*The "Socialization" and Enculturation of Ecologists in Formal and Informal Settings

by

G. Michael Bowen
Lakehead University

and

Wolff-Michael Roth
University of Victoria

A bear could look back and see you. Padding across the log in a stream the bear might suddenly hear the whirr of the video camera, or smell your scent, stop walking, look up from its feet, and stare at you. And you know, as they probably know, that they can run through the tangled brush far, far faster than you can. You just hope that it doesn't occur to them to do so. (Fieldnote after Ted's presentation of his field research 02/99)

Research conducted in remote settings away from the formalized experimental settings found in universities is often a mix of science research and survival and is comprised of complexities that extend far beyond the actual conduct of the scientific research. For instance, an ecologist conducting field research needs to realize that encounters with bears may occur, during which they are within only a few meters. Yet, presentations of the research in the formal texts of lectures, textbooks, and journal articles used to enculturate newcomers to ecology rarely detail the experiences of the field researchers in an explicit fashion that can prepare newcomers; nor do they detail the methods used to collect the data in the study to a degree that they could be applied in any simple manner (Roth & Bowen, 2001b). This raises the question, "Where do beginning field ecologists (undergraduates or new graduate students) learn about the conduct of field research and how researchers feel during that work?"

Actual or vicarious field experience also affects ones perception of field settings. For instance, how a videotape of a bear walking in a forest is perceived depends on whether the viewer has ever seen a bear move through underbrush before. The videotape segment underlying the field note above showed a bear moving slowly, seemingly with studied deliberation, as it walked along the fallen, moss-covered trees in a British Columbian rainforest. Yet, how one "sees" that video depends on the understanding one has both of bears and of the setting in which the bear was seen; professional vision is not given but develops in communities of practice (Goodwin, 1994). Before seeing a black bear for the first time (while we were conducting ethnographic research with ecologists) we assumed a human could outrun a small black bear. However, after working as field assistants with ecologists in mountain underbrush, and after having observed bears moving through that underbrush, the videotape had different meaning--we now know that if the bear in that video had begun an attack against the researcher making the videotape, who was less than six meters away from the bear, then there was little the researcher could have been done to avoid that attack. Our framework for interpreting the video of the bear shifted as a result of our experiences in the field with bears.

It is clearly not possible for all field researchers to be able to experience all such possible encounters for a *field sense* to develop which would allow successful field research to be conducted--the various settings from which one could learn about successfully conducting field research (either methodology or survival) must also play a significant role in communicating this information. For us, this raises the question, "By what means and where is critical information about field practices relayed in the community of ecologists?"

From our research among ecologists, we present evidence that the formal settings of classrooms--lectures, journal articles, textbook writings--convey little of the information that is necessary for ecologists (especially undergraduate and graduate students learning to become ecologists) to effectively do field research and that other resources are critical to enable a future ecologist to do this type of work. This paper is about the appropriation of knowledge, *information*, *in formal* and *informal* settings by ecology students (i.e., individuals *in formation*). We address the questions, "How are formal texts (both written and spoken) and informal texts (such as in bars, over coffee, and during informal public talks) in which ecologists discuss their work structured?" and "What are the implications of any similarities and differences for the enculturation of newcomers into the concerns, practices, and discourse(s) of ecology?"

Previous Research on Enculturation into Science Practices

There are few ethnographic studies that examine the enculturation of new researchers into scientific research practices (Roth & Bowen, 1999b, 2001a). Some of the existing work comes from the study of physics students. One study of the formal texts in undergraduate physics detailed how students engaged in group problem solving activities working on theoretical and abstract problems (Nespor, 1994). During these activities, students develop an identity as part of a "physics actors network" within which they learned to explain physical phenomena primarily in mathematical terms. The textbooks are "useful in holding networks together in a stable configuration and keeping activity ‘on-track’" (p. 59) so that students become enculturated to the standardized practices and interpretations of solving the mathematical problems. These mathematical problems are presented as if they *were* physics, not as mere representations of phenomena (which mathematics approximates). In addition, the lectures students attend differ little from the textbooks. Overall, the descriptions of the programs suggest that undergraduate physics students learn little about doing physics research but learn to use mathematical formulae. Even at the graduate student level, formal physics texts differ little from those of the undergraduate physics students (Traweek, 1988). Both graduate and undergraduate students study the heroes of the discipline and learn how to succeed by examining how those heroes were successful. Graduate students they learn a little about style of "doing" physics by listening to stories of success and failure. Both undergraduate and graduate physics students are enculturated into thinking of physicists (and then themselves, if successful) as people who are specially gifted and above the common milieu.

An examination of an undergraduate program in environmental biology (EB) led to the conclusion that the "EB view of a scientist is a kind of challenge to the hegemony of the theoretical, laboratory, or research scientist who is widely celebrated in the physical sciences" (Eisenhart, 1996, p. 175). Employers of graduates from this program are dissatisfied with their preparation to deal with "real-world issues" (p. 180). Students were well schooled in the concerns

of environmental biology but not skilled in balancing the concerns of different communities (i.e., business, political, etc.) or in applying them at their future job site.

In summary, research on enculturation therefore suggests that undergraduate science students are enculturated into the concerns, practices, and claims of their respective disciplines but little into the respective research practices. An important aspect of scientific research is the construction and interpretation of inscriptions (Latour, 1993)--particularly tables and graphs--which are central to the claims derived from research.

Research Design

We each participated in extended ethnography studies among ecologists over several years. During this time we attended most settings common to ecologists in both their field and laboratory settings, interacting with them both in their work related settings and at their social gatherings. To address our research questions we analyze texts from a multitude of different settings that were both formal and informal. We considered formal texts such as those that were structured for a particular professional audience (in the discipline). Thus, we conducted a fourteen-week ethnographic study in a second year ecology class, attended university seminars, participating in university fieldtrips (for both graduate and undergraduate students), and attended conferences and symposia. We also considered textbooks and journal articles as formal texts. In addition, we conducted over fifty interviews with various members of science communities (ranging from undergraduates to senior professors) around and about their interpretations of graphical inscriptions. In most of these settings we documented practices on videotape (occasionally only audio recordings were possible), collected samples of written artifacts, and recorded impressionistic ethnographic fieldnotes.

We also participated in countless "informal" gatherings of ecologists where they discussed their work practices. We considered informal settings or texts as those which included the characteristics of being unstructured, included or were directed towards non-professional participants (i.e., those not a formal trajectory to become a scientists), were held in non-academic settings, and which may have been spontaneous or serendipitous (such as accidentally meeting others in the community of ecologists in a coffee shop). These informal settings included after-work gatherings at someone’s house, in coffee shops, bars, pool halls, hallways in the university, and so forth. We both observed and participated in social interactions ("chatting") in all of these settings. The informal texts included television interviews and newspaper articles. The nature of these settings is such that video or audio recording was often impossible, so the main data resources for these settings are impressionistic ethnographic fieldnotes (van Maanen 1988) and artifacts from television and newspaper articles.

Much of our data was collected as we worked as field assistants with ecologists over several years (during which we examined both their field research practices, their construction of scientific claims, and the enculturation of newcomers into these practices). In so doing, we were following in the tradition of conducting ethnography through apprenticing in the discipline (Coy, 1989). In addition, we contextualize our analysis for this paper with our past work with students with and without B.Sc. degrees as they interpreted inscriptions and conducted field research projects of their own (Bowen, Roth, & McGinn, 1999; Roth & Bowen, 1999a, 2001a) and with

eighth-grade students as they conducted ecology field research (Roth, 1996; Roth & Bowen, 1993, 1994, 1995).

Prolonged and intensive engagement in the field provided the bases for thick descriptions, a foundation for our understandings (Guba & Lincoln, 1989). Ongoing analysis of the field data was conducted to help establish the "credibility" of claims from our ethnographic and qualitative research--a parallel to internal validity (Guba & Lincoln, 1989). Two of the criteria for establishing credibility are peer debriefing and member checking and these both occurred as a consequence of the ongoing analysis of data as the various studies progressed. During the field sessions, active analysis of the collected data was shared between the authors so that interpretations and observations could be critiqued and further questions asked. In addition, analyses could then be checked with the member ecologists or un/substantiated with further observations.

Our analyses of the interviews/transcripts and other texts were informed by the method of Interaction Analysis (Jordan & Henderson, 1995). This method involves both individual and collective interpretation sessions. First, we individually conducted an interpretive analysis of the audio, video and textual resources (including transcripts) by reading them over and identifying both broad themes of interest and specific critical instances of discourse or text. These themes were used to frame assertions, which were subsequently evaluated in the light of supportive or contradicting evidence. We then met collectively to examine our individual assertions and negotiated differences in our interpretations. From this process we developed new assertions or reformulated earlier ones. Through repeated cycles of interacting with each other over our individual assertions and independent analysis, we formulated collective claims from the dataset and established supporting episodes for those claims. This sharing and critiquing assisted in the process of progressive subjectivity (Guba & Lincoln, 1989) and helped guard against developing nonviable interpretations.

In addition to the understanding of the difficulties conducting field research, which emerged in the informal settings, we developed an understanding of the difficulties encountered by new researchers (such as new M.Sc. students) during their first research projects in two other ways. First, we review a study of the process and products of recent biology B.Sc. graduates as they engaged in an independent research project in a professional program. Secondly, we conducted several semi-structured interviews (a short list of pre-determined questions was elaborated in reaction to issues discussed by the interviewee) with "new" graduate students who had engaged in a recent study of their own. Collectively, the data from these many different settings allowed us to develop a better understanding of how and where new researchers in ecology learn about the conduct of field research.

We begin first by reviewing our related studies that render as problematic the interpretations of graphical inscriptions by graduates from B.Sc. biology programs. We then review the research practices enacted by science graduates when participating in their own short-term ecology field studies. To make sense of these studies, we examine the experiences of undergraduate biology students in the formal texts from which they learn disciplinary practices and then analyze the content of the informal settings where graduate students and some undergraduates frequent.

Science Graduates do not Enact Canonical Scientific Practices

Competencies in Graph Interpretation and Field Research

An understanding of what science practice competencies accrue to students during their undergraduate study provides a foundation to discuss the sources of ecologists' field research competencies. Our work with graduates of various undergraduate science programs provides insight into the development of competency with inscription use and the conduct of field research projects. We summarize the inscription practices of these students (Bowen & Roth, 1998; Roth & Bowen, 1999a) and then sketch the competencies of these individuals as they pertain to conducting small field research projects.

When asked to interpret a graph, individuals with science degrees (having completed B.Sc. degrees) frequently have difficulty in elaborating an interpretation; these difficulties also exist when they work in groups. Interpretations are often referentially isolated--that is, they are concerned with the form of the graphs rather than with the natural phenomena that graphs might refer to. The individuals get "stuck" within the details of the signs themselves and do not draw on their knowledge of the world to help them read the graphs. This often results in breakdown of the interpretive process; individuals and groups are unable to proceed in their interpretations of some graph. For example, these students used only a small number of resources, such as references to natural populations or mathematical tools in their interpretations of a population graph. In addition, the linguistic resources brought to the graph interpretation task made it difficult for them to make important distinctions between different concepts necessary to develop any interpretation appropriate to the academic field. The resultant ambiguities made arriving at a shared interpretation during group work difficult. In general, students learn to provide correct answers to specific graph-related questions but do not come to make linguistic distinctions, increase their knowledge of specific populations, and do not develop general interpretive skills (Bowen, Roth, & McGinn, 1999). Rather, students learn to apply the interpretation of specific graphs as provided in lectures and seminars.

Science graduates rarely enact canonical research practices or interpretation of data sets. For example, students in a post-baccalaureate program conducted a small field research project in ecology for which they were asked to examine correlations between one biotic feature (such as density of a type of plant) and two abiotic features (such as soil moisture and temperature). Students conducted the study in groups of two or three and then wrote group reports on their findings. Although their reports contained most of the components of scientific reports, there were problems with most regarding the content of each component. Generally, students planned research questions unanswerable by the study design, inappropriately operationalized the constructs to be used, reported and transformed data using inappropriate representations, and failed to match research claims and research questions to data.

In total, there were 12 reports containing 24 research questions. In many cases the investigations were framed as causal investigations ($N = 14$) that were not possible to conduct given the parameters of the project. For example, questions included such topics as "How does moisture effect horsetail height?" "How does moisture affect growth?" and "How does pollution from cars affect plant productivity?" In seven reports, variables were inappropriately operationalized, replication was problematic or sampling was done such that it was not possible to answer their research questions or to draw conclusions from their data. The subsequent reports reflected some of their difficulty with the conduct of the field research. Tables ($N = 14$) were used to summarize

data but several were structured in non-standard ways and did not aid in understanding any patterns. Ten reports used graphical inscriptions but in such a way that these negatively affected interpretation of the data. They used inappropriate graphs when another type might have better portrayed the relationship (e.g., line graph instead of a bar graph or vice versa), infrequently fitted lines-of-best-fit, and conducted no outlier analysis. In addition, there were often structural problems that confounded interpretation. With this work we gained insight into students' difficulties interpreting inscriptions. Given that their experience with graphs was such that they could not effectively use them to understand their own research experiences; it was perhaps unreasonable to expect them to be able to re-construct the experiences of others when interpreting inscriptions.

It is possible that these science graduates are unrepresentative of those who go on to actually do field research, however this is not supported by our observations in the community. For instance, it is common lore amongst biology professors that even those graduate students who were top undergraduate students initially have few competencies at conducting field ecology or laboratory research. As was clear from our informants, a notable consequence of this for those who engage in field research, most particularly those who engage in field research during which one is working alone, is that little useful data is collected in the first field season. Graduate students commonly indicate that their first field season did not result in usable data because of the errors they committed due to their lack of knowledge and experience.

Students' interpretations of graphs contrasts those of experienced field researchers reading graphs related to their work. Experienced researchers engage in a dialectic process in which different kinds of experiences and understanding mutually constitute one another. These include their own research experiences, commonly held ecological knowledge touchstones, examples of live populations, and anecdotal narratives related to them by others. Frequently, we observed a combination of these resources. For example, Jan (a post-doctoral theoretical ecologist) drew together three of these features as he made sense of a graph depicting a population of organisms with density dependent features affecting the birth rate but not the death rate in the population.

> This is an extreme, when you start to go from the traditional density dependent factor affecting declining birth rate to one that takes us all the way down below here <below the death rate line> [this] is a fairly extreme Allee effect. You could just argue that this doesn't happen. It's what this is. That's the Allee effect, trouble finding mates when they're at a very low density. Like [ecology professor] was telling me a story the other day. He said they're at the low of the snowshoe hair cycle in Killarney or something, no hares around at all for miles and, he caught one female hare and it's pregnant. There haven't been any hares for three years in this area or something, he said.

When scientists develop interpretations of graphs, they use a combination of resources; as a result, they make sense of individual graph components and the relations between variables depicted. Stories, such as the rabbit story above, are accumulated in a variety of settings and frequently play an important role in the interpretations of experienced researchers.

Given that graduates from baccalaureate science programs experience such difficulties when it comes to field research and graph interpretations, we have to ask "How and at what point do scientists learn to do research and interpret graphs?" Since the common experience shared by

undergraduate students and beginning graduate students in biology are the formal texts of science —lectures, textbooks, laboratory activities, and journal articles— an examination of those should help us understand the beginnings of ecology researchers.

Formal Settings: Current Biology Education Settings

The formal information sources available to undergraduates present knowledge about ecology in an impersonal style with infrequent reference to the scientific practices and field experiences of the scientific authors; reports thereby constitute "a world from which persons are virtually excluded" (Gross, 1996, p. 70; Roth & Bowen, 2001b). This information is rarely presented against the background of the social contexts in which researchers work, a context critical to understanding the different perspectives and interpretive stances that ground the claims. Our examination of ecology textbooks and journal articles (Bowen & Roth, in press; Roth, Bowen, & McGinn, 1999) suggest that they rarely include any detailed references to the field research and methods. When researchers *in formation* engage in their first projects, they therefore have limited resources on which to draw for judging the quality of their work. This is especially problematic in in the field science rather than the laboratory including ecology, archaeology, and geology (Delamont, Atkinson, & Parry, 2000). Newcomers to laboratory sciences such as chemistry, physics, or genetics find themselves in settings rich in informational resources— post-doctoral students, doctoral students, and professors work in the same locale as the new researchers and academic paper resources are readily available. Field research is often conducted in far-flung settings far removed from other individuals and formal academic resources. In some settings, such as field stations, this is less problematic as there are often others (Nutch, 1996); in many other settings there is substantial isolation and little academic or technical support (Roth & Bowen, 2001b). Thus, researchers *in formation* often experience considerable frustration when they start their research careers. It is latest at this point that the problematic of formal education become salient to the newcomers.

In this section, we provide an analysis of information sources encountered by students during their formal education. During their time at the university, undergraduate and graduate students obtain access to *information* about science from four basic, *formal* sources: lectures, textbooks, journal articles, and formal verbal presentations (at conferences, symposia, etc.). In the following sections we describe these settings and what informational resources for a new field researcher (*in formation*) are present in each.

Textbooks and Formal Courses

Textbooks and lectures are highly similar in that they present a purely factual view of ecology, a view from which human agency has largely been eliminated (Bowen, Roth, & McGinn, 1999; Nespor, 1994; Roth, Bowen, & McGinn, 1999). Both of these *information* sources provide those *in formation* with a limited sense of ecology. The *information* presented is in the form of broad conceptual knowledge claims that constitute compilations of individual research projects. The *information* is presented as if there was complete agreement amongst scientists within the discipline as to the interpretation of the data; the sources of the *information* are rarely discussed. Pieces of *information* are matter-of-fact as if they existed independently of their own constitutive historical foundations. This ahistorical nature also extends to the variables presented conferring to them an a priori nature independent of the knowing subject.

This ahistorical way of teaching ecology was also present in practical activities for undergraduate ecology students. Our observations of a field research exercise for a second-year ecology course suggests that students experience these activities as disconnected from the lecture component of their course and the research methods as inviolable, pre-determined, and standardized. The following field note provides a sense of the experience of participating in such activities.

> The first groups are sent out to set up in their transect. The lab instructor provides instructions and descriptions of how beach transects are done while the rest of us are still marooned on the edge of the parking lot. She describes how we are to lay out transect lines every 50 or 100 meters, a standard that was "predetermined in the lab before going out using Canadian Hydrogeographic Survey maps and then checked in the field," using differential GPS. The lab instructor describes to us how we are to measure one-meter quadrates every few meters down the transect line; we are to measure the distance from the center of each to the transect line but we do not have a description why the quadrates should be at different distances from the line other than that the sites chosen were to be random. She tells us that we should record the substrate, time, and location (latitude and longitude) on the sheets she had handed to us and that we could "never have too much information." She continues to tell us that this was an intertidal survey but that normally a subtidal survey to fifty or sixty feet under water would be done with a diver. She tells us to head down to the midtidal area, to "pick a random area," and to measure the distance to the line.
>
> We proceed and stop at an area that was sort of clear (no others were working close by). The TA brings us a plastic frame. We are told to use mining tape to mark the corners of the quadrat and then pass the frame on. By eyeballing the distances, we turn the quadrate into 9 equal areas. I stand beside Nancy and was responsible for section C3. Nancy, holding the clipboard, discussed with others what should be looked at. (GMB; November 1998)

The students in this field note conducted a cookbook exercise for which they attempted to follow step-by-step instructions. Each group of students only participated in a part of what was described to constitute a whole research activity. Each group collected their samples from one spot along the transect line and only later, after sharing of data amongst groups, wrote their reports in which they examined the data for patterns. The students who participated in this activity experienced ecological field methods as a set of standardized procedures predetermined by an external authority that made all relevant decisions beforehand. Outdoor research exercises such as this one are treated by instructors as activities that are separate from both the lecture material and the exercises in the laboratory. This made it difficult for students to identify the organisms because they had not previously done any identification activities. They not only had to learn new field methods but also the organisms by relying on field identification sheets that they had not seen before; this identification is in itself a difficult task (Law & Lynch, 1990). We noted in our participation that the second-year students were not particularly motivated to accurately identify the organisms in the quadrate and were often satisfied with settling on their first identification without interrogating its accuracy and thus numerous mistakes were made in identification. This was not surprising given the paucity of resources on which they could rely. Even when they realized that errors had occurred (which happened once) corrections in the counts recorded on the table were not made. The students' most immediate goal was to have the data sheet completed to the satisfaction of the TA so they could later write a laboratory report based on the data— their orientation to the task was notably as students, not as researchers with a

vested interest in defensible data recording. Clearly, the point of the exercise was that student understanding of the distribution of organisms was to develop from the analysis of the entire classes' data set, not that this analysis and which variables one should attend to should emerge from observations arising in the field.

The physical discomfort often experienced by field researchers (Roth & Bowen, 2001b) was the one aspect of field research students could in fact experience. However, this "real" aspect of field research was rather under-appreciated by the students who attributed the discomfort to poor planning on the part of the instructors. The poor weather conditions under which the data was collected probably contributed to the reduced motivation for accuracy in identifying species and enumerating them in their quadrat.

Journal Articles

University students at the senior undergraduate and graduate levels also experience *formal* contexts as they read journal articles and attend conferences and symposia. Unlike textbooks and lectures, which portray the knowledge foundations of ecology in broad strokes, these resources focus on reports of individual research projects and how they contribute to the overall understanding of ecology. Many authors (e.g., Gross, 1996) note that the *formal* writings of scientists dramatically underdetermine the activities in which they engage. They thereby portray a depersonalized image of ecology that reaffirms the objectivity of their work. Here, we conduct an analysis of parts of the "Methods" sections of two journal articles written by an author to whose informal accounts about his research we later return. In the course of his work on a particular fish, this ecologist made observations on bears and their feeding on salmon. We determine what cues these articles offer to researchers *in formation* to *inform* current or future fieldwork. We later contrast the *information* provided in this formal context with that provided in *informal* settings such as presentations to lay audiences or with graduate students in a bar ("B(e)ar Stories").

The first journal article (in a major journal in the discipline) presents aspects of bear genetics and its implications that had for discrete populations and population distribution. For the present analysis we focus on the part of the methods section dealing with how the "samples" were obtained:

> DNA from [the bears] was obtained primarily from muscle tissue, although blood samples were used from [N] members from [site]. A hide preserved with salt was also used because fresh tissue was unavailable. Sample details are given in Table [X].

This text describes the body part from which the tissue samples were obtained. A table lists fifteen geographic locations as sources of the samples, how many samples were collected at each site, and who provided the samples (mostly the authors themselves). Thus, sampling was discussed in two forms: location of the tissue samples on and source location of each bear. From the information in the table, a reader might also infer muscle tissue as the preferential tissue for conducting the DNA sequencing technique used and the geographic range and an adequate sample sizes for such a study. The remainder of the "methods" section provides considerable detail of the genetic sequencing activity, although a graduate student interested in conducting

such research would find few resources detailing how such samples are actually collected from a bear.

The second journal article makes reference to the first paper and deals with patterns in foraging behavior of bears. It offers considerable detail about doing the research including the geographic location, the number of salmon returning, dates of salmon movements, periods of observation, and number of visual surveys of bears. The variables examined were presented as if they were predetermined before the fieldwork was conducted. A matter-of-fact neutral tone, typical in science writings (Gross, 1996), is used throughout when describing the actions of the researcher, even when describing situations such as following a bear at a distance of two meters. In keeping with our findings of inscription use in ecology journals (Roth, Bowen, & McGinn, 1999) these articles provided detailed captions and explicit readings of the inscriptions so that the readers were channeled into the interpretation of the graphs desired by the writer. So, these articles are structured so that the claims appear unassailable, however they offer few resources to new researchers desiring to conduct such research themselves.

Formal Verbal Presentations

We observed and recorded two formal presentations about this research with bears, one presented by the principal researcher and one by a graduate student, at two different symposia 16 months apart. To be considered "formal presentations" they met the following criteria: a list of speakers with presentation times was printed and distributed to the attendees, there was a common theme to the series of talks being given (e.g., "Nth Annual Vertebrate Symposium"), presentations had a "chair" who introduced and closed each session, presentations conformed to a standardized format (i.e., 15 minutes with slides/overheads, questions from audience) and reported on research. The presentations typically often involved preliminary results of research that is still active. The two presentations we discuss were typical of those we saw at over eight such gatherings we attended.

Both presentations were similar in structure providing an initial background to the research by showing color images with a commentary about what was being seen. These included images of the watershed, a map, the salmon species, the bears, a carcass being consumed or left behind by a bear, and so on. The images of the research site and organisms were followed with a presentation of various inscriptions used to represent the findings. Often detailed readings of the inscriptions with accompanying hand gestures to emphasize the important components were provided. In addition, graphs and tables were presented in clusters in support of the claims presented.

The text of these talks mostly dealt with constructing a persuasive rhetorical argument so that the knowledge claims at the end appeared unassailable. This included the amount of time spent doing the study, the variables chosen for examination and the rationale for their being chosen (from which methodology could sometimes be inferred), the amount of data collected, and the juxtaposition of text and gestures that accompanied the inscriptions. Physical objects (and organisms) constituted privileged *information* and the human agency during data collecting was downplayed. The following segment of a presentation by the professor illustrates these points:

> (Describing an image) The bear here captured a salmon and is bending over and is just sniffing to see what sex the salmon is and then continued into the forest where it is

> consuming it, normally about fifty percent of each carcass. So this is what I spent my time watching. After the bear departed I would go and then see what tissues the bear did not consume, look at the sex of the fish, I would look to see if it was gravid when it was captured and that's how I started to collect this data. The bears spent quite a bit of time after capturing the salmon and going into the forest and with it came usually about a hundred and fifty crows and often up to two hundred gulls following the bears around.

This description contains *information* about bear activity and what the data collected, but there is little from which a researcher *in formation* could gather about how that data was obtained. The ordering of the information, undoubtedly done for rhetorical purposes, pre-supposes *information* obtained by doing the study in two ways. For instance, the statement that the bear consumes 50% of each carcass requires that the initial fish weight— *before* the bear consumed it— was either known or determined, and for a new researcher how this was determined in this study is important information. Additionally, that *information* is described prior to the study itself, even though it was determined by doing the study. Generally, formal presentations focused on where the research was conducted, what organism(s) the research was conducted on, and what findings were made. Little information was available about the methodology so that these *formal* presentations bore a strong resemblance to textbooks and lectures. In essence, *formal* talks present *information* such that those *in formation* can gather little about the process of research.

Experiences of New Researchers

What are the consequences for new researchers of the enculturation to ecology and field research in the manner described above? It is not surprising that our graduate student *informants* complained about the lack of access to *information* that leads to undeveloped and underdeveloped understandings regarding the contingencies that mediate field research. One of our *informants* (a doctoral student) suggested that the main reason for quitting graduate work were the unpredictable factors that impeded with the research. Researchers *in formation* often experience such difficulties as unique to their situation and attribute the blame to themselves because the *formal* sources never presented such problems.

> I was surprised by the bad luck I had in the sense that I thought if I really. . . . Up to this point in my university career if I worked really hard it would show, you know? . . . And I tried really hard last summer but it didn't matter. I had crappy luck. I didn't get to sites. My protocol was ill suited for my species. My supervisor over in biology says that ya, we probably should have changed things around. She just wasn't aware of certain aspects of my species, blah blah blah. So yeah, there were things I couldn't anticipate. Things I had no control over. And uh, so that part was hard to take. (Donna, in interview after her first field season)

In addition, researchers *in formation* rarely know about the isolation and independence that are also features of fieldwork. Graduate students who had acquired their first field experiences in the past season discussed their isolation in the field, the effect it had on their work, and how they wished to a different supervisor.

> I'm not really comfortable striking out on my own. And that's kind of what I was expected to do in the field last summer. Which in a sense is good for me because I'm not good at that

> but it, it forced me to do that. To some extent that was probably helpful but it also makes me feel that the data I collected is seriously flawed. I know it is, in large part due to mistakes that I made. (Donna)

This isolation and the lack of input regarding field research methods meant that new researchers were insecure about the quality of their work. These concerns about the quality of data, and the lack of any reference to compare their work to which would allow them to receive affirmation for the quality of work, was a frequent stress factor for researchers *in formation*.

Researchers *in formation* often recognize in hindsight that their undergraduate experiences poorly reflected their newly gained experiences conducting research. Donna had completed one field season and had considered dropping out of her program. Her reflections are indicative of her discontent with the realities of conducting field research:

> They really didn't spend a whole lot of time talking about what happens in real science. You know, it's like, you get these very pat results and this is, I mean textbooks are marvels of this right? They package everything up as if it's all very neat and tidy and this is what we've figured out up 'til now and it's all packaged as if there was no problem getting to that stage. It was all a very nice linear progression of great minds and adding a little bit to the pile and standing on the shoulders of giants and all that crap and then, you know, you don't hear about the real things that don't make sense; and [you don't hear] the things that don't fit and the problems that you have. There isn't much emphasis put on that. You might have the odd professor that'll give you the odd anecdote about their research, but, very little, very little, about the realities. (Donna)

It was the contrast between science as practiced and that portrayed in her undergraduate lectures that caused Donna considerable stress. She wanted to conduct field research that was similar to the science with which she was familiar from her undergraduate education. The uncertainties of field research— what should be measured, what variables are important, the dealing with missing data caused by bad weather— she found hard to cope with. Further, her research meant spending weeks in the field collecting samples in remote areas so she had no peers to rely on, no email to use to ask questions of her supervisor, no feedback on whether the decisions she was making about research were the right decisions--she considered field methodologies as subject to externally determined criteria of correct or incorrect. Left to her own, she struggled with every situation "guessing this or that was the right thing to do." Donna considered learning to do research as a process of trial and error and was discontent with "not knowing if a decision was right." She felt that her methods would be judged external to her data, her arguments, and the context in which they were applied. If she had known what field research was like, she would have never started a graduate degree in ecology.

Clearly, the *formal* structures of undergraduate and graduate education in ecology poorly prepare students to do field research. This raises the question, if field research and field methods are communicated so little in the formal settings of ecology, how do new researchers develop competence and confidence in conducting field research? Here, *information* exchanged between researchers in *informal* settings provides substantially more to researchers *in formation* than the *formal* settings. The paucity of stories of field experiences in the formal texts of ecology, the important role they play in interpretations of conceptual claims, and their potential role in relating

field research experiences suggests an analysis of informal settings in which ecologists gather may offer some insights.

>Informal Settings: What Graduate Students Learn

During our two-year ethnography we spent considerable time interacting with and observing ecologists in *informal* settings. These settings included coffee shops, pool halls, bars; cars (as we traveled to conferences or field research sites), *informal* events at *formal* conferences, and private homes of a participant. *Formal* sessions such as symposia were frequently followed by adjournment to a local pub for *informal* meetings. Finally, we considered presentations to public groups as informal settings (corresponding to our criteria for "formal" settings).

Our observations in the *informal* settings suggest that different types of interactions occur at different times and places. This is often related to the amount of research experience the ecologists have. Thus, there are more conversations about field research in groups that included field researchers with PhDs in their composition than in groups composed of just M.Sc. students. In the presence of doctoral students but absence of Ph.D. researchers, fewer stories about field experiences are exchanged. In groups composed of M.Sc. students only, fieldwork stories are even less frequent. It is notable that in conversations about research work new M.Sc. students (even those who had participated in numerous research projects as field assistants) often do not participate in conversations about fieldwork. As time passes, even without having gained new field experiences, these students begin to participate to an increasing degree up to the "old-timer" level.

When someone joins a group of ecologists, the ensuing conversations are generally about field experiences if the joining person has a science background. The conversation takes notably different turns if the joining person is perceived as a non-science person. We recorded numerous instances where the conversations became more technical and work-oriented after those present were told that we, the authors, also had graduate degrees in science. However, in the case of non-science people joining a group of ecologists resulted in a change of the conversation.

Unlike the work of laboratory-based scientists, ecological field research varies widely in terms of its geographic locations and circumstances. Even ecology researchers from a single research group can work in geographic locales distributed around the world. This lack of similarity in research settings provides ecologists researchers with variability in their personal experiences. Thus, when groups of ecologists congregate they possess considerable experiential resources in their conversations with other ecologists permitting members to find common aspects in their observations, practices, and conclusions.

The stories we heard were of several different types and served different purposes; they differed markedly both in form and content from the formal exchanges discussed earlier. Substantial *information* about the research work in field settings was exchanged in exactly these situations and noted by its difference. We noted four general types of stories that deal with the conceptual or experiential nature of ecology research: (a) stories about ecology based on the tellers personal experiences (b) stories about ecology that were being retold (after being initially told by somebody else in a previous setting), (c) stories of the field which are used to reflect typical situations in ecology, and (d) stories of the (hero and eccentric) characters of the field and their

activities. These narratives served different roles, including information about surviving and conducting research in field settings (often related as allegories from which a listener could infer what to do or not do in their own research), how to interpret different observations, and in many cases provided a foundation for social cohesion of the community.

Informal conversations constitute the main source of *information* on field research practices for researchers *in formation*. Such *information* takes a narrative form. We illustrate the use of these stories through presenting a series of field notes and anecdotes collected from *informal* settings over an eighteen-month span. To maintain an interpretive thread with our earlier content analysis of conference presentations and journal articles, many of these stories are about bears— in part because, more than any other organism, bears formed a common thread in discussions amongst ecologists across research settings, topics, interests, and locales through this community. This focus on bears was particularly notable because only three researchers in the communities of ecologists we worked with actually did research with bears (and one of these never participated in any of the informal gatherings that constitute our database).

Storytelling, such as engaged in by ecologists in informal settings, does not often appear to be done just for reasons of entertainment. Usually embedded within the story is an allegory about what actions are appropriate or inappropriate (depending on the narrative) when conducting field research. These allegories deal with issues of safety, what to be careful about from a research perspective when doing specific fieldwork (such as collecting lizards), cautions about using volunteers, and warnings about working with specific individuals.

>**Safety Allegories**

Ecological fieldwork can be fraught with danger. Poisonous snakes, cougars, and bears are but a few of the dangerous wildlife a researcher may encounter, but numerous other hazards also await the unwary researcher. Although these hazards warrant little mention in the formal texts of the discipline, stories about safety issues are frequently exchanged amongst researchers in informal settings--particularly those working in similar geographic settings. Ecologists, either ecologists *in formation* or those from other geographic areas, rely considerably on *information* contained in the stories to develop their local knowledge about any hazards in the area. Allegorical stories were quite frequent in *informal* settings and provide *information* that pertains to doing effective research.

> July 4: While driving to the research area Stephanie [an undergraduate field assistant] and Sam [a doctoral researcher] are talking about Cary (another doctoral researcher who has just left the field site who Stephanie was first working with) saying that he was paranoid about cougars and bears, and was always worried that there would be cougars waiting on the roof of the trailers for somebody to come out. Stephanie said that it was like he was almost going to buy shotguns for his field research team to carry for safety. Bear safety was discussed a bit and when we hopped out of the car, and start putting on our packs, water bottles, etc. Stephanie demonstrated a trick she had been shown— how to "make yourself big" by pulling your sweater up over your head and onto upraised arms so that the bear would be scared off. (GMB field notes while doing field research)

The example is an allegory that deals with field safety. In groups such as this the hierarchy within the research project does not dictate who contributes to the conversation. Here, the extent of the local knowledge seems to be a better predictor. *Information* is shared among participants. A notable aspect of this exchange is that field lore such as "how to make yourself big" is not necessarily based on experience but on other *information* sometimes derived from exchanges with other field researchers. Topics such as this are not discussed in *formal* situations. The depersonalized nature of the formal texts would not lead a researcher *in formation* to suspect that working within a few meters of bears really presented any danger. Field researchers who have had interactions with bears relate their stories in *informal* settings about these encounters with much greater intensity than that expressed by Stephanie:

> July 15: In one informal setting, a fieldworker related (to others not involved in the project) how when rushing back from a field site one day without a second thought he hiked along a trail at the edge of a marsh which ran towards a pond of water. The next day, sitting on a ridge overlooking that trail, he saw a mother black bear and a cub tumbling along the trail towards the waterhole. He said that he "knew" that such a trail was probably one used by wildlife from what he had read before, but now he *knew* [his emphasis] that wildlife had made it, and really used it. He swore he'd never use a trail like that again, and I (and the rest) filed the story away drawing the same conclusion. (GMB fieldnote)

Safety allegories were also present in stories relating the conduct of field research. The following field note relates a story told as a warning to field assistants to encourage them to pay attention to the surroundings while gathering data. This story was for the benefit of a less-experienced researcher and included the warning that one should listen for twigs breaking and leave rather than risk a confrontation.

> July 21: Later in the afternoon, just after 5, Sam went to a site up the road she hasn't visited with us before. Over dinner she said it was unnerving because while she was flipping rocks she could hear sticks breaking but couldn't figure out why. She then noticed that a bear was in her site eating berries. She watched it a bit, figuring she'd see if it left, but it was showing no signs of slowing down on its meal, so Sam left rather than risk a confrontation. (GMB field notes)

These tales of shared common experiences of survival also contribute to the social cohesion of the community of ecologists because they are examples of common experiences individuals working on even quite diverse projects can share. In an exchange between two M.Sc. students near the end of their program the dangers of participating in field ecology research and the precautions that should be taken come to the fore.

> RR said no, [she didn't miss doing fieldwork] because last year had been hell, and that [turning to another researcher present] he mustn't be missing it either, because his field season last year was pretty rough too. Nat said he was missing it, but figured if he was out this year then he'd be visiting the hospital even more this year than last and that he thought he was just too old to hack fieldwork any more. He talked about his injuries, how he'd gone to hospital numerous times, and then RR related her hospital trip. . . . "I slipped off a log when marking a trail with orange tape and fell onto my ribs across another log and fought for consciousness and then passed out. I awoke fifteen minutes later with my face buried in the

> moss, draped over a log [she described this very dramatically] almost unable to breathe or move. I painfully made my way out of the woods, which thankfully I was only into 100m, to my truck and then drove to my camp. It took my [camp] partner three hours to drive me to the hospital over the logging roads with every bump causing me to stop breathing because of the pain and they kept me off work for ten days." After she concluded her story, Nat asked if she had spikes [on her boots], to which she replied, "No." He berated her for that and for not having other safety equipment with her so that after she had passed out she'd be able to call for help if she couldn't make it to the road on her own. (GMB field notes)

Safety issues were ever-present in stories related about field experiences, especially when newer researchers were present. To newcomers, stories like this relate the physical rigors involved in doing field research serving as a warning for what they might expect. However, these stories seemed to be related less for the utilitarian purpose of exchanging information and more for the sharing of common experiences that contributes to the social cohesion between the ecologists.

Methodological Allegories

Other stories were told which quite clearly were meant to provide insights into the conduct of field research--as a warning against or a suggestion for what actions may be appropriate for certain activities in the field. Given that most formal texts contain few resources about how to do fieldwork, allegorical stories dealing with field research practices have particular significance to the enculturation of newcomers into the practices of research. For many newcomers the exchange of stories about field experiences is a valuable resource in learning to conduct research of ones own. Allegorical stories can also possess different meanings for different members of the audience. One of our informants frequently related a story about a volunteer field assistant she utilized in her fieldwork.

> I had this field assistant last summer, Bill, that came up from the U.S. to help for a few days. What a guy, he goes out with me to help collect lizards and in one day, ONE day, he must’ve pulled the tail off of half a dozen lizards. There was blood everywhere on the slopes that day. He was great at capturing lizards, but waaay too rough with them. (Sam)

This story can be seen to have multiple meanings for different members of her audiences. For those who were helping her in her fieldwork, this story had the message "do not do this to the lizards." (We both heard this story many times making us particularly cautious in our own attempts of capturing lizards.) For researchers who used volunteer assistants in their own work the story was a cautionary tale with the sense that you have to "keep an eye on your field helpers, choose help carefully." This story was often in response to similar stories from other researchers about the problems of using field helpers. Our informant frequently discussed with us her own experiences with field assistants, how some were helpful while others constituted more work than if she was on her own. She hired them for the sole reason of maintaining "good community public relations."

Allegorical stories that *inform* research practices of old-timers and researchers *in formation* also involve research aspects other than data collection. This field note excerpt describes a situation where a story was told again and, in this, obtained a particular salience to those present.

> July 22: Sam told a story about inappropriate causal attributions she had heard told by a methods professor at her university, "one of Vlad's favorites is about somebody getting data from veterinarians about injuries sustained by cats and the heights they were dropped from and concluding from the data that if the cat drops from high enough then it reaches terminal velocity, doesn't feel like it's falling, and relaxes so that when it hits it doesn't sustain much injury. (Then strongly) Think about the biology of it, most times the cat is going to be so injured when dropped from a high height that the people wouldn't even take it to the vet. Think about where your data's coming from!! And that was a published paper." (GMB field note)

Sam told this story because of her irritation with inappropriate causal claims that she heard both at conferences and from the undergraduates she taught. At the time we recorded this note, it did not seem like much. We found out later that this tale was a reflection of the connections between individuals over time and space.

> July 23: During lunch a comment was made, in the context of bears falling from trees on your head as a fear--"Imagine if it fell on you." Sam replied, "Imagine if it missed." I [GMB] then made the comment as a joke, "You know, bears can fall from a 10 story building without any damage because they reach terminal velocity and just relax." which had Sam chortling and Stephanie asking where that comment came from. Sam explained the story she had told me the day previously and Stephanie [who attended a different university] said that it [the story about the cats] "was also Ron Taybor's favorite story in class too, he must spend two periods on it." Sam replied, "That's pretty funny, because Ron Taybor and Vlad [the professor from yesterday] did their graduate work together." Stephanie tells us that Ron was her biostatistics professor at [her home institution]. Sam's person yesterday was from [a different university]. (GMB field note)

Stories that are told time and again in a community encapsulate particular community concerns and interests. In this case there are two possible cautionary tales about conducting research offered here. The first relates to the general (scientific) concern of making claims of causality without proper consideration of the variables that might affect your results. The second is a warning about using (and misunderstanding) data which you did not collect yourself— an activity which field ecologists think that theoretical ecologists do as they models ecological situations. Thus, this narrative both cautions against making inappropriate causal claims and also contains an implicit critique of theoretical models not grounded in empirical data.

Formal conference presentations provide little *information* about field research methods on which those *in formation* could draw to guide their own research. There are, however, other opportunities at conferences to gather such *information* during *informal* discussions. These informal discussions are an important resource for researchers. We observed that after the principal investigator returned from an international conference, many conversations over the next three weeks turned up as *information* gathered there, often in *informal* meetings. However, our informants frequently referred to such *information* as "anecdotal" because it dealt with topics unsubstantiated by formal observation. Nevertheless, these conversations influenced the research done by our ecologists. For example, in the following excerpt, Sam describes a conversation she had at the conference with a researcher who worked with pit vipers.

> People don't think about the behavior of reptiles. They think it's not- I was talking to a guy at this conference and he was all excited. We talked and he thinks these guys show some maternal care. For about the week following birth of the young. And he's real excited. He's just discovered this in snakes. It's not, it's not like the birds but- you see lizards that will lick the young after they've given birth to them and they'll spend some time. He presented a paper on pit vipers, they're a kind of rattlesnake, and they stayed with the young for about a week until the young [have] had their first shed, which they have within a week. And they stayed with them. And uh, and this has never really been reported at all. Nobody's ever looked at this so he's all excited and stuff and we talked and he got me all excited about the lizards. I want to expand their homes and build some area so I can watch them so that's one of the activities for the next few weeks. Set up areas so I can watch them and get some data on their behavior. . . . And Larry was all excited about this when he talked and I got all excited because he looks at behavior in snakes. . . . I still think it would be neat to do this movement stuff first and we can get some idea of what areas they're using and then supplement that with behavior but the maternal, the behavior associated with the partition and birthing would be easy. It would be totally easy to collect that data so I think I'll set up those and if it comes close I might move them home [to where I'm staying] or I might move out to the trailers [where the lizards were kept] or something and just like monitor them. (Transcript of lunchtime discussion)

The enthusiasm of both belies the detached stereotype of the scientist portrayed in science education reform documents (e.g., AAAS, 1993; NRC, 1994) and as often portrayed in popular media (such as television and movies). Larry's suggestion influenced Sam who spent considerable time over the following weeks building new, much larger enclosures for her lizards. A discussion about an observed behavior in a species quite different from hers prompted Sam to reconstruct enclosures she had used in a previous field season and (plan to) engage in observations that were not at all central to her original research plan. During an interview seven months later, where she was providing a reading of some of her graphs, Sam commented on the value of "anecdotal" stories she heard at conferences and what they offered her.

> And people, people seem to really like this species, it's funny--when I went to the meeting, lots of feedback, people, oh they tell you stories, of lizards, on and on, people get all excited. They've had, some have had the experience with it [her research organism], 'cause it's got quite a big distribution--so, they've, yeah, they've played with critters or know somebody that had them. Some guy, he grew up on Vancouver Island, so he grew up playing with them and they just, they like to tell lizard stories, they seem to get all excited which is fun 'cause it's really informative for me to hear lizard stories because they're all anecdotal but it's, it's interesting to jog some memories or to prompt questions or to reinforce observations. (Sam, interview, April 1998)

Sam recognizes that the stories she hears provide considerable insight into her own fieldwork--even those stories that do not pertain to the organism she studies. *Informal* conversations contribute more than the *information* contained in *formal* presentations. Stories contribute particularly to the work of ecologists and help them contextualize their own "anecdotal" observations. Several months later, Sam talked about the *information* she had obtained in an *informal* situation about maternal care in reptiles.

> Larry was really helpful to talk to, this fellow that put me on to the fact that the pattern is probably a lab artifact, he presented some work on parental care. This is a phenomenon that's been seen in fish but it's not that common in reptiles, they simply drop them and bolt. And so he had some, done some work with snakes and suggested that this phenomenon existed and he had an alligator lizard in a tank in his office and he watched it give birth one afternoon and he was under the impression that potentially the mum was involved and so we talked at length and I did some observations on my guys to see if this phenomenon existed. So, I haven't got back to them yet, I don't think it does, as far as I can tell they just drop and bolt. But, yeah, it was really helpful for me. (Sam, informal interview)

This story about maternal care in reptiles, and how it developed and was elaborated in her conversation with Larry, obviously had considerable salience for Sam because she returned to it unprompted seven months later. In that time she had reconstructed her enclosures, structured her time so she could make observations on the lizards when they gave birth, and concluded from her "anecdotal" observations that maternal care did not exist in the type of lizard she studied. In this case, being able to observe a behavior never before reported in her species and the suggestion that a (distantly) related species might engage in the same behavior was enough to add a new research focus (though temporarily). Informal conversations therefore act as a considerable *information* resource even for researchers with more extensive field experience.

Informal public talks contained far more *information* about doing field research than *formal* presentations. They provided field researchers *in formation* with a greater resource for learning about doing research. An *informal* public talk about the bear research described above differed considerably from the *formal* texts on the same topic by the same research group. Whereas the *formal* texts presented variables as if they were pre-determined, interactions with bears as if they were benign, and little discussed field methods and experiences, the *informal* presentation were characterized by *information* on the methods used in conducting the research. This presentation provided details about how initial field observations resulted in a focus on specific features of the environment (in other words, how variables were developed), described in emotive tones the experience of working quite near to bears, and provided considerable *information* about how the data from which claims were derived was collected.

As with many of the *formal* oral presentation in ecology, the talk began with maps and diagrams that provided a geographic context for the research, rationales for choosing the locale, and the historical roots of the project. The initial stages of the study were clearly observational as the researcher developed his sense-of-the-field for that site.

> So, what I was simply was doing in this first part of the study was document all of the species that utilized the salmon. And so, um, in the daylight um, every hour I'd make observations of the birds I saw, the number of seals I saw in the estuary, and I'd walk up the creek, record the crows um, what they were eating, and it sort of went on uh, day after day. So, when you put together the overall, wonders of species that we see in the estuary during salmon season you get sort of numbers for this particular locality of about nineteen seals, one stellar sea lion, eight black bear, and a bunch of loons, grebes and ducks, etcetera coming down here [reference to an OH map], three hundred and seventy-five gulls, approximately four species, and the other big species, two hundred crows. Until you see all of these [indicating a pictorial representation on an overhead], using either directly the

> salmon, or the rotting salmon carcasses, or conceivably the eggs that float down the stream. You go out there a week before [the salmon start spawning] and you seldom see any of these things. And you go there a week after and you seldom see any. And so this is a real concentration [of organisms] in response to the presence of salmon. (Transcript of public talk)

This narrative provides graduate students *in formation* several valuable pieces of *information*. These include insights on the frequency of observations, type of information to make note of (number of species, what they were eating), how long one surveys the area ("day after day") and the length of time one stays at the research site (from before the salmon arrive until after they are no longer spawning).

Formal scientific texts present variables as if exist they existed a priori and independent of the knowing subject. Formal texts rarely suggest that in field research variables frequently emerge as scientists become familiar with the local setting. For researchers *in formation* this presents a substantial difficulty, for how should they decide what factors to examine in a setting they have not yet experienced? *Informal* discussions of research projects, such as the *informal* talk on bear research, provide a different perspective on variables in ecology research: they may develop as the study progresses. In the excerpt below the researcher talks about how field observations led to making a determination that was to further guide his data collection:

> We began to focus on bears because they were one of the major consumers of salmon [at this site]. We actually looked for bears in the daytime and they're not present in the estuary at all. From seven o'clock [a.m.] through to about three to four o'clock in the afternoon, no bear is ever on the estuary despite the prevalence and abundance of salmon everywhere in the estuary. Come twilight, rustle, rustle out of the forest comes the first bear, and five minutes after night you have the maximum number of bears feeding and throughout the night these bears are capturing salmon. (Transcript from public talk)

Having determined through field observations that bears consume more salmon than any other organism in the watershed and estuary, the project was narrowed to the impact of the bears alone. In the previous description, a listener could learn *information* about bear movement patterns not at all present in the *formal* texts. The researcher then talked about the human agency involved in the research.

> I have a lot of sort of anecdotal studies of observations of the [bears], that were sort of quite intimidating at first. In the daytime when you see a bear in the forest these bears will avoid you visually. They just do not like the sight of you and they do not like the sight of other bears so if they see another bear or if they see you they will try to walk around you just to get to you outside of their visual range. So you're accustomed to the bears giving you some leeway when they go [by]. At nighttime bears don't see, but with your night viewing glasses you can see everything. Well, these bears come, walk straight past you. Obviously they have no visual component. They're cognizant of you from your smell, right? But they show no adverse response to you. They don't go around you; they come right past you. The bears would rather pass me at close range, in spite of my potential threat, than step off their trails . . . which are olfactory corridors. (Transcript from public talk)

This description provides considerable detail, which elaborates the statement in the journal article that the bears were observed at a distance of "two meters to twenty-five meters" (both this description and the one in this informal presentation are still lacking in detail compared to the bear story related in an even more informal setting). For new researchers this narrative is rich in detail about what a field ecologist might encounter when conducting research at nighttime. Notable is that bear behavior at night is such that they cannot see well, do not perceive humans as a potential threat, and will not avoid you if you are on their scent trail. For those about to conduct field research such information, not at all present in formal texts, is of considerable importance.

As is also clear from this passage, and as our field observations support, variables emerged in the conduct of the field research and as the study progressed numerous new variables emerged to the point that at least one new separate project developed from them. How new variables developed in the course of the study was contained in the narrative with such frequency that researchers *in formation* would have picked up on it. This contrasts *formal* presentations about his work that implied that variable choice preceded the research.

Information provided in *informal* settings can also influence the conceptual understandings of researchers *in formation* and can thus guide future research. The following excerpts show how researchers *in formation* can learn to do field observations on quite disparate organisms at different locations. Such *information* also provides insights into animal behavior and ecological principles.

> In a bar a researcher was sitting and describing how, when observing bears and salmon at nighttime, he could wade into the stream and literally "pet" the fish without them moving, or at least moving very much. He said this was quite different from how they behaved in the daytime where they would impossible to approach and reacted to any shadows or movement near them. He speculated that this might have something to do with the seals that were in the mouth of the estuary and the slight phosphorescence of the water which if moved through quickly would make the moving animal visible. (GMB field notes)

The researcher speculated reflected particular motivations behind the animal's actions, which is of interest, but not the sort of thing reported in a *formal* journal article. However, individual field observations gain a broader salience and meaning when other individuals contribute to the conversation. In this case, a contribution made by another group member provided broader ecological context to the speculation.

> Related a story about radio-tracking porpoises . . . and not being able to "figure out why they logged [seemed not to move] at the surface at night time until we had one in captivity in a large salmon net and watched him doing the same thing--and when he moved his outline was quite noticeable and sharks [a major predator of porpoises] might have cued in on this." This individual also related being able to clearly see dolphins riding the bow wave of a sailboat on a dark, overcast night because of the phosphorescence in the water that outlined their body. (GMB fieldnotes)

This comment resulted in the conversation returning to the first speaker who strengthened his comment about the possible reasons for the behavior observed in the salmon based on the comments about the marine mammals.

> Conversation went back to [the first speaker] about the salmon being afraid to move and that they must have known this went on [seals seeing the "glowing" fish] because if they were disturbed they'd move a short distance and then stop--which is not normal salmon behavior. (GMB field notes)

Thus, observations made of similar circumstances, although with different species, contributed to a broader sense of what was happening in nature. For researchers *in formation*, such conversations offer insights into how field observations lead to new studies and how knowledge claims develop in ecology.

Formal and Informal Settings: Comparisons

This paper, unlike most papers in science studies about the construction of knowledge, focuses on *formal* and *informal* texts available in *formal* and *informal* settings contribute to the *information* of those *in formation*. Little work on the exchange of *information* by scientists in *informal* settings such as bars, parties, or over coffee has been conducted; previous studies of informal texts instead examined discussions held in the laboratory as work was being conducted (Lynch, 1985), explicit discussions of conceptual issues (Garvey & Griffith, 1971), and *information* solicited in interviews (Gilbert & Mulkay, 1984). Unlike these studies, we observed our participants as they discussed their research in *formal* and *informal* settings unprompted by our intervention. From these observations we conclude that the formal and informal texts are fundamentally different in the information they convey about the conduct of field ecology research. These conversational settings have some similarity to those that were examined in a community of service technicians (Orr, 1990). The conceptual setting of our work differs from this work in that the communities under study engaged in quite different tasks. Orr studied technicians who were engaged in repairing office equipment. They both knew what their purpose was (to repair machines) as well as what the indicators of success at that task would be (a working machine). In addition, the focus of their work, a machine, was constructed of a limited number of parts that can experience a limited number of possible breakdowns.

At the end of four years of enculturation with *formal* texts undergraduate ecology students have been presented with the broad conceptual issues about which ecologists are concerned, but have few resources on which they can draw to plan and conduct field research. Students experience few opportunities from which they can learn that research is conducted (and papers written) as part of an inter-related series of investigations by a researcher or a group of researchers--this is almost never discussed in lectures and the structure of the laboratory exercises does not emulate this. In fact, school-based research activities (such as the one described above) and the structure of lectures develop in students a sense that the knowledge claims of ecology exist as distinct and unconnected bits (Bowen & Roth, 1998). Most crucially, lectures and other *formal* teaching situations do not provide students with a sense of how research is done. This lack of embeddedness extended beyond the decontextualized, impersonal, presentation of ecological truisms found in lectures and textbooks to the practice field research activities (the equivalent of physics and chemistry laboratory exercises) in which undergraduate ecology students engaged. In addition, courses rarely offer students the opportunity to examine a series of papers from a single author which would help them develop the understanding of the embeddedness of individual research projects in the broader of the discipline and individual researchers. For example, the Science Citation Index provides evidence that the project on bears is embedded in a series of

projects in that area over twenty years involving organisms at different trophic levels. In addition, collaboration with other researchers from other disciplines has allowed their tool-based practices and skills to be adopted for application to the broader ecological interests of the informant. Students have little guidance to aid them in observing research in this manner.

Many authors noted that a characteristic of most *formal* texts of laboratory science is the removal of all aspects of agency of the actors (e.g., Latour, 1987). Thus, through this stylistic structuring, greater authority is attributed to them because of distancing of the subjectivity of the agents involved in their construction (Gross, 1996). This process of lending authority to *formal* texts is enhanced by the manner in which the research is discussed ahistorically. The ahistoricity of the presentation in *formal* texts of knowledge claims and variables is problematic for those *in formation* planning their own field research. The absence of a sense of the passage of time provides those *in formation* little understanding of how experienced researchers frame and develop understanding. This includes the understanding of problems, how the concerns of the discipline change, and what variables are important in doing the research.

The *formal* texts of science present an objectivist perspective of the claims and processes as if they were purely factual (Gilbert & Mulkay, 1984). This differs from *informal* accounts of field research that has a contingent character. The degree of detail in *informal* texts about field practices (how observations are made, how features are considered important enough to warrant being defined as a variable for study, and how interpretations change over time) is not found in the *formal* texts. Discussions of field research in *informal* settings present this *information* differently than *formal* texts. Little or no discussion of this occurs in *formal* texts. These *informal* texts (and our ethnographic work in the field) reveal that data is collected because the opportunity arises for it to be collected, not because there is necessarily an immediate or conceptual reason to do so. Thus, the *informal* settings provide context and *information* about field research unavailable in *formal* texts to researchers *in formation*. For new (and old-timer) researchers detailed descriptions of fieldwork constitute a useful resource informing their (future) field research work. *Informal* settings provide this very sort of *information* within the narratives exchanged as researchers talk about their work and discuss their experiences.

In addition, the underdetermined nature of the *formal* texts has more significance for researchers *in formation* than for experienced researchers. Experienced researchers can draw on their own experiences to contextualize the *formal* written texts but those *in formation* have to rely on the text itself; so that which is unstated in those *formal* texts, available in some sense to experienced researchers as they use their lived experience to make sense of their readings, is unavailable to those *in formation*.

B(e)ar Talk and Social Cohesion

Interactions and storytelling in *informal* settings are quite important to ecologists for reasons other than for research purposes alone--ecologists seem to form a network of acquaintance that is based around the exchange of stories. Stories appear to reinforce this network of acquaintance in several ways and contribute to a social cohesion amongst ecologists. Within *informal* settings stories of work in the field are told over and again which contributes to cohesion between members that crosses more than just the immediate group of participants. Being a member of this community means being able to participate in those stories in diverse settings as one meets

unfamiliar ecologists when traveling or conducting research. We noted that several aspects of *informal* discussions contributed to cohesion (as well as being resources for new researchers). These aspects include discussions about individuals, discussions of common experiences, discussions of experiences across which ecological parallels can be drawn, and discussions of common (ecological) cultural touchstones that have salience to community members.

Social cohesion develops when individuals can find common ground in their interests and narratives. The excerpts related earlier represent one way in which stories contribute to social cohesion--by offering the opportunity for individuals to find examples of persons they know in common. In addition, such widely shared stories contribute to social cohesion by providing narratives that communicate concerns and issues of the discipline in a manner accessible to any member of a group in which the story is discussed. Thus, exchanging stories allows ecologists to form a community not just of practice and concerns and language, but also of social experience--our work suggests that the social interactions outside of work hours are of considerable importance in becoming an ecologist.

During our ethnographic work who-knows-whom was a frequent topic of conversation in *informal* settings. We noted that individuals who conduct field research, even in unrelated topic areas, are often broadly known. Researchers were known and talked about because of groundbreaking research they had done in the past and were commented upon in conversation in the context of talking about individuals who had influenced their own research work. In one case, an individual who did graduate work with turtles in the mid-1980s was known by ecologists who worked with lizards, migrating ducks, snakes, tree ecology, and minuscule insects. We also noted that knowledge about various individuals and being able to relate tales of that work appeared to be a key factor that allowed us to be accepted into groups of ecologists. We were struck by the extended network that linked ecologists, for it was a rare assembly where there was not at least one common acquaintance. Clearly, part of his acceptance into groups of ecologists was because Bowen could claim prior acquaintance with other members in the network of ecologists.

Story telling, and the topics and individuals about which those tales are told, provided us access into even newly-met groups of ecologists. In this, as we noted earlier with inexperienced researchers, it was not sufficient to merely have experiences to tell, but to be able to relate them in the context of the work of others that was important. We observed newer graduate students, over many months, at first sit quite quietly in groups, and then begin to contribute field-based narratives into the context of the conversations. As noted, this rarely happened when they were in groups of M.Sc. graduate students (they did not try out their stories in settings of peers) but instead usually occurred in discussions at which professors, Ph.D. students, or post-doctoral fellows participated.

In part, social cohesion develops because of experiences shared in common not directly related to research but arising as a consequence of engaging in field research. For instance, whether one is concerned about ecology of a particular lily that grows on the edge of meadows, studies lizard biology, is interested in insects which grow at the top of thirty-meter tall trees in rainforests, examines distribution and breeding of woodpeckers, or is interested in the utilization of spawning salmon in coastal streams— quite diverse ecological topics— there are stories which are based in the common experiences of those respective individuals which can be related amongst individuals in those projects.

Informal settings also offer ecologists the opportunity to share observations that they refer to as "anecdotal," in other words, observations that are not sufficiently substantiated to warrant publication. Our observations during *informal* conversations suggest that these conversations help ecologists make sense of their anecdotes in a broader ecological context by providing a forum for people working on different organisms or in different biomes. For instance, the observations regarding salmon behavior at nighttime in the estuary and porpoise behavior are not related in any *formal* texts, and were not mentioned even in the *informal* verbal presentation. Yet sharing these observations helped develop understanding of ecological relationships. For researchers *in formation*, these anecdotal conversations would contribute to their understanding of the development of scientific claims.

Many of the stories that contribute to social are heroic stories because they relate unusual accomplishments and dangerous encounters. Although these heroic stories occur to some degree in other *informal* settings, they are notably frequent in bar settings attended by mixed groups of researchers. In these settings stories about getting into street fights in foreign countries, dangerous situations in remote areas, and survival in adverse conditions are common. It is not surprising that much of the stories involved bear because of the geographic location of our research groups and the wilderness settings in which they worked. Thus, in bar settings stories about research on bear-salmon interactions included details not provided in other forums.

> Told the people in the bar (when stories were being traded) about having bears brush up against him, when he was observing them at night times, as they rushed to the stream to get to the salmon. He talked about how unnerving this was at first but that the bears seemed to ignore him completely because of their focus on getting to the stream. (GMB field notes)

In this most *informal* of settings, we heard stories about working with the bears and salmon unlike any of those related in any of the verbal presentations or formal writings about the work. For researchers *in formation*, this is a view of research unavailable in other contexts. In contrast to his *formal* texts, our bear researcher admitted how nervous he was initially. In the public talk he told how close he came to the bears and how he could see them with his night glasses but that the bears were unable to see him. In the bar setting, we first heard him talk about the initial stages of the research when he saw little after night fall but felt and heard the bears close at hand. What our words here communicate poorly is the intensity of the feeling he had about those encounters— the initial perception of danger was communicated in his voice unlike that in any other setting.

Heroic stories about bears are not just related by the researchers engaged in bear research, but are common currency in the stories of field research, as the following field note suggests. These heroic stories also contribute to the social cohesion of the ecologist community.

> She then related another short story . . . about another time a bear was "that close" [gestures about three to four meters] and how she made a loud noise to scare it off. RR then related that the "biologist in me just wants to watch," but then she realizes the danger and makes a loud noise so the bear knows she is there. Nat then related a story of spraying the bear that was "this close" [points to a spot about two meters away] away, then followed it up with a story about walking along a trail towards his quad [a bush vehicle] and then "I noticed three patches of black up a tree, three cubs. I froze, and then looked around. I couldn’t see the

> mother anywhere, but didn't know where to go. I didn't know what to do. If she was behind me (and away from the quad) then I'd walk into her and be between her and the cubs. If I walked towards the quad then I'd be walking towards the cubs, also not the smartest thing to do. I debated whether to cut off into the woods off the trail and circle around, and that's what I finally did. At first when something like this happens you think about getting your camera out of your backpack because it would make a neat picture. And then you realize that would be stupid, that you've got to get out of there."

These heroic stories were present in other settings as well, but the social groupings in the bar (where professors sat with graduate students more so than other places) appeared particularly conducive to the relation of harrowing stories of survival and danger in field settings. What is significant about these stories is that while some stories were told and retold in the form of autobiographies, others were retold by individuals who had heard the stories from another ecologist. Thus, these stories, much as those about well-known individuals (such as the east coast eccentric) constitute some of the cultural capital that constitutes membership in the community of ecologists. By learning, and being able to retell, these stories new members are enculturated into the community thus gain access to the pool of knowledge and the individuals within it who share these common experiences and stories.

Discussion

Becoming a member of the community of ecologists is more than becoming a member of the community of practice, for being an ecologist is more than just engaging in the science aspects of field research and interpretive practices. The stories and other informal exchanges within ecology provide substantial resources for new ecologists to draw upon for their own work— often unavailable in the formal texts of ecology. However, informal settings and the narratives related in them also embed new ecologists in a social framework of experiences and activities apart from the academic ones. Unlike participating in many professions, participating as researcher in ecology includes commitment to social gatherings (Friday beers, Wednesday pool, conference drinking) as much as it includes commitment to doing research.

Undoubtedly, part of the reason for differences between the content of *formal* and *informal* oral presentations was the amount of time and space available; the *informal* talk was eighty-five minutes in length compared to formal conference presentations are typically fifteen minutes long. However, the ecology lectures we observed were fifty minutes in length and yet rarely discussed field research in the manner it was presented in informal settings. This suggests that the differences in content reflect an epistemological view that students are there in a lecture to learn the knowledge claims of ecology and not about "anecdotes" of field practices--even though field researchers themselves recognize the importance of anecdotes to the success of their work.

Stories play an important role in the social fabric of practitioner communities. Thus, "knowing the stories and performing in the appropriate style is an unmistakable sign of being a real particle physicist, of knowing particle physics, and of knowing how to make knowledge of particle physics" (Traweek, 1988, p. 121). However, Traweek's descriptions of the stories suggests that they are often highly technical using specialized language and that the conversations frequently dealt with learning what new claims are made and what new techniques are developed in the discipline. In this, the stories of physicists differ from those told among ecologists which often

deal less with knowledge claims and more with doing research; how someone deals with a research problem or survives a dangerous situation. Nevertheless, the outcome of this "gossip" amongst high-energy particle physicists seems similar to what we note in ecologists--it helps structure and connect a small, geographically diverse community. However, whereas stories are used by particle physicists to control who is (to become) a particle physicist, being able to participate in the stories is one of the ways in ecologists are accepted. *Informal* settings contribute substantially to the success of field research. This needs to be considered when educators examine and plan the programs for those *in formation*. Divisions that occur in post-secondary institutions between undergraduates, graduate students, and professors are clearly counter-productive; for the most substantial resources of *information* on field practices rarely interact in *informal* settings or socially with those who are about to engage in their own work.

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About the authors...

G. Michael Bowen is on faculty at Lakehead University, 955 Oliver Road, Thunder Bay, Ontario. P7B5E1. All Correspondence should be directed to him via post or e-mail: gmbowen@yahoo.com.

Wolff-Michael Roth is a Lansdowne Professor, Applied Cognitive Science, at the University of Victoria, British Columbia.

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