

## **Advisory Committee for Environmental Research and Education (AC-ERE)**

March 18, 2021

### **Summary Minutes**

**Committee Members in Attendance:** Megan Bang, Lora Billings, Ann Bostrom, Andrés Clarens (Chair), Vicki Grassian, Peter Huybers, Charles Isbell, Kimberly Jones, Maria Carmen Lemos, Amanda Lynch, Julia Parrish, Diane Pataki, Raina Plowright, Jeanne VanBriesen

**Subcommittee Members in Attendance:** Sharon Burke, Geoff Dabelko, Patricia Matrai, Shannon O’Lear

**NSF Staff:** Anjuli Bamzai (GEO, Executive Secretary for AC ERE) Brandi Schottel (ENG/CBET), Suzi Iacono (OH OIA), Steve Meacham (OD OIA), Steven J. Breckler (SBE/BCS), Sethuraman Panchanathan (Director), F. Fleming Crim (COO/OD), Brian Stone (Chief of staff/OD)

**Notetakers:** Ashley Pierce (AAAS S&T Policy Fellow, ENG/CBET), Amanda Shores (AAAS S&T Policy Fellow, GEO/OAD)

### **Thursday – March 18, 2021**

**11:00 – 11:30a Welcoming Remarks,** Andrés Clarens (AC-ERE Chair), Suzi Iacono (Head, OIA)

Dr. Bamzai welcomed and thanked everyone for attending.

Dr. Clarens welcomed the committee, thanked everyone for attending, and noted that the committee is incredibly busy with four reports currently in progress. Dr. Clarens went over the schedule for the day and explained the reasoning behind holding a meeting in March and in June. Dr. Clarens then introduced Dr. Bamzai as the new AC-ERE Executive Secretary and thanked Dr. Schottel for serving as the previous Executive Secretary.

Dr. Iacono welcomed the committee and introduced the two new members, Dr. Vicki Grassian, distinguished professor and chair of the Department of Chemistry and Biochemistry at UC San Diego and Dr. Raina Plowright, associate professor of Microbiology and Immunology at Montana State University and bid farewell to the AC-ERE members, Dr. Raymond Arnaudo, Dr. Benjamin Preston, and Dr. Lisa White, who rotated off the committee.

Dr. Iacono then went over NSF’s FY21 budget increase from FY20 and explained that the FY22 budget request was delayed, as is usual during an administration transition. Dr. Iacono briefly went over the schedule for the meeting and then gave some cross-NSF updates on the [Growing Convergence Research \(GCR\)](#) and the [Established Program to Stimulate Competitive Research \(EPSCoR\)](#) programs.

**Minutes from the October 22-23, 2020 meeting were approved by the committee.**

**11:30 – 12:15p Committee Business**

**Environmental Change and Human Security Report** (Ann Bostrom, Subcommittee Chair)

Dr. Bostrom gave an overview of the report, noting that the report was started at the end of Dr. Tony Janetos’ service before he passed away. The goal of the report was to highlight what the research needs are and what can be done to address them regarding environmental change and security. The subcommittee

interviewed security folks, researched the literature, and looked at what the NSF has funded and then identified opportunities within the NSF to promote research at the intersection of environmental science and security. There are eight primary research questions that summarize the research opportunities.

The discussion that followed touched on the timeliness of the report and the unique role the NSF has to play in this space. The report was received positively by the committee and there was some discussion on next steps for dissemination of the report to the NSF and public audiences.

### **Environmental and Human Health Research Priorities Report (Diane Pataki, Subcommittee Chair)**

Dr. Pataki gave an overview of the report. The pandemic highlighted gaps in our understanding of interactions between the environment and health that go beyond infectious disease. The subcommittee reviewed NSF-funded COVID-19 RAPIDS, EAGERS, and supplements and discussed emerging literature, research agendas, national, and global initiatives. The subcommittee also interviewed staff at NSF, NIEHS, NIH, DOD, and EPA. The subcommittee determined that there are emerging uncertainties at the health-environment nexus that are difficult to address in any current NSF or federal agency program and there is a need for new programs in this area. The key recommendations in the report include clarifying NSF's role in funding public health research, identifying the research that is difficult to fund in current programs, and address this difficulty with new programs and potentially with collaboration/coordination between other agencies.

The discussion that followed also touched on the timeliness of the report and the need to work with partners (e.g., other agencies) to cover some of the research gaps. The report was received positively by the committee and there was some discussion on next steps for dissemination of the report to the NSF and public audiences.

The committee discussed the dissemination plan for both reports. Generally, the consensus was to hold internal webinars for program officers at the NSF as well as external webinars for partners, stakeholders, and practitioners to disseminate the content of the reports.

### **Engaged Research Subcommittee Update (Maria Carmen Lemos, Subcommittee Co-chair)**

Dr. Lemos gave a brief update on the Engaged Research Report. The subcommittee has a substantial draft focused on emerging issues in the environment and how co-production as a process with research can be used to address these issues. The goal is to have a draft by the June meeting.

### **Environmental Research and Education Subcommittee Update (Megan Bang, Subcommittee Chair)**

Dr. Bang gave a brief update on the Environmental Research and Education Report. The subcommittee has made good progress on a draft with shared insight for environmental research and education. The goal is to have a draft by the June meeting.

### **12:15 – 12:30p NSF Program Update, Strengthening American Infrastructure (SAI): Steven J. Breckler (Program Director, SBE/BCS)**

Dr. Breckler introduced [Strengthening American Infrastructure \(SAI\)](#) as a program that focuses on projects that are centered in and led by SBE researchers to foster deep and convergent collaboration between SBE and relevant infrastructure expertise. The program aims to foster a deep understanding of human cognition, perception, decision making, legal frameworks, and government structures integrated with design. SBE is leading the program with collaboration from all other directorates and the Office of Integrative Activities (OIA), and the program was featured in the FY21 budget to congress.

A [DCL](#) was released Nov 3, 2020, calling for conferences or workshops and EAGERs. The DCL generated strong interest. There is no specific infrastructure focus, the DCL left this to the proposers to determine. Conference proposals were due Nov 30, 2020 and expect to fund at least one. EAGER concept papers were due Dec. 11, 2020 and received hundreds of concept papers. SAI approved a large subset to submit full EAGER proposals which were due in February 2021 and are currently being reviewed. SAI expects to fund about 20 projects and hopes to announce these in a couple of weeks. The next step for SAI is to release a formal solicitation.

In the discussion that followed, the committee showed interest in SAI and encouraged SBE to continue the conversation on infrastructure with the committee.

**12:30 – 1:00p      Break**

**1:00 – 1:45p      Committee Flash Presentations on Opportunities and Challenges of “Green Infrastructure”, Moderator: Andrés Clarens (AC-ERE Chair)**

Approval of the two reports:

Dr. Bostrom made a motion, Dr. Lynch seconded, to approve the Environmental Change and Human Security report. There were no objections, and the report was unanimously approved.

Dr. Jones made a motion, Dr. Pataki seconded, to approve the Environmental and Human Health Research Priorities Report. There were no objections, and the report was unanimously approved.

The subcommittees will address any committee comments and typos and then work with NSF to get the reports published.

Committee Flash Presentations:

Dr. Bang discussed green infrastructure in the context of pK-12 education systems. Dr. Bang noted that 1 in 6 Americans routinely interacts with the pK-12 education system which has one of the largest environmental footprints for change. The pK-12 education system is a huge distributor and user of energy, transportation, and food and there are currently only six states that have plans for net zero energy consumption in schools. There are current limitations in budgeting that make it difficult to make changes to this system. The pK-12 education system presents an opportunity to re-imagine green infrastructure for learning, turning school yards into learning yards, influencing behavior change, and in the long-term, influencing intra- and intergenerational shifts of paradigms.

Dr. Bostrom discussed green connectivity to improve ecosystem functionality for ecosystem services to enhance risk management. Improving risk decision making and protection for natural hazard and climate change mitigation. Dr. Bostrom noted that the way people think about nature shapes how they think about everything else.

Dr. Clarens discussed green to grey infrastructure options for negative emissions technologies. Dr. Clarens noted that to stabilize the climate the world will need to cut emissions as well as remove emissions. Strategies for achieving negative emissions that people are most often excited about are on the greener side, e.g., costal blue carbon, afforestation/reforestation, soil carbon, etc. However, there are many grey options, e.g., biomass energy with carbon capture/storage, accelerated chemical weathering of rocks, direct CO<sub>2</sub> capture, etc. Moving forward, the decision and impacts of grey and green infrastructure will need to be better understood.

Dr. Grassian provided slides but had to leave the AC-ERE meeting early. Dr. Grassian's slides touched on the importance of environmental chemistry in green materials for use outdoors and indoors.

Dr. Jones talked about green to grey infrastructure in the context of water management. Dr. Jones noted that 10 trillion gallons of untreated stormwater occurs across the country which is in need of more natural solutions before that water enters drinking water sources. Dr. Jones discussed the opportunity to incorporate cyber-physical systems into this process. Dr. Jones also brought up the opportunity for community engagement and the inherent equity issues that exist with water access.

Dr. Lynch talked about urban water and green infrastructure. Dr. Lynch noted that urban areas are regions of rapid change where freshwater is the single largest material flux into cities globally and that 2/3 of the global population are affected by periodic water scarcity. Water sensitive cities enact soft and hard water management solutions to ensure resilience and lessons can be learned from such practices. There is an important focus in this area on practitioner stakeholders such as meteorologists, hydrologists, etc.

Dr. Pataki conceptualized green infrastructure as living infrastructure and noted that urban trees are often referred to as urban forests even though they do not meet the definition of a forest. Green infrastructure can be characterized as a hybrid between natural and grey infrastructure. Can this hybrid model be leveraged to exceed the current biophysical capacity of natural systems?

Dr. VanBriesen discussed the importance of long-term performance modeling to understand how green stormwater infrastructure performs into the future given a changing climate. Dr. VanBriesen noted that green stormwater infrastructure may perform as designed but may not perform as needed as the climate changes. Historical information on performance of green stormwater infrastructure combined with climate models that simulate wetter or drier future conditions to predict long-term performance under changing climatic conditions is therefore needed.

Dr. Parrish discussed engaging ecologists and environmental scientists with communities to understand what communities are interested in and already doing. The idea is to move away from helping communities and move towards ideas that are coming from and sustained by communities. Identifying what communities are already doing and then determining if these projects can be scaled up. Projects can range from green roofs and rain gardens to large-scale protected areas to preserve ecosystems. This is likely an area of research that would engage the BIO, GEO, SBE, and EHR directorates.

Dr. Plowright discussed using green infrastructure as a tool for ecological restoration to benefit human health. Using the Hendra virus in Australia as an example, currently, the major intervention to avoid Hendra virus is vaccination, however there are social issues around vaccination. By addressing the root cause of spillover events, winter habitat loss, spillover can be avoided.

Dr. Huybers discussed the scope of green infrastructure and what is included in the definition. Examples of the range of green infrastructure included agricultural infrastructure such as irrigation to offset temperature effects and power infrastructure such as the need to electrify the power grid and the issues with the power grid brought to light by the recent storm in Texas.

Dr. Billings discussed a way to cultivate skills and add value to green infrastructure projects as broader impacts. An example was green teams where students do internships at different places where they work on a variety of different projects. The students learn skills that can then be applied elsewhere while projects benefit the local community.

Dr. Lemos discussed climate resilient pathways as a means for engaging cities. An example was climate information in the Great Lakes area and stormwater management which has a triple benefit of mitigating climate change, improving adaptation to climate change, and sustainable development for the future. Cities could increase participation in green infrastructure policies to determine more equitable distribution of ecosystem services and test different options with communities to understand the choices that different communities would make.

**1:45 – 2:15p                    Preparation for Discussion with NSF Senior Leadership**

Dr. Clarens will introduce the committee at the start, the Director will have some remarks for the committee and then Dr. Bostrom and Dr. Pataki will update the Director on the Security and Human Health Reports that were just approved by the committee. Any time at the end may be used to get the Director's perspective on green infrastructure. Dr. Iacono noted that the Director is a computer scientist/electrical engineer and may not have a specific perspective on green infrastructure, but he will be interested to know from the committee why the committee is interested in it. Dr. Pataki brought up partnerships outside of the obvious choices (NIH, CDC, EPA, USDA). Dr. Bang noted the minimal mention of tribal nations, territories, or waters in the reports and that partnerships with other agencies that have different capacities for engaging tribal nations may need to be addressed. Dr. Meacham noted that emphasizing the wide spectrum of partnership, including tribal nations, is a good idea.

**2:15 – 2:30p                    Break**

**2:30 – 3:00p                    Discussion with NSF Office of the Director**

Dr. Clarens welcomed the Director and had the committee introduce themselves. Dr. Clarens noted that the committee has transitioned from a business model of producing decade scale reports to more frequent reports of interest. There are four reports coming out this year from the committee including reports on Security, Human Health, Engaged Research, and Education as they relate to environmental research and education.

Dr. Panchanathan thanked Dr. Clarens and the committee for the time spent on the reports and looks forward to reading all the reports. Dr. Panchanathan then thanked the committee members who were rotating off the committee and welcomed the incoming committee members. Dr. Panchanathan noted that the NSF is thrilled with the fundamental emphasis on science in the new administration and the four pillars of COVID-19, economic recovery, racial equity, and climate change. Dr. Panchanathan noted that the two reports that were approved today are very timely and that it will continue to be important to engage on how to be more resilient.

Dr. Bostrom gave an overview of the Environmental Change and Human Security Report. Dr. Panchanathan noted that he is in contact with leaders across the globe and everyone is anxious to work on climate change, security, and public health and there is an interest to collaborate with more intensity.

Dr. Pataki then gave an overview of the Environmental and Human Health Research Priorities Report. Dr. Pataki pointed out that although the report was precipitated by COVID-19, it goes beyond infectious disease, however the boundaries between NSF and other agencies on health is not always very clear. Dr. Panchanathan noted that human health happens in a significant way at the NSF but that there is still work to do across the silos and Directorates. Dr. Panchanathan also noted that health disparities are often exacerbated by environmental issues which tend to be complex systems issues.

As the webinars are being put together the Director encouraged the AC-ERE to think in a partnership mindset and invite other agencies to attend. Dr. Panchanathan noted that having actionable

recommendation to take to another agency's leadership is the most helpful in moving forward specific topics. The AC-ERE sits in OIA because it addresses agency-wide issues, and the Office of the Director will be looking at potential programs to develop based on the AC-ERE recommendations.

### **3:00 – 5:00p            Brainstorming Session on “Green Infrastructure” Research and Education Opportunities**

#### **3:00 – 3:15p            Introduction**

Dr. Clarens introduced the plan for the brainstorming sessions. The committee would move to two breakout rooms. Each room would spend half an hour on the definitions and theories of green infrastructure and then would switch to discussing co-design, monitoring, and management for the second half hour. After a 15-minute break, the committee would reconvene for a half hour report out and discussion on next steps.

#### **3:15 – 4:15p            Breakout sessions**

##### Breakout room 1:

The discussion on definitions and theory touched on what is considered green infrastructure. There is blue (water), brown (soil), and green (natural) labels but it is not always clear what these mean. “Green” can refer to structures necessary for the environment, structures that deliver benefits to humans and environments, nature-based solutions, etc. There was discussion on the artificial barrier between human and natural systems and it was noted that the divide between these two makes it hard to solve complicated problems. Built infrastructure has its own ecosystem, but research that bridges human and natural systems tends to fall between the Engineering and Biological Sciences Directorates. Most research in this area seems to go to the [Dynamics of Integrated Socio-Environmental Systems \(DISES\)](#) program, [Coastlines and People](#), or the [Polar Programs](#). However, if research does not fall into these programs, it can get stuck in the historical silo-ing of the NSF and it seems challenging to make programs that cross that interface. The [10 Big ideas](#) and [Strengthening American Infrastructure \(SAI\)](#) try to address this issue, but there is still research falling through the gaps. Partnerships with agencies like NIH seem important in this area because of the correlation between the environment and human well-being.

There is also an issue with language across disciplines and what “benefits” mean, it is not always economic benefits or benefits to humans that are included in “green”. This also arises in the review process, as research spans disciplines in these programs it is essential to have reviewers that also span disciplines and can understand the different ways words are used and the different approaches across disciplines. It also important to understand coupled human-natural systems and is not currently explicitly included in broader impacts.

The discussion on co-design, monitoring, and management centered on contextualized engineering systems in the social systems and how to create and manage institutions that are sustainable and equitable. The historical aspect is important here in ensuring that development of infrastructure does not replicate or enforce inequities. Transitional institutions may be needed to address equity. Social positioning and power dynamics of societies will determine what is created and how benefits are interpreted. There was also discussion on how to ensure people are included as full participants and adequately (economically and culturally) compensated for their participation. Funding is an issue here as it takes a lot of time to build trust and who is eligible for funding is based on western determination of knowledge which does not include other knowledge holders (e.g., someone with a degree vs. an Indigenous elder, for example). Care needs to be given to the communities that are engaged and the flexibility to develop relationships so that existing partners are not relied upon too heavily. There may need to be a new funding mechanism that is both long-term (decadal) and flexible so that researchers can build trust and not have all the research

questions determined at the start. Working with a researcher on a proposal that does not get funded can add to harm and mistrust in communities. Planning grants are a good start to funding the process, but it is not always clear what should come out of a planning grant and the timescale may not be long enough. Other longer-term programs may also need to be imagined, similar to the [Long-Term Ecological Research \(LTER\)](#) or [Research Coordination Networks \(RCN\)](#).

#### Breakout room 2:

The conversation started out discussing definitions for green infrastructure, how to determine what it is and is not, and understanding the overlap between traditional and non-traditional forms of infrastructure. Different terms are used across biology, engineering, and beyond. Restore is used in biological contexts, while build is used in engineering, and invent could be used in both if talking about something like bio-mimic. Under the lens of ecosystem services, one can build function, restore function, or restore function that was lost by building new things. There are also structures that are not material that allow society to exist, how does social infrastructure as well as culture, values, and norms factor in? The committee will need to incorporate humans and the natural world. There was a question on whether green infrastructure was the right term to use.

The conversation then touched on benefits and impact. Who benefits and what makes a positive impact? This may vary depending on the goals. In some cases, the goal is not to restore but to sustain or to stop the rate at which something is declining. Scaling is also important here. Small-scale, community-driven, green infrastructure has merit for some issues but may not be adequate for others. There are limits to the use of green infrastructure for some scales and issues. The best course of action may be not to give a definition but to identify gaps in the space between BIO and ENG that money coming to NSF can start to support.

The conversation on co-design, monitoring, and management touched on the difficulties of management for green infrastructure. Scale and time are important topics in this aspect. Green infrastructure projects will be bigger or smaller based on location and may last shorter or longer than the problem they are fixing. Artificial intelligence could factor in here if infrastructure moves towards larger scales and distributed computer systems monitor these large-scale infrastructure projects. At what stage in a problem do interventions occur and make sense? Should some green infrastructure move towards governance instead of management so that it is co-designed and maintained within communities?

**4:15 – 4:30p            Break**

**4:30 – 5:00p            Report out and next steps**

#### Breakout room 1 report out:

Dr. Bang and Dr Bostrom reported out the wide-ranging conversation from breakout room 1 which covered the spectrum between natural and built and the trends in different disciplines. The need to carefully think through what is meant by “green” and “infrastructure” which are expansive and could mean a lot of things. There are temporal and spatial scales for green infrastructure. Dynamic systems maintained over long-term is a challenge. Infrastructure generally is thought of benefiting human and natural systems. However, different NSF programs have different relationships to natural and built infrastructure. What would it mean to encourage broader impact for human and environmental systems?

There was also discussion of design that considers equity and sustainability. This touched on institutions and the need for historical context and potentially using transitional institutions. The social position of a person changes how they perceive benefit. There are also differences in norms for compensating participants across directorates. Long-term partnerships and the issue of trust and sustaining or maintaining relationships was also discussed and the differences in how expertise is valued, e.g.,

credentialed vs. not. To solve these issues, planning grants may need to be reframed and there may need to be a next generation of LTER and RCNs focused on green infrastructure. The difference in engaging with sovereign nations and involving Indigenous people in research was also brought up as well as the need to engage sovereign nations similarly to international partners.

Breakout room 2 report out:

Dr. Parrish, Dr. VanBriesen, and Dr. Clarens reported out on the discussion from breakout room 2. There appears to be very different values and approaches to what green infrastructure is. Green infrastructure is defined differently by different groups and that is good as one definition does not fully cover the breadth of it. The committee will need to think practically on how to craft statements that would invite equally the different directorates to be involved. The group talked about differences and connections of restoration (of ecosystems services), building (creating physical or social structures), and inventing (nature but better). Systems are dynamic and not static, and values, norms, practice, and law will all factor in.

The group discussed spatial, temporal, and complexity scales and how those differ across disciplines. From an engineering standpoint, many of the things that are green infrastructure require a lot of local care and management to keep going. To scale up (distributed scale not necessarily big in size) would increase the infrastructure to support. However, at the ecological scale, one small project is meaningless and therefore need projects at larger scales. However, legal and policy issues and social management at scale are more complex at larger scales. There is tension between easier larger projects and the small-scale projects that are more charismatic. There was also a question about whether green infrastructure had to have a positive impact.

Next steps:

There was general enthusiasm from the committee to write a report on green infrastructure. It was pointed out that there is overlap with the Human Health Report through health science and green infrastructure. From the BIO point of view, it is an interesting space and bringing up green infrastructure may help to support researchers that often struggle to get funding in BIO. Having an SBE economic committee member would be useful in working through some of the social issues. A subcommittee and chair of the subcommittee will need to be formalized.

**5:00p      Adjourn**