1. Project Title and Person(s) Submitting

Quantitative Analysis and Critical Thinking for the Environmental Studies Major: Developing Part II of the Introductory Core Series

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2. Courses to Be Changed and Rationale

The Environmental Studies (ENVS) major at the University of Colorado, Boulder (CU-Boulder) is one of the largest majors on campus. Currently (Fall 2016), ENVS has 709 students, an increase of 68% over the last decade, which mirrors the national upward trend in this field (Maniates and Whissel 2000). Environmental Studies 1000 (ENVS 1000) is a large, > 350 students class that serves as the introduction for the major, as well as a natural science core elective for non-majors. The course is designed to provide an introduction to quantitative reasoning skills and to give students an overview of the grand, interdisciplinary challenges of a changing environment, ranging from the science of climate change to developing natural resource policies and social well-being. The course is structured as a four-hour class with both lecture and recitation.

ENVS 1000 is a logical first step for incoming freshman and in ENVS, we have undertaken a major overhaul of this class in the past several years. This includes restructuring the course to include content acquisition and evaluation outside the class, synthesis and exploration of ideas within the class using a variety of active learning approaches, and development of critical thinking and quantitative skills within the recitation. These efforts coinside with creation of new digital resources for the class. In 2015, Neff published *A Changing Planet*, an online, introductory environmental science text that contains integrated assessment of student knowledge. From 2009 to 2015, during the development of this text and assessment platform, Neff used a variety of assessment and digital deployment tools in ENVS 1000 (including D2L) to prototype the approaches now available in a single online package. Despite this work (and perhaps because of it), we in the ENVS program recognize that students in the major need further support to build quantitative analysis and critical thinking skills. For this reason, the program seeks to create a new course, ENVS 1001, that will fill this gap in the curriculum and better prepare students for the demands of upper division courses within the major. **We request support from TRESTLE to leverage our work in ENVS 1000 to develop ENVS 1001, including course materials, assessments, and mapping to broader programmatic learning goals.**

2.1 Our approach
There is clear evidence that active, problem-based, and collaborative learning approaches collectively represent a successful model for teaching students quantitative analysis and critical thinking skills (Freeman et al. 2014, Gasiewski et al. 2011, Prince 2004). We define *active learning* (AL) as a method that engages students in the learning process through activities and thinking about what they are doing (Bonwell and Eison 1991), *problem-based learning* (PBL) as an approach in which relevant issues are introduced at the beginning of a unit and used to provide context and motivation for the content that follows (Prince 2004), and *collaborative learning* (CL) as mode by which students work in small groups to complete a common task (Roberts 2004). Not only do these approaches promote greater student engagement and learning, but they

also model effective strategies for addressing environmental issues that are inherently inter- or multi-disciplinary. Our goal in developing a course grounded in these approaches is that students who progress through the ENVS core series will be better equipped to learn complex coursework in upper-division classes, and leave CU as a more scientifically informed citizenry, equipped to work toward environmental solutions.

We propose to engage in four primary activities in the development of ENVS-1001:

(1) Develop a body of course materials that consists primarily of background preparation (readings, videos, and short evaluations), and in-class problem sets, exercises, and other small group activities (AL and CL). Over the course of the semester, guest experts will introduce four environmental themes (i.e., "units"): farming and food supply, land management, alternative energy, and acid mine drainage. We will use these themes as motivation to unpack the concepts and quantitative skills introduced in the in-class activities (PBL).

(2) Design meaningful pre-, post- and concurrent assessments of student learning gains.

(3) Map the learning objectives of ENVS-1001 to those of ENVS-1000 and the overarching learning goals of the ENVS Program.

(4) Participate in cross-CU STEM department meetings to discuss what is/is not working in the classroom and to share materials.

3. Course Development Plan

3.1 Timeline
The timeline for the proposed work is one year, beginning January 2017 (Spring semester 2017). Figure 1 shows a Gantt chart with the three phases of the project, the major tasks to be completed within each phase, and the associated milestones. In this section, we describe the primary tasks and milestones in greater detail.

Phase I. January through May 2017
During Phase I. of the proposed project, Hinckley, Neff, and an hourly graduate student (HGS) will *develop the course materials for a pilot version of ENVS 1001*, including in-class activities and assignments. Professor Andrew Martin, Faculty Advisor to ASSETT, as well as ASSETT staff, will meet regularly with the team to provide input on the development and implementation of the course. ASSETT staff will advise on new, appropriate educational learning technologies, and provide feedback (see letter of support from Martin). Hinckley will teach the pilot to 50 students (approximately one-third of the expected enrollment for the course). She, with input from Neff and the HGS, will give attention to mapping course activities to ENVS 1000 and broader ENVS programmatic learning goals, although the bulk of the mapping documentation will be done during Phase II. A full-time graduate teaching assistant (TA) will be provided by ENVS to assist with in-class activities and small group work. Throughout this process, Hinckley will document her experience, and keep a log of the STEM faculty and CU educational resources with which she interacts. Martin and ASSETT staff will use these data to understand how faculty build networks during the course development process. **The primary milestone at the end of Phase I. will be finishing the body of course materials.**

Phase II. June through August 2017
Immediately following the development of materials during the pilot semester, Hinckley and Neff will work closely with the HGS to *develop a written document that maps ENVS 1001 to ENVS 1000 and broader programmatic learning goals, and collaborate with Mark Werner and his team at the Office of Information Technology (OIT) to develop assessments that can be deployed online*

in formative assessments and during in-class summative assessments. At the end of Phase II., they will *present the course development work* to the ENVS faculty (likely at a pre-fall semester retreat) and to CU STEM department faculty. The latter will include, at minimum, Professors Andrew Martin and Lisa Corwin, EBIO, who will be teaching a similar quantitative methods course for biologists. Hinckley and the HGS will gather feedback during the presentations to inform the next iteration of the course. This approach takes advantage of experience gained during the pilot ENVS 1001 course and allows a much closer mapping of that course to the content and approach to ENVS 1000. **Major milestones for Phase II include: the mapping document for ENVS 1001, development of assessments, and actionable recommendations from ENVS and other STEM faculty to inform further course updates.**

Phase III. August through December 2017
In the final phase of the proposed work, Hinckley will *scale the pilot version of ENVS 1001 to full student enrollment (150-180 students)*. At this time, she will leverage CU's learning assistant (LA) program to include additional student instructors who can work with the two departmental TAs to help teach in-class activities and provide formative assessments. Hinckley will meet regularly with the instruction "team" to *update course materials and discuss in-class assessment results* (e.g., formative assessments). She will regularly seek input from Neff, Martin, the ASSETT staff, and others with experience in course design and student assessment. Simultaneously, *OIT will make any further adjustments to the assessments and the hourly graduate student will analyze the results from this semester*. **At the end of Fall semester 2017, our major milestones will be completion of digitized assessments and preliminary results of student performance.** The course will continue to be taught by ENVS faculty, as part of the transformed ENVS core series. There is potential that this approach to teaching an interdisciplinary topic with rigor will serve as a model for undergraduate environmental studies education beyond CU.
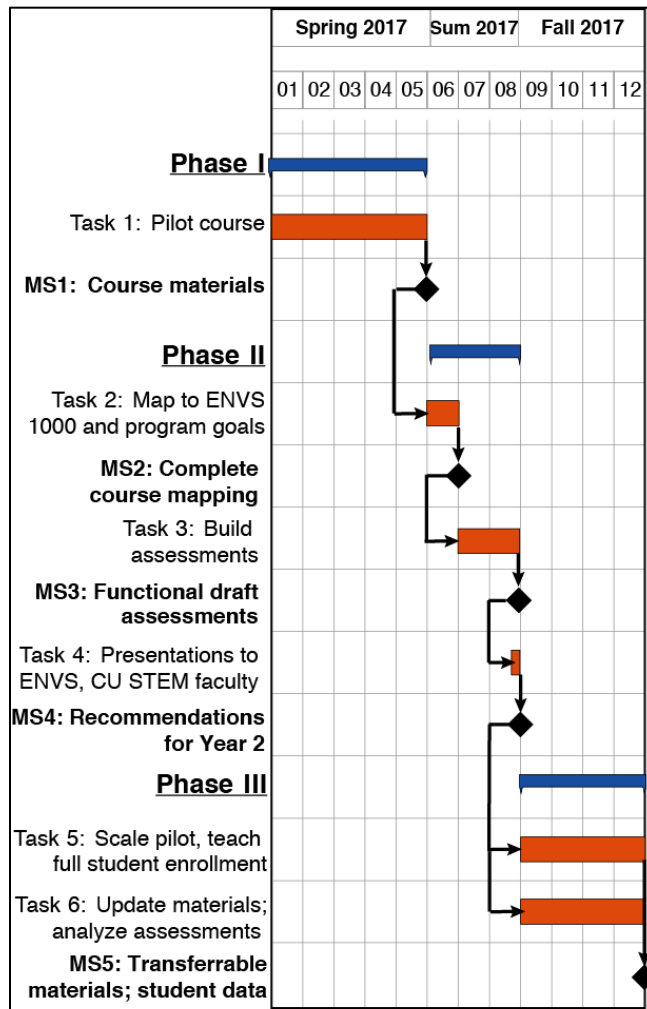

Figure 1. Gantt chart showing timeline of project activities, including phases, tasks, and milestones (MS) with dependencies.

3.2 Leadership plan
Eve-Lyn Hinckley (Assistant Professor, ENVS and INSTAAR) will lead the proposed course development activities, coordinate meetings with ENVS faculty and other STEM faculty across campus, and supervise the supported hourly graduate student assistant (Phases I-III) and TA/LA team (Phase III). She has received the endorsement of her faculty colleagues in ENVS and

Program Director (Professor Carol Wessman) to develop ENVS 1001 with Neff (see letter of support from Wessman).

Jason Neff (Professor, ENVS) will provide guidance on how to fit the proposed work into the existing structure of the ENVS major as well as experience in prior assessment and pedogodical reforms in ENVS 1000. Neff served as undergraduate director in ENVS for three years and oversaw the development of program level learning objectives. Neff also has experience with a variety of assessment instruments and has carried out a number of structured studies within ENVS 1000, including a semester-long evaluation of the value of metacognitive interventions in class outcomes.

Andrew Martin (Professor, EBIO) and Brett Melbourne (Associate Professor, EBIO) have co-developed a similar course to ENVS 1001, EBIO 1010 Introduction to Quantitative Thinking for Biologists. Martin is now the faculty advisor to ASSETT. Martin and Melbourne have already met with Hinckley, and have expressed enthusiasm about developing a cross-department group of faculty who teach quantitative methods and critical thinking at CU. Although Melbourne will be on sabbatical during the proposed project period, Martin will be co-teaching EBIO 1010 with Lisa Corwin. Together, Hinckley, Neff, Martin, and Corwin will hold regular meetings, including other members of the ASSETT staff, to discuss what works and does not in their courses, and to share materials. Ideally, this exchange will expand beyond ENVS and EBIO over time (see letter of support from Martin).

3.3 Assessment plan
Assessment of student learning achievement pre-, post-, and during courses is critical, both to reinforce students' own understanding, as well as to provide quantitative feedback to instructors. We carry out assessment at the start and end of ENVS 1000 to provide a baseline for student progress, but propose to develop a more detailed assessment program for ENVS 1001 that includes formative and summative assessments throughout the course. Hinckley met with Mark Werner at OIT to discuss options for working with the staff to design the assessments, and Werner has agreed to provide resources to assist with the proposed work (see letter of support from Werner). We have included time (Phase II, Summer 2017) and resources (support for an hourly graduate assistant) to develop the assessment tools. We will use D2L to digitize the assessments and implement them in Fall 2017 (Phase III). Over time—beyond the duration of the award—we will build a record of student data that can be used to evaluate student performance and outcomes by semester, or from year to year, in order to guide our approach to teaching the course and developing undergraduate eduction in ENVS.

3.4 Faculty and instructor involvement
Hinckley and Neff have already identified a core group of faculty in ENVS who will teach ENVS 1001 as part of their rotation of courses after the initial development phase. These faculty members include Professors Sharon Collinge and James White, both of whom have had experience teaching ENVS 1000, and possess the background necessary to teach a quantitative methods course. They will be involved in periodic meetings (likely two per semester) during the development year, as well as the presentation to ENVS faculty. Our plan is to deliver a fully transferrable course that is integrated within the department's learning objectives for undergraduates. All of the materials will be provided to other instructors, including appropriate documentation. As such, faculty will benefit from not needing to "reinvent the wheel" each year that ENVS 1001 is taught, and learning about how to integrate assessment successfully in the classroom. They will also have opportunities to provide input during the development of course materials and assessments.

Martin plans to hold regular meetings with Hinckley and Neff to initiate exchange among a cross-department team of faculty teaching quantitative methods courses. As faculty director of ASSETT, he also plans to include ASSETT staff in these discussions, as well as Professor Lisa Corwin, who will co-teach EBIO 1010. This group will benefit from sharing teaching materials and ideas both in person and through Dropbox.

3.5 Sustainability
Our proposed activities include development of documentation and regular presentations to ENVS faculty to aid in successful creation of the course material and assessment tools, as well as transferability of the course. In addition, ENVS has a core group of instructors who will teach this course after the development phase: Hinckley, Neff, Collinge, and White. Broadly, the program recognizes the importance of this course to the ENVS major, and is committed to its successful inclusion in the degree requirements (see letter of support from Wessman).

3.6 Coordination across the department
In 2012-2013, the ENVS program developed a series of program level learning objectives that include a range of content and skills-oriented objectives. These objectives now provide an overall perspective on program learning goals and a basis for the development of new courses in the major including a substantive focus on developing critical thinking and quantitiative skills (e.g. Halpern 2001; Brundiers et al., 2009; Thomas 2011) . Of the stated high-level programmatic objectives and skills, we anticipate that ENVS 1001 will build student capacity in the areas summarized in Table 1. Specifically, these goals address critical thinking, data analysis and interpretation, and teamwork. One of the important missing elements from the existing ENVS curriculum is a course that develops these skills at the level needed to succeed in subsequent courses. In developing ENVS 1001, we will work closely to map the creation of course level goals to the needs and expectations of upper level courses. Hinckley and Neff began this work in 2015/2016 when they convened an undergraduate curriculum sub-committee (including faculty and instructors in ENVS) to discuss development of ENVS 1001.

Table 1. Undergraduate Program Learning Objectives in the Environmental Studies Program that will be addressed in ENVS 1001

Category	Description
Top Learning Objective	To read and interpret graphs and data to identify patterns and relationships
Top Learning Objective	To develop a scientific hypothesis based on theory and/or observations of data
Top Learning Objective	To use mathematical and computational reasoning skills to address a novel environmental problem
Quantitative Skills	To apply data exploration and analysis techniques to scientific datasets in order to describe patterns and relationships between two or more factors
Quantitative Skills	To use data to examine, evaluate, and revise scientific hypotheses
Quantitative Skills	To analyze scientific data to support or refute environmental claims
Integrative Skills	To work collaboratively with others on a task or goal

4. Broader Impacts
While Hinckley and Neff will lead the development and transformation of the ENVS undergraduate core series, the process is meant to be inclusive within the larger ENVS program and across STEM departments. To ensure that this effort is far-reaching across the program and campus, the proposed plan includes plans for presentations and updates to ENVS and other

STEM faculty, with the opportunity to provide feedback on the course and assessment design. In addition, the ultimate goal of the proposed work is to provide a transferrable course with documentation to support future instructors, and digitized assessment tools to assess student learning and guide future course modifications. These materials could be shared beyond ENVS to other CU departments, and, potentially, other universities interested in building quantitative skills in their undergraduate environmental studies programs.

The course also stands to benefit students directly by better preparing them to approach their upper-division coursework with rigor. It will provide them with a skillset – including understanding of statistics, data analysis and interpretation, and working collaboratively in small teams – that positions them well for entry-level employment in the natural sciences or pursuing graduate degrees.

Historically, the ENVS program has not had resources comparable to other STEM departments to support course reform and development, including enhancement of STEM learning. In addition, the ENVS program is small (<12 full time faculty) compared to other STEM units. However, there is growing interest and commitment among the ENVS faculty to work toward improving the quality of the ENVS undergraduate education as well as a need to do so to better serve a major that is similar to size to the largest of the STEM majors at CU. This project will serve to support a junior and senior faculty member focused on developing a new course with modern STEM education approaches and integrated assessment. The benefits of this investment will extend to the hundreds of undergraduates who come into the ENVS major each year. In addition, it will expand the nework of STEM departments across the CU campus benefitting from resources to develop and reform undergraduate education.

5. Evidence of Expertise

Eve-Lyn Hinckley is a new Assistant Professor in ENVS and INSTAAR (started Fall 2015). She has a keen interest in developing coursework that promotes STEM learning, and, in particular, retention of women in STEM fields. In her brief time here, one of the courses Hinckley designed is ENVS-4050 Field Methods in Ecosystem Science, inspired by teaching upper-level undergraduates in CU's Department of Geography (GEOG) as a postdoc (Spring 2011), as well as the movement toward engaging students in authentic research experiences (Gasper and Gardner 2013). GEOG students commented to Hinckley that they felt ill prepared for the job market in environmental fields upon graduation; they lacked first-hand experience doing research. In response, Hinckley developed ENVS 4050 as a combination of lecture and field/lab activities, during her first semester on

Figure 2. Students in Hinckley's ENVS 4050 Field Methods in Ecosystem Science course, a flipped class focused on research design, methodologies, and professional development.

the CU faculty. Based on student input following the first semester, and after taking the ASSETT Flipped Classroom workshop (June 2016), Hinckley completely flipped the course in Fall 2016. She designed learning goals, created pre/post course assessments, and developed a suite of

background learning materials (reading, video lectures, and online evaluations). Now, she focuses all class time on field and lab activities, including small group research design. Each course period, she includes an opportunity for students to discuss confusing concepts and further applications together (approximately 30 min per 2.5 hour class period). She is motivated to develop ENVS 1001 in a way that will better prepare students for taking upper-level courses like this one, and to have a positive impact on undergraduates early in their time at CU.

Jason Neff is a professor in the Environmental Studies program and has taught ENVS 1000 annually over the last decade. Neff is the sole author of a new digital text and assessment platform published by Pearson Education called *A Changing Planet* published in 2015 and designed to support active learning/flipped classroom approaches to teaching environmental science. In developing this text, Neff carried out a wide variety of assessment approaches in ENVS 1000 to examine what approaches succeed and which fail. In addition to this work, Neff has carried out multiple CLASS surveys in ENVS 1000 and led the use of the attitudinal surveys across the ENVS curriclulum as Undregraduate director to examine changes in student attitudes toward science over the course of student tenures in the program. Neff, in collaboration with ENVS graduate students, also designed and carried out a randomized study of metacognition intervention in ENVS 1000 that yielded evidence for sizable performance increases (on exams) following recitation-based metacognition interventions in recitation.

6. Resources Requested

6.1 Budget
We request support from a TRESTLE grant to support an HGS during Spring and Summer 2017 and Fall 2018. The role of the HGS will be to help develop the course materials (Phase I., Spring 2017), develop assessments in collaboration with OIT and write documentation of the course learning goals to aid in course transfer to other faculty (Phase II., Summer 2017), and analyze assessment data during Phase III., Fall 2018. These are all time-consuming activities that are critical to evaluate student learning in the course and provide transferability of materials. Support for assistance with these efforts is not available to us via other sources. The role of the HGS is distinct from the TAs supplied by ENVS to assist with in-class learning activities and recitation sections; he or she will be focused on course design and development, and will have a background and/or strong interest in education research.

Table 2. Proposal budget

Budget Item	Rate	Hours		
		Phase I.	Phase II.	Phase III.
Hourly graduate student	$22/hr[a]	120	200	120
Total		$2640	$4400	$2640
Total Request				**$9680**

[a]Rate is based on a Student Assistant VI at the CU Boulder. The HGS must have a specialized skillset (background in education research and/or experience teaching new STEM pedogological approaches in the classroom).

6.2 Non-financial resources requested
As part of the proposed work, Hinckley is interested in participating in semi-regular faculty learning community meetings with others actively working to develop/transform STEM courses, and would be interested in connecting with other Center for Stem Learning (CSL) faculty advisors.

7. Resources Leveraged
We plan to leverage multiple resources, in the form of personnel time and expertise across campus, to complete the proposed work. Table 3 summarizes the CU resources available to us.

Table 3. Resources leveraged from the ENVS program and broader CU campus

Project Phase	Description
I, III	Two teaching assistants from the College of Arts and Sciences to help teach ENVS 1001 each semester. These TAs will primarily focus on in-class learning, and help conduct formative assessments
I, III	Online access to *A Changing Planet*. Students will use this text to support learning in ENVS 1000 and 1001.
I, II, III	Exchange with (1) Professors Andrew Martin and Lisa Corwin, EBIO, who have developed a similar quantitative methods course for biologists, and (2) ASSETT staff
II, III	Collaboration with OIT staff (contact: Mark Werner) to develop the assessment tools suitable for ENVS 1001, as well as best practices for analyzing and curating the data
III	Student Learning Assistants to help with in-class activities and formative assessments

8. Agreement to Expectations
Hinckley and Neff agree to all expectations for successful awardees, including documentation, evaluation, and presentation of course development and transformation activities. In addition, Hinckley would like to participate in the optional faculty learning community opportunity.

9. References

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September 27, 2016

To: Eve-Lyn Hinckley and Jason Neff

Cc: Carol Wessman, Mark Werner, Deane Bowers, Brett Melbourne, Lisa Corwin, Stephanie Chasteen

Re: New Quantitative Analysis and Critical Thinking for the Environmental Studies Major

Hi-

There is a growing demand and need for courses that emphasize quantitative and critical thinking in Science, Technology, Engineering, and Mathematics (STEM) fields for early-stage undergraduates at CU. Two faculty members in EBIO (Brett Melbourne and myself, along with Maxwell Joseph) recently developed a course called Introduction to Quantitative Thinking for Biologists (EBIO 1010). The course was proposed and designed after the department adopted a set of core learning goals for the EBIO major and it was clear that we needed to introduce our students to a solid quantitative foundation.

Eve-Lyn Hinckley and Jason Neff have proposed a similar course for the environmental studies program (ENVS). Our hope is that the two departments can co-develop and align the two courses so that we have better integration of the curricula in ENVS and EBIO, in part because the two departments share many of the same core learning goals and students.

The proposal to develop this course comes at an opportune time. Eve-Lyn and Jason will develop and implement the new ENVS introductory course in Spring 2017. At the same time, Lisa Corwin and I will be co-teaching two sections of EBIO 1010. Our hope is to use this opportunity to promote teaching excellence within and between two departments. In particular, we seek to:

1) Develop and share curricula and materials (problem sets and in-class activities);
2) Develop and share teaching strategies and pedagogy among the four faculty members;
3) Record meta-data for each course, including classroom observations, faculty and student interaction networks, and learning gains;
4) Encourage mutual adoption of educational technology that supports achievement of learning goals and encourages sharing of teaching materials.

In the spring, we plan to engage in regular meetings of ENVS and EBIO faculty members teaching the two courses—and perhaps other STEM faculty interested in participating in a Faculty Learning Community—to evaluate curricula, teaching strategies, and observation data for the purpose of formative assessment and the development of metrics for collecting qualitative and quantitative data of teaching.

In short, I couldn't be more enthusiastic about Eve-Lyn and Jason's proposal and will assist their efforts towards developing an exceptional education experience for early-stage undergraduates interested in environmental sciences. Please call or email me if you have any questions (303-325-1790; am@colorado.edu)

Sincerely yours,

Andrew Martin
Professor, EBIO
Advisor, ASSETT program
Presidential Teaching Scholar

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30 September 2016

Re: Quantitative Analysis and Critical Thinking for the Environmental Studies Major: Developing Part II of the Introductory Core Series

PI: Eve-Lyn S. Hinckley, ENVS Assist. Professor; Co-PI Jason C. Neff, ENVS Professor

I'm writing to provide my strong and enthusiastic support for Drs. Eve-Lyn Hinckley and Jason Neff's proposal to the Trestle Course Development Award. Their project focuses on a new and critical step for our Environmental Studies Program, namely the development of a second semester to our foundational course for >800 ENVS majors. As our Program has matured, we have seen a clear need to support students further in their quantitative analysis and critical thinking skills in preparation for upper division coursework. This proposed class, ENVS 1001, serves that critical gap and is a top priority for our undergraduate curriculum.

The ENVS faculty and myself have full confidence in Dr. Hinckley's ability to develop ENVS 1001 in the form she has outlined in the proposal. With input from Dr. Neff, this course will take a similar active, problem-based and collaborative learning approach as that which he developed for our ENVS 1000. The pairing of these two courses will be particularly powerful for our majors, and will serve not only our students, but also a need across campus for quantitative skills at this early level.

The preparations for this course have been thorough and inclusive. Dr. Hinckley chaired an undergraduate sub-committee in 2015-2016 to scope out the course. Dr. Neff has given considerable input throughout, and the rest of the faculty has reviewed the development at critical intervals. In Spring 2016, we received from A&S the commitment of 2 TA positions to assist with instruction. One TA will help with the pilot Spring 2017, and another will come on board in Spring 2018 when the course is scaled to its "final" form.

The ENVS Program is fully committed to this course. We are appreciative of the time and energy Drs. Hinckley and Neff have given to its development and their incorporation of approaches that will effectively promote student engagement and learning. This is the kind of effort we at CU hope to see across campus as we lift our teaching mission to a higher level.

Sincerely,

Carol A. Wessman
Director, Environmental Studies Program
Professor, Ecology and Evolutionary Biology
Assoc Director, Ecosystem Science Division, Cooperative Institute for Research in Environmental Sciences

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September 16, 2016

Eve-Lyn S. Hinckley
Assistant Professor, Environmental Studies
Fellow, Institute of Arctic and Alpine Research
Director, Arikaree Environmental Lab
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Boulder, CO 80309

Dear Professor Hinckley:

I am writing to you to express my support for the TRESTLE proposal, "Quantitative Analysis and Critical Thinking for the Environmental Studies Major: Developing Part II of the Introductory Core Series," that you are submitting with Professor Jason Neff.

With this letter, I acknowledge that we have met to discuss the project, and after your pilot of the spring of 2017 my assessment and analytics team will to help you with your assessment design work in the summer of 2017, with some follow-up modifications in the fall of 2018.

Best wishes with the proposal!

Sincerely,

Mark Werner, Ph.D.
Associate Director of Academic Technology Strategy and Support