

AN EVALUATION OF NATURAL HERITAGE PROGRAMS

by

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EXECUTIVE SUMMARY

NatureServe, a nonprofit that seeks to provide access to high quality biodiversity data, works with a network of natural heritage programs across the United States, Canada, Latin America, and South America to collect data about rare and at-risk species. In 2020, NatureServe conducted a survey of the natural heritage programs it works with in the United States and Canada. NatureServe's goal was to assess the status of the natural heritage programs it works with by better understanding how these programs operate and identifying ways to improve struggling natural heritage programs. This report analyzes the responses to the 2020 survey.

The introduction section of this report provides an overview of NatureServe, natural heritage programs, and past studies of natural heritage programs. NatureServe is a non-profit that seeks "to provide the scientific basis for effective conservation action" through a public-private partnership with a network of natural heritage programs. The natural heritage programs that NatureServe works with are government organizations located across the United States, Canada, Latin America, and South America that were created to "gather, organize, and distribute" high quality data about the biodiversity in the jurisdictions in which they are located. Natural heritage programs can vary greatly in size, budget, staff, and program priorities. In 2016, NatureServe conducted a survey similar to the one conducted for this report and produced a series of descriptive statistics to analyze the results.

The methods section of this report provides information on the 2020 survey, describes the analyses of the survey responses, and critiques the structure of the 2020 survey. NatureServe distributed the survey to natural heritage programs in the United States and Canada and received 64 responses. The survey asked questions about budgets, staff, data collection, and challenges faced by natural heritage programs. I created a linear regression model with the size of a natural heritage program's element occurrence data backlog as the dependent variable and a natural heritage program's estimated funding, average yearly data requests, number of programmatic positions filled, and number of programmatic positions that need to be filled. Descriptive statistics were conducted on the survey responses. The survey could be improved by refining the purpose of the survey, using more precise language in the questions, and refining the answer choices to closed ended questions.

The results section of this report describes the results of the analyses conducted on the responses to the 2020 survey. The linear regression model was unable to explain the variation in the size of a natural heritage program's data backlog in a statistically significant way. This section of the report also provides tables of descriptive statistics of the survey results grouped into categories of challenges, funding, stakeholders, staffing, data and tools, land management, guiding statute, collaborating with other programs, and COVID-19.

The discussion section of this report discusses the results of the linear regression model and provides recommendations on actions that NatureServe can take to improve the natural heritage program network based on the descriptive statistics. There was no statistically significant relationship between the size of a program's element occurrence data backlog and the independent variables. This could be due to the high variability between natural heritage

programs that defies accurate predictions by quantitative models. Alternatively, the size of the backlog could be explained by variables not included in the model and not captured in the survey. Natural heritage programs consistently identify funding and staffing as challenges that they face. The average budget for a natural heritage program did not change significantly between the 2016 and 2020 survey. To address the funding challenges faced by natural heritage programs, NatureServe could consider encouraging programs to ask for more government funding, apply for more grants, and consider ways to increase funding from the private sector. Additionally, the staffing needs of natural heritage programs did not change significantly between the 2016 and 2020 survey. NatureServe could address the staffing needs faced by natural heritage programs by encouraging natural heritage programs to implement intern and extern programs and connect with university career services centers to increase recruitment of new staff.

The report offers the following conclusion. A successful natural heritage program is one that can remain flexible and responsive to the challenges that it will face in the coming years. NatureServe can support the natural heritage programs in its networks by helping them to address their funding and staffing challenges. Regular and continued monitoring of the status of natural heritage programs would be helpful moving forward in order to identify new challenges and to determine if the responses to past challenges have been effective.

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INTRODUCTION

NatureServe, a nonprofit that seeks to provide access to high quality biodiversity data, relies heavily on its network of natural heritage programs to collect data on rare and at-risk species across the United States, Canada, Latin America, and South America. By initiating this masters project, NatureServe hopes to build off of a past 2016 survey of natural heritage programs to better understand how each natural heritage program operates, the different forms the natural heritage programs can take, and identify ways to improve struggling natural heritage programs.

To reach the goal of better understanding the status of natural heritage programs in its network, NatureServe sent out a survey in 2020 to its network of natural heritage programs in the United States and Canada with a series of questions aimed at gathering information to the following broad questions: what limitations are placed on natural heritage programs by state law, how is the annual budget of a natural heritage program set annually, over what areas of the agency/institution does a natural heritage program have purview, what other local laws, regulations, limitations, or factors affect the operations of a natural heritage program, what mechanisms are provided for change or improvements to the natural heritage program, and what is the natural heritage program's budget, size of staff, and data backlog. Sixty-four of the ninety-eight natural heritage program's in the NatureServe network of programs provided a response to the survey.

Given the diverse mission statements, goals, and constraints on each natural heritage program, it can be difficult to articulate a definition of what a successful natural heritage program looks like. However, given NatureServe's institutional focus on providing high quality conservation data and the information collected in the 2020 survey, the most appropriate proxy

for natural heritage program success based on the information collected in the survey is the size of the natural heritage program's backlog in processing Element Occurrences.¹ Thus, the primary question of this project, what makes a successful natural heritage program, will be answered through this lens. However, this project will also examine the areas in which natural heritage programs identified themselves in the 2020 survey as being areas of concern for the long- and short-term success of their natural heritage program in order to give NatureServe a more holistic picture of the needs of natural heritage programs across the network and to give NatureServe an idea of where future efforts to strengthen natural heritage programs should be focused. Further, this project will provide quantitative analysis that seeks to predict the factors that cause some programs to have larger element occurrence data backlogs than other programs.

This masters project seeks to analyze the results of a 2020 survey that NatureServe sent to natural heritage programs within its network to gauge the status and health of the network and provide recommendations for future analysis of the natural heritage programs within NatureServe's Network. The introduction provides a background on NatureServe and natural heritage programs as well as describes past analyses that have sought to examine the status of natural heritage programs. The methods section provides information on the 2020 survey that NatureServe sent to the natural heritage programs within its network, describe the qualitative analysis employed for this project, and discuss other methods of analysis that could be employed for future surveys. The results section contains quantitative analysis from the 2020 survey, descriptive statistics from the 2020 survey, and comparisons between the 2020 survey and a

¹ An Element Occurrence "is an area of land and/or water in which a species or natural community is, or was, present." NatureServe, *Element Occurrence*, NATURESERVE (last visited Feb. 13, 2021), https://help.natureserve.org/biotics/Content/Record_Management/Element_Occurrence/EO_Element_Occurrence.htm (defining element occurrence how NatureServe uses the term throughout its database).

similar survey conducted in 2016. The discussion section provides an analysis of the main results and recommendations for moving forward.

NatureServe

Building off of The Nature Conservancy's early efforts that established the first state natural heritage programs in the United States,² NatureServe's mission as a 501(c)(3) nonprofit is "to provide the scientific basis for effective conservation action."³ As an organization, NatureServe is guided by a desire to create a world where the value of biodiversity is fully understood by decision makers who are equipped with a sound scientific understanding of biodiversity.⁴

In order to realize this mission, NatureServe has expanded from the initial natural heritage program established in 1974 to create a robust public-private partnership and network of programs that cover the United States, Canada, Latin America, and South America.⁵ The information on rare and endangered species and threatened ecosystems that is collected and maintained through the partnership is now recognized as one of the most comprehensive and detailed compilations of such information.⁶ Through its network of natural heritage programs, NatureServe is able to provide comprehensive and high-quality biodiversity data to scientists, governments, communities, and individuals.⁷

² NatureServe, *Our History*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/about-us/our-history>.

³ NatureServe, *Mission and Vision*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/about-us/mission-and-vision>.

⁴ *Id.* (defining decision makers as governments, conservation organizations, corporations, landowners, and the scientific community).

⁵ *Our History*, *supra* note 2.

⁶ *Id.*

⁷ Nature Serve, *What is NatureServe?*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/about-us> (explaining that as a whole, the NatureServe Network has assessed over 100,000 species and classified over 7,000 types of ecosystems).

NatureServe provides a wide range of conservation tools and services on its website to easily allow access to the data and information that has been compiled through its network.⁸ In addition to the National Species Dataset, which includes over 900,000 location records collected across the United States and Canada,⁹ NatureServe provides access to a variety of interactive tools and GIS data sets that landowners, governments, land trusts, and citizens can use to learn more about natural world around them.¹⁰

Natural Heritage Programs

In order to provide high quality conservation tools and data services, NatureServe works closely with natural heritage programs located across the United States, Canada, Latin America, and South America. The first natural heritage program was created in 1974 in South Carolina to “gather, organize, and distribute” high quality data about the state’s biodiversity.¹¹ Since the establishment of the first natural heritage program in South Carolina, the network of natural heritage programs has grown to include natural heritage programs in all 50 of the United States, numerous Canadian provinces, and several Latin American countries.¹² The broad geographic coverage of the natural heritage program network has given researchers and decisions makers at

⁸ NatureServe, *Conservation Tools & Services*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/conservation-tools>.

⁹ NatureServe, *National Species Data Set*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/conservation-tools/national-species-dataset>.

¹⁰ NatureServe, *Tools*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/conservation-tools/tools>; *see, e.g.*, NatureServe, *iMapInvasives*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/conservation-tools/imapinvasives> (providing a tool to track and manage invasive species); NatureServe, *Climate Change Vulnerability Index for Ecosystems and Habitats*, NATURESERVE (last visited Feb. 13, 2021), <https://www.natureserve.org/conservation-tools/climate-change-vulnerability-index-ecosystems-and-habitats> (providing a tool to assess the vulnerabilities of communities and habitats to climate change).

¹¹ THE NATURE CONSERVANCY, *PRECIOUS HERITAGE: THE STATUS OF BIODIVERSITY IN THE UNITED STATES* 11 (Bruce A Stein, Lynn S. Kutner & Jonathan S. Adams eds., 2000).

¹² *Id.* at 25.

all levels important conservation data to consider.¹³ For example, natural heritage programs often help state agencies develop conservation priorities, and data from natural heritage programs have been shown to be particularly useful outreach tools to get landowners involved in voluntary conservation actions on their land.¹⁴

The importance of natural heritage programs to conservation is demonstrated by the wide variety of public and private decision-making processes in which the data collected by natural heritage programs is used. For example, data from natural heritage programs in states like North Dakota and South Dakota help to shape siting decisions for energy development projects.¹⁵ Additionally, natural heritage program data is used to explore important questions about biodiversity and identify areas of concern. Further, data from natural heritage programs was used in creating a model to predict future extinction rates of freshwater fauna in North America.¹⁶

While biodiversity data collection is a key function of natural heritage programs, natural heritage programs are also involved in other important conservation related activities. For example, the natural heritage program staff in North Carolina spent time researching the factors that make a landowner with Significant Natural Heritage Areas on their land more likely to participate in voluntary conservation programs, providing insight into ways that public-private cooperation on conservation can be strengthened.¹⁷ Further, natural heritage programs spend a

¹³ *Id.* at 42; Lawrence L. Master, *Assessing Threats and Setting Priorities for Conservation*, 5 CONSERVATION BIOLOGY 599 (1991) (praising the quality of objective information for determining conservation priorities that is generated by natural heritage programs).

¹⁴ Loring Schwarz, *State Natural Heritage Programs*, 1 J. OF NATURAL AREAS ASSOC. 10, 12 (1981) (describing the initial success of natural heritage programs).

¹⁵ Lee Paddock & Lea Colasuonno, *Minimizing Species Disputes in Energy Siting: Utilizing Natural Heritage Inventories*, 87 N.D. L. REV. 603 (2011).

¹⁶ Anthony Ricciardi & Joseph B. Rasmussen, *Extinction Rates of North American Freshwater Fauna*, 13 CONSERVATION BIOLOGY 1220 (2001).

¹⁷ Kristen M. Cassingham, Erin O. Sills, Subhrendu K. Pattanayak, & Carol A. Mansfield, *North Carolina's Natural Heritage Program: A Case for Public-Private Cooperation*, J. OF FORESTRY 16 (2002).

considerable amount of time analyzing the data they have collected and compiling the data into reports that can be easily accessed by the public.¹⁸

Even though every natural heritage program is connected through the natural heritage program network and NatureServe network, standardized data collection practices, and approaches to biodiversity inventory, each natural heritage program is independently operated within the state in which it exists.¹⁹ Consequently, there is some variation among natural heritage programs. Depending on the state in which it is located, a natural heritage program can take many different forms. Some states house their natural heritage programs within a state agency, such as the natural heritage programs in Texas²⁰ or Washington,²¹ and some states house their natural heritage programs within a university located in the state, such as the natural heritage programs in Colorado²² or Alabama.²³ Further, natural heritage programs can vary based on many factors including: whether or not they are created by statute, in the amount of funding they receive, the source of their funding, the number of staff they employ, and the priorities of the program.

¹⁸ See e.g., STEVE KETTLER & AMY McMULLEN, COLORADO NATURAL HERITAGE PROGRAM, ROUTT NATIONAL FOREST RIPARIAN VEGETATION CLASSIFICATION (1996); WILLIAM R. BOSWORTH III, STATE OF UTAH DEPARTMENT OF NATURAL RESOURCES, VERTEBRATE INFORMATION COMPILED BY THE UTAH NATURAL HERITAGE PROGRAM: A PROGRESS REPORT (2003).

¹⁹ THE NATURE CONSERVANCY, *supra* note 11, at 11.

²⁰ Texas Parks and Wild, *Texas Natural Diversity Database (TXNDD): Methodology*, TPWD (last visited Feb. 13, 2021), https://tpwd.texas.gov/huntwild/wild/wildlife_diversity/txndd/about.phtml (explaining that Texas' natural heritage program is located within the Texas Parks and Wildlife agency).

²¹ Washington State Department of Natural Resources, *Natural Heritage Program*, WASHINGTON DNR (last visited Feb. 13, 2021), <https://www.dnr.wa.gov/natural-heritage-program> (explaining that Washington's natural heritage program is located within the state's department of natural resources).

²² Colorado Natural Heritage Program, *About Us*, COLORADO STATE UNIVERSITY (last visited Feb. 13, 2021), <https://cnhp.colostate.edu/aboutus/aboutus/> (explaining the Colorado's natural heritage program is located within Warner College of Natural Resources at Colorado State University).

²³ Auburn University Museum of Natural History, *Alabama Natural Heritage Program*, AUBURN UNIVERSITY (last visited Feb. 13, 2021), http://www.auburn.edu/cosam/natural_history_museum/alnhp/index.htm (explaining that Alabama's natural heritage program is located within Auburn University's Museum of Natural History). Interestingly, Montana's natural heritage program is housed partly in the Montana State Library's Natural Resource Information Center and the University of Montana. MONTANA NATURAL HERITAGE PROGRAM, (last visited Feb. 13, 2021), <http://mtnhp.org>.

This variation amongst natural heritage programs is important to understand because it can impact an individual program's funding, staffing, and the projects and data collection that the program prioritizes. The variability can make it difficult to make sweeping statements about the status of the programs as well.

Review of Past Natural Heritage Program Evaluations

Given the importance of natural heritage programs and the NatureServe Network, several past studies have sought to evaluate natural heritage programs to better understand how to support and improve them. The focus of these studies ranges from getting a wholistic picture of natural heritage programs in general, to evaluating a single natural heritage program, and to examining the quality of data collected by natural heritage programs on a particular subject. A review of these past studies reveals the unique nature of the 2020 and 2016 NatureServe surveys as these more recent surveys seek to paint a picture of the natural heritage program network as a whole rather than focus on a single issue or program within the network.

The most recent evaluation of natural heritage programs took place in 2016, and it sought to assess the status of the natural heritage program network as a whole.²⁴ To do this, NatureServe conducted a survey “designed to assess the housing, funding, staffing capacity, guiding statutes, unique assets, and critical challenges faced by individual programs with the goal of strengthening the network and leveraging network access.”²⁵ The 2016 survey received responses from all of

²⁴ NatureServe, *Network Member Program Survey* (2016) (Power Point) (on file with Allison Gratz). Allison Gratz is the Director of Network Relations at NatureServe and was the main point of contact with NatureServe for this project. She can be contacted by email at allison_gratz@natureserve.org.

²⁵ *Id.*

the natural heritage programs in the United States and Canada and most of the natural heritage programs in Latin America and South America.²⁶

The survey collected basic information about the natural heritage programs and collected information that could be used to make recommendations and identify areas of need for natural heritage programs in general.²⁷ The greatest needs identified for the natural heritage programs were a need for funding for core data processing, filling staff vacancies, web programming, addressing data backlogs, nonvascular plant expertise, invertebrate animal expertise, and younger staff.²⁸ NatureServe also set the goal of conducting a similar survey at regular intervals to track the progress and health of the natural heritage programs.²⁹

In addition to the studies like the 2016 NatureServe survey that seek a more global picture of the natural heritage programs and the NatureServe network, studies have also been conducted to evaluate single natural heritage programs. This particular kind of study is helpful for developing a fine-grained picture of a single natural heritage program rather than for developing a global view of the natural heritage program network.

For example, in a 2001 report written by a California Department of Fish and Wildlife employee, Roxanne Bittman, closely examined the natural heritage program in California.³⁰ The report answered questions about the natural heritage program similar to the ones asked by this project, questions about data collection and use, technology use, and anticipated issues, such as budget constraints, advances in technology, and ethical concerns, for the natural heritage

²⁶ *Id.*

²⁷ *Id.*

²⁸ *Id.*

²⁹ *Id.*

³⁰ Roxanne Bittman, *The California Natural Diversity Database: A Natural Heritage Program for Rare Species and Vegetation*, 29 *FREMONTIA* 57 (2001). An early analysis of the natural heritage program in Massachusetts identified the areas in which the program could improve and best serve the state and biodiversity. Martha N. Fisher & Steven C. Buttrick, *Massachusetts Natural Heritage Program*, 82 *RHODORA* 227 (1980).

program.³¹ Several master's theses have also examined single natural heritage programs, including one that evaluated how data from New York's natural heritage program impacted development decisions,³² one that evaluated participation in by private landowners in North Carolina's natural heritage program,³³ and one that provided specific recommendations for improvements for Montana's natural heritage program early in its history.³⁴ Natural heritage programs also undertake evaluations of their own programs to set goals and improve in the future.³⁵

A survey conducted in 1999 that was sent to all natural heritage programs in the United States sought to explore gaps in data collected by natural heritage programs related to spiders.³⁶ The twelve-question survey was designed to understand current levels of spider knowledge across the natural heritage program network, past development of spider data, plans for future data development on spiders, and the usefulness of potential options for better developing spider data.³⁷ The survey had a 74% response rate, which enabled scientists to draw helpful conclusions about where improvements could be made in terms of collecting spider data at natural heritage

³¹ Bittman, *supra* note 30.

³² Tara Salerno, *Evaluating How New York Natural Heritage Program Information Affects Developmental Projects in New York State* (2011) (M.S. Thesis, University at Albany, State University of New York) (ProQuest).

³³ Kirsten Michael Cassingham, *Voluntary Conservation: Private Landowner Participation in North Carolina's Natural Heritage Program* (spatial analysis of the Natural Heritage Program in North Carolina (2001) (M.S. Thesis, North Carolina State University) (on file with NC State University Libraries).

³⁴ George M. Schunk, *Selected Review of State Natural Heritage Inventories with Recommendations for Montana* (1979) (M.S. Thesis, University of Montana) (ProQuest).

³⁵ LISA GAINES & JIMMY KAGAN, OREGON STATE UNIVERSITY INSTITUTE FOR NATURAL RESOURCES, *THE HERITAGE PROGRAM 25 YEARS OLD AND LOOKING AHEAD ASSESSING THE FUTURE OF THE HERITAGE PROGRAM* (2006).

³⁶ Kevin L. Skerl, *Spiders in Conservation Planning: A Survey of US Natural Heritage Programs*, 3 J. OF INSECT CONSERVATION 341 (1999). Similar to the spider data study, a 1996 study conducted a survey of natural heritage programs in the United States to determine how widespread the use of data from natural heritage programs was in land use planning decisions and how often planners and local government consider the data in land use decisions. Cheryl A. Cort, *A Survey of the Use of Natural Heritage Data in Local Land-Use Planning*, 10 CONSERVATION BIOLOGY 632 (1996); *see also* John Shuey, *NatureServe and the Natural Heritage Program Network*, 50 NEWS OF THE LEPIDOPTERISTS' SOCIETY 17 (2008) (explaining the positive impact of natural heritage programs on lepidopteran conservation but the systemic need for greater awareness about the tools available through natural heritage programs for lepidopteran conservation).

³⁷ *Id.* at 342.

programs.³⁸ The survey found that interest amongst natural heritage programs to collect more spider data was high, and responses enabled the researchers to identify problems that made it difficult for natural heritage programs to collect more data.³⁹ The narrow focus of this study on one data collection issue made it particularly helpful for identifying steps for a particular issue that could be taken to improve the natural heritage programs.

METHODS

In 2020, NatureServe sent out a survey to natural heritage programs in its network in the United States and Canada. Sixty-four natural heritage programs provided a response to the survey, however, not every program answered every question. The full list of natural heritage programs that responded to the survey can be found in Appendix A. The purpose of the survey was to understand the current state of natural heritage programs, to discover areas where natural heritage programs could improve, and to build off of the survey conducted by NatureServe in 2016.⁴⁰ The full list of questions asked in the survey can be found in Appendix B.

The data collected in the survey was analyzed to answer the two main questions of this project. The questions are: (1) What variables cause some natural heritage programs to have larger element occurrence data backlogs than others? and (2) What is the overall status of natural heritage programs within the NatureServe network? A linear regression model was conducted to answer the first questions, and descriptive statistics were analyzed to answer the second.

³⁸ *Id.*

³⁹ *Id.* at 343–46.

⁴⁰ NatureServe, *supra* note 24.

Linear Regression Model

A linear regression model is used to describe a relationship between a predictor variable, or independent variable, and a response variable, or dependent variable.⁴¹ The analysis for this project sought to explain the size of a natural heritage program's element occurrence data backlog using data collected in the 2020 NatureServe survey and a linear regression model. The size of a natural heritage program's element occurrence data backlog was chosen as the dependent variable for this analysis for two reasons. The first reason is that 88% of natural heritage programs reported that they consider element occurrences to be a data type that is essential to the future of the natural heritage program network. The second reason is that NatureServe is focused on providing high quality biodiversity data to decision makers, and element occurrence data is what makes up the most comprehensive data set that it provides.

Two linear regression models were run using the statistical package R.⁴² One regression was run with the size of a program's plant element occurrence backlog as the dependent variable. The other regression was run with the size of a program's animal element occurrence backlog as the dependent variable. The communities element occurrence backlog size was not used as a dependent variable because many programs did not provide data regarding the size of their communities element occurrence backlog. Further, not every natural heritage program was included in this analysis. The analysis only included programs that provided element occurrence backlog estimates for plant species and animal species and provided information on all of the independent variables that were used in the analysis. Thus, the sample size for the linear regression model was n=44.

⁴¹ NICHOLAS J. GOTELLI & AARON M. ELLISON, A PRIMER OF ECOLOGICAL STATISTICS 239 (2013).

⁴² THE R PROJECT FOR STATISTICAL COMPUTING, <https://www.r-project.org> (last visited Mar. 22, 2021).

Each linear regression model included four independent variables: a program's estimated funding, a program's average yearly data requests, the number of programmatic positions filled within the program, and the number of programmatic positions that needed to be filled within the program. The variables were chosen based on whether there was a possible connection between the variable and the size of a program's data backlog. The survey questions producing these variables were also asked in a way which produced answers that could be used in a quantitative analysis. Additionally, the analysis did not include the number of full time or part time staff employed by a program because several programs did not provide an answer to the question about the number of staff and the size of the program's element occurrence data backlog.

To supplement the quantitative linear regression model and confirm the results of the model, NVivo software⁴³ was used to visually compare the data back log of element occurrences for a natural heritage program with a natural heritage program's budget, number of programmatic positions that are critical to a natural heritage program that are vacant, and the number of filled programmatic positions at a natural heritage program.

Descriptive Statistics

While an exact comparison between the data collected in the 2016 survey and the data collected in the 2020 survey is not possible due to differing response rates and differing programs that responded, the questions asked in both surveys are similar and comparisons between the two could show how the natural heritage program network has changed over the past five years. So, in addition to the linear regression model, this project analyzed the 2020 survey responses to summarize the data in a way that could be compared with the responses to

⁴³ NVIVO, <https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home> (last visited Feb. 13, 2021).

the 2016 survey. The survey responses from the 2020 NatureServe survey were analyzed in Microsoft Excel.⁴⁴

Survey Design

A well-designed survey can be a helpful tool for understanding trends or features of large groups and can shed light on a topic on which it is otherwise difficult to gather information.⁴⁵ The success of using a survey as a tool as a systematic way to gather information about the world depends in large part on the survey design.⁴⁶ A survey can collect information through a series of closed ended questions, open ended questions, or a combination of both.⁴⁷ However, the choice of what kinds of questions to ask can greatly influence the types and amount of analyses that can be conducted on the results of the survey.⁴⁸ This retrospective analysis of NatureServe's 2020 survey design will focus on the types of questions that were asked in the survey in order to provide suggestions for future network wide surveys.

While surveys can vary in the method of data collection, such as face to face interview, telephone interviews, and email surveys, all effective surveys have several characteristics in common that allow them to function as helpful tools for information gathering.⁴⁹ Questions in an effective survey must be clear and concise while avoiding compound questions.⁵⁰ Further, questions related to a particular topic should be grouped together and the easiest to answer questions should be asked first.⁵¹

⁴⁴ MICROSOFT EXCEL, <https://www.microsoft.com/en-us/microsoft-365/excel> (last visited Feb. 13, 2021).

⁴⁵ RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 167 (Rajat Acharyya & Nandan Bhattacharya eds., 2019).

⁴⁶ Arevik Avedian, *Survey Design*, HARVARD LAW SCHOOL (2014) (last visited Feb. 13, 2021), <http://hnmcp.law.harvard.edu/wp-content/uploads/2012/02/Arevik-Avedian-Survey-Design-PowerPoint.pdf>.

⁴⁷ *Id.*

⁴⁸ *Id.*

⁴⁹ RESEARCH METHODOLOGY FOR SOCIAL SCIENCES, *supra* note 43, at 173, 175.

⁵⁰ *Id.* at 175.

⁵¹ *Id.*

Additionally, surveys should strive to employ short questions that avoid negatives and double negatives to reduce the potential for confusion and make it easier for respondents to accurately interpret questions.⁵² Jargon should generally be avoided, but jargon can be used in surveys that target a specific organization that regularly uses the jargon.⁵³ Most importantly, an effective survey should have clear objectives for what the researcher hopes to learn from the survey.⁵⁴

In addition to the best practices for survey design discussed above, the questions in a survey can be judged by asking several questions about the survey.⁵⁵ The first question simply asks: “are the questions asking about the rights things.”⁵⁶ The next set of questions looks at how respondents understand the questions and asks: “do respondents understand the questions consistently,” “do [respondents] have the information required to answer them,” and “are [respondents] willing and able to formulate answers to the questions.”⁵⁷ The last question looks at the usability of the survey and asks: can the respondent easily complete the survey as intended.⁵⁸

Overall, the survey created by NatureServe follow many of the best practices for creating an effective survey. The questions are short and avoid using compound questions. The questions are grouped by topics such as biographical/demographic information, budget and funding, staffing, stakeholders, data, and expected challenges. The survey also has a fairly clear stated purpose, “to assess the housing, funding, staffing capacity, guiding statutes, unique assets, and

⁵² Arevik Avedian, *supra* note 44.

⁵³ *Id.*

⁵⁴ KEITH F. PUNCH, SURVEY RESEARCH: THE BASICS (2003).

⁵⁵ ROBERT M. GROVES, SURVEY METHODOLOGY 259 (2d ed. 2009).

⁵⁶ *Id.*

⁵⁷ *Id.*

⁵⁸ *Id.*

critical challenges faced by individual programs with the goal of strengthening the network and leveraging network access.”⁵⁹

The survey could be improved by further refining the purpose of the survey and explaining why NatureServe wants to collect and assess this particular information from its network of natural heritage programs. Further refining the purpose of the survey could allow for more effective analysis of the data collected from the survey and would allow NatureServe to ask more effective questions.

Since the survey’s general purpose is to understand more about natural heritage programs and how to improve them, NatureServe should add questions to the survey that ask about actions that have been taken to improve natural heritage programs. The survey could ask open ended questions such as what has a natural heritage program done to respond to challenges that it identified in NatureServe’s previous survey, how has NatureServe helped natural heritage programs respond to challenges faced by the program, and have any programs instituted by NatureServe to help natural heritage programs respond to challenges been effective? These questions could help NatureServe better understand what is already being done to improve natural heritage programs and whether those approaches have been effective.

Additionally, several of the questions ask the natural heritage program if a data product, area of staff expertise, or NatureServe network data standard is essential to the program’s mission. The concept of whether something is essential to a program’s mission is vague and open to interpretation. Further, some natural heritage programs reported that the program did not have an official mission statement. Refining the language on those questions could help to develop more detailed and meaningful findings given the fact that natural heritage programs are so

⁵⁹ NatureServe, *supra* note 24.

varied, and many have different priorities and missions. A question like “which of the following NatureServe network data standards does your program consider essential to its mission” could be rephrased to read “which of the following NatureServe network data standards does your program consider essential to its day-to-day operations?”

NatureServe could further refine its questions about stakeholders in natural heritage programs. It would be helpful to clarify exactly how the stakeholders are involved with the natural heritage program and expand the types of stakeholders that a program can identify. When asking natural heritage programs to identify stakeholders in the program on the 2020 survey, NatureServe defines stakeholders as “users, partners, funders in the products your program produces.” However, the list of stakeholders that NatureServe provides for natural heritage programs to select an answer from is the same as the list of funders. By limiting the list of stakeholders to the list of funders, NatureServe is missing the opportunity to better understand who is using the products and services provided by the natural heritage programs. NatureServe should expand the list of stakeholders to include universities, professors, students, indigenous peoples, and others to help NatureServe develop a more holistic picture of stakeholders in natural heritage programs.

The structure of the survey could be improved for ease of data analysis in three ways. The first is by adding an answer option such as “not applicable” or “no response” for each question to reduce ambiguity as to whether a program is simply not answering a question or whether the program is answering the question in the negative by not providing a response. Second, it would be easier to conduct quantitative analyses on the data collected by the survey if questions requiring a numerical answer were not answered with a range of numbers but with a single, discrete number for each program. Third, NatureServe should standardize the questions

asked, if it continues to conduct periodic surveys of the natural heritage programs, to allow comparisons to be made across the surveys.

RESULTS

The data analysis of this project focused on two main questions: (1) What variables cause some natural heritage programs to have larger element occurrence data backlogs than others? and (2) What is the overall status of natural heritage programs within the NatureServe network?

The first question was partially answered by performing a linear regression analysis using element occurrence backlog as the dependent variable and estimated program funding, average yearly data requests, number of programmatic positions filled, and number of programmatic positions that need to be filled as independent variables. As demonstrated by the large p-values in Table 1, these variables do not accurately predict whether a program will have a large backlog of element occurrence data.

The second question was answered by providing descriptive statistics of the answers to NatureServe's 2020 survey and comparing the results, where appropriate, to NatureServe's 2016 survey. Overall, the second analysis shows that the state of the natural heritage programs in NatureServe's network have not changed greatly since 2016.

The remainder of this section lays out the results from these analyses.

Linear Regression Model

The following table provides the p-values associated with the linear regression model that was created to predict the relationship between a program's element occurrence backlog and several factors examined by the 2020 NatureServe survey including a program's estimated

funding, the yearly average of data requests received by a program, the number of programmatic positions filled at a program, and the number of programmatic positions that need to be filled at a program. As indicated by the insignificant p-values in Table 1, none of the predicting variables included in the linear regression model adequately predict a program’s element occurrence back log.

Table 1. This table provides the p-values associated with the linear regression model.

Variable In Linear Regression Model	Plant Element Occurrence Model P-Value	Animal Element Occurrence Model P-Value
Estimated Program Funding	0.3533	0.82618
Average Yearly Data Requests	0.96967	0.46826
Number of Programmatic Positions Filled	0.8876	0.97035
Number of Programmatic Positions that Need to Be Filled	0.62049	0.52224

Descriptive Statistics

The following tables provide descriptive statistics that catalogue the information gathered in the 2020 NatureServe survey. The tables are grouped into subject matter categories including Challenges, Funding, Stakeholders, Staffing, Data and Tools, Land Management, Collaborating with Other Programs, and COVID-19. Many of the tables that show the percentage of programs that provided a certain answer to a question on the survey show the overall percentage and the number of individual programs providing that answer in parenthesis. Where comparisons between the 2020 NatureServe survey and 2016 NatureServe survey were possible based on the similarities between the two surveys, the tables also depict the results from the 2016 NatureServe Survey.

Challenges

Table 2. A list of challenges that the natural heritage programs identified as being of top concern in the coming years. Programs were allowed to identify up to two areas of concern or challenges that they expected to face in the coming years in an open-ended question. This table summarizes the challenges listed while omitting duplicative concerns.

Challenges Facing Natural Heritage Programs
Relevancy
Capacity
Staffing
Funding
Waning natural history skills of staff
Recruitment of new staff
Retirement/Aging of staff
Addressing understudied species
Distributing data to clients
University restructuring
Public outreach
Data collection
Increased demand for surveys
Keeping up with data processing
Technology

Funding

Table 3. This table provides summary statistics of the estimated budget for individual programs from both the 2020 NatureServe survey and the 2016 NatureServe survey. Even in light of the discrepancy in the number of respondents, the reported budgets are similar in both surveys.

Budget in U.S. Dollars	2020 Survey	2016 Survey
N	51	54
Mean	1,459,973	1,296,214
Median	743,120	712,500
Max	8,000,000	9,500,000
Minimum	10,000	4,000
Total	41,511,578	69,995,594

Table 4. This table provides descriptive statistics for sources of funding for each program. The table shows mean, median, minimum, and maximum percentages that each source contributes to a program’s budget. While a similar question was asked in the 2016 NatureServe survey, the categories of funding sources were slightly different and did not lend themselves to comparison here. Fifty-three programs responded to this question.

Funding Source	Mean %	Median %	Minimum %	Maximum %
State /Provincial for Core Functions	43%	35%	0%	100%
Federal for Core Functions	20%	10%	0%	90%
Private for Core Functions	4%	0%	0%	100%
Federal, State, or Private for Projects	29%	25%	0%	90%
NatureServe	2%	0%	0%	25%
Fees for Data Requests or Subscriptions	3%	0%	0%	30%

Table 5. This table depicts the possible sources of funding for a natural heritage program and the percentage of natural heritage programs that receiving funding from that source.

Funding Source	Percent of Programs Receiving Funding From Source
U.S. Forest Service	46%
Bureau of Land Management	14%
U.S. Fish and Wildlife Service	70%
National Resource Conservation Service	21%
Bureau of Indian Affairs	2%
U.S. Geological Survey	5%
Landscape Conservation Cooperative	10%
Environmental Protection Agency	34%
Audubon	4%
State Department of Transportation	34%
State Fish and Game	61%
State Department of Natural Resources	46%
Land Trusts (not including Nature Conservancy)	16%
County Planners	11%
Watershed or Soil Conservation District	2%

Private Industry	23%
Parks Canada	16%
Environment Canada	18%
Nature Conservancy	14%
Other	54%

Stakeholders

Table 6. This table depicts a list of stakeholders identified by NatureServe in natural heritage programs and the percentage of natural heritage programs that consider the entity to be a stakeholder. This list of stakeholders identified by NatureServe overlaps with the sources of funding for programs identified in Table 5. Fifty-two programs responded to this question.

Stakeholder	Percentage of Programs
U.S. Forest Service	69% (36)
Bureau of Land Management	26% (14)
U.S. Fish and Wildlife Service	76% (40)
National Resource Conservation Service	53% (28)
Bureau of Indian Affairs	17% (9)
U.S. Geological Survey	30% (16)
Landscape Conservation Cooperative	23% (12)
Environmental Protection Agency	40% (21)
Audubon	28% (15)
State Department of Transportation	75% (39)
State Fish and Game	82% (43)
State Department of Natural Resources	71% (37)
Land Trusts	61% (32)
County Planners	59% (31)
Watershed or Soil Conservation District	34% (18)
Private Industry	82% (43)
Parks Canada	15% (8)
Environment Canada	19% (10)
Nature Conservancy	59% (31)
Other	21% (11)

Table 7. This table compares the number of programs that hold regular stakeholder meetings at regular intervals based on the 2020 NatureServe survey and the 2016 NatureServe survey. Slightly more programs answered that they hold regular stakeholder meetings in the 2020 survey versus the 2016 survey. Fifty-two programs responded to this question.

Regular Stakeholder Meetings?	2020 Survey	2016 Survey
Yes	34% (21)	24% (19)
No	50% (31)	64% (50)
No Response	16% (10)	12% (9)

Table 8. This table lists sectors that request data from a natural heritage program and the percentages of natural heritage programs considering each sector to be within the top three sectors requesting data from the program. Fifty-two programs responded to this question.

Sectors	Percentage of Programs Listing the Sector as a Top 3 Data Requester
Forestry Industry	31% (16)
Oil & Gas	33% (17)
Transportation	44% (23)
Federal Government	60% (31)
State/Local Government	71% (37)
Housing/Development	42% (22)

Table 9. This table represent the number of data requests that programs receive on average each year. Most programs that responded receive more than 20 requests a year. Fifty-one programs responded to this question.

Number of Data Requests on Average	Percentage of Programs
0 to 5	6% (3)
5 to 10	6% (3)
10 to 15	0% (0)
15 to 20	6% (3)
20+	82% (42)

Staffing

Table 10. This table lists a range of people on staff and the percentage of natural heritage programs that fall within that range for full time staff and part time staff. Most programs employ 1 to 10 full time staff members and 1 to 10 part time staff members. Forty-five programs responded to this question.

Number of Staff	Percentage of Programs with Full Time Staff	Percentage of Programs with Part Time Staff
1 to 5	40% (18)	67% (29)
6 to 10	20% (9)	21% (9)
11 to 20	16% (7)	9% (4)
21 to 30	13% (6)	0% (0)
31+	11% (5)	2% (1)

Table 11. This table provides a list of programmatic functions within a natural heritage program, the percentage of natural heritage programs that have the programmatic function filled, and the percentage of natural heritage programs seeking to fill the programmatic function. It should be noted the percentages seeking to fill a function and the percentages that have a function filled do not always equal 100%. This could be due to programs not prioritizing or having capacity to hire for certain programmatic functions or it could be due to some programs answering one of the questions and not the other. The discrepancies could also be attributed to differences in staffing practices across the programs.

Programmatic Function	Percentage of Programs that Have This Function Filled 2020	Percentage of Programs that Have This Function Filled 2016	Percentage of Programs that Need This Function Filled 2020
Director / Coordinator	89% (47)	74% (58)	14% (7)
Finance or Grants Administrator	32% (17)	9% (7)	4% (2)
Office Manager	19% (10)	23% (18)	0% (0)
Database Manager / Administrator	85% (45)	67% (52)	16% (8)
Web Programmer	15% (8)	13% (10)	16% (8)
General Data Assistant	51% (27)	38% (30)	18% (9)

Botanist with vascular plant expertise	81% (43)	67% (52)	16% (8)
Botanist with nonvascular plant expertise	30% (16)	18% (14)	4% (2)
Botanist with mycology expertise	8% (4)	64% (50)	6% (3)
Zoologist with terrestrial vertebrate expertise	75% (40)	64% (50)	12% (6)
Zoologist with aquatic vertebrate expertise	47% (25)	27% (21)	16% (8)
Zoologist with terrestrial invertebrate expertise	49% (26)	36% (28)	24% (12)
Zoologist with aquatic invertebrate expertise	43% (23)	29% (23)	14% (7)
Wetland or Aquatic Plant Community Ecologist	38% (20)	26% (20)	12% (6)
Terrestrial Plant Community Ecologist	62% (33)	49% (38)	18% (9)
Environmental Review Coordinator	43% (23)	35% (27)	4% (2)
Wetland Mapper	17% (9)	9% (7)	4% (2)
GIS Analyst with photogrammetry expertise	30% (16)	26% (20)	0% (0)
GIS Analyst with predictive modeling expertise	34% (18)	26% (20)	8% (4)
Natural Areas Coordinator	25% (13)	15% (12)	8% (4)
Wildlife Action Plan Coordinator	17% (9)	14% (11)	6% (3)
Other (please specify)	41% (22)		28% (14)

Table 12. This table lists types of expertise the staff of a natural heritage program might have and the percentage of programs that consider each area of expertise essential to the mission of the natural heritage program. Fifty-one programs responded to this question.

Staff Expertise	Percentage of Programs Considering Expertise as Essential to Their Mission
Botany - general taxonomy and global ranks	80% (41)
Botany - vascular plants - bryophytes and lichens	43% (22)
Mycology - general taxonomy and global ranks	21% (11)
Zoology - general taxonomy and global ranks	74% (38)
Zoology – vertebrate	47% (24)
Zoology – invertebrate	45% (23)
Ecology – terrestrial	50% (26)

Ecology - wetland/aquatic	45% (23)
Database/data standards	90% (46)
GIS Analyst - predictive distribution modeling	39% (20)
Web Programmer	25% (13)
Other/Comments	17% (9)

Table 13. This table identifies training materials and classes provided by NatureServe that programs consider to be essential to their mission. This table can help NatureServe to identify areas of high priority when it comes to planning future training opportunities for the programs. Fifty-one programs responded to this question.

NatureServe Training Material or Class	Percentage of Programs Considering Training as Essential to Their Mission
Core Methodology Training (training for network staff about NatureServe methodology standards)	78% (40)
Biotics Training	82% (42)
Network Leadership Training	15% (8)
Data Use Training (training to orient clients to our methods and data)	33% (17)
Habitat Suitability Modeling Training	23% (12)
Mapping Species and Ecosystems Training	25% (13)
Citizen Science Strategy resources	21% (11)
Ecological Integrity Assessment Training	13% (7)
Conservation Status Ranking Training (including use of rank calculator)	72% (37)
Climate Change Vulnerability Index Training	15% (8)
Priority Conservation and Managed Areas	13% (7)
Other	23% (12)

Table 14. This table provides a list of the top training needs identified by the natural heritage programs. For this question, programs were given the chance to answer an open-ended question to express their top training needs in their own words. This table lists the needs identified by the programs while omitting any duplicative or similar answers.

Top Training Needs
Diversity, Equity, Inclusion
Natural Community Sampling
Project Management
Biotics
Data Science
Nature Serve Methodology
GIS Training
Leadership Training
LiDar Data Training
Grant Acquisition and Management
Database Management
Taxonomy
Public Engagement
Insect Collection and ID
HSM and SQL Training
Community science data
Scripting
Species Ranking
Modeling
Indigenous Relations
Electronic Data Collection
Lichen and Moss ID

Data and Tools

Table 15. This table shows the number of programs that have element occurrences (EOs) backlogs of each size range and subject matter from the 2020 NatureServe survey and the 2016 NatureServe survey. The numbers are similar across both surveys.

EOs in Backlog	Plant Elements 2020	Plant Elements 2016	Animal Elements 2020	Animal Elements 2016	Community Elements 2020	Community Elements 2016
0 to 10	8	9	5	8	7	17
11 to 100	7	9	8	5	7	13
101 to 1000	19	20	17	16	11	10
1001 to 10000	12	13	9	13	2	4
>10000	2	1	5	7	2	0
	n=48	n=52	n=44	n=49	n=29	n=44

Table 16. This table provides a list of the types of data a natural heritage program collects and the percentage of natural heritage programs that view that type of data as being essential to the future of the network of natural heritage programs. Fifty-two programs responded to this question.

Data Type	Percentage of Programs Considering It Essential to the Network's Future
Species Taxonomy	96% (50)
Species Status Ranks	98% (51)
Species biology/ecology information	78% (41)
Observations	86% (45)
Surveys (positive using standard protocol)	69% (36)
Surveys (negative using standard protocol)	57% (30)
Element Occurrences	88% (46)
Predictive Distribution Model Output	71% (37)
Terrestrial Habitat Information	61% (32)
Wetland Habitat Information	55% (29)
Land Management/Stewardship Information	36% (19)
Conservation Sites	50% (26)
Monitoring activities	48% (25)
Other	15% (8)

Table 17. This table provides a list of data related services a typical natural heritage program provides and the percentage of natural heritage programs that actually provide the service. Fifty-one programs responded to this question.

Core Data Service	Percentage of Programs Providing Data Service
Imperiled species data management & delivery	96% (49)
Vegetation community data management & delivery	70% (36)
Invasive species data management & delivery	33% (17)
Protected area data management & delivery	43% (22)
Identification of high priority conservation areas (and managing this data)	60% (31)
Distribution modeling	31% (16)
Animal surveys	66% (34)
Plant surveys	78% (40)
Ecological surveys	58% (30)
Terrestrial mapping	35% (18)
Wetland & Riparian mapping	29% (15)
Developing land management recommendations	41% (21)
Land stewardship	17% (9)
Other	13% (7)

Table 18. This table provides a list of data-related products a natural heritage program provides and the percentage of natural heritage programs actually providing the product. Fifty-three programs responded to this question

Core Data Product	Percentage of Programs Providing Product
Animal observations	56% (30)
Plant observations	58% (31)
Animal element occurrences	79% (42)
Plant element occurrences	86% (46)

Animal predictive distribution models	28% (15)
Plant predictive distribution models	30% (16)
Community occurrences	73% (39)
Wetland maps	15% (8)
Riparian maps	7% (4)
Land cover maps	20% (11)
Land management/stewardship information	33% (18)
Species information via a field guide	35% (19)
Conservation sites	41% (22)
Protected Areas	45% (24)
Invasive species data	24% (13)
Other (please specify)	30% (16)

Table 19. This table lists data standards for the NatureServe network and the percentage of natural heritage programs that find the data standards essential to its mission. Fifty-one programs responded to this question.

NatureServe Network Data Standard	Percentage of Programs Considering Data Standard Essential to Their Mission
Conservation Status Rank Calculator and Assessment Standard	88% (45)
Climate Change Vulnerability Index	23% (12)
Element Occurrence Data Standard	92% (47)
Observation Data Standard	60% (31)
Ecosystem Classification Data Standard	33% (17)
National Vegetation Classification	49% (25)
Ecological Integrity Assessment	23% (12)
Coastal and Marine Ecological Classification Standard	1% (1)
Other/Comments	15% (8)

Table 20. This table provides a list of tools and services offered by NatureServe and the percentages of programs that consider the tool or service to be essential to its mission. Fifty-one programs responded to this question.

NatureServe Information Tools and Services	Percentage of Programs Considering Tool Essential to Their Mission
Biotics 5	84% (43)
Observation Data Management Tool	21% (11)
iMapInvasives	15% (8)
Environmental Review Tool	31% (16)
NatureServe Explorer	72% (37)
Biodiversity Indicators Dashboard	3% (2)
NatureServe Web Services for species data	21% (11)
NatureServe Web Services for Ecological Data	15% (8)
Terrestrial Ecological Systems of the United States	29% (15)
Other (please specify)	27% (14)

Table 21. This table lists the resources a natural heritage program might provide through its website and the percentage of natural heritage programs that provide the resource through their website. Fifty-four programs responded to this question.

Website Resource	Percentage of Programs Offering Resource
No website	3% (2)
Basic program information and contacts for data	94% (50)
Environmental Review tool	37% (20)
Field Guide of Species of Concern	30% (16)
Field Guide of all species	15% (8)
Interactive map application for animal data	49% (36)

Interactive map application for plant data	54% (29)
Interactive map application for community data	32% (17)
Species of Concern list	88% (47)
Invasive species web resources	18% (10)
Custom Field Guide generation	5% (3)
Wetland and/or riparian mapping information	15% (8)
Land cover information Reports	16% (9)
Spatial data (e.g., geodatabase or shapefiles)	43% (23)
Other (please specify)	24% (13)

Land Management

Table 22. This table depicts the percentage of programs that report direct involvement with land acquisition or management. The table compares the percentages from the 2020 NatureServe survey and the 2016 NatureServe survey. The percentages are similar across both surveys. Variation in the results could be due to the lack of responses to the 2020 NatureServe survey. Fifty-three programs responded to this question.

Is the program directly involved with land acquisition or management?	2020 Survey	2016 Survey
Yes	30% (19)	36% (28)
No	55% (34)	54% (42)
No Response	15% (9)	10% (8)

Guiding Statute

Table 23. This table describes the number of programs reporting that they are governed by a guiding statute in their home state. Fifty-two programs responded to this question.

Guiding Statute?	2020 Survey	2016 Survey
Yes	48% (30)	54% (42)
No	35% (22)	36% (28)
No Response	16% (10)	10% (8)

Collaborating with Other Programs

Table 24. This table describes the percentage of programs that have collaborated with another program in the past five years. Over half of the responding programs reported such collaboration. Information about which programs collaborated with each other or the projects they collaborated on is not available from the survey. Fifty-two programs responded to this question.

Has The Program Teamed Up With Another Program In the Past 5 Years?	Percent of Programs
Yes	63% (33)
No	37% (19)

COVID-19

Table 25. This table summarizes the response of programs when asked whether they expect the program to be negatively affected by the COVID-19 pandemic. In an open-ended question asking natural heritage programs to identify the negative impacts they would experience, natural heritage programs identified several impacts including decreased funding, hiring freezes, cancelled data subscription contracts. A majority of the programs expect to be negatively affected. Fifty-three programs responded to this question.

Does The Program Expect To Be Negatively Impacted By COVID	Percent of Programs
Yes	64% (34)
No	17% (9)
I Don't Know	19% (10)

DISCUSSION

This project seeks to define the attributes of a successful natural heritage program by better understanding the causes of element occurrence data backlogs and by understanding the current state of natural heritage programs and the challenges the programs will face in the future. In order to better understand these aspects of natural heritage programs, this project asked two

main questions. What variables cause some natural heritage programs to have larger element occurrence data backlogs than others? What is the overall status of natural heritage programs within the NatureServe network? This section will discuss the results from the analyses conducted to answer these questions.

Element Occurrence Data Backlog

The variables in the linear regression model for predicting a program's element occurrence data backlog size did not effectively forecast the size of a program's backlog. According to the model, variables other than a program's funding, average yearly number of data requests received, number of programmatic positions filled, and the number of programmatic positions that need to be filled are driving the size of a natural heritage program's element occurrence data backlog size. The visual inspection of the data in NVivo confirmed the lack of a relationship or discernable pattern between a program's element occurrence data backlog and the individual variables. Given the results of the linear regression model, a variable or combination of variables other than the ones included in the model for this project influence the size of a program's element occurrence data backlog.

There are several variables that can be explored in the future to better understand the factors driving the size of a program's element occurrence data backlog. One such factor that could be examined is the geographical size of the state where the natural heritage program is located. The size of the state could determine the size of the backlog if there is a correlation between the geographical area of a state and the number of element occurrences. Thus, natural heritage programs located in larger states that are responsible for a wider geographical area may have more element occurrences to catalog and manage, causing the larger backlogs. A similar

relationship could exist between the size of a program's backlog and the number of different types of ecosystems that occur within a state.

Certain characteristics of a natural heritage program could also be used to predict the size of a program's element occurrence data backlog. The age of the natural heritage program could influence the backlog of a program if younger programs still have more unique areas and species that need to be accounted for versus older programs that have accounted for more of the biodiversity in the state already. So, younger programs may have larger backlogs that need to be categorized to catch up with older programs. Another factor that could influence the size of a program's backlog, one that would be difficult to quantify, is the level to which a natural heritage program is conducting activities to collect new data and element occurrences. Thus, a natural heritage program that is actively collecting new data may have a larger backlog from the newly collected data than a program that is not collecting new information.

In the alternative, the size of a program's element occurrence data backlog may defy accurate predictions by quantitative models. Each individual natural heritage program can vary greatly in where the program is housed, how the program is run, and the types of activities the program prioritizes. This wide variability inherent in the natural heritage programs in NatureServe's network may counsel an individualized approach for each natural heritage program when it comes to reducing a program's element occurrence data backlog. Therefore, while NatureServe should continue collecting data to explore the relationship between a program's element occurrence data backlog and other variables, NatureServe should also advise programs to take an individualized look at the program's own needs to assess what can be done on the individual program level to decrease the backlog.

Overall Status of Natural Heritage Programs

The overall status of natural heritage programs has not changed significantly in between the 2020 NatureServe survey and the 2016 NatureServe survey. Where comparisons between the two surveys are possible, the results of the descriptive statistics are similar. Further, natural heritage programs identified similar concerns and challenges that the program would be facing in the short-term future in both surveys. Given the overall lack of change in the status of natural heritage programs in between the two surveys and the continued challenges faced by the programs, NatureServe should begin identifying steps that it can take to help the programs face these challenges and strengthen the network. The remainder of this section addresses two of the main challenges identified by the programs, funding and staffing, by comparing the results from the 2020 NatureServe survey and the 2016 NatureServe survey and providing initial suggestions for solutions that NatureServe and natural heritage programs can explore.

Funding

Several programs in the 2020 NatureServe survey identified lack of funding as one of the top challenges facing the program. Similarly, programs in the 2016 survey identified a lack of funding for core data processing as one of the program's great needs.

Based on the continued challenge of a lack of funding faced by many natural heritage programs, it is unsurprising that there was little variation between the annual budgets reported in the 2016 and 2020 surveys. In 2020, the median annual budget was \$743,120 and the mean was \$1,459,974. In 2016, the median annual budget was \$712,500 and the mean was \$1,296,214. The numbers are similar for 2016 and 2020, though it should be noted that fewer natural heritage programs answered the question about budgets in 2020, some gave their answers in Canadian

dollars which had to be converted, and some gave their answers as a range (for this category, the middle of the range was selected for calculations). These slight estimations and conversions required by the results of the 2020 NatureServe survey add another layer of uncertainty when comparing the reported budgets between the two surveys.

State funding plays a significant role in the amount of funding that a natural heritage program receives. The results of the 2020 NatureServe survey revealed that, on average, a natural heritage program receives about 35% of its funding for core functions from the state or province where it is located. Further, 61% of natural heritage programs report they receive funding from the state fish and game department in their state. Given the important role of state funding in a natural heritage program's budget, NatureServe and natural heritage programs should be considering tools that individual programs can employ in their own state to increase the amount of funding they are already receiving. NatureServe should also encourage programs not currently receiving funding from a particular source to apply for funding.

NatureServe should explore how private funding and the payment of private fees for data could increase funding for natural heritage programs. Only 23% of natural heritage programs reported receiving funding from private sources. However, 31% of natural heritage programs report the forest industry as being a top three data requesting sector, 33% of natural heritage programs report the oil and gas industry as being a top three data requesting sector, and 44% of natural heritage programs report the transportation sector as being a top three data requesting sector. Since private sector industries are requesting data from natural heritage programs at higher rates than they are providing funding for them, there is room for NatureServe to encourage natural heritage programs to implement programs to charge the private sector for the data they request or increase the fees already charged.

Natural heritage programs also have the opportunity to increase the amount of funding they receive through increased applications for grants. Several programs identified grant acquisition and management as a top training need in the 2020 NatureServe survey. NatureServe could help individual natural heritage programs increase the amount of funding they receive by providing trainings and support to programs applying for grants.

Staffing

In both the 2020 and 2016 surveys, several programs identified the need to fill empty staff positions and to recruit younger staff members. Programs that responded to the 2020 survey also identified the more specific need for younger staff who are knowledgeable about current taxonomy.

In addition to the consistency of concerns related to staffing, there was not a large change in the number of staff employed at natural heritage programs between the surveys. Both surveys ask natural heritage programs how many full-time staff work at the natural heritage program. However, the 2016 survey required the natural heritage programs to provide the exact number of full-time staff while the 2020 survey required the natural heritage programs to provide a range that proceeded in 5 person increments (i.e., 1 to 5, 6 to 10, 11 to 20). The 2016 survey allowed programs to provide a more precise answer that could give a clearer picture of the situation at a specific program. Nevertheless, rough comparisons can be made, and in terms of full-time staff employed by natural heritage programs, it appears that there may have been a slight decrease in full time staff from 2016. In 2016, the mean number of full-time staff was 11.3 and the median was 7. In 2020, 40% of natural heritage programs employ 1 to 5 full time staff and 20% employ 6 to 10 full time staff.

In order to address the concerns that natural heritage programs have about staffing, expertise, and an aging staff, NatureServe should consider implementing programs that encourage graduate students in the natural sciences to join the staff of a natural heritage program after graduation. Since many natural heritage programs have funding that is constrained by state budgets, NatureServe could create or promote paid or unpaid internships for graduate students with natural heritage programs to increase future interest in employment with the programs. Budget strained natural heritage programs could also offer externships for class credit rather than payment. Natural heritage programs that are located within a university could also apply for funding through the National Science Foundation's Research Experience for Undergraduates program and host undergraduates through the program in the summer months.

Additionally, Natural heritage programs could connect with the career services centers at universities to better advertise their open staff positions to qualified graduating students and identify opportunities to participate in career fairs at universities. Natural heritage programs could also encourage their current staff to reconnect with their alma maters to recruit graduating students. Further, natural heritage programs that are located within a state university should use this to their advantage by making connections with professors at the university and current students.

Natural heritage programs were also asked to identify their top needs for staff training in the 2020 survey. The training needs they identified included training on data science and project management, training on grant acquisition and grant management, and training on lichen and moss ID, insect ID, and taxonomy in general. These training needs further reflect the more general needs and challenges natural heritage programs will face in the future. NatureServe should take these training needs into account when deciding how to best strengthen their network

as many of the training needs expressed by natural heritage programs are related to the staffing issues faced by these programs.

CONCLUSION

A successful natural heritage program is one that can remain flexible and responsive to the challenges it will face in the coming years. Continued success requires the natural heritage programs and NatureServe to work together to address the continued staffing, training, and funding issues that the programs are likely to continue facing in the future.

Lack of funding continues to be a challenge faced by many natural heritage programs. Increased training for natural heritage programs on how to secure more funding could afford programs the opportunity to increase their budgets and alleviate the pressing nature of the challenges posed by a lack of funding.

Additionally, some of the main challenges cited by natural heritage programs in the 2020 survey centered on an aging staff, lack of new staff with sufficient natural history knowledge, and capacity for continued operations. Interestingly, the natural heritage programs also cited biology and taxonomy knowledge as areas of expertise that are essential to their missions as natural heritage programs. Given the relative lack of incoming, younger staff with extensive natural history and taxonomy knowledge important to the mission of many natural heritage programs, NatureServe should begin exploring how it can support the development of future staff who are equipped with the requisite knowledge of natural history and taxonomy. Internships, externships, and building relationships with university career services centers are all great places for NatureServe and natural heritage programs to start.

Looking forward, the 2020 survey can be used as a tool to help identify areas that NatureServe can address to help strengthen its network of natural heritage programs. Additional surveys in the future, if conducted by similar means, can serve as a way to check in with the natural heritage programs and evaluate the effect of the support provided by NatureServe and to identify any new emerging challenges that the natural heritage programs might face.

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APPENDIX A

Table 26: List of natural heritage program participating in the 2020 NatureServe Survey.

Alabama Natural Heritage Program	Natural Heritage New Mexico
Alabama Natural Heritage Program	NC Natural Heritage Program
Alaska Center for Conservation Science	ND Natural Heritage Program
Alberta Conservation Information Management System	Nebraska Natural Heritage Program
Arizona Heritage Data Management System	Nevada Division of Natural Heritage
Arkansas Natural Heritage Commission	New Jersey Natural Heritage Program
Atlantic Canada Conservation Data Centre	NT CDC
BC Conservation Data Centre	Nunavut Conservation Data Centre
California Natural Diversity Database	NY Natural Heritage Program
Centre de données sur le patrimoine naturel du Québec	Office of Kentucky Nature Preserves
Colorado Natural Heritage Program	Ohio
CT NDDB	Ontario NHIC
Delaware Division of Fish & Wildlife	Oregon Biodiversity Information Center
Delaware Division of Fish & Wildlife	Pennsylvania Natural Heritage Program
Florida Natural Areas Inventory	Rhode Island Natural History Survey
Idaho Fish and Game	Saskatchewan Conservation Data Centre
Idaho Natural Heritage Program	SD Natural Heritage Database
Illinois Natural Heritage Database	South Carolina Heritage Trust Program
Indiana Natural Heritage Data Center	Tennessee Division of Natural Areas
Iowa Natural Areas Inventory	Texas Parks & Wildlife Department
Kansas Natural Heritage Inventory	Utah Natural Heritage Program
Kentucky	Vermont Natural Heritage Inventory
Louisiana Wildlife Diversity Program	Virginia Natural Heritage Program
Manitoba CDC	Washington Natural Heritage Program
Maryland Natural Heritage Program	West Virginia Natural Heritage Program
Michigan Natural Features Inventory	West Virginia Natural Heritage Program
Mississippi Natural Heritage Program	Wildlife Conservation Section
Missouri Natural Heritage Program	Wildlife Diversity Branch - Texas Parks and Wildlife Dept
MN Biological Survey	Wisconsin Natural Heritage Conservation Program
Montana Natural Heritage Program	Wyoming Natural Diversity Database
	Yukon Conservation Data Centre

APPENDIX B

The following is the list of questions, in order, that appeared in the 2020 survey conducted by NatureServe.

1. Contact Information: Name, Network Member Program, Address, City/Town, State/Province/ Zip Postal Code, Country, Email Address, Phone Number.
2. What institution houses your program?
3. Is the entity that developed the State Wildlife Action Plan housed within the same institution?
4. Does your program have guiding statutes from your state/provincial/national legislature?
5. Please provide your program's mission statement or a link to it.
6. Is your program directly involved with land acquisition or management?
7. If yes to question 6, please describe.
8. On average, in the last 5 years, what is the total annual amount of funding (including base funding for salaries, housing, grants, etc.) your program received from all sources, including funding for data management, information delivery, and projects?
9. Please characterize your program's funding sources by percentage (numbers should total to 100%)? Categories of funding include: state/provincial funding for core functions, federal funding for core functions, private funding for core functions, federal, state, or private funding for projects, NatureServe (BLD projects, contracts, others), fees charged for individual data requests and/or data subscriptions.
10. Which of the following provide funding to your program (check all that apply)? Options include: U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Natural Resource Conservation Service, Bureau of Indian Affairs Tribal Nations,

U.S. Geological Survey, Landscape Conservation Cooperative, Environmental Protection Agency, Audubon, State Department of Transportation, State Fish and Game, State Department of Natural Resources or Environmental Quality, Land Trusts, County Planners, Watershed or Soil Conservation Districts, Private Industry Local Government, Parks Canada, Environment Canada, Nature Conservancy (U.S. or Canada), Other (please specify).

11. Please identify your top funders (choose up to 5). Options include: U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Natural Resource Conservation Service, Bureau of Indian Affairs Tribal Nations, U.S. Geological Survey, Landscape Conservation Cooperative, Environmental Protection Agency, Audubon, State Department of Transportation, State Fish and Game, State Department of Natural Resources or Environmental Quality, Land Trusts, County Planners, Watershed or Soil Conservation Districts, Private Industry Local Government, Parks Canada, Environment Canada, Nature Conservancy (U.S. or Canada), Other (please specify).

12. What activities do the top 5 funders from the previous question support? (check all that apply). Options Include: Core Functions, Project Specific Functions, Surveys, Data Maintenance, Other (please specify).

13. How many full-time staff does your program currently have?

14. How many part-time staff does your program currently have?

15. What programmatic positions does your program currently have (select all that apply)?

Options include: Director/Coordinator, Finance or Grants Administrator, Office Manager, Database Manager/Administrator, Web Programmer, General Data Assistant, Botanist with vascular plant expertise, Botanist with nonvascular plant expertise, Botanist with

mycology expertise, Zoologist with terrestrial vertebrate expertise, Zoologist with aquatic vertebrate expertise, Zoologist with terrestrial invertebrate expertise, Zoologist with aquatic invertebrate expertise, Wetland or Aquatic Plant Community Ecologist, Terrestrial Plant Community Ecologist, Environmental Review Coordinator, Wetland Mapper, GIS analyst with photogrammetry expertise, GIS Analyst with predictive modeling expertise, Natural Areas Coordinator, Wildlife Action Plan Coordinator, Other (please specify).

16. What programmatic functions are critical to your program, but [are] currently vacant (select all that apply)? Options include: Director/Coordinator, Finance or Grants Administrator, Office Manager, Database Manager/Administrator, Web Programmer, General Data Assistant, Botanist with vascular plant expertise, Botanist with nonvascular plant expertise, Botanist with mycology expertise, Zoologist with terrestrial vertebrate expertise, Zoologist with aquatic vertebrate expertise, Zoologist with terrestrial invertebrate expertise, Zoologist with aquatic invertebrate expertise, Wetland or Aquatic Plant Community Ecologist, Terrestrial Plant Community Ecologist, Environmental Review Coordinator, Wetland Mapper, GIS analyst with photogrammetry expertise, GIS Analyst with predictive modeling expertise, Natural Areas Coordinator, Wildlife Action Plan Coordinator, Other (please specify).

17. What are the top two training needs your program has?

18. Does your program have funding partner or stakeholder meetings at regular intervals?

19. How many data requests, not including BLD requests from NatureServe does your program receive annually, on average?

20. Please select the top 3 sectors requesting data from your program. Options include:
Forestry Industry, Oil & Gas, Transportation, Federal Government, State/Local Government, Housing Development.
21. Which of the following are stakeholders (i.e. users, partners, funders) in the products your program produces (check all that apply)? Options include: U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Natural Resource Conservation Service, Bureau of Indian Affairs Tribal Nations, U.S. Geological Survey, Landscape Conservation Cooperative, Environmental Protection Agency, Audubon, State Department of Transportation, State Fish and Game, State Department of Natural Resources or Environmental Quality, Land Trusts, County Planners, Watershed or Soil Conservation Districts, Private Industry Local Government, Parks Canada, Environment Canada, Nature Conservancy (U.S. or Canada), Other (please specify).
22. What core data products does your program provide (check all that apply)? Options include: Animal observations, Plant observations, Animal element occurrences, Plant element occurrences, Animal predictive distribution models, Plant predictive distribution models, Community occurrences, Wetlands maps, Riparian maps, Land cover maps, Land management/stewardship information, Species information via a field guide, Conservation sites, Protected Areas, Invasive Species Data, Other (please specify).
23. What core data services does your program provide (check all that apply)? Options include: Imperiled species data management & delivery, Vegetation community data management & delivery, Invasive species data management & delivery, Protected area data management & delivery, identification of high priority conservation areas (and managing this data), Distribution modeling, Animal surveys, Plant surveys, Ecological

surveys, Terrestrial mapping, Wetland & Riparian mapping, Developing land management recommendations, Land stewardship, Other (please specify).

24. For each of the following element groups, please characterize your program's backlog in processing Element Occurrences from underlying observations and/or source feature information according to the following numeric categories (0-10, 11-100, 101-1,000, 1,001-10,000, or >10,000). Options: Plant Species, Animal Species, Communities.
25. Which website resources does your program offer (check all that apply)? Options include: No website, Basic program information and contacts for data, Environmental Review tool, Field Guide of Species of Concern, Field Guide of all species, Interactive map application for animal data, Interactive map application for plant data, Interactive map application for community data, Species of Concern list, Invasive species web resources, Custom Field Guide generation, Wetland and/or riparian mapping information, Land cover information Reports, Spatial data (e.g., geodatabase or shapefiles), Other (please specify).
26. Which of the following NatureServe information tools and services does your program consider essential to your mission (check all that apply and add relevant comments)? Option include: Biotics 5, Observation Data Management Tool, iMapInvasives, Environmental Review Tool, NatureServe Explorer, Biodiversity Indicators Dashboard, NatureServe Web Services for species data, NatureServe Web Services for Ecological Data, Terrestrial Ecological Systems of the United States, Other (please specify).
27. What staff expertise at NatureServe does your program consider essential to your mission (check all that apply and add relevant comments)? Options include: Botany - general taxonomy and global ranks, Botany - vascular plants - bryophytes and lichens, Mycology

- general taxonomy and global ranks, Zoology - general taxonomy and global ranks, Zoology – vertebrate, Zoology – invertebrate, Ecology – terrestrial, Ecology - wetland/aquatic, Database/data standards, GIS Analyst - predictive distribution modeling, Web Programmer, Other/Comments.

28. Which of the following NatureServe network data standards does your program consider essential to your mission (check all that apply and add relevant comments)? Options Include: Conservation Status Rank Calculator and Assessment Standard, Climate Change Vulnerability Index, Element Occurrence Data Standard, Observation Data Standard, Ecosystem Classification Data Standard, National Vegetation Classification, Ecological Integrity Assessment, Coastal and Marine Ecological Classification Standard, Other/Comments.

29. Which of the following NatureServe training materials or classes does your program consider essential to your mission (check all that apply and add relevant comments)? Options Include: Core Methodology Training (training for network staff about NatureServe methodology standards), Biotics Training, Network Leadership Training, Data Use Training (training to orient clients to our methods and data), Habitat Suitability Modeling Training, Mapping Species and Ecosystems Training, Citizen Science Strategy resources, Ecological Integrity Assessment Training, Conservation Status Ranking Training (including use of rank calculator), Climate Change Vulnerability Index Training, Priority Conservation and Managed Areas, Other (please specify).

30. Which of the following data types are currently essential to your program (check all that apply and add relevant comments)? Options Include: Species Taxonomy, Species Status Ranks, Species biology/ecology information, Observations, Surveys (positive using

standard protocol), Surveys (negative using standard protocol), Element Occurrences, Predictive Distribution Model Output, Terrestrial Habitat Information, Wetland Habitat Information, Land Management/Stewardship Information, Conservation Sites, Monitoring activities, Other (please specify).

31. Which of the following data types are essential to the future of the network (check all that apply and add relevant comments)? Options Include: Species Taxonomy, Species Status Ranks, Species biology/ecology information, Observations, Surveys (positive using standard protocol), Surveys (negative using standard protocol), Element Occurrences, Predictive Distribution Model Output, Terrestrial Habitat Information, Wetland Habitat Information, Land Management/Stewardship Information, Conservation Sites, Monitoring activities, Other (please specify).
32. Has your program teamed with other programs on specific projects over the last 5 years? If so, please describe any benefits that accrued to your program and list any downsides to your partnership?
33. What are the top 3 challenges your program faces in the next 10 years?
34. Do you expect your organization to be negatively impacted financially by the COVID-19 pandemic?
35. If yes, when would you expect to see these impacts?
36. If yes, what are the top three impacts that would affect your organization the most (choose top three)? Options Include: loss of financial or in-kind support from parent agency, Cancelled contracts, Decrease in contracts and/or subscriptions for data, Decrease in donations, hiring freezes, Other (please specify).

37. How significant of revenue loss would cause your organization to make deep cuts (i.e. eliminate positions, decrease in use of Network tools, etc.)?
38. If your organization experienced a significant loss of revenue, please rank in order (1 being first) where you think your organization would make cuts (Use NA for any activity Not Applicable to your current budget). Options include: staff positions, survey/ new data collection, Land management, travel, meetings, training, conferences, Use of Biotics/Biotics fees at NatureServe, Use of ERT/ERT fees to NatureServe, Use of iMapInvasives/iMapInvasives fees to NatureServe, NatureServe membership dues.
39. Do you see any opportunities for NatureServe and the Network that we are not currently taking advantage of?