sustainability

MDPI

Article

Uncovering Trends and Spatial Biases of Research in a U.S. National Park

Daniela Agostini Ferrante [1], Jelena Vukomanovic [1,2,*] and Lindsey S. Smart [2]

[1] Department of Parks, Recreation and Tourism Management, North Carolina State University, Raleigh, NC 27695, USA; danielamaferrante@gmail.com
[2] Center for Geospatial Analytics, North Carolina State University, Raleigh, NC 27695, USA; lssmart@ncsu.edu
* Correspondence: jvukoma@ncsu.edu

Abstract: National parks are vital public resources for the preservation of species and landscapes, and for decades have provided natural laboratories for studying environmental and cultural resources. Though significant scholarship has taken place in national parks, syntheses of research trends and biases are rarely available for needs assessments and decision making. In this paper, we demonstrate procedures to close this information gap using Congaree National Park (CNP) as an example of a protected area characterized by disparate research. We conducted a systematic review of research topics and funding sources of all peer-reviewed, published research conducted since its inception as a National Monument in 1976. We next paired our evaluation of research trends with a spatial analysis of study locations to uncover patterns and biases in research. A total of 49 peer-reviewed publications describing research conducted at CNP have been published between 1976–2018, with over 75% published since 2003. Quantitative studies accounted for nearly 90% of all studies, and vegetation was the most commonly studied discipline. Most studies were funded by federal agencies, with the National Park Service providing the most funding instances. Spatial analyses revealed statistically significant ($p < 0.05$) hotspots of studies near the park entrance, visitor center, roads, and hiking trails. In providing a comprehensive evaluation of research patterns and trends within a single park, we developed an approach that can be applied by managers in other parks or public lands to maximize the utility of past research, identify potentially valuable but understudied park resources, and prioritize research needs.

Keywords: natural and cultural resources; parks and protected areas; public land; research funding

Citation: Agostini Ferrante, D.; Vukomanovic, J.; Smart, L.S. Uncovering Trends and Spatial Biases of Research in a U.S. National Park. *Sustainability* **2021**, *13*, 11961. https://doi.org/10.3390/su132111961

Academic Editor: Antonio Boggia

Received: 15 September 2021
Accepted: 22 October 2021
Published: 29 October 2021

1. Introduction

Since its establishment in 1916, the National Park Service has protected many of North America's most outstanding natural, cultural, and recreational resources. National parks supply numerous ecosystem services that improve human health and well-being [1,2]. They strengthen local economies through increased tourism [3], improve mental health by reducing stress [4], and offer students powerful, hands-on learning experiences that increase scientific engagement and literacy [5]. Importantly, parks also provide opportunities for scientific research and discovery. For decades, national parks have functioned as ready-made laboratories, where researchers could monitor environmental changes, quantify climate change impacts, and test management effectiveness (e.g., [6–8]). Parks also provide a unique platform for qualitative research on human behaviors, attitudes, and perceptions related to the environment and recreation [9,10].

Although considerable research has been conducted in national parks, to-date there have been few systematic attempts to describe and categorize studies conducted in protected areas (however, see [11]). Therefore, syntheses of research trends and biases are rarely available for needs assessment and decision making. While there has been little systematic exploration of trends in national park research, research trends have been studied in associated disciplines, especially the conservation sciences. In the conservation sciences, research trends indicate biases in the location of study sites [12,13] and unbalanced representation of topics and methods [14,15]. Funding agencies and publishers are also strong drivers of geographic and topic trends [16,17]. These reviews in the conservation sciences have identified patterns in research that both reveal knowledge gaps and biases and provide recommendations for the direction of future research. Given these important findings, a similar study on research trends within national park research could help both researchers and managers better understand patterns and characteristics of park research.

Much of the research conducted in national parks has an inherently spatial dimension—whether it is measuring soil pH, invertebrate abundances, or visitor preferences, all of these data involve an element of time and place. Our understanding of the spatial dimension of research has greatly improved through application of geospatial technology and approaches. For example, using geospatial tools in natural resource management research has proven key in assessing environmental characteristics and monitoring changes [18], predicting future scenarios [19], mitigating natural hazard risks [20], and creating disaster recovery plans [21]. However, not all researchers describe the spatial component of their work or make their data accessible to others [22–24]. Inaccessible or poorly reported spatial data can lead to missed opportunities for scholars to leverage existing research or conduct longitudinal studies [24]. Lack of spatial data reporting limits the ability to evaluate the spatial patterns of research conducted in national parks, preventing researchers and managers from identifying geographic biases in data that may limit the generalizability of research results. For example, De Palma et al. [25] compiled a global dataset of bee diversity from published sources and used this dataset to explore whether bee responses to land-uses changes were robust to geographic and taxonomic biases. They found that responses were regionally variable, indicating that projections using biased datasets are not transferable across regions. Because research results and their management implications are frequently generalized to support broader natural resource management decisions and policy recommendations, an improved understanding of these biases will clarify levels of uncertainty and identify underrepresented systems for future research. An improved understanding, however, is predicated on the availability and accessibility of spatial data.

Trends, biases, and spatial patterns in research can limit research outcomes and misrepresent reality, constraining effective planning, decision-making, and management [13,25,26]. As external pressures like climate change and development fragment and diminish natural areas [27,28], we need a comprehensive evaluation of patterns and trends in national park research to help managers prioritize research needs, maximize the utility of existing research, and plan for the future [11,29,30].

To address these knowledge gaps, we conducted an in-depth systematic review and comprehensive spatial analysis of peer-reviewed literature for a national park in South Carolina, USA. Our analysis answers the following research questions: (1) what are the characteristics of research conducted at a focal park, specifically the topics studied, methods used, and research designs applied? (2) who is funding park research and where are researchers coming from? and (3) what are the spatial patterns in research conducted in the park? Answers to these questions provide insights into trends, biases, and patterns in national park research. The results can be used by environmental managers to prioritize research needs, leverage funding opportunities, and foster increased collaboration. Our approach can be applied to other parks and public lands to comprehensively evaluate and compare the characteristics of research conducted across protected areas.

2. Methods

2.1. Study Site

The unique natural and cultural resources in Congaree National Park (CNP) make it a prime location for an assessment of scholarly research in a national park. The 106 km^2 park in Richland County, South Carolina (Figure 1) is known for its expansive old-growth southern bottomland hardwood forests, rivers and streams, and cultural significance. Archaeological evidence suggests that numerous Indigenous peoples inhabited the lands in or near Congaree starting around 8000 BCE. Following contact with colonial settlers starting in the late 1500s, Congaree Indian populations were decimated by introduced smallpox in the 1700s [31]. Attempts by settlers to farm the floodplains of the Congaree River were met with little success and similarly poor accessibility confined logging to the main rivers [31]. In more recent history, Congaree became a National Monument in 1976, following a citizen action campaign to protect rare old-growth forests [31]. In 1983, Congaree was designated an International Biosphere Reserve, a Wilderness Area in 1998, a Globally Important Bird Area in 2001, a National Park in 2003, and a Ramsar Convention Wetland of International Importance in 2012 [32,33]. Currently, the park attracts between 100,000–140,000 visitors each year.

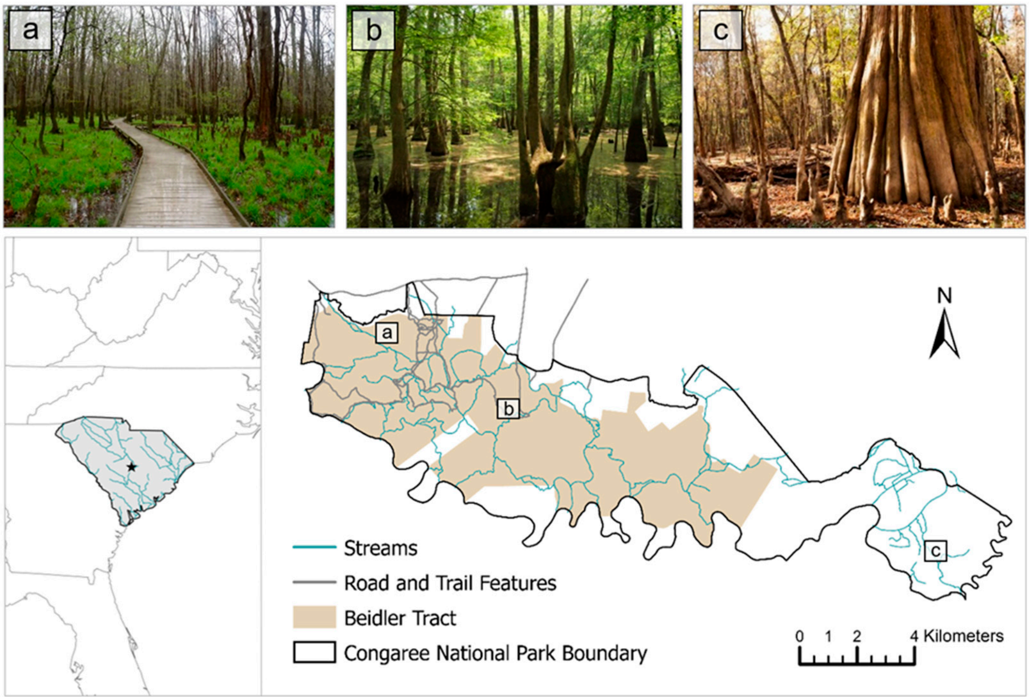

Figure 1. Congaree National Park is located in central South Carolina, USA (highlighted in the inset map). The park includes: (**a**) lower boardwalks that transects the park, (**b**) bottomland forest adjacent to the Kingsnake Trail, and (**c**) large bald cypress trees. Photos courtesy of Congaree National Park.

The park protects approximately 45 km^2 of intact old-growth bottomland forest, the largest remnant in the US [32]. Shaped by natural storm disturbances and hydrologic processes, these forests play an important role in water management and flood mitigation. The main water sources flowing into the park are the Congaree River, Cedar Creek, and Tom's Creek [34]. On average, the riverbanks of the Congaree River flood ten times each year, submerging up to 90% of the park [35]. CNP provides important habitat for federally listed endangered and threatened species like the eastern cougar, red-cockaded woodpecker, and the bald eagle, as well as crucial habitats for Neotropical migratory songbirds [33,36,37].

2.2. Systematic Review

We conducted a comprehensive systematic review of peer-reviewed publications of research conducted in Congaree National Park from 1976 to 2018. We used the Congaree National Park Historical Archive (CNPHA), a database managed by the park, as the primary data source because it contains the most complete collection of peer-reviewed literature on Congaree National Park. We also used the Web of Science (WoS) database and the NPS Integrated Resource Management Applications (IRMA) database to check for any additional publications that may be missing from the CNPHA.

We included all peer-reviewed articles and conference proceedings published between 1976 (the year Congaree was established as a National Monument) and 2018. In WoS, we used the search terms "Congaree National Park" and "Congaree Swamp National Monument". In the IRMA database we reviewed all articles indexed under "Congaree National Park", which includes articles and reports that precede National Park designation (records go back to 1956). We screened publications for eligibility and inclusion following Liberati et al. [38]. We classified the attributes of all articles under 15 descriptive categories, including disciplinary focus, research approach, and funder information (summarized in Table 1). Article discipline was matched to one of 66 "topics" in the National Park Service Research Permit and Reporting System topic list. Five external reviewers separately classified the subjective article attributes to check for coding consistency and validity.

Table 1. Review categories and descriptions.

Category	Description
Field of Study	Article field of study assigned to one of 66 "topics" in the National Park Service Research Permit and Reporting System file tree list.
Study Start and End Date	Data collection initiation and completion date.
Journal & Year Published	
Data Collection Visits	Data collected during a single visit (1), multiple visits (2+) or no visit (secondary data).
GIS Data	Use of geospatial technology as part of data collection or analysis.
Author Affiliation	Organization or university and location
Funding	Specific entity funding research as reported in the article. Also grouped by research funding type: (a) research institute, (b) federal agency, (c) state agency, (d) non-profit, or (e) private corporation.
Study Site Location	Data collection location.
Research Methods	Studies classified as qualitative (open-ended questions, non-numerical data, etc.) or quantitative (close-ended questions, numerical data, etc.). Studies applied a research design that is: (a) descriptive, (b) correlational, (c) quasi-experimental, or (d) experimental.
Data Collection	Specific quantitative or qualitative method used, including the use of secondary data.

2.3. *Spatial Analysis*

For each article in the systematic review, we recorded all information on study site location(s). We developed an approach to standardize use of different spatial data types by categorizing the data based on spatial precision. We used accessible or provided GIS layers, geographic coordinates, and precise point locations in static map figures to create 'high precision' geospatial data layers. We heads-up digitized polygons in map figures to create 'medium precision' geospatial data layers. For 'low precision' geospatial data, we generated a 300-m resolution grid to delineate locations without geospatial coordinates. We assigned weights based on these three categories of precision: 1 for high precision data, 0.5 for medium precision, and 0.25 for low precision data (Figure 2).

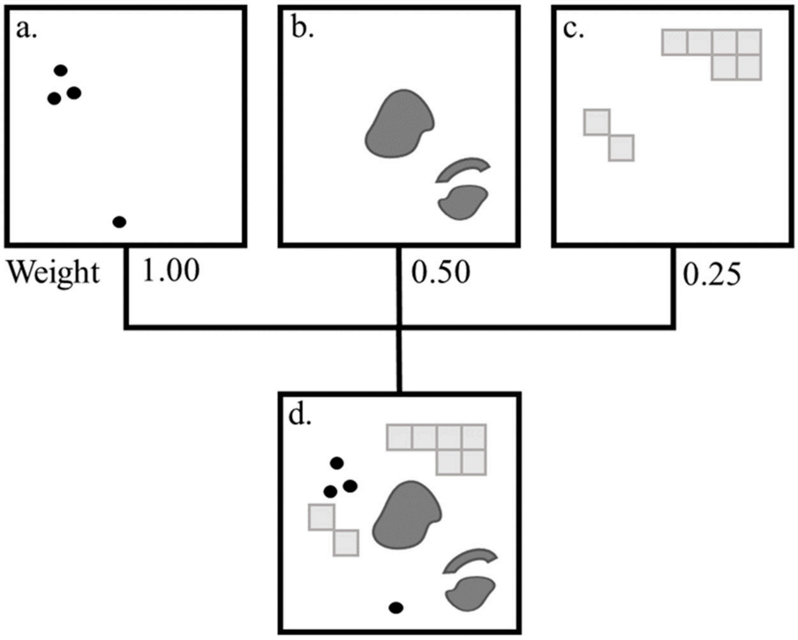

Figure 2. Schematic of the spatial data weighting approach. High-precision data (**a**) were assigned a value of 1.0; these data were obtained from the study authors as shapefiles or GPS coordinates or were manually digitized from detailed map images of study sites (26 files*). Medium-precision data (**b**) were assigned a value of 0.5; these data were manually digitized polygons from detailed descriptions or map images of study sites (3 files*). Low-precision data (**c**) were assigned a value of 0.25; these data were manually digitized 300-m by 300-m grid cells based on broad descriptions found within research articles (3 files*). Weighted data were aggregated (**d**) by topical research study. Seventeen articles had no accompanying spatial information (i.e., no geographical identifiers and no indication of location within the park). * Each file was comprised of multiple features.

We also categorized the geospatial data according to their associated discipline: vegetation, hydrology, soil, vertebrates, invertebrates, and culture/history. We used a 300-m grid to summarize the weighted geospatial data layers for each discipline, and for all disciplines combined, within each grid cell. We used the Getis-Ord Gi* statistic [39] of local spatial autocorrelation on the summarized and weighted spatial locations to identify statistically significant clusters of study site locations (p-value < 0.05). Using the Global Moran's I statistic method on the distribution of the weighted input features, we determined the appropriate scale of analysis (ultimately identifying fixed distance band for each spatial dataset, ranging from approximately 900–2100 m) to identify the number of neighbors used for each observation (Table S1). We used the critical values from the Gi* statistic (z-scores) and statistical significance levels (p-values) to identify spatial clustering. p-values were adjusted for multiple testing and spatial dependence using the False Discovery Rate (FDR) correction method [40]. Cultural/historic data collection locations were omitted from the hotspot analyses because they had fewer than the 30 points required for analysis.

3. Results

3.1. Systematic Review

Our search resulted in 49 unique publications across the Congaree National Park Historical Archive (CNPHA), NPS Integrated Resource Management Applications (IRMA), and Web of Science (WoS) databases (Table S2). The first peer-reviewed research article on CNP was published in 1980 (Figure 3). From 1980–2003, publication numbers increased slowly (~10% per year). Starting in 2003, the year that Congaree was designated a National Park, there was a marked increase in the output of scholarly work (~25% per year).

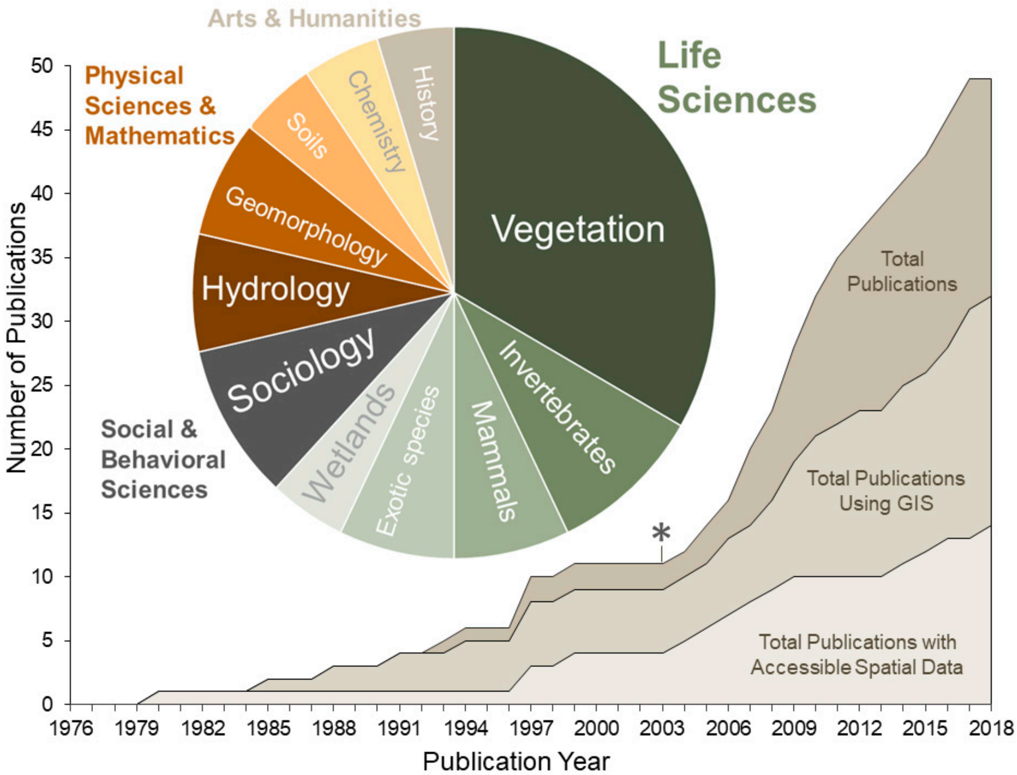

Figure 3. Cumulative publications reporting research conducted at Congaree National Park (1976–2018). Filled areas in the graph indicated the number of publications that used Geographic Information System (GIS) technology) and the number that made spatial data accessible to the park. Starting in 2003 (denoted by *), the year that Congaree was designated a National Park (previously a National Monument), there was a marked increase in the output of scholarly work. The pie chart indicated the representation of academic disciplines across all 49 studies.

From 1976 to 2018, vegetation was the most researched discipline (29% of studies), followed by invertebrates and sociology (Figure 3). Research in CNP was published in 32 different journals (Table S3). Of these journals, *Forest Ecology and Management* (8% of publications), *Southeastern Naturalist* (8%), *Canadian Journal of Forest Research* (6%), *Castanea* (6%), and *Geomorphology* (6%) were most commonly used to share research findings. Disciplinary focus in CNP has changed over time, slowly encompassing a broader range of topics and approaches. Initially (1980–1999) only four disciplines were represented in CNP research, with 72% of those studies focused on vegetation. Between 2004 and 2018, however, 16 different disciplines were represented and vegetation studies comprises only 18% of articles.

The University of Georgia was most frequently affiliated with CNP research studies (13 studies), followed by Clemson University (12 studies), and the University of South Carolina (11 studies).

Out of 49 articles, 43 used quantitative data collection methods and 6 used qualitative research methods (Figure S1). Vegetation plot sampling was the most commonly used quantitative method (26% of studies), followed by wildlife monitoring (25% of studies), and soil sampling (19% of studies). The first qualitative study conducted in CNP was a literature review published in 1997. From 1976 to 2018, literature reviews (does not include meta-analyses) were the most common qualitative data collection method and were used in two-thirds of the qualitative studies. Data collection through interviews (1 article) and open-ended survey questions (1 article) started in 2011. Of the research methods used to analyze these data, correlational research methods were most common (21 studies, 41%), followed by quasi-experimental (10 studies, 20%), and experimental (6 studies, 12%) methods. Study periods (including data collection and analysis) lasted an average of 2 years, with 11% of studies occurring over a period greater than 3 years.

Funding details were disclosed in 80% of articles for a total of 93 unique instances of funding (Table 2). Where a study listed more than one source of funding, each was counted as a funding instance. Federal agencies had the highest number of funding instances (62%), followed by non-profit organizations (22%), universities or university-affiliated centers (11%), state agencies (3%), and private corporations (2%; Table 2). Among federal agencies, the U.S. National Park Service (U.S Department of the Interior) provided 32% of funding instances, the U.S. Department of Energy provided 10% of funding instances, and the U.S. Geological Survey provided 6% of funding instances.

Table 2. Source of funding supporting research in Congaree National Park (1976–2018). Where multiple sources of funding were reported in a publication, all were tallied as unique funding instances.

	Number of Publications
Federal Agency	**58**
U.S National Park Service	30
U.S. Department of Energy	9
U.S. Geological Survey	6
U.S. Forest Service	5
U.S. Department of Agriculture	4
National Science Foundation	2
U.S. Fish and Wildlife Service	2
Non-Profit	**20**
Andrew W. Mellon Foundation	4
Friends of Congaree Swamp	4
Society for Wetland Scientists	3
Association of American Geographers	2
The Nature Conservancy	2
Bat Conservation International	1
Belle W. Baruch Foundation	1
Society of the Sigma X	1
Electric Power Research Institute	1
South Atlantic Chapter of the Society of Wetland Scientists	1
University	**10**
University of South Carolina	3
University of Georgia	2
Auburn University	1
Clemson University	1
Colorado State University	1
Duke University	1
Ohio Agricultural Research and Development Center	1
State Agency	**3**
South Carolina State Government	3
Private Corporation	**2**
Duke Power Company	1
IDEXX Laboratories	1

3.2. Spatial Analysis

Thirty-two articles (65%) included spatial information on study site locations. The first reported use of geospatial technology in CNP research was in 1980 and use of GIS in publications has followed overall publication trends, with a marked increase starting in 2003 (Figure 3). The first article to make spatial data accessible to the park was published in 1980 and the first study to make spatial data available to the general public was published in 1996.

Of those studies that contained spatial information, 44% provided coordinates or geospatial data layers. Fifty-three percent of all articles were classified as having high precision geospatial data. Of these high precision data, vegetation points were most common, followed by soil sampling or study sites, and hydrology monitoring locations. Six percent of articles had medium precision geospatial data and an equal number had low precision data (Figure S2). Medium precision geospatial data came from hydrology studies and low precision geospatial data were from a combination of invertebrate, soil, and vegetation studies.

Results from the hotspot analysis indicated heterogeneous spatial patterns of research within CNP. With all studies combined, statistically significant hotspots (p-value < 0.05) of study site locations covered 26 km^2 of CNP (Figure 4). These hotspots were located in the north-northwestern section of the park and the southeastern section. Examining hotspots by discipline, hotspots of hydrology studies covered the largest area of the park (42 km^2). These hotspots clustered in the north-central portion of the park, in addition to a small cluster in the southeastern most portion. Hotspots of vegetation studies covered the second largest area (32 km^2), followed by vertebrate studies (14 km^2). Smaller hotspot clusters representing soil (4 km^2) and invertebrate (6 km^2) study sites were in the north-northwest portion of the park. Hotspots for vertebrate, invertebrate, and vegetation studies were clustered in the north-northwest region. Hotspots for vegetation and soils studies were located in the south-southeastern region.

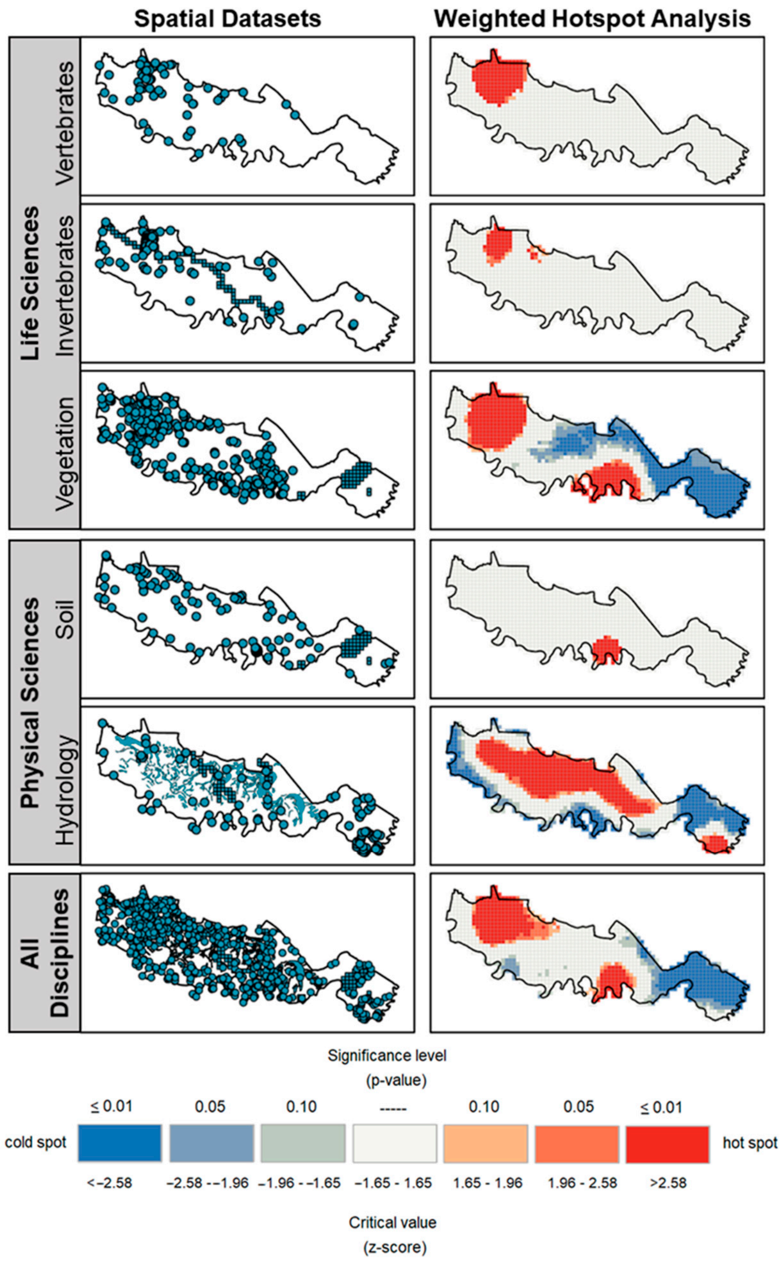

Figure 4. Hot spots (high value clusters statistically significant at $p < 0.05$; red) and cold spots (low value clusters statistically significant at $p < 0.05$; blue) of study sites in Congaree National Park (1976 to 2018) shown both by individual discipline and all disciplines combined. Statistically significant clusters ($p < 0.05$) identified by the Getis-Ord Gi* statistic.

Cluster analysis of all studies combined identified cold spots in the southeast section of the park, covering an area of 28 km^2. Statistically significant cold spots were identified for hydrology and vegetation studies as well. Cold spots for hydrology covered 34 km^2 and were located along the southern and southwestern park border. Cold spots for vegetation studies were in the north-central and eastern region.

4. Discussion

National parks play important roles in scientific exploration and discovery. These protected lands provide researchers with opportunities to investigate natural features and biological phenomena, as well as to study historic artifacts, cultural resources, and the people who visit parks. Many important studies have been conducted in national parks over the past century, however detailed, comprehensive records of past research are rare [11]. Examinations of the scholarly efforts within and across National Parks is key for assessing research needs and planning and our results highlight disciplinary, funding, and spatial biases in park research that can be used to inform planning and increase the breadth of research conducted. Given the importance of NPS research worldwide, a comprehensive evaluation of NPS research in parks is key and our approach can be used by managers to quantify research patterns and trends other parks and protected areas.

The general increase in research at CNP since 1976 broadly reflects key research policy and priority changes within NPS. Starting in the late 1990s, a call for an explicit NPS research mission by the National Research Council, the creation of Cooperative Ecosystem Studies Units (CESUs) to leverage university collaborators for NPS research, and the establishment of the Inventory and Monitoring (I&M) Program for long-term ecological monitoring, all provided directives for enhanced participation in NPS research [11,41]. The above-mentioned policy changes, in combination with the re-designation of Congaree as a national park may have led to the notable increase in research publications starting in 2003.

We found that vegetation was the most studied topic at Congaree National Park. This might be explained by the fact that the park contains large contiguous areas of old-growth bottomland hardwood forests in the park, a rare ecosystem types with very few extant patches remaining in the US [33] and corresponds to NPS mandates and objectives [11,42]. The focus on vegetation studies likely drives the use of quantitative data collection and research methods in the majority of CNP research (88% of research articles). In general, quantitative research secures more funding than qualitative research [43,44] and we found that only one of the six qualitative studies conducted in CNP reported any kind of funding, in this case a university and a non-profit organization. This may suggest that other qualitative studies were unfunded or self-funded. A comparison of the cultural study sites found in this review with the locations of known cultural resources in the park [31] found that 29 out of 36 (80%) of know cultural features in CNP have yet to be explored in academic research. Increasing recognition of the importance of human dimensions in natural resource management, demonstrated most visibly by the creation of the NPS Social Science Division in 2010, may bolster future research in the social sciences.

We found that 62% of funding instances were from federal agencies. Fifty-two percent of these were National Park Service funded. The heavy reliance on such a limited set of funding sources, threatens the viability of continued research during lean years. For example, even though funding for basic sciences has remained consistent for the past decade, more of that funding is coming from the private sector [45]. In the last decade or so, US government funding has decreased, and in 2013, dipped below 50% of total spending on basic research [46]. This also exemplifies the struggles that small, lesser-known parks endure in comparison to larger, more popular parks that receive funding from multiple and diverse sources (e.g., international, non-profit, private industries). This reliance underscores the need to address barriers to research in understudied parks. The approach can be used to identify 'at-risk' parks and match them with university or non-profit collaborators with alternate funding sources. Dedicated collaborations can be highly productive, for example as evidenced by frequent affiliation with nearby Clemson

University and University of South Carolina on CNP research outputs. However, fostering these relationships can take time, highlighting the potential need for dedicated liaisons between parks and collaborators.

Most of the research articles reviewed have a spatial component and we found that 65% of studies in CNP included spatial information about study sites. However, the precision of this spatial data varied greatly. Out of 49 articles, 14 provided the park with spatial data in the form of coordinates or shapefiles. Of those 14 articles, only two made spatial data easily accessible to other researchers (e.g., including coordinates within the publication). Though there can be reasons to withhold spatial data (e.g., locations of endangered species), in many cases access to spatial data provides opportunities to leverage and build upon existing research. Open and accessible spatial data can improve impact management and research efforts (e.g., more longitudinal studies, more resources for scholars conducting similar studies, and better understanding of over- or understudied resources).

Where data isn't accessible, we present an approach to derive location information from spatial data of varying precision. Our approach includes all available spatial data weighted by precision and allowed us to explore spatial biases in research patterns. We found that hydrology, vegetation, and vertebrate studies clustered in the north-northwest portion of the park, highlighting a well-studied area. These patterns may be driven by the natural features, such as the presence of major rivers or streams. It may also be the result of accessibility; roads and trails tend to concentrate research in specific locations. The park entrance, easily accessible roads, and several trails exist in the north-northwest section of the park, likely driving the hotspots of research there. Furthermore, over 50% of the original geospatial data were within 500 m of a road or trail. Unlike hotspots, which clustered in the north-northwest, cold spots were found in the south-southeast portion of CNP. These areas are thus understudied, highlighting potential locations for future studies. For Congaree, these cold spots may be driven in part by areas that have been added to the park more recently, such as Riverstone and Bates Fork, which were added in 2003 [47]. An understanding of spatial biases in park research can help managers identify understudied areas and more complete inventories can help better inform conservation designs and management plans.

This research benefited greatly from access to the Congaree National Park Historic Archive. Through this archive we were able to locate peer-reviewed publications that did not appear in either the NPS IRMA database or in the Web of Science. Those most involved in the management and long-term health of parks and protected areas, such as Chief Resource Officers (or equivalent) are likely best equipped to comprehensively collect, curate and organize scholarly efforts related to their parks. Additional support—in the form of funding, staff, and other resources—could allow all parks to establish and maintain similar inventories, which would allow for more informed planning of future research.

5. Conclusions

Research requires funding, time, and other resources, which are all limited, and consequently there are gaps in the available literature [13,25,26,48]. As a result, relatively small bodies of specialized literature are commonly used to understand diverse systems and inform decision-making [48–50]. To understand these gaps are and inform future research needs and planning, we developed an approach to comprehensively evaluate the peer-reviewed research in a national park, using CNP as our case study. We identified spatial trends and possible biases among research study sites and highlighted potential gaps in knowledge. Future research efforts could use our approach to examine and compare research trends and patterns in national parks of different sizes and in different locations. From this, we can develop a better understanding of potential drivers of park research. As funding for research is limited and natural areas are shrinking, scholars and public land managers can use improved understanding of research patterns and trends in national park research to prioritize future work. In turn, more comprehensive assessments can maximize the utility of research that has already been conducted in these "living laboratories".

Our analysis illustrates several key points. First, vegetation has been the most frequently studied topic area in CNP, although opportunities to examine human dimensions and undertake more interdisciplinary research abound. Second, most funding for research comes from federal agencies, and more specifically, NPS itself. Reliance on a limited set of funding for research needs may be a common challenge for smaller parks, emphasizing the need to explore unconventional and innovative collaborations. And third, spatial biases in park research can lead to over- and understudied resources in parks. Having open access to spatial data could help resource managers better plan future research activities. More complete inventories and more balanced study result in better informed conservation, restoration, or management plans. This analysis can support environmental managers, researchers, and policy-makers to assess needs and guide the future direction of park science and management.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su132111961/s1, Figure S1: Data collection method used in studies conducted within Congaree National Park, South Carolina, USA and published between 1976 and 2018, Figure S2: Data collection sites in Congaree National Park shown both by individual discipline and all disciplines combined. Of the three data types, data points are the most precise, digitized polygons are somewhat precise, and grid interpretations are the least precise, Table S1: Key parameters from the hotspot analysis for each weighted disciplinary spatial dataset evaluated, Table S2: Publications included in this systematic review, Table S3: Journals publishing Congaree National Park research from 1976 to 2018.

Author Contributions: Conceptualization, D.A.F. and J.V.; Data curation, D.A.F.; Funding acquisition, J.V.; Investigation, D.A.F. and L.S.S.; Supervision, J.V.; Visualization, D.A.F. and L.S.S.; Writing—original draft, D.A.F.; Writing—review & editing, J.V. and L.S.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the National Park Service (award P17AC01439).

Data Availability Statement: The data that support the findings of this study are included in the Supplementary Materials.

Acknowledgments: We thank K.L. Martin, M.F. Floyd, J. Randall, N. Inglis, and A. Yoshizumi for input and feedback that helped to shape and improve this manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Ethics Approval: No ethics approval was required for this research.

References

1. Soares-Filho, B.; Moutinho, P.; Nepstad, D.; Anderson, A.; Rodrigues, H.; Garcia, R.; Dietzsch, L.; Merry, F.; Bowman, M.; Hissa, L. Role of Brazilian Amazon protected areas in climate change mitigation. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 10821–10826. [CrossRef] [PubMed]
2. Palomo, I.; Martín-López, B.; Potschin, M.; Haines-Young, R.; Montes, C. National Parks, buffer zones and surrounding lands: Mapping ecosystem service flows. *Ecosyst. Serv.* **2013**, *4*, 104–116. [CrossRef]
3. Haefele, M.; Loomis, J.; Bilmes, L. Total economic value of US National Park Service estimated to be $92 billion: Implications for policy. *Georg. Wright Forum* **2016**, *33*, 335–345.
4. Bratman, G.N.; Hamilton, J.P.; Daily, G.C. The impacts of nature experience on human cognitive function and mental health. *Ann. N. Y. Acad. Sci.* **2012**, *1249*, 118–136. [CrossRef]
5. Francis, J.; Easterday, K.; Scheckeland, K.; SBeissinger, S.R. The world is a park: Using citizen science to engage people in parks and build the next century of global stewards. In *Science, Conservation, and National Parks*; The University of Chicago Press: Chicago, IL, USA, 2017.
6. Gonzalez, P.; Neilson, R.P.; Lenihan, J.M.; Drapek, R.J. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. *Glob. Ecol. Biogeogr.* **2010**, *19*, 755–768. [CrossRef]
7. Westerling, A.L.; Turner, M.G.; Smithwick, E.A.; Romme, W.H.; Ryan, M.G. Continued warming could transform Greater Yellowstone fire regimes by mid-21st century. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 13165–13170. [CrossRef] [PubMed]
8. Roland, C.A.; Stehn, S.E.; Schmidt, J.H.; Houseman, B. Proliferating poplars: The leading edge of landscape change in an Alaskan subalpine chronosequence. *Ecosphere* **2016**, *7*, 1–30. [CrossRef]
9. Floyd, M.F. Managing national parks in a multicultural society: Searching for common ground. *Georg. Wright Forum* **2001**, *18*, 41–51.

10. Leaman, G. Co-managing parks with aboriginal communities: Improving outcomes for conservation and cultural heritage. *Georg. Wright Forum* **2013**, *30*, 287–294.
11. Vukomanovic, J.; Randall, J. Research trends in US national parks, the world's "living laboratories". *Conserv. Sci. Pract.* **2021**, e414. [CrossRef]
12. Trimble, M.J.; van Aarde, R.J. Geographical and taxonomic biases in research on biodiversity in human-modified landscapes. *Ecosphere* **2012**, *3*, 1–16. [CrossRef]
13. Roberts BE, I.; Harris, W.E.; Hilton, G.M.; Marsden, S.J. Taxonomic and geographic bias in conservation biology research: A systematic review of wildfowl demography studies. *PLoS ONE* **2016**, *11*, e0153908. [CrossRef]
14. Di Marco, M.; Chapman, S.; Althor, G.; Kearney, S.; Besancon, C.; Butt, N.; Maina, J.M.; Possingham, H.P.; von Bieberstein, K.R.; Venter, O.; et al. Changing trends and persisting biases in three decades of conservation science. *Global Ecol. Conserv.* **2017**, *10*, 32–42. [CrossRef]
15. Donaldson, M.R.; Burnett, N.J.; Braun, D.C.; Suski, C.D.; Hinch, S.G.; Cooke, S.J.; Kerr, J.T. Taxonomic bias and international biodiversity conservation research. *Facets* **2017**, *1*, 105–113. [CrossRef]
16. Krimsky, S. Do Financial Conflicts of Interest Bias Research? An Inquiry into the "Funding Effect" Hypothesis. *Sci. Technol. Hum. Values* **2012**, *38*, 566–587. [CrossRef]
17. Okagaki, L.H.; Dean, R.A. The influence of funding sources on the scientific method. *Mol. Plant Pathol.* **2016**, *17*, 651–653. [CrossRef]
18. Meyer, W.S.; Bryan, B.A.; Summers, D.M.; Lyle, G.; Wells, S.; Mclean, J.; Siebentritt, M. Regional engagement and spatial modelling for natural resource management planning. *Sustain. Sci.* **2015**, *11*, 733–747. [CrossRef]
19. Smart, L.S.; Vukomanovic, J.; Sills, E.O.; Sanchez, G. Cultural ecosystem services caught in a 'coastal squeeze' between sea level rise and urban expansion. *Glob. Environ. Chang.* **2021**, *66*, 102209. [CrossRef]
20. Pareschi, M.T.; Cavarra, L.; Favalli, M.; Giannini, F.; Meriggi, A. GIS and volcanic risk management. In *Natural Hazards*; Springer: Dordrecht, The Netherlands, 2000.
21. Tomaszewski, B. *Geographic Information Systems (GIS) for Disaster Management*; Routledge: New York, NY, USA, 2020.
22. Wehn de Montalvo, U. *Mapping the Determinants of Spatial data Sharing*, 1st ed.; Ashgate: Aldershot, UK, 2003.
23. Elwood, S. Grassroots groups as stakeholders in spatial data infrastructures: Challenges and opportunities for local data development and sharing. *Int. J. Geogr. Inf. Sci.* **2008**, *22*, 71–90. [CrossRef]
24. Hartter, J.; Ryan, S.J.; Mackenzie, C.A.; Parker, J.N.; Strasser, C.A. Spatially Explicit Data: Stewardship and Ethical Challenges in Science. *PLoS Biol.* **2013**, *11*, 1–5. [CrossRef] [PubMed]
25. De Palma, A.; Abrahamczyk, S.; Aizen, M.A.; Albrecht, M.; Basset, Y.; Bates, A.; Blake, R.J.; Boutin, C.; Bugter, R.; Connop, S.; et al. Predicting bee community responses to land-use changes: Effects of geographic and taxonomic biases. *Sci. Rep.* **2016**, *6*, 31153. [CrossRef]
26. Pandey, R.; Khadka, K.K.; Papes, M. Geographic and taxonomic biases in conservation research efforts in Nepal. *Asian J. Conserv. Biol.* **2015**, *4*, 89–91.
27. Hannah, L.; Midgley, G.; Andelman, S.; Araújo, M.; Hughes, G.; Martinez-Meyer, E.; Pearson, R.; Williams, P. Protected area needs in a changing climate. *Front. Ecol. Environ.* **2007**, *5*, 131–138. [CrossRef]
28. Vukomanovic, J.; Singh, K.K.; Vogler, J.B.; Meentemeyer, R.K. Protection status and proximity to public-private boundaries influence land use intensification near US parks and protected areas. *Conserv. Sci. Pract.* **2020**, *2*, e190.
29. Parsons, D.J. Supporting basic ecological research in U.S. national parks: Challenges and opportunities. *Ecol. Appl.* **2004**, *14*, 5–13. [CrossRef]
30. Wilson, J.R.; Procheş, Ş.; Braschler, B.; Dixon, E.S.; Richardson, D.M. The (bio)diversity of science reflects the interests of society. *Front. Ecol. Environ.* **2007**, *5*, 409–414. [CrossRef]
31. Kinzer, M. *Natures Return an Environmental History of Congaree National Park*; The University of South Carolina Press: Columbia, SC, USA, 2017.
32. Culin, J.D.; Scholtens, B.; Snyder, J. *Characterization of the Moth (Lepidoptera) Diversity of Congaree National Park*; NPS Report; Park Science: Washington, DC, USA, 2014; pp. 1–54.
33. National Park Service, Congaree National Park [NPS CNP]. Foundation Document: Congaree National Park, South Carolina. 2014. Available online: https://www.nps.gov/cong/learn/management/upload/CONG_FD_SP.pdf (accessed on 26 August 2020).
34. Thompson, A.J. An Ecological Inventory and Classification of an old-Growth Floodplain Forest in the Southeastern United States Coastal Plain. Master's Thesis, University of Georgia, Athens, GA, USA, 1998.
35. Patterson, G.G.; Speiran, G.K.; Whetstone, B.H. *Hydrology and Its Effects on Distribution in Congaree Swamp National Monument*; USGS Report; US Department of the Interior: Reston, VS, USA, 1985.
36. National Park Service, Congaree National Park (NPS CNP). *Resource Management Plan*; NPS Report; National Park Service, Congaree National Park: Washington, DC, USA, 2004.
37. Bitsadze, M. Identifying Values and Benefits of Congaree National Park. Master's Thesis, University of South Carolina, Columbia, SC, USA, 2013.

38. Liberati, A.; Altman, D.G.; Tetzlaff, J.; Mulrow, C.; Gøtzsche, P.C.; Ioannidis, J.P.; Clarke, M.; Devereaux, P.J.; Kleijnen, J.; Moher, D. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *PLoS Med.* **2009**, *6*, 1–28. [CrossRef] [PubMed]
39. Getis, A.; Ord, J. The Analysis of Spatial Association by Use of Distance Statistics. *Geogr. Anal.* **1992**, *24*, 189–206. [CrossRef]
40. Ord, J.K.; Getis, A. Local spatial autocorrelation statistics: Distributional issues and an application. *Geogr. Anal.* **1995**, *27*, 286–306. [CrossRef]
41. National Research Council [NRC]. *Science and the National Parks*; The National Academies Press: Washington, DC, USA, 1992.
42. National Park Service [NPS]. Research Learning Centers (RLC). 2016. Available online: https://www.nps.gov/rlc/index.htm (accessed on 16 December 2020).
43. Carey, M.A.; Swanson, J. Funding for qualitative research. *Qual. Health Res.* **2003**, *13*, 852–856. [CrossRef]
44. Lester, J.N.; O'Reilly, M. Is Evidence-Based Practice a Threat to the Progress of the Qualitative Community? Arguments from the Bottom of the Pyramid. *Qual. Inq.* **2015**, *21*, 628–632. [CrossRef]
45. National Center for Science and Engineering Statistics [NCSES]. *National Patterns of R&D Resources: 2017–18 Data Update*; National Science Foundation: Alexandria, VA, USA, 2019. Available online: https://ncses.nsf.gov/pubs/nsf20307 (accessed on 16 November 2020).
46. Mervis, J. Data check: US government share of basic research funding falls below 50%. *Science* **2017**, *355*, 1005. [CrossRef] [PubMed]
47. Janiskee, B. The Riverstone Tract is a Vital Addition to Congaree National Park. 2009. Available online: https://www.nationalparkstraveler.org/2009/12/riverstone-tract-vital-addition-congaree-national-park5150 (accessed on 27 October 2020).
48. Martin, L.J.; Blossey, B.; Ellis, E. Mapping where ecologists work: Biases in the global distribution of terrestrial ecological observations. *Front. Ecol. Environ.* **2012**, *10*, 195–201. [CrossRef]
49. Pyšek, P.; Richardson, D.M.; Pergl, J.; Jarošík, V.; Sixtová, Z.; Weber, E. Geographical and taxonomic biases in invasion ecology. *Trends Ecol. Evol.* **2008**, *23*, 237–244. [CrossRef] [PubMed]
50. Wilson, E.O. Parks, Biodiversity, and Education: An Essay and Discussion. In *Science, Conservation, and National Parks*; Beissinger, S.R., Ackerly, D.D., Doremus, H., Machlis, G.E., Eds.; University of Chicago Press: London, UK, 2017.