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DOI: 10.1007/s00267-003-2900-2

Communication in Ecosystem Management: A Case Study of Cross-Disciplinary Integration in the Assessment Phase of the Interior Columbia Basin Ecosystem Management Project

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ABSTRACT / Effective communication is essential to the success of collaborative ecosystem management projects. In this paper, we investigated the dynamics of the Interior Columbia Basin Ecosystem Management Project's (ICBEMP) cross-disciplinary integration process in the assessment phase. Using a case study research design, we captured the rich trail of experience through conducting in-depth interviews and collecting information from internal and public documents, videos, and meetings related to the ICBEMP. Coding and analysis was facilitated by a qualitative analysis software, NVivo. Results include the range of internal perspectives on barriers and facilitators of cross-disciplinary integration in the Science Integration Team (SIT). These are arrayed in terms of discipline-based differences, organizational structures and activities, individual traits of scientists, and previous working relationships. The ICBEMP organization included a team of communication staffs (CT), and the data described the CT as a mixed group in terms of qualifications and educational backgrounds that played a major role in communication with actors external to the ICBEMP organization but a minor one in terms of internal communication. The data indicated that the CT-SIT communication was influenced by characteristics of actors and structures related to organizations and their cultures. We conclude that the ICBEMP members may not have had a sufficient level of shared understanding of central domains, such as the task at hand and ways and timing of information sharing. The paper concludes by suggesting that future ecosystem management assessment teams use qualified communications specialists to design and monitor the development of shared cognition among organization members in order to improve the effectiveness of communication and cross-disciplinary integration.

Ecosystem management is an approach to management of natural resources characterized by a science-based integration of ecological, social, and economic elements of the resource to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products, values, and services over the long term (Grumbine 1994; Interior Columbia Basin Ecosystem Management Project 1996). This management approach is currently implemented by several U.S. land management agencies (Cortner and others 1996), including the United States Department of Agriculture, Forest Service (FS), and United States Department of Interior, Bureau of Land Management (BLM) (www.fs.fed.us; www.blm.gov). Cortner and others (1996) list collaborative decision building as one of five recurring principles in definitions of ecosystem management, and concrete ecosystem management projects may be characterized by a collaborative approach to planning and management across traditional boundaries, such as those between disciplines, agencies, governments, and interests (Haynes and others 1996). This emphasis implies that communication among scientists from different disciplines, resource management agencies, private interests, and other stakeholders is an essential part of ecosystem management. Little empirical evidence exists on the communication processes used in ecosystem management (Conley and Moote 2003; Guthrie 1997; Lachapelle and others 2003; Shindler and Nuburka 1997; Whiteman 1993; Wondolleck and Yaffee 1994; Wondolleck and Yaffee 2000) and in interdisciplinary efforts in natural resource contexts in general. How-

KEY WORDS: Communication process; Cross-disciplinary integration; Ecosystem management assessment; Interdisciplinary; Interior Columbia Basin Ecosystem Management Project; Shared cognition

Published online May 4, 2004.

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ever, numerous scholars and practicing professionals have written about the importance of communication (Haynes and others 1996; McCoy and others 1994; USDA Forest Service 1993; Wallace and others 1994) and integration across disciplines in a natural resource context (McIntyre and others 2000; Wijkman 1999). In the context of team work, integration can be defined as the "capacity [of team members] to enter into the mind-set of others" (Kasl and others 1997, p. 242) in order to "[s]ynthesize their divergent views" (p. 230). In this definition, integration can be both an end product (a capacity) and a process (synthesis of perspectives).

Some scholars present frameworks (Clark 1999) or specific disciplinary approaches (e.g., ecological economics (Meppem and Gill 1998) or landscape ecology (Moss 2000)) to carrying out interdisciplinary efforts. However, the literature on the barriers and facilitators to interdisciplinary integration is largely anecdotal or nonempirical discussions (e.g., Clark and others 1999; Norgaard 1992). Ultimately, being able to understand the communication processes within interdisciplinary efforts and the associated barriers and facilitators to integration across disciplines is essential for increasing the likelihood of the success of collaborative ecosystem management efforts.

The objective of our research was to address the question: How was communication carried out in the scientific assessment phase of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) from the initiation in July 1993 through the release of the scientific assessment documentation in July 1997? In this study, the communication process included communicative interactions among individuals and groups, internal (multiagency team) and external (stakeholders outside the agencies) to the ICBEMP organization, as well as the influences that directly or indirectly affected communications. Influences are here defined as social, psychological, cultural, or institutional factors that affect communication processes. These factors were hypothesized to potentially act as barriers or facilitators of communication.

Background

The focus of our study, the ICBEMP assessment phase, took place in the rapidly changing Pacific Northwest of the United States. In this case, the FS and BLM used an ecosystem management approach in landscape level planning for about 31 million ha (75 million acres) of land administered in the Columbia, Klamath, and Great Basins, United States. The entire assessment area was 58 million ha (145 million acres), which included all public and private land in the basin (Haynes and others 1996).

The ICBEMP was initiated in July of 1993 as part of President Clinton's directive to implement ecosystem planning in the Pacific Northwest (Quigley and others 1996). The ICBEMP's ecosystem planning model is composed of monitoring, assessment, decision-making, and implementation components (Haynes and others 1996). The scientific assessment was initiated in July 1993 and completed in July 1997. The decision-making component was temporally overlapping with the assessment. During the decision-making component, the ICBEMP organization produced a Draft Environmental Impact Statement (released in June 1997), a Supplemental Draft EIS (released in March 2000), and a Final EIS and Proposed Decision (released in December 2000). Finally in January 2003, the involved agencies signed a memorandum of understanding to implement the Interior Columbia Basin Strategy (http://www.icbemp.gov/).

Throughout its duration, ICBEMP has been embedded in a contagious environment of interest-based gridlocks and high levels of political conflict. Indeed, the selected final draft of the management plan had advocates of different interests expressing their dissatisfaction (Associated Press 2000). ICBEMP followed the highly controversial Forest Ecosystem Management Team's (FEMAT) assessment of the Westside of the Cascades in Oregon, Washington, and Northern California, United States (FEMAT goes to court 1994; Steabler 1994). As a result, the ICBEMP set out to do its public involvement efforts in a more open fashion than had been the case in the FEMAT process. After the FEMAT, ICBEMP was initially called the Eastside Ecosystem Management Project with a focus on Washington and Oregon east of the Cascade Mountains. It was later expanded to include assessment of all lands within the interior Columbia River basin, including parts of Idaho, Montana, Nevada, Utah, and Wyoming.

In response to President Clinton's directive, the Chief of the FS and the Director of the BLM jointly directed through a Charter (Quigley and others 1996) that an ecosystem management framework and assessment of lands administered by the two agencies be developed. Federal employees from the FS, BLM, Environmental Protection Agency, US Geological Survey, and the Bureau of Mines were organized into functional and disciplinary teams. Contractors were also employed for the assessment. The project was headquartered in Walla Walla, Washington, and had detached units located throughout the basin. Functional teams were set up to carry out specific tasks outlined in the ICBEMP charter. These included Science Integra-

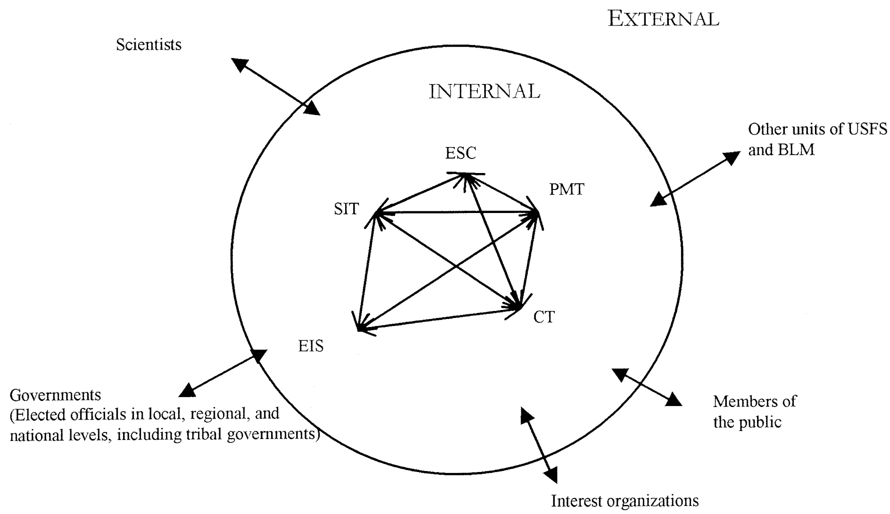

Figure 1. Important communicative interactions in the ICBEMP assessment phase. *Internal* includes groups or individuals internal to the ICBEMP assessment organization; *External* includes groups and individuals external to the ICBEMP assessment organization. Arrows indicate emerged communication pathways between actors that were important for carrying out the ICBEMP assessment. Abbreviations for internal groupings are *ESC* (Executive Steering Committee), *PMT* (Project Management Team), *SIT* (Science Integration Team, including 7 disciplinary subteams), *EIS* (Environmental Impact Statement team), and *CT* (Communications Team).

tion, Environmental Impact Statement, Tribal Liaison, Communications, Administration, and Spatial Analysis teams. The Science Integration Team (SIT) was further organized into disciplinary groups: landscape ecology, terrestrial resources, aquatic resources, economics, and social sciences. The overall assignment of the SIT included developing a scientific framework (Haynes and others 1996), conducting a scientific assessment, and evaluating management alternatives (Quigley and others 1996).

Of the components in ICBEMP's ecosystem planning model, only the decision-making has a legal requirement for public involvement. In spite of this, the ICBEMP included stakeholder participation throughout the entire process. Our research investigates only the communication processes associated with the scientific assessment phase, during which the SIT set out to conduct an integrated, interdisciplinary analysis of the included land area. The individuals concerned with and responsible for this communication had a high level of freedom to be creative and experiment with new ideas.

Descriptive Network Model

A descriptive network model (Miles and Huberman 1994) depicting the communication used in the ICBEMP assessment phase (Figure 1) was developed via in-depth interviews and available project documents. ICBEMP personnel organized communication in two components (Figure 1). First, internal communication was communication within the ICBEMP organization. This included communication within and among the Executive Steering Committee (ESC), the Project Management Team (PMT), the Science Integration Team (SIT), the Environmental Impact Statement team (EIS), and the Communications Team (CT) in Walla Walla. Second, external communication included communication with all outside parties, including other units of the USFS and BLM, governments (elected officials in local, regional, and national levels, including tribal governments), interest organizations (industrial, environmental, etc.), members of the public (the general public, individuals or groups, not representing a specific interest), and scientists (the SIT members' peers outside ICBEMP). Communication among actors outside the Internal circle in the model was reported as being significant, substantial, and highly influential with respect to communication and dynamics internal to ICBEMP. Although external communication is important to overall communication in ecosystem management, the focus of this paper is on the internal communication process.

The creation of the scientific assessment involved not only the scientists on the SIT but also other functional teams in the ICBEMP organization (Figure 1). This interdependence among functional teams required and resulted in communication between them. The internal ICBEMP communication formally had a

Table 1. Outcomes of internal communication, as perceived by members of the ICBEMP organization

Outcomes of internal communication
The integrated assessment document has useful information but not a high level of integration
Only 1 or 2 people out of the 300 involved scientists see the whole integrated picture
The gaps between disciplines still remain even though some level of understanding of other disciplines occurred, e.g., between economic and aquatic disciplines

hierarchical structure with traditional chains of command. Members at a lower level in the organization communicated to higher levels through the leader of the lower level unit. For example, CT and SIT members communicated to the PMT through the CT or SIT leaders. However, our data show that over time, a more informal communication structure developed where the traditional chains of command were crossed, for example, when members of the CT directly communicated with members of the ESC (Figure 1). This more horizontal and organic (Daft 2001) communication structure is unlike the tradition of the parent organizations, the USFS and the BLM.

In contrast to the FEMAT process, the ICBEMP clearly intended to be innovative in terms of communication efforts. For the internal communication, this was expressed in a goal of integration across multiple spatial scales and scientific disciplines in order to build an integrated scientific assessment (Haynes and others 1996). ICBEMP publications indicate that some level of integration did take place across disciplines as illustrated by the development and use of concepts like "composite ecological integrity" and "socioeconomic resiliency" (Haynes and Quigley 2001; Quigley and others 2001). Our analysis found three outcomes of internal communication related to integration (Table 1) emerged from the data. They all indicate that the SIT did not reach the level of cross-disciplinary integration that was hoped for. One member of the ESC used the following analogy to describe expectations and disappointments related to the science integration process and outcomes:

> I don't just want to see brush strokes, I want to see paintings. [· · ·] The functionally [disciplinary] separate assessment activities are brush strokes, and the only way you can really get the brush strokes to paint a beautiful painting is for you to understand the painting you want to paint when you start, and then do the brush strokes to bring out that painting rather than just kind of randomly give a whole bunch of brush strokes, and then to try to put them together and see what it looks like. So, to the extent that it was difficult to have complete communication up front about the vision of the painting, the result was that the brush strokes didn't necessarily paint as complete a picture or as vibrant a picture once all the pieces were integrated as it could have. (Agency Decision Maker 1997)

These descriptive findings, depicting the internal communication network, indicate that in spite of the ICBEMP emphasis on innovative communication approaches, the team members involved in our study perceived the internal ICBEMP communication to be only somewhat successful. Using this as our starting point, we explored an additional research question: What were the dynamics of the communications in the cross-disciplinary integration process during the ICBEMP assessment phase as seen by members of the SIT, CT, ESC, and/or EIS teams? Based on our model, we set out to describe the influences on the integration of information across disciplines; the character and role of the Communications Team in terms of internal and external communication; and finally the influences on communication between the SIT and the CT.

Guiding Methodological Decisions

Overall Research Framework: Paradigm and Methodology

We chose to use a contextual constructivist (Madill and others 2000), qualitative (Henwood and Pidgeon 1992), inductive approach to the research. This perspective requires the active inclusion in the research process of those involved in the experience under study. The generated data guided our categorization and analysis. Our approach reflects an ongoing interplay between data and conceptualization, and a constant interaction between ideas and research experience (Henwood and Pidgeon 1992). This research approach allowed us to identify a range of perspectives on the communication process, rather than searching for the most common or a consensus perspective. Existing organizational behavior theories were examined after the empirical work was completed to assess the extent to which they could explain some or all of the findings and thus potentially be applied to communication processes in landscape level assessments in the United States.

An exploratory single-case (holistic) research design (Yin 1994) was chosen as the most appropriate design, because we were unable to identify previous in-depth empirical studies of the communication process in ecosystem management projects. Additionally, it allowed us to investigate contemporary communication events and dynamics that were not influenced by us. Because the communication process included interactions among individuals, organizations, and the political system, it

Table 2. Sources of information used in the qualitative case study

Source types	No. of sources
Interviews	
Preliminary Interviews[a]	3
Agency Decision Makers[b]	2
Project Decision Makers[c]	4
Science Integration Team Members[d]	4
EIS Team Member[e]	1
Communications Team Members[f]	3
Interviews Total	17
Documents from ICBEMP	
Science Documents From the ICBEMP	3
Science Team Leader's Archive Notebook	1
Communication Team Archive Notebooks	10
News Clips 10/93–6/97	All available
Videos from the ICBEMP[g]	3
Observations of ICBEMP events	
Public seminar in Spokane, March 3–5, 1997	1
Internal meeting in Post Falls, June 18–20, 1997	1
Visits to the Walla Walla ICBEMP headquarters	Multiple

[a]ICBEMP key informants.
[b]Members of the Executive Steering Committee or Agency leaders in the Interior Columbia River Basin.
[c]Project Management Team Members and Science Integration Team Leaders.
[d]Scientists working in one of the six staff areas on the scientific assessment.
[e]Anybody working on the Environmental Impact Statement Team during the scientific assessment.
[f]Anybody working on the Communications Team during the scientific assessment.
[g]Videos: Interior Columbia Basin Ecosystem Management Project 1995. Upper Columbia River Basin Scoping Meeting. Satellite Recording—28 January 1995. Interior Columbia Ecosystem Management Project, Walla Walla, Washington. USDA Forest Service and USDI Bureau of Land Management.
Interior Columbia Basin Ecosystem Management Project 1994. Employee Briefing. Eastside Ecosystem Management Strategy Project, Walla. Walla, Washington. Feb. 28. USDA Forest Service and USDA Bureau of Land Management.
Interior Columbia Basin Ecosystem Management Project 1995. Panel Discussion on Economic Life of Rural Communities, Walla Walla, Washington. Feb. 16th. USDA Forest Service and USDA Bureau of Land Management.

was difficult to draw a boundary between the process under study and its context. Finally, we had the opportunity to corroborate findings by collecting information from multiple sources and using multiple data collection methods. These characteristics are all typical traits of case studies (Yin 1994). Our selected case was the ICBEMP assessment phase, and the embedded unit (Yin 1994) was the communication process used.

Sampling, Data Collection, and Database Development and Analysis

Table 2 displays the variety of sources of information used in the study. The combination of our selection of sources and sampling strategies ensured that a wide range of perspectives on the communication process was included.

Data sources (interviewees, documents, videos, and events) were selected using nonprobability sampling approaches (Table 3), such as maximum variation sampling (Patton 1990), snowball sampling (Kuzel 1992), and criterion sampling (Patton 1990).

In sampling texts (documents, interview transcripts, etc.), we used theoretical sampling, a "sampling on the basis of concepts that have proven theoretical relevance to the evolving theory" (Strauss and Corbin 1990, p. 176). When no new relevant information about the communication process arose from the data, we assumed saturation.

During the interviews, we generated information by using a common set of guiding questions designed for the study. Questions used included the role of the interviewee in ICBEMP, their descriptions of actual communications processes, their perception of the significance of communication processes, influences and events, who else should be contacted, and whether they had anything else they wanted to tell us about communication. As the process of interviewing and analyzing data proceeded, additional questions were added to the interview guide to obtain specific insights from those whose roles gave them access to particular viewpoints and information. In some cases, these questions were asked of interviewees previously interviewed. The new questions most often were related to concepts that were identified during interviews or in our analysis process through coding. Other times, concepts emerged as we

Table 3. Selection of data generation sources and methods

Selection of sources	Nonprobability sampling method	Data generation or collection method	Data analysis method
Anyone internal to the assessment organization	Maximum variation, snowball	Qualitative interviews	Descriptive and pattern coding
All communication documents related to the assessment produced by ICBEMP in the case period. Documents internal and external to the ICBEMP	Maximum variation	Archival retrieval of documents	Descriptive and pattern coding
All videos produced by ICBEMP in the case period	Criterion	Archival retrieval of videos	Descriptive and pattern coding
All events where ICBEMP personnel communicated, internally or with external actors	Criterion/convenience	Observations	Descriptive and pattern coding

engaged in peer debriefing (Erlandson and others 1993). The questions and topics for discussion served only as guidelines; we deviated from them during the interview if we felt that, by doing so, additional relevant information about the communication process might be obtained. Overall, the initial interview guidelines proved useful and increased our efficiency in obtaining relevant information as predicted by Kvale (1996).

Most interviews were conducted face-to-face in an informal neutral setting or in an interviewee's office. All interviews except for one were tape-recorded. In several cases, it was necessary to interview over the telephone, but these were also tape-recorded. From our experience, we believe, as others have argued, that nonverbal reactions can be used as an additional way of detecting understanding of the questions (Kvale 1996). This was a clear advantage of face-to-face interviews compared to telephone interviews.

After each interview, we made an entry in the case study journal (reflective journaling), and an interview transcript was created. The transcripts ultimately became part of the NVivo (Fraser 1999) database (see below). The journal entry contained information about what role the interviewee played in the assessment and the interviewer's reflections on the interview situation, including aspects of nonverbal communication the interviewer judged important. To enhance the consistency of the tape-recorded transcriptions, transcriptionists were given guidelines to follow (Siddoway 1995).

The following search protocol was used to select information from documents (in order): (1) the table of contents (if present), (2) the subject index (if present), and (3) the whole document or the parts selected from table of contents or subject index. Text units were selected if they pertained to communication internal or external to the ICBEMP. Key documents, for example, the Communication Plan, were scanned and became a part of the NVivo database (see below). Proxy (summarized) documents were created for ICBEMP videos and documents that were not scanned.

Observation data were captured by recording an entry into the case study journal. The researchers took notes about (1) what they had experienced (2) what the event taught us about communication processes in the ICBEMP assessment phase. This journal was not included in the NVivo database, but rather it was seen as a separate source for keeping track of information relevant to the project. It also allowed us to remember the logic we used for making decisions throughout the research process.

Nvivo 1.1 (Fraser 1999) was used to store, code, index, structure, and record the data and information about the data throughout the interactive data collection and analysis processes. This permanent electronic database includes all materials we used directly in the analysis.

We carried out two levels of analysis descriptive coding and pattern (inferential) coding (Miles and Huberman 1994). Codes are "tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study" (Miles and Huberman 1994, p. 56). The content of the tables in the results section are examples of clusters of descriptive and inferential codes with a shortened version of their definitions. Each cluster of codes facilitates understanding of a theme, for example, facilitators and barriers to integration across disciplines. We let the codes emerge from the data as opposed to starting with a list of provisional codes. The text units obtained from original transcripts, documents, and so on varied in size from a few words to whole paragraphs, and more than one code often fit the same unit. Throughout the cod-

Table 4. Techniques for establishing trustworthiness, we used the criteria of credibility, transferability, dependability, and confirmability (Erlandson and others 1993)

Criterion	Activity (technique)
Credibility	8 months interaction with project personnel (prolonged interaction)
	Participation in two project events and on-site visit to headquarters (persistent observation)
	Triangulation of sources and methods (triangulation)
	Interview guide (flexibility to see informant's constructed reality)
	Study journal and memos in NVivo (reflective journals)
	Regular interactions with peers (peer debriefing and checking)
	Having informants review intermediate products (reality checking)
Transferability	Explain case context in terms of geographical area, organizational context, the task, and the characteristics of the project (thick description of case and context)
	Availability of database (access to details)
	Used snowball, maximum variation, theoretical sampling to maximize the range of information (purposive sampling)
	Journal entries about project characteristics and methods (reflective journal)
Dependability	Interview guide (consistency guide)
	Traceability via NVivo (dependability audit)
	Case Study Journal entries about changes in direction and logic (reflective journal)
	Descriptions and record of procedures in research reports (dependability audit)
Confirmability	Accessibility of database (external reviewer check)
	Traceability of sources of specific emerging concepts via NVivo (constructions can be traced to their sources)
	Case Study Journal entries & NVivo memos (reflective journal)

ing process, all codes were clearly defined to assist us in being consistent in our use of the codes and to increase the replicability of the coding. At the start, and after we were about two thirds through the coding process, independent peer debriefing of coding was carried out. We used this process to adjust our coding technique as suggested by Miles and Huberman (1994) and to receive suggestions for further analysis and alternative interpretation of the findings. The codes became more precisely defined and often more focused as the analysis proceeded and as more data were coded and recoded as predicted by Miles and Huberman (1994).

The descriptive coding consisted of searching the text units for relevant categories that were associated with communication. After an initial set of codes was created, we carried out pattern coding, a more inferential approach to analysis than the descriptive codes. The results of the analysis process and the draft manuscripts for this paper were reviewed by a variety of selected interviewees (member check) to make sure that we had understood the information in the database accurately. It also provided the opportunity to make the coding and ultimately the results truly cooperative efforts between those who experienced the situation under study and the researchers.

Addressing Trustworthiness

A range of credibility, transferability, dependability, and confirmability techniques (Table 4) were used throughout our research process to increase the trustworthiness of the study. Trustworthiness is the constructivist criterion for goodness or quality of a study (Lincoln and Guba 2000). The diversity of techniques used within each of the four criterion areas ensured that our study has a high level of trustworthiness (Erlandson and others 1993).

The transferability (Erlandson and others 1993) of our descriptive findings are limited to the context of ICBEMP, but the applicability of the conceptual findings to other contexts can be refined through the process of replicating this research and building upon it in other scientific ecosystem assessment projects.

Results

This section describes influences on integration across disciplines; describes the character and role of the CT; and finally describes influences on communication between the SIT and the CT. For each result, we present examples of codes and for these codes, one or more quotes are provided to illustrate the link from the raw data to the findings.

Influences on Integration Across Disciplines

The lists of facilitators and barriers that were perceived to influence integration across disciplines in the SIT are displayed in Table 5. Two major categories emerged as facilitators and barriers: individual traits of

Table 5. Facilitators of and barriers to integration across disciplines, as perceived by members of the ICBEMP organization

Facilitators		
Barriers		
Individual traits of scientists	Individual traits of scientists	Organizational structures and activities
Cross-disciplinary literacy among scientists	Cross-disciplinary illiteracy among scientists	Tight deadlines and time constraints
High level of interdisciplinarity in scientists' training	Disciplinary training	Inefficient timing of information exchange
Integrators facilitating the cross-disciplinary communication	Personal characteristics (e.g., resistance to change, defensiveness of disciplinary turf)	Informal power structures as an obstacle to information exchange and integration
	Different ideas of what integrative processes and products are or should be	Disciplinary division of SIT
Organizational structures and activities	Lack of perceived responsibility for integration of own work with other desciplines	Closedness of SIT communication process—some say it was closed, others did not agree
Quantitative measurements as a common "language"—some say it could facilitate integration, some say it could not		Lack of effective activities or structures to make integration happen
Use of co-leads for disciplinary teams stationed in Walla Walla	**Previous working relationships**	
Interactive activities (e.g., field trip)	Prior relationships among scientists because they either did not know each other and how to work together or they might have to deal with "baggage" in their relationship	**Discipline-based differences**
		Differences in underlying values between disciplines
		Different methodology used in different disciplines

SIT = Science Integration Team.

scientists and organizational structures and activities. Two additional categories of barriers emerged. Discipline-based differences and the lack of or poor previous working relationships. Selected examples of codes (Table 5) and the underlying data (presented as quotes) are now provided.

One of the influences that emerged as a facilitator in the Individual traits of scientists category was Cross-disciplinary literacy among scientists. Literacy refers to understanding of other disciplines' methods, traditions, terminology, and underlying assumptions. This understanding was identified as occurring on a scientist-to-scientist basis by multiple interviewees. In particular, it was mentioned that the aquatics and terrestrial teams talked the same language. Cross-disciplinary literacy was seen as related to Interdisciplinary training, where scientists have a formal educational background in multiple disciplines, including social and biophysical sciences.

It was stunning to me because I have training in ecology and natural and social sciences and so, when the landscape ecologists talked about the stem exclusion stage, I knew what they were talking about and I just assumed that all the other biological scientist knew what they were talking about too, and it turned out that they didn't. So how could all the information that the landscape team was developing be of use to the wild life biologists or to the aquatic ecologists if they didn't understand what it was? (SIT Member 1997)

Cross-disciplinary illiteracy was seen as a barrier to integration in the Individual traits of scientists category. Scientists in different disciplines were seen as holding different worldviews. As one member of the ESC described the scientists:

Different disciplines are like continents of the mind that are separated by very rough seas and have only a very few safe harbors in which boats can take temporary refuge. (Agency Decision Maker 1997)

The difficulties in understanding other disciplines often were not based on differences in terms but in the meaning of those terms held by different disciplines. Persistent attempts to clarify meanings were seen by some as a successful way of crossing this disciplinary boundary.

The example of scale, the term itself is readily obvious to anybody, but try and interpret that in terms of "We're only going to deal with the broad scale issues." I remember at one meeting when an SIT Member was describing this and he described broad scale as being a particular thing, I said, "OK, if that's broad scale, then what would this be?" I then described another thing to him and he said, "Well, that's really broad scale." I said, "Well, OK, I think I'm understanding better now." The times when we had problems were when the approach was taken that "I'm not going to help him understand." The times when it worked effectively was when they said, "I guess I have to find some other words to describe this then. Let me try again." (Project Decision Maker 1997)

Another example of a barrier to integration across disciplines was the Informal power structures in the Organizational structures and activities category. The term "power" was controversial, but during the member check it remained a strongly supported code and was triangulated by multiple sources.

Some disciplinary groups within the SIT were perceived to have more power than others. This was perceived as an obstacle to integration because it negatively influenced the flow of communication and the distribution of information among the disciplinary teams. Furthermore, teams with more power controlled the selection of the shared units of analysis, and the SIT exercises aimed at integration.

When we had science team meetings, people routinely just ignored what I said. It was really frustrating to me, and I would have to play lots of communication games like ask questions, and there was one person who would never ever hear anything that I said. (SIT member 1997)

[It was] a model that was developed by the landscape team. ...It was mostly developed in Missoula [and] only people who knew information that was relevant to the landscape team were invited to participate ...but

that modeling happened, in my perspective, in a black box. ...And I kept asking, what are your parameters? ... what's your documentation, what does your model look like? Because I needed to know that in order to integrate with what they were doing. There were also things that they did modeling that were issues important to me ...and yet, I was never invited to participate in developing that information. ...So that was a real barrier to integration. (SIT member 1997)

In other words, the distribution and use of power was seen as an obstacle to development of shared understanding among scientists. The power hierarchy as identified by participants ranged from the most powerful group, the landscape team, to Geographic Information System (GIS), Terrestrial team, Aquatics team, Economics team down to the least powerful group, the Social Science team. Different interviewees described the power hierarchy slightly differently and it changed over time. The differences and changes were mainly at the higher levels; the Social Science team remained at the bottom throughout the assessment development.

For much of the project, the landscape team had the most political power, followed by the aquatics team, but as we got closer to developing alternatives, then the legal aspect of the salmon stocks being listed as endangered species became more and more important, so the aquatics team gained more and more power over time. Particularly since the landscape team was so late in actually providing any information so the aquatics team started getting relevant policy relevant information on the table ...they developed a stronger position. ...In the Fall of 1995 was when they started gaining power: (SIT member 1997)

Interviewees described different types of power and sources of power. The Landscape team was perceived as having "quiet power" related to their umbrella function, "the glue" for the whole SIT.

Most of the work of the other teams was based on the work, methodologies, and findings of the landscape ecology team. They set the stage for vegetative and biophysical conditions, trends, and projections over time. This was a key factor for integration. (Project Decision Maker 2000)

The GIS team's power was seen as related to the importance of its unique technical skills for the rest of the SIT. The Terrestrial team and Aquatics team, using the more established sciences, were seen by some as having "testosterone power" and as acting like a brotherhood to which other, lower ranking, scientists had no access. This perspective indicates that the power hierarchy was related to tradition within the scientific community, and some interviewees felt it was reinforced by the culture of the USFS.

I feel that there was almost a fraternity among the scientists who were traditional [biophysical] and that the social scientists weren't considered real scientists and there was a little bit of snobbishness at the table. (CT member 1997)
Social sciences were really second class sciences within the project and the tradition in the Forest Service is that those are used to display impact. So the people who are experts in the biological management would come up with the decisions or the alternatives of what was going to be done, and then the economists and social scientists would describe the impact. (SIT member 1997)

Another suggested source of power was that the Terrestrial and Aquatics teams were working with species listed under the Endangered Species Act and conditions under the Clean Water Act. There were no such legal mandates or responsibilities for the Social or Economic Teams. This suggests that the political context external to the ICBEMP influenced the internal power relations among SIT teams. A third source of power put forth by interviewees was the power of the data from the different SIT teams.

The first to come together with strong data and tools were the biophysical subteams. The power that was represented in the maps, datasets, and projections (in a modeling sense) were obvious to other

> teams, to the agencies that were attempting to make decisions, and to the public we communicated with regularly. In that sense the social and economic subteams found themselves in a constant game of catch-up, because the information, data, and tools they brought to the process were not as powerful in their communicative ability (verbal or written). ...In my mind's eye, as one of the dominant players in the whole process, the power of information meant much more to me about making decisions relative to the process than fraternities, brotherhoods, Forest Service culture, or level of experience. (Project Decision Maker 2000)

Our analysis shows that distribution and use of power were barriers to integration when they interfered with communication of information that was important to other SIT members and thus negatively influenced the development of shared understanding of colleagues from different disciplines and the task at hand. This finding has been corroborated in other organizational team contexts, where production of new knowledge was inhibited by existence or lack of control of unequal power levels between team members (Brooks 1994).

The three examples presented demonstrate how barriers and facilitators were described to influence cross-disciplinary integration in the ICBEMP assessment. For an item to be included in Table 5, similar traceable textual evidence was required.

Character and Role of the Communications Team

The ICBEMP organization included a team of communication staffs. This section includes answers to the questions: Who were they and what role did they play in the design and implementation of communication processes?

Characteristics of the CT. The CT was a very mixed group of people, few of whom had academic credentials or formal training in communications. Some CT members were described as highly intelligent, highly energetic, highly capable people. Others were perceived to be nonperformers, individuals who did not fit into their previous agency context, and spouses of members on other teams who needed a job in Walla Walla. Furthermore, the size of the CT fluctuated continually, changing from two to eight to three over the course of the assessment. One CT member described the reason behind the mixed skills of CT members as follows.

> There is a mixture of us within the agency [USFS]. The Forest Service region was downsizing its workforce at the time. This influenced availability of communication professionals. Why? Those with good communication jobs were not about to leave them or face losing their jobs when they came back. Those who were available for these assignments were non-communication background types. Their goal was to gain work experience to be placed somewhere else. (CT member 2000)

Some interviewees felt that this may be related to an underlying assumption in the culture and tradition of USFS that "anyone can communicate." Another perspective put forth was that the hiring pool for communication jobs in the USFS does not include communication specialists because the agency does not have a history of hiring them. This mix of personnel on the CT, combined with the lack of sufficient experience of the CT leaders, made it difficult for the team to work efficiently. Some interviewees felt that the CT leaders spent a lot of time managing people, who had little skills and/or experience in communication and at the same time had a hard time working together.

> CT leadership had experience in supervision ranging from 65 people to 2 in past experience. Nothing compares to the project experience in which the leadership occurred [ICBEMP]. Leaders lacked experience in supervising a whole team in this type of setting. Maybe 4 to 5 people in FS agency have this experience. (CT member 2000)
>
> The mix of personnel on the CT made it extremely difficult for the supervisory or team leader to develop a coherent and strategic approach, and at the same time address the issues that pressed for immediate attention within the project and within the team. The result was that the CT lacked a clear vision, with strategic direction focused on the overall project needs. (Project Decision Maker 2000)

Just like quality of the science, communication internal to the ICBEMP was a high priority. However, our data indicated that staffing of the CT with handpicked communication specialists who had sufficient experience and credentials to play a significant role at a strategic and operational level of internal and external communication in the project did not occur.

The role of the CT in internal and external communication. The CT's role changed over time from a broad, open, innovative approach, including both internal and external communication, to a narrower, more traditional one focused mainly on external communication, as described by a SIT member:

> Well it [the role of the CT] changed, ...over time. When we started the project out and there was all this optimism about this being a new way of doing business, people on the CT were struggling with how to do things differently in a better way and having a broader definition of what their role would be. People on the project, on the science team and EIS team ...also struggled with what their [CT's] role should be. But over time, I think their role became sort of narrowed down more and more to the traditional, more narrow Forest Service role of simply getting out announcements and mailing, doing mailings and press releases and that sort of thing, rather than a more substantive role in the overall processing. (SIT member 1997)

Table 6. Influences on communication between CT and SIT, as perceived by members of the ICBEMP organization

Actor influences	Structural influences
Personalities, individual skills, or traits	Culture of scientific community
Resistance to change among SIT and CT members	USFS organizational culture
Illiteracy in each other's field	Pecking order and power relations internal to SIT and between SIT and CT
Perceived importance of communication among SIT members	Titles in ICBEMP organization or educational credentials
Confusion about each others' roles	Tight and changing time lines
Qualifications of CT in terms of communication as perceived by SIT	Pivotal events for communication between SIT and CT
	CT's role as buffer from media
	Learning by trial, perception that there were no similar previous projects to learn from

CT = Communications Team; SIT = Science Integration Team; USFS = U.S. Forest Service.

From the NVivo database, a set of CT functions emerged. Throughout the project, the team's primary responsibilities were to be a bridge to the public and a link to agency communications staff, higher-level agency staff, and line, media, and congressional staff. CT members worked as trainers for scientists in their interaction with the public and the media (e.g., training in public speaking) and were responsible for designing, planning, and facilitating public involvement. These functions are all related to external communications.

We had to wrestle that [the role of the CT] out. Initially, we thought that we'd use some of the communications team people as facilitators for some of our internal meetings. We would use them in an internal sense to facilitate communication within our teams. That worked sometimes and didn't work other times, and we ended up sort of adapting that process as well. So there was an internal communication process [and] there was an external communication process. I think in the end that the communications team took a greater responsibility for the external and each of our internal teams took the responsibility for communications internal to our own teams, and we pulled in communications team members to help us get that job done, but we didn't really sit down with them and strategically design that internal communication with them. (Project Decision Maker 1997)

It mostly fell on them [CT] to treat in a higher priority sense the external than the internal [communication] because, in many respects, the internal would sort of take care of itself if it was ignored by the communications team, but the external wouldn't. (Project Decision Maker 1997).

Internally, the CT's role developed into a less proactive approach than with the external communication. CT members were seen sometimes as managers of project crises, and at other times as the source of the crises.

Although a few CT members were able to build enough trust with the SIT to actually be proactive in the interaction with the scientists, generally, CT members were not perceived as strategic thinkers. They were perceived as doers providing their expertise as a toolbox for other teams in a need-based approach. CT members were involved in strategizing about specific external public involvement efforts but not in terms of developing internal communication activities to promote shared understanding and integration across disciplines.

Internal [SIT] communications were the primary responsibility of the five team leaders plus the overall Science Team leader and deputy. The CT was asked to provide periodic meeting management and facilitation services for the many meetings that happened. As I recall, they were not often asked to deal with such things as inter-team dynamics, although they supported the teams in their publications and public meetings. (Project Decision Maker 2001)

Influences on Communication Between SIT and CT

Table 6 displays structural and actor influences that affected the communication between SIT and CT. These influences were perceived as either facilitating or inhibiting the flow of communication between the two teams. Actor influences include characteristics of individuals on SIT and CT. Examples are individuals' personality, skills, and traits as well as their perception of others and their roles relative to the actor's self and role in this specific context. Structural influences include characteristics of organizations and their cultures, including power relations, timelines, roles, and specific events. Culture is here defined as "a set of values, beliefs and feelings, together with the artefacts of their expression and transmission (such as myths, symbols, metaphors, rituals), that are created, inherited, shared and transmitted within one group of people and that, in part, distinguish that group from others" (Cook and Yanow 1993, p. 379). We will elaborate on CT's qualifications in terms of communications and The culture of the scientific community influences to describe their effect in more detail.

As described in the section Characteristics of the CT, some members of the SIT thought the CT members were not well qualified, and that influenced the communication between the two teams. This negative perception of the CT was seen by some interviewees as related to the USFS culture and tradition.

> The tradition of the Forest Service of non-performers being put in public relations positions predisposed scientists to look down on people in communications. (SIT member 1997)

The culture of the scientific community, including the importance of peer acceptance or respect as success criteria, was also perceived as an influence on the SIT–CT communication. One view held was that CT members were not seen as peers but as a service unit within the ICBEMP. Scientists are traditionally mainly accountable to their peers, not to the public. Another perspective emerged that suggested that the importance of peer recognition influenced SIT members' interaction with the public and thus indirectly the interaction with the CT, who facilitated this interaction. Again, the communicative action was influenced by perceived power differences. Our analysis showed that some scientists were eager to support CT efforts by giving "mini" science lessons to CT members. However, it was clear there also was the perspective that CT members should not cross the invisible line between co-worker and peer scientists.

> But as a social scientist and as a science team member, he was a peer. It was different from me speaking to the science team. I'm not a scientist; I don't have a master's degree. I'm not seen as a colleague, I'm seen as a co-worker. (CT member, 1997)

When asked why the responsibility for the internal communication went to the SIT as opposed the CT, one project decision maker answered

> I would suggest that some of it was personality driven, where not everyone on the science team was easy to work with and ...some of the science team members ...didn't want to take direction from somebody outside of the science world, so they were sort of suggesting that they could handle that aspect themselves. They didn't need help with that. (Project Decision Maker 1997)

These examples demonstrate the importance of individuals' personality to communication between CT and SIT. The CT's ability to be respected and contribute significantly to the internal communication process also was inhibited by characteristics of the team (e.g., qualifications and team size) and other structural factors listed in Table 6.

Development of Shared Cognition and Conclusions

In ICBEMP, a purpose of developing an integrated scientific assessment was to address issues that transcend traditional disciplinary boundaries by moving beyond the simple accumulation of knowledge of individual scientists and disciplines and create new, integrated knowledge about the assessed ecosystem. Integration across disciplines occurred as both part of a task (creating an integrated assessment) and a team process (sharing and integrating information across disciplines). To interpret our results, a theoretical framework that could capture the idea of shared understanding or vision and relate it to integration as an end product and a process was needed. The concept of shared cognition was selected. This concept can be traced back to the 1920s and 1930s when it was referred to as the "group mind," including the idea that "groups of people can retain information through sharing in a way that transcends the cognitive facilities of individuals" (Klimoski and Mohammed 1994, p. 406). According to the theory, a certain level of shared cognition is theorized to result in better task performance (e.g., efficiency in developing the assessment, level of integration in assessment document, timeliness of final document, etc.), better team processes (e.g., more efficient internal communication, similar interpretations across disciplines, and better coordination across teams), and motivational outcomes (e.g., cohesion within SIT and the ICBEMP organization as a whole, trust between scientists from different disciplines, collective efficacy, and satisfaction with SIT) (Cannon-Bowers and Salas 2001a). Most recently, shared cognition has been put forth in a variety of fields, including organization studies (Cannon-Bowers and Salas 2001b), psychology (Banks and Millward 2000), and education (Pontecorvo 1993). We found Cannon-Bowers and Salas' conceptualization of shared cognition useful. They describe it as "the notion that effective team members hold knowledge that is either compatible, complementary, and/or overlapping with teammates" (Cannon-Bowers and Salas 2001b, p. 87).

In applying the theory to our results, it appears that a lack of sufficiently shared cognition about the desired outputs of the assessment existed among SIT members, resulting in dissatisfaction with the quality of the task performance (the level of integration in the scientific assessment document). Furthermore, a lack of sufficiently shared cognition regarding the team process resulted in an inefficient timing of information exchange, a negative influence of the discipline-based power hierarchy, and lack of similarity of interpretations of information among the scientists.

This fits with Cannon-Bowers and Salas' (2001a) idea that shared cognition may be developed according to different domains. In other words, cognition may be shared regarding the task at hand (goals of performance in creating an integrated assessment and the difficulties facing the group in reaching those goals), representations of other group members (their knowledge, beliefs, skills, preferences, and habits), perceptions of what is an effective or appropriate way of interacting, and finally regarding equipment or tools a group uses (e.g., GIS) (Mohammed and others 2000). In the ICBEMP, the scientists did not have a shared understanding of the task at hand (what is integration in the ICBEMP context and who is responsible for making it happen?) or of other SIT members (what are the values, methodological traditions, terminology, or underlying assumptions of other individuals and disciplines involved?). Furthermore, ICBEMP members did not agree on ways of interacting and communicating as a team (when, how, and with whom should what information be shared?) or on tools, such as units of analysis, to use.

The degree to which knowledge in different domains (task, work process, tools) may be shared among group members ranges from fully shared or overlapping to similar/identical, complementary/compatible, and distributed (Cannon-Bowers and Salas 2001a). In a multidisciplinary team, such as the SIT, it is not likely—or even desired—that all team members have fully overlapping knowledge in terms their scientific knowledge. An aim for complementary or distributed scientific knowledge is an advantage to maximize the range of information to be considered in the assessment. A higher degree of overlap in cognition is required in terms of the task, the work and communication process, the other team members, and the use of technology. In ICBEMP, knowledge or understanding in these domains seemed to fall closer to a complementary than an overlapping level of sharedness.

Our results suggest that one goal for internal communication in future assessments should be the explicit development of shared cognition or understanding among team members as a way to foster integration. This development needs to occur in multiple domains and across personal as well as disciplinary boundaries. Klimoski and Mohammed (1994) described factors that may influence the development of shared cognition. These factors include formal training on essential concepts (e.g., integration), group members, level of experience with teamwork, the recruitment process (voluntary or assigned membership), life cycle of the group (changes in team membership), communication patterns (e.g., timing and forms of communication), group cohesiveness, level of social interaction, team history, and team longevity. Our results indicate that the SIT actually did work together for an extended period of time, and several group members had experience in working across disciplinary boundaries, although not in accomplishing an integrated output.

Based on our results as viewed in terms of the conceptual framework of shared cognition, recommendations for improvements in similar contexts as the one we studied would first focus on teams formally defining the domains (e.g., the task at hand, other team members, and the team process) in which they need to share cognition in order to accomplish their task. Second, we recommend formal training specifically in cross-disciplinary literacy (vocabulary, theoretical assumptions, etc. of the different disciplines) and techniques (conceptual modeling, GIS, etc.) in the beginning of the project. This training should foster experiential-based opportunities that require teams of scientists to interact and solve problems, draft conceptual models, write, and develop integrated presentations.

Third, future integrated assessment processes could aim at promoting cross-disciplinary thinking by selecting scientists who already have formal cross-disciplinary training as opposed to narrow disciplinary training. These scientists would function as integrators of participants, and as role models for other scientists in terms of integration. Fourth, interactive activities should be designed and encouraged to foster integration rather than exclusion and upholding of preexisting power relationships (Table 5). In the ICBEMP, field trips open to and with participation from all disciplines were seen as a facilitator of shared understanding and integration. In contrast, closed-door activities, where only some disciplines were included, were seen as not only inhibiting integration, but actually preventing it from happening.

Finally, initial and continuous training promoting desired interdisciplinary attributes should be designed and monitored by qualified communication specialists rather than by scientists educated in narrow disciplines (biophysical or social), who would be likely to perpetuate the fragmented perception of knowledge building that currently dominates the scientific community. The ICBEMP data (Table 6) suggest that the success of similar cross-disciplinary efforts is likely to be related to how well structural and actor influences are addressed. Our results suggest that the selected specialists, in addition to being experienced in designing cross-disciplinary communication, should have both formal training in communication and academic credentials that match the involved scientists.

For future integrated assessment projects to be successful, we further recommend that the structural influences related to cultures and power relations need to be actively addressed in the transition to working in teams and integrating across boundaries. Brooks (1994, p. 231) described the process of shifting to working in teams in U.S. organizations as "not just a structural change in how work is done, but a significant historical and cultural shift that affects the way many individuals identify themselves and attempt to establish their social worth." We argue that adding the element of integration across disciplines to the team process makes the shift even more radical for those involved. This means that the move toward integration of disciplines can be a painful and slow process for the involved individuals and organizations. Future assessment projects need to acknowledge the magnitude of the task and allow time and space for the transformation to take place.

This field of research is still in its infancy, and even if we use our findings to adjust communication strategies, organizational structures, and collaborative thinking in future assessment projects, experimentation and evaluation will be essential to determine the extent to which they strengthen integration. A focus on development of shared cognition among team/organization members may be a way to improve the effectiveness of internal communication of bioregional assessment teams.

Acknowledgments

The completion of this study was dependent on the repeated, generous sharing of time and insights by ICBEMP personnel.

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