

Interdisciplinary problemsolving: Next steps in the Greater Yellowstone Ecosystem

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Abstract. The Greater Yellowstone Ecosystem, a 7.6-million-hectare region in the Central Rocky Mountains of the United States, is used to illustrate both the challenges and means to improve problem solving in the natural resources arena. The challenges in this world-famous region are contextual (rapid change, growth, pluralism, complexity, state/federal conflicts, and lack of a common perspective), institutional (multiple organizations with overlapping authority and control and disparate mandates, uneven leadership, lack of creativity in problem solving, and resistance to change), and human (diverse perspectives and values and epistemological limitations). To overcome these challenges, an interdisciplinary method that integrates knowledge to improve policy making is briefly described. It provides a framework with a comprehensive set of categories to use in investigating and analyzing problems and inventing alternatives for substantive, process, and structural improvements. Five programs or interventions, all of which are based on this method, are suggested to address the challenges facing Greater Yellowstone: (1) workshops for 'capacity building,' (2) leadership, staff development, and student internships, (3) case analyses and appraisals for policy learning, (4) problem-solving exercises and decision seminars, and (5) prototyping exercises to improve interdisciplinary and interagency coordination. These are described, examples given, and benefits outlined.

Introduction

All nations face the challenge of developing and applying effective problem-solving strategies to manage their natural resources for the common interest of their citizens. Strategies that integrate knowledge to improve policy and on-the-ground action are being demanded by many sectors of society. In universities calls for interdisciplinary problem solving are growing, in natural resources arenas the new emphasis is on comprehensive ecosystem management, and in business the focus is on integrating environmental concerns to modernize operations. Interdisciplinary problemsolving is the means by which knowledge integration can take place.

But a number of problems limit interdisciplinism. Complex dynamic social and political contexts focus people's attention on immediate concerns. Fragmentation of knowledge is pervasive and institutions are inflexible. The epistemology of positivism and professional training philosophies are among other variables that underlie many failed problem-solving efforts (Lasswell, 1970). Although disciplinism, positivism, and other forms of institutionalized knowledge production have many advantages, we must also develop our capacity to integrate

across disciplines, epistemologies, organizations, and policies. We must therefore find or create opportunities to use integrative methods explicitly and systematically, describe and teach them, and diffuse and adapt them widely (Brewer, 1992; 1995).

This paper uses the policy arena of the Greater Yellowstone Ecosystem (GYE), a nineteen-million-acre (7.6 million ha) region in the Central Rocky Mountains of the United States, to characterize the challenges of integration, introduce a method to facilitate interdisciplinary problem solving, and describe ongoing (or planned) efforts to facilitate knowledge integration, build skills, and improve policy and action for the sustainable use of resources.

Challenges in the Greater Yellowstone Ecosystem

Ideally, effective, group-based problem-solving must include ‘ways and means for blending wisdom and science, for balancing free association and intellectual discipline, for expanding and refining information, and for building a problem-solving culture that balances “permanent” with “transient” membership, thereby remaining open to new participants and to fresh ideas while retaining the capacity for cumulative learning that refines, clarifies, and simplifies’ (Burgess and Slonaker, 1978: p. 1). This ideal is seldom approximated in practice in GYE, and the region’s decision makers, managers, and citizens face numerous difficulties of context, institutions, and people before they can achieve it.

Contextual challenges

The GYE, a global model for natural resources conservation for over a century, is a relatively intact block of national parks, forests, and wildlife refuges interspersed with state and private lands (Figure 1a). Yellowstone and Grand Teton National Parks are at its heart. Presently, the context is changing rapidly because of a great influx of new residents and tourists, associated developments, and diverse demands on public lands management. Modern populations and uses are threatening unique features such as scenery, wildlife, and geothermal features. Ironically, the very institutions and people who manage and enjoy the GYE are also part of the problem. Rigid bureaucratic and interorganizational relationships and over-reliance on traditional disciplinary problem-solving frameworks and standard operating procedures have produced this situation. In recent years, however, some officials, managers, and citizens have sought to improve intergovernmental coordination, democratic responsiveness, and adaptability (e.g., Lichtman and Clark, 1994; Primm and Clark, 1996). Ultimately, the GYE’s institutions and people must also be the source of innovations for its improvement.

Since the region’s discovery by Euro-Americans almost two centuries ago, human occupancy and use have increased dramatically. There was little white

settlement prior to the establishment of Yellowstone in 1872. From 1872 to 1916 the GYE was sectioned into territorial jurisdictions (i.e., states and departments) and private interests (i.e., ranches, mines, and logging). The years from 1917 until the 1980s saw heavy resource extraction; although well established by World War I, ranching, mining, logging, and related activities spread inward rapidly and intensively from the GYE's periphery. In the last fifteen years there has emerged a more integrated or ecosystem management approach involving many scientific, policy, and organizational changes; nongovernmental organizations (NGOs) have been instrumental in calling for these changes. Today, the GYE's unique assemblage of geological, geothermal, and biotic features attracts about ten million visitors annually, while about 250,000 permanent residents live in the GYE. These people express a growing demand for a better quality of life, a trend that reflects global and American demands in general (McDougal et al., 1988), but also signals accumulating stress (Brunner, 1994). The last decade, for instance, has seen more lawsuits than ever before on public land management, and citizens, NGOs, and government are seeking 'conflict resolution' and 'public participation' means to address some problems.

Change in the GYE will likely accelerate and the context will become more complex. There will be growing pluralism, more diverse value demands, more organized interest groups, increased demands for market solutions to problems, more calls for private/public partnerships, and growing tension between state and federal governments. At the same time, there will be more pleas for effective conflict resolution and increased citizen participation in public policy processes. At present, there is no comprehensive contextual map that outlines key trends in the GYE, reasons for the trends, or projections of future conditions. This lack of a common, shared contextual map perpetuates unproductive dialogue, conflict, and fragmentation in perspectives and value-institutional divisions.

Institutional challenges

The institutional makeup of the GYE is also dynamic and complex. Responsibility for management of the region's natural resources has changed over the last 150 years. Today, about twenty-eight governmental agencies at national, state, and local levels administer the region, resulting in a highly bureaucratically organized and territorial arena (Figure 1b; Clarke and McCool, 1985). The National Park Service's job is to 'conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations' (Winks, 1997: p. 575). The U.S. Forest Service operates under multiple-use policies that manage for timber, watersheds, range, wildlife, and outdoor recreation. Mining and oil and gas extraction also occur. Three state governments also manage various aspects of the GYE's resources, including wildlife. They variously embody conservative, states'-rights perspec-

Greater Yellowstone's Future

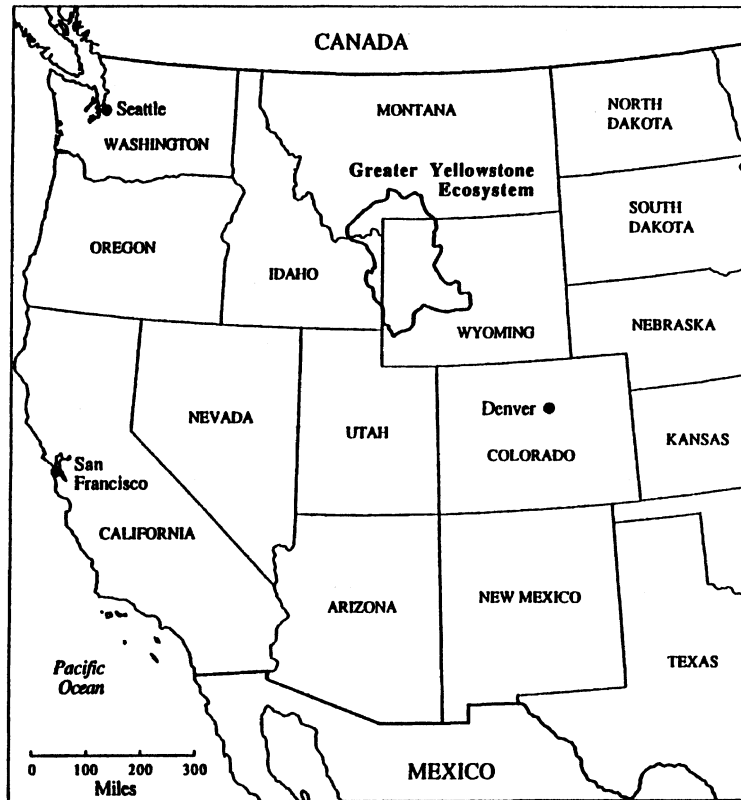


Fig. 1a. Location of the Greater Yellowstone Ecosystem in the Central Rocky Mountains of the United States. Map of western United States showing location of the Greater Yellowstone Ecosystem in the Rocky Mountains. To the east lie the Great Plains, and to the southwest is the Great Basin, or Intermountain West.

tives about authority and control, and they often conflict as well as cooperate with federal agencies (e.g., Davis and Lester; 1992). Many private organizations, especially businesses, also operate in the region; some, such as commodity extraction interests and the tourism industry, are loosely organized. Other organizations play important roles, including county and town governments, business associations, the media, as well as state governors and U.S. congressional representatives. NGOs play various roles, including critiquing government at all levels. Probably the largest and most influential is the Greater Yellowstone Coalition, a conservation group whose mission is 'to preserve and protect the Greater Yellowstone Ecosystem and the unique quality of life it sustains.' Many of these organizations support one another cooperatively, but others conflict directly and indirectly in a shifting mosaic of issues over time.

An Overview

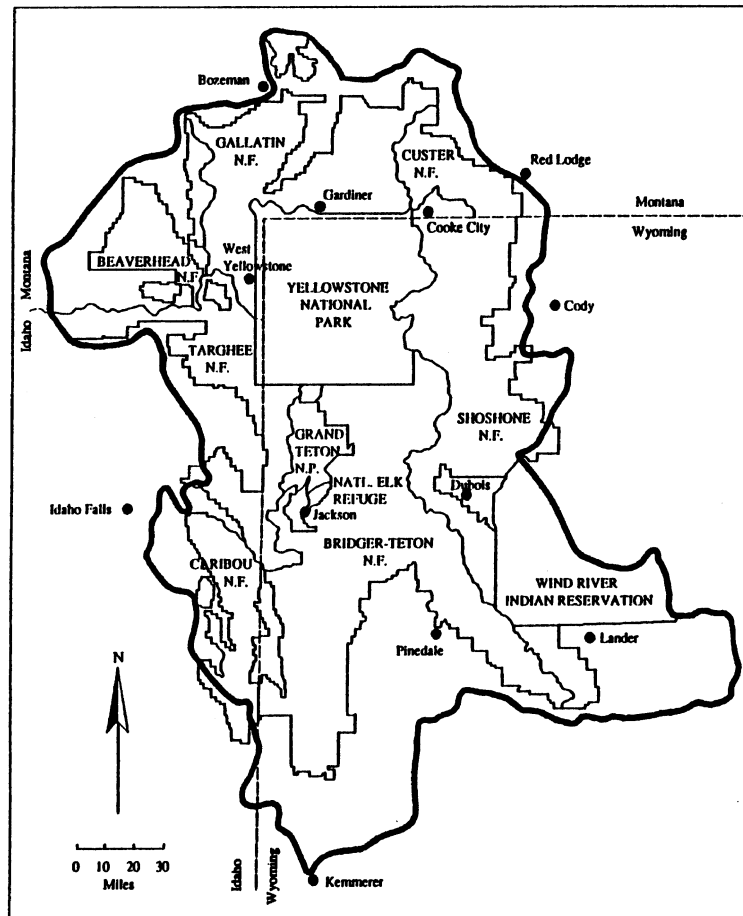


Fig. 1b. Administration of the Greater Yellowstone Ecosystem showing major jurisdictions. Approximate extent of GYE (thick line) and federal administrative units in the Greater Yellowstone Ecosystem (based on Greater Yellowstone Coordinating Committee, CRS 1987; after Schmidt and Eschler in Manuscript). Boundaries of national forests (N.F.) and national parks (N.P.) are shown; most of the remaining area is administered by other federal agencies or is state owned or privately owned. Major cities or 'gateway communities' to the GYE are Idaho Falls, West Yellowstone, Bozeman, Cody, Lander, Dubois, Jackson, Pinedale, and Kemmerer.

Interdisciplinary problem solving will come about only if these organizations facilitate it. Few organizations in the GYE have demonstrated a knowledge of how to find common interests in a genuinely interdisciplinary, cooperative way. Few motivated and skilled individuals have surfaced to carry out interdisciplinary problem solving and provide strategic leadership. Within organizational contexts, problem solving is a dynamic process that is part of a complex set of

cultural, social, political, and other practices, all of which are focused on particular values. The scientific disciplines as well as government and private organizations are sites for constructing and sustaining disciplinary and conventional social and cultural identity in relation to other institutions. Interdisciplinary problem solving will require changing these patterns of social and cultural identity.

Mixed trends in value-institutions will likely continue in the GYE. Few of the region's organizations currently strive for integration as they struggle to adapt to a rapidly changing context, including new patterns of value demands by citizens as well as special interests. Many public agencies have not only down-sized staffs and budgets, but their influence is also diminishing as a result of declining public respect. At the same time, however, many opportunities exist to develop interdisciplinary skills through workshops and forums, individual and cooperative problem-solving exercises, and improved leadership.

People challenges

Diverse people with complex and shifting perspectives live in the GYE and staff its organizations. Many dedicated people in government, friends of the agencies, and citizens work hard to perpetuate the conservation ideals of the national parks, forests, and wildlife refuges and to improve natural resources policy. However, the problem-solving methods and cognitive styles of both individuals and groups are often less than fully effective (Miller, 1985; Doob, 1995). Because the world is complex and uncertain, individuals need to simplify it in order to comprehend the myriad factors and forces that shape problems and social processes (Simon, 1983). Each person uses a framework to abstract, organize, and understand experience and to guide future problem solving. These models, maps, or metaphors vary in sophistication, comprehensiveness, and practicality, and as Einstein noted, how we see things determines much of *what* we see. Some ways of seeing and thinking are justifiably better than others (Brunner, 1997a, b). Interdisciplinary problem solving is a 'better way' that can be taught, learned, and applied and can eventually replace less effective methods (Clark, in manuscript).

At the heart of all problem solving, individual or social, are various epistemologies or systems of knowledge. Epistemology deals with 'the whole range of efforts to know and understand the world, including the unrefined, workaday practices of the layman as well as the refined, specialized methods of the scientist or scholar' (Goldman, 1995: p. 13). Some frameworks and epistemologies permit interdisciplinary problem solving, while others prevent it. The framework widely shared in technical fields in and out of government is 'positivism' or experimental science, which is defined as 'rational inquiry into nature in terms of logical inference aimed at finding universal laws, preferably written in the language of mathematics, and the prediction of new empirical facts deducible from theory confirmed by observation and experiment' (Lenoir, 1997: p. 4). The crucial

assumptions of positivism – realism, objectivity, disinterestedness, and autonomy – have been criticized by many people (e.g., Torgerson, 1985; Dryzek, 1990; Appleby et al., 1995). Despite its limitations, though, it is still deeply entrenched in many individual and group problem-solving frameworks and in the practices of many organizations. Positivism is the social epistemology that dominates in the GYE, and despite the sincere efforts of many people in the region to improve their own problem-solving methods, individually and collectively, their primary difficulty in this struggle is epistemological. These trends are expected to continue.

A framework for interdisciplinary problem solving

Facing these challenges, natural resources policy in the GYE could benefit from the knowledge and skill to synthesize diverse disciplines and perspectives into a common program. Interdisciplinism requires disciplined rationality – clarity, accuracy, precision, consistency, relevance, depth, and breadth. It demands a commitment to fair-mindedness and the ability to understand others' thinking, to use a framework for reasoning across diverse knowledge holdings, and to critique one's own thinking (Brunner, 1997c). Becoming an interdisciplinary problem solver may require partially unlearning what one already knows.

The first requirement of interdisciplinary problem solving is a framework that can accommodate, conceptually and practically, diverse data, epistemologies, and disciplines. The policy analytic framework of Harold Lasswell (1971) meets these criteria. This method is part of a global professional movement to improve policy decisions and quality of life through genuinely comprehensive and integrated inquiry. The framework seeks to generate practical and theoretical insight and action (Lasswell, 1971; Lasswell and McDougal, 1992). Its comprehensiveness, yet clarity, helps users find, analyze, store, recall, and relate important information for use in creating realistic policy alternatives. Social processes are very complex, but rather than avoid or deny complexity, the framework seeks to organize information about it in manageable ways to improve problem solving (Burgess and Slonaker, 1978). Other 'approaches may appear to offer simpler or easier solutions, but each usually turns up lacking in important ways – not the least of these being their relative inability to help one think and understand, and hence to become a more humane, creative, and effective problem solver' (Brewer and deLeon, 1983: p. 22).

Table 1 illustrates the four main dimensions of the framework – problem orientation, social process mapping, decision process mapping, and observational standpoint – and offers a series of questions to guide readers in its use. Empirical data about each category must be gathered, organized, and interpreted in actual situations. Each category contains an investigative checklist to guide attention to procedures as well as content (Clark et al., in press a, Table 1).

Problem orientation is a strategy to analyze problems and invent solutions. It

Table 1. An interdisciplinary problem-solving framework showing integrated categories designed to guide research and management decisionmaking.

Problem orientation (after Lasswell, 1971; Burgess and Slonaker, 1978; Clark, in press a)

- 1) *Goal clarification:* What outcomes or future states do the participants prefer?
- 2) *Trend description:* To what extent have past events approximated the preferred goals? What discrepancies exist between goals and trends? What problems hinder achievement of the goals?
- 3) *Analysis of conditions:* What factors or conditions have affected or caused the direction and magnitude of the trends described? How do these contribute to the problem?
- 4) *Projection of developments:* If current policies are continued, what are the probable future trends with regard to goal realizations and discrepancies? How will these affect the problem?
- 5) *Invention, evaluation, and selection of alternatives:* What other policies or practices might achieve the goals and solve the problems? How should these be evaluated with regard to past trends, conditioning factors, and projected trends?

Social process mapping (after Lasswell, 1971; Willard and Norchi, 1993; Burgess and Slonaker, 1978; Clark, in press a)

- 1) *Participants:* Who are the relevant participants, both individuals and groups? Who ought to participate? Who is demanding to participate?
- 2) *Perspectives:* What do the participants think, believe, feel about the policy, problem, or issue? What values, institutions, people, ideas, etc., do the different participants identify with? What are their expectations about what will happen? What demands are they making and on whose behalf?
- 3) *Situations:* Where are they and what are the occasions for their interaction with other participants? What is the geographic setting and time frame? Is the setting organized or not? To what degree are current policies institutionalized? Have any crises affected the participants?
- 4) *Base Values:* What assets (capabilities, perspectives, values, or resources) do the participants have? *Power* is to make and carry out decisions. *Enlightenment* is to have knowledge. *Wealth* is to have money or its equivalent. Well-being is to have health, physical and psychic. *Skill* is to have special abilities. *Affection* is to have family, friends, and warm community relationships. *Respect* is to show and receive deference. *Rectitude* is to have ethical standards.
- 5) *Strategies:* What strategies do participants employ in their efforts to achieve their goals – diplomatic, ideological, economic, or military? How do they manage and how are they likely to manage their assets (base values)?
- 6) *Outcomes:* What outcomes are achieved in terms of values in the ongoing, continuous flow of interactions among participants? Outcomes can be considered in terms of changes in the distribution of values. Who is indulged in terms of which values? Who is deprived in terms of which values? What outcomes do the participants seek? Outcomes also refer to changes in practices or institutions in society.
- 7) *Effects:* What net distribution of values is likely to be realized by the interactions of the participants? How are institutions and practices changed in the long run?

Decision process mapping (after Lasswell, 1971; Burgess and Slonaker, 1978; Clark, in press a)

- 1) *Intelligence (planning):* How is information that comes to the attention of decision makers gathered, processed, and disseminated? Is intelligence being collected on all relevant components of the problem and its context and from all affected people? To whom is intelligence communicated? Is the intelligence process factual, reliable, complete, selective, creative, and available to everyone?

Table 1. (Continued).

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- 2) *Promotion (open debate)*: How are policy decisions recommended and promoted? Which groups (official or unofficial) urge which courses of action? What values are promoted or dismissed by each alternative and what groups are served by each? Is the promotional process rational, integrative, comprehensive, and effective?
 - 3) *Prescription (setting rules or guidelines)*: How are general rules of a newly adopted policy developed/prescribed? Will the new prescriptions harmonize with rules by which participants already operate, or will they conflict? What prescriptions are binding (these are easier to determine if they are written down)? Is the prescription process effective in meeting people's expectations, is it rational, is it inclusive and open, and is it future oriented? Does the prescription have appropriate content and authority, and is it adequately communicated?
 - 4) *Invocation (enforcing)*: How are general rules of the policy prescription provisionally invoked in reference to people's conduct? Is implementation consistent with prescription? Who should be held accountable to follow the rules? Who will enforce the rules? Is the enforcing function prompt, dependable in characterizing facts, non-provocative? Is it open to abuse by individuals? Does it serve the common interest?
 - 5) *Application (dispute resolution)*: How are general rules applied? Will disputes be resolved by people with authority and control? How do participants interact and affect one another as they resolve disputes? Is the dispute resolution process rational in meeting the rules, is it contextual, unbiased, and workable, and is it constructive in mobilizing consensus and cooperation?
 - 6) *Appraisal (reviews)*: How is the working of prescriptions appraised? Is the program or policy evaluated fully and regularly? Who is served by the program and who is not? Who is responsible and accountable for success or failure? By whom are one's own activities appraised? Is the appraisal process realistic, continuing, independent (unbiased), and contextual in terms of taking many factors into account, including matters of rationality, politics, and morality?
 - 7) *Termination (ending and succession)*: How are the prescriptions, programs, practices, or policy arrangements brought to an end? Who should stop or change the rules? Who is served and who is harmed by ending a program? Is termination timely, comprehensive, dependable, ameliorative, respectful, and consistent with human dignity?

Observational standpoints (from Willard, 1997, personal communication)

- 1) *Roles*: What roles are you (and others) engaged in – student, teacher, advocate, advisor, reporter, decisionmaker, scholar, facilitator, concerned citizen, or others?
 - 2) *Intellectual Tasks*: What intellectual tasks do you carry out when performing your roles – clarifying goals, determining trends, analyzing conditions, projecting trends, and inventing and evaluating alternatives?
 - 3) *Shaping Factors*: What factors shape how you carry out your tasks and roles – culture, class, interest, personality, and previous experience?
 - 4) *Conditioning Factors*: What conditioning factors shape your 'contemplative orientation' in general and in reference to particular subjects of inquiry? Which orientations or roles are you predisposed toward or against, and how are you predisposed to conduct observation from each orientation?
 - 5) *Contemplative Orientation*: How does your contemplative orientation shape how you carry out the intellectual tasks associated with your roles? For example, what is the impact of your contemplative orientation on the goals you clarify and how you specify them? the trends you identify and describe? the conditions you analyze and how you analyze them? the projections you make and how you make them? the alternatives you invent, evaluate, and select?
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focuses on the rationality component of problem solving. Goals that people seek must be specified in relation to the problems at hand, and thus problems must be identified and defined. Historic trends must be described to see if events are moving toward or away from goals. Factors or conditions that have influenced trends must be determined; projections of future trends are possible if past trends and conditions are known adequately. Finally, potential solutions or alternative actions must be invented, evaluated, and selected (assuming projections are viewed as harmful). If these five tasks are carried out comprehensively, yet selectively and realistically, a practical solution is most likely.

Social process mapping is an effort to comprehend the social context in which all problems are embedded and which affects every detail. Social process focuses on the political and moral components of problem solving. A set of conceptual categories develops awareness of both the larger context and the details of particular situations. Every problematic setting, regardless of its subject matter, is made up of participants with perspectives interacting in particular situations. Participants employ whatever values, or assets, they have through different strategies to obtain desired value outcomes, which have additional effects (e.g., power, well-being, respect, affection). Values are both the things that people strive for and the assets they use to get them (e.g., wealth, enlightenment, skill, rectitude). They are the medium of exchange; values are used and exchanged, or shaped and shared, through social interactions to gain more values. In any social and decision process, participants are both indulged and deprived of values. Eight value categories are recognized: power, wealth, enlightenment, skill, well-being, affection, respect, and rectitude.

Decision process mapping is the analysis of the decision-making process integral to all policy problems. Decision process focuses on the political and moral components of problem solving as well as the problem at hand. Decision processes consist of seven interrelated functions, or activities. In actuality not all these are always carried out. Intelligence must be gathered about the problem at hand and its context. In turn, intelligence must be debated, discussed, and solutions recommended, advanced, and promoted. Rules or guidelines must then be established to solve the problem. Subsequently, these must be initially specified or enforced. Eventually, the rules must be fully enforced and disputes resolved. All these functions must be appraised. Finally, the process will be terminated. Standards have been recommended for the adequate completion of each function, and preferred outcomes for each have been outlined to assist participants (Lasswell, 1971; Lasswell and McDougal, 1992).

Observational standpoints are held by all people who engage in policy analysis. Standpoint consists of one's value orientations and biases stemming from personality, disciplinary training, parochial/universal experiences, epistemological assumptions, organizational allegiances, and other sources. People should seek to be clear and realistic about their own standpoints and the perspectives of others.

Empirical study can yield data on problem orientation, social and decision process variables, and standpoint. These few sets of categories must be considered

repeatedly in interdisciplinary problem solving because information is cumulative (Table 1). Diverse methods – qualitative and quantitative, observational and experimental, intensive and extensive, contemplative and manipulative – are required to obtain empirical data on all the framework's categories. This process thus serves as a disciplined, self-corrective device, the utility of which can best be appreciated by applying it to actual problems. One way is to array data (by categories in Table 1) in a matrix of social process \times decision process and fill in the cells based on research. Other possible 2×2 matrix combinations can also guide research and decisions, such as decision process \times base values and social process \times problem orientation. This exercise quickly tells the problem solver which cells he has data about and which he does not. It identifies what he knows and where the gaps are in his knowledge of problem orientation, social process, and decision process.

Diverse methods can improve insight, understanding, and control of the problem environment. Among the techniques designed to cope with complexity and the future-oriented aspects of problem solving are 'decision seminars,' 'prototyping,' and 'developmental constructs,' according to Lasswell (1971). Other more familiar methods include program budgeting, operations research, systems analysis, forecasting, linear and dynamic programming, brainstorming, risk assessment, and computer simulation and gaming (Brewer, 1986). Dryzek (1990) suggests conflict resolution, management by objective, arbitration, and others. These and other methods can be extended, adapted, or integrated as needed in solving problems.

Some suggestions for successful problem solving

Goldman (1995) listed several components of problem solving that should be considered in any interdisciplinary problem-solving exercise. First is how the problem solver understands, formulates, or 'represents' the problem to himself and others. Different conceptualizations may make it harder or easier to solve. The importance of this 'framing' issue cannot be underestimated, and much study has gone into identifying the variables that influence representation, including what stimuli prompt one's representation and the difficulties of revising one's initial representations. The rule is avoid commitment to initial representations, which tend to structure subsequent thinking and may confine it to rigid 'loops' in which the person (or group) keeps recycling the same themes. Experts and novices represent problems differently. What enables experts to solve more problems more quickly than novices seems to be how they conceptualize the 'domain' of the problem; experts tend to have more global, or abstract, categorizations of the problem space.

Second is how well people can abstract general ideas from particular circumstances. Some people are very good at distilling 'macrostructural' representations of problems and devising analogies necessary to solve problems. Breakthroughs in problem solving often occur when the problem solver discerns an analogy

between the target problem and previously encountered problems, possibly from different domains. An appropriate level of abstraction is necessary even before analogies in different domains can be discerned.

The third consideration in problem solving is its social setting: problem solving is a group as well as an individual exercise. Groups of diverse kinds – communities, government agencies, scientists, and whole societies – share an interest in finding answers to questions about natural resources policy. Groups vary in their practices and structures; some promote while some inhibit problem-solving power. Collective problem solving can outstrip that of individuals in many ways. People can pool their factual information, yielding more facts for each individual to work with. Their ideas, hypotheses, and insights can also be multiplied so that each person profits from a larger menu of candidate solutions. Critical assessment of alternatives is also facilitated, since an isolated problem solver may be easily seduced by the allure of his own ideas, while defects are easier to detect and weed out when they come from others. Complex solutions often need many skills to refine and test, and a division of labor among group members can facilitate several testing tasks at once. The group can offer incentives to make intellectual specialization possible, which may be needed for the long-term investment required for solving complex problems, and it can impose sanctions for behavior inimical to truth (lies, fabrications, and the like).

Interdisciplinary problem solving in the Greater Yellowstone Ecosystem

There are a number of ongoing cases in the GYE in which officials, professionals, and citizens are already trying to integrate knowledge to improve policy, although these are generally understood in terms of conflict management, improved governance, and various substantive issues. Additional opportunities exist or can be created to find rational and practical solutions to the problem of knowledge fragmentation. The ‘Governance and Natural Resources Management’ project by Ronald Brunner and Tim Clark is but one example. I would like to recommend five possible activities or programs that can help integrate knowledge and policy. The underlying approach in all five programs is to infuse interdisciplinary problem solving into the GYE’s management and policy dynamic (Brunner and Clark, 1996). The precise mix of projects will be determined by interest, opportunity, and funding.

The five activities (described below) can be used singly or jointly to address substantive problems, process or governance problems, and structures for research, practice, and education (Table 2). First, substantive issues might include improving wildlife management (e.g., grizzly recovery, wolf restoration, bison management), human growth management (e.g., winter recreational use, road building, ranching), and management of other natural resources (e.g., rivers, biodiversity, air and view sheds). Resolving substantive problems could bring to light new ways to address process problems. Second, process or governance

Table 2. A matrix of five activities to improve interdisciplinary problem solving in the Greater Yellowstone Ecosystem by challenges and targets or kinds of improvements sought. The five activities are: (1) Workshops for 'capacity building,' (2) Leadership, staff development, and student internships, (3) Case analyses and appraisals for policy learning, (4) Problem-solving exercises and decision seminars, and (5) Prototyping exercises to improve interdisciplinary and interagency coordination.

<i>Targets (kinds of improvements)</i>	<i>Challenges in the GYE</i>		
	<i>Context</i> (rapid change, growth, pluralism, conflicting value demands, complexity, lack of common outlook)	<i>Institutions</i> (multiple groups, overlapping authority and control, uneven leadership, institutionalized problem-solving approaches, resistance to change)	<i>People</i> (diverse perspectives, differences in base values, epistemological limitations, bounded rationality)
<i>Substantive</i> (e.g., outcomes)	2, 3, 4	3,5	1,3
<i>Process</i> (e.g., patterns of interaction, governance)	1, 3, 4, 5	1, 2, 3, 5	2,1
<i>Structure</i> (e.g., designs for research, practice, and education)	4	5, 1, 2	2

issues might include improving patterns of participation, data acquisition, open debate, planning, implementation, and evaluation. These might best be addressed by prototyping exercises (e.g., decentralizing the planning function), cooperation and conflict resolution (e.g., improving open debate), coordination of official and non-official policy (e.g., finding better rules or guidelines for management), management (e.g., better implementation, monitoring, and appraisals), and learning (e.g., better reviews and evaluations, easier succession to new policy and programs, and improved knowledge integration). Third, improving interpersonal and organizational structures for research, practice, and education might include decision seminars, and workshops or lectures on specific or general problems on a scale and frequency currently lacking.

The principal task for participants is to sharpen their focus on applied goals within the primary goal of common interest natural resources policy and management. Leadership is key to the success of all three activities and must be supported to become more skilled and effective. A multi-year effort to improve the GYE's natural resources policy and management has been initiated among Yale University, University of Colorado (a cooperative project on governance and natural resource management with Ronald D. Brunner), and the University of Michigan (a cooperative project on interdisciplinary problem

solving with Garry D. Brewer), U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, and the Northern Rockies Conservation Cooperative (Jackson, Wyoming). Other national, state, and local public and private partners may also join in.

(1) Workshops for 'capacity building'

Workshops would teach knowledge and skills for interdisciplinary problem solving to the staffs of government agencies and NGOs as well as community leaders and interested citizens. The goals would be to upgrade knowledge, standards, and skills by articulating new ways to gather, array, and synthesize information, develop critical thinking, and avoid technical, parochial, or special outlooks. A workbook is needed and will be written.

Two well-received workshops have already been conducted. In the fall of 1996 the Teton County (Wyoming) Commissioners and about twelve citizens convened to discuss sustainable planning and review previous county planning. They were introduced to interdisciplinary problem solving and the framework's categories and applied them to issues of concern. They concluded that the methods and range of human values they had used in planning and public process were too narrow and that this was a major reason why past planning had been less than fully successful. Through the workshop, they developed skills in thinking more comprehensively about future planning and public problems. In the other workshop in September 1997, twenty-three government and NGO participants compared their experiences using the framework. They systematically analyzed the decision processes of several GYE policy issues, including management of grizzly bears, wolves, bison, and elk, ecosystem management, tourism, the Yellowstone to Yukon biodiversity project, planning, private land issues, professional effectiveness, and others. Similar workshops have been held in other countries and at the Yale School of Forestry and Environmental Studies, and additional exercises are planned (e.g., Clark et al., in press a,b). Comments from participants from the 1997 workshop suggested that they had learned new skills: (1) A government biologist wrote, 'I have gained very practical ideas on how to concretely proceed to start to resolve a complex, highly-conflicted real-life situation.' (2) An NGO conservationist concluded that 'the workshop was helpful primarily in opening new possibilities for action.' (3) An independent biologist and educator said, 'I think anyone interested or affected by natural resources management would benefit from this workshop... . More people need to be thinking and analyzing with this perspective.'

Workshops could be particularly useful in development of leaders and staffs and in building skills for carrying out decision seminars or prototyping exercises.

(2) Leadership, staff development, and student internships

A special kind of strategic, policy-oriented leadership is needed in the GYE to aid heterogeneous (pluralistic) communities in clarifying and securing their common interests. Considerable experience already exists in the leadership of

diverse organizations in the GYE that could be 'harvested' and diffused widely. But even experienced leaders and public officials could explicitly and systematically upgrade their practical, policy-oriented outlooks and interdisciplinary problem-solving skills through workshops and exercises (Brewer and Clark, 1994). Models for support of leadership already exist at the Yale School of Forestry and Environmental Studies and elsewhere (Berry and Gordon, 1993) and in previous workshops. In the GYE, top-level managers of Bridger-Teton National Forest and the National Elk Refuge as well as other leaders are open to exploring ways to be more effective. Additional opportunities also exist, and there are several coordinating groups and leaders who could be approached to inquire about their interest in implementing interdisciplinary options.

At the staff level, agency and NGO personnel could take 'sabbaticals' to work on interdisciplinary team-efforts or ecosystem-wide projects or to attend Yale University or other academic programs. Professionals would then return to their employing organizations with new knowledge, skills, a practical policy orientation, and especially an ability to use the framework. For agency staff and other professionals, fellowships exist for study at Yale, for example. More opportunities need to be made available for practicing professionals to aid one another and to improve their knowledge and problem-solving skills in cooperative settings and with the public.

It would also be beneficial to the agencies and NGOs in the GYE to have students who are knowledgeable about interdisciplinary problem solving to participate in management and policy programs. One effort currently underway on the National Elk Refuge is a partnership of the University of Michigan, Yale University, National Elk Refuge, and the Northern Rockies Conservation Cooperative. Students will use the framework to analyze ongoing management processes and recommend improvements. These projects will include: (1) a review of past and ongoing elk management, which is costly and problematic, (2) finding lessons from nearby situations directly applicable to the refuge, such as elk management in Yellowstone National Park and bison management in the region, (3) and assessing the full value of the refuge, incorporating all eight value categories, to understand the diverse benefits. And (4) other projects are planned to further the goals of sustainability and biodiversity conservation.

This effort would directly address the human challenge of diverse perspectives and base values, epistemological characteristics, and bounded rationality among a select number of potential participants. It would improve process or governance issues by helping leaders, staff, and interns to develop the policy orientation needed by individuals and by organizations to deal with complex, dynamic contexts and institutional settings.

(3) Case analyses and appraisals for policy learning

We should look to the experience of individuals and organizations in the region for lessons to improve our collective performance. Greater Yellowstone could provide an even more powerful exemplar if its programs and policies were described and analyzed in ways that could be generalized to other situations.

Constructive reviews of selected management and policy efforts could be carried out to find and promote successful methods. Comparative case studies, widely used in professional education, seek to describe actual policy dynamics and make practical recommendations. Similar appraisals have been conducted for endangered species conservation in Australia (Stephens and Maxwell, 1996; Clark, 1996). Wolf reintroduction and recovery, grizzly bear conservation, and northern Yellowstone elk management are three programs that will likely furnish useful examples.

The interdisciplinary, problem-solving framework provides a basis for sophisticated appraisals and policy learning. As a stable frame of reference, it provides a systematic basis for finding, describing, and communicating lessons. The framework's integrated categories can be used as an analytic lens to guide these studies, which could be published and disseminated widely. The utility of the framework as an interdisciplinary tool can be illustrated in this way and its broader use encouraged.

One recently completed case is a study of grizzly bear management focused on a high-profile incident in Grand Teton National Park in summer 1996. Cromley (in press) examined the killing of bear #209 and the history that led to this incident to understand the perspectives of various participants in the ongoing debate about bear management. She used the framework to research the case, analyze it thoroughly, and recommend future management. Results are being published. In another ongoing project, Rutherford (1997) will employ the interdisciplinary framework to examine ecosystem management efforts in the GYE to find out how best to devise and implement such efforts in the GYE and elsewhere. Ecosystem management has been recommended as a science-based innovation to improve management of public and private lands and resources (Grumbine, 1994), it has been nominally adopted by many federal and state agencies, and a multitude of ecosystem management projects are underway (e.g., Yaffee et al., 1996). Additional ongoing GYE projects can be studied to learn how to improve practices and programs, among them co-planning efforts between the Forest Service and county governments just west of Yellowstone National Park and a variety of citizen-based, problem-solving initiatives, such as the Conflict Resolution Group in Teton County, Wyoming.

By harvesting the lessons of experience in systematic, understandable ways and thereby improving policy learning, case analyses and appraisals can make substantive improvements in institutions and, secondarily, in the complex and rapidly changing contexts and participants in the GYE. Such analyses and appraisals can be useful to the overall program by building a knowledge bank of case material on which to base prototyping exercises, capacity-building workshops, and problem-solving exercises.

(4) Problem-solving exercises and decision seminars

Joint problem-solving exercises of government, NGOs, and citizens would seek to develop 'common interest' solutions to specific management and policy problems. A decision seminar could be used – a cooperative, genuinely inter-

disciplinary approach that can generate practical insights for decision making, fully explore problems and methods of analysis, assess proposed solutions, clarify institutional responsibilities, and manage data (Lasswell, 1971). The power of the decision seminar rests on its unique methodological integration (Brewer, 1986). A decision seminar in the GYE would consist of selected agency leaders and others in the region as well as qualified people outside the region. Such exercises could be added to efforts already underway or set up as parallel efforts closely allied to ongoing formal programs.

Leaders can use decision seminars as a strategy to develop effective problem-solving routines (Burgess and Slonaker, 1978). This design has three characteristics that 'enable' problem solving. First, it demands a contextual approach that permits movement between the parts and the whole and back and forth among the past, the present, and the future. Second, it requires multiple methods to ensure a healthy diversity of approaches to problems and to encourage cross-field investigations. Ideas, creativity, and novel hypotheses are fostered by the use of multiple, aggregative, interpretive, and projective methods. Third, it requires the initial specification of the objectives or purposes of the problem-solving activity in a way that allows for refinement while promoting consensus. Brewer (1986) reviewed methods for synthesizing information for policy purposes through decision seminars. Bolland and Muth (1984) offered one application of this method to solving urban problems; to date no decision seminar has been used in GYE.

There are a number of long-standing management issues that could greatly benefit from a directed, problem-solving exercise like this. Among the high-profile possibilities are bison, grizzly bear, and wolf cases, all of which have been underway for decades, and, despite some advances, show continuing weaknesses in decision making. More broadly, a decision seminar could also be carried out at the ecosystem level for the fundamental purpose of constructing a comprehensive, realistic 'map' of the changing context of natural resources policy and management in the region. Such a map, continuously updated, would be immensely valuable in day to day decision making on both small and large scale issues.

One long-contentious issue in which interdisciplinary problem solving was encouraged was large carnivore conservation in the northern Rocky Mountains of Canada and the United States (Clark et al., 1996). Diverse participants, including social and biological scientists from various organizations, were asked to contribute articles to a special journal section to develop a broad understanding of the large carnivore conservation challenge and offer ways to improve matters. Resources were not available to bring all contributors together, but the editors sought to integrate the contributions throughout the publication. A similar interdisciplinary, large-scale effort on Australian koalas is underway (Cork et al., in progress). Again diverse participants are working together to construct a reliable, broad overview of the challenges confronting koala conservation. Recommendations include various substantive, process, and structural improvements. Again, limited resources have precluded convening

the contributors early in the process, but a concluding conference was convened in summer 1998. The editors seek to integrate knowledge, perspectives, and recommendations using the policy sciences framework to the extent possible.

Problem-solving exercises and decision seminars help create new structures for tackling the difficult problems of context in the GYE by widely useful contextual maps. These efforts could reinforce the capacity-building workshops and professional development of leaders, staffs, and interns.

(5) Prototyping exercises to improve interdisciplinary and interagency coordination

A prototype is a small-scale, trial intervention in a social or policy system. Its main goal is to gather information about what factors are relevant to solve problems, especially in highly uncertain, complex, and conflict-laden situations. Successful elements can then be repeated, adapted, and improved in other policy systems and institutions. In other words, it is a way of finding out what practices work and why and how to diffuse them. Prototyping has been used in endangered species recovery (Clark et al., 1995) and in community development (Dobyns et al., 1971), and similar efforts are common elsewhere (e.g., Miller, 1996; White et al., 1996; Pye-Smith et al., 1996).

The potential exists to set up trial interventions in policy systems in partnership with agencies, NGOs, businesses, and citizens. One place to begin might be the coordinating committees that have been established for many GYE species and resources, including grizzly bears and elk. The overarching one is the Greater Yellowstone Coordinating Committee (GYCC), which seeks to coordinate federal management and policy. These coordinating groups vary in structure, creativity, deliberativeness, and effectiveness in clarifying and securing common interests. To build on their accomplishments to date, new problem-solving approaches and organizational arrangements could be introduced to aid their management and coordination activities. These approaches could be designed to help them better understand and address challenges of context, institutions, and people. In addition, some committees might welcome constructive appraisal – a sort of ‘business plan’ – as well as direct support to improve their effectiveness (Clark and Cragun, 1994). Comparing and sharing experiences among committees can diffuse successful efforts and restrict or eliminate unsuccessful practices.

In addition to the coordinating committees, there are other interorganizational or ‘transboundary’ projects that are trying to achieve co-planning and are moving toward interdisciplinary problem solving involving different stakeholders, reliable science and data collection, and facilitated civic discourse (Glick and Clark, 1998; Knight and Clark, 1998). Four such programs are: (1) Beaverhead County partnership, an ecosystem planning effort in Montana between county government and the U.S. Forest Service; (2) Madison Range Landscape Assessment and Adaptive Management Project, a landscape assessment between Forest Service and local residents; (3) Henry’s Fork Watershed Council, an NGO and the Fremont-Madison Irrigation District (1,700 members) working together on water management issues; and (4) Greater Yellowstone

Coalition Stewardship Program, an NGO working with private landowners in a twenty-county area to address public and private land management issues. The 'Cooperative Resource Management' efforts in the Big Horn Basin of Wyoming and on the National Elk Refuge in Jackson Hole, Wyoming, are two other examples.

Prototyping to improve interdisciplinary and interagency coordination offers great promise in creating structural and substantive improvements in institutions. It can also improve patterns of interaction within institutions and contexts in the GYE. Prototyping exercises can support leadership and staff training as well as substantive problem-solving efforts. It can also provide case material for analysis and appraisal.

Creating, finding, and promoting the successes and lessons from the GYE is the 'innovation-diffusion process.' All five of these activities require education and outreach activities to complete the mission of integrating knowledge to improve natural resources policy and management in the GYE. Conferences, publications, electronic teleconferencing, and issue and leadership forums may be useful in this regard. The format of these forums may include organized, facilitated, and open designs depending on the target audience, technical or general nature of the issues, and the problems at hand and their contexts. Specific issues will be covered, in-depth case studies will be analyzed for lessons, and leadership forums will be featured. Experienced people can share their experience with others. Participants in all aspects of this undertaking are expected to disseminate their results to colleagues, co-workers, the public, and people on other sides of the issue.

Although they do not focus on the GYE, two books are currently in progress that will detail the interdisciplinary framework and illustrate its application. *The Policy Process: A Practical Guide for Natural Resources Professionals* (Clark, in press) is an introductory book, while *Fundamentals of Natural Resources Policy and Management* (Clark et al., in press) contains several in-depth case studies, as well as background and theory.

Conclusions

Creating an arena for effective interdisciplinary problem solving in the common interest should be a high priority in the GYE and elsewhere. U.S. Secretary of Interior Bruce Babbitt called for development of an 'interdisciplinary science' to meet today's natural resources challenges. Achieving this will require terminating certain aspects of conventional, discipline-based education, institutional boundaries, and standard operating procedures. Clearly, there are tremendous difficulties in making such changes, including contextual, institutional, and people challenges. But human dependence on the sustainable use of natural resources requires that we meet the challenges with new tools and concepts. The five activities outlined here can improve problem-solving skills, upgrade integration of knowledge, and guide development of natural resources policy in

the common interest. The GYE, long cherished by the nation and emulated by the world, is worthy of all our efforts to build common interest policies and practices. The benefits can be enormous – in perpetuating our natural heritage, in building democratic processes, in cooperating toward common goals, and in providing a model for improved problem solving everywhere. Commitment, leadership, and resources are required to develop interdisciplinary problem solving within institutional and policy processes in the GYE. The challenge is clear, the opportunities exist, and the means are known.

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Appendix

A word on my standpoint

I have been interested in these subjects and have worked in the GYE for thirty years. Although I began work in the GYE as a field ecologist and ethologist, I refocused my interest after about fifteen years on making organizational and policy improvements in endangered species and other natural resources systems, and today spend nearly all my time on interdisciplinary conservation efforts. I teach policy sciences as related to natural resources at Yale University and in workshops to government, nongovernmental groups, and citizens. I also research diverse substantive natural resources policy issues in the GYE, elsewhere in the U.S., and internationally.

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