Report of the Review Committee for Earth and Space Sciences

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Committee Members

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Contents

1. Committee Charge. The Earth and Space Sciences (ESS) Review Committee was charged to assess the quality of the undergraduate and graduate degree programs in ESS, and to provide ESS faculty with constructive suggestions for strengthening their program.

2. Committee Operation. A first meeting of the local members of the Committee with representatives from the Graduate School, the Acting Dean of the College of the Environment, other UW officials, and the Chair of ESS (Prof. Robert Winglee) occurred on May 27th, 2010. The initial review scheduled for early February was postponed due to travel restrictions for outside committee members due to a winter storm. The review was rescheduled for May 22-24, 2011. Committee members communicated via email before the first working dinner on the evening of May 22nd. Meetings with students, faculty, and staff took place May 23-24 as described in the review agenda (Appendix A). A debriefing with UW administration and the Chair of ESS concluded the review. It should be noted that the review was extremely well organized, largely due to the efforts of Prof. Winglee and his staff.

3. Recent Program History and Current Demographics. The previous program review was performed in 1999 as part of an overall review of four academic units: Atmospheric Sciences, Geological Sciences, Geophysics, and Oceanography. Shortly after this review, Geological Sciences and Geophysics were combined to form ESS. As described in the current ESS self-study (SS) document, this merger was unanticipated by the two departments, and required substantial effort to implement. Shortly after this merger, ESS was relocated to accommodate the renovation of Johnson Hall (a renovation that the previous review committee highlighted as a priority given the dilapidated state of the building). ESS

moved back into Johnson Hall in 2005. In 2009 ESS was combined with several other academic units to form the College of the Environment (CoEnv). In summary, ESS has seen a substantial amount of externally-driven change (the word "turmoil" was used more than once) over the past decade. The SS document reflects the uncertainty and concern generated by these changes. However, in our meetings with ESS faculty, students, and staff the review committee was struck by their enthusiasm and their vision for the future. This vision and the resources required to see that vision come to fruition are presented below.

The demographics of ESS are as follows:

Faculty. The current academic-track FTE count is 24, down from 30 in 2001 (Figure 1 of the SS). The current head count is 29, greater than 24 FTE stated above since many ESS faculty have partial appointments in other academic units (e.g. atmospheric sciences, oceanography) or "external organizations" (e.g. Quaternary Research Center, Pacific Northwest Seismic Network). A significant number of research faculty (13) are incorporated into the research mission of ESS. In addition, scientists from the Quaternary Research Center, the Pacific Northwest Seismic Network, and the Washington Space Grant Consortium also participate in ESS research and instructional programs on an *ad hoc* basis and are therefore not included in the head count. A significant issue confronting ESS is the age distribution of the tenure-track faculty (Figure 11 of the SS). An improved economy (hopefully) combined with time is likely to lead to a significant number of retirements in the coming decade.

Graduate Students. There are ~80 graduate students in ESS with the vast majority pursuing a Ph.D (Figure 9 of the SS). The size of the graduate student body has remained roughly constant over the past decade. The proportion of female graduate students has increased from 35% to 50% over the past decade. In addition, the proportion of racial minority students has increased to 10% of the graduate student body during that period. The quality of the graduate students is high, with three students this year receiving NSF graduate fellowship awards.

Undergraduate Majors. The number of undergraduate majors has increased from ~100 to ~150 students since 2002 (Figure 7 of the SS). Faculty representatives of the undergraduate program suggested that the capacity exists to accommodate 200 majors. Roughly 10% of the undergraduates participate in the departmental Honors Program which requires that students perform an independent research project.

4. Quality of Program

The research programs in ESS are internationally recognized as being strong. The department is ranked #13 in the overall category of Earth Science by the US News and World Report, with top-ten rankings in two of four sub-specialties (Geophysics and Seismology; Geology). The NRC ranking is a bit lower; however, there are issues with the most recent NRC rankings involving faculty over-counting and other inaccuracies which negatively impact comparative metrics that are normalized to the number of faculty (e.g., awards/faculty, publications/faculty, etc.). The strength of the research program is also attested to by the number of awards received by ESS faculty over the past decade including the election of four faculty as AAAS Fellows, two National Academy of Sciences members, and selection of one MacArthur Fellow (see page 11 of the SS). The number of publications in high-impact journals is also strong.

4a. Research and External Collaborations. The research activities of ESS are organized into eight areas, and representatives from each area were interviewed during the site visit. The current and future

research activities of each area, and their relationship to the CoEnv were discussed, as were current needs. A brief summary of these discussions is provided below.

Solid Earth: Geophysics One of the missions of this group is to understand subduction, or the movement of one tectonic plate under another. Since the Pacific Northwest is in an active subduction zone, the department is ideally located for studying the associated earthquake, volcanic and tsunami hazards. The members of this group are recognized experts who continue to make significant contribution to geophysics. This group is highly involved with the Pacific Northwest Seismic Network (PNSN), with a subset of faculty holding positions in PNSN. In addition to leading the investigation of episodic tremor and slip, this group is also interested in volcanic and seismic activity under Mt. St. Helens. Subduction has a significant impact on the environment of the Pacific Northwest; therefore, the research activities and interests of this group should be easily incorporated into the CoEnv. With regards to future activities, this group has suggested that ESS is in need of a Geodesist, or an expert on the use of GPS and other positional data to map displacement of the Earth's surface. Expertise in this area would add new capabilities to an already strong research group as well as aiding other groups such as glaciology and surface processes.

Solid Earth: Geology. Also known as the Earth Materials group, this group employs physical, chemical, and field-study tools to understand the composition and properties of the Earth. Although small in number, the impact of this group's research is substantial. A subset of this group specializes in magmatism and volcanism, which complements PNSN efforts to understand subduction zones and the Cascades, in particular. This group has been involved in a series of interdisciplinary activities including the imaging of magma systems in the Cascades with the USGS (Cascade Volcano Observatory), as well as isotope and geochemical tracer analysis of early Earth environments with astrobiology, biology, and oceanography colleagues. The breadth of research interests combined with a history of interdisciplinary activity makes this group well positioned for the transition to CoEnv. A concern of this group is the analytical, experimental, and computational infrastructure of the department. The age of the microprobe, the limited staff/faculty to maintain this and other key pieces of instrumentation and the imperative to advance the analytical infrastructure of ESS, were noted as areas of need.

Glaciology. The glaciology group studies the cryosphere and its impact on the environment. This group studies sea-level rise with glacier melting and the seasonal snow packs that serve as a source of water for many regions of the world. This research is highly interdisciplinary (with Atmospheric Sciences and Oceanography), and the contribution of this group to the research portfolio of CoEnv is clear. This group noted that many other Earth Science departments are trying to create glaciology groups (within the context of global climate change), and the UW is fortunate to already have one of the premiere glaciology programs in the world. Of the faculty contributing to this group, only two are academic tenure track (Waddington and Warren) and both expected to retire in the near future. These impending retirements pose a significant threat to the UW's strength in this important area of environmental studies and climate change.

Planetary Sciences. The goal of this research group is to understand the interiors, surfaces, and atmospheres of Solar System objects and the processes governing them. Faculty in this area are involved in modeling, laboratory studies, and instrument development for NASA and international space probes for deployment to the moon, Mars, Jupiter, and Saturn. When asked how this research would fit into CoEnv, the group made a compelling case that "comparative planetology" or the study of processes and system evolution on other planets would help inform our understanding of Earth's systems and their evolution. Towards this end, additional expertise involving Titan would strengthen

their research enterprise . The growing international reputation of this group is evidenced by an increase in the number of applicants to the PhD program in planetary sciences. Expansion of graduate course offerings (from the current single course of ESS 581) was identified as area of need.

Geobiology. This area involves the study of the reciprocal interactions between the Earth and life in all its forms over time. This area was identified in the previous 10-year review as an emerging area, and two faculty (Buick and Gorman-Lewis) were subsequently hired. With the inclusion of ESS into CoEnv, the research portfolio of this group would be enhanced by the addition of expertise in the interactions between macro-organisms (plants and/or animals) and Earth surface environments (soils and/or rocks). This would provide linkages between research areas within the department (geobiology and surface processes) as well as potential linkages with other academic units in CoEnv (forestry and oceanography). This additional expertise would position ESS to capitalize on an under-exploited research area in geobiology, which has to date concentrated mostly on interactions of micro-organism with rocks, minerals and fluids.

Surface Processes I. The interest of this group spans the atmosphere, climate, cryosphere, Earth surface dynamics, sedimentation, crustal deformation, tectonics, and deep-earth processes. The faculty participating in this group is strong, and well positioned to address emerging areas of Earth science including the interactions of the atmosphere, surface, and deep-earth processes, the impact of surface processes on ecosystems, and the impacts of human activities on Earth systems. Two main areas of concern were raised by this group. First, the limited number of TA lines in ESS has constrained the number of first-year graduate students that can be accepted into the Ph.D. program. This in turn restricts the number of new research opportunities that can be pursued. Second, the number of faculty is this area is limited, and this group views the addition of research and tenure-track faculty as an important and long-term investment.

Surface Processes II. This group addresses diverse issues ranging from fluvial processes to sedimentation in the continent to the cryosphere. In addition, the focus of this group has expanded to understanding environmental issues, climate effects and feedbacks, and planetary analog studies. In their research this group employs analytical methods, modeling, and field studies with sites in the US, South America, Greenland, Antarctica, and New Zealand. The interests of this group overlap with other areas within and beyond ESS. Interdisciplinary research areas of interest include: the interplay of landscapes, soil, and biology; tectonics, topography, and climate; and surface processes and seismology. This group also studies and maps natural hazards in King County with respect to seismic hazards, tsunamis, coastal erosion, and soil stability. The research activities of this group should find much synergy with other academic units in CoEnv.

Space Science. This group is interested in the thin atmospheres of the Solar System, space plasma environments and advanced plasma propulsion, ionospheric and mesospheric dynamics, and atmospheric electrification. It is an internationally recognized area of strength in ESS. A primary concern discussed during the site visit was how the fundamental research performed by the space science faculty would fit into the research portfolio of ESS. The activities of this group can be viewed as similar to the planetary sciences group, with comparative planetology being a natural connection between this group and CoEnv. The loss of Prof. Harris to UC Davis and the duties of Prof. Winglee as Dept. Chair were noted as significant factors that have diminished the academic faculty time committed to this group (Prof. Harris' position was not filled due to budget cuts). As such, another hire in this area was viewed as critical to ensure the continued success of this group.

External Collaborators. There are a number of external partners who assist with the research mission of ESS. The Quaternary Research Center continues to foster interdisciplinary research at the UW through seed grants, seminars, workshops, and the publication of "Quaternary Research" (the latter supplies the operating budget of the Center). The Pacific Northwest Seismic Network is charged with monitoring seismic activity in Washington and Oregon, providing information regarding earthquakes to the public, and developing measures to limit the harmful effects of earthquakes and volcanoes. The Program on Climate Change is a UW program designed to develop interdisciplinary research and teaching on climate change. Finally, the Astrobiology program promotes interdisciplinary research in the field of astrobiology, or the study of life on Earth (and potentially elsewhere). The review committee was not charged with reviewing these programs; however, many faculty in ESS participate in these programs, and scientists from these centers assist with the research mission of the department. ESS clearly benefits from these collaborations, and their role in the department is valued by faculty and students throughout ESS. One area of concern expressed by participants in these collaborations was sustainability. For example, the astrobiology program is centered around an IGERT grant from the NSF. The grant funding much of this activity (a renewal of the original grant) will expire shortly, and new sources of support to maintain a cohesive effort (for example, part time staff) are not apparent. Given the role of these collaborations in the research program of ESS, a mechanism by which to maintain these programs between funding cycles would be of great value.

4b. Graduate Program

ESS offers both Ph.D. and M.S. degrees, with the Ph.D. program having the vast majority of students, and is therefore the focus of this section. Enrollment in the Ph.D. program has been consistently around 80 students since the creation of ESS. Women comprise 50% of the graduate student body, an increase from 35% immediately after the last 10-year review. The number of students from racial and ethnic minority groups is 10%, also increased from the last review. Prof. Winglee mentioned that ESS is partnering with the Graduate Opportunities and Minority Achievement Program (GO_MAP) to further increase the number of students from underrepresented groups in the graduate program.

Coursework for first-year graduate students involves the introduction of common analytical and research skills required by all students to perform research in the Earth Sciences. In addition, students are required to take courses in three of the four core research areas in ESS (with one of those core courses being the area of research the student will ultimately pursue for their dissertation). Various courses are offered beyond the core course offerings, with the number of courses varying by research area. For example, the glaciology group has a significant number of graduate courses, while the planetary sciences group has a single course. Graduate students felt that the introductory coursework served as a good preparation for their research, and had no complaints about the quality or number of courses offered.

Students are supported through a mix of TA and RA funds, with the specific mix dependent on the field of study. Typical of any program with multiple research groups, some activities are better funded than others. Students working in better-funded areas spent more time on RA appointments. With regards to TA positions, two issues were raised by the graduate students. First, students from groups where support is largely TA-based felt that progress towards their degree was hindered by obligations associated with their TA appointment (the perceived time to degree by the graduate students was ~6 years, consistent with the ~5+ years stated in the SS). Second, some of the TA assignments were viewed as very time consuming, with a consensus that some students were working upwards of 40 hours/week. Surprisingly, the students comments about this substantial workload could

be summarized by the quote, “Someone has to do this; undergraduate education is important.” Students also noted that faculty work extremely hard in the undergraduate program, and thus they felt an obligation to do the same. Although this sense of commitment is commendable, the impact of this commitment on graduate students (and faculty) is not sustainable, and must be addressed.

A new initiative involves a professional M.S. degree, a prospectus for which is provided in the SS document. This new degree program is envisioned to enroll ~15 students/year, and the tuition generated by this program will provide a new revenue stream for the department. One area of concern was that there would be two populations of M.S. students: those with access to TA and RA support, and those without such access. Prof. Winglee stated that the intention of the department was to not guarantee support to any M.S. students (those in either the professional M.S. program or the traditional tuition-based program).

4c. Undergraduate Program

The undergraduate program in ESS has grown substantially over the past 5 years, with the number of majors increasing from ~100 to ~150 students. Continued growth is expected until a capacity of 200 is reached. The reason for this increase is unclear at present, but may involve other science units converting to competitive entry (Chemistry has done this, and Biology is soon to follow suit). There was some concern that ESS would become the “science degree of last resort”. Alternatively, the national trend of increasing majors in Earth Science may be due to a growing awareness of employment opportunities related to energy/mineral resources and environmental issues. ESS offers a BA degree, and four options for the BS degree (Standard, Biological, Physical, and Environmental). Coursework for the degree options is similar at the 100 and 200 level, with upper-division coursework at the 300 and 400 level differing for the various degree options. The “Standard” option is the most popular, subscribed to by ~80 of the declared majors. ESS also offers an Honors track subscribed to by ~10% of their majors. In this track students are provided professional skills development and introduced to research in ESS. Undergraduates in this program described the importance of research in their studies, and were extremely enthusiastic about their research experience.

The undergraduate degree program in ESS is comprehensive, well designed, and a point of pride for ESS faculty. The undergraduates interviewed during the site visit were very satisfied with the degree programs. One theme of the ESS undergraduate degrees is that of “hands on” science, including a substantial commitment to laboratory and field work. To quote one ESS faculty member, “We won’t be just a textbook science.” Extensive laboratory and field work requires sufficient TA resources. Unfortunately, the 16 TA lines/quarter are not sufficient to sustain the existing degree programs (without heroic efforts as described above). ESS faculty have acknowledged this issue, and are currently revamping curricula and incorporating efficiencies (reduced reporting, adding web-based learning, etc.) to reduce the TA work load. Increases in efficiency will help, but the committee strongly supports the allocation of more TA resources. With the advent of activity-based budgeting and increases in undergraduate tuition rates, ESS is well positioned to command additional resources that are surely on the horizon.

The previous 10-year report neglected to mention the role of ESS in 100-level or “general science” instruction at the UW. That was an unfortunate oversight since the faculty of ESS made it quite clear that they are extremely proud of their 100-level instructional program. Over 13000 SCH of instruction are provided at the 100-level, largely by lecturers (in particular, Terry Swanson). In addition to the workhorse “Intro to Geological Sciences”, other highly subscribed courses including “Dinosaurs”, “Volcanoes”, and “Space and Space Travel” are offered. In the area of foundational science instruction,

ESS faculty (in particular, Mike Brown) have taken campus-wide leadership roles in the development of a new interdisciplinary sciences degree designed for middle- and high-school instructors. The primary threat to the 100-level instructional program is limited support. Many of the courses are taught by temporary instructors, and the TA resources to run these courses (including field work) are very modest given the number of SCHs delivered. The committee hopes that the efforts of ESS in foundational science instruction will be supported with new resources that should become available after the introduction of activity-based budgeting and continued increases in tuition.

ESS and the Washington Space Grant Consortium have done a great deal to promote STEM educational initiatives including summer research opportunities for undergraduates. We would like to take the opportunity to mention the substantial contribution of consortium participants to the undergraduate research mission of the UW, and acknowledge their substantial leadership role on this campus (much of which has been expanded with the transition of Janice DeCosmo from WSGC to the Office of Undergraduate Education).

5. Operations

5a. Physical Plant. The renovation of Johnson Hall addressed a significant area of need identified in the last 10-year review. ESS faculty stated that the laboratory space was adequate. The instructional space was also viewed as adequate for current needs, but the continued increase in the number of majors could place a strain on available space. That said, the physical plant was viewed as more than adequate for current research and instruction.

5b. Instrumentation. The computational infrastructure in support of the educational and research activities of ESS was recently upgraded. In addition, new instructional equipment was provided during the Johnson Hall renovation. One issue is the aging microprobe, which is approaching the end of its useful life. A replacement/upgrade for this central piece of instrumentation will be required in the near future.

5c. Staff. ESS staff are enthusiastic about their contribution to the department, and feel that they are valued members of ESS. The level of enthusiasm was surprising given the challenges the staff have faced. In addition to the merger and relocation ESS experienced, budget reductions have resulted in a loss of 4.6 FTE staff positions. Many staff members are wearing “multiple hats” after taking on additional responsibilities after these losses. Essentially every academic unit at the UW is thin with respect to staff support, but the level of support in ESS is “bare bones”. One staff member put it best, “If we lost any part of the current staff, then things simply wouldn’t get done.” A second issue raised by the staff was the continued migration of tasks from central offices to the department (for example, processing of travel reimbursements). Difficulties in getting a timely (or any) response from OSP was also mentioned as a point of friction between ESS and central administration. Although this later issue is not unique to ESS, it is important in that it impacts departmental operations. As such, this issue demands some attention from UW administration.

6. Recommendations

Overall the Review Committee was struck by the enthusiasm and collegiality expressed by all members of ESS. Although the department has faced several challenges in the past decade, those challenges have been met and the department is strong. The research programs are active and externally supported, the faculty are productive and internationally respected, and the commitment to quality instruction at both the graduate and undergraduate level is clear. Our recommendation is for “continuing status” with a review in 10 years.

Having stated the above, there are significant threats to ESS that need attention over the next decade (hopefully sooner):

1. *The modest FTE count combined with an impending tide of retirements will significantly damage many of the research programs in ESS if not addressed*. This Committee understands that we are currently living in financially unusual times where the generation of new faculty lines is a challenge (to say the least). The point to be made is that planning for future hires must occur with a commitment of resources. In the past ESS faculty have developed numerous hiring plans, but the resources required to implement those plans have not appeared. This has resulted in ESS faculty having a bit of a jaundiced eye towards yet more planning. However, strategic hiring to protect core competency and to open new areas of research is critical in order for ESS to maintain its standing. Clearly, opportunities for joint hires with other academic units inside CoEnv and beyond will be part of this plan, but it is not up to this Committee to recommend areas for hire; that is the domain of the ESS faculty. The Committee was informed that one (maybe two) lines will be made available to ESS in the fall, and this is an excellent start. Working with the Dean of CoEnv, the faculty of ESS should develop a long-term vision for their program, identify key areas for hiring, AND be provided the resources to achieve their vision.

2. *Adequate TA resources should be directed to ESS to support their undergraduate program*. Having graduate students work 40 hours/week as a TA is not sustainable. Prof. Winglee is working to address this issue, and faculty members are exploring instructional efficiencies to reduce this workload. Even with new efficiencies, resources beyond the 16 TA lines/quarter (of which only 10 are permanent) are required to maintain the undergraduate program. Additional TA lines would also allow ESS to support additional graduate students which will in turn open up new research (and funding) opportunities. To be clear, we are not suggesting that ESS be given TA lines to grow their graduate program. Instead, this would be an additional benefit of a much needed investment in the undergraduate program. The Committee was struck by the comments of David Montgomery on this point, "If TA funds were available to support just a few more graduate students, it would help the undergraduate program and it would allow us to pursue new research opportunities."

3. *A lecturer line should be provided to ESS in support of their 100*-level instructional program. Over 13000 SCH of instruction is delivered at the 100-level. This substantial instructional program is supported by one lecturer and various temporary instructors. This situation is simply not sustainable. The advent of activity based budgeting combined with increased tuition revenue should result in new resources to support undergraduate instruction, and ESS is clearly in need of additional resources to support their undergraduate program.

4. *ESS should be encouraged to develop and launch their professional M.S. program*. The creation of this program would create a new revenue stream for ESS, and address an educational need in the private sector (as outlined in the Degree Feasibility Study appended to the SS).

5. *Some thought should be given to the development and support of research faculty in ESS*. The research efforts in ESS involve the participation of research faculty. A logical response to the loss of tenure-track FTE while trying to maintain a strong research program is the hiring of research faculty. If research faculty were not present, many of the research areas described above would decay (in short order). Many of the research faculty expressed concern regarding the security of their positions, and the availability of other avenues of support (for example,

temporary teaching). Since these are soft-money positions, there is inherent uncertainty and risk that research faculty are exposed to (especially in financially challenging times). There is no clear "solution" to this problem at present, and the inclusion of this concern here is intended to bring some awareness to this issue.

6. *ESS has made some excellent young hires over the past decade, and it will be a challenge for the UW to keep them*. As faculty salaries decline relative to peer institutions, talented faculty at the UW will be attractive targets for hire by other institutions. The Committee was impressed with the quality of the junior faculty in ESS. Prof. Winglee expressed some concern that other institutions are already recruiting some of the young stars in ESS. He is right to worry, and plans for pre-emptive actions to retain top faculty are warranted. A little investment here can go a very long way towards keeping young talent at the UW.