Using Web-Based Technology to Deliver Scientific Knowledge: The Southern Forest Encyclopedia Network

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Abstract

Forest science, like any science, is a continuous process of discovering new knowledge, reevaluating existing knowledge, and revising our theories and management practices in light of these changes. The forest science community has not yet found the solution to the problem of getting continuously changing science efficiently and effectively into the hands of those who need it in their daily work, the forest practitioners. The Forest Encyclopedia Network or FEN (www.forestencyclopedia.net) represents a new approach to the synthesis and delivery of forest science knowledge. The USDA Forest Service Southern Research Station, the Southern Regional Extension Forestry system, the USDA Forest Service State and Private Cooperative Forestry Program and the Southern forestry university community are all engaged in building and testing this new science delivery concept. The network currently has four encyclopedias in various stages of completion: The Encyclopedia of Southern Appalachian Forest Ecosystems, The Encyclopedia of Southern Fire Science, The Encyclopedia of South-Wide Forest Science, and The Encyclopedia of Southern Bioenergy. This paper will describe the history, current status, and future plans for the FEN project.

Keywords: Knowledge management, World Wide Web, hypertext encyclopedia.

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Background

It has long been recognized that knowledge has great value. Until fairly recently, however, most people did not think in terms of "managing knowledge." They felt that knowledge was a personal asset, the sum of our experiences, education, and our informal community of friends and colleagues that help us perform better in our complex world (Plunkett 2001).

As computer technology improved and became cheaper in the early 1990s, researchers in academia, government, and private industry began to explore the gains that could be made by organizing knowledge, codifying it, and sharing it more widely. The early innovators began to demonstrate that actively improving the management of knowledge could improve the ability of scientists to deliver their research results into the hands of users (Rauscher 1987), help government cope with downsized budgets and increased work (Plunkett 2001), and assist private industry with gaining and maintaining competitive advantage (Heinrichs et al. 2003).

We can define knowledge management as the systematic strategy of creating, conserving, and sharing knowledge to increase the performance of individuals, companies, or nations (Heinrichs et al. 2003, Plunkett 2001). The Forest Encyclopedia Network (FEN) was designed as a system for managing knowledge for the forestry community, based on Web technology, which is both maintained and distributed over the Internet.

Forest science poses a number of challenges to knowledge management. Certainly one challenge common to science in general is the way in which scientific

knowledge largely resides in highly technical, narrowly focused research publications. More particular to forest science is the array of disciplines on which it is based. Southern forestry brings extra challenges including its rich and evolving scientific literature and its diverse mix of landowners. Some 5 million private landowners control the forests of the South, with government managing just 11 percent (Wear and Greis 2002). Getting information to this large, diverse audience is a challenge that inspired us to develop FEN.

Web technologies offer a number of features useful for knowledge management and distribution. These include a rich set of development tools, universally available access, and an easy-to-use interface. Of special attraction is how links between pages can help organize large amounts of information into a hypertext and how Web standards permit the display of various media in an attractive and interactive interface. The FEN exploits these features, building on earlier efforts in forestry. These include Rauscher (1987), who introduced the concept of modern knowledge management to the natural resource field. Rauscher (1991) followed with the first electronic hypertext encyclopedia called "The Encyclopedia of AI Applications to Forest Science." Other hypertext products for nonnetworked personal computers followed in rapid succession (Rauscher et al. 1997, Reynolds et al. 1995, Thomson et al. 1993).

With the growth of the Internet, knowledge management systems using Web-based hypertext gained an enormous competitive edge over stand-alone systems. In a pioneering effort, Thomson et al. (1998) combined knowledge-based systems processing and hypertext markup language (HTML) to provide forest tree disease diagnosis over the Internet. Anyone with a Web browser could now access the diagnostic software. Examples of Internet-based knowledge management systems for natural resource management can be found at FEN where a growing number of scientific encyclopedias can be found (Kennard et al. 2005).

Approach

The FEN facilitates the transfer of usable knowledge from scientific experts to managers, policymakers, and natural resource professionals. Users of the site are offered what adult educators call a self-directed learning tool where individuals can obtain information on an as-needed basis.

A typical encyclopedia project begins with the development of the "core material." It is directed by one or more subject matter experts who act as the managing editors. These editors are responsible for creating an information architecture, identifying the content and engaging authors to write needed synthesis pages. They are also responsible for guiding the peer-review process for each section. Assistant editors work with the managing editors to ensure that the content material gets properly placed into the hypertext encyclopedia and that the figures, tables, and citations are all properly linked. Finally, technical specialists are responsible for maintaining the common computing infrastructure and making improvements in page design, workflow, and system function.

All of the various encyclopedia projects share the same computing infrastructure to reduce implementation costs. Once the "core material" for an encyclopedia is in place, it moves to a continuous update mode where various authors submit new or revised material to keep the content current and expanding.

Content

The FEN offers concise, authoritative syntheses of knowledge tied to the scientific literature on which it is based and organized to meet user needs. Content is often drawn from existing review documents but if necessary is custom written for the encyclopedia. Content can be in several forms, including narrative text pages, citations, data tables, and figures. Each page is embedded in a subject matter outline that provides context and enhances understanding.

Content is arranged as a set of narrowly focused Web pages, each tied to a rich set of related information. Arranging content into a large set of tightly focused Web pages makes it easier for users to find specific content relevant to their needs. A search for the term of interest brings the user to a particular page, and the navigation pane places the page in context and identifies pages with related content. Arranging content in this way also makes it easier to delegate authoring and revision processes, speeds downloading of content by the user, and makes it easier to reuse the same content in different contexts.

Quality of content is ensured through the same means used in more traditional scientific publications. All content includes author attribution and full citations. All content must also pass anonymous peer review before being published on the Internet. Updates to the content must undergo the same peer and editorial review as original content.

A hierarchical information architecture organizes this wealth of information. Every page clearly displays to the user where the current page resides in that hierarchy and offers navigation options to other portions of the hierarchy (see fig. 1). These supplement the hyperlinks provided in the body of the content. The hierarchy is easily extended and modified to adapt to evolving content and user needs. Indeed, although not yet implemented, the system can permit users to select alternative architectures, rearranging the navigation structure to better suit particular needs. Alternative architectures could be offered to facilitate reuse of the same content for specific workshops or courses, for special-purpose collections, or to highlight specific topics.

The four encyclopedias at FEN together offer about 1,700 pages of content, over a thousand images, and over 7,000 citations. By sharing a common set of development tools, the individual encyclopedias at FEN can share content and operate more efficiently. However, each encyclopedia retains its own management and information architecture.

Contributors

Creating and maintaining encyclopedias takes a great deal of effort and thus requires contributions from a wide array of institutions and individuals.

The FEN was created as a collaboration of the USDA Forest Service Southern Research Station, the Southern Forestry University community, the USDA Forest Service State and Private Cooperative Forest Program and the Southern Regional Forestry Extension System. The first two organizations have conducted forest research and the latter have worked closely with landowners and managers to use resulting information to improve forest practices in the South. This multiagency collaboration draws on the strengths of all parties to improve how scientific information is summarized and delivered to the broader forestry community.

Funding from these sponsoring organizations has been augmented by grants from USDA's National Research Initiative and Bioenergy program, the National Fire Plan, and the Joint Fire Science Program.

Editors for the various encyclopedias in FEN design the information architecture for each encyclopedia, identify source materials, and recruit authors and peer reviewers. Editors also edit content for consistent style and formatting and add hyperlinks when necessary.

Authors write original content either expressly for an encyclopedia or for more traditional outlets. Authors are generally experts in their field. Various federal and state agencies and nonprofit organizations have contributed authors. The majority have come from universities and the Southern Research Station.

The FEN currently has an editorial board of nine editors and is drawing on content from over a hundred corresponding authors.

Process

Specialized software tools and efficient project organization are needed to coordinate the efforts of numerous editors and authors across diverse organizations and locations. The FEN uses a customized content management
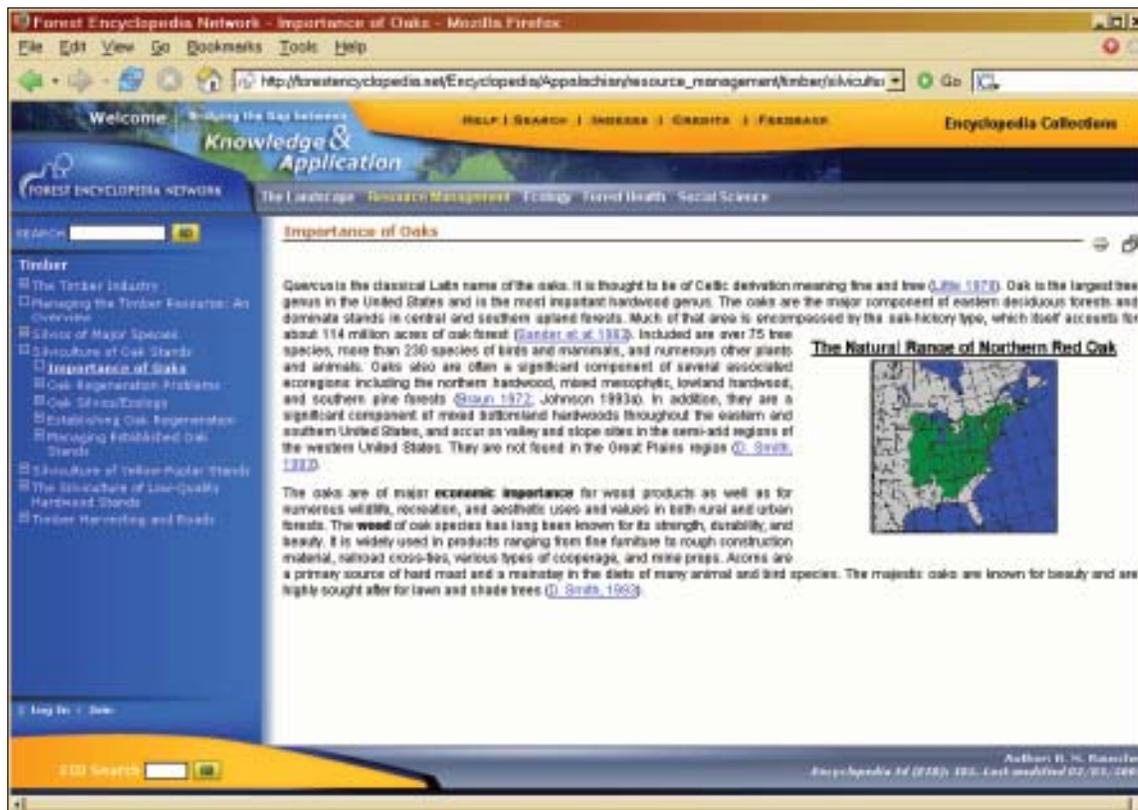
Figure 1—Sample content page in the Encyclopedia of Southern Appalachian Forest Ecosystems showing top-level (near top) and lower level (left side) navigation options.

system (CMS) based on the Content Management Framework of Zope, itself an open source Web development environment (Learner 2002). Jordin and others (2003) provided technical details. This paper will focus on current workflow and features.

Customized CMS software simplifies Web authoring and citation management, standardizes page design and display, enforces role-based security, and manages the flow of work from content creation through peer review, editing, and publishing.

The FEN leverages Web technology and the Internet not only for distributing its content but also for managing it. Editors, authors, and peer reviewers can all perform their tasks from anywhere on the Internet by using commonly available browsers. This capability makes it easier to recruit talent regardless of their location.

Role-based permissions allow editors to perform tasks different from those of authors or peer reviewers. They also control access to information. For example, to ensure the anonymity of the peer-review process, editors can see the identity of peer reviewers but authors cannot. Each individual can be assigned authority over portions of content. Identities are confirmed by ID and password combinations.

The content management system manages content as an object-oriented database, assembling Web pages dynamically when requested. This allows the navigation options to dynamically reflect existing content and makes it much easier to change the information architecture. The system automatically generates a table of contents and lists of figures and tables, as well as a search index. Improvements to the user interface are applied easily and consistently across the site.

Predefined workflows ensure that content moves from authoring through peer review and editing, with editorial approval prior to publishing on the public site. Task lists are generated for each individual with email notification of newly added tasks. Published pages that are undergoing revision remain visible to the public until the revised content is approved for publication.

Hyperlinks are automatically adjusted when content is moved in the information hierarchy to prevent dead links. Advanced portal tools permit construction of alternative displays and functions for different user groups or preferences.

Implementation

The FEN is the result of both insightful design and experience. In April 2000 it began with a single encyclopedia—the Encyclopedia of Southern Appalachian Forest Ecosystems, abbreviated ESAFE (Kennard and others 2005). The first managing editor of ESAFE was Deborah Kennard. When Kennard moved to managing the Encyclopedia of Southern Fire Science, Michael Rauscher took over as managing editor of ESAFE and Patricia Flebbe, David Wear, Kenneth Cordell, and Dennis Ward became section editors. The ESAFE was published in 2004 following full peer review. It demonstrated the feasibility of using a Web-based organization and delivery platform for scientific knowledge.

The ESAFE provided a number of lessons. Its logistic underpinnings were woefully inadequate for managing the content of multiple authors and did not provide the flexibility to evolve with content over time. It did, however, prove its utility to customers, as expressed through a customer survey conducted in 2002. Visitors to the site appreciated the content, organization, and navigation but wished to see improved access to the underlying scientific publications, more content and more illustrations. Their suggestions were incorporated into the present product.

The success of ESAFE encouraged the establishment of other encyclopedias. The Encyclopedia of Southern Fire Science, edited by Deborah Kennard and Cynthia Fowler, was second to the network and is now largely complete. A third encyclopedia, the broader Encyclopedia of Southern Forest Science, is well underway. It will draw initial content from two publications offering a combined 1,000 printed pages of peer-reviewed content (Rauscher and Johnsen 2004, Wear and Greis 2002). Editors are Mike Rauscher and John Pye, with completion expected by 2006. The most recent encyclopedia, still in its early stages, is the Encyclopedia of Bioenergy/Bioproducts (Smith, in press)[2]. Its managing editor is C.T. Smith and is scheduled for completion by late 2006. We expect to shift to maintenance activities on the first two encyclopedias around mid-2005. Several additional projects are under evaluation.

At present, each encyclopedia has its own content and information architecture. Revisions currently unfolding will allow the same content to be used in multiple encyclopedias, facilitating the creation of broader collections of information as well as the reuse of specific content wherever it is appropriate.

Challenges

The FEN is a new approach to the delivery of scientific knowledge to users. Project members have successfully launched four encyclopedias on various topics and guided the software infrastructure through three major revisions. Many challenges have been overcome to prove that the encyclopedia approach is indeed a viable scientific knowledge management and delivery mechanism. Some challenges remain.

One continuing challenge is motivating scientific experts to synthesize scientific information and provide it in appropriate form to the editors. The FEN must find ways to demonstrate the worth of the contributions of authors and editors in a way that is recognizable and

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[2] Smith, C.T. Knowledge products to inform rural communities about sustainable forestry for bioenergy and biobased products. This was a power point presentation at the conference.

valued by their peers. The Director of the Southern Research Station has indicated he supports allowing its scientists to claim encyclopedia contributions as a peer-reviewed product in their performance evaluations. A marketing effort is currently underway to persuade the scientific community that contributions to the encyclopedia are an excellent way to get research results into the hands of users while earning a peer-review credit for their own career enhancement. Page activity reports can also provide authors and their supervisors feedback on the utility of their work.

Writing style is another challenge. Most scientists are more familiar with writing in the lengthy, linear style common to traditional journals than the punchy, conclusion-first style needed in the hypertext world of the Internet. Forest Encyclopedia Network's editors can assist the authors with this transformation. Closely related to writing style is inclusion of graphics, another area where the assistance of editors and graphics support staff could improve migration of material to the Web.

Just as writing styles need to change, so too must content. Procedures must be developed to identify obsolete content, enlist authors to update it, and provide proper attribution to what in some cases may be minor revisions. One option FEN is exploring is an archiving system that would allow visitors to "peel back" current contents to reveal previous versions, showing what previous authors wrote on the subject. This could show visitors how scientific understanding and its expression in the encyclopedia have changed over time. Most Web sites focus on delivering current information. Designing an interface that shows change in content over time without confusing the audience would be a substantial achievement.

Another challenge is refining how we promote the encyclopedias to potential users. Although promotion can include traditional outlets like trade journals and conferences such as this one, additional avenues need to be explored including link promotion, improving the ranking of key content by commercial search engines, and sharing of FEN content with broader collections.

Particularly critical is the use of the encyclopedia content by extension professionals. Extension specialists should be able to easily take encyclopedia content and use it in various forms to support end-user training and education programs. The FEN collaborators are currently designing a marketing program to improve the visibility of FEN among extension specialists and natural resource managers and to encourage their advice on how to improve its content and delivery.

Literature Cited

Heinrichs, J.H.; Hudspeth, L.J.; Lim, J.S. 2003. Knowledge management. In: Hossein B., ed. Encyclopedia of information systems, Academic Press. 3: 13–31.

Jordin, J., Jr.; Hubbard, W.; Kennard, D.; Milnor, W.; Rauscher, M.; Veal, B. 2003. Using the Zope Web application framework to build and manage a large encyclopedia of scientific knowledge. In: Innes, T., ed. Putting knowledge to work. FORREX Series No. 8. Kamloops, B.C.: FORREX—Forest Research Extension Partnership: 135–145.

Kennard, D.K.; Rauscher, H.M.; Flebbe, P.A.; Schmoldt, D.L.; Hubbard, W.G.; Jordin, J.B.; Milnor, W. 2005. Using hyperdocuments to manage scientific knowledge: the prototype Encyclopedia of Southern Appalachian Forest Ecosystems. Forest Ecology and Management. 207: 201–213.

Plunkett, P. 2001. Managing knowledge @ work: an overview of knowledge management. Knowledge Management Working Group of the Federal Chief Information Officers Council, U.S. General Services Administration, Office of Information Technology. pearl.butler@gsa.gov. 36 p.

Rauscher, H.M. 1987. Increasing scientific productivity through better knowledge management. AI Applications. 1(2): 21–31.

Rauscher, H.M. 1991. The encyclopedia of AI applications to forest science. AI Applications. 5(2): insert (592 KB, 235 Chunks, 449 Links [electronic]).

Rauscher, H.M.; Loftis, D.L.; McGee, C.E.; Worth, C.V. 1997. Oak regeneration: a knowledge synthesis. FORS Compiler. 15(1): insert (electronic).

Rauscher, H.M.; Johnsen, K., eds. 2004. Southern forest science: past, present, and future. Gen. Tech. Rep. SRS-75. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 394 p.

Reynolds, K.M.; Rauscher, H.M.; Worth, C.V. 1995. A hypermedia reference system to the forest ecosystem management assessment team report and some related publications. Gen. Tech. Rep. PNW-357. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13 p. + electronic files

Thomson, A.J.; Sutherland, J.R.; Carpenter, C. 1993. Computer-assisted diagnosis using expert system-guided hypermedia. AI Applications. 7(1): 17–27.

Thomson, A.J.; Allen, E.; Morrison, D. 1998. Forest tree diagnosis over the World Wide Web. Computers and Electronics in Agriculture. 21(1): 19–32.

Wear, D.N.; Greis, J.G. 2002. Southern forest resource assessment–technical report. Gen. Tech. Rep. SRS-53. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 635 p.