Developing Science and Technology Policy Fellowships in State Governments without Full-Time Legislatures

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Executive Summary: Science and technology policy fellowships train scientists and engineers to use their expertise to advise government officials in technical matters to inform policymaking. There are many such fellowships at the federal level. State-level fellowships are beginning to emerge as opportunities for scientists and engineers to contribute more locally. However, differences in legislative structures between states (e.g. legislative size, session duration, state resources) require state-specific fellowship design. We describe two case studies of emerging fellowships in North Carolina and Virginia and use these examples as a model to suggest how three other states—Ohio, Texas, and Tennessee—might implement similar policy fellowships. We highlight the government structures in each of these states, focusing on how each unique type of legislature informs the most promising options for host locations, funding sources, and duties for fellows in each state. For coalitions to establish successful state science policy fellowships, we recommend understanding the particular structure and needs of state governments, communicating with key stakeholders, and identifying additional opportunities for fellows to engage outside of the state government.

I. Introduction

The United States federal government has been the primary driver of US science and technology policy since World War II; state governments play a secondary role (NAS, NAE, and IM 2008). To design and implement evidence-based policies, the federal government seeks scientific advice from advisory bodies including the Office of Science and Technology Policy, the National Science Board, and the National Laboratories, as well as independent institutions like the National Academies of Sciences, Engineering, and Medicine. As modern science and technology advance, the consequences of these advancements impact regions and states in distinct ways. State governments are increasingly tasked with legislating on scientific matters with local impacts, supporting innovation, and incorporating new knowledge into policymaking. However, states generally have fewer and less-established mechanisms than the federal

government for seeking scientific and technical expertise to aid in the policymaking process.

Science and Technology Policy Fellowships (STPFs) are a powerful mechanism to inject technical expertise, provided by PhD-level scientists and engineers, into federal- and state-level policymaking. The American Association for the Advancement of Science (AAAS) pioneered national efforts by establishing the first STPF. In the last four decades, the AAAS STPF has placed over three thousand scientists, engineers, and specialists in federal agencies and legislative offices. The program bridges the gap between the scientific enterprise and the federal government, helping fellows develop policy skills not commonly taught in scientific and engineering PhD programs and connecting decision-makers with impartial expertise and analyses (NASEM 2018).

The first state-level STPF was launched in 2010 by the California Council on Science and Technology (CCST), using the AAAS STPF as a model. The CCST Fellowship began by placing ten PhD scientists and engineers for one year in California state legislative offices. Over half of CCST alumni continue working in the California state government, so the state retains these experts as an additional benefit extending beyond the fellowship tenure (Alberts et al. 2018).

Alumni of the AAAS and CCST programs cite profoundly positive impacts of these experiences on their professional careers (CCST, n.d.(c)). Similarly, agencies and offices at the federal level and in California have benefited from the advice and contributions of highly skilled fellows. The success of AAAS STPF and CCST spurred the development of new STPFs. In 2019, Connecticut placed one fellow in an executive department, and New Jersey placed four fellows in legislative and executive offices (ESAL 2018; Eagleton, n.d.). In addition, Idaho, Missouri, North Carolina, and Virginia will launch STPFs in 2020 (Table 1; CZI 2020; MOST, n.d.; Mosher 2020; COVES, n.d.). State governments grapple with increasingly complex scientific issues, from water standards in Tennessee and the opioid epidemic in Ohio, to flood management in Texas and coal ash in North Carolina (Reese 2018). Importantly, more states are recognizing the value of PhD-level fellows in developing unique policy solutions based on sound science. STPFs have demonstrated benefits for both scientists and policymakers. Therefore, **we recommend the expansion of the policy fellowship model to more US states and the establishment of a new generation of state-level STPFs tailored to each unique state government.**

Fellowship design should be adapted from state to state to best match the needs and varying governmental structures of each state. Legislative branch positions are popular and effective fellowship placements, so it is necessary to understand the differences in state legislative structure when designing fellowships. The National Conference of State Legislatures (NCSL) classifies US state legislatures into three categories based on legislative workload: full-time, hybrid, or part-time. The differences between these categories are reflected in session length, legislators' time-commitment, legislators' compensation, and legislative staff size (Figure 1; NCSL 2017). These differences across state legislatures underscore a need to tailor the mechanisms and logistics of potential STPFs in each state. Accordingly, states with hybrid and part-time legislatures must carefully consider how STPFs can best work for them.

State	Legislative Type[1]	Fellowship Status	Fellowship Placement
California	Full-time	1-year; since 2010[2]	Legislative, Executive (new)[9]
Connecticut	Hybrid	2-year, since 2019[3]	Executive[3]
Idaho	Part-time	1-year, inaugural 2020[4]	Executive[10]
Missouri	Hybrid	1-year, inaugural 2020[5]	Legislative[5]
New Jersey	Full-time	1-year, since 2019[6]	Executive[6]
North Carolina	Hybrid	1-year, inaugural 2020[7]	Executive[7]
Virginia	Hybrid	12-weeks, inaugural 2020[8]	Legislative, Executive, Industry/NGO[8]

Table 1: States, their legislative session type, fellowship status, and fellowship design.
Sources: [1]Governing n.d.; [2]Alberts et al. 2018; [3]ESAL 2018; [4]Himes 2019; [5]MOST, n.d.; [6]Eagleton n.d.; [7]Mosher 2020; [8]COVES n.d.; [9]CCST n.d.(b); [10]CZI 2020.
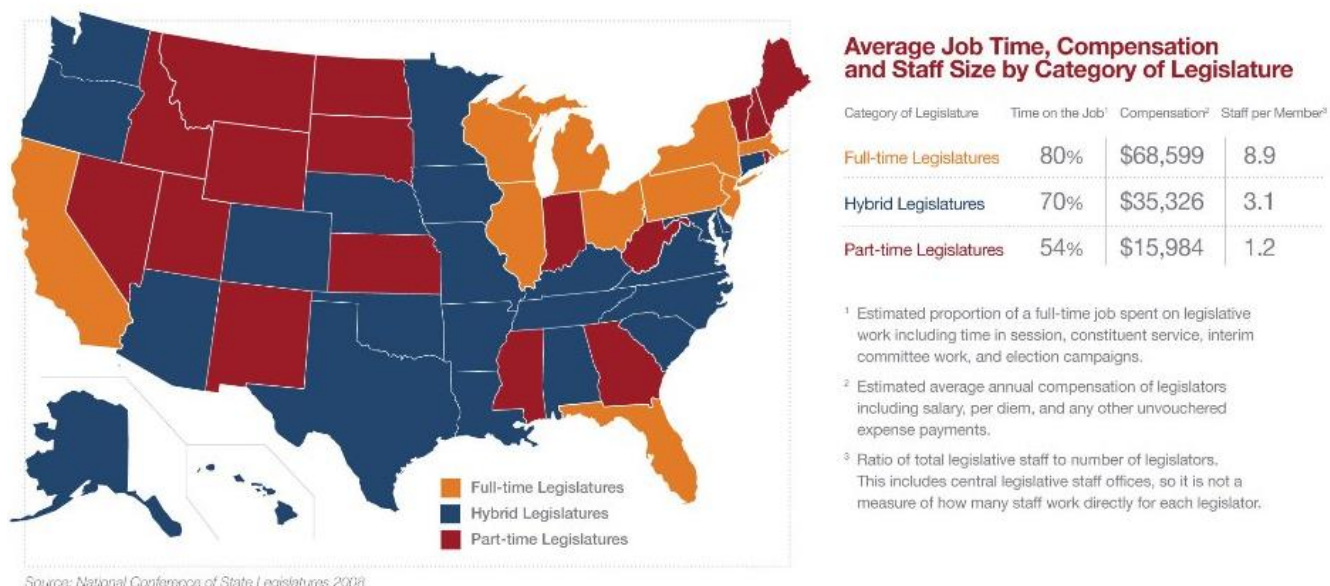
Figure 1: Map of United States indicating the types of state legislatures. Broadly, most states can be classified into one of three categories: full-time (orange), hybrid (blue), or part-time (red). Image reproduced from [Governing](#), data from NCSL (Governing, n.d.(a)).

Further, the best fit for a fellow within a state government depends on the type of legislature in each state. Connecticut's STPF places fellows in executive departments, ensuring full-time work during the fellowship despite Connecticut's hybrid legislature, whereas the full-time New Jersey state legislature enables executive and legislative placements. These considerations of unique governmental structures must be done state-by-state to optimize fellowship effectiveness. It is also necessary to consider potential funding sources— optimal funding sources will vary significantly based on fellow placement, governmental structure, and the local values underlying scientific issues that impact their structure and funding within the government. The most effective STPFs must consider all of these aspects in their design.

Here, we review the opportunities and challenges in establishing a STPF in five states with different political cultures and legislative landscapes: North Carolina, Virginia, Ohio, Texas, and Tennessee. We first describe two fellowship programs, set to begin in 2020, in hybrid legislature states (North Carolina and Virginia). We then discuss how features of these models could be implemented by other states (Ohio,

Texas, and Tennessee) working to develop similar programs.

II. Overview of selected state governments

i. North Carolina

Overview of North Carolina State Government
The legislative body of North Carolina is the General Assembly, comprised of the 50-member State Senate and the 120-member State House of Representatives (NCGA, n.d.(b)). In North Carolina's hybrid legislature, members serve part-time, returning home after each session adjourns. During odd-numbered years, the General Assembly convenes in January for approximately six months. In even-numbered years the legislature meets for about six weeks (NCGA, n.d.(b)). The General Assembly also employs a full-time Central Staff with five divisions (NCGA, n.d.(a)). The Central Staff are non-partisan and not associated with any particular legislative office, instead serving the entire General Assembly and offering independent legal research, bill drafting assistance, and program oversight assistance.

The executive branch includes eighteen departments led by a Secretary (a gubernatorial appointment) or a Commissioner (an elected position), along with

several State Boards and Commissions, the Office of the Lieutenant Governor, and the Office of the Governor (SLNC 2016). Executive branch leadership is divided between the Council of State and the Governor's Cabinet.

Science and Technology Policy in North Carolina
 The General Assembly has no legislative committees or divisions dedicated to science or technology, so related bills are handled by the most relevant committee. The Legislative Analysis Division, Program Evaluation Division, and Fiscal Research Division provide research and analysis services as necessary (NCGA, n.d.(a)).

The General Assembly established and continuously funds programs to increase scientific research and technological discovery in North Carolina. For example, the North Carolina Policy Collaboratory studies environmental quality and human health by leveraging the extensive research expertise within the University of North Carolina System, while the North Carolina Biotechnology Center supports job development and technological growth in the life sciences.

Science and technology policy activities in North Carolina are more evident within the executive branch. North Carolina's Board of Science, Technology, and Innovation, housed within the Department of Commerce, fosters scientific and technological innovation to improve the state's economic well-being (NC Commerce, n.d.). Staff in the Office of Science, Technology, and Innovation issue grants through strategic programs such as the Green Business Fund and the Research Opportunities Initiative and produce policy research for innovation and advancement in areas such as data science (Doron et al. 2016). Executive agencies rely heavily on scientific information to fulfill their charges and engage in research and analysis: the Department of Environmental Quality seeks to protect, preserve, and enhance the state's natural resources through science-based stewardship, and the Office of Recovery and Resilience, a division of the Department of Public Safety, provides disaster relief and recovery assistance. Separately from the state government, the research environment within North Carolina's Research Triangle Park may provide unique opportunities for a state STPF to integrate the state

government with nearby academic and private-sector institutions.

ii. Virginia

Overview of Virginia State Government
The Virginia General Assembly is a hybrid legislature with a 40-member Senate and a 100-member House of Delegates. Annual sessions convene in January for thirty days in odd-numbered years or sixty days in even-numbered years. The Assembly reconvenes in April to consider recommendations from the governor and reconsider vetoed legislation.

The Virginia executive branch includes numerous Departments, Agencies, Boards, Commissions, Offices, and bodies. These groups are categorized and led by eleven governor-appointed Secretaries (Secretary of the Commonwealth's Office, n.d.). The Governor's Cabinet also includes a Chief of Staff, a Chief Workforce Advisor, a Chief Diversity Officer, and legal Counsel (The Commonwealth of Virginia, n.d.).

Science and Technology Policy in Virginia
There is no dedicated scientific advisory office in the Virginia executive branch. A previous position, the Office of the Secretary of Technology, was dissolved as part of a restructuring of the Governor's Cabinet; its duties were distributed to other Cabinet members (Library of Virginia 2002; Wood 2018). Therefore, in designing a state-level fellowship in Virginia, we focused on the legislature.

The General Assembly has two bodies focused on science and technology. One body is the Joint Commission on Technology and Science (JCOTS), a bicameral group of legislators that studies science and technology topics for its members or the General Assembly as a whole. The other is a standing Committee on Science and Technology in the House of Delegates. Other committees deal with science and technology issues as needed. Committees and commissions may meet outside of the legislative session.

Given the General Assembly's hybrid nature, most members have additional jobs outside their legislative roles. However, the legislative session structure limits the careers represented. In 2020 less than 10% of the legislators are engineers, scientists,

medical professionals (including dentists), or economists (VAGA 2020). As a result, few members of JCOTS or the Committee on Science and Technology have scientific expertise to draw on.

Virginia has a large science and technology base to support science policy advising. Virginia is the fourth largest recipient of federal research and development funding (Research!America, n.d.). The jobs provided by this federal and private research funding comprise 6% of all the jobs in Virginia and 4% of the national science and engineering workforce (Khan and Falkenheim 2013). Yet, there are few mechanisms to take advantage of this expertise when designing policy.

iii. Ohio

Overview of Ohio State Government
The Ohio General Assembly is a bicameral and biennium full-time legislature. General Assembly sessions begin the first Monday of odd-numbered years. The General Assembly consists of a 33-member Senate and 99-member House of Representatives. The Legislative Service Commission provides research and analysis to legislators (OLSC, n.d.(a)).

The Ohio executive branch is composed of twenty-six departments of government, such as the Ohio Environmental Protection Agency and the Health Cabinet, underneath the governor (DAS, n.d.). Since Ohio is a full-time legislature, the governor and other executive positions are elected for a four-year term, and the governor then appoints directors of departments in the executive branch.

Science and Technology Policy in Ohio
The Ohio General Assembly has no specialized science and technology committees. Science and technology topics are scattered across committees, particularly in Agriculture and Rural Development, Health, and Energy and Natural Resources Committees (Ohio Legislature House Standing Committees, n.d.). Though legislators have staff who prepare information for these committees, there is a clear need for scientific expertise in the legislative process. There is no focus on technology policy within the legislative process, or through the Legislative Service Commission.

While Ohio has no established science and technology bodies, the government is dedicated to addressing Ohio's needs using science and technology, housing scientific expertise in established state agencies such as the Ohio Environmental Protection Agency and the Opioid Abuse, Prevention, and Treatment Technology Initiative in the Development Services Agency.

iv. Texas

Overview of Texas State Government
The Texas Legislature is bicameral, consisting of a 31-member Senate and a 150-member House of Representatives. The Lieutenant Governor presides over the Senate, establishes standing and special committees, refers legislation to committees, and determines when bills are considered on the floor. The House elects a Speaker with similar control over committees and legislation. With the exception of special sessions, the legislature meets only during odd-numbered years for up to 140 days starting in January.

Texas has a plural executive, where executive branch power is distributed between multiple elected officials, including the Governor, Lieutenant Governor, Secretary of State, commissioners, and appointed agency directors (Texas State Historical Association, n.d.).

Science and Technology Policy in Texas The Texas Legislature has no committees focused on science and technology. However, there are several committees with science and technology topics in their purview. In the House, these committees include Agriculture & Livestock, Energy Resources, Environmental Regulation, Higher Education, Natural Resources, and Public Health. Relevant Senate committees include Agriculture, Health & Human Services, Higher Education, Natural Resources & Economic Development, and Water & Rural Affairs (Texas Legislature Online, n.d.).

There are also Texas state agencies where science and technology expertise are essential. These include the Cancer Prevention and Research Institute of Texas, the Texas Commission on Environmental Quality, the Texas Health and Human Services Commission, the Texas Parks and Wildlife Department, and the Texas State Soil and Water Conservation Board (Texas State Library and Archives Commission, n.d.).

v. Tennessee

Overview of Tennessee State Government
The General Assembly of Tennessee is bicameral, consisting of a 33-member Senate, each serving four-year terms, and a 99-member House of Representatives, each serving two-year terms. The representatives of each body elect Speakers for their chamber, who subsequently appoint the chamber's officers, including committee membership and leadership. The General Assembly has ninety session days spread over two calendar years. It convenes in January, with sessions lasting until late April or May.

The executive branch includes twenty-two Departments led by governor-appointed Commissioners, which comprise the governor's cabinet. The rest of the executive branch is organized into agencies, boards, commissions, and councils that govern various roles to help the governor develop programs and enforce laws.

Science and Technology Policy in Tennessee
There are no legislative committees explicitly focused on science and technology, but existing committees, such as the Senate Committees on Energy and Agriculture and the House committees on Natural Resources and Health, do overlap with science and technology issues. There are also departments in the executive branch that impact science and technology policy in Tennessee, such as the Departments of Economic & Community Development; Environment & Conservation; and Health. Further, state agencies and organizations such as the Tennessee Wildlife Resources Agency and the Tennessee Emergency Management Agency also address science and technology issues.

Tennessee lacks a central science and technology body in the state government. Many issues are approached through adjacent topics. This is evident in the higher education landscape in Tennessee, which includes the Department of Energy's Oak Ridge National Laboratory and two Research I universities, Vanderbilt University and the University of Tennessee–Knoxville (UTK). Both Oak Ridge and The Bredesen Center at UTK provide context for science and technology policies related to energy, while policy efforts at Vanderbilt tend to relate to medicine due to its large Medical Center and federally supported medical research.

A major opportunity in Tennessee is the Governor's Management Fellowship (Tennessee Office of the Governor, n.d.). The program places five fellows each year in the Office of Customer Focused Government to work with the state's executive leaders on various projects. All graduate and undergraduate students, including PhD scientists, can apply. Fellows are exposed to effective government solutions related to technology and government operations—an excellent alternative to a traditional STPF. However, the program began recently, thus public evaluation metrics are not available, which limits comparisons to similar STPFs.

Private organizations also play a major role in Tennessee's science and technology landscape. Life Science Tennessee, a state affiliate of the Biotechnology Innovation Organization, is a member organization of companies whose mission is to grow the local life sciences industry (Life Science Tennessee, n.d.). Another local organization, Launch Tennessee, is an entrepreneur-focused partnership that attracts and supports startups (Launch Tennessee, n.d.).

III. State-level science and technology policy fellowships: two case studies

i. North Carolina
In 2016, a team of students and faculty from Duke University and North Carolina Sea Grant (NCSG) received a planning grant to evaluate the possibility for a STPF in North Carolina (CCST, n.d.(a)). Throughout 2017, the recipients met with over thirty stakeholders, including state officials from the legislative and executive branches, and encountered varying levels of support for a post-graduate STEM policy fellowship. The team found champions within the General Assembly, including legislators and central executive staff from several agencies and offices.

After receiving positive feedback on the feasibility of a STPF, the next challenges were to fund and administer the program. NCSG embraced the role of host institution and allocated $120,000 to hire fellows and administer the fellowship for a two-year pilot program (Mirabilio 2019). The Burroughs Wellcome Fund matched support to fund two fellows each year and cover related administrative costs during the two-year pilot (Mirabilio 2019).

Sara Mirabilio, a fisheries extension specialist at NCSG with experience administering the institution's Coastal Management Fellowship, is the new Fellowship Coordinator for the NC STEM Policy Fellowship. Sara Mirabilio and Dr. Susan White, Director of NCSG, serve as the contacts for the pilot fellowship program, which launched in 2020 (Mosher 2020). The program is particularly focused on diversity, equity, and inclusion, and is committed to training fellows from the diverse communities and backgrounds that comprise the entire state.

Fellows will serve for twelve months starting August 1, 2020 (Mosher 2020). In the first year of the program, NCSG plans to place two fellows in the executive branch. One fellow will be placed in the Office of Science, Technology & Innovation in the Department of Commerce and the other in the State Energy Office within the Department of Environmental Quality, with the potential to expand to legislative offices in the future (Mosher 2020). The NC STEM Policy Fellowship will be evaluated at the end of a two-year pilot program to determine the feasibility of a full program in the future (Mirabilio 2019). The success of the fellowship could be assessed with metrics such as the retention of fellows in state government or subjective measures including the impact of the program on fellows' career trajectories. Qualitative performance reviews and exit surveys could also be implemented to measure the success of the STPF.

ii. Virginia

Members of the Science Policy Initiative (SPI) at the University of Virginia met with several legislators or their staff before and during the 2019 session, including representatives from JCOTS and the House of Delegates Science and Technology Committee. With the dissolution of the Secretary of Technology, there is no centralized body to provide science and technology policy advice in the executive branch, so a legislative placement for a fellowship was seen as more practical. SPI received enthusiastic support for the project, but also got feedback that a shorter fellowship might be more appropriate for the workload associated with these groups as few matters are referred to them and are often presented to other, related committees. In 2019, no new legislation was referred to JCOTS and only twelve bills were referred to the Science and Technology Committee (JCOTS 2019; LIS, n.d.). Commissions and committees meet year-round, but generally have sufficient staff. They would benefit from having an expert as part of that staff but not necessarily full-time.

Based on these discussions, SPI proposed a shorter, twelve-week fellowship, modeled as a hybrid of the CCST Fellowship and the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program at the National Academies of Sciences, Engineering, and Medicine, which is twelve weeks long and is open to current graduate students (NASEM, n.d.). Legislative staff suggested the most effective time for substantive science policy advice would be in the summer or fall when bills are drafted, the ideal time for technical advice and research. A summer fellowship could also be an opportunity for current graduate students, who frequently teach during the academic year. Legislators and staff agreed that PhD candidates would meet their technical needs. Additionally, administering a shorter fellowship for early-career researchers would be cheaper than other fellowship models, which eased initial funding requests.

In 2019, SPI began discussing a fellowship proposal with the Virginia Academy of Science, Engineering and Medicine (VASEM), an independent, non-profit organization comprised of NASEM members who live or work in Virginia. Since 2014, VASEM has hosted summits and published annual reports on science and technology issues to advise Virginia policymakers. VASEM agreed to administer the fellowship as an independent program open to participants from Virginia universities. With VASEM's active connections to science and engineering activities across sectors, the proposed fellowship can now include host offices in the legislative and executive branch, as well as policy-focused divisions in companies and nonprofits.

The 2020 pilot, dubbed the Commonwealth of Virginia Engineering and Science (COVES) Policy Fellowship, will be funded by five Virginia universities and the Chan Zuckerberg Initiative. The inaugural cohort will consist of one fellow from each of these universities and a sixth fellow from a historically black college or university in Virginia. In the future, COVES hopes to open applications to candidates from across Virginia and to postdoctoral researchers (CZI 2020; COVES, n.d.). The fellowship

will be in Richmond, VA or at a legislator's home office. To judge the effectiveness of COVES, VASEM will follow recommendations outlined by CCST (CCST 2016). VASEM will collect data from fellows, participating universities, and host offices, for the use of philanthropic funding applications to maintain and expand the program.

IV. Towards science and technology policy fellowships in additional states

i. Ohio
As the Ohio executive branch has no offices directly relevant to science and technology, initial efforts in establishing a fellowship would be better focused on the legislative branch, expanding to possible executive placements once a fellowship has been run effectively for a few years. The full-time status of the Ohio General Assembly allows for year-long fellowship opportunities, similar to CCST and AAAS fellowships. The Ohio Legislative Service Commission currently houses the Legislative Fellows Program (LFP), though this program focuses on recent graduates from undergraduate programs with experience in public policy wishing to learn more about the state government and careers in public policy (OLSC, n.d.(b)). In the past ten years, less than 1% of Legislative Fellows had a science background, none with advanced scientific degrees. The current LFP assigns fellows to several Legislators as their aides for research and constituent work. The infrastructure of the LFP can be applied to a STPF executed like the CCST and AAAS STPF programs, where fellows are embedded in different Legislators or Committees within the Legislative Branch to help advise policymakers on evidence-based policy. The LFP is funded through the OLSC and is therefore state funded, but implementation of a science and technology fellowship program might need further funding from private or public grants to appeal competitively towards PhDs.

ii. Texas
Elements of the Virginia STPF are particularly applicable to the development of a state STPF in Texas. The twelve-week fellowship timeline fits well with the Texas Legislature's relatively short regular session and, even if fellows are placed with state agencies, the shorter fellowship model minimizes funding and administrative requirements. Like VASEM, The Academy of Medicine, Engineering &

Science of Texas may serve as a central administrator for a fellowship program, but funding would need to primarily come from other sources. One possibility is a decentralized funding model involving contributions from universities or science and engineering professional societies, with possible expansion by future philanthropic grants.

Even with the relatively short legislative session, there has been evidence that indicates interest from legislators in hosting science policy fellows: graduate students from Austin volunteered as part-time interns during the legislative session and developed committee memoranda on technical subjects related to their research. However, this model is limited; it depends on students being located in the same city as the Texas Legislature, requires students to independently establish contacts, and relies upon multiple funding sources. Thus, an impactful step for Texas would be to establish a more structured and accessible pathway for scientists and engineers to participate in the legislative process. The positive impacts of their contributions could then be used to leverage support for further expansion of the program to a full-time twelve-week fellowship model. Additionally, placing fellows at executive agencies with a science and technology purview could be an option for a STPF.

iii. Tennessee
Due to the legislature's short and busy sessions, the most effective timing for a science policy fellow in Tennessee falls outside of the sessions. This allows for sustained input from the fellow when bills are being debated and written, similar to the design implemented in Virginia. However, this is also dependent on whether the fellow is positioned in the legislature or executive branch. Because of the existing Governor's management fellowship that already focuses on government operations and business development, an executive fellowship would likely be centered on a specific policy idea within an executive department. In contrast, a legislative fellow placed outside of the busy session window could more effectively explore multiple science policy topics in consultation with member(s) of the legislature.

A successful science policy fellow would need to approach problems from the scope of Tennessee lawmakers. Tennessee's largest industries—energy,

agriculture, and medicine—necessitate a strong scientific foundation. This dependence on science provides a direct path for a STPF to achieve policy goals, independent of the state's political makeup. Thus, examples of potential fellowship placements include working as a research analyst for various committees in the legislature, working with the executive branch in a relevant agency or department, or working as an advocate with a non-profit like Life Science Tennessee.

V. Conclusion

Based on elements for successful STPFs identified by CCST (CCST 2016), we identify three questions to consider when developing new programs:

1) Who will host the science and technology policy fellows?
2) What will be the funding source for the fellowship?
3) How can fellows be most effective within the state's government structure?

When addressing these questions, it is important to consider that every state has different legislative structures and session lengths, which could impact fellowship design. Thus, it is necessary to find the most effective STPF model in each state. For groups interested in starting a state-level STPF, we recommend the following action items:

1) Collect information on the state government to understand where science policy fellows can effectively contribute.
2) Communicate plans for your fellowship and solicit feedback from state government stakeholders.
3) Research other organizations that work on science and technology policy to identify additional opportunities for science policy fellows outside the government.

During the research collection stage of development, we recommend coordinating with established programs, as many ideas are translatable state-to-state. In Tennessee and Texas, there are merits for both a year-long and a twelve-week fellowship since both state legislatures are not full-time. The full-year fellowship would allow for fellows to offer legislative support during session and as subject matter experts out of session, while a targeted twelve-week fellowship could offer key support in the legislation drafting phase, as was noted in the Virginia program.

The implementation of a STPF is a dynamic process that will be unique to each state. Utilizing these guiding questions and action items, graduate students and science policy organizations across the United States can begin working with their state governments toward the implementation of science and technology policy fellowships.

References

Alberts, Bruce, Barry D. Gold, Lora Lee Martin, and Mary E. Maxon. 2018. "Opinion: How to Bring Science and Technology Expertise to State Governments." *Proceedings of the National Academy of Sciences* 115, no. 9 (02): 1952-1955. https://doi.org/10.1073/pnas.1800543115

California Council on Science and Technology (CCST). 2016. "Elements of a Successful Science and Technology Policy Fellowship Program for State Legislatures." *CCST Science Fellows Program*, January 2016. Accessed March 1, 2019. https://ccst.us/wp-content/uploads/Beyond_California_Elements_2016.pdf

California Council on Science & Technology (CCST). n.d.(a). "State Fellowships Planning Grant." Accessed October 1, 2019. https://ccst.us/reports/science-and-policy-beyond-california/planning-grants/

California Council on Science & Technology (CCST). n.d.(b). "CCST Science Fellows." Accessed February 3, 2020. https://ccst.us/ccst-science-fellows-program/

California Council on Science & Technology (CCST). n.d.(c). "CCST Science Fellows Frequently Asked Questions." Accessed February 3, 2020. https://ccst.us/ccst-science-fellows-program/frequently-asked-questions/

Chan Zuckerberg Initiative (CZI). 2020. "Supporting State Science and Technology Policy Fellows." EurekAlert!, January 31, 2020. Accessed February 3, 2020. https://www.eurekalert.org/pub_releases/2020-01/czi-sss013120.php

The Commonwealth of Virginia. n.d. "Governor's Cabinet." Accessed February 25, 2020. https://www.governor.virginia.gov/the-administration/governors-cabinet/

COVES. n.d. "The Commonwealth of Virginia Engineering and Science Policy Fellowship." Accessed February 3, 2020. http://www.vasem.org/covesfellowship/

Doron, Scott, Shannon McKeen, Lena Leonchuk, David Knowles, and John Hardin. 2016. "NC in the Next Tech Tsunami: Navigating the Data Economy." North Carolina Opportunities in the Data Economy. Last modified November 2016. Accessed October 5, 2019. https://files.nc.gov/nccommerce/documents/files/NC_Big_Data_Report.pdf

Eagleton Institute of Politics (Eagleton). n.d. "Eagleton Science and Policy Initiative." Accessed February 3, 2020. https://eagleton.rutgers.edu/eagleton-science-and-politics-initiative/#eagleton-science-and-politics-fellowship

Engineers and Scientists Acting Locally (ESAL). 2018. "Expert Guidance: The Connecticut Academy of Science and Engineering." Last modified October 14, 2018. Accessed October 3, 2019. https://www.esal.us/blog/expert-guidance-the-connecticut-academy-of-science-and-engineering/

Governing. n.d.(a). "Full-Time, Hybrid, Part-Time Legislatures." Accessed September 30, 2019. https://www.governing.com/gov-data/politics/Full-Time-Hybrid-Part-Time-Legislatures.html

Governing. n.d.(b). "States with Most Government Employees: Totals and Per Capita Rates." Accessed September 30, 2019. https://www.governing.com/gov-data/public-workforce-salaries/states-most-government-workers-public-employees-by-job-type.html

Governing. 2019. "Federal Employees by State." Last modified January 25, 2019. Accessed September 30, 2019. https://www.governing.com/gov-data/federal-employees-workforce-numbers-by-state.html

Himes. 2019. "Idaho Universities Join Forces to Launch Policy Fellowship Program." *University of Idaho News.* Accessed February 3, 2020. https://www.uidaho.edu/news/news-articles/news-releases/2019-april/041719-istpf

Joint Commission on Technology and Science (JCOTS). 2019. "Meeting Summary." Last modified April 2, 2019. Accessed September 30, 2019. http://dls.virginia.gov/commission/summaries/jcots%20summary%2004_02_2019.pdf

Khan, Beethika and Jacquelina Falkenheim. 2013. "Regional Concentrations of Scientists and Engineers in the United States." National Science Foundation, National Center for Science and Engineering Statistics. Last modified August 2013. Accessed September 30, 2019. https://www.nsf.gov/statistics/infbrief/nsf13330/

Launch Tennessee. n.d. "Launch Tennessee - Resources for startups in Tennessee." Accessed October 2, 2019. https://launchtn.org/

Legislative Information System (LIS). n.d. "2019 Session: House Science and Technology." Accessed November 15, 2019. http://lis.virginia.gov/cgi-bin/legp604.exe?191+com+H21N01

Library of Virginia. 2002. "A Guide to the Secretary of Technology, 1998-2002." Last modified June 4, 2002. Accessed October 1, 2019. http://ead.lib.virginia.edu/vivaxtf/view?docId=lva/vi00482.xml

Life Science Tennessee. n.d. "Life Science Tennessee - Non-Profit Member Organization." Accessed October 2, 2019. https://www.lifesciencetn.org/

Mirabilio, Sara. 2019. Discussion with Ryan Dudek, Anna Dye, and Meredith Schmehl on July 31, 2019.

Mosher, Katie. 2020. "Sea Grant Accepting Applications for NC STEM Policy Fellows." Last modified January 10, 2020. Accessed February 2, 2020. https://ncseagrant.ncsu.edu/news/2020/01/sea-grant-accepting-applications-for-nc-stem-policy-fellows/

MOST Policy Fellows. n.d. "MOST Policy Fellows." Accessed February 4, 2020. https://mostpolicyinitiative.org/fellows/.

National Academies of Sciences, Engineering, and Medicine (NASEM). 2018. *Graduate STEM Education for the 21st Century*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25038

National Academies of Sciences, Engineering, and Medicine (NASEM). n.d. "Christine Mirzayan Science and Technology Policy Graduate Fellowship." Accessed February 4, 2020. https://sites.nationalacademies.org/pga/policyfellows/

National Academy of Sciences (NAS), National Academy of Engineering (NAE), and Institute of Medicine (IM). 2008. *State Science and Technology Policy Advice: Issues, Opportunities, and Challenges: Summary of a National Convocation*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12160

National Conference of State Legislatures (NCSL). 2017. "Full- and Part-Time Legislatures." Last modified June 14, 2017. Accessed September 30, 2019. http://www.ncsl.org/research/about-state-legislatures/full-and-part-time-legislatures.aspx.

North Carolina Department of Commerce (NC Commerce). n.d. "Board of Science, Technology, and Innovation." Accessed September 30, 2019. https://www.nccommerce.com/about-us/boards-commissions/board-science-technology-innovation#history-of-the-board.

North Carolina General Assembly (NCGA). n.d.(a). "Divisions". Accessed September 30, 2019. https://www.ncleg.gov/Divisions.

North Carolina General Assembly (NCGA). n.d.(b). "Structure of the North Carolina General Assembly." Accessed September 30, 2019. https://www.ncleg.gov/Help/Topic/232.

Ohio Department of Administration (DAS). n.d. "About State Government." Accessed February 22, 2020. https://das.ohio.gov/for-State-Employees/Orientation-and-Onboarding/Understanding-State-Government#4018132-executive.

Ohio Legislative Service Commission (OLSC). n.d.(a). "About Us." Accessed October 1, 2019. https://www.lsc.ohio.gov/pages/general/aboutus.aspx?active=idA.

Ohio Legislative Service Commission (OLSC). n.d. (b). "LSC Legislative Fellowship Program: About the Program." Accessed October 1, 2019. https://www.lsc.ohio.gov/pages/general/fellowship/legislativefellows.aspx.

Ohio Legislature House Standing Committees. n.d. "House Standing Committees." Accessed February 5, 2020. https://www.legislature.ohio.gov/committees/house-committees.

Reese, April. 2018. "The Most Important Science Policy Issue in Every State." Popular Science. Popular Science, October 17, 2018. Accessed February 3, 2020. https://www.popsci.com/important-science-issues-every-state/.

Research!America. n.d. "Virginia." Research Funding and Economic Impact of Funding by State. Accessed September 30, 2019. https://www.researchamerica.org/advocacy-action/research/research-funding-and-economic-impact-funding-states/virginia.

Secretary of the Commonwealth's Office. n.d. "Organization of Virginia State Government." Accessed February 25, 2020. https://www.commonwealth.virginia.gov/va-government/organization-of-virginia-state-government/.

State Library of North Carolina (SLNC). 2016. "Organizational chart of North Carolina state government." Last modified 2016. Accessed September 30, 2019. http://digital.ncdcr.gov/cdm/ref/collection/p249901coll22/id/704114.

Tennessee Office of the Governor. n.d. "Governor's Management Fellowship." Accessed October 2, 2019. https://www.tn.gov/governor/contact-us/governor-s-management-fellowship.html.

Texas Legislature Online. n.d. "86th Legislature Regular Session." Accessed January 20, 2020. https://capitol.texas.gov/.

Texas State Historical Association. n.d. "Government." Accessed February 21, 2020. https://tshaonline.org/handbook/online/articles/mzgfq.

Texas State Library and Archives Commission. n.d. "State Agency List." Accessed January 20, 2020. https://www.tsl.texas.gov/apps/lrs/agencies/index.html.

Virginia General Assembly (VAGA). 2020. "Members and Session." Accessed February 25, 2020. https://virginiageneralassembly.gov/membersAndSession.php?secid=1&activesec=0#!hb=1&mainContentTabs=0.

Wood, Colin. 2018. "Virginia's smart communities work expected to continue under new governor." *StateScoop*. Last modified January 11, 2018. Accessed September 30, 2019. https://statescoop.com/virginias-smart-communities-work-expected-to-continue-under-new-governor/.

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