Barriers to USGS scientists' participation in collaborative research and decision-making

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11.941 The Role of Joint Fact Finding in Environmental Decision-making

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Abstract
Changes in the way in which science interacts with society are driving a transformation in the mandate of federally sponsored science. Federal agencies like the United States Geological Survey (USGS) are adapting to the call for greater public and stakeholder involvement in the framing of research questions, the development of socially and policy-relevant science, and collaborative decision-making processes emerging from that science. In "a radical, non-trivial departure from the way in which agencies do business," the USGS is researching collaborative decision-making techniques like Joint Fact Finding via the Science Impact program (Susskind, 2004). However, structural, educational, and cultural barriers complicate the nature of changing from a bureaucratic science agency to a nimble, innovative organization that promotes collaborative decision-making. This paper explores disincentives to change at the individual level that operate through agency structure and culture, particularly the Research Grade Evaluation (RGE) process. It also describes and evaluates current efforts by the USGS to promote institutional change through individuals. Strategic opportunities and potential further mechanisms of change in the areas of education/training, evaluation/promotion, and programmatic interventions are then identified and considered.

Methods
The methodology of this paper relies on a literature review of both secondary sources and primary documents from the Office of Personnel Management (OPM) and the USGS, as well as a transcript of the USGS Dialog on Science Impact held in Columbia, MO in October 2003. It also synthesizes comments from visiting speakers (researchers, policymakers, and managers representing various agencies and organizations) to the MIT-USGS Science Impact Collaborative course on Joint Fact Finding in Environmental Decision-making in fall of 2004. Finally, I conducted key informant interviews with: Laure Wallace, an employee of the USGS Office of Employee Development (OED) who has worked extensively on the RGE; Ron Webb, manager of doctoral recruiting and university relations for Procter and Gamble and representatives at DuPont—two of the leading corporations in Research and Development in the world; and Dan Larson, a research physicist who has worked at a large research university, a small Ivy League university, and is currently doing post-doctoral work on biomedical physics.

Why collaboration?
The relationship between science and society in the United States has undergone massive changes in the last fifty years. A fundamental shift is occurring: from positivism, wherein science is defined as being comprised of neutral facts and objective findings, to constructivism, where science is considered constructed knowledge with subjective judgments like all other forms of human knowledge (Van de Klerkhof, 2004). This paradigm shift particularly affects the goals and roles of government science (both government-funded and agency-generated), which has a special responsibility not only to expand the frontiers of knowledge, but also to serve the public interest—to ensure that science is serving a normative function. The changing values are epitomized by the contrasting mandates put forth by Vannevar Bush in 1945 and Jane Lubchenco in 1998 (Guston, 2000). Bush's "Science: The Endless Frontier" report came at the end of World War II, when optimism in the ability of science to solve social problems was at an all time high during the "golden age" of American science. Lubchenco's address to the American Association for the Advancement of Science notes the failure of modern researchers to conduct socially relevant science and calls for a "new social contract for science" that prioritizes society's

"most pressing problems of the day, in proportion to their importance, in exchange for public funding" (Lubchenco, 1998: 491). She argues that not only must science advance knowledge, but also it must be policy-relevant in a changing world with new global and ecosystem-scale challenges. The shift in the relationship between science and the federal government is still in progress and is shaped at multiple levels: from the federal budget treatment of science, to science agency priority setting, to individual researchers acting out of interest for self, science, and society.

Occurring in parallel to the changing science mandate is an upsurge in public desire for participation in decision-making, including scientific decision-making (Sarewitz, 1997). These demands for participation and due process grew from disparate movements including the civil rights movement and the environmental movement, coalescing in the 1960s and 70s. Not coincidentally, it was during this time of strong social movements and heightened public awareness that most of the country's core federal environmental regulations were created. Laws like the National Environmental Protection Act (NEPA), "never intended to be the overarching structure for public involvement, [have] become the basic template for agency actions in many cases" and frame the way in which agencies and citizens interact, forcing federal agencies to adapt (Wollondeck and Yaffee, 2000: 243). Web-based technology and the proliferation of accessible information have also brought into question agency legitimacy on the basis of technical wisdom alone. Agencies that were created to be technical advisors and facilitators now have to be communicators and public process managers (Wollondeck and Yaffee, 2000; Jacobs, 2001).

The limitations of NEPA, particularly in its ability to manage complex and controversial projects, have become apparent. Despite efforts to frame NEPA in a manner that ensures public participation, the difference between meaningful participation and token participation are relevant in a democratic society (Arnstein, 1969). Public input in NEPA generally consists of a public comment period on the Environmental Impact Statement that the managing agency can either choose to take into account or not; which can hardly be considered more than token involvement and is not a means for fostering environmental democracy (Peyser, 2003; Jasanoff, 1996). The current system is not well suited to manage and promote citizen involvement, making legal tactics common and costly. Without denying the critical role of the right to and power of legal action, groups of stakeholders and agencies are both realizing that the adversarial science involved in a lengthy court case is a drain on resources and often counterproductive (Wollondeck and Yaffee, 2000). As Rich Whitley, National Stewardship and Partnership Coordinator of the Bureau of Land Management stated, "the current system is broken and dysfunctional" (2004). The need for functional participation spans all scales of issues, from regions and water basins to municipal and even site-specific concerns.

Therefore, a second wave of change that goes beyond one-way communication towards real collaborative decision-making is currently taking place. Agencies recognize the need for credible science that is reputable by the highest standard, salient science that is policy-relevant, and legitimate science that is trusted and generated in a transparent manner to support participation and inform decision-making (Cash et al., 2003). Sheila Jasanoff notes that information exchange alone will not generate solutions to complex environmental problems, rather institutions of community and trust are also required to move towards collective action

(1996). The Department of Interior (DOI) has placed a priority on collaboration through its "Four Cs" philosophy of "conservation through communication, consultation and cooperation" that has now spread to include other agencies as well (DOI, 2004a; Hess, 2004). Indeed, DOI has over 200 employee training courses with "collaboration" in the title (Whitley, 2004). The USGS is taking societal relevance and collaboration seriously, through the creation of the Science Impact program and a broadened definition of research in the RGE that includes science translation and information dissemination (USGS, 2001; USGS, 2002). Given the growing pressures on federal budgets, the trend toward promoting innovation since the 1993 Government Performance and Results Act (GPRA), and the 1995 USGS Reduction in Force, Science Impact is both a core value (along with Science Excellence and Science Leadership) and a critical program to help guide the existence and growth of the Survey (Groat, 2004).

However, as with all major organizational changes, there are barriers and institutional resistance to overcome. The Office of Personnel Management (OPM) enumerated ten common barriers to institutional change:

1. Turf battles
2. Employee and manager resistance to change
3. No one "owns" change process
4. Lack of incentives to change
5. Difficulties in thinking outside the box
6. Resources tied up in current systems
7. No champion in top management
8. Skepticism
9. Lack of resources
10. Do not see a compelling reason to change (OPM, 2000a: 4)

This paper focuses specifically on barriers at the individual level: workforce composition, the evaluation and promotion structure, and the culture of research that exists at the USGS. It is clear that educational, structural, and cultural barriers are interwoven and overlapping in the complex environment of an organization, but these divisions are useful to think about the different types of challenges the USGS faces and to begin to identify what might be levers of change from the perspective of Science Impact.

Educational barriers

Disciplinary Structure

In thinking about institutional change, it is intuitive to consider current employees as likely points of resistance (and indeed that will be addressed in the section on cultural barriers), but it is perhaps more important to think about new and potential hires when charting the course of the future of an organization. A National Science Foundation project examining undergraduate science courses found that they generally do not discuss policy applications or societal relevance. Science and engineering education is fundamentally different from liberal arts education, with students in the science disciplines often lacking the necessary training and skills in leadership and communication (Wallace, 2004).

The USGS research scientists of tomorrow are being taught by individuals situated in departments that are still functionally independent units. Indeed, a value of reductionism drives knowledge and education systems in America into a disciplinary structure (Karlqvist, 1999). For example, though collaborative projects within universities (e.g. the Cornell Genomics Initiative) attempt to hire interdisciplinary faculty, potential hires must still pass muster at the departmental level and faculty must also be able to teach the discipline-specific undergraduate foundation courses. This presents hurdles to universities going beyond "lip service" to interdisciplinary research unless they create a well funded, truly interdisciplinary department (e.g. Harvard University's Department of Systems Biology) (Larson, 2004). Sung et al (2003) explored disciplines as cultures, noting "the cultural barriers are at least as great as the institutional barriers. A scientific language, approach, and training style are passed from mentor to student within disciplines, like a tribal culture" (1485). Thus, disciplines are cultural tools but are also social relationships that promote group identity (Lattuca, 2002). Chubin and Maienschein (2000) expand upon this to note that while the sciences champion individual accomplishments, originality, and ownership of ideas, the policy arena requires communication and "speaking for someone else"; the authors describe this difference as no less than a culture clash.

Tenure

Barriers to collaboration stem not only from the fundamental way in which academic institutions are organized but also from the way in which academic success is measured. Success in most academic science disciplines requires specialization, with a priority towards reductionist science, both for graduate students and certainly for tenure-seeking faculty. In a study of interdisciplinary faculty, Lisa Lattuca found that her informants were concerned about promotion, tenure, and rewards of interdisciplinary research (2002). Kostoff (2002) notes that without other potential rewards, most researchers will "take the path of least resistance" and focus in one discipline or participate in collaboration that exists only on paper. Physicist Dan Larson discussed the impact of tenure on collaborative science research,

> "The most important job of a young investigator is to get tenure. This is achieved by starting a research program, getting funding, and producing results. However, there is also this unspoken requirement that the investigator 'own those results', so to speak. The department wants to see that this person is running his own show, not depending too much on collaborators. So if there is collaboration, a young professor has to be very careful to make sure that it is on his terms, so he can state, in no uncertain terms, that it is his research program. People look down on scientists if they rely too much on collaboration" (Larson, 2004).

The academic structure of science informs hiring options at the USGS. There is a tradeoff between hiring boundary spanners who have training in science-policy and hiring scientists who have built up their credentials through single-discipline, self-directed research.

Educational barriers to collaboration are not limited to the sciences alone. Natural resource management education has a tendency to stress field-based work, such that often those graduating with range management degrees or forestry degrees seek to work out on the grassland or the forest, rather than in the office or conducting stakeholder meetings. Certainly there are notable exceptions—like the Yale School of Forestry and Environmental Studies or the

University of Michigan School of Natural Resources and Environment, to name a few—that truly promote policy and leadership. Reinforcing the educational approach is the fact that people who self-select into this field often have, as Karl Hess of the Fish and Wildlife Service said, "a desire to be a true hands-on manager and a love of the resource"(Hess, 2004). Overall, Clark and Meidinger (1998) note, "scientists must become more comfortable with the history and practice of resource management, and resource managers must become more comfortable with the history and practice of science" (6).

Structural barriers

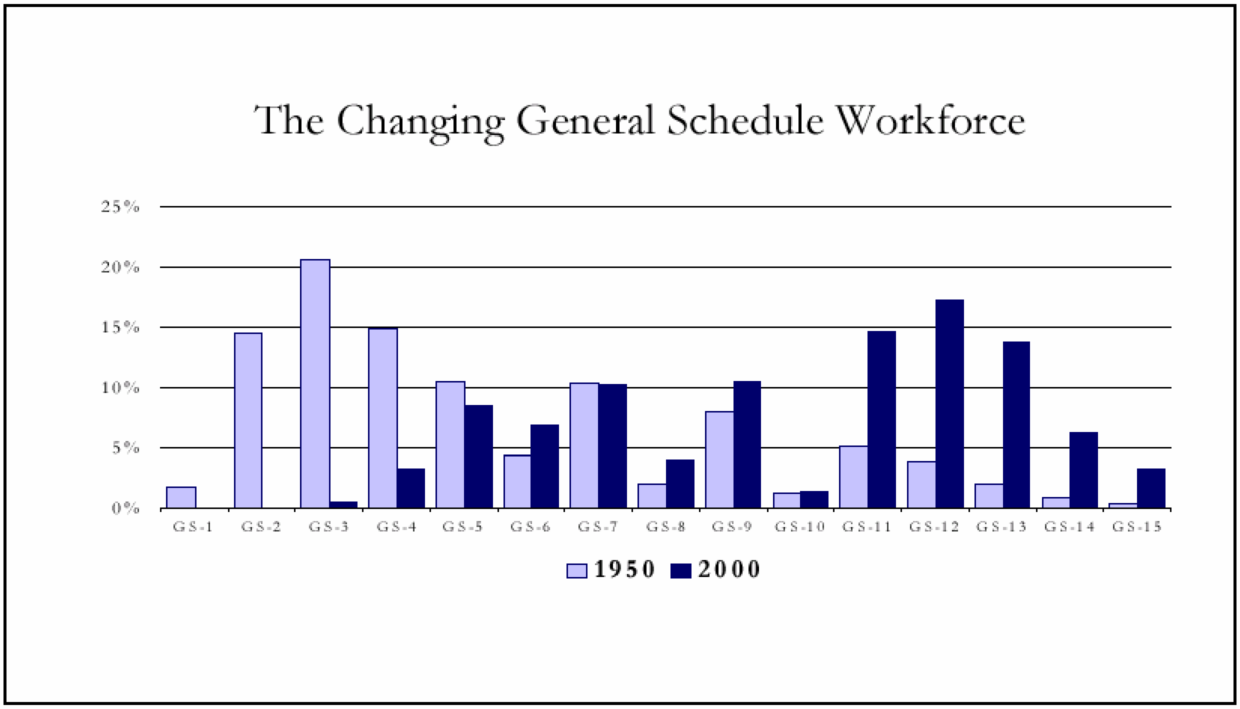
The General Schedule

In order to understand the structure of evaluation and promotion and how it affects USGS scientists' involvement in collaborative decision-making processes, one must consider it in the context of the broader federal pay system, the General Schedule (GS). The GS covers 1.2 million federal employees and was initially created through the Classification Act of 1949. The GS is a system that emphasizes "internal equity" as a value of utmost importance, meaning that employees across the government are paid equally for equal work (OPM, 2002). The goal of the GS is to standardize pay and rank according to "scope and complexity" of work, essentially equating, for example, a GS-13 attorney with a GS-13 geologist, with a GS-13 manager (Wallace, 2004). The OPM explains the origin of this structure and how that structure no longer fits with the knowledge-based modern workforce of the federal government:

> "The fundamental nature of the Federal compensation system was established at the end of the 1940s, a time when over 70 percent of Federal white-collar jobs consisted of clerical work. Government work today is highly skilled and specialized knowledge work. Yet in the age of the computer, the Federal Government still uses—with few modifications—pay and job evaluation systems that were designed for the age of the file clerk." (OPM, 2002: 4)

The changing nature of work conducted by the federal government has, therefore, led to a change in the distribution of federal workers; making it top-heavy as an organization (see Figure 1). Informal observations suggest that this trend also exists in the USGS Geology Discipline, with its clustering of GS-13 and GS-14 research scientists (Karl, 2004). The GS structure effectively treats all agencies of the government as a "single employer", is extremely hierarchical, and was designed for administration not innovation (OPM, 2002). At times, the structure may even create a disincentive to innovation, in that one inherently gains responsibilities as one climbs the hierarchy. Karl Hess of the Fish and Wildlife service reported knowing of individuals that stay at the GS-13 level in order to maintain some freedom, rather than take a pay increase, noting that "the financial incentives aren't large enough" (Hess, 2004). The organizational literature is divided on the effects of stratification: whether it encourages specialization and good performance or whether hierarchy's organizational control fosters conformity (Baron, 1984). The GS structure can certainly be juxtaposed with that of smaller, less hierarchical, more team-based approaches like those used by software development firms in Silicon Valley whose mainstay is innovation. It can also be juxtaposed larger organizations that nonetheless retain their nimbleness out of necessity, such as the United States Armed Forces (Hess, 2004).

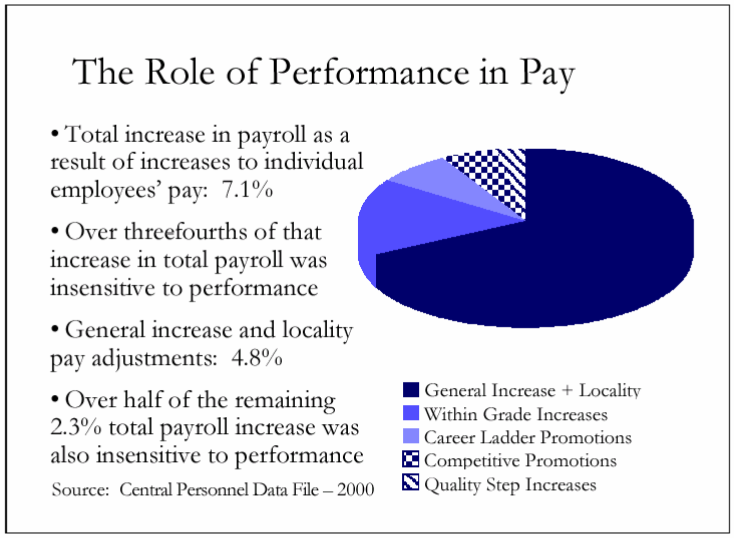
Figure 1: from (OPM, 2002: 5)



With its emphasis on "internal equity", the GS system lacks "external equity", wherein pay within the government is equivalent to that which one would receive doing similar work for the private sector. This presents challenges for some agencies in the recruitment and retention of highly qualified individuals. The National Research Council reviewed evidence through the early 1990s that showed that by the late 1980s federal white-collar employees were paid less than their private-sector counterparts in most occupations and most geographic regions (NRC, 1993). Private firms like Proctor and Gamble, which spends upwards of $5 million on research and development per day, stress that "no factor has played a more important role in the success of R&D at P&G than its record of hiring and retaining some of the most talented people in the industry. Once on board, R&D staff members are rewarded and recognized for their contributions through financial compensation, promotions, freedom to influence project selection, and financial support for their projects" (P&G, 2004). There are limits in the extent to which a business model can be compared to the federal government, particularly given the decreasing resources for federal science research, as opposed to the growing amount of resources spent on R&D by Procter and Gamble in every year since World War II (P&G, 2004). Moreover, the literature on public service suggests that there are a number of non-monetary motivators (including humanitarianism, communitarianism, patriotism, and a good Samaritan ethic) that drive people to work in the public sector as opposed to the private sector, so external equity may not be the most problematic issue (Brewer, Selden, Facer, 2000).

Finally, the government pay structure lacks "individual equity", wherein one's pay is inherently linked to one's performance (OPM, 2002). The GS generally rewards loyalty more strongly than it rewards performance, with over 75% of all increases in federal pay in the year 2000 bearing no relationship to individual achievement or competence. Figure 2 indicates that increases for inflation and locality comprise the majority of pay increases. The second highest proportion of increase comes from Within Grade Increases, which are the natural progression up the ten steps of a grade that occur simply with the passage of time (OPM, 2002). Business literature suggests that to improve performance, firms need a structure of performance-based incentives (McKenzie and Lee, 1998). Firms like Procter & Gamble and DuPont ensure that pay is linked to performance by conducting regular evaluations of deliverables that support the goals of the corporation. Researchers are not evaluated by profitability, but by other measures such as patents awarded. Bill Provine of DuPont commented, "if you cant divide the task into something measurable, then you need to take it down to something smaller. It's hard to predict that you will invent a widget to do a task, but you could break it down into measurable, definable units like 'completed literature review, met with producers, etc'" (2004). Critical to the structure of these evaluations is that the goals and objectives are jointly crafted by supervisors and employees to ensure that the plan functions like a contractual work plan. Pay for performance is linked not only to basic salary level, but also to bonuses and promotions. Both Procter and Gamble and DuPont use annual reviews that rate employees *relative* to their peers—rewarding top performers and flagging low performers (Webb, 2004; Provine, 2004).

Figure 2: from (OPM, 2002: 21)



Clearly, not all business strategies translate to the government. Government lacks the simple test of profit increase/decrease as an evaluative measure of performance, which makes establishing GPRA targets for strategic performance plans extremely difficult (IAGCPMR, 1993). Despite the need for improved evaluation of government performance, GPRA did not implement an overhaul to the GS. A particular challenge identified by Wise and Agranoff (1991) lies in the evaluation of public sector research. Traditionally, that evaluation has focused on the quality of research products but as federal budgets tighten, there is a need also to measure "research efficiency and effectiveness" (IAGCPMR, 1993: 9). Evaluating that effectiveness in terms of Science Impact is precisely the challenge facing the USGS. Despite having recognized and documented the myriad problems with the current GS as related to innovation, OPM responses are slow in coming, illustrating the point of that National Research Council that "one of the eternal verities of federal personnel policy is that it has been saddled with a considerable amount of inertia" (NRC, 1993: 85).

Research Grade Evaluation

The federal pay structure is not as entirely undifferentiated as a first glance at the GS might suggest. In the 1950s, several systems of evaluation were created that distinguish between the different roles government employees serve. Though employees progress up the same steps and grades, they are evaluated by different guidelines, which include the RGE that will be discussed in greater depth here, the Leader Grade Evaluation, and the Research-Grants Grade Evaluation, among many others. At the USGS, a distinction is made between research scientists and science and technology practitioners, with the RGE applied to those who spend at least half of their time on research (USGS, 2001). A metaphor for this distinction is in the evaluation one would conduct for a family doctor and for a researcher at the National Institute of Health. Though both are "doctors", just as both USGS employees are "scientists", one would want to ask them very different questions to evaluate whether or not they are performing well (Wallace, 2004). The guidelines for the Biological Resources Division of the USGS further define the application of RGE:

> Many different professional job series require scientific training and application of scientific skills. Individuals assigned to such positions are usually called "scientists" and many have advanced degrees, e.g., Master of Science or Doctor of Philosophy. **The RGEG is used to evaluate the grade of a professional scientific position only if the nature of the work performed is research.** Research, as defined by the RGEG, is systematic, critical, intensive investigation directed toward development of new or fuller scientific knowledge. It may be with or without reference to a specific application. (USGS, 2001, emphasis original)

Having different evaluative tools is one essential way in which hierarchical rank can be better evaluated and is an important tool for spurring organizational change by emphasizing agency core values, competencies, goals, and tasks. It is also extremely challenge to design an effective structure, as an Interagency Taskforce on evaluation stated, "if one were to ask federal human resource practitioners to name the biggest challenges they face, designing and administering an effective performance appraisal system would rank at or near the top" (Orr in IAGCPMR, 1993).

The RGE provides a career track for researchers that is distinct from managerial and supervisory tracks and introduces an element of performance-based pay through a peer review process. There have also been efforts to standardize the RGE across various agencies, including USGS, the USDA Forest Service and Agricultural Research Service, in order to improve interagency cooperation (USGS, 2001). Evaluation is conducted in the USGS at a minimum of once every four years (faster if an employee is producing new work at a rapid rate and requests an expedited review) and consists of a panel peer review conducted under OPM's four factors, which are:

- I. Research situation or assignment
- II. Supervision received
- III. Guidelines and originality
- IV. Qualifications and scientific impact (USGS, 2004: 50)

Panels are not anchored to any particular locality, but are more like academic peer review in which specialists from around the country in a scientist's distinct sub-field evaluate her body of work on the above criteria. Each discipline of the USGS (geology, biology, geography, and water) conducts a separate, staggered review, leading to evaluations going on across the agency at all times. These panels sole responsibility—though a large one—is to determine the appropriate title, position description, and whether scientists should remain in grade, be promoted, or be demoted. They do not assess performance in terms of offering awards (Wallace, 2004; USGS, 2001).

The new guidelines make clear that the intent of the RGE is to evaluate research for its Science Impact, as defined by the whole continuum of promoting partnerships, conducting good research, and having outcomes/impacts (USGS, 2004). Whether these stated guidelines are actually followed is a question of the culture of the USGS and will be addressed in a later section. In essence, there is nothing in the language of the RGE that *prevents* Science Impact from being the standard by which scientists are measured, however that are other cultural barriers and perhaps interpretation barriers of the intent of the RGE that stand in the way (Wallace, 2004). Cultural barriers are real barriers nonetheless, and will require further structural solutions to ensure that the panel process is serving its intent. Current USGS efforts to improve the RGE and further possible interventions will be discussed in later sections as well.

Supervisor Review and Awards

It is the supervisor's job every year, working with a classifier, to ensure that employees are being evaluated at the appropriate grade level and to assess their performance in that level. This means that supervisors exercise the first judgment as to whether an employee should be pursuing the research track, the technology track (Equipment Development Grade Evaluation), or a practitioner track. Indeed, language on the panel review process noted "The RGEP should not be expected to do a supervisor's work; poor research performance should be managed through the performance appraisal process at the Center or Cooperative Unit level in concert with the respective servicing personnel office" (USGS, 2001). Supervisors and center directors also work with scientists to identify mentors, cyclical funding streams, and projects that will build up research credentials for their scientists (USGS, 2003). Thus, supervisors appear to represent less of a barrier and more of an underutilized resource as agents of change.

A particular challenge facing supervisors is the evaluation of individuals working in a team environment. Teams are critical to interdisciplinary science, but evaluation of individuals on those teams should not be reduced to whether the scientist is the first author on a refereed journal article alone. However, this is a common shortcut used by supervisors and panels alike to quickly assess the contribution of a scientist to a project. It involves more work on the part of the assessor to ascertain the real contribution of someone on the team then to the simple rubric of whether they are the first author or not (Wallace, 2004). A number of techniques exist that would serve to better evaluate team performance, falling roughly into the following typology:

Figure 3: from (OPM, 2000b: iii)

A TYPOLOGY OF PERFORMANCE ASSESSMENT APPROACHES IN AN INTERDEPENDENT WORK ENVIRONMENT: EVALUATING TEAM PERFORMANCE

Focus Continuum	Individual Focus>------------------------------------->Team/Organization Focus			
Model	**Model #1** **Individual Assessment in a Team Setting**	**Model #2** **Employee's Contribution to the Team**	**Model #3** **Group Performance Element**	**Model #4** **No Individual Performance Assessment**
Approach	Only individual performance is addressed. (Rating has traditionally been done by the first-line supervisor.) Does **not** include elements addressing team work, even though employee is a member of a team.	Only individual performance is addressed. However, at least one appraisal element addresses the employee's contribution to the work group.	The focus is on the work group's performance. Employee appraisals use a combination of team\org'l productivity measures and individual performance measures. At least one element addresses group performance.	Performance is determined at the group level only. No individual appraisals or ratings are done. Team\org'l performance measures are used to determine group monetary awards, e.g. Gainsharing.
Example(s)	Organizations which use only individual-focused elements in the appraisal	Components of Labor, USAF; DMEC, GAO, agencies that have teams.	ASO (PMRS), Gateway 2000, Metropolitan Life, NPRDC Proposal	US West, Pacer-Share, GM Powertrain, (Deming Approach)

Supervisors can, in assessing employee performance, recommend people for rewards and offer constructive and positive feedback. In a 1998 OPM study of 15 agencies that were revising their performance-based awards, none of these agencies had defined “excellence”, although they were giving awards on the basis of excellence. There is very little monitoring and evaluation of the impact of award programs. Furthermore, a later study of federal employees found that only 23% believe that awards have an impact on performance (OPM, 2000b). Some scholars, including W. Edwards Deming, have even argued that monetary rewards for individual performance actually have a demoralizing and negative effect on the organization as a whole, perhaps suggesting a need for a greater emphasis on team-based rewards and asserting the importance of team-based evaluation (IAGCPMR, 1993). Others argue that the lack of rewards for innovators and risk takers stymies change (Groat, 2004). One case study from the USGS Science Impact Best Practices highlighted the basin modeling tools and collaborative management that were undertaken in Albuquerque, NM. Although the agency identified this project as one of its touchstone cases of Best Practice, the manager got no recognition or positive feedback over the course of conducting the project (Posson, 2004).

Perhaps one could argue that reward systems will not drive change, but the lack of awards and appropriate encouragement for those who are moving the agency in an innovative and mission-critical direction are a potential missed opportunity. Respondents from Procter & Gamble and DuPont both highlighted the importance of awards for excellence, such as the Victor Mills Society at P&G, along with other recognitions like titles and listing in corporate publications. These are of particular importance for publicly reinforcing group values given the relatively private nature of wage status (Webb, 2004). Recognizing rewards and other informal recognitions as important feedback mechanisms, this paper's focus is on evaluation and promotion structures and the cultures that surround them as primary incentives.

Cultural barriers

Organizational change does not happen easily or quickly; it is mediated by a number of factors, including the values of the employees and the culture of the organization. Lubchenco's mandate for socially relevant science is not wholly consistent with the priorities and objectives of many research scientists. Scientists commonly enter the field due to an interest in self-directed, inquiry-driven science. Larson discussed academic science research and social relevance,

> "My opinion is that scientists do the research in which they are interested and find de facto justifications for it after the fact. Yes, we all write into the grants how our research is going to cure breast cancer, or halt the spread of HIV, but the fact is that every lab I have ever been associated with has been a pure research lab. In fact, unless there you are a M.D./Ph. D, the chances that you are doing clinically relevant work are low. I think a lot of scientists have a love/hate relationship with the topic [of societal relevance of research]. Many of them have a dim view of that sort of translational research, because it doesn't involve imaginative, creative science. Maybe the first part, the original kernel of the idea, was creative, but the actual reduction to practice is in most cases tedious and time consuming" (Larson, 2004)

Similarly, in the Science Impact Dialog, one USGS researcher noted the challenge of having to be "fairly creative in figuring out how to make science out of some of that data", when working on client-driven research (USGS, 2003). Scientists' individual values for pure science as opposed to policy relevant science should not be discounted as a relevant factor slowing change.

USGS has an external reputation as a credible science agency wherein research is often conducted in a "pure science" rather than a "regulatory science" framework. USGS has a culture that values the status of the research scientist above the manager and is closer in nature to academia than to other federal agencies (Wallace, 2004; Karl, 2004). In contrast with USGS, Chris Racher of EPA Region 1 said that at the EPA, "policymakers are better communicators and get promoted more", which reinforces a hierarchy of policy over science in this regulatory agency; presenting essentially the opposite problem that the USGS faces as a neutral science agency that is trying to be policy relevant (Racher, 2004; Powell, 1999). This comparison is offered to clarify that simply because a public agency is involved in science, a status hierarchy of science over policy does not always emerge—rather, I would argue, the relationship responds to the mission of the group. Different organizations have different cultures that evolve in service to the mission of the agency, but the effects of those cultures must constantly be revisited, particularly in the public sector. The status of research at the USGS drives a wedge between the intent of the RGE guides and their use in practice in two ways: 1) individuals are sometimes evaluated under the wrong rubric and 2) panels often ignore the full breadth of Science Impact that is supposed to be evaluated under the review (Wallace, 2004).

Person evaluated under wrong rubric

Wallace described a case of the first problem wherein an extremely innovative information technology specialist initially began his career as a research scientist but progressed to doing innovative information management and web-based tool development that supported the work of hundreds of scientists. Despite this, he remained at the mid-range grade of GS-11 and his panel was not able to recommend him for a grade increase on the basis of his research. Essentially, he could not be appropriate evaluated under RGE. Despite this, the panel refused to recommend that the specialist be considered for non-research grade evaluation as that would mean losing his title of "researcher", even though it mean a likely increase in grade and wage (Wallace, 2004). This challenge points to the need for improved supervision to ensure that employees are being properly evaluated. More importantly, though, it speaks symbolically to the status of research as an incentive and a cultural value within the agency, even eclipsing the motivation of pay.

Review panels ignore full breadth of Science Impact

The second cultural barrier of panelists giving primacy to peer-reviewed publications in certain journals above all other criteria in the evaluation was a concern throughout the literature and identified by a number of informants familiar with the USGS. The practice encourages reductionist science and discourages interdisciplinary, client-driven, or collaborative science in preferring peer-reviewed publications above all other types of research (Karl, 2004; USGS, 2003). One USGS scientist in the Dialog on Science Impact noted, "we're still in the old mode of, in the end, see how many publications you've got and that's the criteria for success. And it's extremely difficult to quantify impact" (USGS, 2003). Karl Hess of the Fish and Wildlife Service noted, "if you're a USGS scientist who writes a policy document or book that changes the world, if you're not publishing peer reviewed articles, it doesn't matter." USGS scientists face the pressure of producing peer-reviewed work, just as academic scientists do (Hess, 2004). A similar tradeoff exists in academia, between producing journal articles and pursuing teaching, an important form of societal impact. Recognition and rewards come from publishing in recognized journals, not from conducting outreach or education (Jacobs, 2001). USGS scientists operate in this framework without the eventual possibility of the freedom of tenure.

A case study also illustrates the point. A GS-14 research hydrologist of USGS appealed his panel's decision to a second panel, to the DOI, and eventually to OPM. The OPM decision includes a careful weighing of a number of issues, but an excerpt from the section on Factor IV speaks to this issue:

> "….Although the appellant has authored a number of publications of considerable interest to other researchers emphasizing the importance of ecological considerations in multipurpose water management, there is no indication that his research has as yet had a major impact on advancing the field or that it has resulted in new inventions or techniques as contemplated at Degree E. The appellant's work involving network simulation flow modeling and multicriteria decision making is not yet accepted as definitive within the scientific community. **Information from our contacts stressed the lack of peer-reviewed publications by the appellant in the past ten years**. They noted that this lack of publications might be because the appellant has spent a large portion of his time furthering his professional development through active participation in professional society and academic committees and conferences. Because of the limited

> degree of published data in scientific journals that has been subjected to peer review, with the conclusions accepted and proven repeatable, this aspect of Degree E cannot be credited to the appellant's position…." (OPM 2000c: 11, emphasis added)

The Factors include the language of science impact and are intended to measure originality, science leadership, scientific validity, and societal benefit, but the shortcut of using peer reviewed publications as the key metric is a culturally determined priority (Wallace, 2004). Daniel Sarewitz offers a hypothetical alternative:

> "What if public service were rewarded as strongly as number of publications or patents? If helping a community or an organization to address a technical issues or problem was a criterion for promotion, peer approval would follow. It is hard to imagine that such a change would lessen public support for R&D. Moreover, positive feedback between social needs and the research agenda would begin to evolve at a grassroots level" (Sarewitz, 2000: 31).

Differences between the disciplines

Though the USGS is one agency, it is comprised of four disciplines that differ in their focus, composition, and culture, as well as in how they view and evaluate collaboration. A striking contrast can be made between the Geology and Biology Disciplines on one hand and the water and geography divisions on the other. The Water Resources Discipline comprises almost half of the entire survey, with 4,000 employees, of which 1500-2000 are working hydrologists, but only 300 are research-grade scientists. In the geology staff of 1800 employees, 600 of the 700 scientists are research grade scientists. Biology has a similar ratio as that of Geology, whereas Geography is comprised predominantly of practitioners (Wallace, 2004). Physically having a water office in each state further promotes greater public interaction, akin to a university extension service model (Barrington, 2004). Simply through the employee distribution, it is evident how a culture of pure research can be promoted in certain divisions.

The culture is also driven by the way in which research is funded in the different divisions, with geology receiving a much larger proportion of core, long-term funding for pure, curiosity driven research, while water relies largely upon research with reimbursable funds and cooperative programs that are more client-driven (USGS, 2003; Barrington, 2004). Wallace also noted funding limitations for "systems level thinking" when doing client-driven research (Wallace, 2004). This impacts research scientists' ability to be promoted, particularly young scientists, as the following interchange at the USGS Science Impact Dialog in Columbia, MO:

> A: "As a new research-grade scientist, listening to everyone who has careers of probably 10, 15, 25 years of research, how can a new research-grade scientist develop an area of expertise if she's following reimbursable funds, if she's always answering a client's question?"
>
> B: "I'm glad you asked that question early."
>
> [LAUGHTER]
>
> C: "Yeah, because not in this agency." [joking] (USGS, 2003)

The laughter of the group indicates a shared understanding of a fundamental issue within the USGS. The Dialog participants noted that many scientists will "walk away" from a client-driven project if it will not lead to peer-reviewed science; but not every unit or discipline has the option of doing so, nor should this practice necessarily be encouraged from the perspective of Science Impact (USGS, 2003). Although there is a critical interaction between resource flows and incentives to individual scientists, this paper continues to focus on the interventions at the individual rather than the institutional level. Further research on the issue of budgeting influences on collaboration needs to be conducted. The take away message for evaluation and review is that peer reviewed materials should not continue to be valued above other outputs.

Evaluation of current USGS strategies promoting change and recommendations for further interventions

Structural Reorganization and Science Impact

With a total of approximately 10,000 employees, the USGS is one of the smaller agencies in the federal government and should be able to promote change with greater ease than other agencies. USGS is taking structural, cultural, and educational steps to facilitate this change. The agency recognizes that the switch from curiosity-driven science to science with greater social relevance is a large transition for a 125-year-old organization to make (Wallace, 2004). The change benefits from having leadership that believes in the direction, but ultimately it must be driven by peer learning and not just top-down mandates (Jacobs, 2001; Posson, 2004). Perhaps the largest and most significant trend in the USGS supporting this belief is the move towards greater regionalization in order to diffuse decision-making out from headquarters (Groat, 2004). The existing framework of the four disciplines also provides a useful starting point for affecting organizational change, recognizing the different funding structures, employee compositions, and research goals of the different disciplines. Future efforts related to organizational change should use the disciplines as conduits, rather than simply creating separate offices related to collaboration or public involvement.

Since the Science Impact program is still in the early stages of development, information gathering and listening sessions are key strategies for peer learning. A series of group and individual listening sessions and discussion sessions with senior management and senior scientists have been held to get there input on Science Impact, including the October 2003 Dialog on Science Impact (USGS, 2003). Highlighting examples of innovation in collaborative science and decision-making is the goal of the USGS Best Practices project (see an analysis of Best Practices by Peter Brandenburg, 2004). The Best Practices project is useful both to extract lessons learned from case studies on the ground, but also to affect incremental cultural change by celebrating non-traditional, client-driven, and decision-relevant science. These are important first steps to understanding the status quo (both best practices and common practices via the dialogues). As Science Impact is incorporated as a research program into the Geography Division, it needs to move beyond simply and understanding of the status quo if it truly wishes to "serve the public and sustain the USGS" (Posson, 2004). Organizational leadership, a clear action plan for coordinating research between the different centers, and sufficient sustained funding is necessary to develop Science Impact into a robust, effective research program.

The MIT-USGS Science Impact Collaborative has offered comments to senior management on the "Draft Guidelines for USGS Participation in Collaborative Public Engagement Processes and

Neutrality in Policy Decisions", which could potentially serve two functions. The agency needs a short policy statement on collaborative decision-making that makes clear the vision of senior management. It also needs a distinct working document with detailed sets of guidelines for various employee roles (scientists, managers, etc) that establish the boundaries of advocacy neutrality and collaboration that is created collaboratively with employees in the different disciplines.

Another trend specifically relevant to collaboration and boundary spanning is the greater effort on the part of the USGS to partner with other agencies, particularly those in the DOI. This is occurring first in high profile, often joint federal and state funded, highly complex projects such as the Everglades, CALFED, and the Missouri River Basin (Groat, 2004; USGS, 2003) In the Everglades case, a DOI Coordinated Science Plan was created in May 2004, involving the efforts of dozens of scientists to craft common questions on how to restore and protect water quality, natural resources on DOI lands, and endangered species of the region (DOI, 2004b). USGS participated as an agency and through its individual scientists. The Everglades case study involves a range of different collaboration mechanisms, including virtual information sharing through the South Florida Information Access website (http://sofia.usgs.gov/) that is maintained by the USGS. Transferring this level of collaboration down to more routine, lower profile issues (without federal appropriations) remains a systematic challenge to the agencies. Expanding beyond just intra-DOI and intra-agency collaboration to true public collaboration is the goal of Joint Fact Finding processes that involve stakeholders in the framing, scoping, and conducting of science.

Hiring and Education

Change is being promoted in USGS with an emphasis on "building from the existing human capital" of the organization (Posson, 2004). One means of doing this is by shifting existing employees who are qualified and interested from various disciplines into the Science Impact program. However, significantly changing the ratios of research scientists to practitioners is not currently a priority for the Survey, with existing scientists arguing that too many managers and other non-scientists are already employed by the Survey (Wallace, 2004; USGS, 2003). From an organizational change perspective, I argue that senior management needs to evaluate its objectives and hire accordingly. If USGS'goal is to increase societal relevance of both science and the agency at large, the USGS will need to hire different sorts of individuals than if it wishes to continue prioritizing inquiry driven science above science translation, tool development, and collaborative decision-making. This change can occur gradually with the natural attrition of older research scientists that move into retirement. In their wake, boundary spanners ought to be hired and promoted, with an eye towards "hiring for attitude and training for skill" (Groat, 2004). Boundary spanners are particularly needed in team leader roles, leading interdisciplinary teams (Hess, 2004). Strategic early appointments of exceptional boundary spanners should also be considered, given the ability of well-intentioned and similarly well-positioned individuals (even within a resistant organization) to affect change and the role for remarkable individuals at the early stages of innovation (Rex, 2004; Hess, 2004).

This can best be achieved by increasing linkages to universities with strong interdisciplinary science-policy programs. These linkages will serve both to improve recruitment, but should also be thought of as a co-learning process of model sharing, with current USGS employees learning what is on the cusp of new academic knowledge. This approach is used by businesses and agencies alike. For example, DuPont and MIT have a current $35 million, 5-year long term research and development partnership. Uniquely, this partnership "encourages the formation of multidisciplinary teams from the science, technology and engineering community, and the business, management and policy arenas" (DuPont, 2004). Agencies and universities can exchange knowledge and practices related to the common struggles to foster interdisciplinary research and innovation. USGS could establish itself as a mentor organization and willing employer of students doing interdisciplinary work, as suggested by Sung et al. (2003). In some cases, USGS could create affiliations and temporary appointments with interested universities. (See Anna Brown's paper on the USGS as a Boundary Spanning organization to complement this discussion of individuals as Boundary Spanners).

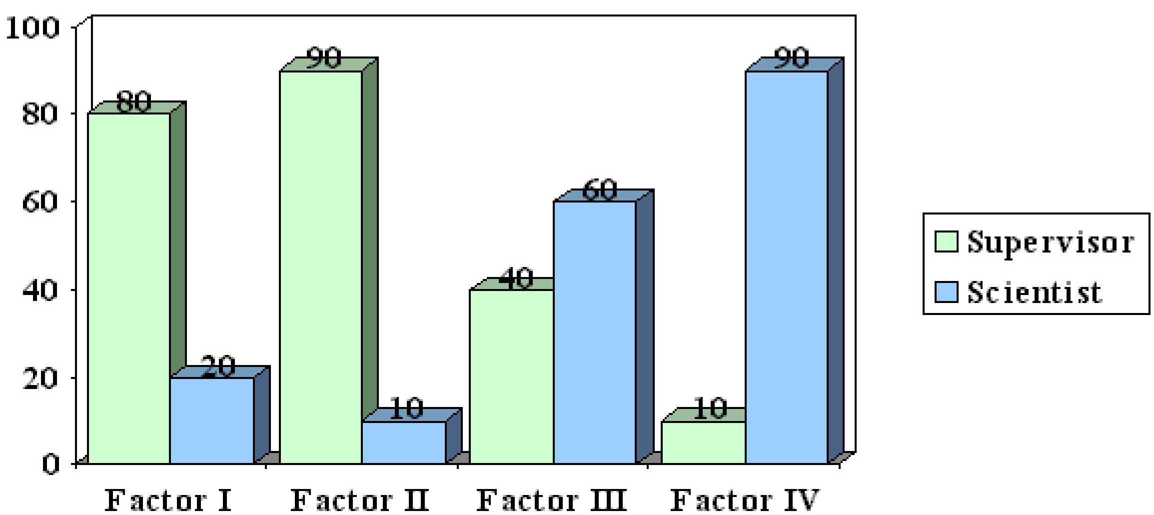
Training is one tool through which current employees, including research scientists conducting inquiry-driven projects, can learn new approaches to public involvement. The existing course on Joint Fact Finding, for example, is a useful start, but thus far only 60 employees throughout the entire agency have taken it (Karl, 2004). This training should be expanded to reach not just team leaders and supervisors, but elements of collaboration should be mainstreamed into the employee training and leadership training that all employees of USGS can take. Training on Joint Fact Finding and other collaboration and decision-making tools and approaches being developed under Science Impact should be presented to employees in a coordinated manner. The barrier of fear and misinformation related to procedural issues as a federal employee is also an issues, particularly as related to the Federal Advisory Committee Act and its interpretation through the Solicitor's office. This fear can lead employees to be risk averse and wary of innovative collaboration models (Hess, 2004; Karl, 2004). Thus, trainings on FACA and the guidelines related to advocacy neutrality for USGS should be incorporated into courses on collaboration.

Finally, education does not occur solely through the one-way transfer of information, rather it is often facilitated through a peer-learning process. Moving from "listening sessions" both one-on-one with supervisors and in groups as in the Science Impact Dialogs, to decentralized innovation information sharing across localities and disciplines should be a priority for the agency. These sessions could feature keynotes/ presentations from successful Boundary Spanners within the USGS both for others to learn from their experiences and as a way of giving positive feedback through a nontraditional mechanism to that individual/team. These should be informal settings for sharing information allowing ample time for informal networking and small group discussion, perhaps even working with professional facilitators to extract key lessons learned. They should be ongoing to encourage continued innovation. Mentoring programs and cross-discipline information sharing are techniques used in the business world to encourage innovation and collaboration across corporate divisions, which can have both physically distinct offices and inherent cultural differences (Webb, 2004). Though a certain amount of dialogue internal to the USGS needs to occur, the USGS senior management should also convene exploratory discussions/workshops with stakeholders in areas that seem appropriate for collaborative decision making, in order to try and catalyze the process.

Evaluation and promotion
Much of the argument put forth on structural barriers to innovation is related to the overarching GS pay and promotion framework. This structure remains in place for all agencies, and though there are clearly still cultural barriers to effectively using the RGE, it is clear that the RGE brings some element of merit-based promotion into the federal government through peer review. Given that the USGS must operate within OPM constraints related to the RGE, the agency is not attempting to radically revise its evaluation standards. Rather, the Office of Employee Development is taking the approach of clarifying rules and educating employees, having just revised the Research and Development Evaluation Process Handbook in November 2004. They are focusing particularly on new supervisors, as potential levers of change (Wallace, 2004).

I recommend that the USGS work with supervisors not only to help them understand the basics of RGE and who should be evaluated how, but also to partner with them to strategically devise ways of promoting boundary spanning and collaboration as a value in their unit. Supervisors' involvement in creation of position descriptions is one critical leverage point. The recommendations from the USGS Biological Resources Division reveal current thinking on supervisor and scientists roles in describing their own positions, with the following *hypothetical*□ division of labor related to defining the response to OPM's four factors:

Figure 3: from (USGS, 2001)



This distribution places almost all of the responsibility for description of Factor IV "Qualifications and Science Impact" on the scientist himself, whereas I argue the supervisor could play a critical screening role for existence and form of science impact at this stage. Moreover, I would argue that a spectrum of collaboration should be built into the role and the official job descriptions of all scientists to help reduce organizational stigma. For some scientists, that might involve simply more science translation and communication of their work, for others it might mean involvement in public peer review panels, and for some it could include participation in Joint Fact Finding efforts. Goals for the agency as a whole need to be developed at the organizational level, but individual scientists, teams, and their supervisors can work to develop where, when, and how their original research is used by the public. Supervisors also facilitate the review of individuals under "mixed positions" who spend some of their time dedicated to research and other time dedicated to other activities. The RGE allows for these research/practitioners to have just the research aspect of their work evaluated through the panel process (USGS, 2004). Supervisors should be aware of this option, and use it with greater frequency.

It is worth continuing to explore where the flexibility in the RGE system might lie.

- Currently, scientists select their primary peer group from a list of subject areas, and that peer group plus one other peer group create the panel, along with a personnel office "observer" (USGS, 2001). Interdisciplinary panels with a wider array of peer groups could be encouraged to get a broader perspective on science impact. This would involve a tradeoff in specificity between engaging with the details of the science and examining a candidate with critical distance regarding impact.
- Perhaps the peer groups themselves can be revised, as they include just one category for social science but more for each other discipline. Given the role of social science in integrating scientific information with policy action, greater involvement of social scientists in panel review is a reasonable goal (Jacobs, 2001).
- Additionally, I would argue that either the role of the personnel officer needs to be increased or every panels need to include someone whose dedicated role it is to evaluate research for its social relevance/science impact. If there is no one whose specific responsibility is evaluation of science impact, the culture of the group will likely remain the same, since "when serving on the panels, it is very difficult to think outside of the context of 'these articles count'" (Karl, 2004).
- It is recognized that evaluating science impact is not a simple task to be put off on one panel member without support, therefore I recommend the further development and implementation of a comprehensive program of monitoring and evaluation on the customer/client side. Current customer reviews are used on a selective basis, but in order to be effective they ought to be used throughout the agency (Posson, 2004). This information would be invaluable in the RGE process for comparing different collaboration and outreach practices.
- Another relatively radical recommendation would be to alter the current titling scheme to de-emphasize the difference between researchers and practitioners, as is done in the Australian Geological Survey, though Wallace noted that this is not a very viable scheme given OPM constraints.
- Finally, given the existence of the Senior Scientist and Senior Executive Service ranks, perhaps the creation of a Senior Collaborative Service (or at minimum the recruitment of some truly outstanding boundary spanners to the existing services should) be encouraged. A Senior Collaborator role would demonstrate that this is a growth area and help push the frontiers of the agency.

There are a number of different strategies USGS can pursue to continue to make the RGE work better at pursuing the USGS core value of science impact.

In order to truly push the envelope on change, the USGS might consider an OPM demonstration project with an alternative human resource management and evaluative structure. Agencies can apply to conduct these sorts of projects to test models within their own organizational environment by waiving existing title 5 law and regulations. An OPM Demonstration Project Team exists to work with agencies to devise new projects, particularly if they have a specific vision in mind (OPM, 2000a). For example, the USGS could pilot a team-evaluated approach that engages in collaborative decision making processes as a core part of its work (involving both scientists and practitioners), and using performance-based pay to the extent possible. This would be one experimental way to test innovative business models and hopefully to make a compelling case to the established USGS scientists on the value of an alternative evaluation and reward structure.

Finally, further research specific to the USGS needs to be conducted to fully understand barriers, particularly at the cultural level. Perceptions of panelists in the RGE and variations between the disciplines both require more in depth study. Collaborative research that involves scientists themselves in exploring incentives and barriers to collaboration would also be useful and consistent with the value of collaboration.

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