# MANAGING AMERICA'S ENDURING WILDERNESS RESOURCE

**Seeing Wilderness Management Solutions With Computer Graphics**



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SEEING
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SOLUTIONS WITH
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GRAPHICS

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# DEVELOPING AN IMAGE CAPTURE SYSTEM TO SEE WILDERNESS MANAGEMENT SOLUTIONS

David G. Pitt[1]

ABSTRACT. Image capture systems provide wilderness managers the opportunity to see realistic portrayals of the visual consequences of wilderness management proposals before implementation occurs. A basic image capture system that allows managers to view videotape simulations of wilderness management activities can be assembled in an IBM-AT microcomputer environment for approximately $13,000. System components include video image input devices, microcomputer hardware and software for storing and processing video image files, and an assortment of video image display devices.

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Within the past five years, computer-assisted video image capture technology (ICT) has advanced dramatically. Individual frames of video tape recordings as well as slides and photographic images of actual environments can now be stored in computer memory as image files. Once entered into memory, an image file can be processed to delete elements contained in the original image or add elements from a different image file. Wilderness managers can use image capture technology to create video simulations of resource management proposals such as tree harvesting operations and trail, road or campsite design alternatives. The display of these video simulations on videotape or in slides or photographs is more realistic than the display capabilities provided by alternative simulation technologies such as line drawings or photo-montage. Video image capture technology offers wilderness managers the opportunity

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to efficiently view accurate portrayals of several alternatives before management activities are implemented.

Most video image capture systems operate within the relatively inexpensive environment of an IBM-AT microcomputer. The purchase price of a basic image capture system (approximately $13,000--including purchase of an IBM-AT) is within the budget range of most wilderness management field units (e.g. an individual National Park Service unit or a USDA-Forest Service forest supervisor's office). The menu-driven operating procedures of most image capture systems means that a wide array of disciplines involved in wilderness management can use the systems to visualize management alternatives prior to their implementation.

A companion paper in this proceedings describes the potential uses of video image capture systems in wilderness management (Lime 1990). Other papers provide case studies of the systems role in wilderness management decision-making (Chenoweth 1990, Nassauer 1990). The purpose of this paper is to describe the basic hardware and software components that are used to: 1) input original video images into computer memory; 2) store and process this imagery to create simulations of management alternatives; and 3) display the simulations in video, slide or photographic format. The configuration and function of key image capture system components (Figure 1) are described. Where appropriate, alternative system configurations are discussed.

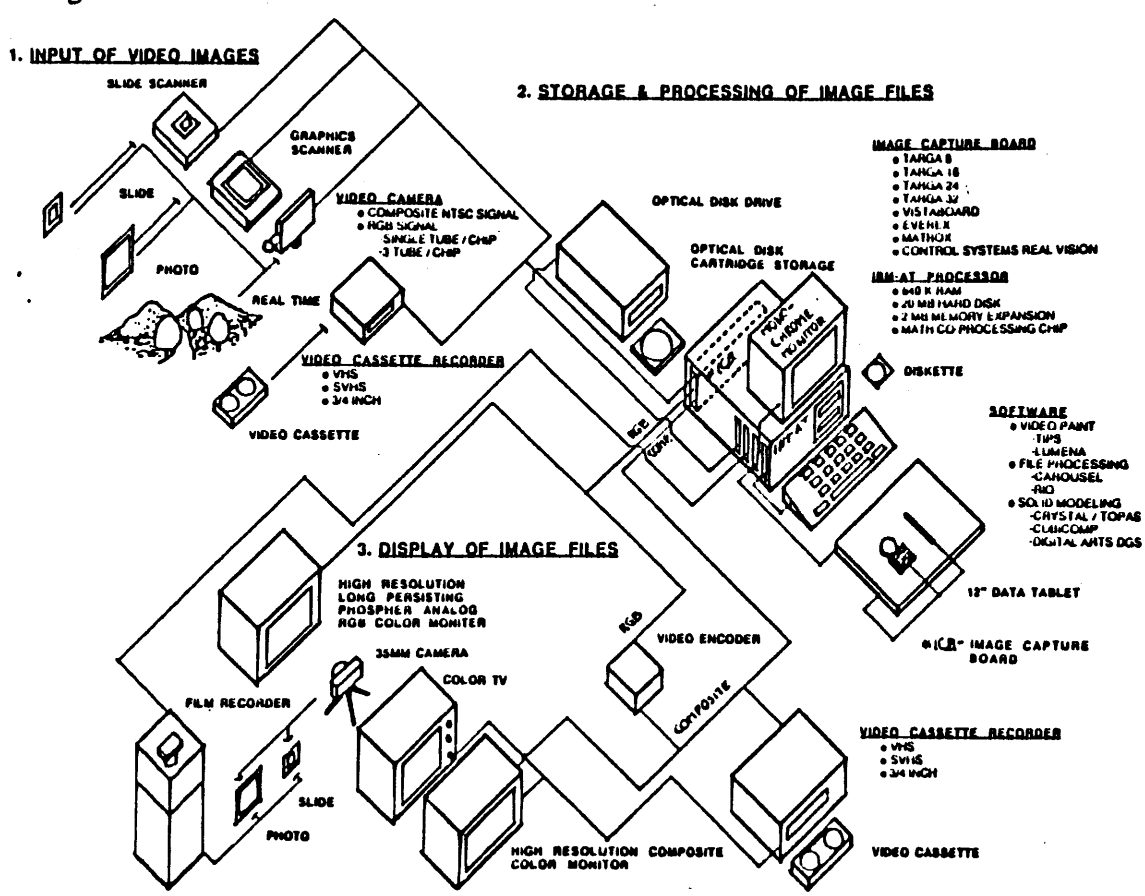


Figure 1. Schematic drawing for an image capture system.

## INPUT OF VIDEO IMAGES INTO COMPUTER MEMORY

The first step in using video image capture technology to create video simulations is converting the image(s) to be processed into digital video files. As shown in Figure 1, four types of devices can be used to initially enter wilderness images into an image capture system. Slide scanning devices enable the entry of 35 mm. slides of wilderness environments into computer memory while photographs can be entered using a graphics scanner. Individual frames of videotape recorded in a wilderness environment can be entered directly from a video cassette recorder (VCR). All three types of conventional VCR technology (i.e. standard 1/2 inch VHS, super 1/2 inch VHS, and commercial grade 3/4 inch) can be used as input devices by connecting the VCR's video-out jack to an image capture board. Finally, live imagery of wilderness environments can be entered directly into computer memory using a video camera. A camera becomes a live input device by connecting the cable that normally conveys the video signal to a VCR for video recording directly to an image capture board. Standard 1/2 inch VHS, super 1/2 inch VHS, and commercial grade 3/4 inch cameras can be used as live video image input devices as long as they do not have a VCR that is integral to the camera body. Cameras producing either a composite NTSC signal or a RGB signal (i.e. a video signal separated into its red, green and blue components) can be used as live video input devices.

Figure 1 illustrates that all four types of video image input devices are connected directly to an image capture board inserted into an IBM-AT computer. The quality of the final simulation display produced by an image capture system varies with the quality of the devices used to capture wilderness environment video imagery and send this video signal to the image capture board. Quality of the video signal is often described in two dimensions: vertical lines of resolution (or clarity); and color hue and saturation.

A higher number of vertical lines of resolution in the video signal input device means the final display signal will be sharper. In this regard, standard 1/2 inch VHS video cameras and standard VHS videocassette recorders (VCR) produce approximately 240 vertical lines of resolution. Super VHS cameras and VCRs produce in excess of 400 vertical lines of resolution. Higher quality 1/2 inch RGB video cameras and 3/4 inch cameras provide over 600 vertical lines of resolution. Many slide and graphics scanning devices can produce in excess of 2000 lines of resolution. Thus 1/2 inch RGB cameras, 3/4 inch cameras and most scanning devices produce much sharper video input signals and will result in greater clarity in the final simulation display.

Input devices that send to an image capture board a video signal that has been separated into its red, green and blue constituents (i.e. a RGB signal) generally provide a more faithful representation of color hue and saturation than do devices which send a composite NTSC signal. Degradation of hue and saturation occur as the combination of reds, greens and blues in the original image is translated into a composite color signal before being sent to the image capture board for storage and processing. The scanning devices, 1/2 inch RGB cameras and 3/4 inch cameras send RGB signals to the image capture board. They will produce higher quality color signals than composite signal video cameras, standard VHS videocassette recorders or super VHS VCRs which can transmit only composite color signals. RGB cameras that have a separate tube or chip for each of the three primary hues (i.e. red, green and blue) produce more faithful hue and saturation than do RGB cameras having only one tube or chip. They also tend to have a higher number of vertical lines of resolution. Thus, three tube or three chip RGB cameras produce a higher quality input signal than do single chip or single tube RGB cameras.

For most wilderness management applications, a RGB camera has the greatest flexibility as a video image input device. A RGB camera can be used to capture and store individual video tape frames of imagery in the field. Alternatively, it can be mounted on a copy stand and used to enter both 35 mm. slides and photographs. The combination of a RGB camera used to enter back-lit slides is best adapted to the light conditions found in most wilderness environments. The low light intensity, high value contrast conditions of many wilderness settings are more easily captured with 35 mm. slides than with field use of a video camera. Being one photographic processing step closer to the original scene than photographs, slides offer an inexpensive and accurate portrayal of actual conditions. Use of a three tube/chip RGB camera costing less than $4,000 to enter back-lit slides will produce video image input quality that approximates that obtained from slide scanning devices costing over twice as much money.

## STORAGE AND PROCESSING OF VIDEO IMAGE FILES

### Hardware System Components

The video signals captured by a slide scanner, graphics scanner, VCR or video camera are sent to an image capture board inserted into a microcomputer. As of January 1990, image capture boards exist for use with MacIntosh microcomputers, and MS-DOS computers including the IBM 286, 386 and their clones. However, since the greatest amount of image file processing software has been produced for image capture boards that are compatible with 286 microcomputers, this discussion of video image storage and processing will focus on the requirements and capabilities of boards operating in a 286 environment.

Image capture boards receive either composite NTSC video signals or RGB signals. Composite signals are translated into RGB signals. An image capture board digitizes the RGB signals sent directly from scanning devices,3/4 inch commercial or RGB video cameras. Composite signals sent from composite VHS video cameras or VCRs are converted to RGB signals by a video encoding device that is integral to the board's construction. This translation of composite signals to RGB signals results in further color quality degradation. The translated RGB signal is subsequently digitized. The row by column matrix format of the digitizing process varies with the type of image capture board being used.

The most widely used image capture boards are the TARGA boards distributed by the Truevision Corporation. As shown in Figure 1, TARGA boards are available in 8 bit, 16 bit, 24 bit and 32 bit models. All TARGA boards have a display matrix resolution capacity of 512 columns by 482 rows. Since the number or rows contained in the image capture board display of a digitized video image file approximates 75 percent of the vertical lines of resolution contained in the video input signal, the resolution of a TARGA board can effectively display up to 642 vertical lines of video signal. This level of resolution is commonly found in 3 tube/chip RGB cameras.

The TARGA 8 and TARGA 16 boards contain a maximum of slightly over 32,000 colors. The TARGA 8 board can display only 256 colors at any one time while the TARGA 16 board can display all 32,000 colors simultaneously. Both the TARGA 24 and the TARGA 32 contain and can display over 16 million colors. Image capture boards competing with the TARGA family boards include the Everex and Matrox boards which are comparable to the TARGA 16 board and the 16 bit and 24 bit Control Systems Real Vision boards.

Truevision has recently released a new image capture board known as the Vistaboard which can display over 16 million colors and has a matrix resolution that can be programmed to operate anywhere from 512 columns by 482 rows to 1024 columns by 768 rows. While the color quality of the 24 and 32 bit boards surpasses that of the 16 bit boards and the expanded resolution of the Vistaboard offers exceptional clarity in image display, the capabilities of a 16 bit board, costing between $1,000 and $1,500, are sufficient for most wilderness management applications.

Once the RGB signal of a video frame has been digitized, the image capture board stores the red-green-blue spectral composition of each pixel in the matrix resolution. The complex nature of most wilderness environments makes this a memory intensive process. Individual image files generated on a TARGA 16 often approach 500,000 bytes of memory. At a minimum, the microcomputer in which the image capture board operates must be equipped with a 20 megabyte hard disk drive, and it must contain 640,000 bytes of random access memory (RAM) and a 2 megabyte memory expansion chip and an 80287 coprocessing chip.

In processing video image files to create an individual wilderness simulation, it is not uncommon for system operators to be actively using a dozen separate files. File management and storage becomes a significant issue since two or three operators using the same system to create multiple simulations can rapidly fill a 20 megabyte hard disk. Individual simulation files can be stored on diskettes at a rate of approximately three files per one high density double-sided diskette using a TARGA 16 board. Alternatively, files can be transferred to an optical disk drive for permanent storage on a high capacity optical disk cartridge.

The most commonly used software systems available for processing video image files are menu driven systems. Thus, a monochrome monitor used in displaying the menu separately from the image being processed is helpful. Moving around on the menu as well as processing an image file also requires a graphics tablet equipped with a four button cursor puck or a stylus.

**Software Systems**

Three types of software exist for processing video image files. Video paint software is used in manipulating the red-green-blue spectral composition of individual pixels in a digitized video image file. File processing software allows system operators to adjust file dimensions, further process image files for subsequent display in slide or photographic media, and send "story-board" sequences of files for subsequent video display. Solid modelling systems integrate image files processed with video paint software into software systems that create models of three-dimensional solids and apply colors and textures to the solid's surfaces.

The most commonly used video-paint software systems used with an image capture board include the TIPS software distributed by AT&T and LUMENA, a product of Time-Arts Corporation. Both systems allow complete transformations of the spectral composition of individual pixels within the color capabilities of the image capture board on which they are operating. The spectral properties of pixels or designated sets of pixels can be moved around within the matrix of a given file or entered into storage and moved to another image file. Visuals elements contained in a file can be rotated 360 degrees, reflected, altered in size, and be given an appearance consistent with a designated visual perspective. A number of smoothing algorithms which blend or accentuate color differences between pixels can be used to visually integrate an introduced element into an existing video image file. The menu operating procedures of LUMENA are more user-friendly than those of TIPS. LUMENA allows system operators to work interactively with several image files including a live video image, and it also allows files to be superimposed on each other at varying degrees of transparency. These added features make LUMENA better suited to wilderness management applications. Whereas TIPS retails for under $1,000, LUMENA has a retail price of $2,500. Both systems read files generated with either TIPS or LUMENA.

The CAROUSEL file processing software is used to organize "story-board" sequences of TIPS files. Operators can organize a sequence of files, adjust the way in which each file unfolds in the display, regulate the duration of file display, and send the entire sequence to a display monitor. CAROUSEL is especially useful in presenting before and after images of a particular wilderness management proposal or sequence of proposals.

The RIO file processing system is used in segmenting a digital video file whose matrix resolution exceeds that which can be displayed by the resolution capacity of an image capture board. For example, an image signal produced by a slide scanning device may contain 2000 vertical lines of resolution. A digital file of this signal would contain 1500 rows of information. Since the display resolution capacity of a TARGA board is limited to 482 rows, over two-thirds of the information in the original digital file will not appear if it is displayed directly on an image capture board. RIO divides this larger digital file into segments which can then be individually displayed and processed on a TARGA board. RIO can reassemble the larger file for subsequent processing by a digital film recording device. A film recorder can produce slide or photographic displays at resolutions varying between 2000 and 8000 vertical lines.

Image files generated with video-paint systems can be "painted" onto three dimensional solids using three dimensional solid modelling software systems. In wilderness management applications, this involves using various Computer-Aided Design and Drafting systems (CADD) or Geographic Information Systems (GIS) to generate three-dimensional digital terrain models of the geographic form of the environment to be simulated. These three-dimensional models are entered into solid modelling systems such as CRYSTAL, TOPAS, CUBICOMP or a Digital Arts DGS system. The video-paint files that are to be applied to the surface of the three-dimensional model are also entered into the solid-modeling system. After the system operator selects a particular vantage for viewing the solid model, the system "paints" the video image file onto the model's surface as it would appear in perspective from the selected viewing station. Several vantage points may be selected, and the system will generate a dynamic simulation of the environment as it will appear in sequence from each viewing station. Solid modelling systems are exceptionally memory intensive. The cost of establishing a solid-modelling system, over and above the costs of an image capture system, exceeds $10,000.

## VIDEO IMAGE DISPLAY

Video image simulations created with an image capture system can be displayed in video, slide or photographic formats as well as on color monitors. The flexibility of display formats makes the image capture system highly versatile in several aspects of wilderness management (Lime 1990, for further discussion of potential uses).

The primary mode of displaying image files generated by an image capture system is through a color monitor attached to the image capture board. Just as the board is capable of receiving either a composite NTSC video signal or a RGB signal, so also is it capable of transmitting both composite and RGB video signals. Thus an Image Capture Board can be connected directly to either a composite color monitor or an analog RGB color monitor. In either case, the monitor should have high resolution capabilities. At a minimum, the display monitor should be able to display the matrix resolution and color potential of the image capture board to which it is connected. RGB monitors present higher quality color displays than do composite monitors. Monitors having long persisting phosphors have more stable displays that ease eye-strain and improve viewing since the images do not flicker as much as those presented on conventional color monitors.

The image capture board can also be connected directly to a videocassette recorder (VCR). When operated in record mode, the VCR records all images that appear on the color monitor. Individual images may be recorded or an entire sequence of images created with the CAROUSEL software package can also be recorded. The videocassette can be subsequently played back on any VCR compatible with the recorder on which the tape was produced. The image capture board can be connected to a standard 1/2 inch VHS, super 1/2 inch VHS or commercial grade 3/4 inch VCR. When recording on a VHS recorder, only composite signals can be recorded. However, the resolution and color quality of the videotape can be enhanced by connecting the image capture board's RGB output to a video encoder. These devices provide a higher quality translation of the RGB signal to a composite signal than is possible on the image capture board's encoder. The encoded composite signal is then recorded onto VHS videotape. Videotape images are displayed on conventional color TV sets or high resolution composite color monitors.

Video simulation images can be displayed on slides through two processes. An inexpensive slide can be produced by using a 35 mm. camera to take pictures of a simulation image file displayed on either a composite or RGB monitor. Slides taken from a RGB monitor image are considerably sharper and truer in color than those taken from a composite monitor image. However, slides photographed from both monitor types tend to encounter image quality degradation when compared to either the original monitor display or that recorded on standard VHS videotape.

A considerably more expensive slide production process involves use of a film recorder which reads a simulation image file directly from the computer's hard disk. The film recorder contains a 35 mm. camera back. The image file is electronically printed onto 35 mm. film at between 2000 and 8000 vertical lines of resolution (depending on the quality of the film recorder). The camera back accepts both slide and print film so the film recorder can be used to produce either slides or photographic negatives. Retail prices on film recorders suitable for use in wilderness management applications begin at approximately $6,000. Individual simulation image files can be electronically printed onto 35 mm. film at commercial film recording establishments for between $5 to $10 per file.

## SUMMARY

Image capture systems offer wilderness managers the opportunity to view realistic simulations of the visual consequences of their management actions before implementation. These simulations can be viewed as color monitor image displays and subsequently transferred to videotape, slide or photographic format for additional viewing by a variety of audiences. A basic image capture system suitable for creating and viewing high quality color monitor displays or standard VHS videotape displays of most wilderness management activity simulations would consist of the following components: a 35 mm. single lens reflex camera, a single tube/chip RGB video camera and a copy stand to enter slide images of wilderness settings and wilderness management activities; image file storage and processing equipment including an IBM-AT microcomputer equipped with 640,000 bytes of random access memory, a 2 megabyte memory expansion chip, a 20 megabyte hard disk drive, a 12 inch graphics data tablet and a TARGA 16 image capture board; image capture software including TIPS and CAROUSEL; and image display equipment including a high resolution, long persisting phosphor color RGB monitor, a high resolution composite color monitor and a 1/2 inch standard VHS videocassette recorder. The total retail price of such a system is approximately $13,000.

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# IMAGE CAPTURE TECHNOLOGY: AN EXCITING NEW TOOL FOR WILDERNESS MANAGERS!

David W. Lime[1]

ABSTRACT. Recent advances in computer technology have provided wilderness managers and scientists with a new tool to help evaluate alternative landscape settings and conditions. Image capture technology (ICT) is a computer-based system, integrated with video components, which allows existing landscape conditions to be modified to portray realistic changes in the natural and built landscape. Image capture technology (ICT) has at least four important uses in wildland resource management: (1) training of managers, (2) public involvement, (3) enhancing visitor sensitivity, and (4) evaluating appropriate visitor use conditions.

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It is not often that a new computer technology appears on the scene that captures the imagination and excitement as much has image capture technology (ICT)! Advances in microcomputing during the last half decade make it possible to capture video, slide, or photographic images and, at will, to alter them to simulate a changed landscape. Papers in this section by Chenoweth (1990), Nassauer (1990), and Pitt (1990), illustrate the exciting promise of this innovative, cost-effective capability to aid wildland and other natural resource management.

One is instantly impressed by the realistic quality of the simulated image displays produced by ICT. The rapid advancement of computer software and hardware suggests that the possibilities for this technology are just beginning. Nevertheless, there is limited experience in simulating change in natural environments (Chenoweth n.d.). Most work has focused upon simulating change in architectural settings, such as modifying the appearance of buildings.

The use of this technology in natural resource management is enhanced greatly by its capacity to simulate alternative landscapes rapidly and cost-effectively. Until the advent of ICT, most discussions of alternative landscape impacts and treatments and their consequences relied upon intuition, engineering drawings, artists' sketches, or photographs. Several research efforts have investigated public perceptions of human-caused impacts in wildland settings. For example, research in Montana (Martin et al. 1989) explored managers' and visitors' perceptions of wilderness campsite impacts in which panelists responded to an artists' color illustrations depicting a variety of wilderness campsite settings and conditions. While this and related research has been fruitful in helping to understand how wilderness visitors evaluate campsites, the capability to simulate realistic images representing a range of landscape impacts while holding the general setting constant is a promising advance for research and management purposes.

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## USES OF ICT IN WILDERNESS MANAGEMENT

Image capture technology (ICT) has at least four important uses in wildland resource management: (1) training of managers, (2) public involvement, (3) enhancing visitor sensitivity, and (4) evaluating appropriate visitor use conditions. Of course, such uses could extend to other resource settings, such as in urban/suburban environments.

### Training of managers

Image capture capabilities could be effectively used in staff training of field managers as well as central administrators to both sensitize them to resource problems and discuss potential solutions. For example, simulations could be developed to show the incremental impacts of increasing horse use on a fragile meadow or how a hillside is impacted by prolonged off-road vehicle use. The general landscape setting would remain constant with a portrayal of increasingly impacted site conditions. Not only could the simulations show how the landscape might look with increased use, it also could be used to help visualize the landscape before any use was present. Such simulations would permit discussions about what conditions are in need of management and what standards management wants to achieve. The simulations would be especially helpful to depict desired standards as part of the Limits of Acceptable Change (LAC) process. Simulations could focus upon both social and physical standards and show a range of possible alternatives.

As another illustration of the ICT, simulations could show predictable ecological changes to wildland settings in response to various types of fire disturbance. Successional response to natural or prescribed burns could be presented and their management implications discussed.

Helping central-office administrators of public agencies and other decisionmakers to recognize wilderness problems is another potentially powerful use of ICT. By actually "seeing" the landscape change before your eyes resulting from (1) increased visitor use, (2) development or removal of facilities, and (3) alternative facility designs or locations is a realistic and meaningful way to "make the point"! The ICT capability was used for this purpose recently to show Minnesota Congressman Bruce Vento and his staff the landscape effects of alternative sustainable agricultural land management practices (Nassauer 1989). Such demonstrations can help persuade decisionmakers of the need to place, or increase the importance of, critical problems and issues on an agency's agenda for funding, staffing, or general discussion and public awareness.

### Public involvement

Just as ICT could be employed to show resource managers the effects of change, the technology has important implications for use in public discussions about wildland management. Citizens and decisionmakers together can review the issue and "see" how the landscape will look under various management scenarios. Such simulations are being used in several cases in Minnesota (Nassauer 1990) and Wisconsin (Chenoweth 1990).

While ICT could be used both in large and small public involvement exercises, perhaps its most effective use would come in small group settings--such as in transactive planning (McCool et al. 1986). In these small working sessions, participants could use ICT for identifying the problem(s), its severity, and what might be the effects of not mitigating it. Simulations generated by ICT could then help evaluate various alternatives and serve as a means of deciding on an appropriate course of action.

## Enhancing visitor sensitivity

Closely related to public involvement, ICT has the capability to help inform and educate wilderness users about wilderness management activities, the impacts visitor behavior has on wilderness settings, and how to behave responsibly in the wilderness (Cole and Benedict 1983). Wilderness managers need to find new and innovative ways to reach the visiting public. Because of the vital role that television and video technology plays in our lives today (approximately 60 percent of America's households now have a VCR--it is expected to reach at least 80 percent by the end of this decade) and because ICT can show change over time (illustrating cumulative effects of human disturbance and change in ecological communities), ICT is a logical media to help the public visualize wilderness and how best to protect and enjoy it. The public is highly sensitized to the visual image, and resource managers should "play" to this form of communication.

Finding new ways to educate wilderness visitors about the effects of their behavior in wilderness was a driving force behind a cooperative study to investigate visitor awareness of campsite impacts (Nassauer 1990, Pitt and Nassauer 1989). This ongoing study in Minnesota's Boundary Waters Canoe Area Wilderness is exploring how "damaged" a campsite must be before managers and visitors rate the campsite as "unacceptable." The study also is examining how various Forest Service informational programs influence visitors' sensitivity to impacts. Understanding how wilderness visitors (and managers) perceive site impacts will help in further developing new or modified rules and regulations as well as expected wilderness norms. For example, in developing an educational video, how impacted must a campsite be (such as amount of bare soil or peeled birch trees) before visitors understand that contributing to such damage is inappropriate? What types and levels of impacts are most effective to teach minimum impact camping behaviors?

## Evaluating appropriate visitor use

Wildland resource managers continue to struggle with questions about appropriate types and levels of visitor use and resulting resource impacts. ICT will permit various impacts to be simulated and evaluated in an effort to document when conditions exceed acceptable standards. Studies, such as those in progress in the Boundary Waters Canoe Area Wilderness, should aid in setting standards under the LAC process. For example, understanding how both wilderness visitors and area managers perceive campsite impacts and what types and amounts of impact differentiate between managers' and visitors' definitions of acceptable and unacceptable conditions can play an important role in establishing tolerance levels to guide management. Standards can then be applied to ongoing monitoring activities to assess the conditions of the more that 2,000 Boundary Waters' campsites.

The ICT capabilities also could be applied to a host of resource management questions in wilderness related to issues such as prescribed fire, wildlife habitat, and prairie restoration. "Base line" conditions could be compared with a variety of alternative management treatments. For example, landscape restoration scenarios could be evaluated both from a technical standpoint to review the appropriateness of several vegetation types and from an aesthetic perspective to assess experts' and the publics' perception of a pleasing landscape setting. In discussions about prescribed fire, various visual characteristics of a burn in alternative vegetative conditions could be reviewed and evaluated.

## CONCLUSION

Image capture technology (ICT) is an innovative computer-based communication and wilderness resource evaluation tool with exciting potential for wildland managers. Simulated images are extremely realistic, and the simulations allow a variety of people to "view" a diversity of landscape management proposals and compare them with existing conditions. Not only can ICT help managers evaluate alternative decisions before they are implemented, this technology also can enhance efforts in public involvement as well as visitor information and education. Continuing efforts to research and develop this tool should provide exciting dividends both for wilderness managers and the visiting public--as well as for the wilderness resource itself.

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# USING IMAGE CAPTURE TECHNOLOGY TO GENERATE WILDERNESS MANAGEMENT SOLUTIONS

Joan Iverson Nassauer[1]

ABSTRACT. The purpose of this paper is to examine how the capability of image capture technology (ICT) to produce highly believable landscape simulations can be used to generate wilderness management solutions. ICT is a system of computer hardware and software components linked with video input and video or photographic output devices. Operationally, ICT allows an existing landscape or "base image" to be changed by the addition of features from other landscapes ("borrow images") or by the multiplication of features within the base image (for example, a single tree may be multiplied to represent a tree plantation). For wilderness managers, ICT provides a means of displaying landscapes that don't currently exist. The base image is changed to simulate a landscape appearance that illustrates some management concern. Managers could use ICT capabilities in least the four following ways: before and after simulations, historic portrayals, simulation of alternative policies and plans, and simulation of incremental change. Several examples from the University of Minnesota Landscape Simulation Laboratory are described.

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Image capture technology (ICT) is a system of computer hardware and software components linked with video input and video or photographic output devices. Pitt (1990) describes ICT systems elsewhere in this section of the proceedings. The purpose of this paper is to examine how the capability of ICT to simulate the appearance of landscapes can be used to generate wilderness management solutions. Several examples from the University of Minnesota Landscape Simulation Laboratory are described.

The most powerful technical capability of ICT is the believability of simulations generated with the system. ICT is a new technology used for landscape simulation only within the last five years (Orland 1986). While statistical measures of the validity of ICT are only now being developed, the intuitive reaction to ICT simulations displayed as video output is "this looks like the real thing."

Operationally, ICT allows an existing landscape or "base image" to be changed by the addition of features from other landscapes ("borrow images") or by the multiplication of features within the base image (for example, a single tree may be multiplied to represent a tree plantation). Landscape features or qualities photographed or recorded by video in one place are digitally collaged onto a base landscape image.

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For wilderness managers, ICT provides a means of displaying landscapes that don't currently exist but that might result from particular management strategies or that might have existed in the past. The base image is changed to simulate a landscape appearance that illustrates some management concern. Visitors can then be informed about past and future appearances of the landscape, and visitor reactions can be measured and anticipated before a management strategy is actually implemented. Decisionmakers also can be informed about the way the landscape will look as the result of planned policy changes or wilderness plans.

## FOUR WAYS THAT WILDERNESS MANAGERS COULD USE ICT

Managers could use ICT capabilities in least the four following ways: before and after simulations, historic portrayals, simulation of alternative policies and plans, and simulation of incremental change.

### Before and after simulations

In a situation where a management plan has been developed that will result in specific changes to landscape appearance, the landscape can be displayed both before and after plan implementation. These before and after simulations can be used to present changes to concerned citizens or to public officials engaged in review or approval of management plans.

For example, in the Hamden Slough National Wildlife Refuge project in the Red River Valley of northwestern Minnesota, landscape architects at the University of Minnesota Landscape Simulation Laboratory assisted staff of the U.S. Fish and Wildlife Service to show how farmland will look after it is restored to a prairie wetland complex. The plan entails plugging an agricultural drainage system constructed in 1915 to restore wetlands associated with the Hamden Slough, two lakes, and numerous prairie potholes; provision of waterfowl food plots; restoration of native prairie communities in the terrestrial interstices of the wetland complex; predator fencing of critical nesting sites; and conservation tillage practices on nearby agricultural lands to maintain spring and fall sources of food and cover. Aerial and ground perspective photographs and slides of the proposed refuge site were used as before images and also as base images for simulating how the site would look after restoration (figs. 1a,b and figs. 2a,b).

These before and after simulations were incorporated in three videos produced by the U.S. Fish and Wildlife Service (FWS) to assist in seeking state and federal approval for the wetland restoration and waterfowl management plan for Hamden Slough. The videos were used to provide information to local residents and jurisdictions and to decisionmakers in the FWS, the Minnesota Department of Natural Resources, the Minnesota Land Exchange Board, and the U.S. Migratory Bird Commission.

### Historic portrayals

Just as ICT can be used to show how a landscape could look in the future, it can be used to show how a landscape has looked in the past. For wilderness managers, simulating the past appearance of a landscape may be helpful in providing information about the historic importance of a wilderness area and its past users, and in establishing a sense of perspective about the inevitable ecological change and evolution of wilderness landscapes.

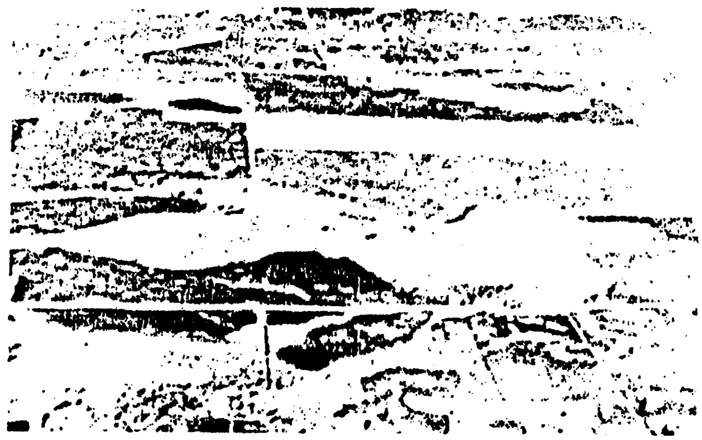

Figure 1a. An oblique aerial perspective of an existing Hamden Slough landscape.

Figure 1b. A Hamden Slough landscape as it will appear following implementation of the refuge management plan.

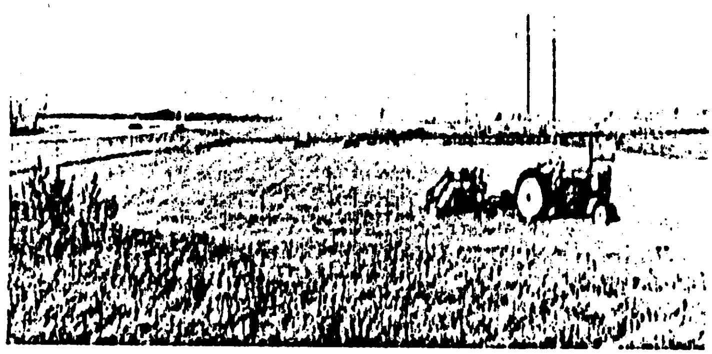

**Figure 2a.** An eye-level perspective of the existing landscape in the vicinity of the main slough.

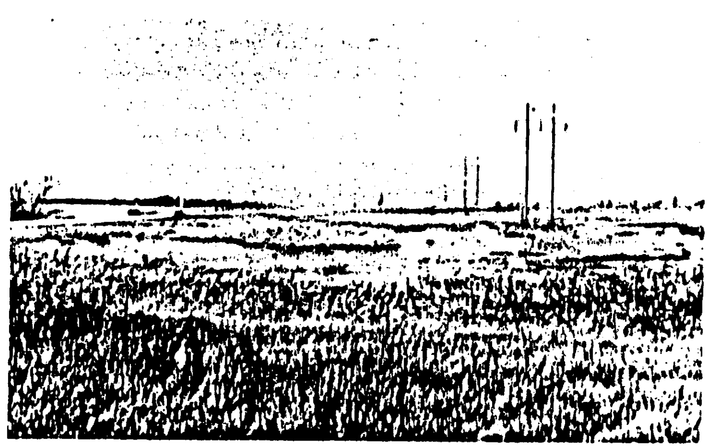

**Figure 2b.** The main slough depicted after wetland restoration.

For example, a project underway at the University of Minnesota is being undertaken in collaboration with the Minnesota Department of Natural Resources (DNR) to investigate the prospect of removing a nonfunctioning low-head hydroelectric dam from the Kettle River near Sandstone, Minnesota. The dam was constructed in 1908, and many nearby residents enjoy the use of a town park on the reservoir's shores. However, the DNR believes that removing the dam will improve in-stream fish and wildlife values and enable restoration of a Class I whitewater in the Kettle River.

To help local residents visualize the appearance of the restored whitewater, a series of video simulations are being developed. Bases for the simulations will be archival historic photographs of the rapids taken before construction of the dam. These will be merged with digital terrain models of the valley constructed from USGS topographic data.

**Simulation of alternative policies and plans**

ICT allows several alternative landscape appearances to be illustrated for a single site or base view. Without ICT alternative policies and plans must be illustrated by images of different existing sites, each displaying a different management practice. ICT has several advantages over this approach in that it: 1) can illustrate practices that have not yet been implemented, 2) can show the effects of a given practice in a selected location, which may be of particular concern to citizens or decisionmakers, and 3) allows many practice alternatives to be illustrated on a single site, controlling on the visual effects of extraneous landscape variables, factors that are not within the purview of the policy or plan.

For example, as part of a University of Minnesota Agricultural Experiment Station project to assess perceptions of agricultural conservation measures, the University of Minnesota Landscape Simulation Laboratory developed simulations of several agricultural conservation alternatives for each of several fields in southeast Minnesota (figs. 3a,b,c,d,e). Under provisions of the 1985 Food Security Act, landowners can be paid to take highly erosive fields out of production and into perennial cover. The simulations were developed to show the visual effects of typical perennial cover practices and to demonstrate alternative cover patterns that might achieve conservation goals in a way that is more acceptable to landowners and more attractive to people who use farmland for contemplative recreation (e.g., hiking, biking, driving for pleasure). In an effort to inform agricultural policy on conservation reserves and habitat restoration, the American Society of Landscape Architects used these video simulations to quickly and credibly inform policymakers about alternatives to the 1985 FSA approach to agricultural conservation.

**Simulation of incremental change**

Because ICT simulations are created by altering a base image, creating a series of images of a single place to illustrate sequential increments of a single condition is relatively simple. The increments illustrated may be changes over time; for example, the growth of vegetation after a fire, water levels, or seasonal changes in the appearance of a place. Or increments of a condition that could vary with management strategies or levels of use may be illustrated; for example, campsite size, wilderness signage, or visitor impact.

Simulations of incremental change may be used to provide information about ecological processes at work in the wilderness, about alternative management strategies or about appropriate wilderness behavior. They also may be used to measure how the a range of

Figure 3a. This southeast Minnesota landscape is currently strip-cropped. This slide served as the base for an ICT simulation.

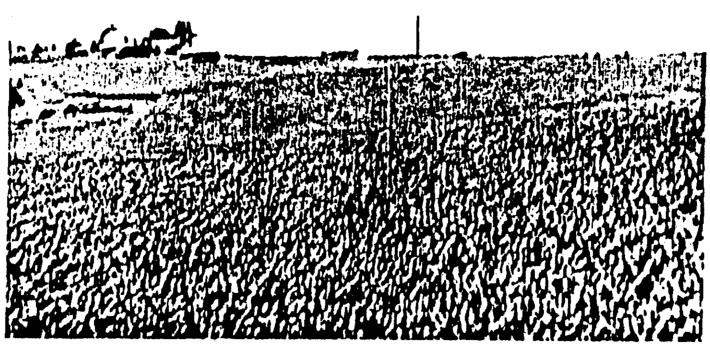

Figure 3b. This ICT simulation shows how the landscape would look if it were completely under cultivation for corn. Local people would be likely to see this as having lower landscape quality than the strip-cropped landscape.

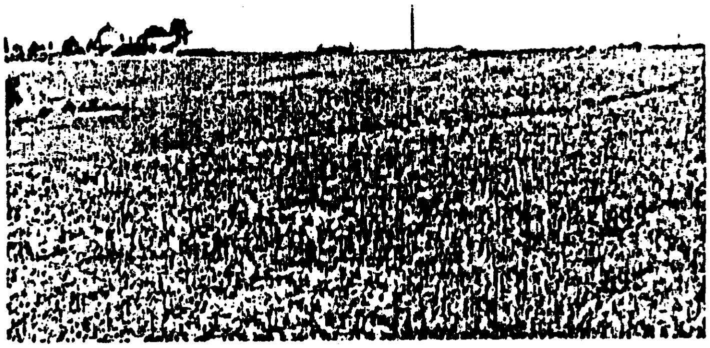

**Figure 3c.** With the planting of typical RIM or CRP seed mixes, the strip-cropping pattern would be replaced by perennial grasses and forbes.

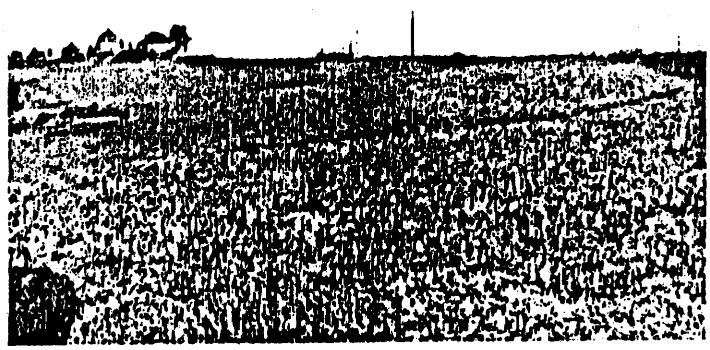

**Figure 3d.** ITC simulations expand the range of alternatives for implementing the RIM or CRP conservation policies by demonstrating visual effect of introducing a mowed filter strip.

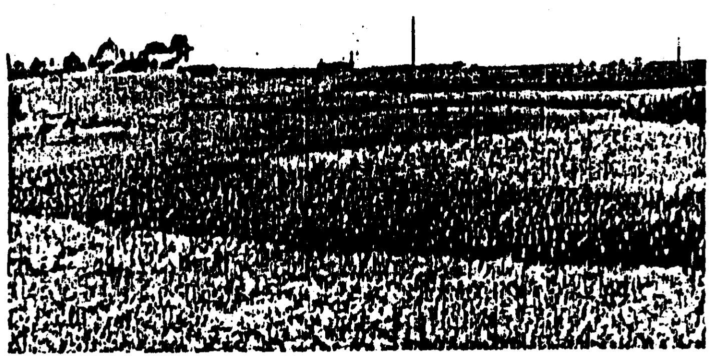

**Figure 3c.** ICT makes another alternative concrete for policymakers.

possible landscape appearances is perceived, so that visitor, manager, and decisionmaker perceptions can inform policy and practices.

For example, in a cooperative project with the U.S. Forest Service, the University of Minnesota Landscape Simulation Laboratory has developed simulations to illustrate 23 increments of visitor impact on 5 campsites within the Boundary Waters Canoe Area Wilderness (BWCAW). Environmental degradation produced by the intensity, distribution and physical characteristics of visitor behavior is a primary concern for the recreation resource management staff of the Superior National Forest, the unit of the USDA Forest Service responsible for BWCAW management. About 140,000 visitors use the BWCAW each year.

Visitor impact on BWCAW campsites takes several forms. Shrub and groundcover vegetation are trampled or removed resulting in extensive sheet erosion. Trees die from soil compaction or are removed for firewood or construction of on-site camping facilities. Trees are also damaged by visitors who peel bark, whittle on tree trunks, or pound nails into trees. Visitors also litter campsites. All these impacts reduce the integrity of the experience of subsequent campers (Lime and Stankey 1971). Superior National Forest managers are interested in knowing how great visitor impacts must be before they are noticed and how the Forest Service's appropriate wilderness behavior information and education programs effect sensitivity of visitors to visitor impacts.

The 23 increments of impact shown on each of the five BWCAW sites used as bases for the simulations illustrate 8 increasing levels of ground plane impact, ranging from removal of groundcover vegetation or pine needle duff, combined with four increasing levels of tree damage, ranging from peeling and whittling of bark to removal of trees (figs. 4a,b,c). Videos of these simulations are being shown to wilderness managers and BWCAW visitors to develop a scale of noticeable visitor impact and to compare the effectiveness of three different formats of the Forest Service appropriate wilderness behavior program in altering visitor sensitivity to visitor impacts.

## CONCLUSION

ICT can help wilderness managers test response to management decisions before they are implemented, it can help managers inform users and decisionmakers about the effects of management decisions, and it can help managers inform users and decisionmakers about the history and dynamic ecological processes of wilderness. ICT communicates management decisions in a medium, video, that can present complex ideas in a short time and in a compelling format that is highly convivial to contemporary culture. For all of these reasons, ICT is a powerful tool waiting to be adapted to further use by wilderness managers.

**Figure 4a.** An existing B.W.C.A.W. campsite.

**Figure 4b.** The same B.W.C.A.W. campsite restored to a verdant, pristine condition.

**Figure 4c.** The B.W.C.A.W. campsite depicted with severe soil erosion and vegetative damage attributable to visitor impact.

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