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Computer Tools Developed for Aquatic Plant Management

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ABSTRACT

Over the past fifteen years, the Aquatic Plant Control Research Program (APCRP) has pursued development of personal computer (PC) -based information systems for technology transfer in aquatic plant management. Initial development was limited to DOS compatible simulation models and other computational tools. Though effective in generating computational information for several control techniques, the DOS operating system did not allow the models to be interlinked with other information sources required for development of effective aquatic plant management technology transfer tools. However, the advent of the WINDOWS operating system and ensuing software advances for PC's have allowed the recent development of more comprehensive information systems. Of these, the Aquatic Plant Information System (APIS) is the first system scheduled for release for the APCRP. In addition to the simulation models developed in the past (i.e., HARVEST, AMUR/STOCK, and HERBICIDE), the system will include both aquatic plant and biological control identification strategies based on expert system programming, instructional information on a diversity of aquatic plant management topics, and other utilities all accessible through an online HELP supported graphical user interface. The system will be distributed on CD-ROM. Additional DOS-based models not converted to a WINDOWS-compatible format (INSECT, HYDRIL, and MILFO) will be also be included for direct installation from the CD-ROM.

Key words: aquatic plant management, information systems, technology transfer tools, simulation models, expert systems.

INTRODUCTION

Over the past fifteen years, the Waterways Experiment Station (WES), in support of the Aquatic Plant Control Research Program (APCRP), has developed a series of personal computer (PC) -based tools to facilitate aquatic plant management technology transfer. The goal of these tools is to provide government agencies and private firms and associations involved with aquatic plant management information that will help them plan and implement environmentally sound management programs that are both effective and economically efficient.

Development of these PC-based tools has proceeded along the lines of technological advances in PC architecture and operating systems. Initially, tools were limited to simulation models and related procedures which were heavily computational. Though numeric outputs were useful information, their applicability was restricted both spatially and temporally to a defined point and time. Extrapolation of model outputs to other locations, or to the same location at a different time, was tenuous. Further, processing of other types of information was extremely limited. As instructional tools, PC's were actually less effective for packaging textual and graphical/visual data than text books, reports, or other forms of printed media. However, recent improvements in information packaging and management made available by current multimedia PC platforms have expanded the potential opportunities for developing PC-based information systems. This manuscript presents a chronological sequence in PC-based technology transfer tool development by WES for the APCRP.

SIMULATION MODEL DEVELOPMENT

The Waterways Experiment Station (WES) investigated development of computer-based simulation models for evaluating growth of nuisance aquatic plants through a workshop held in 1980 (Wlosinski 1981). As a result, a generic submersed plant growth model was developed (Collins et al. 1985). The first model developed by WES of an operational technique for controlling nuisance growth of aquatic plants was the HARVEST model (Hutto 1982, Sabol 1983). This model includes algorithms that simulate aquatic plant control cutting operations, collecting operations, and transport operations (i.e., both over-water and road-based). As an analytical tool, the HARVEST model allows users to test overall operational productivity (i.e., acres or tons of plant material harvested per hour) of existing mechanical harvesting systems under "user-defined" operational and environmental conditions. Initially developed for a mainframe computer, HARVEST was modified in 1982 for installation on DOS-based personal computers, and was cleared for public distribution in 1983. HARVEST has been converted to a WINDOWS-based format.

In addition to the HARVEST model, WES also began distributing a grass carp stocking rate model (STOCK) in 1983. Development of this model at WES coincided with the large-scale operations management test (LSOMT) of grass carp stockings for hydrilla control in Lake Conway, Florida. The STOCK model (Miller and Decell 1984) was intended to be

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used as a tool whereby an aquatic plant resource manager could "define" selected growth characteristics of a targeted hydrilla infestation (e.g., area of infestation and seasonal "biomass" growth pattern) and evaluate the effectiveness of different grass carp stocking strategies in controlling that infestation. The AMUR/STOCK model has been expanded to allow stocking strategy evaluations for controlling other target plant species (Stewart and Boyd 1994), and was recently converted to operate under the WINDOWS operating system.

Based on the ability of the HARVEST and STOCK models to help aquatic resource managers evaluate application strategies for the above two operational control techniques, development of additional simulation capabilities were planned for other "operationally proven" techniques. HERBICIDE, a simulation tool for evaluating herbicide application techniques, generates estimates of the post-application partitioning (water, sediments, and plants) and dissipation of the active ingredient fraction of an herbicide formulation following application. Examples of intended applications of this model are provided in Stewart (1994). Developed initially as a DOS-based model, HERBICIDE has been converted to a WINDOWS-based format (Stewart and McAllister 1995).

Development of a simulation model for two insect species introduced in the United States for the biological control of waterhyacinth was also undertaken at WES. The INSECT model (Akbay et al. 1988) provides a multiple-year simulation of the population dynamics of waterhyacinth and two introduced weevil species. In comparison to the STOCK model, the INSECT model represents a significantly more complex biological system (e.g., reproductive viability and multiple generations and life stages of the control agents). Though the model has been released in DOS-based format (Stewart and Boyd 1992), knowledge gaps in our understanding of many of the governing mechanisms of this system have necessitated the inclusion of several "black box" relationships and a rigid set of assumptions under which the model is valid. For these reasons, INSECT has had limited success as a technology transfer tool. Its main utility to date has been to identify knowledge gaps in our understanding of the population dynamics of the two weevil species and their mode of impacting waterhyacinth growth (Howell and Stewart 1989; Grodowitz and Stewart 1989).

Due to its modular construction, the INSECT model also provides an independently functional, DOS-based plant growth model for waterhyacinth. DOS-based plant growth models have also been developed for hydrilla (HYDRIL; Best and Boyd 1996) and for Eurasian watermilfoil (MILFO; Best and Boyd 1997). As independently functioning models, these simulation tools were designed to help users understand how selected environmental site conditions affect the growth of these nuisance plant species. Through a better understanding of these relationships achieved through hands-on model evaluations, it was hoped that users could design better control strategies for managing aquatic vegetation.

SIMULATION MODEL LIMITATIONS

Though successful in many respects, simulation model development as the main means of PC-based technology transfer had several limitations. First, development of the models was painstakingly slow because this depended on the availability of a relatively comprehensive knowledge of the systems being modeled. Because knowledge was typically lacking for some of the key processes, a given model's applicability was restricted by a set of assumptions which defined the limited conditions under which the model was valid. Further, many of the processes represented by the simulations (e.g., plant photosynthesis, water exchange, etc.) are driven by environmental and biotic conditions that are both spatially and temporally heterogenous. For this second reason, coupled with the fact that spatial databases (e.g., geographic information systems and hydrodynamic databases) had memory requirements in excess of what could be provided on PC's, the utility of the models was often limited to "generalized" initialization conditions.

Due to these and other limitations, packaging of the models as PC-based technology transfer tools was initially hampered by limitations in PC technology. What was needed was a PC platform that not only would allow execution of the models, but one that could also include support information for operating the models and interpreting their outputs. In general, prior to the introduction of the WINDOWS operating system and object oriented programming tools, IBM compatible PC systems were not capable of performing these other functions. These same limitations in pre-WINDOWS PC systems also prevented them from being a practical platform for packaging other types of information (e.g., control technique "how to guides", plant identification information, aquatic plant and biocontrol agent life history and ecological data) that should be included in comprehensive aquatic plant management technology transfer tools.

NEW APPROACHES FOR INFORMATION SYSTEMS

New capabilities provided by the WINDOWS operating system and related object oriented software tools allowed for the development of new information systems that had not been possible on DOS-based systems. The first true information package pursued by APCRP for aquatic plant management was the Aquatic Plant Resource and Operations Online System (APROPOS, Madsen and McAllister 1995). APROPOS was designed to provide a consistent procedure for evaluating pertinent information for development of aquatic plant management plans. The different types of information to be included in the system were to be arranged in separate, but interlinked modules accessible through a graphical user interface (GUI) shell operating under WINDOWS 3.1. Through point and click selection, the system would provide access to a management strategy planning module which helped identify the particular problem species and then access other "toolboxes" in the system for further information. Other toolboxes for the planned system were to provide access to a literature database on plant life history and ecological data, a literature database specific to control technique options, and a literature database which presented "how to" guides on developing sampling plans and carrying out field data collection efforts. A simulation model toolbox, a spatial database toolbox, and a HELP facility toolbox for instructions on system operation had also been planned. In planning APROPOS, it was envisioned that

Figure 1. Information manager screen of the Aquatic Plant Information System (APIS). Access to information in APIS is achieved through mouse activation of the appropriate icon on the left side of the screen.

all models previously developed by WES for the APCRP would be converted for WINDOWS operation and would be accessible through the simulation model toolbox. However, development of APROPOS would have taken considerable time and resources. Due to the reduction in APCRP funding beginning in 1995, this extensive and long-term investment did not appear reasonable.

Concurrent to our planning and initial development of APROPOS, other PC based information systems were being developed at WES to facilitate technology transfer. Both the Noxious and Nuisance Plant Management Information System (PMIS) (Grodowitz et al. 1996) and the Zebra Mussel Information System (ZMIS) (Grodowitz et al. 1997) contain a variety of information on the management of troublesome pest species. For various reasons, development of these systems proceeded more rapidly than development of APROPOS. Operational CD-ROM versions of both PMIS and ZMIS have been widely distributed, and initial reviews of both systems have been highly favorable.

Resources scheduled for further development of APROPOS were redirected toward development of an aquatic plant management information system similar in design to ZMIS and PMIS. The newly designed system, which incorporated existing information, programs, and expertise, as well as the demonstration material for APROPOS, has been titled the Aquatic Plant Information System (APIS).

DESCRIPTION OF APIS

APIS will operate under Windows 3.1 or Windows 95. The system, which was developed using a combination of Borland's® C++ and Microsoft's® Visual Basic, will operate using a 386 processor but a 486SX 25 MHz (or faster) utilizing 8 MB of RAM is recommended. The system will be contained on a single CD-ROM and can be loaded entirely on your hard drive using a 2X (or faster) drive. APIS will also run directly from the CD-ROM thereby limiting hard drive space requirements from about 100 MB (i.e., a full install) to a minimum

TABLE 1. SIMULATION MODELS RELEASED WITH THE AQUATIC PLANT INFORMATION SYSTEM (APIS).

Model	Description	Status	Integrated or Stand-Alone	Reference
Harvest	Mechanical harvesting model	Both DOS and WINDOWS version available	Integrated	Hutto 1982, Sabol 1983
Amur/Stock	Grass carp stocking model	DOS and WINDOWS versions available	Integrated	Miller and Decell 1994, Stewart and Boyd 1994
Herbicide	Herbicide dissipation model	WINDOWS version available	Integrated	Stewart 1994, Stewart and McAllister 1995
Insect	Insect biocontrol model for waterhyacinth	DOS/ FORTRAN version available	Stand-alone	Akbay et al. 1988, Stewart and Boyd 1992
Hydril	Hydrilla plant growth model	DOS/ FORTRAN version available	Stand-alone	Best and Boyd 1996, Boyd and Best 1996
Milfo	Eurasian watermilfoil plant growth model	DOS/ FORTRAN version available	Stand-alone	Best and Boyd 1997

of only 1 MB. Since large numbers of color images are included in APIS, your system must contain a video board, video drivers, and monitor capable of displaying a minimum of 256 colors simultaneously for Windows 3.1 and 65,000 colors simultaneously for Windows 95. Information/image access will be relatively rapid even when using APIS with minimum system requirements and operating it directly from the CD-ROM. Since the system will be highly graphical in nature a mouse or similar pointing device also will be required. Installation instructions will be straight forward and contained on the inner title page of the CD-ROM cover. While APIS will be highly intuitive to operate, detailed instructions for system operation will be contained in hyper-linked text files which can be accessed directly from the program.

Accessing information in APIS is accomplished through mouse selection of icon choices included on the left hand side of the "Information Manager" screen depicted in Figure 1. Through these icons, the user gains access to system tools which perform the following respective functions. The top icon allows the user to select a plant species of interest from the list of over sixty species included in the system. Information can then be obtained on the plant's distribution, history of introduction, and textual description, as well as full color images. If the user is unsure of the plant species in question, the third icon provides a link to an identification tool. If biological control agents are available for the plant species, information regarding their identification is obtained through the second and fourth icons. Once the plant species is determined, the fifth icon provides access to helpful information on biological, chemical and mechanical control options. The sixth icon provides access to WINDOWS compatible versions of several of the simulation models described earlier in this manuscript. As an aid to species identifications, the seventh icon accesses high quality images of each of the aquatic plant species and their included biocontrol agents. Incorporation of the models within APIS facilitates many of the user-friendly execution features as envisioned through APROPOS. Simulation models accessible through APIS are identified in Table 1.

AVAILABILITY OF APIS

A limited test release of APIS during December 1997 will be followed by a full distribution of the system during the latter half of 1998. The system will be distributed on CD-ROM, and should function on most personal computers utilizing the WINDOWS 3.1 or WINDOWS 95 operating systems. Those interested in receiving a copy of APIS can submit a request (by standard mail, telephone, FAX, or E-mail) with name and address to: Dr. Michael J. Grodowitz, U.S. Army Engineer Waterways Experiment Station, ATTN: CEWES-ER-A, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, phone (601) 634-2972, FAX (601) 634-2398, or E-mail at grodowm@mail.wes.army.mil.

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