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THE BUGWOOD NETWORK

Supporting forest integrated pest management and sustainable forestry practices with Information Technology

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Abstract

The Entomology and Forest Resources Digital Information Work Group at The University of Georgia (USA) has developed **Bugwood**, a World Wide Web-based system to support and assist in implementation of integrated pest management (IPM) in forest systems. The development of this site was directed by an entomologist and a forester with the original goal of learning to use and apply information technology (IT) to provide synoptic, broad-based educational information to Georgia (USA) extension clientele. The larger project goal now includes using these technologies to improve communications, and to support the implementation and utilization of IPM and sustainable practices in forestry and agroforestry (in Africa) to clientele wherever they are located.

Bugwood contains extension-oriented information in consistent formats for direct use by users or for intermediaries for subsequent delivery to end users. **Bugwood** materials are both original and repurposed, but are in consistent forms and formats, with full authorship credits and citable references. The site has a consistent look and feel throughout. Most items on the site are available in formats for both on-screen (hypertext mark-up language - HTML) and controlled printable pages (Adobe Acrobat). Various applications of multimedia are made, with particular emphasis on quality color photographs. Other information available includes links to other relevant sites, author biographies and reference and contact information. Applications under development include on-line databases and a multipurpose newsboard.

Bugwood is currently in its third version, and is comprised of three sites: **Bugwood USA; Bugwood Africa; and Bugwood SFIWC. Bugwood Africa** is a demonstration site being developed to support forest and agroforestry IPM in eastern and southern Africa. **Bugwood SFIWC** is maintained as a service for the Southern (US) Forest Insect Work Conference.

This paper will provide background, lessons learned, and examples of the current and planned components of **Bugwood.** The URL for **Bugwood** is: http://www.bugwood.caes.uga.edu/ .

Keywords: *Bugwood* , integrated pest management, World Wide Web, entomology

Introduction

One of the most daunting issues facing forestry extension workers in the United States (US) is that of the increasing number of clientele who call upon us for services and information. The number of publicly-funded forest health professionals in the US has decreased during recent years while there has been an increase in the numbers and complexity of governmental rules and regulations by which our clientele must operate. Additionally, it has become increasingly more important that our programs be multidisciplinary in scope as well as scientifically founded. There are also a growing number of "professed professionals" who from time to time appear and promulgate approaches and management options which may not be founded on science.   These professed professionals are the movie stars, TV personalities and workers in lawn and garden stores, etc.   Many of these individuals are in contact with large numbers of home- and landowners and/or receive high visibility through media coverage.

We asked ourselves this question: How can we overcome some of these obstacles and more effectively carry out our job responsibilities? This inherently implied that we needed to develop approaches capable of identifying and addressing the needs of our clientele. It was decided that we should investigate the available and emerging computer-, communication-, and information technologies (IT). We saw tremendous potential in using compact discs (CDs or CD-ROMs), interactive multimedia programming and the World Wide Web to deliver effective, sometimes complex programming to large audiences. We quickly realized that as scientists and educators, we were not computer and multimedia specialists, and decided to develop, either through cooperative arrangements or by obtaining grant-funding, a team that would enable us to begin using IT in our programs.

In 1995, we began earnestly attempting to secure grant funds that would allow us to hire needed expertise. We were successful in securing several grant projects which made it possible for us to begin exploring the possible application of IT to our entomological and forestry problems. As we hired our two IT professionals, it became apparent that, if we were going to effectively develop content suitable for delivery via these new technologies, expertise in such areas as cinematography, graphic design, digital imaging, etc. would also have to be acquired. Our concept of The Entomology and Forest Resources Digital Information Work Group (EFRDIWG or The Work Group) would have to be expanded to include professionals from other units as well as collaborators and cooperators from outside of the College of Agricultural and Environmental Sciences and the Warnell School of Forest Resources (including other state and federal agencies as well as some private IT and publishing entities). This expansion was not limited to the technological aspects of our information system. We also developed similar working relationships with specialists in other program areas and biological science disciplines with whom we could develop more diverse content.

Integrated pest management

In the forest context, integrated pest management (IPM) can be defined as the maintenance of destructive agents, including insects, at tolerable levels by the planned use of a variety of preventive, suppressive, or regulatory tactics and strategies that are ecologically and economically efficient and socially acceptable. It is implicit that the actions taken are fully integrated into the planning and operational phases of the total resource management process. Pest management, therefore, must be geared to the life span of the tree crop, at a minimum; and to a longer time span where the resource planning horizon requires (Waters 1974). Pest management is based upon the principles of ecology, involves the intelligent use of a combination of tactics aimed at suppressing or prevention of the growth of populations. The functional goal of IPM is to reduce or maintain populations of organisms at tolerable levels. Economic, ecological, and social values are used in determining what "tolerable" levels are. IPM is a component of total forest resource management (Coulson and Witter. 1984).   IPM is therefore an interdisciplinary approach to reducing crop losses through the use of optimum mixes of pest control techniques. It combines the aims of agricultural productivity, environmental sustainability and cost effectiveness (IPMForum, 1998). With its emphasis on making the best use of local and human resources, IPM encourages, wherever appropriate, the use of natural control mechanisms (for instance pest predators, parasites, resistant germplasm) and "traditional" pest management techniques used by farmers (Weiss 1991). IPM in forested systems is a component of forest health. Forest health is a component of ecosystem management, which in turn is a component of sustainable forestry.

Impediments to IPM implementation

There are numerous barriers and/or limitations that can impede the implementation of IPM programs. These include, but are not limited to:

1. the lack of communication and coordination between professionals within and between states and different agencies;
2. limited availability of quality, synoptic information about forestry, forest insects and diseases and forest practices;
3. fragmentation of and difficulty in obtaining the forest IPM resources that are available;
4. the inability to obtain and modify the available information to suit the needs of practitioners and users;
5. the lack of quality images (pictures) relating to these forest issues for use in illustrating IPM materials. This is particularly true for insects and disease organisms [Quality pictures are, in our opinion, extremely important additions to educational materials to insure that correct identifications are made and that appropriate management tactics are implemented (Douce, et al. 1997).];

6. timely acquisition of printed materials is often limited by: costs, physical availability and distribution issues;
7. limited ability to locate, distribute and deliver needed information to educators, intermediaries and users on a timely basis; and
8. the lack of funding to monitor developing problems, make appropriate management decisions, and to implement the IPM management activities.

Situation

There is, in general, inadequate management of forest resources across the southeastern U.S. In part, this is due to a relatively poor understanding of the complex issues dealing with management of forest resources, particularly with respect to the impact, or potential impact, of indigenous and introduced pests.

Integrated pest management (IPM) holds great promise in assisting and guiding landowners and other managers of forests. However, IPM is a knowledgerich system. In order to appropriately use IPM, farmers, landowners and managers of forest lands must have an understanding of the interactions of various system components as well as having ready and reliable access to the needed information on a timely basis. This is particularly true when dealing with insects and disease organisms. Not only is it imperative that insects and disease organism and their impacts be correctly identified, but that their potential impact on hosts and other aspects of the ecosystem be understood as well. Of paramount importance, when acquiring and delivering IPM information, is to insure that only credible, accurate, and scientifically valid information is made available to users.

Important issues relative to delivery of information via the Internet that we have identified and have strived to address as we developed and evolved *Bugwood* are discussed in the next sections. These include delivery methodology, quality of content and credibility of its source, and the perception of trustworthiness and usability of content by users.

Delivery methodologies: Traditional methodologies for delivery of information follows the basic 500-year-old model of taking information, putting it on a substrate, and distributing it.   The substrate in this case may be paper, CD-ROMs, magnetic tape, diskettes, and other formats. But the fundamental model is beginning to be changed by the Internet and the wiring of the society, it is no longer necessary to put information on a substrate. It's only necessary to put information in some form on the Net and it can be accessed immediately. The Internet changes the distribution of the information and the cost structure of the entire process. These forces are what are causing the growth of the Internet, changing the way information is relayed (Warnock 1996).

Quality of content and credibility of its source: We agree with Wehmeyer (1997) who states:

> Internet documents differ in intensity, but not in nature, from those related to print materials. The differences are consequent upon the control procedures and the familiarity we have developed in the world of print, but as yet lack in cyberspace. Readers rely on particular publishers and selected journals for their information. ... For the most part, a quick glance at graphics, layout, article titles, and footnotes or references (or lack thereof) differentiates [in the readers mind the quality and reliability of the information]. Thus, the world of print has established a structure for selecting, formatting, and disseminating materials that helps the experienced reader judge the reliability of publications.

Perception of trustworthiness and usability of content: There is a plethora of information available from many sources on the Internet. Relative to these issues, Lynch and Horton (1998) feel that the WWW:

> ... is fast becoming overrun with documents that lack clarity, order and are of questionable trustworthiness.   This is not because Web authors are by nature disorderly and untrustworthy. Web authors create Web sites because they want their content to be accessed and accessible. The trouble is that the skills required for effective information and graphic design are not innate, but instead require work and careful study... Pages that are read directly from the screen must be concise, with the amount of graphics carefully "tuned" to the bandwidth available to the mainstream of your audience... Pages with long passages of text should always be designed to

print properly, as the majority of [users] will print those pages.

Our belief

We believe that existing and evolving technologies aimed at the delivery of digital information, including the World Wide Web (WWW), can be effectively used to assist in implementing the concepts and practice of IPM in forest environments. We also believe that electronicallydelivered materials provide an opportunity to include a multitude of enhancements, such as motion video, audio, color pictures, etc., that can help practitioners and managers correctly identify organisms and make appropriate management decisions. The Work Group's vision of the Internet, and the WWW more specifically, is one of a "virtual library" where information is readily available and easily accessible.

While the Internet's inherent benefits of paperless publishing and instantaneous dissemination have spawned an online community dedicated to the ideal of free access to information, actually locating needed information in an efficient manner is still not a probable occurrence. With **Bugwood**, we are moving beyond the limitations of the traditional publishing paradigm while striving to become recognized as an identifiable source for forestry and agroforestry IPM and sustainable system information.   Our concept of the "virtual library" also includes providing a mechanism whereby users/clientele can obtain high quality printed versions of the desired information, when needed, that are fully referenced and meet the publishing standards of traditional print media.

Approach

We have developed **The Bugwood Family of Sites**, an Internet-based information system as a mechanism to deliver information on forest entomology, forest health and sustainable forestry to our clientele. This system was originally designed as a tool through which current and evolving information technologies could be applied to synoptic, broad-based educational information for more efficient and effective delivery to Georgia (USA) extension clientele. The concept of this system has now grown to address such program areas as IPM and sustainable practices in forestry and agroforestry in the US, in Africa and wherever else they may be located.

We reported on an earlier IT project at the 1996 IUFRO Extension Working Party meeting in Freising, Germany, which was, in part, a precursor to **Bugwood** (Douce, et. al. 1997). We indicated our belief that a quality picture is truly worth a thousand words when trying to describe or identify an organism or damage found in the forest. Unfortunately, quality images are frequently not available, particularly at sites removed from major research and extension facilities. We developed a quality, identified archive of quality photographs of forest insects and their damage which was made available to users in digital format as a CD-ROM set (Douce, et. al. 1995). These images can be used in a variety of ways to enhance and illustrate materials and to aid in the identification of organisms and damage. Currently, over 900 of these CD-ROM sets have been purchased by scientists, educators, foresters, landowners and others across the U.S. (and other parts of the world). We make extensive use of digital images throughout **Bugwood**.

Some of the objectives for the **Bugwood** information system include the facilitation of improved communications between and among forest IPM and forest health professionals; the constant development and expansion of a library of biologically reliable, easily accessible digital information to both professionals and our clientele; the development, coordination and consolidation of specific (but brief) IPM materials that include quality pictures; and the utilization of emerging and evolving electronic technologies to implement and/or deliver these materials and services to users.

Components of the information system

The WWW component of our information system, **The Bugwood Family of Sites**, serves as the backbone for the entire system. Around this framework, we have the ability to add components in a modular fashion so that not only are the component WWW sites easily expandable, but other components such as a newsboard feature, can be added as well.

Information contained in **Bugwood** is extension-oriented and is consistently formatted for direct use by users on the computer screen. Regardless of whether the materials are original or repurposed, they are consistently formatted to conform to our layout and standards before they are loaded. Each article carries with it full authorship credits, including title and address. Each article also carries adequate information that allows it to be fully cited and referenced. Most of our documents which can be printed, contains an authorship and brief citation running head as well as a standard footer that points back to the document source (our site).

We strive to maintain a consistent look-and-feel throughout and between components of our site. Most of the items on **Bugwood** are available in formats for both on-screen (hypertext mark-up language - HTML) and controlled printable pages (Adobe Acrobat).   Although most web browsers allow the user to print most documents from a web site, because of printer differences (how the browser interprets page layout commands, type font differences, the layout design and special features used by the author of the web document), the appearance of the printed document can vary greatly from one printout to another. However, before the user can access and print Acrobat documents, they must download and install a free Adobe Acrobat reader. The use of Adobe Acrobat allow us to insure that the user can obtain a high-quality, good looking document that has the same high quality appearance of the original document that we created.

We make use of various multimedia applications, with particular emphasis on quality color photographs. Other information available includes links to other relevant sites, author biographies and contact information and references. Applications under development include online databases and a multipurpose newsboard.

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World Wide Web Site

The *Bugwood* home page

The home page is the normal entry point for anyone coming into **Bugwood** . In addition to providing an access point to all three of the sister sites, it contains features common to all of the current sites such as information "About the Work Group" and our cooperators, a "Search" engine to assist users in finding the information that they desire, a "Picture of the Month", and a "Current Feature" section.

The Picture of the Month is a very popular feature. The picture may be something that is currently of importance, such as a particular pest that we are receiving a lot of telephone calls about, a pest new to our area, or maybe just something interesting, for example we used a picture of an African elephant feeding on a tree after one of us returned from a trip to Kenya.   Each picture of the month either has a short writeup, including scientific name, common name and what it does associated with it or it is linked to a formal Fact Sheet on our site. Therefore, it is BOTH a picture of interest AND an opportunity to educate our user!

The Current Feature can be an item of interest on any of the three sister sites. For example, when we first placed information about Cotton Pest Management on **Bugwood**, we featured it as a new item on the site. Other times, we have used this to draw attention to other items of interest, such as an activity report covering the Georgia State FFA Forestry Field Day Forest Tree Disorders competition that was coordinated by one of the authors.

Bugwood USA

This site is partitioned into the Library, Video, Products, Recent Additions, Links and Help sections.

The Library is the heart of the information transfer section. We have partitioned it into various sections or menus which allow the user to focus his/her search for information. Currently, the library contains sections on Entomology, Forestry, Integrated Pest Management, Cotton, Insect Damage Reports, a

Regulatory Pest Survey Program, Christmas Tree Production, 4H/FFA, and Information Technology. Depending upon the amount of information under each of these sections, there may be additional submenus to help the reader find the desired information. For example under Entomology , the user can select one of the subsections such as Forest Insects, Cotton Insects, Exotic Insects, etc. Under some of these subsections, there may be another finer level menu, depending upon the amount of information available. Our goal is to make it easy for the user to find the information that he/she needs. The information in this section is principally textual-based Fact Sheets, reports, papers and lists. However, in several cases, we also have information in other digital formats available, which is "hot-linked" from the textual documents. Many of the "documents" are listed in multiple sections of the library.

Video. The video section provides the user with access to our information that is contained in video formats. We currently have two applications that demonstrate the use of motion video and relative to forest entomology applications. We have not had adequate funding or cinematography support to expand this section at this time. However, we do feel that these technologies will be important components of future IT systems.

Links. Much like most other WWW sites, we provide URL links to other web sites from Bugwood. We are currently redesigning our links section to be case-sensitive. That is, we plan to place the links under the appropriate sections of our site rather than having one links section. We have a relatively diverse group of content on *Bugwood* and we feel that it would better serve our users to put a selected list of links to other Entomology sites under Entomology, and links to other Forestry sites under Forestry, and so forth rather than having them all at one location.

Help. Under help, we provide general background information about The Work Group, descriptions of the features and capabilities of each of the "plug-ins" that we make use of and how to obtain them, describe our general layout and navigational features, suggest the basic computer hardware and software to use, how to setup the users systems to take advantage of certain features on our site, and so forth.

Bugwood Africa

This web site was constructed as a demonstration site for viewing by attendees at the Integrated Pest Management Communications Workshop for Eastern and Southern Africa (ICWESA) in Nairobi, Kenya in March 1998. Entomology and Forest Resources Digital Information Work Group personnel designed and implemented this site in cooperation with personnel with the USDA Forest Service - Forest Health Unit, and with the Kenyan Forest Health Centre, in Nairobi, Kenya. This site visually demonstrates what we view as possible applications of existing and evolving electronic technologies to improve communications and to support implementation and utilization of Integrated Pest Management in agroforestry and forestry in eastern and southern Africa. *Bugwood Africa* is very much a demonstration site at this time, although we are actively seeking funding to make it an active and dynamic WWW site.

Bugwood Africa is partitioned into several sections to address some of the impediments to forest/agroforestry IPM implementation that we identified as we were designing the site. Only a brief overview of the background and rationale used in developing this site will be presented here. Please refer to documents on *Bugwood Africa* for more details. *Bugwood Africa* is partitioned into an Introduction, a Library, Projects, Professionals and Help sections. Also included is a listing and WWW links (if available) to the (anticipated) cooperators and collaborators with us on this project. Note, that the Introduction and Professionals sections on this site are not included on the USA site. These are special features that we felt were appropriate for the developing African countries because of there special needs and situations that we did not feel were appropriate or needed in the USA. Additionally, because of the integral nature of agroforestry in Africa, we have expanded the content of this site to encompass agroforestry as well as forestry.

The Introduction contains background and information specifically pertaining to the rationale and structure of this site.

The use of the Internet and of the WWW is very new to many individuals from and working in Africa. Therefore, we felt it necessary to provide some background and rationale for the development of this site. Basically, the introduction is a summarization of a paper that was presented at the ICWESA meeting.

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The Library is very similar in design to that described above for the USA site. However, we have provided (and plan to continue to provide) the Fact Sheets in English, French and Swahili, three languages commonly used across the portions of Africa for which the web site is intended for use. We also anticipate inclusion of information on tree and shrub species, reference information, glossary of forestry and agroforestry terms, a list of pertinent African-based publications and reports, a listing of active African Integrated Forest Pest Management projects, perhaps a glossary of botanical terms, and a tree and shrub species selection system. When implemented, this section will contain detailed definitions of IPM in the context of African forestry and agroforestry, as well as descriptions of the methodology and techniques that can be used (predators, parasites, resistant germplasm, timing, cultural, etc.). Much of this information is available only in scattered locations and is not readily available to those practicing professionals in African counties. We will apply the same strict credability, layout, credits and referencing standards that we outlined in the Library section for *Bugwood USA*.

Perhaps the next two sections, the Projects and the Professionals sections are the most interesting and potentially most helpful in implementing forest IPM and sustainable forestry practices in Africa.

The Projects section is designed to provide a system and a network for communications and information sharing among and between individuals, agencies and entities working on specific projects within Africa. There may be several to many countries, each with individuals from several agencies, and personnel from regional and international agencies involved in a particular forestry/agroforestry project in Africa. For many reasons, there is often a problem finding out who is involved, where they are located, what the project is about, what the status of the project is, etc. Additionally, there are problems communicating and sharing information among individuals involved in a specific project. We are implementing this section, along with the Professionals section that will be discussed below, to aid in improving this process.

We have just initiated activity on two projects that are just getting underway on *Bugwood Africa*. The first deals with supporting The Tree Pest Management Network for Central, Eastern and Southern Africa. This project involves personnel from a number of countries as well as several international advising agencies and deals specifically with forest IPM and forest health issues. The second current project deals with initiation of a pilot project at selected highpriority sites in the Eastern Arc Mountains of Tanzania and Kenya to describe fragmentation using remote sensing technology and monitoring trends in forest health by the establishment and periodic measurement of permanent forest health plots. Within each project is an Introduction -- e.g. background information, a Private Area, a Public Area, and a Request Access area. The private area makes use of a newsboard feature that has password access protection and allows, via password protection, those involved in a project to freely communicate between each other, project leaders, and develop future project proposals ... all areas where limited access to information and communciations are desired.

The Professionals section is designed to provide information about Bugwood Africa personnel, IPM service providers working in Africa (such as identification and library services), and material and equipment supplier addresses and contact information; contact information for international, regional and consulting services that are multinational in scope; and a country by country governmental organizational contact list of forest information and service providers. This area is principally a directory of personnel, resources, and services that have bearing on implementation of forest and agroforestry IPM in Africa.

The Links section, will like many other sites, contain a listing of what we feel are appropriate and complimentary links to other World Wide Web sites. These links will contain sites specific to IPM, forestry (as well as demographics), communications, etc. as both references and starting points for more research.

Bugwood SFIWC

Bugwood SFIWC is maintained and operated by The Work Group as a service to The Southern Forest Insect Work Conference USA to further objective of the membership and to facilitate communications.

Future

We plan to:

1. broaden the depth and scope of content on the *Bugwood* sites.

2. expand the scope and depth of our digital image database to include a comprehensive set of images relating to all areas of our activity.
3. expand our use of other digital information technologies such as video and interactive presentations that can be delivered over the WWW, CDROM, or other emerging technologies.
4. develop a comprehensive set of digital "tools" that can be accessed and used by anyone to develop a digital training and educational presentation or system. Included would be such items as, quality photographs, a set of standard downloadable and editable fact sheets, course and curriculum outlines and modules, focused training sets, etc.
5. develop and execute practical distance education courses, shortcourses, and training resources, for use by:
   - extension agents in the areas of forest IPM, forest entomology and general forestry,
   - youth educators wording with 4-H and FFA programs,
   - educators working with elementary school children, and
   - educators working in developing countries.
6. integration of improved search engines.
7. development of relational database systems for use in lookup tables for scientific vs common names, translations from one language to another (particularily relevant in developing countries).
8. strive to stay current and implement promising IT developments to support our future programming and educational efforts.

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