Réduction de la vulnérabilité aux inondations des infrastructures de recherche-développement-innovation du bassin de la Loire et ses affluents

Après avoir mené des actions de réduction de la vulnérabilité des activités économiques (http://www.eptb-loire.fr/rvi-entreprises/) ainsi que des biens culturels patrimoniaux (http://www.eptb-loire.fr/reduction-de-vulneraribilite-des-biens-patrimoniaux/), l'Etablissement a lancé en septembre 2017 une analyse exploratoire de la vulnérabilité aux inondations des investissements de recherche-développement-innovation sur le bassin de la Loire et ses affluents.

Partant du constat que les institutions de recherche publiques ou privées sont des moteurs du développement économique dans leurs domaines de compétence, et qu'elles font l'objet d'investissements importants, il est apparu opportun de s'interroger sur leur vulnérabilité par rapport à une inondation majeure sur le bassin de la Loire et ses affluents. Quels impacts celle-ci pourrait-elle avoir sur l'appareil productif de recherche (dans le secteur privé, six branches de recherche : automobile, aéronautique, pharmacie, activités spécialisées, scientifiques et techniques, activités informatiques et services d'information et chimie exécutent la moitié de la dépense intérieure de R&D des entreprises ; dans le secteur public, les organismes de recherche (EPST, EPIC) exécutent 54 % de la dépense intérieure de R&D des administrations) ?

Une crue majeure entrainerait-elle l'endommagement, l'arrêt, voire la perte d'investissements lourds : installations ou équipements, et par-delà une destruction de l'intelligence acquise par les centres de recherche ? En termes de compétitivité des territoires, bouleverserait-elle l'organisation, aurait-elle un impact sur les flux de financement et même, éventuellement, sur le crédit de certains pôles de recherche ou de laboratoires. A titre de retour d'expérience, on citera les conséquences néfastes de l'ouragan Sandy sur le plus gros hôpital universitaire des Etats-Unis (Université de New-York) ou bien, dans un raisonnement en termes de filière de recherche, l'analyse menée par l' *Academic Biomedical Research Community* (2017) : (https://www.nap.edu/catalog/24827/strengthening-the-disaster-resilience-of-the-academic-biomedical-research-community).

En 2014, en France, les travaux de recherche et développement (R&D) effectués sur le territoire national représentent une dépense de 47,9 Md€ (source Ministère), soit 2,24 % de la richesse nationale (PIB) Par ailleurs, entre janvier 2014 et septembre 2016, la France a perçu 2,1 Md€ au titre de ses participations au programme-cadre européen Horizon 2020 (H2020) en faveur de la recherche et de l'innovation. Avec 10,6 % des subventions allouées, la France est le 3ème bénéficiaire des crédits européens en faveur de la recherche. Pour la période 2014-2020, l'Union européenne a prévu d'allouer un budget d'environ 77 Md€ à la recherche, au développement et à l'innovation, soit près d'1,5 fois le budget alloué lors de l'exercice précédent.

Au vu de ces chiffres, explorer et questionner cette vulnérabilité éventuelle, dans la perspective de préparer l'appareil productif de recherche, sur le bassin de la Loire et ses affluents, à être plus résilient au risque inondation apparaît utile, voire indispensable sur les territoires à risque important d'inondation (TRI) qui concentrent un important « capital » RDI.

En effet, ce bassin fluvial comporte de nombreux centres ou pôles de recherche publics et privés, certains d'importance nationale[1]. Leur vulnérabilité au risque inondation reste néanmoins à appréhender à l'échelle du bassin. Ainsi, un recensement des sites et équipements stratégiques de recherche, qu'ils soient publics ou privés, est à croiser avec une cartographie du risque inondation.

Ce croisement sera analysé et mettra en évidence les risques financiers potentiels sur les investissements réalisés et prévus (court, moyen ou long termes). Des indicateurs économiques et géographiques illustreront le risque potentiel. Ils pourront être ouverts à d'autres champs liés au croisement vulnérabilité/recherche : démographie, emploi, formations, rayonnement, etc…, des ratios existants ou à déterminer pourront être utilisés et présentés.

Après avoir fait une photographie et une cartographie des vulnérabilités éventuelles, il est attendu des propositions sur la manière de conduire une analyse et de construire une méthodologie visant à réduire rapidement et significativement la vulnérabilité des infrastructures de recherche sur le bassin de la Loire et ses affluents : identification des acteurs plus particulièrement concernés et de la réglementation « spécifique » applicable le cas échéant, sensibilisation et conscientisation au risque inondation, ainsi que d'éventuelles recommandations de mesures. Les recommandations stratégiques comme opérationnelles (hiérarchisation, priorisation des filières, des sites, …) pourront s'appuyer sur des retours d'expériences en France ou à l'étranger.

Il est à noter qu'un comité de suivi est prévu pour accompagner la réalisation de cette action. Il associera les collectivités compétentes ainsi que les structures représentatives des organisations intervenant en RDI.

Les crédits pour la prestation dont il s'agit (achèvement prévu fin avril 2018), d'un coût total prévisionnel maximum de 30 k€ TTC, sont déjà inscrits au budget 2017. Il est envisagé de solliciter une subvention de l'Europe (FEDER).

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[1] Dans cet ordre de considérations, l'INSEE analyse l'effort de recherche dans les régions : https://www.insee.fr/fr/statistiques/1287833#graphique-figure1. Une mise en perspective à l'échelle du bassin pourrait, le cas échéant, apporter des éléments d'appréciation supplémentaires sur cet enjeu.

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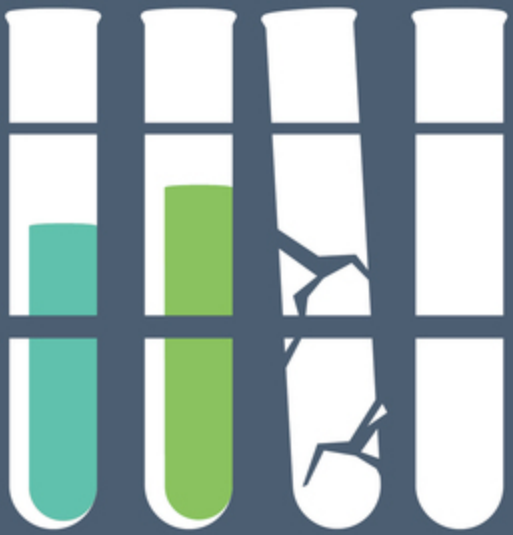
CONSENSUS STUDY REPORT

Strengthening the Disaster Resilience of the Academic Biomedical Research Community

Protecting the Nation's Investment



Summary[1]

The academic biomedical research community[2] is a hub of employment, economic productivity, and scientific progress. Sponsors' financial investments can be substantial; funders external to academic research institutions invest about $27 billion annually in academic life sciences research. Academic research institutions are drivers of economic development in their local and state economies and, by extension, the national economy. Beyond the economic input that the academic biomedical research community both receives and provides, it generates knowledge that in turn affects society in myriad ways.

The United States has experienced and continues to face the threat of disasters, and, like all entities, the academic biomedical research community can be affected. Recent disasters, from hurricanes to cyber-attacks, and their consequences have shown that the investments of the federal government and of the many other entities that sponsor academic research are not uniformly secure. First and foremost, events that damage biomedical laboratories and the institutions that house them can have impacts on the safety and well-being of humans and research animals. Furthermore,

[1] This summary does not include references. Citations for the discussion presented in the summary appear in the subsequent report chapters.

[2] For the purpose of this report, the committee defines the academic biomedical research community as broadly encompassing those research sponsors, academic research institutions and their research enterprises, and researchers involved in the conduct of biomedical and biological research. The committee uses the term "research enterprise" to define the policies, procedures, organizational structure, staffing, facilities, and practices used to fulfill the academic institution's research mission.

disasters can affect career trajectories, scientific progress, and financial stability at the individual and institutional levels. Disasters can very directly influence investigators' ability to meet grant goals and requirements, in turn influencing the metrics for and program outcomes of their sponsors. This should be a signal that the academic biomedical research community should begin discussing how to prepare for the worst, as the worst clearly can happen. Historically, the protection of research as a critical national resource and economic driver has been less of a priority than promoting the research itself. This report discusses the importance of protecting the academic biomedical research community, and the committee makes 10 recommendations to achieve this goal.

Resilience is an imperative that should be sought throughout all sectors of American society, and the academic biomedical research community's contribution to that national resilience is critical, given its substantial integration within the national fabric. Recognizing a profound need, the Alfred P. Sloan Foundation, the Doris Duke Charitable Foundation, the Howard Hughes Medical Institute, and the National Institutes of Health (NIH) requested that the National Academies of Sciences, Engineering, and Medicine assemble an ad hoc committee to develop recommendations and guidance to enhance the disaster resilience of the academic biomedical research community, with a special focus on the potential actions researchers, academic research institutions, and research sponsors can take to mitigate the impact of future disasters. The full charge to the committee is presented in Chapter 1.

This report is organized into three parts that collectively define the committee's vision of a resilient academic biomedical research community and provide recommendations and guidance for how this vision can be achieved. Part I describes the various ways in which prior disasters have affected the academic biomedical research community (Chapter 2) and presents an overview of the academic biomedical research community and its key components in the context of disaster resilience (Chapter 3). Part II lays out the strategic planning process necessary for academic research institutions to achieve a resilient research enterprise by using the National Preparedness System (Chapter 4), focusing specifically on prevention, protection, and mitigation actions and priorities (Chapter 5), as well as on response and recovery actions and priorities (Chapter 6). The final part discusses special considerations for laboratory animal research (Chapter 7), the built environment (Chapter 8), capital planning (Chapter 9), and research sponsors (Chapter 10). Each chapter in these three parts concludes by highlighting the committee's key messages and recommendations for strengthening the disaster resilience of the academic biomedical research community.

A RESILIENT ACADEMIC BIOMEDICAL RESEARCH COMMUNITY: HOW THE PIECES FIT TOGETHER

As part of its statement of task, the committee was asked to describe the extent of the impact of prior disasters on the academic biomedical research community. Through extensive search of the existing literature, the committee found that if the academic biomedical research community is not protected in advance of disasters, the impacts can be felt at all levels: impacts on the safety and well-being of humans and research animals; disruptions to the careers of individual researchers; departure of research faculty and students; loss of data, samples, reagents, specialized equipment, and other materials; damage to buildings and physical infrastructure; interruptions to the institutional research mission; impacts on research funding and research sponsor investments; and so on.

Resilience is defined as the ability to prepare for, absorb, recover from, and more successfully adapt to adverse events, and the academic biomedical research community should set a goal to prioritize and institutionalize resilience. Resilience involves a long-term commitment that requires every stakeholder of the academic biomedical research community to accept responsibility and act on it, from the individual researcher all the way up to the institutional leadership and the research sponsor. The academic biomedical research community can benefit by understanding that the integration of resilience into routine functions and other overarching goals and initiatives, such as improving laboratory safety, can help mitigate the impact of disasters. To achieve resiliency, the academic biomedical research community should undertake actions necessary to develop, sustain, and improve its ability to mitigate against, prepare for, respond to, continue operations during, and recover from disasters (see Figure S-1).

THE ROLE OF THE ACADEMIC RESEARCH INSTITUTION AND THE INDIVIDUAL RESEARCHER

An academic research institution's research mission functions within a complex set of institutional functions and priorities. Resilience planning should be an institution-wide process that requires the full endorsement of the senior leadership, the authority to establish priorities, and the necessary financial support; the plans themselves require the full engagement of individuals and operating units with the detailed understanding of the research enterprise necessary to develop, maintain, and test the plans. In this way, both the senior leadership and the individual researcher share accountability in the resilience planning process.

The committee found that the institutional organizational structure affects the feasibility of implementing various resilience strategies and can create challenges to achieving disaster resilience for the research enter-

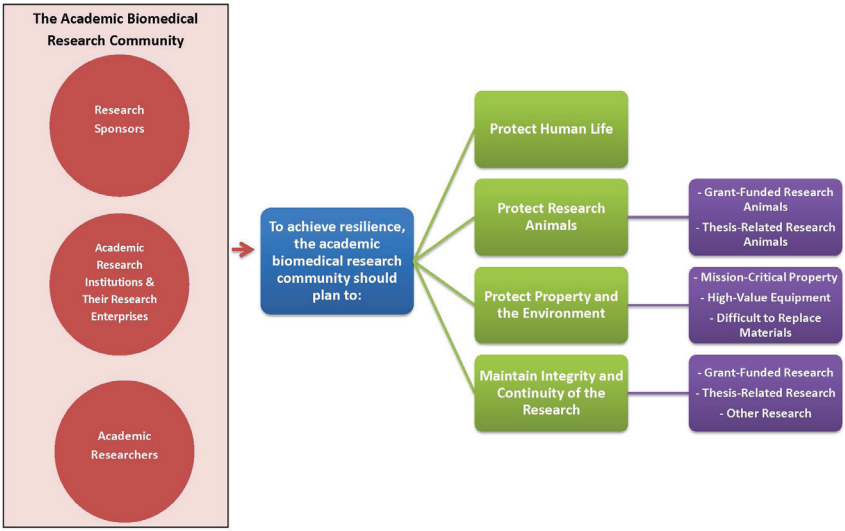


FIGURE S-1 Goals of a resilient academic biomedical research community.

prise. Achieving a disaster resilient research enterprise is likely to require dedicated effort for leadership of the research enterprise planning process that will complement and integrate with the overall institutional planning process. Therefore, the committee recommends that support for disaster resilience for the research enterprise should come from a high level within institutional research leadership. The committee refers to this function as the "chief resilience officer for the research enterprise" (see Figure S-2).

Designate a Qualified, Senior Individual with Oversight of Disaster Resilience Efforts for the Research Enterprise

RECOMMENDATION 1: Academic research institutions should designate a qualified, senior individual with oversight of disaster resilience efforts for the research enterprise. The qualified, senior individual should be integrated within the framework for institutional disaster preparedness to ensure that the research enterprise is represented in and coordinated with overall institutional disaster resilience efforts. The qualified, senior individual should lead a research enterprise planning committee to work in coordination with the institution to assess the unique characteristics of the research enterprise; to determine resilience goals and objectives; and to develop, implement, and maintain plans.

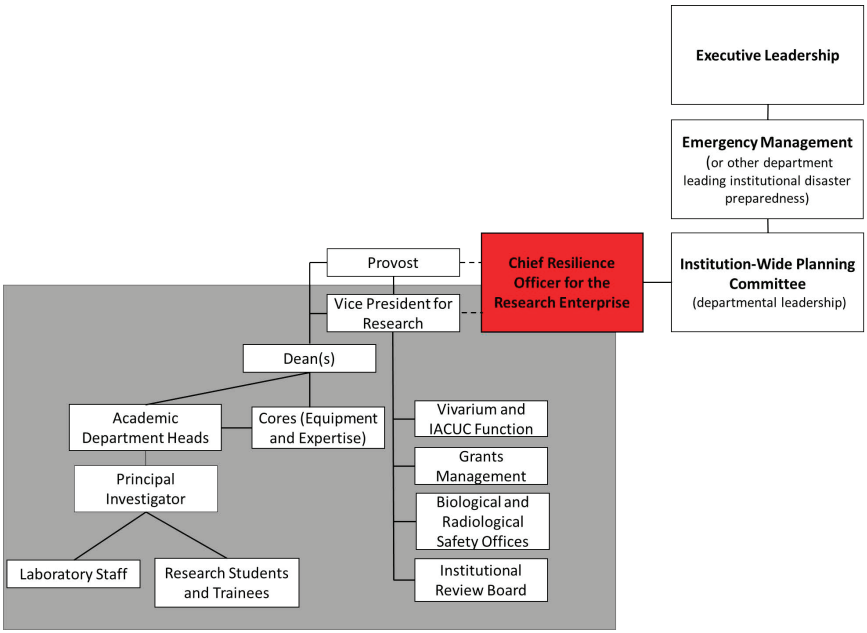


FIGURE S-2 Example of how the chief resilience officer for the research enterprise represents the concerns of the research community within the framework for institutional disaster preparedness.
NOTES: The function could be represented by an existing position or could be a delegated role, but the key takeaway is that this function resides at a high level within the institutional research leadership and integrates within the institutional disaster preparedness framework. The committee also acknowledges that the organizational structure will change in response to a disaster based on the incident command system structure, which is a uniform structure that outlines authority and delegates decision-making responsibilities to respond in times of disaster.

Possible responsibilities of this individual could include, but are not limited to:

- Developing a vision of resilience to protect the research enterprise.
- Providing oversight, communication, collaboration, and coordination of a broad and diverse group of institutional stakeholders to engage in all-hazards planning for the research enterprise in concert with institutional planning.
- Developing, enhancing, and leveraging local, state, and national partnerships that inform efforts to enhance the disaster resilience of the research enterprise.

- Supporting the understanding and use of the National Incident Management System and the Incident Command System among peers.
- Enhancing disaster resilience of the research enterprise through the development of trainings and exercises germane to the research community.
- Striving for multi-dimensional communications and enhancing education, awareness, and understanding of what to do before, during, and after disasters among students, staff, and faculty of the research enterprise.
- Monitoring the implementation of and compliance with disaster resilience policies and procedures.

The chief resilience officer for the research enterprise should focus on plans specific to the research enterprise and complement the broader resilience efforts conducted by the institution. The chief resilience officer for the research enterprise should represent the interests of the research enterprise and integrate into the overall institutional disaster preparedness infrastructure. Placing this function at a high level within the institutional research leadership ensures there is comprehensive understanding of the research enterprise and authority for action. This function is necessarily complemented by the emergency management function, which holds the formal education, training and expertise in emergency management and disaster resilience planning. The committee concludes that the chief resilience officer for the research enterprise should lead a research enterprise planning committee in coordination with the academic research institution to assess the unique characteristics of the research enterprise, determine resilience goals and objectives, and develop, implement, and maintain plans. The research enterprise is best protected if researchers are involved in the planning process and if senior leadership champions and participates in the planning process. To facilitate this approach, participation on the research enterprise planning committee could include those who are most knowledgeable about the resources required to perform research functions, those who have a personal stake in the outcome and the ability to follow through on a sustained program of planning and implementation, and those involved in disaster planning at the institutional level.

The chief resilience officer for the research enterprise and the research enterprise planning committee, in coordination with the institution-wide planning committee, should be tasked with developing the "family of plans" for the research enterprise—plans encompassing the spectrum of prevention, protection, and mitigation actions as well as response and recovery actions. The National Preparedness System, promulgated by the federal government, consists of standardized emergency management principles

and practices that are commonly used by emergency management agencies to engage in an organized planning process that is part of the whole community's effort to move forward with achieving resilience. Because the disaster preparedness and resilience of academic research institutions is closely tied to the preparedness and resilience of the broader community, academic research institutions should align planning practices with the National Preparedness System.

Implement Comprehensive and Integrative Disaster Resilience Planning Efforts for the Research Enterprise

RECOMMENDATION 2: Academic research institutions should implement comprehensive and integrative disaster resilience planning efforts for their research enterprise that are aligned with planning at the local, state, and national level (the National Preparedness System). The fundamental goal of these efforts should be to protect human life, research animals, and property and the environment and to maintain the integrity and continuity of the research.

Possible actions could include, but are not limited to:

- Identifying dedicated resources and individuals with the authority to oversee the development and execution of disaster resilience planning.
- Developing and implementing policies, plans, and procedures related to disaster resilience.
- Compiling up-to-date threat and hazard identification and risk assessments based upon the local and regional hazards that are relevant to the academic research institution and specifically the research enterprise.
- Determining which research programs and research functions are critical for the continuing viability of the academic research institution and the safety of the community. Research programs should be prioritized, and the necessary resources to safeguard and support these programs should be identified and acquired.
- Engaging principal investigators in the disaster resilience planning for their research program and laboratories.
- Developing a training and exercise plan to document overall training and exercise priorities for a specific multi-year time period.

Furthermore, given that academic research institutions are large, complex systems that face unique challenges, and have a large array of vulnerabilities, they require a multitude of partnerships. It is crucial that strong community partnerships be developed with both private and public entities

in order to facilitate planning, information sharing, and mutual assistance. Partnerships offer opportunities for the alignment of resources and innovation. Additionally, when a disaster occurs, academic research institution staff, community emergency responders, and key stakeholders must interact efficiently to provide a timely, coordinated, and cohesive response. For example, under the Emergency Planning and Community Right-to-Know Act, Local Emergency Planning Committees (LEPCs) must develop an emergency response plan, review the plan annually, and provide information about chemicals in the community to citizens. These plans are developed by LEPCs who include at a minimum: elected state and local officials; police, fire, civil defense, and public health professionals; environment, transportation, and hospital officials; facility representatives; and representatives from community groups and the media. This is a great opportunity for academic research institutions to participate in planning with the local community. It is important that local first responders have advanced knowledge of the research enterprise disaster resilience plans to understand the unique research environments they may be responding to (e.g., animal facilities, chemicals, and biological agents), and to set expectations for response and identify aspects of planning that may need to be revised.

Develop, Enhance, and Leverage Local, State, and National Partnerships

RECOMMENDATION 3: Academic research institutions should actively engage with key local, state, and national agencies to establish a mutual understanding of the unique disaster resilience efforts necessary for the research enterprise. Local agencies with the delegated authority to respond during a disaster should understand the unique laboratory conditions. In the event of disaster, the research enterprise's resources could prove valuable to the local community.

Possible actions could include, but are not limited to:

- Identifying a method of engagement with external community partners such as the Local Emergency Planning Committee, emergency management, law enforcement, fire, public works, weather service, the department of transportation, and others.
- Developing a mechanism to engage the local emergency operations center.
- Establishing partnerships with suppliers and peer institutions so that crucial resources (e.g., food, water, emergency generator fuel, etc.) can be directed to the institution promptly following an interruption of normal supply channels. Examples of formal agreements include mutual aid agreements and memoranda of understanding.

- Developing a mechanism for peer institutions to engage in proactive dialogue about disaster management and resilience and to foster communication and transparency between institutions.
- Carrying out exercises together on a regular basis.

In addition to the high-level strategies and planning efforts described in this report, individual researcher–based efforts are essential to achieving resilience. The committee found that while institutions as a whole are undertaking disaster planning, researchers rarely, if ever, consider what might happen to their research should a disaster occur. The principal investigator (PI) is the central focus of research efforts. PIs and their laboratory members are in the best position to understand the specialized needs of their specific research. To promote a resilient laboratory and protect their research, PIs should actively engage in disaster planning with institutional leadership.

Ensure the Preservation of Research Data, Samples, and Reagents

RECOMMENDATION 4: Principal investigators should work with their academic research institution to safeguard and preserve critical research data, samples, and reagents. As stewards of their research and creators of the valuable intellectual property of their academic research institutions, principal investigators should play a pivotal role in protecting the intellectual assets of their academic research institution through the development and implementation of policies, plans, and procedures related to disaster resilience. Academic research institutions should work to increase incentives for off-site storage and the duplication of critical samples and data. Protecting the research data, samples, and reagents of the research enterprise is ultimately the responsibility of both the principal investigator and the academic research institution.

Possible actions could include, but are not limited to:

- Developing and implementing plans, policies, and procedures to ensure operational continuity.
- Ensuring critical research data are backed up using reliable, tested, and secure methods.
- Documenting and backing up research methodology.
- Storing selected duplicate samples in a remote location.

In order for academic research institutions to adequately implement and execute plans for their research enterprises, they need their researchers to remain up to date on accreditations, current trends, and trainings. Essentially all academic research institutions have various levels of required

training for researchers in areas related to safety, ethics, and compliance as well as new employee orientation tailored to systems and requirements for the specific institution. These types of researcher training activities may aid institutions in disaster resilience; for example, some of the existing training programs and modules could have components added that are relevant to disaster resilience.

Encouraging researchers to attend trainings and workshops focused on disaster preparedness and response will systematically increase the academic research institution's awareness of the necessary tools and strategies used in preparation for a disaster. It is important that researchers maintain a culture of compliance and strive to practice safe work practices in their day-to-day duties in order to minimize the cascading effects that typically follow a disaster. By undertaking personal preparedness actions both at home and in the laboratory, researchers themselves can strengthen the disaster resilience of the academic biomedical research community.

Implement Mandatory Disaster Resilience Education and Training Programs

RECOMMENDATION 5: Academic research institutions should implement mandatory disaster resilience education and training programs and integrate these programs within the broader safety, ethics, and compliance training programs for students, staff, and faculty of the research enterprise. Those individuals in the research enterprise who are responsible for responding during a disaster should understand their roles; therefore, education and training programs for researchers should be modeled after education and training programs for first responders.

Possible actions could include, but are not limited to:

- Educating and training new researchers in disaster response and resilience upon hiring or enrollment. Training should emphasize that personal preparation is the key to participation in any disaster response, and new researchers should have plans for family independence and communication in place before a disaster strikes.
- Involving research students in the education and training process, both because they can bring a fresh enthusiastic perspective to the planning efforts, and because they provide an opportunity to educate the next generation of researchers about disaster resilience-related activities.
- Training of the key responders at the institution in the Incident Command System (e.g., ICS Courses 100.HE and 700) to greatly improve their ability to communicate with the first responders outside of the academic research institution.

THE WELFARE OF RESEARCH ANIMALS IN A DISASTER

It has been documented that the presence of animals during a disaster alters response and recovery operations following a disaster. Currently, the *Guide for the Care and Use of Laboratory Animals* (the *Guide*) remains the primary guidance document addressing disaster planning for the animal research community. Institutions that receive any funding from the Public Health Service (PHS) must comply with the PHS Policy on Humane Care and Use of Laboratory Animals (PHS Policy), which uses the *Guide* as its standards document. NIH Office of Laboratory Animal Welfare (NIH-OLAW) oversees the implementation of the PHS Policy. Animal research programs at AAALAC International–accredited institutions must have a disaster plan that follows the *Guide*. A second set of regulatory requirements for animal disaster plans was proposed by Department of Agriculture's Animal and Plant Health Inspection Service (USDA–APHIS) in 2012; however, objections from the regulated community resulted in the issuance of an indefinite stay in 2013. The current guidelines available to the animal research community to guide disaster planning activities are incomplete and do not align with effective planning principles as outlined in the National Preparedness System.

Additionally, there are several entities that collect first-hand reports of adverse impacts and deaths of research animals that occur during disasters, but this information is not currently shared with the animal research community at-large. The absence of credible, published information about what contributes to the success or failure of disaster plans is unfortunate. The communication of best practices could be used to improve many plans, and the acknowledgement of lessons learned from unanticipated failures could minimize the propagation of errors.

Animal research professionals at institutions must also play a key role in defining and communicating to the architects and engineers on the design team the level of protection that is necessary for the vivarium. In the event of a disaster, essential facilities are required to be designed to maintain their operations during and following a disaster, and facilities that handle or store hazardous materials are required to be designed to maintain containment. Therefore, the academic research institution should consider their vivaria as essential facilities and work to incorporate fail-safe design criteria.

Improve the Disaster Resilience of Animal Research Programs

RECOMMENDATION 6: Academic research institutions should acknowledge that **there is an ethical imperative to conduct disaster resilience efforts to preserve the lives and prevent the suffering of research animals.** Academic research institutions should consider designating vivaria as essential facilities and should work to incorporate fail-safe design criteria.

Possible actions could include, but are not limited to:

- Conducting comprehensive planning for the animal research program by a multi-disciplinary planning group that is integrated with the institutional planning group.
- Identifying a method of engagement with external community partners, such as the Local Emergency Planning Committee, emergency management, law enforcement, fire, public works, weather service, department of transportation, and others, to communicate the unique public health and safety issues of the animal research program.
- Developing evacuation and shelter-in-place procedures, as well as procedures in the event research animals escape, in emergency operations plans for animal facilities. Facilities maintenance staff should be involved in the planning process so that they are aware of the power and utilities requirements for the vivarium post-disaster for successful sheltering-in-place. Plans should include contact information for the people who can facilitate the acquisition of outside assistance and help meet regulatory reporting requirements. The Office of the State Veterinarian (or the authority having jurisdiction for animals) is the point of contact for obtaining any outside assistance for animals that might be available at the local, state, or federal levels. Institutions that receive Public Health Service funds are required to contact NIH–OLAW; those with species regulated under the Animal Welfare Act are required to contact USDA–APHIS; and accredited organizations are required to contact AAALAC International.
- Incorporating fail-safe criteria in vivarium design, as appropriate for each animal research program. Examples include: (a) designing and testing emergency power systems on a schedule that is similar to that required for a hospital; and (b) ensuring that the valves controlling reheat coils on heating, ventilation, and air-condition systems fail in the closed position.
- Basing the vivarium location on a threat and hazard identification and risk assessment. A safe location within the building should be selected. A vivarium should never be placed in flood-prone areas within a building.

A RESILIENT BUILT ENVIRONMENT FOR THE RESEARCH ENTERPRISE

For an institution committed to improving the disaster resilience of its current and future research enterprise an in-depth consideration of how

the built environment can be made more resilient to mitigate losses and speed-up recovery is an invaluable and cost-effective strategy. Protecting the research is not dependent simply on a laboratory process, but it is also dependent upon the infrastructure designed for maintenance, safety, and security. Very little to no consideration is currently given to how best to protect and sustain the research laboratory space, equipment, research-related assets, or research animals—each of which plays a critical role in support of scientific endeavor—in the event of a disaster. Because of the unique value of the experiments, research-related assets, and research animals and because of the general neutral priority that their protection is given by the building codes and emergency-response operations, academic research institutions should establish and implement comprehensive performance-based design criteria to ensure that their research facilities adequately protect the experiments, research-related assets, and research animals in the event of a disaster.

Develop Performance-Based Standards for Research Facilities

RECOMMENDATION 7: Academic research institutions should work with key stakeholders to develop performance-based standards for facilities and critical infrastructure that support their research enterprise.

Possible actions could include, but are not limited to:

- Aligning the resilience plan and performance-based standards with the Department of Veterans Affairs Standard H-18-80 and the National Institute of Standards and Technology's *Community Resilience Planning Guide for Buildings and Infrastructure Systems*.
- Ensuring that disaster-resistant construction is an explicit design requirement for all new research buildings. For each new research building that is planned, performance goals and expectations should be set during the architectural planning process. If the new research building includes a vivarium, incorporating fail-safe design criteria is essential.
- Preparing an inventory based on vulnerability to existing hazards for existing research buildings. As existing research buildings require repairs or renovations, disaster-resistant features should be incorporated where possible. Build-back standards should be adopted and used to improve the overall resiliency of research buildings owned by the academic institution.

FUNDING A RESILIENT MISSION

Reducing disaster risk in the academic biomedical research community is a long-term commitment. Disaster prevention, protection, mitigation, response, and recovery planning must be strategically prioritized by each academic research institution, not only to reduce reliance on insurance, but also to establish a future-oriented and resilient vision for the long-term viability of an institution. In the context of the current acceleration of disasters, each academic research institution needs to ask how to best invest its constrained financial resources in the pre- and post- disaster environments to sustain and grow its research enterprise. Identification of new sources or reallocation of traditional sources of capital funds to enhance the disaster resilience of the academic biomedical research community should be undertaken. A more rigorous and integrated capital planning process—with clear criteria for resource allocation priorities—will be required to support capital and operational improvements over the long time period required to implement effective disaster resilience.

Develop an Institutional Financial Investment Strategy for Disaster Resilience Efforts for the Research Enterprise

RECOMMENDATION 8: Academic research institutions should develop an institutional financial investment strategy based upon comprehensive and integrated resilience planning activities for their research enterprise.

Possible actions could include, but are not limited to:

- Conducting business continuity analytics, disaster resilience vulnerability assessments, short- and long-range mitigation plans that resolve identified vulnerabilities, and, most importantly, developing a financial plan to implement the mitigation measures proposed in an institution's approved short- and long-range capital plans.
- Carrying commercial disaster insurance, as well as purchasing supplemental, business interruption, or cyber insurance.

THE ESSENTIAL ROLE OF RESEARCH SPONSORS

In general, research sponsors have not protected their investments by prioritizing the inclusion of disaster resilience principles and practices into the research enterprises they fund. There is a critical need for these research sponsors to measure their risk, develop mitigation measures, and work in partnership with academic research institutions to implement these mitigation measures. Research sponsors should consider taking a more assertive role in protecting their research investments through resilience initiatives

and development of policies to incentivize resilience at academic research institutions. Given the crucial importance of the academic biomedical research community to the nation's economic and knowledge prospects, high-level attention and coordination from research sponsors is needed to ensure that efforts to achieve resilience succeed.

Convene a Consortium of Stakeholders to Discuss Efforts to Enhance the Disaster Resilience of the Academic Biomedical Research Community

RECOMMENDATION 9: The National Institutes of Health should convene a consortium of research sponsors (both federal and private), academic research institutions, professional associations, and private-sector stakeholders to jointly discuss efforts that research sponsors can take to enhance the disaster resilience of the academic biomedical research community. In support of this effort, key federal agencies that support biomedical research should each identify within their respective agencies a locus of responsibility and authority to lead and coordinate efforts in pursuit of a resilient academic biomedical research community. This initiative would guide and support academic research institutions in their development of disaster resilience programs for their research enterprises.

Possible discussions could include mechanisms for research sponsors to:

- Conduct evaluations of prior disaster response and recovery actions taken by research sponsors.
- Communicate with academic research institutions pre-disaster to discuss potential disaster response and recovery actions, set expectations, and highlight current initiatives in place.
- Standardize response and recovery procedures.
- Match or leverage incentives to encourage academic research institutions and researchers to incorporate disaster resilience into their research programs.
- Provide funding sources for capital improvements that will improve the resiliency of research facilities at academic research institutions so that they meet appropriate performance goals.
- Establish resilience standards and require evidence of disaster-resistant design and construction and business continuity planning as a condition of award.
- Increase incentives for off-site storage and duplication of critical samples and data.
- Develop a national approach to preserve unique animal lines, samples, and data through disaster resilient repositories.

- Explore funding for national centers of excellence for disaster resilience efforts at academic research institutions that would analyze existing data, serve as a repository for after-action reports and post-disaster analyses, and promulgate best practices for the academic biomedical research community.
- Actively participate in the Healthcare and Public Health sector–specific activities, such as the Government Coordinating Council.

THE ACADEMIC BIOMEDICAL RESEARCH COMMUNITY—VITAL TO THE NATION

The nation's academic biomedical research community provides essential services that underpin American society, especially with respect to addressing emerging public health issues and chemical, biological, radiological, nuclear, and explosives threats on an emergent and long-term basis. The Healthcare and Public Health (HPH) Critical Infrastructure Sector includes entities that provide these essential services, such as publicly accessible health care facilities, research centers, suppliers, manufacturers, and other physical assets, as well as public-private information technology systems. The goals, priorities, and activities included in the *HPH Sector-Specific Plan* are developed by the Sector Coordinating Council (SCC) and the Government Coordinating (GCC)—which represent the private and government subsectors, respectively. Currently, the academic biomedical research community is not classified as a subsector and is not actively engaged in the HPH Sector. The academic biomedical research community (from federal research sponsors to academic research institutions) should be considered a subsector of the HPH Sector and represented on the SCC, as well as the GCC. Academic research institutions could participate on the SCC through appropriate associations. Increased participation of federal research sponsors on the GCC could result in discussions about the funding of resilience efforts for academic research institutions, as well as other ways the government could support resilience efforts for academic research institutions.

Recognize and Engage the Academic Biomedical Research Community as a Subsector of the Healthcare and Public Health Critical Infrastructure Sector

RECOMMENDATION 10: The Department of Health and Human Services, as the Healthcare and Public Health Sector-Specific Agency, should explicitly recognize and engage the academic biomedical research community as a subsector of the Healthcare and Public Health Critical Infrastructure Sector, and actively work to engage the academic

biomedical research community in Sector-specific activities—such as the Sector Coordinating Council and the Government Coordinating Council.

Engaging the academic biomedical research community in the Healthcare and Public Health Sector–specific activities could be achieved through the following mechanisms:

- Active participation of appropriate academic biomedical research community associations and stakeholders on the Sector Coordinating Council.
- Active participation of key federal agencies that support biomedical research on the Government Coordinating Council.

CONCLUDING OBSERVATIONS

The continuation of scientific advancement and the promise of future discoveries necessitates a commitment to resilience. Improving the disaster resilience of the academic biomedical research community will require an unparalleled partnership across the emergency management and academic research sectors with a sustained commitment from leaders at all levels.

The actions recommended by the committee in this report—from recognizing the academic biomedical research community as a key component of the HPH Critical Infrastructure Sector to PIs working with their academic research institution to safeguard and preserve their research data, samples, and reagents—highlight the fact that all levels of the academic biomedical research community have roles to play in building resilience (see Box S-1).

BOX S-1
Blueprint for Advancing the Disaster Resilience of the Academic Biomedical Research Community

The following points collectively summarize the necessary actions recommended by the committee to achieve a resilient academic biomedical research community.

Academic Research Institutions and Researchers

- Designate a qualified, senior individual with oversight of disaster resilience efforts for the research enterprise
- Implement comprehensive and integrative disaster resilience planning efforts for the research enterprise
- Develop, enhance, and leverage local, state, and national partnerships
- Ensure the preservation of research data, samples, and reagents
- Implement mandatory disaster resilience education and training programs
- Improve the disaster resilience of animal research programs
- Develop performance-based standards for research facilities
- Develop an institutional financial investment strategy for disaster resilience efforts for the research enterprise

Research Sponsors and Stakeholders

- Convene a consortium of stakeholders to discuss efforts to enhance disaster resilience for the academic biomedical research community
- Recognize and engage the academic biomedical research community as a subsector of the Healthcare and Public Health Critical Infrastructure Sector