Turning Climate Information into Action for Stormwater Management in the Mid-Atlantic Region

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Key Needs for Stormwater Managers

- Practical guidance to be able to select from a range of projected precipitation changes, emissions scenarios, and future time periods.
- Educational materials for policymakers and the public explaining why climate-informed planning and management is needed.
- Examples and case studies of entities that are early adopters of climate-informed stormwater management.
- Data, relevant science, and practical guidance from independent, trustworthy sources.
- Support for how to estimate the cost of inaction against the cost of adaptation.

Recommendations

- Increased funding for national and regional applied policy research could be directed to address these needs, including the development of practical educational materials, guidance documents and case studies.
- Rigorous coproduction processes should be implemented to ensure that funding is used to generate products that address the real needs of stormwater managers.
- Direct support for communities to understand their future flood risk, with funding from state and/or federal departments, could provide much needed capacity.

Flooding is one of the costliest types of natural disasters in the United States. A single major flood event can lead to losses of around $4.6 billion on average (National Centers for Environmental Information, 2023) with average nationwide annual losses from both major and minor flooding totaling around $32.1 billion (Wing et al., 2022). Across the Mid-Atlantic region, extreme precipitation-induced flooding has occurred nearly every season since 2018, leading to property damage, business disruptions, injuries, and loss of life (Mid-Atlantic Regional Integrated Sciences and Assessments [MARISA], undated-a). In one case, from August 14 to 15, 2021, southern Maryland and northern Virginia experienced rainfall rates of up to three inches in 30 minutes. At nearly double the rate for a 100-year storm event, this storm resulted in dozens of flooded basements, closed roads, and downed trees (Miro et al., 2021b; Rosenzweig-Ziff and Samenow, 2021). These extreme precipitation events are occurring more frequently across the Mid-Atlantic region and are expected to continue to increase in frequency and impact.
in the future as a consequence of a changing climate (Wuebbles et al., 2017). Figure 1 shows a map of projected changes in days with precipitation greater than three inches for the Chesapeake Bay Watershed. Many parts of the western portion of the watershed could see a doubling in these extreme precipitation events by the middle of the century. At the national scale, cost estimates suggest an increase in average annual losses of 26 percent, resulting in a potential loss of $40 billion annually because of flooding by 2050 (Wing et al., 2022).

Communities throughout the region will continue to incur significant losses unless they undertake enhancements in stormwater planning and management to mitigate current and future flood risk. However, planning for extreme precipitation poses a broad set of challenges to stormwater management agencies. As described in recent reports (e.g., Galloway et al., 2018; ASFPM Foundation 2019; National Academies of Sciences, Engineering, and Medicine, 2019), aging and inadequate infrastructure, changes in land use and population growth, tight finances, and regulatory requirements already stress existing capacity to contend with extreme precipitation. Inequalities in resources and in technical capacities among communities further magnify the impact of these challenges, as will the increased intensity and frequency of extreme precipitation events combined with sea level rise, tropical cyclones, and other changes in climatic conditions.

Stormwater managers and communities at all resource levels are struggling with how to handle current extreme rainfall events and incorporate knowledge of how climate change could influence these events in the future. Recent and ongoing research and on-the-ground experience from practitioners has demonstrated that this is a multifaceted issue that cannot be addressed by technical support alone.
FIGURE 1
Percentage Change in the Number of Days with Daily Precipitation Above Three Inches for Representative Concentration Pathway 4.5 from 2036 to 2065

SOURCE: Adapted from Fischbach et al., 2018.
NOTE: This figure was created using the Localized Constructed Analogs (LOCA) downscaled climate data product that has a 6-km resolution over the continental United States for the Representative Concentration Pathway (RCP) 4.5, which represents a low emissions future.
it only at the local level. It requires larger-scale policy changes and decisions to meaningfully enhance resilience.

In prior work, researchers from the Mid-Atlantic Climate Adaptation Partnership (CAP) (formerly the MARISA Program) worked with regional funders and stakeholders to develop an easy-to-use online tool that would allow users in stormwater agencies to easily incorporate climate change into their existing planning, design, and management processes. The tool is built on a graphical representation of rainfall statistics called an intensity-duration-frequency (IDF) curve, which has been widely used in water resources engineering design for more than 90 years (Chow, Maidment, and Mays 1988). IDF curves relate the intensity, duration, and frequency of rainfall (e.g., the amount of rainfall from a ten-year storm that lasts 24 hours) and are used to simulate flooding or to determine the amount of rainfall that stormwater infrastructure must retain to reduce flooding. IDF curves that are commonly used in engineering practice, specifically the National Oceanic and Atmospheric Administration’s (NOAA’s) Atlas 14, are based on historical precipitation observations and do not account for recent and projected future changes in the region’s climate. MARISA’s IDF curve tool (hereafter referred to as “the IDF curve tool”) provides users with change factors (e.g., a 20 percent increase) that could be used to scale design storm depths from Atlas 14 to account for future climate change. The interactive online tool and associated report can be found on the MARISA website (MARISA, undated-b; Miro et al., 2021a). Since its publication, many users have shown con-
consistent and continued interest in the IDF curve tool, and users in various localities in the Mid-Atlantic have already begun the process of incorporating the tool’s information into their infrastructure planning and design processes. However, more efforts are needed to substantially broaden and deepen the tool’s use.

In this follow-on work to MARISA’s IDF curve tool, we discuss the types of additional information and support that are needed by stormwater practitioners across the Mid-Atlantic region to apply and fully operationalize the climate-informed IDF curves published in the tool. To learn directly from current and potential users, we spoke with several groups of stormwater managers, engineers, and consultants working for county-level governments across Maryland, Washington, D.C., and Virginia. We also spoke with several engineers and planners at the state and regional levels. From these interviews, we identified three barriers to climate-informed stormwater planning and policy: (1) climate communication and uncertainty, (2) varying community priorities, and (3) infrastructure and regulatory constraints. Our discussion also outlines options for lowering or eliminating these barriers as suggested by or codeveloped with interviewees.

These findings are broadly applicable to the climate services community, which seeks to develop and disseminate climate information and products that support decisionmakers in understanding future climate change and its impacts on their decisions. A variety of organizations and governmental entities are actively working in this space, supported by growing federal funding and increased demand among decisionmakers. This makes the findings of this work not only highly relevant but also timely for the development of climate services products that are actionable in practice. In particular, the NOAA Atlas 15 update process could specifically benefit from incorporating an understanding of key barriers and needs among stormwater decisionmakers. We therefore conclude by presenting suggested next steps for the climate services and applied research communities that would support ongoing and near-term planning efforts to improve the resilience of communities in the region to extreme precipitation events.
Climate Communication and Uncertainty
STORMWATER MANAGERS AND CIVIL ENGINEERS are generally not trained as climate scientists, but they nonetheless need to rely on the output of global climate models or other derived information to adequately protect their communities from extreme precipitation events. This means that climate literacy—an understanding of the science of climate change, the ability to make decisions on the basis of climate change, and the ability to communicate about climate change in a meaningful way—is fundamental for effective climate adaptation. At the same time, stormwater managers attempting to make progress on climate adaptation must also contend with uncertainties about future climate conditions. There is no single best estimate because future climate depends on scenarios of future emissions and economic conditions. Instead, managers need to select a set of future projections on which they will base their planning and design. Discussions with stormwater managers stressed the following challenges: developing their own climate literacy, interpreting and communicating their understanding of climate change to stakeholders and decisionmakers, and facilitating public choices that are robust across a range of future conditions.

Complicating efforts for stormwater managers are the costs of accessing and using current technical resources. When seeking out climate projections to inform planning
efforts, users encounter a variety of potential sources: different global climate models, emissions scenarios, and analyses and tools from different sources (e.g., consultants, government agencies, universities, nongovernmental organizations). In addition, as the climate science community progresses in its understanding of climate change, new datasets are continuing to be made available (e.g., Coupled Model Intercomparison Project 6 [CMIP6]), bringing new projections, emissions scenarios, and vocabulary to learn. The multiplicity of information sources introduces even more complexity to decisionmaking for stormwater managers. Some counties and communities might have enough staff to develop the body of knowledge that is needed to interpret and act on climate information (or to hire consultants to do so), but in less resourced communities, staff could find it too time consuming to incorporate climate into their stormwater planning and design efforts.

In practice, interpreting uncertainty about future climate conditions requires stormwater managers to select from a range of projections of future precipitation generated from multiple emissions scenarios and global climate models that will serve as the basis for their infrastructure or other plans. Figure 2 presents an IDF curve generated by the tool for Franklin County, Virginia. The graph includes the range of projections of changes (shown in blue) for the IDF curve based on one emissions scenario for a two-year return period. Determining whether to choose from the median (dark blue line), the 75th percentile (blue band), or the 95th percentile (light blue band), as well as choosing the emissions scenario or future time period, was a common challenge described by stormwater managers. Such decisions can have important implications for cost (e.g., designing for a 3.5-inch storm instead of a 3-inch storm) that need to be justified and communicated. Additionally, stormwater managers need to understand how much flood risk reduction is actually provided by any increases in cost.

Once a decision has been made on which projected value or values to plan for, stormwater managers are then faced with explaining these choices to decisionmakers and constituents who are the ultimate approvers of their plans. Communicating climate uncertainty in the context of decisionmaking is particularly important given the need to justify costs and defend engineering design numbers. In addition, not only is climate communication and literacy important for stormwater managers but also for policymakers and the public. A lack of climate literacy among these groups is another barrier to climate-informed stormwater management.

Needs Identified by the Interviewees

All of the groups that we interviewed mentioned a need for independently produced guidance for how and why to choose among the range of projected changes, emissions scenarios, and future time periods, as well as a need for
educational materials to help explain these decisions to stakeholders, including policymakers, constituents, and clients. Additionally, several groups expressed a need to have updated data, such as sub-hourly IDF curves or IDF curves that are based on the most up-to-date global climate model output (e.g., CMIP6). Finally, several community representatives mentioned that having hydrologic and hydraulic modeling case studies would be helpful. Specifically, these representatives would appreciate case studies that show (1) how the use of different emissions scenarios changes projections in flood inundation and/or (2) cost estimates that compare the costs of climate adaptation with projected losses from future flooding in the absence of adaptation. The latter could help stormwater managers present the cost of inaction to their stakeholders, as well as the potential benefits from adaptive planning and investment.
Varying Community Priorities
THE PRIORITIES OF A COMMUNITY, as determined by policymakers, the public, or stormwater agencies, can serve either as a barrier or an enabler for efforts to update design standards or build infrastructure to withstand future storm sizes. In large part, this is because these entities must weigh the benefits, costs, and impacts of flood mitigation against a myriad of other public priorities, including property values, economic growth, and equity. Although stormwater managers might approve changes in policy, these changes might not win out in the competition among other worthy public needs at a higher political level, often because nearer-term demands tend to outweigh longer-term needs. In many cases, other priorities could win out in the face of limited budget, capacity, and political will.

Specifically, stormwater managers raised the issue that stormwater regulation, policy, and management can pose increased costs on development. Increases in stormwater management requirements on private developers can be seen as a deterrent to development. Because jurisdictions compete with one another for development, policymakers are often concerned about pushing out developers that might go to neighboring communities with lighter requirements, thus hindering growth in the policymakers’ own jurisdictions. Additionally, increasing development costs
can drive up the costs of housing, which carries its own set of political challenges for policymakers.

At the same time, engineers and policymakers tend to rely on standard approaches to infrastructure design as a way to minimize project implementation risk. While this sounds like it would be an enabler to climate-informed planning, this approach has often meant that these individuals can be slow to adopt new approaches or resist being the first group at the local level out in front of an issue. Many groups suggested that the county, state, or federal government could provide the confidence and top cover needed to change longstanding planning and design approaches.

Often in practice, a small group of practitioners leads efforts within a stormwater management entity to incorporate climate projections into the planning and design of infrastructure. In these cases, these efforts are driven by the initiative of thought leaders rather than on the basis of established regulations. Groups mentioned that prioritizing adaptation efforts can thus be downgraded in the absence of a driving policy or professional standard. Groups also described the need, when proposals are considered, to present airtight rationales, supported by data and analysis, to ensure proposals are technically sound beyond reproach before submitting the proposals to their decisionmakers.

Finally, stormwater managers also raised concerns about identifying new areas of flood risk and the damage this could pose to property values. If new flood maps are released that suggest increases in the number of properties at risk of flooding, property values in these at-risk areas could fluctuate. This a critical issue not only for the residents of these properties but also for the governmental
entities that generate a substantial share of their revenue from property taxes. Some groups suggested that it would be helpful for the Federal Emergency Management Agency (FEMA) to show leadership on this issue and produce updated flood risk maps that incorporate climate change.

**Needs Identified by the Interviewees**

To overcome some of these barriers, many of the groups we interviewed suggested that examples and case studies of entities that are early adopters of climate-informed stormwater planning, regulations, engineering design, and implementation could help support proposals within their own communities. They also described the continued need for independent, nonpartisan organizations and researchers to provide data, relevant science, and practical guidance they can trust and use in their work. Multiple groups framed this need as one of independent verification, noting the critical value of having data or work from an independent organization validate their own analysis. Finally, stormwater managers described the need for support when estimating the cost of inaction against the cost of adaptation to better quantify if and how climate change and any adaptation strategies could affect development, property values, and tax revenues.
Infrastructure and Regulatory Constraints
EXISTING INFRASTRUCTURE CAN LIMIT OPTIONS for adaptation, whether it is the location of residential developments, upstream land use and runoff, the size of underground collection systems, or other built environment features of a community. When existing infrastructure assets are aging and underdesigned for the current climate, they can present significant vulnerabilities and enhance the need for adaptation. One group estimated that 40 to 60 percent of their system is undercapacity to cope with current rainfall patterns. Another group highlighted frequent flooding that is occurring in a residential development built according to outdated codes and standards and located closer to a stream than would be allowed under current permitting processes. Others mentioned that developers often build stormwater infrastructure, which is then handed over to the city, county, or other stormwater entity to manage. Stormwater managers must then work within the constraints of these systems, which can sometimes be a patchwork of neighborhoods with different sized systems, vulnerabilities, and flooding concerns.

In many cities and communities around the region, the core motivation for stormwater management entities is regulatory compliance. This can significantly impede efforts to enhance stormwater mitigation beyond the requirements that are already in place through stormwater-
related regulations. Discussions with stormwater managers often touched on this point. One group gave an example in which attempts to work with other regional entities to respond to increasing storm sizes were dismissed because such increases were beyond regulatory requirements. Others noted that in the absence of state or county leadership (e.g., the issuance of guidance or policy), it would be difficult to convince local policymakers to incur additional costs or to change design requirements unilaterally.

Finally, even when regulations, design standards, or policies are updated to consider climate change, this process can take a significant amount of time. An update to a state stormwater design manual can take eight to ten years from start to finish, for example (Wood, 2023). During this period, climate change projections, which are generally released on a five-year cycle, and our methods to assess and use them will change. This will require regulations to be adaptive, perhaps by referring implementers to an authoritative source that is regularly updated. For example, policies and regulations could point to standards that are recommended by the American Society of Civil Engineers or the U.S. Army Corps of Engineers.
Needs Identified by the Interviewees

Given the nature of built infrastructure and regulatory constraints, stormwater managers noted that some major infrastructure needs could be addressed through funding and capacity building, but that additional guidance was still desirable to ensure new built systems are robust to future conditions. Educating the public and policymakers on why such investments are needed, particularly those that go beyond current regulations, was also a top concern. Updating policies and regulations was commonly discussed by the groups, as this would not only justify the consideration of future precipitation and flooding but require it. One group expressed their desire for state-level regulations that could be applied across all counties. Finally, interviewees noted the value of case studies for instances in which stormwater entities had navigated the practical and logistical aspects of implementing such changes.
Next Steps
OVERALL, moving from understanding climate change to operationalizing climate information in local policies, regulations, and infrastructure design requires more than data alone. Local policy and planning must balance climate considerations alongside local capacities and priorities, including equity, cost, politics, and development and growth. Stormwater entities need support in clarifying objectives, analyzing options, and illuminating trade-offs—all in the service of enabling a better understanding among constituents of the values at stake and facilitating better choices by decisionmakers. In the following paragraphs, we describe the next steps for applied research that could provide this support to communities at national, regional, and local levels. Given the rapid growth in demand and support for climate services, these findings are also highly relevant to the broader climate services community, which could benefit from guidance materials and other support that enhance the usability of climate information and products.

National and Regional Applied Policy Research

Regional climate service providers, such as MARISA and our regional-level counterparts in NOAA’s CAP national network, could support the needs identified in this paper...
by continuing to provide data and tools derived from the most current peer-reviewed science and at the same time working with users to develop implementation-focused educational materials and decision support tools (e.g., decision trees and matrices). These types of resources could be supported by such federal funders as NOAA, the U.S. Environmental Protection Agency, FEMA, U.S. Housing and Urban Development, the Department of Transportation, and the U.S. Department of Agriculture and would provide additional guidance for how local and state practitioners can choose from a range of climate projections for their planning and design purposes and how they can communicate these choices with decisionmakers and constituents. A specific example of a resource that is needed in this space is guidance for stormwater managers on when the selection of climate scenarios matters, including simple heuristics for determining when and how to select among climate scenarios. For infrastructure assets with shorter life cycles, the difference between climate scenarios could be less stark, making the decision among multiple scenarios less important. For infrastructure designed to last 50 or 100 years, the choice of climate scenario can have important implications on the cost and efficacy of these assets.

Importantly, any data products and educational materials that are intended for stormwater managers should be created via a rigorous coproduction process that centers on the real needs of local, county, and state stormwater managers and their constituencies. One example of guidance material developed under this type of process is A Practitioner’s Guide to Climate Model Scenarios from the Great Lakes Integrated Sciences and Assessments CAP (Briley et al., 2021). Additional funding from federal or regional agencies might be needed to develop locally relevant educa-
National materials and decision support tools, particularly to support codevelopment.

**Local Engagement with and Support for Communities**

Applied research teams could also work directly with communities to develop flood maps based on climate projections. This would help communities understand how various climate projections and land uses, current and projected, could influence local flooding and provide those communities with a fuller picture of their flood risk. These types of analyses could further support climate change-informed decisionmaking. As a part of the Consortium for Climate Risk in the Urban Northeast CAP, researchers have been working in partnership with engineers in Camden, New Jersey, to develop flood models that can be run under a range of future climate scenarios to characterize how flooding might change in the future. While some local entities might have the resources to fund this type of work, the majority would benefit from increased federal funding (e.g., from NOAA or FEMA) or funding from state departments of transportation, departments of environment, departments of natural resources, or similar agencies with a role in climate adaptation and flooding.

Guidance materials for stormwater entities could offer simple approaches for estimating the benefits and costs of adaptation options, the benefits and costs of inaction, and other critical planning considerations, such as the equity of benefits and costs across the community. One example
of recent research that combines hydrologic and hydraulic modeling across multiple scenarios through an examination of costs and benefits is the RAND Corporation’s work in Pittsburgh’s Negley Run watershed (Fischbach et al., 2020). A more technical contribution aimed at the water resources engineering community would enhance the IDF curve tool or similar datasets, including projections of changes in storm sizes at subhourly durations.

Finally, research teams could collate and detail case studies of entities that have implemented climate-informed design, planning, and/or management. The case studies could include both the technical details of how climate information was integrated into planning, design, or other management decisions (e.g., how and why engineers selected from a range of climate projections) and the policy and political context that was navigated. This type of information could provide examples of trade-offs that these locations considered, such as cost versus risk mitigation, and illustrate to decisionmaking bodies that some localities have already directly incorporated climate change into their work or generate ideas for navigating local policy or political barriers. Case studies could include a focus on locations, such as Pittsburgh and Philadelphia, Pennsylvania; Camden, New Jersey; and Virginia Beach and Hampton Roads, Virginia.

Adapting stormwater infrastructure to changing climate conditions is crucial for effective management, for mitigating risks to people and property, and for protecting water resources in the future. However, adaptation means more than simply changing numbers in an engineering design calculation; it requires understanding and making decisions based on a range of future climate projections, communicating those decisions, and effectively implementing those decisions. The barriers, needs, and next steps presented in this paper summarize some of the challenges and opportunities for stormwater managers and the research and funding communities that support their work.
Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>CAP</td>
<td>Climate Adaptation Partnership</td>
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<td>CMIP6</td>
<td>Coupled Model Intercomparison Project 6</td>
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<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
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<td>IDF</td>
<td>intensity-duration-frequency</td>
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<td>MARISA</td>
<td>Mid-Atlantic Regional Integrated Sciences and Assessments</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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Notes

1. A 100-year storm event is an event with a one-in-100 chance of occurring based on historical records of precipitation. Similarly, a ten-year storm would have a one-in-ten chance of occurring based on the historical record.

2. This project was funded by the Chesapeake Bay Trust under the Chesapeake Bay Program’s Goal Implementation Team, the Virginia Transportation Research Council, and the Commonwealth Center for Recurrent Flooding Resiliency. The Virginia team of funders was led by the special assistant to the governor for coastal adaptation and protection from the state of Virginia.

3. As of June 23, 2023, the tool had more than 2,600 individual users over the prior 12-month period. Users viewed the tool from locations across the United States, but Maryland and Virginia had the top numbers of users with more than 400 users each.

4. See, for example, A Federal Framework and Action Plan for Climate Services (Fast Track Action Committee on Climate Services, 2023).

5. The Atlas 15 update will be complete for the continental United States by 2027 (Office of Water Prediction, 2022).

6. The choice of emissions scenarios leads to greater differences between IDF curve change factors in future time periods (e.g., 2050 and beyond).

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References


MARISA—See Mid-Atlantic Regional Integrated Sciences and Assessments.

Mid-Atlantic Regional Integrated Sciences and Assessments, “Mid-Atlantic Regional Climate Summaries,” webpage, undated-a. As of July 25, 2023: https://www.midatlanticcrisa.org/climate-summaries.html

Mid-Atlantic Regional Integrated Sciences and Assessments, “Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia,” webpage, undated-b. As of July 25, 2023: https://midatlantic-idf.rcc-acis.org/


**About This Perspective**

Flooding is one of the costliest types of natural disasters in the United States. Across the Mid-Atlantic region, extreme precipitation-induced flooding has occurred nearly every season from 2018 to 2023, leading to property damage, business disruptions, injuries, and loss of life. These extreme precipitation events are occurring more frequently across the Mid-Atlantic region and are expected to continue to increase in frequency and impact in the future as a consequence of a changing climate. We discuss key information needs for these agencies that could help lower barriers to understanding climate change and operationalizing climate information in local policies, regulations, and infrastructure design. Our discussion also provides recommendations for applied research that would address these barriers and support stormwater management agencies in more effective climate adaptation at local, regional and national scales. The findings and recommendations detailed in this paper are further summarized in a short video available at www.rand.org/t/PTA2794-1.

**NOAA Mid-Atlantic Climate Adaptation Partnership (formerly RISA) Program (MARISA)**

The Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) program was established in September 2016 with a five-year grant from the National Oceanic and Atmospheric Administration’s (NOAA’s) Climate Program Office (CPO); MARISA received a second five-year grant in September 2021. It is one of a network of Climate Adaptation Partnership teams across the United States and Pacific Islands funded by the NOAA CPO. MARISA supports integrated, flexible processes for building adaptive capacity to climate variability and change in diverse settings in the Mid-Atlantic region. MARISA is led by the RAND Corporation, in partnership with researchers at Pennsylvania State University, Johns Hopkins University, Cornell University, the Virginia Institute of Marine Science, Carnegie Mellon University, and Morgan State University.

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