesting patterns in the *number* of program types offered. Fifty-nine percent of the ISECs we surveyed offered more than three categories of programs. These "program-diverse" ISECs are more likely to appeal to a wider audience because of the diversity of age groups that multiple program types are likely to serve, and the diversity of content included. On the other hand, "program-sparse" ISECs offering three or fewer program types may be less likely to provide adequate diversity in terms of content, activity, or time offerings. The frequency of program types at these ISECs reflected the overall frequency of program types, with a notable exception of a much higher frequency of exhibits at "program-sparse" ISECs. Indeed, exhibits were the most common program type available at "program-sparse" ISECs. The "exhibits" category includes a wide range of exhibit types, from engaging, hands-on exhibits to simple signs along walking trails. Previous literature indicates that self-directed, sign-based exhibits are one of the least engaging program types (Ross et al. 2012, Moss and Pavitt 2019). This suggests that in ISECs that are already program sparse, visitors may be disengaged due to the types of programs that are available. Previous research has shown that visitor engagement is directly tied to learning outcomes in ISE environments (Jensen et al. 2017, Moss and Pavitt 2019). We suggest that ISECs in the region may be able to increase visitor engagement and learning outcomes by promoting hands-on exhibits and interactive programs, such as workshops, guided hikes, or inquiry-based science lessons. We envision an opportunity for the expansion of ISEC attendance and visitor engagement in the southern Appalachians to leverage a cultural land ethic to protect and preserve the surrounding ecosystem.

This project represents the first step in evaluating informal science education in the region. Our study included several limitations that constrain the conclusions that may be drawn from our results. Specifically, our investigation was limited by our data collection procedure. Because of the exploratory nature of this study, we recognize that the ISECs evaluated do not represent all the possible ISECs in the Appalachians, nor does our study capture all the possible data that could be drawn from these ISECs. Furthermore, there may be ISECs that exist in our study area that were excluded because they do not have an online presence. There also may have been ISECs with an online presence that were not found on Google search engines, and this could have potentially been due to our search terms. While we were as mindful as we could have been to include all possible search terms that may have been related to ISECs, there is a distinct possibility that we could have missed important keywords. Some states, like North Carolina, provided pre-cataloged lists of ISECs in their state (e.g., https://www.eenorthcarolina.org/). Datasets like this are useful for researchers and members of the public and should be encouraged in more states in order to increase public interaction with ISECs and future research into ISEC programming and presence. Finally, our conclusions, especially as they relate to program types and how to successfully leverage informal education in the southern Appalachians, are limited due to our single data mode of using only website data. Conclusions from single-mode data may be subject to incorrect interpretation and thus, future work should collect multi-modal data, such as participant reflections, survey data, or interviews with educators in the region.

CONCLUSION

Given the population growth in the southern Appalachians in the past decade and the hope that ISE may help to protect this threatened ecosystem, this study examined the current state of ISE in the region. We found important geographic gaps in ISEC coverage, as well as details about which entities primarily run and fund ISECs in the region. This study also revealed the frequency of program types at ISECs in the region, highlighting gaps in virtual and research-based educational programs. Future research should evaluate program topics to identify content gaps as well as survey participant learning outcomes, to further understand ISE in the region.

DATA AVAILABILITY

Data from Supplemental Table 1 are available upon request from the authors.

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