COMMITTEE OF VISITORS REPORT

REVIEW OF THE DIVISION OF ENVIRONMENTAL BIOLOGY

JUNE 22-24, 2009

COMMITTEE OF VISITORS:

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Introduction

The Division of Environmental Biology (DEB) appointed a Committee of Visitors (COV) to conduct a review of DEB for the fiscal years 2006, 2007, and 2008. The charge to the Committee was:

1) To assess the quality and integrity of operations, including technical and managerial matters pertaining to proposal recommendations.

2) To comment on how the outputs and outcomes generated by awardees have contributed to the attainment of NSF's mission and strategic goals.

In addition the 2009 COV was asked to address the following questions related specifically to the division.

1. How is DEB positioned relative to national emphasis areas such as climate change and energy? What could it do better or differently?
2. Are the current programs and clusters appropriately structured to foster emerging research areas?
3. What actions should DEB consider to foster more innovative "broader impacts" activities?
4. What is your advice on progress made by DEB during the last three years on the issues raised by the previous COV.

The twelve-member COV conducted its review 22-24 June, 2009 at NSF. Dr. Joseph Travis, representing the Advisory Committee for the Biology Directorate (BIO), participated in the meeting and provided insights on NSF and BIO policy, history, programs, and current concerns. The COV used the DEB self study document for analysis, and supplemented the data provided in that document by reviewing the 120 proposal jackets (including both awards and declines) supplied by DEB. The COV conducted both qualitative and quantitative assessments of the jackets. The COV met with DEB program officers and staff and with allied program officers and staff from other divisions that often co-fund projects with DEB. In addition, the COV met with Dr. Fae Korsmo, Senior Advisor, Office of the Director; Ms. Charlene Arietti, Branch Chief, Division of Human Resource Management, OIRM/HRM; and Dr. James Collins, Assistant Director for Biological Sciences.

The COV thanks Dr. Robert Sterner, Division Director, DEB, and Dr. Penelope Firth, Deputy Division Director, DEB, for their assistance and commitment to the COV review. The COV also thanks the numerous DEB Program Officers and staff who contributed their insights to the review, and provided logistical support for the meeting.

The COV is particularly grateful to Division Secretary, Shayna Daniel, who organized travel and pre-meeting arrangements and Science Assistant, Emily Leichtman, who responded to our requests for additional information and help during our three days at NSF. Finally, the COV recognizes the important contributions of the DEB Science Assistants, Administrative Staff, and Program Officers who assembled the self study document. Their efforts were instrumental in increasing the efficiency of the COV, by providing more time for discussing strategic issues and less time gathering data.

The results of the COV review are provided in response to specific questions in the report template. In addition the COV responded to four questions posed that are specific to DEB. The COV recommendations are summarized at the end of the report (Executive Summary).

DEB is the primary source of funding in the United States for research and training in environmental biology, an area that includes such diverse disciplines as ecosystem studies, ecology, population biology, evolutionary biology, and systematics. Continuing and new challenges such as climate

change, biodiversity, and energy sustainability will provide new opportunities for DEB to provide the leadership for scientific advances within and outside of the United States. NSF/DEB-sponsored research is the gold-standard among scientific institutions and remains of the highest quality, despite a continuing struggle for resources to support increasing demands of the scientific community. As observed by the previous COV, DEB has insufficient resources to adequately fund high-quality research, and success rates in many research programs can reach as low as 10%. Although funding has remained flat as demands on DEB continue to rise, the program is remarkably well managed by a highly dedicated staff working at all levels. With greater commitment from the federal government, DEB could better realize its tremendous potential to lead, foster, and promote advancement of science and the scientific community, to the great benefit of the nation. DEB is uniquely positioned to address the many national and global problems that exist in environmental sciences.

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

A.1 Questions about the quality and effectiveness of the program's use of merit review process. Provide comments in the space below the question**.** Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE[1]
1. Are the review methods (for example, panel, ad hoc, site visits) appropriate? Comments: Yes, however specific areas might be improved: The COV observed that the current policies may be too restrictive and have not kept up with changes in proposal submission practices. For example, there has been a large increase in the number of collaborative projects. Consequently, in some cases many of the most appropriate reviewers with sufficient expertise to evaluate the proposals are excluded from the review process because of current conflict of interest standards (e.g., PIs may have served as co-authors on a reviewer's paper with minimal contact/interactions, yet are still deemed in conflict). The COV noted occasional "disconnects" between reviews and the panel summaries. Some panel summaries appear to deviate from the advice of the majority of ad hoc reviewers. While the COV recognizes the wisdom of the	Yes

[1] If "Not Applicable" please explain why in the "Comments" section.

panel, perhaps more attention should be paid to improve continuity between the ad hoc reviews and the panel summaries, and to better and more honestly justify the decisions not to fund. Increased use of Science Assistants (SAs) during panel meetings could mitigate this problem. SAs are knowledgeable, and a valuable resource for assisting panelists to provide a thorough panel summary, and to ensure a continuity between the reviews and panel assessment.	
2. Are both merit review criteria addressed	Yes
a) In individual reviews?	Yes
Although the reviewer template clearly identifies broad impacts, ad hoc reviewers sometimes neglect to address this aspect of the proposal in their review. Perhaps the reviewer community can become better educated as to the importance of this criterion in their evaluation of a project's value.	
b) In panel summaries? The panel summaries clearly provide input on both review criteria.	Yes
c) In Program Officer review analyses? The P.O. addresses both criteria and the process is carefully evaluated.	Yes
Comments:	
The COV suggests that more could be done to ascertain whether the broader impacts promised in proposals are realized upon project completion, and are accurately documented in "Results from Prior Support" section of resubmissions. This additional input could be considered when assessing subsequent proposals from the same investigator.	
Perhaps the broader impacts project requirement could be better coordinated among individual projects to reduce duplication of effort and address the needs of the entire program. For example, it seems feasible to consider special sessions or workshops in a coordinated plan for broader impacts especially aimed at educating the public (including policy-makers) in ways that serve a number of proposals aggregated within a single program (such as AToL or PBI). The identification of more innovative approaches could be facilitated through further collaboration among educational programs within NSF and in other agencies devoted to such goals. Also, the list of suggested broader impact activities provided to the research community (http://www.nsf.gov/pubs/2002/nsf022/bicexamples.pdf) should be revisited, updated, and made more explicit, with some examples of a proof of concept taken from more recently funded projects that include highly successful, broader impact activities.	

3. Do the individual reviewers provide substantive comments to explain their assessment of the proposals? Comments: In general, the program is receiving in-depth and substantive reviews. There remains variance in the level of detail provided by reviewers so that the panel must continue to review and separate relevant from inadequate or misguided comments. Could the method be improved in the selection of ad hoc reviews? See elsewhere comments about COI policies, and the need to avoid excluding reviewers with the most appropriate expertise.	Yes
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Panel summaries are usually very clear in their rationale to fund or not fund. Comments: In general, the process works well. However, the COV observed that proposal resubmissions are occasionally weaker than the original submission. This decline in scores on resubmission might call for more clear feedback from the panelists AND continuity in panel composition. Perhaps more guidance, in these cases, could be given to the PI as to how best to present their responses to reviewer criticisms.	Yes
5. Does the documentation in the jacket provide the rationale for the award/decline decision? (Note: Documentation in jacket usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), program officer review analysis, and staff diary notes.) Comments: The jackets are very comprehensive in the information contained and in their accessibility.	Yes
6. Does the documentation to PI provide the rationale for the award/decline decision? (Note: Documentation to PI usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), and, if not otherwise provided in the panel summary, an explanation from the program officer (written or telephoned with diary note in jacket) of the basis for a declination.	Yes

Comments: In most cases, the documentation is complete. However, see comments above regarding occasional lack of information provided by the panel summaries and the ad hoc reviews.	
7. Is the time to decision appropriate? Note: Time to Decision --NSF Annual Performance Goal: For 70 percent of proposals, inform applicants about funding decisions within six months of proposal receipt or deadline or target date, whichever is later. The date of Division Director concurrence is used in determining the time to decision. Once the Division Director concurs, applicants may be informed that their proposals have been declined or recommended for funding. The NSF-wide goal of 70 percent recognizes that the time to decision is appropriately greater than six months for some programs or some individual proposals. Comments: Most decisions and notification of PIs are within less than six months.	Yes
8. Additional comments on the quality and effectiveness of the program's use of merit review process: The COV applauds the excellent quality of the merit review process and also recognizes that some program officers face a challenge in finding additional appropriate expertise of ad hoc reviewers. A possible mechanism for meeting this challenge might be to refine and expand the current NSF database of reviewers and their expertise. This would allow investigators to self-describe their expertise and availability. Also, the NSF could consider working with scientific societies for assembling reviewer databases and increasing the diversity of reviewers.	

A.2 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	**YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE[2]**
1. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: Most proposals have 6 to 7 reviewers (mix of ad hoc and panel) which appear sufficient and above the minimum required by NSF policy. Expertise of reviewers appears appropriate for proposal content. There has been an increase in the number of proposals co-reviewed, especially with other Divisions. This increase reflects an effort to obtain appropriate expertise for interdisciplinary proposals.	Yes

[2] If "Not Applicable" please explain why in the "Comments" section.

2. Did the program use reviewers balanced with respect to characteristics such as geography, type of institution, and underrepresented groups? Note: Demographic data is self reported, with only about 25% of reviewers reporting this information. Comments: Program officers have considerable success in obtaining geographic balance among reviewers. The COV did not have sufficient data to evaluate inclusion of underrepresented groups as reviewers. We note that non-research intensive PhD institutions are well represented in the reviewer pool. Inclusion of early-stage and under-represented investigators is an important goal and provides more opportunities for these investigators to learn the review process. The COV recommends that criteria for searching and including more of these new reviewers be developed with assistance from several sources for identifying outstanding early investigators.	Data not available
3. Did the program recognize and resolve conflicts of interest when appropriate? Comments: The program has been extremely diligent in identifying COI according to the NSF categories. From the self study, DEB sampled 40 proposals at random, 22 of these had COI with panelists and only one of these was improperly documented, indicating general effectiveness of the mechanism for identifying COIs among panelists. However, identifying COIs has become increasingly labor intensive with the increase in multidisciplinary research and thus the proliferation of conflicts within DEB. Examples of large collaborations that create very large numbers of COIs include AToL, IGERT, large working groups in NESCENT, NCEAS, LTER and others. Two areas might be improved: 1) a method for tracking COIs for individual researchers; and 2) relaxation of the COI category regarding some types of collaborators, so that very brief collaborative associations do not automatically result in a COI.	Yes
4. Additional comments on reviewer selection:	

A.3 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE[3], OR DATA NOT AVAILABLE
1. Overall quality of the research and/or education projects supported by the program. Comments: Based on the proposal jackets reviewed by the COV as well as the research highlights generated by each DEB cluster, the quality of scientific research is extremely high. The outreach/education supported by the Division is also of extremely high quality and is appropriately focused based on geographic and demographic criteria.	Appropriate
2. Does the program portfolio promote the integration of research and education? Comments: While the level of proposed integration of research and education varied widely, the projects selected for awards exhibited a high degree of integration. It is unclear whether the funded education efforts came to fruition. Assessment of education outcomes at the program level are encouraged, such as the recent efforts by program officers to obtain full reporting of outreach activities in "prior results" sections of proposals and in annual reports.	Appropriate
3. Are awards appropriate in size and duration for the scope of the projects? Comments: The award amount and duration are appropriate given the severe funding constraints that DEB has operated under during the past 3 years. Some research areas that are inherently more costly to fund (e.g. metagenomics) and are likely to play increasingly important roles in future proposals will require higher levels of funding.	Appropriate
4. Does the program portfolio have an appropriate balance of: • Innovative/potentially transformative projects?	Appropriate

[3] If "Not Appropriate" please explain why in the "Comments" section.

Comments: A significant proportion of funded projects are highly innovative and have a strong likelihood of changing paradigms in environmental biology. The recent separation of the SGER awards into two categories (EAGER and RAPID) is viewed as an improvement in communicating the importance of these programs. The clear focus of EAGER on high-risk, innovative research is a positive development. Over 50 DEB projects in the last three years resulted in innovative and transformative research. Their contributions were widely reported in the public media with titles ranging from "Estimating the Costs of Invasive Species in the Great Lakes" to "Climate Change Drives Widespread Amphibian Species Declines." Additional innovative results are discussed below in Section B.	
5. Does the program portfolio have an appropriate balance of: • Inter- and Multi- disciplinary projects? Comments: The mix of inter- and multi-disciplinary projects appropriately reflects the rising trend in collaborative research in environmental biology. Program Officers in other NSF programs consistently commented to the COV that the DEB is highly collaborative in coordinating research funding, and Program Officers outside DEB indicated that "they particularly enjoyed working with DEB program officers owing to their broad, interdisciplinary perspective. There is widespread enthusiastic support among program officers for the collaborative research planning that characterizes DEB.	Appropriate
6. Does the program portfolio have an appropriate balance considering, for example, award size, single and multiple investigator awards, or other characteristics as appropriate for the program? Comments: The COV finds an appropriate balance among the range of research participation in the many areas funded by DEB. The COV is particularly pleased to note the increase in awards granted to collaborations among multiple investigators, which reflects the changing culture of environmental biology. In this light, the number of proposals reviewed jointly among clusters or across divisions as well as the number of funded awards resulting from joint reviews reflect DEB's embrace of inter- and multidisciplinary environmental biology.	Appropriate
7. Does the program portfolio have an appropriate balance of: • Awards to new investigators? NOTE: A new investigator is an investigator who has not been a PI on a	Appropriate

previously funded NSF grant. Yes. The data indicate that new investigators have a success rate that is roughly two-thirds the rate of established investigators. While the COV does not have an a priori expectation for these comparative rates, it does expect new investigators to have lower success rates than more experienced and established investigators. This difference in success rate seems reasonable in magnitude.	
8. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments: Yes. The COV did not detect any striking deviations among states or regions in the success rate of proposals. However, the COV observed some disparity among states or regions in the number of proposals submitted.	Appropriate
9. Does the program portfolio have an appropriate balance of: • Institutional types? Comments: The distribution of awards across types of institutions is difficult to evaluate. In particular, the COV would need data on the number of submissions of proposals from institutions of different types and the distribution of numbers of institutions of different types. The data available are not surprising; research-intensive institutions received about 60% of the awards and non-research-intensive doctoral institutions received 14-19% of the awards.	Data not available
10. Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity? Comments: Balance across disciplines has two elements. The first of these is the substructure of DEB and its ability to cover the range of subdisciplines practiced by the community; the second element is the distribution of success rates among proposals covering different topics within the purview of an individual program. The structure of the four clusters within DEB appropriately reflects the diversity of subdisciplines within environmental biology. The COV is impressed with the Division's ability to balance consistency of structure with the need to be responsive to the changing needs of the community and the perceptions of the community. For example, this responsiveness is reflected in the recent restructuring of two clusters, Evolutionary Processes and Population and Community Ecology. This new framework will provide a clear home for population genetics and evolutionary genomics. While the COV did not perform a quantitative assessment of awards within	Appropriate

individual programs, the committee's perusal of proposal titles and award titles did not suggest any evident bias favoring proposals on some topics at the expense of investment in others.	
11. Does the program portfolio have appropriate participation of underrepresented groups? Comments: In the COV's view, the success rates of proposals submitted by PIs from underrepresented groups are appropriate; those rates are equal to or greater than success rates in general. However, the COV noted that the absolute numbers of both proposals submitted and awards granted remain discouragingly small. Considerable work remains to be done within and outside of the NSF to learn how to be more effective in recruiting, training, and establishing new scientists from underrepresented groups.	Appropriate
12. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports. Comments: (See section B and D for further examples). The program clearly supports fundamental research into environmental processes that underlay the generation and preservation of biodiversity and the maintenance of ecosystem services along with research into the history and pattern of life's diversity. In an age of growing recognition of the importance of the health of our environment, DEB is central for building a sustainable environmental future. The program is also firmly planted in the agency's mission to promote the fundamental progress of science. Investigators supported by the agency have made innovative advances in science as demonstrated by long-term senior investigators recognized among the discipline's most well-recognized and highly lauded scientists. The self-study offers ample evidence for these claims. The COV encourages NSF to continue to communicate the many achievements and awards of its DEB investigators as widely as the science and the achievements clearly deserve. This strong record offers ample evidence that the agency's methods of soliciting and selecting the best science, as practiced by the DEB, are extremely successful.	Appropriate
13. Additional comments on the quality of the projects or the balance of the portfolio: BIO support for projects relating to the role of microorganisms in the biosphere has been tentative. DEB supports this science through "Dear Colleague Letter on Microbial Systems in the Biosphere," which attracted 45 applications. Yet, it falls short of the 225 projects received by the discontinued MCB/MO/MIP panel, which funded a substantial amount of transformational research.	

A.4 Management of the program under review. Please comment on:

1. Management of the program.

Comments:

Despite increasing proposal pressure and flat funding, DEB personnel have been highly committed and dedicated. They have done the best possible with limited resources. The COV perceives that understaffing of support personnel is an ongoing problem. Proposal pressure has increased over the years without a proportional rise in the number of Science Assistants and other Support Staff. Proposal pressure will likely continue to rise in the foreseeable future. Thus, the current understaffing situation will likely be magnified and could severely impede the Foundation's promotion of scientific advancement.

It is essential to the Foundation's health that Program Officers maintain sufficient administrative capacity and retain substantial responsibility for developing new initiatives. Program Officers are critically important and need to continue to play an important role in strategic planning at NSF.

2. Responsiveness of the program to emerging research and education opportunities.

Comments:

DEB has continued to incubate and foster programs and initiatives that track new and exciting directions in environmental science. Many of these initiatives have influenced other NSF divisions and directorates. Examples include LTREB, AToL, NCEAS, UMEB, UBM, NESCent, IGERT, NEON, OPUS, and NIMBIOS. "Postdoctoral Starter Grants" and strategically positioned workshops are effective in stimulating innovative research and educational opportunities.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments:

The COV observed that NSF Program Officers are the primary point of contact and interface between the Foundation and the scientific community. They are the closest to the pulse of scientific investigation, and a direct conduit between investigators, reviewers, and panelists.

Program Officers are aware of the changing needs of science in the broader community. A fresh perspective on emerging trends is provided by the rotator system of program officers who lend their expertise to DEB for 1-2 year periods before returning to their own active research programs.

This COV encourages Program Officers to continue to work toward supporting both interdisciplinary areas and core areas of science, an especially challenging task given restricted funding. As noted above, DEB has been an incubator for new ideas, and we applaud the DEB for their resourcefulness during a period of flat funding.

4. Responsiveness of program to previous COV comments and recommendations.

Comments:

DEB has responded effectively to previous COV recommendations wherever possible. This COV recognizes that some of the previous comments remain timely and are still in need of funding. In some cases, resolving these issues is beyond the scope of DEB.

5. Additional comments on program management:

Enthusiasm for the many innovations that characterize all levels of DEB personnel is evident from our discussions with staff, program officers and individuals from outside DEB. The mentoring of new personnel, the use of incentives to achieve results in inter-disciplinary research, advancing synthesis, linking evolutionary processes with ecosystem services, and the thorough evaluations used by DEB are all extremely effective.

PART B. RESULTS OF NSF INVESTMENTS

The NSF mission is to:

- promote the progress of science;
- advance national health, prosperity, and welfare; and
- secure the national defense.

To fulfill this mission, NSF has identified four strategic outcome goals: Discovery, Learning, Research Infrastructure, and Stewardship. The COV should look carefully at and comment on (1) noteworthy achievements based on NSF awards; (2) ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcome goals; and (3) expectations for future performance based on the current set of awards.

NSF investments produce results that appear over time. Consequently, the COV review may include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made.

To assist the COV, NSF staff will provide award "highlights" as well as information about the program and its award portfolio as it relates to the three outcome goals of Discovery, Learning, and Research Infrastructure. The COV is not asked to review accomplishments under Stewardship, as that goal is represented by several annual performance goals and measures that are monitored by internal working groups that report to NSF senior management.

B. Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes ("highlights") as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 OUTCOME GOAL for Discovery: "*Foster research that will advance the frontier of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering.*"

Comments:

DEB-sponsored research has been both high quality and high impact. Topics fostered through DEB awards were quite diverse and transformational, ranging from understanding of the role of symbioses in ecological systems to the accumulation of pollutants in organisms and environments. Here we highlight just two critical areas of environmental biology in which DEB has established global leadership through insightful and coordinated award strategies.

Global Climate Change: How organisms and ecosystems respond to changes in temperature, precipitation, timing of seasonality, and other global-scale alterations associated with climate change is a critical research frontier for the coming decade. DEB has shown an early recognition as well as a strong response to complex questions about the effects, adaptations, and consequences of climate change. Projects include, but are by no means limited to:

1. Prolonged drought can affect the ability of trees to ward off insect herbivores, resulting in massive mortality. Results of this study were published in the Proceedings of the National Academy of Sciences (NSF Award 0236204, Thomas Whitham, Northern Arizona University; NSF Award 0443526, Neil Cobb, Northern Arizona University).

2. Linkages have been discovered between the forms of nitrogen stored in terrestrial ecosystems and their ability to sequester carbon (NSF Award 0108960, Edward Rastetter, Marine Biological Laboratory; NSF Award 0089585, Gaius Shaver, Marine Biological Laboratory
3. Amphibian extinctions have been linked to global warming through a complex relationship between increases in average daily temperatures and the growth of fungal pathogens. Results of this study were published in Nature. (NSF Award 0130273, Bruce Young, NatureServe)
4. The source of carbon dioxide that outgasses from large tropical rivers has been shown to derive from rapid cycling organic carbon recently captured by photosynthesis rather than slower cycling carbon from geological sources. (NSF Award 0107270, Anthony Aufdenkampe, Stroud Center; NSF Award 9815912 and 0213585, Jeffrey Richey, University of Washington)
5. A plant that is a common weed in the U.S. shows phenotype differences when developing from seeds produced after a prolonged drought: plants from post-drought seeds bloom more quickly, possibly to complete their life cycle before conditions become fatally dry. (NSF Award 0345030, Arthur Weis, University of California-Irvine; NSF Award 0345030, Bradford Hawkins, University of California-Irvine; NSF Award 0636812, Arthur Weis, University of California-Irvine; NSF Award 0636812, Bradford Hawkins, University of California-Irvine)
6. What appears to be a highly complex and unpredictable process of nitrogen release into soils has been simplified by a synthesis activity using 10 years of multi-site decomposition data. Results of this study were published in Science (NSF Award 9806493, Mark Harmon, Oregon State University; NSF Award 8805390, Jerry Franklin, Oregon State University)
7. Rising atmospheric temperatures that enhance permafrost melting could accelerate rates of greenhouse gas release, but new data show that growth of mosses might take up some of the excess carbon. (NSF Award 9727800, R. Kelman Wieder, Villanova University; NSF Award 0724412, Merritt Turetsky, Michigan State University)

Biodiversity: The rules that govern diversity in ecosystems as well as the consequences of species diversity on system functions and services are critical research frontiers for the coming decade. They are also inherently linked to global change effects. DEB has shown a long-standing commitment to improving understanding of the underpinnings and consequences of diversity in natural systems. Projects include, but are by no means limited to:

1. Documented patterns of diversity in lizards of New Caledonia suggest they may be particularly susceptible to extinction (NSF Award 0108108; Aaron Bauer, Villanova University)
2. Vegetation corridors that connect fragmented habitats play a significant role in maintaining species diversity. Results of this study were published in Science (NSF Award 9907365; Nicholas Haddad, North Carolina State University; NSF Award 9815834, Douglas Levey, University of Florida)
3. Exploring taxonomic diversity and evolutionary history of >6000 sea slugs has value for both basic ecology and for bio-prospecting. (NSF Award 9978155, Terrence Gosliner, California Academy of Sciences)
4. Plants in "biodiversity hot spots" may not receive sufficient pollen for maximum seed production; this suggests these highly diverse habitats are at a relatively greater risk of extinction due to loss of pollinator services. (NSF Award 0072909, Omer Reichman, University of California-Santa Barbara)
5. A phylogenetic analysis of spiny-rayed fishes combined with a novel computational modeling approach was used to predict the existence of over 1,200 species of venomous fish, most of which are not yet known to science. (NSF Award 0405246, Melanie Stiassny, American Museum Natural History)

B.2 OUTCOME GOAL for Learning: "*Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.*"

The attention to education in DEB's award strategy is exemplified by several grants that work to expand the understanding and support of science by all citizens. It is especially noteworthy that students K-12, graduate students and international scientists were deeply involved in the projects. It is also noteworthy that DEB reacted swiftly to study a natural disaster via SGER funding. Projects include, but are by no means limited to:

1. US biologists, their Mexican counterparts, and a dedicated group of American high school students undertook a multifaceted investigation of tropical forest biodiversity at El Eden Ecological Reserve in Quintana Roo, Mexico. Data collected over 10 years served as the foundation for evaluating the biological effects of Hurricane Wilma, which delivered 110-120 mph winds in October 2005. This collaborative effort revealed that mature forests suffered greater mortality of trees and associated animals and epiphytes than younger forests, underscoring the need for their special protection. Including younger scientists in this work helped convey the message of sustainability to future generations. (NSF Award 0615427, Michael Allen, University of California-Riverside)
2. The Global Climate Change Teacher Institute has trained dozens of middle and high school teachers from across the country in critical issues of climate change by exposing them to current research in physical, chemical, and biological aspects of global change. The week-long program brings teachers to field sites and laboratories where they learn about the impact of elevated carbon dioxide and ozone levels, nitrogen saturation, acid rain, and invasive species on forest ecosystems, while earning graduate course credit. The Teacher Institute multiplies the impact of the instruction by providing teachers with educational tools they can use in the classroom and establishing links with professional scientists. (NSF Award 0315138, Andrew Burton and Kurt Pregitzer, Michigan Technological University)

B.3 <u>OUTCOME GOAL for Research Infrastructure: "</u>*Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools."*

Comments:

DEB has clearly demonstrated the ability to develop strong, innovative and sustainable methods for enhancing the nation's tools, equipment and facilities for enabling excellent research. DEB staff have shown creativeness in developing programs that are interdisciplinary, foster novel scientific research, and provide infrastructures that not only endure but also serve as models for other programs within NSF and for others outside of the Foundation.

Projects include, but are by no means limited to:

1. A novel database now provides detailed data for determining optimal strategies for conserving those species that are threatened currently, as well as those most likely to be at risk in the future. The database, which was assembled in collaboration with mammalian experts worldwide, used new computer software to combine information on the distribution and diversity of over 4000 mammal species and generate fine-scaled maps of their ranges. (NSF Award 0129009, John Gittleman, University of Virginia Main Campus)
2. MorphoBank is revolutionizing morphological biology by allowing teams of biologists across the globe to collaborate in a virtual workspace. The system allows biologists to compare the morphology of organisms to reach agreement on their descriptions and categorizations. (NSF Award 9903964; Maureen O'Leary, SUNY at Stony Brook)
3. An invasive species information resource named ISIS (Integrated System for Invasive Species) has been developed that provides information about the most economical and ecologically effective steps to prevent the further spread of invasive species. Assembled by a team that included economists, mathematicians, and aquatic biologists, ISIS has generated information that is useful both to aquatic resources managers and the general public (NSF Award 0213698, David Lodge, University of Notre Dame)
4. DEB is facilitating research at the National Ecological Observatory Network (NEON). NEON is an innovative observatory network to collect ecological and climatic observations across the US. DEB is evaluating projects with relevance to NEON efforts and will be a focal program for enabling the use of novel infrastructure in transformational ecological research at continental scales.

PART C. OTHER TOPICS

C.1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

This COV concurs with the recommendations of two previous COVs (2003, 2006) that the DEB should increase investment in independent postdoctoral fellowships. Moreover, the COV urges that the DEB weigh this recommendation in light of the challenges arising through interdisciplinary research horizons and the efficacy of a postdoctoral fellowship program that encourages recipients to explore interdisciplinary areas and work at the boundaries between existing disciplines. Postdoctoral scholars are ideally suited to explore the edges of multiple scientific disciplines, bring new approaches to stubborn problems, and move science forward in exciting and unforeseen ways.

The COV believes that a revitalized postdoctoral fellowship program is one of the best investments that the DEB can make in the future. History suggests that previous NSF postdoctoral fellowship programs accelerated the career development of the fellowship holders and facilitated their eventual emergence as scientific leaders. While there are some opportunities for independent fellowships (e.g. the bioinformatics postdoctoral program, NEON-associated fellowships, NCEAS and NESCENT) they are too few in number and too limited in scope and orientation. An investment in postdoctoral scholars whose support is independent of traditional research grants is one of the best ways to accelerate the development of a new generation of environmental biologists with the vision and skills needed to address problems in areas of national priority such as climate change and energy.

C.2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

DEB has been conscientious and effective in developing programs and clusters that track emerging research areas. Nonetheless, the COV encourages the Division to ensure an adequate period of sustainability for some of these programs. For example, DEB was highly responsive to the need for a cross-disciplinary panel for handling the field of phylobiogeography.

The COV commends the DEB on its engagement with the most pressing issues of our time, including climate change, loss of biodiversity, and sustainable energy. In sessions with program officers from across the Foundation, the COV noted that DEB is considered a leader in several areas of interdisciplinary research and environmental education. Moreover, DEB is by far the most significant participant in the OD/OISE and international programs. This cross-directorate participation is viewed as a highly positive impact.

The combined problems of climate change, biodiversity loss, and need for sustainable development exist particularly in developing countries. Therefore, the COV considers international engagement to be a critical area for additional DEB involvement and partnerships. Research Coordination Networks are considered to be an important mechanism for international engagement, and DEB is a leader in first developing and utilizing this NSF initiative.

C.3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

DEB is well positioned to lead a national effort on climate change because it has a long-term record of funding relevant research specifically aimed at the subject and indirectly through the monitoring of biotic phenomena. NEON, STREON, LTER, ULTRA, and other division programs will be "front and

center" of any national initiative on climate change. However, Transition and tipping points in complex environmental systems, a report of the NSF Advisory Committee for Environmental Research Education, clearly demonstrates that society is facing environmental problems of such complexity and magnitude that a single or several NSF Divisions are not sufficient to address the problem, no matter how successful they are today. Nothing short of an NSF-wide effort, in close coordination with other federal agencies (i.e., a government-wide effort) is necessary to effectively address the complexity and urgency of emerging environmental issues facing the nation and the world.

C.4. Please provide comments on any other issues the COV feels are relevant.

C.5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

There is no efficient means for committee members to collaboratively write their performance review and recommendations. This COV strongly encourages the Foundation to update the system before the next COV meets, perhaps in a manner similar to how panels now function electronically. This interactive software would streamline the process and reduce unnecessary duplication of effort.

PART D. Please comment on both scientific and management aspects of each of the following division-specific questions:

1. **How is DEB positioned relative to national emphasis areas such as climate change and energy? What could it do better or differently?**

The DEB is especially well positioned to foster transformative research in areas of national concern such as climate change, sustainable energy development, and related impacts on biodiversity. Given the wide range and connectivity of DEB-sponsored research from microbes to ecosystems, there are urgent needs for additional research that contributes to maintaining essential ecosystem services that are vital to societal needs.

Climate change - This research is critically important to the national emphasis on climate change, especially through research that demonstrates the effects of climate change in the past, present, and predicted future on species, habitats, communities, ecosystems and geographic regions. **There is no other federal program that provides such comprehensive and powerful insights on the biological effects of climate change.** Because the quality of life, and even the survival, of humans are dependent on ecosystem services, these comprehensive studies have enormous implications and value for both science and society.

Thus, the COV commends and encourages continued DEB support of research relating to climate change, as evidenced by the two-hundred and eight (208) grants associated with climate change between 2006-2008. These values are based on search of the NSF public awards database for DEB managed awards with "climate change" or "global warming" in the title or abstract. 40% of these projects were collaborative, and 20% were DDIG grants, with total funding for these projects at approximately 15 million dollars.

DEB also has the potential for promoting other large-scale, inter-agency investments and bringing investigators from different disciplines together to understand and forecast changes in forests, wildlife and fish populations, and habitats with climate change scenarios, and to expand research at

the interface between human health and sources of human disease in the environment in collaboration with NIH and CDC.

The COV endorses the recommendations of the recent *Transition and tipping points in complex environmental systems* report and recommends the NSF ERE Working Group could be assigned to assess the implications of this report to NSF programs, and to its internal organizational structure and function. An unprecedented level of science integration will be required to address the environmental complexity described in the *Transition and tipping point* report, a level that is orders of magnitude higher than now present or advocated in the Foundation's most successful climate change programs. This means that the challenge to the formulation, planning, and execution of research will require extraordinary adjustments on the funding of research and the assembly of research teams capable of dealing with the climate change problem. Collaboration with NOAA, USGS, USDA Forest Service and other agencies will continue to grow in importance.

DEB's effort to address both the response of organisms and ecosystems to climate change and their role in controlling it (e.g., through greenhouse gas emission and carbon sequestration) requires a strong microbial component. With the demise of several programs and initiatives that supported just this type of research (MO, MIP, Microbial Genome Sequencing, EnGen), it is vital that microbe-related climate change research has a home at DEB. Increasing the number of program officers with expertise in microbes and microbial processes is a necessity, as is increasing the number of panelists with microbial ecology expertise on DEB panels.

Energy – Development of sustainable energy requires an environmental perspective. As the NSF's National Science Board (2009) notes in *Building a sustainable energy future*, "Given the relationship between energy and environment, understanding and applying the basic science of the climate system, the carbon cycle, and climate change is essential." DEB's energy research potentially plays a crucial role in its integration of energy and climate change issues. An area that is critical to development of biofuel energy is microbial community genomics, as microbial consortia form a critical link in the utilization of cellulosic materials for fuel. This broad theme largely falls within the DEB arena. Although DOE is currently supporting microbial and plant genomics and metagenomics resulting in large databases relevant to biofuels, DEB can play a complementary role in funding basic studies on the fundamental ecological and evolutionary processes that affect the ability to harness these organisms for energy related purposes. We recommend that DEB specifically consider how it can coordinate its programs in fundamental science so as to complement efforts of agencies such as DOE and USDA that have specific programs in energy-related themes such as biofuels and environmental impacts of alternative energy development.

DEB research areas are also extremely relevant for understanding the interdependence of energy and climate change, such as how biofuel development will impact the environment, both at local and global scales. The recently DEB funded workshop on environmental effects of biofuel development was extremely timely and influential in providing an important perspective on how different options could be sustained. Although relatively few studies from DEB have so far addressed these energy-related themes, there are outstanding exceptions. For example, the 2007 LTER grant to David Tilman illustrates the kinds of new understanding and discoveries that DEB can foster. His DEB-sponsored research investigates how different options for biofuel development impacts biological diversity, structure and dynamics of ecosystems, and the benefits that society receives from natural and managed ecosystems. This kind of science illuminates a path that DEB can follow to establish a program in energy-related environmental science, which we expect to expand dramatically.

Biodiversity Conservation: In addition to the national emphases on climate change and energy it is notable that DEB fosters vital research relating to great societal need. One of these is biodiversity science and its application to biodiversity conservation. DEB is unique in its support of studies that document the diversity, complexity, and distribution of life on earth, a mission that provides the

baseline for assessing the nature of the great biotic extinction event we are now experiencing. Understanding the dimensions, tempo, and effects of this event is critical to identifying approaches to its mitigation. DEB-sponsored programs such as Biodiversity Surveys and Inventories (BSI) Planetary Biodiversity Inventories" (PBI; associated with BSI), and Revisionary Synthesis and Systematics (REVSYS; mostly associated with Systematic Biology, or SB) are unprecedented in fostering the international collaborations of experts for the global scale study of groups that are poorly known and highly endangered, yet are extremely important to providing ecosystem services. Moreover, these programs uniquely offer opportunities in training new generations of scientists often residing in countries that are economically and technologically impoverished but biologically enriched.

Progress in this research is closely linked to the national priority on climate change, because habitat destruction and correspondent biodiversity loss as well as climate change together represent the multidimensional nature of the environmental crisis. The COV strongly endorses DEB's continued commitment to the support of biodiversity research, with the added note that some of these projects address problems of such urgency that their priority and funding should be considered in that light. For example, even greater attention might be given to the PBI competition, which is intended to accelerate the discovery and study of the world's biodiversity. Such focus might also increase the number of lower-cost projects considered eligible for Rapid Response Research (RAPID). Finally, as noted above, DEB-supported research in biodiversity and related environmental sciences should be considered in strategies that integrate research across the foundation in ways that sufficiently address both the complexity and the urgency of the environmental challenge.

Human Health: The environmental crisis presents new threats to human health and well-being. A catalyst for the connection between DEB-supported research in areas such as evolutionary biology and human health is a clear trend in the scientific community. A recent article ("Darwin Applies To Medical School," *Science*, 2009, vol. 324, p.162, http://www.sciencemag.org/cgi/content/full/324/5924/162a) indicates a seven-fold increase in direct interactions (as demonstrated by collaborative research and cross-citations) between evolutionary biology and medicine. Solutions to some of the great challenges to medicine today, including pandemics caused by viruses, clearly lie in an understanding and application of evolutionary biology. Some medical schools are considering the introduction of an advanced course in evolutionary biology to their curricula. Although some of these research areas, including specifically medical ones, are supported by the NIH, DEB has a vital and complementary role in fostering the underlying biological disciplines. DEB promotes the research in evolutionary and comparative biology that offers the greatest opportunity for this connection. Transformational results have emerged from research on Hanta virus and plague supported by the DEB through the LTER, DDIG, CAREER, and other programs. For example, DEB scientists have discovered connections among environmental processes, animal populations, and the sequestration and eruption of human infectious disease.

2. **Are the current programs and clusters appropriately structured to foster emerging research areas?**

DEB has been very conscientious and effective in developing programs and clusters that track emerging research areas. We applaud the recent reorganization of two DEB clusters, Population and Community Ecology, and Evolutionary Processes. Nonetheless, the COV encourages the Division to strive to ensure an adequate period of sustainability for some of these programs. DEB was highly responsive to the need for a cross-disciplinary panel for the field of phylobiogeography, but this program was terminated before the community had time to respond.

3. **What actions should DEB consider to foster more innovative "broader impacts" activities?**

DEB is credited with placing fundamental importance on broader impacts. As described above, DEB-funded discoveries have major implications for society's most pressing issues from human health to energy policy, although most "Broader Impact" goals described in proposals to date have been educational in nature. Many of the proposals reviewed by the COV articulated a plan for achieving such impacts.

The general need for "more innovative broader impact activities" is the focus of substantial research devoted to science education. The great majority of DEB projects are diligent and effective in mapping out programs for teaching and training students and postdoctoral scholars as well as in offering outlets for public education, such as websites, that cover the research in ways that engage a broader audience. Yet the metrics for the effectiveness of many of these activities are unavailable and assessment of their actual impact is uncertain. Elements that are key to developing successful education and outreach are often not sufficiently addressed. The COV encourages DEB to further draw on the insights of potentially collaborative education programs. Such collaborations should greatly facilitate efforts to identify and adopt new and innovative approaches to broad impact activity.

4. **Please provide advice on progress we have made on the issues raised by the previous COV during the last three years.**

As described in the DEB Response to the 2006 COV and the Continuing Progress on 2006 COV Recommendations reports, there has been serious and ongoing consideration by DEB of the 2006 COV. These efforts fall into two main categories: 1) staffing issues, and 2) participation and representation of underrepresented groups and institutions.

In response to the 2006 COV concern that DEB was not adequately staffed, the DEB has attempted to bring staffing in line with the COV recommendations. The suggestion that DEB is fully staffed with support personnel was not fully in agreement with those individuals we interviewed (DEB staff and Program Officers). Many individuals appeared to be overworked and understaffed. To continue to foster innovative research and to develop emerging frontiers while also having sufficient time to handle the increasing workload created by cross-disciplinary proposals, it seems clear to the COV that additional staffing is needed.

Better progress seems to have been made in the context of increasing the participation of underrepresented groups. DEB has increased its efforts to educate the scientific community on the importance of broader impacts.

SUMMARY OF THE RECOMMENDATIONS

Management of Programs

- Examine mechanisms for disseminating information to the scientific community regarding new initiatives. For example, very few members of the community are aware of the "Dear Colleague" initiatives. Of the four initiatives, two have received no response. In total, only 58 proposals were received. Moreover, even if aware, the community is not clear on the funding opportunities associated with the initiatives.
- Understaffing is a serious concern. Proposal pressure has increased since the prior period of COV review without apparent parallel increase in Program Officers, Science Assistants,

and other support staff. Proposal pressure will likely continue to rise in the foreseeable future and problems created by understaffing will be magnified and could severely impede the Foundation's ability to enable scientific advancement.

- Absolute numbers of submissions and awards granted to underrepresented groups remains low. Awards to women have been flat over the period. Continued outreach to professional societies, to minority colleges and organizations, and other sources of potential researchers is an important need.
- Refine and expand the current NSF database of potential reviewers.
- Collaborative submissions have increased, thereby increasing the number of authors per proposal. As this collaborative research continues to increase, it will be more difficult to find highly qualified panelists who do not have a COI. The COV suggests that NSF reassess COI rules to allow panelists and ad hoc reviewers with minor affiliations with collaborators to participate. Systematic waivers for certain types of collaboration would be developed and implemented to enhance the review process.

Science

- Increase international engagement to address global scale research: a fully funded NSF Climate Change Initiative is needed to address the climate-driven changes in complex environmental systems taking place. DEB is well positioned to take the lead in this effort to investigate interactions between climate change, energy, and human impacts.
- Enhance postdoctoral opportunities to sustain independent, creative scholarship, particularly in emerging interdisciplinary areas.
- Continue to increase leverage cross-disciplinary opportunities for fostering emerging scientific fields and technologies.

COV Review Process

- Include at least one member from the present COV on the next COV to ensure a "memory" and continuity of the review process.
- Improve the electronic infrastructure for the COV review system that includes computer software for simultaneous editing of the report (similar to that provided to review panels). There is no efficient means for committee members to collaboratively write their performance review and recommendations.

Findings

1. The DEB is administered with integrity, effectiveness, and considerable creativity. The Program Officers and Staff excel in serving their constituency in the scientific community and responding to the rapidly changing horizons of science and its rapidly changing culture.

2. The products of awards conferred through the DEB illustrate first-class science and validate the methods and approaches used by the DEB to identify the best scientific proposals and encourage a scientific climate of innovation.

3. The DEB has demonstrated its responsiveness to changing horizons of scientific research and its willingness and ability to respond to community needs. It has a strong tradition of adaptive self-management and the community can expect this tradition to continue; the DEB remains a nimble and versatile unit that is well-situated for an era of rapid changes in the boundaries of scientific disciplines and the missions of other scientific agencies. The powerful connections between DEB and other agencies open important opportunities for collaboration in the areas of human health, climate change, and sustainable energy.

4. The DEB is well positioned for a leadership role in advancing the national priorities for research on climate change and for recognizing, understanding, and preserving biodiversity. This position emerges from two factors: the DEB's history of fostering imaginative and rigorous research, and the DEB's history of innovation, particularly in science that requires the integration of multiple disciplines.

5. The DEB is well positioned for a leadership role in advancing the national priority for developing new sources of energy, particularly biofuels, and mitigating the consequences of energy consumption. While the DEB has not built a large portfolio of work in new sources of energy, it has a significant history of supporting rigorous scientific research on the ecosystem consequences of energy consumption and the effects of human activity on ecosystem services.

Major New Recommendations

1. The DEB must lead NSF in embracing the call for action presented by the AC-ERE report, "Transitions and Tipping Points in Complex Environmental Systems." This report calls for a commitment to multidisciplinary environmental research on a scale larger than any program the NSF has implemented thus far. The DEB has a tradition of fostering innovative environmental research and promoting research across divisional and directorate boundaries. There is no Division within the NSF, or group of program officers, more suited to the task than is DEB.

2. The DEB should lead NSF in reassessing how it implements new programs and nurtures successful ones, particularly those that reflect emerging scientific areas or developing interdisciplinary horizons. The mechanism of the "Dear Colleague" letter is not as effective as had been hoped, and new ideas for promoting emerging topics and engaging the community's interests are needed.

3. The DEB should lead NSF in finding appropriate homes for research in microbial genomics and environmental microbiology. Past initiatives proved successful in identifying and supporting innovative, important research in these areas, and recent organizational changes have left the community confused as to the agency's and the DEB's commitment to these areas of microbial biology.

4. The leadership of the BIO directorate and the DEB should engage the program officers more fully and comprehensively in strategic planning. The program officers have the attention of the community and can bring timely insights into the horizons of scientific inquiry, as well as the best means of continually fostering new areas of inquiry and innovative research.

5. The DEB should increase its use of Science Assistants by defining strong scientific support roles for them and increasing their numbers. Science Assistants can play important roles in facilitating the proposal review and panel process; the experience is highly appealing to early-stage scientists, therefore the DEB should be able to recruit from a large corps of talented people.

6. The NSF should review its conflict of interest (COI) policies with an eye toward making them less restrictive. The culture of scientific research in environmental biology has changed dramatically, with an increase in multi-investigator projects. In this culture, the COI policies unduly restrict choice of reviewers and increase the difficulty in recruiting expert reviewers for proposals.

Major Continuing Recommendations (repeating those offered by previous COVs)

1. The DEB should develop a program to support interdisciplinary postdoctoral scholars independent of those supported on individual research grants, particularly in emerging interdisciplinary research areas.

2. The DEB should continue its efforts to ensure that panel summaries reflect the diversity of reviewer opinion and, in particular, address inconsistencies among reviewer opinions. This is an area in which Science Assistants can be extremely valuable, by checking proposed panel summaries against notes from the discussion and reviewer comments and helping to revise summaries when needed.

3. The DEB should continue its efforts to guide PIs in quantifying broader impacts of their prior work so that such achievement can be evaluated reliably and consistently.

4. The DEB should continue its efforts to improve selection of reviewers and enlarge the pool of expert, reliable reviewers upon which program officers can draw.

5. The DEB should continue it efforts to reach out to women and underrepresented minorities and encourage their successful pursuit of funding for research.

SIGNATURE BLOCK:

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For the DEB COV
Alan P. Covich, Chair