

A Method for Knowledge Management and Communication Within and Across Multidisciplinary Teams

Don FLYNN
Erin BROWN
Rebekah KRIEG

Pacific Northwest National Laboratory¹, PO Box 999,
Richland, WA 99352, USA

ABSTRACT

The use of knowledge management (KM) and communication tools in an applied scientific arena where research is performed and knowledge must be managed within and across multidisciplinary teams and organizations is a challenge. Teams of scientists and engineers from up to 17 different technical specialties required knowledge management tools for developing multiple environmental impact statements under challenging circumstances. Factors that contributed to the success of the KM tools included 1) pairing of project staff with Knowledge Systems staff to determine system requirements, 2) the use of the tools by the team as they were being developed thus allowing many opportunities for feedback and interaction, 3) developing the tools to approximate the overall project structure and work flow already in place, 4) providing immediate assistance to the project team as they learned to use the new KM tools, and 5) replacing earlier practices with the new KM approach by “burning the bridges” to past practices after the team had learned to use the new KM tools.

Keywords

knowledge management, multidisciplinary teams, environmental, document storage, records, collaboration, photograph management

INTRODUCTION

The continual growth and presence of information technology in today’s business sector is driving expectations of knowledge management to new heights. The market is rich with web-based services and technologies designed to capture corporate knowledge, retain it, and present it back so learning can be efficiently accomplished by a new era of knowledge workers. While this seems like a straightforward concept and can be applied in some well-defined business areas, it is a much larger challenge in the scientific arena, where research is performed and knowledge must be managed within and across multidisciplinary teams.

In the classic sense, knowledge management is usually considered to be the preservation of knowledge involving people common to a single organization. Most literature on the topic points to business entities, such as the classic customer service model [1]. Service providers build large knowledge bases, making those resources available to new staff members. While this is applicable to stove-piped organizations, the

challenge lies in how to distribute knowledge across sectors, and further, across scientific disciplines. Knowledge needs to be captured and transferred at a level that allows for seamless collaboration, while at the same time being specific enough so that efficiency within a discipline is not undermined.

The key is to enable knowledge transfer—the ability of one individual to learn or gain the knowledge of another individual or set of individuals either within a scientific discipline or across many [2]. Knowledge transfer can be represented by the use of web portals, or more specifically, knowledge portals. Existing services provided over the web for knowledge transfer can be encapsulated in a knowledge portal that contains learning tools such as tutorials, reference materials, knowledge bases for frequently asked questions and portal search capabilities for the support of ad-hoc inquiries. In addition, a host of new services coming to fruition provide additional assets for capturing and sharing domain knowledge across scientific disciplines.

This paper describes a knowledge management and communication solution for a diverse group of scientists who are conducting environmental reviews for a Federal regulatory action as mandated by the National Environmental Policy Act (NEPA). Although not normally considered a highly technical endeavor, in this case several factors required the development of a knowledge management (KM) and communication infrastructure to successfully complete the reviews. The review process, issues that required the infrastructure, the solution that was ultimately developed, and the cultural shift that accompanied its use are described.

REVIEW PROCESS AND KEY ISSUES

NEPA requires government agencies to consider the impacts on the human environment of all proposals for “major federal actions.” The review process used to fulfill the requirements of NEPA covers a wide range of natural resource and socioeconomic impacts. Depending on the action or type of review this may require varying numbers of individuals from multiple technical specialties to coordinate with each other to develop an environmental impact statement.

In the current example, teams of scientists and engineers from up to 17 different technical specialties are collaborating to develop environmental impact statements (EISs) that inform decision-making related to licensing applicants’ plans to construct power facilities to meet national energy needs. This environmental review process is structured so that the review of each site involves an environmental review (ER) team (here after referred to as a “site review team” composed of a team leader and deputy and one or more scientists or engineers

¹ Pacific Northwest National Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under contract DE-AC05-76RL01830.

(subject matter experts) from each of the following technical areas:

- ground water hydrology
- surface water hydrology
- land use
- aquatic ecology
- terrestrial ecology
- socioeconomics
- health physics
- industrial hygiene
- cultural and historic resources
- accident analysis
- alternatives
- system design
- need for power
- cost-benefit analysis
- air quality/meteorology
- environmental justice
- transportation.

The process starts with an acceptance review where the teams inspect the application to construct the power facility. After it is deemed complete, the team conducts a site audit, scoping meeting, and drafts the EIS. The site audit involves visiting the location where the power facilities are to be built. The scoping meeting is where the team gathers information from the public near where the power facilities would be built. This information is basically questions about how the area might be impacted and what concerns the community has. These concerns and questions define the scope of the EIS and allow the team to start creating the first draft. Once the draft is complete it is shown to the public for more comments. Next, the final EIS is constructed and submitted. A hearing is held to officially record the licensing proceedings and reach a final decision about allowing the power facility to be built.

Initially, the overall project team consisted of approximately 25-30 core staff, whose numbers soon grew to 100 to meet the need to staff the growing number of scheduled environmental reviews. Even so, subject matter experts may work on multiple (2-6) reviews at a given time at unrelated facility locations in different parts of the country. In some cases the main subject matter experts may have additional (non-core) staff assisting them with the review. These staff are not able to travel to visit the site being reviewed and must depend on the information and knowledge brought back to them by the main subject matter expert.

Coordination and communication was required between the team members on a given site review team because information developed by one subject matter expert affected the review of other subject matter experts. In addition, each technical area needed to be coordinated across the site reviews so that a subject matter expert on one site review is performing the review in a consistent manner to that being performed by a different subject matter expert reviewing the same technical area on a second site review team, while taking into account differences in facility design or location of the sites. This served two purposes – coordination of the reviews and consistent direction to new staff joining the team as subject matter experts. To this end, in addition to serving on individual site review teams and based on their subject matter expertise, project scientists and engineers also were organized into cross-cutting technical area teams whose membership represents one

of the technical areas listed previously. Figure 1 shows the relationship of three of the review teams. The team members on each site review team must communicate with each other to ensure their review is performed correctly. However, the subject matter experts, such as ecologists, must also communicate with each other between and across site review teams to ensure consistency of approaches taken in each of the environmental reviews. Thus KM tools were needed to assure communication and information sharing between members of each site review team as well as across the site review teams through the individual technical areas.

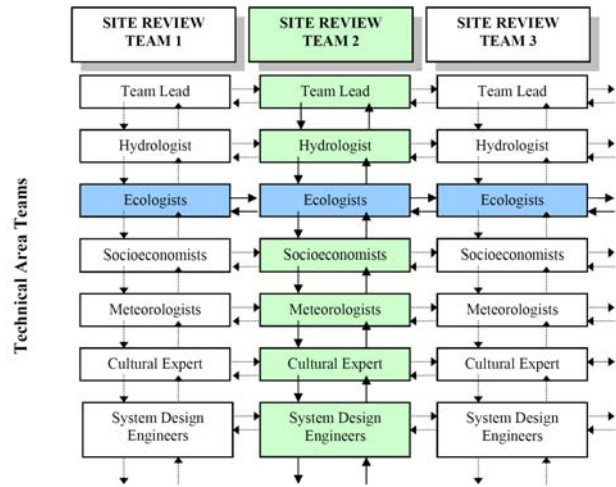


Figure 1. Relationship between the site review teams and the technical review teams showing the lines of communication down and across the teams.

In addition to needing to address the issues of staff growth and communication across technical area teams, other major challenges include the use of separate teams of staff members for pre-review site visits, multiple stakeholder engagements that many or all team members need to be aware of, shifting schedules, and an evolving regulatory environment. The use of separate teams for pre-review site visits and early engagement meant that the KM tools were necessary to assure that appropriate information could be conveyed in a timely manner to provide the reviewers with a history or technical basis for their reviews. The evolving regulatory environment was such that the regulations or regulatory guidance that applied to a specific review might change in the middle of a review or at the beginning of a subsequent review. The changes in regulatory environment meant that specific review tools (such as checklists or templates) or review procedures were periodically shifting, requiring changes to guidance documents and tools to complete the reviews. As a result of the critical schedule and the potential for change in key elements of the review, it was important that all team members be apprised as soon as possible about changes and their effects on the review process and contents from the perspective of each specific review and each technical area.

SYSTEM REQUIREMENTS

The KM tools developed to facilitate and ensure the success of the review process were derived by initially pairing Knowledge Systems experts with the subject matter experts who comprise the ER teams to define the system requirements. Very few of the project staff had any type of experience with more advanced

KM tools and although they recognized the need to implement KM tools they were not sure of the available options. Focus group meetings representing both groups were held at the onset of the project to discuss options, needs, and requirements for KM tools. Approximately 25 core staff attended at least one of the focus group meetings to ensure the acquisition of a broad spectrum of ideas related to the necessary system requirements. Other laboratory staff members were invited to attend these meetings, especially if they were being considered for the project or had previous experience on projects that had developed and initiated team-wide use of KM tools. This engendered a positive blend of ideas and concepts.

As a result of the focus group meetings, system requirements were defined to include the following:

- Document storage capacity. Sufficient document storage capacity was needed for the appropriate review tools (such as checklists, templates, guidance documents, references, and previous review documents), that team members would need to refer to and use on future reviews. It was estimated that the entire project would be storing over 20,000 documents, so a simple method for locating them was also necessary.
- Ability to update and revise review tools. Because of the changing regulatory guidance and evolving nature of project information, the ability to update and revise review tools (with clear instructions for staff members) was required. The potential for two or more site review team members to try to work on a specific document at any time drove the requirement for the ability to “check out” or “lock out” the document.
- Discussion boards and commitment trackers. These system design elements were needed to enable reviewers to communicate insights either within their site review teams or across the technical area teams to assure that the next scheduled site review team would be able to take full advantage of prior lessons learned. Decisions that were made as a result of the discussions and associated commitments to take follow-up actions needed to be captured.
- Team Administration. Information such as contact lists, schedules, team member lists and calendars were necessary to ensure that team members had current information.
- Ability for a reviewer to locate a document, reference, or website that would be used multiple times and store it in an easy-to-find location so that the same reviewer or other members of the site review team could easily find it without having to perform another web search.
- Ability to display photographs of the review site linking to a global positioning system (GPS).
- Ability to view the review process from different perspectives. The documents and information that are important to a team leader differ from those that are important to a hydrologist, so the KM tools needed to enable all team members to quickly move to the document or information that they would be trying to access.

- Ability to develop the technical area team webpages to appropriately reflect the diverse types of reviews performed by the technical area teams. This meant having different content on each site, some requiring internal links to other areas of the site, others requiring links to calculation codes or external links to information such as census data. Each technical area team webpage contained special folders or areas for storing background information specific to the technical area.
- Ability to post and save team announcements or discussions directly on the website rather than having to email the team members.
- Ability to receive an alert via email upon posting an announcement, discussion, or file.
- Ability to protect specific files (read only; protected access) while allowing open access to other parts of the website.

SYSTEM DESCRIPTION

The system requirements were germane to selecting a specific platform for the KM infrastructure. After considering several options, a Microsoft Office SharePoint Server was selected as the most flexible option to meet all requirements. SharePoint handled file storage and document management well. It could also store lists of information to be displayed in many different forms depending on how the user wanted to design the website. There were lists for discussions, data, events, announcements, and more. SharePoint even allowed for customized permissions for individual documents and folders. This product had everything needed to manage the knowledge generated by the team. Our company had already adopted and technically supported SharePoint, so it was also the easiest solution to set up and maintain.

Once the infrastructure platform was selected, website design was initiated. Because the primary function of the site was to store documents, a web part was custom built to display the documents. This web part, which is called a Tree View, improved upon the core functionality of SharePoint’s library features. Because the members of the site review teams were accustomed to working with Windows Explorer, the Tree View was built to resemble Windows Explorer, in that it has folders that can be expanded and collapsed in one pane (on the left) and the contents of the currently selected folder in another (on the right) as can be seen in Figure 2. The Tree View enables users to view all properties of a document, check it out, edit it, view previous versions, customize the permissions, or delete the document. Folders can be created and documents can also be uploaded from this screen.

The Tree View allows users to do everything they do on a file share directly from the website. This web part is used on many different webpages on the site. For example, the reference library page shown in Figure 2 was built as a document storage location where the site review team could count on finding commonly used reference information. The Tree View is used anywhere documents are displayed for the users to edit or read. In some areas, the amount of folders being displayed by the Tree View was growing quite large. To keep this from becoming a problem, we added icons that could filter the documents into different subject areas. This keeps the Tree

View from becoming cluttered and helps the user find what they are looking for faster.

To accommodate the learning needs of the increasing number of people being brought onto the project, a suite of tools was compiled to help during the different phases of the established review process. Webpages, which were developed for each phase of the review, address the information to be gathered and the questions that need to be asked and answered during each phase. Similarly, a page addresses how to prepare for and conduct a site audit to gather the information needed to develop the contents of the EIS. Templates are provided for the documents that need to be written, and other pages address content development, editorial needs, and what to expect at a public hearing. This series of webpages provides a place for staff to refer to when they need help completing a task or developing a product, or when they have a useful tool to post for others to use.

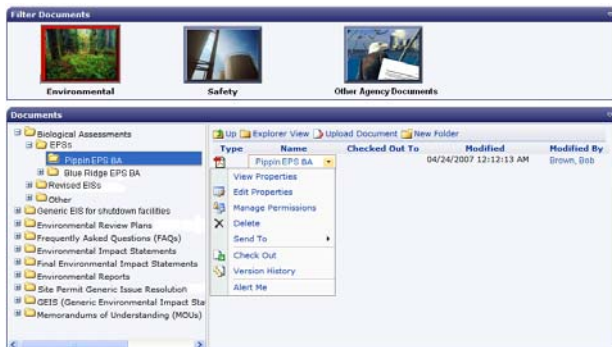


Figure 2. On the reference library page, the custom-designed Tree View displays background documents whose contents remain fairly static. Icons filter the folders shown to reduce clutter.

For each of the technical areas listed previously, a webpage was created as a storage place for information relating directly to that technical area. At first, all of the technical area webpages were designed the same, with a place for documents, a discussion board, and a calendar. With hands-on use of the webpages, the subject matter experts soon found that they had their own ways of doing things and the originally designed webpages didn't really fit the way they worked in their technical area. Now each technical area webpage is customized by the technical area team lead (Figure 3). This way the technical area team members can highlight the information that is more important to them and organize their documents in ways that make sense to their technical area. For example, the hydrologists like to sort their documents by type, so there is a place for the environmental reports, EISs, etc. Then under each type, the documents for each site are listed. However, the aquatic ecologists like to separate the documents for each site into their own page, so they can deal with all of the documents pertaining to a site in one place.

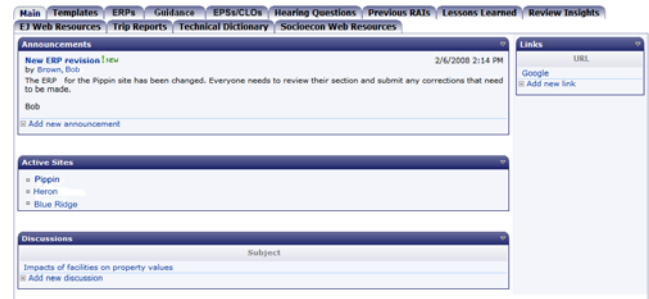


Figure 3. Each technical area has a unique web page. This is the layout of the Socioeconomic's technical team page.

A webpage also exists for each licensing applicant's site (review site) to contain all of the information pertaining to that site (Figure 4). If team members have questions about a trip itinerary or what needs to be done to prepare for a trip, they refer to this page. A place for announcements replaces the need for mass emailing of schedules, deadlines, and other important information and it avoids the problem of people being left out of the communication loop. All of the important announcements are placed on the site for the team to see. As a bonus, SharePoint allows users to set up something called an alert, which is triggered by a specified event to notify the user. In this case, every team member has an alert set to email them the announcement when a new one is added. So people know immediately about anything important, and if they lose the email it is still easy for them to find on the website. Below the announcements, a list of all of the documents uploaded about the site during the last month is provided so people can quickly see what is new. Then there is a calendar of all the site-specific events, a list of the alternative sites, and a list of all of the different teams that have worked on the site. Users can also access review-specific information covering each phase of the review process. Finally, there is a place to view the photos for just that specific applicant's site, a discussion board, and the contact information for the team members.



Figure 4. The layout of the site-specific pages.

Every time team members travel to one of the facility sites being reviewed they take pictures using a camera with a GPS device to document the pertinent areas of the site. This information is brought back to help subject matter experts compose their portions of the EIS. It was decided that the website needed a tool to display this information in a way that would be useful to the team. Google Earth and Virtual Earth were considered as ways to place the pictures on a map to easily track where they were taken. Virtual Earth was selected because, as a Microsoft product, it would be more likely to work in Microsoft's SharePoint environment. A map was

developed showing every photographed plant and providing a way to zoom in to see where each picture was taken along with thumbnails of the photos taken during site visits (Figure 5). This page is also very helpful to team members who do not visit the site. Instead of just looking at a folder full of pictures, they

can see the path that was taken around the plant, where the pictures were taken, and read a description of what is depicted in each photo. Finally, this page enables site visitors to review the pictures before attending a public hearing.

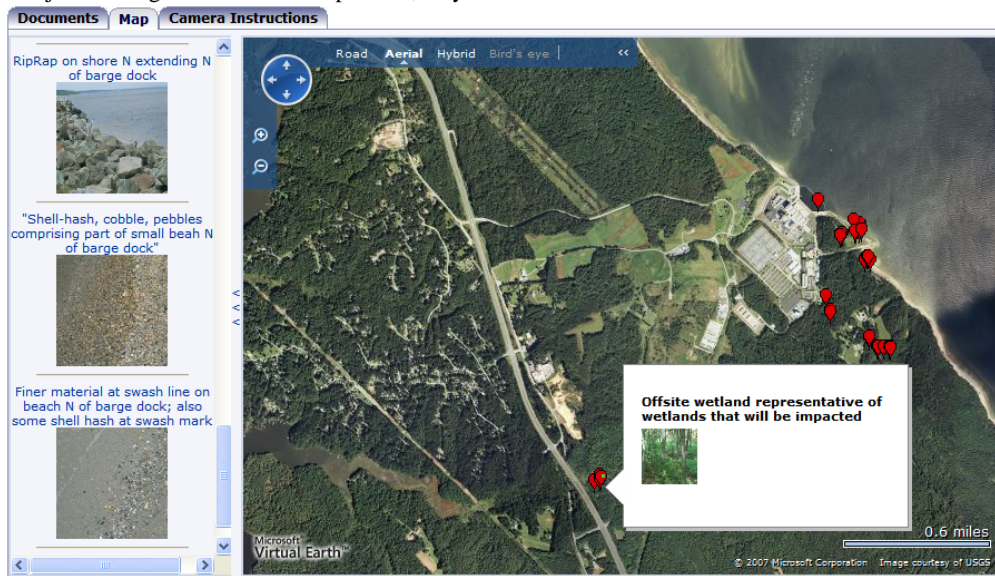


Figure 5. The map page shows the aerial view of the site and captioned photos taken during site visits.

Lessons learned continue to be of growing importance on the website and the way they are handled has evolved from the beginning. Documentation of lessons that had been learned started out as discussion boards where anyone could start a discussion of a problem encountered and people could comment on it. It was soon discovered that this approach did not guarantee any follow-up action. As a result, a custom tool, called the Commitment Tracker, was designed to track a lesson learned through its entire life cycle. When someone submits a problem for discussion, he/she has to assign an action to someone to make sure the problem is resolved and documented properly. The problem is sent to the assigned person who completes the action and informs the originator so that he/she can confirm that the action was completed. In this way all team members learn to apply lessons learned to avoid repeating the actions that prompted the original problem.

STEPS TO SUCCESS

The effectiveness of KM tools can be measured by how well and how frequently the tool is used. In this case, the effectiveness of the KM tools was improved by instituting five primary practices and/or site features (as described below) that proved to be most effective in moving the team culturally toward site use, as described below.

First, as discussed previously, before any development occurred, the core team of subject matter experts and team leads (approximately 25 staff members) participated in multiple focus groups with Knowledge Systems experts to describe their work process and define the system requirements of a KM tool. This enabled participants to leave each meeting feeling that the tool was being built for them and with their input, rather than feeling that they were going to be forced to modify the way they worked.

Second, the site review team members were able to watch the site develop and were given multiple opportunities to provide feedback on the site and its features and be trained in its use. The website was launched with minimal content in August 2006—about 6 weeks after the final focus group met to identify the site requirements. The availability of the website at this time early in the overall project schedule allowed the team to slowly become comfortable with the site and its contents while they were being developed. Feedback groups were initiated approximately 9 months after the site launch to provide team members with further guidance on how to use the site and to obtain their feedback, which was used to further improve the site. Subject matter experts reconvened several months later, this time within their specific technical areas to design and develop the technical area webpages (for areas such as hydrology or socioeconomics). Finally, as the actual environmental reviews were initiated (starting approximately 14 months after site launch), training was again provided to each of the site review teams. This allowed the focus of the training to change from “how does an individual use the website” to “how do you share information as a team on this website.” Again, a large part of the training session involved feedback from the users on how the site organization could be improved to match their work process and their interaction with each other.

Third, after closely engaging users in the development of the site, the site was designed as closely as possible to approximate the way the overall project work was structured and the work process used by the site review team members. For example:

- Instead of forcing team members to use the SharePoint folder structure, the Tree View was built to resemble the application (in this case Windows Explorer) that the team members most commonly used.

- The use of icons (such as shown in Figure 2) on the review site pages, and the reference library, assisted the team members with locating information that pertained to their sections of the review, rather than leaving them to sort through multiple folders for the necessary information. This was a compromise between having the folders set up so that they were understandable and useable by the team leads and having only those folders visible that were necessary for the rest of the team members.
- The technical area teams were allowed to design their own webpages to reflect the type of diverse reviews performed by the experts in the different subject matter areas.
- Team members were allowed to protect specific files (read only or protected areas), which is similar to what they can do on their own hard drive, while allowing open access to other parts of the website.

Fourth, the Knowledge Systems staff made a major effort to assist team members who were having trouble using the website. Team members could call one of the Knowledge Systems staff to obtain assistance on any problems or issues they were having with the website. The Knowledge Systems staff would try to assist them over the phone, but also could travel to the team members' offices. This was a very critical service, because early on several key team members became frustrated with the website only to discover that their desktops were not set up properly to take full advantage of many of the helpful functions of the website.

Finally, the previously used "bridges" were burned; i.e., earlier practices were replaced to support the new KM approach. For example:

- Team leads were required to send emails from the website rather than from email distribution lists. Alerts were set up on the sites so that the appropriate team members received the emails automatically. Documents that were referred to in emails were included as links rather than as attachments so that the team members were again directed back to the site.
- Guidance documents and review tools were changed often enough that ER team members soon learned that they needed to refer to the copy on the website, rather than a previous copy they had downloaded to their desktops.
- Project-related discussions that were initiated on emails were interrupted and moved to the discussion groups on the website. When discussions reached a conclusion, actions were placed on the website's commitment tracker form.
- Share folders where the team had been storing their reference documents were emptied and moved to the website. Although, in most cases, team members could obtain information from other sources, the time that was required to do so far exceeded the time needed to find the information on the website.
- Site review webpages were populated with information that was helpful to the site review teams; and the technical area webpages were populated with

information that was valuable to the specific teams of subject matter experts.

- Links of interest, including links to the company home page, pertinent Federal agency homepages, company travel forms, commonly used sites, weather, etc. were included on the website so that the team will use the website as their homepage rather than using another site.

CONCLUSION

Unlike personal desktop computers, the collaboration capability provided by the knowledge portal has proven to be most useful to the team for information sharing. The portal acts as a central repository of the most current and approved information. Scientists and engineers no longer need to email documents around the group or ask the question, "Which version is the latest?" The knowledge portal addresses this problem very successfully.

The knowledge portal hugely benefits the management and presentation of integrated data sets, such as photos and related metadata. The use of geographical information systems such as Microsoft Virtual Earth allows photographs to be pinpointed exactly to the physical location where they were taken using latitude and longitude coordinates. Each photograph is presented and augmented with additional information such as the date, photographer, direction, description, weather conditions, etc.

The use of knowledge portals has proven to be an effective technology for applying knowledge transfer between workers across different scientific disciplines. While some resistance and lack of desire to learn a new technology were encountered, overall the investment has proven beneficial. The time and energy that is required to post information and collaborate is minimal compared to the benefits and knowledge gained by others who have online and ready access to the information they need.

REFERENCES

- [1] Negash, S. and Rodgers, W. The effects of web-based technologies on knowledge transfer. *Communications of the ACM* (July 2007), 117-122.
- [2] Devin, D.J. and Kozlowski, S.W.J. Domain-specific knowledge and task characteristics in decision making. *Organizational Behavior and Human Decision Processes* 64 (1995), 294-306.