CAREER Proposal Writing Tips and Tales

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Tip #1. Only submit a CAREER proposal if you have the time, intellectual muster, and belief that you can write a *successful* proposal by the July deadline. If not, wait.

Tale #1. I attended a CAREER proposal writing workshop at NSF in March, 2009 and realized there is no way I can do this now. Same in 2010. In 2011, I set aside about 2 months time through May, June, and July to develop + write and that time was barely enough.

Tip #2. Early on, write a 1- or 2-page project summary and shop it around to NSF program officers, peers in your field, technically-competent colleagues outside your field, and friends. Solicit feedback. Incorporate the feedback.

Tale #2. I had three major drafts (see attachments) over 3 years. Some of the most helpful feedback came from colleagues who were not in my field (why near-optimal??).

Tip #3. Read, understand, and address the NSF review criteria for intellectual merit and broader impacts at http://www.nsf.gov/pubs/policydocs/pappguide/nsf13001/gpg_3.jsp#IIIA2.

Tale #3. On a prior non-CAREER proposal, I never even knew there is a criteria to "broaden participation by underrepresented groups." In my CAREER proposal, I titled one section "Broader Impacts" and addressed each broader impact criteria as an individual sub-section.

Tip #4. If possible, attend USU's Proposal Writing Workshop.

Tale #4. About 45% of the material was helpful to me. The most helpful parts were (i) developing strategies to sell a research idea, (ii) workshoping my CAREER proposal, and (iii) getting feedback from peers and USU's professional grant writers (see also Tip #2).

Tip #5. Line up an external colleague to review your full proposal *before* you submit. Ask well ahead of the due date. Choose someone reliable who has previously reviewed proposals for NSF. Attach the NSF review criteria (Tip #4) with the draft proposal.

Tale #5. One month out, I asked two colleagues to review the proposal. Both agreed. 1-week before the submission date, I delivered a (mostly complete) draft. Only one colleague responded. His comments were "(1) you need to dramatically improve the clarity of the science drivers, (2) your hypotheses are weak and need to better exploit your existing work, (3) the proposal organization is difficult to follow, (4) the linear programming approximation techniques are not motivated in the actual problem and its properties and read as a list, and (5) your biggest strength is your use of eco signatures." I debated whether to continue and submit. The last week, I spent nearly every waking hour revising to address his comments. I also asked—and he agreed—to serve on the technical advisory committee for the project and he provided a collaboration letter.

Tip #6. Articulate an overarching research goal. Feature it prominently in the Project Description (i.e., as the first sentence). For help articulating a research goal, read George Hazelrigg's 3-page article at http://www.clarku.edu/offices/research/pdfs/NSFProposalWritingTips.pdf .

Tale #6. At the NSF CAREER proposal writing workshop, George said NSF funds basic research. Most engineering proposals propose to "develop", "advance", "optimize" stuff. These are NOT research. He laid out 4 acceptable research goal templates. None made any sense to me or seemed workable for the applied water resources work I do. Only the 4th template (apply method X from field W to problem Y in Field Z) seemed remotely close. I finalized my research goal just two weeks before submitting.

Tip #7. Obtain a copy of a successful proposal from a colleague in your field. Learn by example.

Tale #7. A colleague heard I attended the NSF CAREER proposal writing workshop, volunteered, and forwarded his successful proposal. I read through it and thought, "this is amazing but there is no way I can do this." Two years later as I wrote my own proposal, I re-read the successful one multiple times, and incorporated many of its successful features. These features included: state the research objective prominently (Tip #6), list hypotheses early, use lots of figures, and conclude with a ¾-page section titled "Career Journey" where I described my past work and vision for my future career.

Tip #8. GOOD LUCK!!

Optimal Water Management for Environmental Purposes Using Collaborative, Shared-Vision Modeling

Introduction

Water system and river basin managers typically allocate scarce water to maximize economic benefits or minimize capital and operational costs subject to existing physical, legal, and regulatory requirements such as meeting in-stream flow requirements. Many optimization models and software support engineering- and economic-based water management. But few methods identify how limited, scarce water can be more efficiently applied to improve the environmental or ecological performance of water systems. This research develops optimization techniques that identify cost- and water-efficient operations for improved environmental management. We embed optimization program development within a collaborative, shared-vision planning effort to involve, build credibility with, and broaden impacts for local water managers and stakeholders.

Research Goals

Research focuses at two scales. At the river basin scale, we will adapt a network flow model to optimize for environmental purposes. We will involve stakeholders to identify and characterize potential management options and constraints plus develop ecosystem response functions that link management options to water allocations and environmental indicators. Subsequently, we will use optimal water allocations and operations identified at the basin scale for more detailed analysis at the sub-catchment scale. Here, we will develop an optimization model that suggests land parcel uses that maximize environmental or ecological performance. This effort will merge a geographic information system user interface with an optimization engine and define plus and code spatial-relational constraints such as minimum habitat areas, buffer zones, and continuality and adjacency of land uses and/or flow paths. Together, the two optimization programs will recommend water allocations and land uses at river basin and sub-catchment scales that improve ecosystem performance.

Project Tasks

1. Identify a study site in Utah and water managers and stakeholders willing to participate
2. Hold facilitated stakeholder meetings to identify environmental water-related problems, potential solutions, performance indicators, and methods to evaluate solutions
3. Collect required data on water flows, environmental quality, and ecosystem responses
4. Develop optimization models and deploy them on the web
5. Hold further facilitated stakeholder interactions to use, test, and evaluate model solutions

Education, Outreach, and Broader Impacts

1. Collaborative, shared-vision modeling brings together USU researchers, local water managers, and stakeholders to improve environmental water use efficiency.
2. 4 undergraduate and graduate students perform project tasks to pursue their education goals.
3. We expand the USU Natural Systems Engineering curriculum to include optimization.
4. We publish web-based models and tools developed as part of education and outreach efforts #1-3 for beneficial application by other practitioners.
5. Together, applying the optimization techniques and implementing recommended actions will reduce water manager related costs, improve the environmental and ecological health of rivers, and showcase methods to improve environmental water-use efficiency.

CAREER: Nearly Optimal Optimization to Sustainably Manage Water for Ecological Objectives
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To sustainably manage water, we are challenged to define, quantify, and apply environmental and ecological performance metrics and their uncertainties in integrated human-hydrological systems models. We must also identify all good solutions rather than a single, modeled optimal solution. The research goal of this CAREER proposal is to apply emerging nearly-optimal systems analysis techniques to the problem of allocating scarce water to improve multiple riparian and wetland services in a watershed. Specific objectives are:

1. Quantify performance metrics for 3 wetland and 2 riparian areas over 4 seasons across 3 indicator species. Relate performance to water flow along riparian corridors and water depth in wetlands.
2. Delineate all nearly-optimal solutions that perform within a specified tolerance of the modeled optimal solution.
3. Compare the structure and composition of optimal and nearly-optimal water allocations plus identify tradeoffs among ecological and non-ecological performance metrics, and
4. Enhance current and future decision makers' skills in observation, data synthesis, sustainability decision making, and leadership.

To achieve these advances, the project will cultivate a systemic problem-based learning (PBL) environment that integrates research and education activities. I see my academic career as an opportunity to present numerous learners with relevant environmental water problems, offer them tools to help solve these problems, encourage mutual learning and discovery, and provide feedback to spur deeper understanding. Here, PBL will have: graduate students, river basin professionals, and researchers define and quantify ecological performance metrics; incoming undergraduate students observe ecological metrics during 5-day leadership development trips along key river reaches and subsequently undertake year-long research experiences to map, synthesize, and present collected data and findings; and graduate students build new nearly-optimal optimization algorithms and together with basin professionals vet and compare model-recommended water management strategies. We will demonstrate techniques in the Bear River, Utah, a nearby watershed where water is already fully allocated for non-environmental uses.

Intellectual Merits include developing and applying multiple ecology performance indicators in a systems framework. New nearly-optimal optimization techniques will systematically identify the range of promising (rather than single best) environmental water management alternatives. Identifying this set will help managers view system flexibility and choose alternatives without quantifying or specifying preferences among difficult-to-characterize social, equity, ecosystem, and other objectives. We will draw on existing state water allocation models, the HydroPlatform open source model user interface, data management, and cyber infrastructure capabilities to integrate performance indicators and nearly-optimal solution techniques. The approach can also promote the new concept of environmental water efficiency and advance decision making in finance, economics, logistics, transport, and other fields that use optimization.

Broader Impacts will accrue among a diverse set of science, technology, engineering, math (STEM) and non-STEM learners at Utah State University (USU) and in the wider Bear River watershed. A systemic PBL environment, Bear River Fellows Program, and nearly optimal computer simulation exercises will further promote training, understanding, and discovery for undergraduates, graduate students, underrepresented minorities, non-majors, the PI, Bear River professionals, and life learners plus extend and strengthen relationships among these learner groups. Applying new environmental performance criteria and nearly-optimal water allocations in the Bear River can advance sustainable planning plus improve critical water purification, storage, hunting, birding, and fishing services in target wetland and riparian areas. Successes can guide sustainable water management in other water-scarce watersheds.

Project Summary Submitted – July 2011

CAREER: Near Optimal Water Management to Improve Environmental and Ecological Decision Making

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The research goal of this CAREER proposal is to apply uncertainty and the modeling to generate alternatives frameworks to the problem of allocating scarce water to improve environmental watershed services. Sustainable environmental decision making requires a new paradigm of flexible water management tied to quantifiable environmental performance metrics. It must also consider pervasive uncertainties. We move beyond the notions and mathematics of "optimal" and "best" which are tied to the objective(s) and constraints considered to achieve four outcomes:

1. Quantify habitat suitability, topological complexity, and hydroperiod environmental service metrics for wetland and riparian areas at monthly and annual time scales with parameter, functional, and conceptual uncertainties. Also, relate metrics to water flow and depth variables.
2. Compare enumeration and parallel coordinate strategies to identify the region of near-optimal water management strategies that perform within a specified tolerance of modeled optimal solution.
3. Embed uncertain environmental performance metrics and near-optimal solution strategies in a watershed systems model to identify tradeoffs among uncertain system components, and
4. Enhance current and future decision makers' skills in observation, data synthesis, leadership, and sustainable decision making.

To achieve these advances, the project will cultivate a systemic problem-based learning (PBL) environment that integrates research and education activities. I see my academic career as an opportunity to present numerous learners with relevant environmental water problems, offer them tools to help solve these problems, and provide feedback to encourage mutual learning and deeper discovery. Here, PBL will have: graduate students, river basin professionals, and researchers define and quantify environmental performance metrics; incoming undergraduate students observe metrics during 5-day experiential learning trips along key river reaches that lead to year-long research experiences to map, synthesize, and present collected data and findings. Graduate students will also build new near-optimal algorithms and together with basin professionals vet and compare model-recommended water management strategies. We will apply techniques in the lower Bear River, Utah, a nearby watershed where environmental managers seek new ways to secure water for wetlands and riparian areas.

Intellectual Merits are to develop and apply multiple environmental performance indicators with pervasive uncertainties in a systems modeling framework. We demonstrate new computationally efficient ways to visualize high-dimensional resource management problems and identify sustainable water management strategies. Near-optimal solution techniques systematically identify promising (rather than single best) water management alternatives without quantifying or specifying preferences among difficult-to-characterize social, equity, and other un-modeled objectives. We also measure and show the impacts of these advances on environmental decision making in the study area.

Broader Impacts accrue among a diverse set of science, technology, engineering, math (STEM) and non-STEM learners at Utah State University (USU) and in the wider Bear River watershed. A systemic PBL environment, Bear River Fellows Program, multi-day river trips, and near-optimal computer animations will promote training, understanding, and discovery for 18 students including underrepresented minorities and non-majors, Bear River professionals, the PI, and life learners, plus will strengthen relationships among these groups. These activities simultaneously help validate environmental performance metrics, advance sustainable planning, and improve critical water purification, storage, hunting, birding, and fishing services in target wetland and riparian areas. Successes will guide management in other water-scarce watersheds and advance near-optimal decision making in finance, economics, logistics, transport, and other fields that use systems analysis.