

Microcomputer Techniques for Developing Hardwood Conservation Strategies¹

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Abstract: Hardwoods are disappearing from the California landscape at alarming rates. This is due to a variety of influences, both natural and man made. It is clear that conservation and rehabilitation of hardwood resources will require a large effort on the part of research institutes, universities, government agencies, special interest groups, private developers, maintenance workers and ordinary citizens. In order to study the problem and arrive at workable solutions, the author has developed computer assisted methods that help the researcher or land planner inventory, evaluate and manage the land, including hardwood stands. Microcomputer techniques can help us determine the cumulative effects of incremental loss of resources as well as help illustrate, through visual simulation, the potential consequences of future actions. Computers allow us to track changes as they occur and give us the means to develop effective conservation and mitigation strategies that will guarantee a landscape with hardwoods in the 21st century. This paper examines techniques that employ a systems approach and utilize geographic information systems, image processing techniques and photorealistic simulations as planning and decision making tools.

Managing the land is a human activity and reflects human values. Human values, in turn, reflect the needs of people to house and feed themselves. These human needs are often in conflict with those of wildlife and other natural systems and an understanding of the requirements of both is required to make intelligent decisions about land use.

Some of the most threatened landscapes occur at the edge of urbanizing areas. Geographic information systems provide a particularly effective tool for understanding the spatial conflicts and impacts inherent in the urbanizing edge because they facilitate the easy generation of composite maps. These composite maps, in the form of suitability or impact studies, provide guidelines for generating creative design solutions that balance the need to preserve the integrity of natural systems while providing for the needs of humans. Digital cartography and image processing of aerial photographs have also been employed by the author to provide thematic maps for insertion into geographic information systems. In addition to geographic overlays, the author has developed a capability for producing

photorealistic simulations. Photorealistic simulations illustrate how a landscape will appear after a change in development or management, and can help us predict many types of impacts. Simulations are particularly effective for eliciting an emotional response from the public.

The Macintosh micro computer, used in these studies provides a powerful tool to assist in this process. It is relatively inexpensive and will run powerful software, while being easy to learn and use. A range of existing software applications have been used to develop the methods reported here. Several geographic information systems were developed, using Filevision IVTM, which runs on all Macs, starting with a Mac Plus. The more sophisticated graphics applications, such as PhotoshopTM, use gray scale or true color (6.8 million colors) and require a Mac SE-30 or a color Mac II series computer. Similar graphic applications are available for DOS and OS/2 machines, however, Filevision IVTM is unique to the Macintosh.

HARDWOOD RESEARCH

While the loss of mature trees is an on-going and acceptable process in a natural ecosystem, one problem facing California is the lack of regeneration of oaks. In some areas, few, if any juvenile trees occur in areas of existing mature oaks. Researchers have hypothesized that a combination of causal factors maybe responsible for losses of young oaks including overgrazing, soil compaction, herbivory by small mammals and rodents, and competition from introduced exotics, but a definitive answer has not yet emerged. Researching potential influences from these and other factors can be very complex and difficult to model with accuracy. In order to model these ecosystems or even to begin to look into these four suspected factors requires an ability to inventory and monitor changes in vegetation patterns. Detailed information about other site characteristics such as soils, steepness of slope, slope aspect, microclimate, elevation and hydrology need to be compared and correlated in order to calibrate the research model. Much of this detailed information will best be viewed in spatial form, as maps and diagrams. In the following discussion, tools and techniques will be presented in relation to case studies. Several projects will be described, each corresponding to a different scale of planning, ranging from a 33 mile long greenway plan to a management plan for a 2400 acre natural reserve.

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LAND PLANNING IN URBANIZING AREAS

In urbanizing areas, tracts of existing oaks are being lost to the bulldozer, an acre at a time. Individual trees trapped within an urban or suburban area are further threatened by root zone flooding from irrigation. In addition, micro climates are often changed by land form modification, deforestation and the addition of water. Air pollution threatens some types of vegetation in urban areas and disruption of the natural burn cycle has left many stands in a senescent state, choked by an overgrown understory.

Preservation of intact wooded areas is an objective of an increasing number of planning agencies. More information is needed by planners and decision makers to address the problems of loss of oaks and other hardwoods from development. Environmental designers need the same basic capabilities as the biological researcher in order to inventory and evaluate vegetation as part of the planning process. This includes a theoretical and factual knowledge of vegetation characteristics, environmental requirements, tolerances to disturbance and reproductive methods. Again, much of this information is spatial in nature and must be available in the form of maps in order to feed directly into the overlay based geographic information system and the land planning process.

GEOGRAPHIC INFORMATION SYSTEMS

Large scale land planning requires storage and retrieval of thousands of variables and site conditions. Geographic information systems (GIS) are computer data bases with an active link between a map and numerical, textual or pictorial information. They are ideal for storing an inventory and spatial description of vegetation associations and individual trees. Once in a computer data base, sensitive vegetation clusters or individual trees can be identified and located on a map so that development can be directed away from these significant resources. The computer also facilitates tracking resources over time so cumulative impacts can be recognized and mitigation measures monitored to evaluate their effectiveness.

Such a data base was developed to assist in designing the San Joaquin River Parkway and Environs Conceptual Plan, prepared for the San Joaquin River Parkway and Conservation Trust. (Miller and McNiel 1989). The site included a 33 mile section of river bottom at the north edge of the Fresno urban area. The geographic information system was structured to contain 13

categories of data, one of which was vegetation. Each category was in turn expanded into more detailed distinctions. Vegetation was broken into separate map overlays that defined riparian zones, tree canopy and endangered species or species of special concern. Likewise data on soils, hydrology, microclimate, archaeology, history, land use, zoning, land ownership, circulation and aesthetic features were mapped and entered into the data base. This type of data base, which provides maps of hundreds of site features at the same scale, allows the environmental planner to look for spatial correlations such as the overlap of sensitive vegetation, buildable soils and development zoning. This combination would indicate critical areas that should be actively preserved since they are in danger of being developed to the detriment of sensitive vegetation. (fig. 1). In the case of the San Joaquin Parkway it was possible to identify areas that are presently being gravel mined in the river bottom, that when rehabilitated, can supplement the surviving remnants of existing vegetation to form larger areas of desirable wildlife habitat and provide recreation opportunities.

To develop more detailed data bases, traditional arboreal inventory information is collected in field surveys and linked to computer maps that show individual trees or groups of trees. If you point at any group of trees on the map and push the computer's mouse button, the information associated with that particular tree is made accessible on screen. Or, conversely, using Boolean search capabilities, one can ask to see all those trees which meet a specific group of criteria, such as a particular species, age, girth, condition and significance. The GIS will print both a map showing the locations and one or more reports displaying the associated information for those individuals that meet all the specified criteria. These maps, along with the associated information can be used to discern regeneration, change in stand structure and densities, stand decline or other patterns. Because of the cartographic format, these analyses can be fed directly into the land planning and management decision making process.

For example, a detailed computerized inventory was developed for the U.C. Davis Arboretum that helps the arboretum staff manage an inventory of over 35,000 plants. Named The Interactive Curator™, the GIS was designed to provide an easy system for locating individual plants as well as a way to monitor growth and change over time. The Interactive Curator™ provides open access to arboretum collections for U.C. researchers and the public as well as providing a means for the arboretum staff to produce annual reports of recent acquisitions and management costs. In addition, the mapping abilities of the GIS allow for the production of highly detailed maps and work orders to guide grounds keeping. (Dawson, Elliot-Fisk and McNiel 1990).

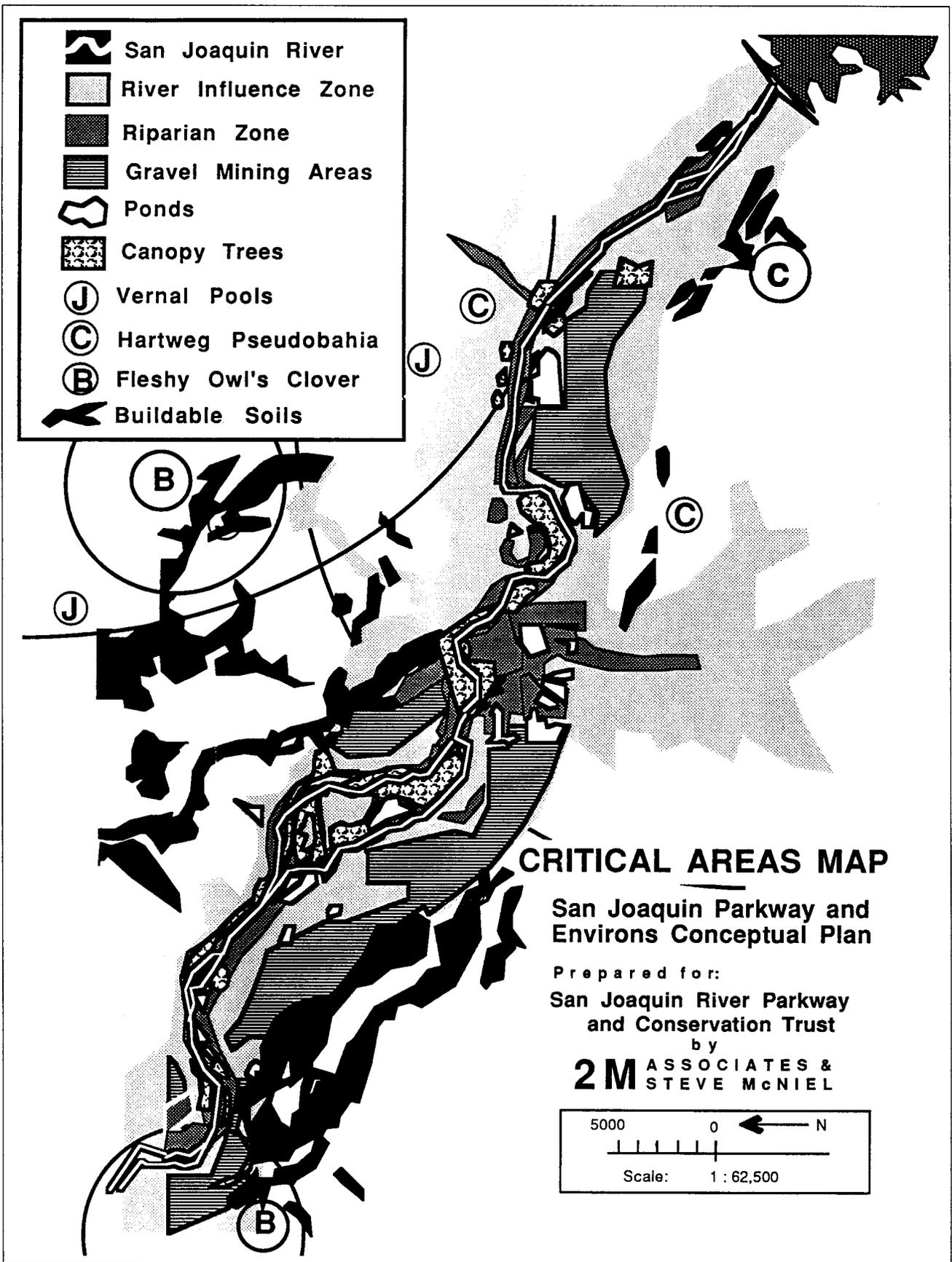


Figure 1—San Joaquin River Parkway Critical Areas Map. This impact analysis predicts areas where gravel mining and housing threaten sensitive biological resources.

DIGITAL CARTOGRAPHY

The spatial distribution of vegetation can sometimes be gathered from existing vegetation maps or even the vegetation tints of a United States Geological Survey (U.S.G.S.) map. However, most often this scale of information is not very useful to researchers or land managers. For example, in the 2400 acre Stebbins Natural Reserve Study several inventory and mapping methods were used, in sequence, to provide an increasingly useful level of information on vegetation for use in a GIS. (Fig. 2).

Originally, gross vegetation associations were determined in the field and mapped from high altitude aerial photographs in the traditional manner, drawing by hand on a mylar sheet placed over the photograph. This information was transferred into a computerized cartographic format by scanning the hand drawn mylar sheet. The resulting TIFF files were adjusted, when necessary, in Image Studio™ or Digital Darkroom™ and resaved as PICT files to save space on the hard disk. The PICT files were then pasted into any one of several drawing applications including Dreams™, MacDraw II™, Freehand™ or Superpaint II™ and redrawn.

However, after a wildfire in the summer of 1988, it was determined that this level of information was inadequate to track the post-fire regeneration of oak woodlands and other vegetation associations. We attempted to map every canopy tree, by species, on the site. The first attempt was accomplished by photographically expanding a portion of a 7.5' U.S.G.S. quad

map to a size of 3 ft. by 6 ft. as a base map, and projecting a slide of the aerial photograph onto this map. Expanded to this scale, each tree was marginally identifiable. Small circles were drawn on the enlarged base map by hand to indicate the location and size of each canopy. The large base map was then reduced photographically and scanned into the computer as the mylar overlay had been before. This technique yielded reasonable results, although, it did not identify individual tree species and lacked accuracy due to the limitations of visually interpreting tree canopy from an expanded, grainy image.

IMAGE PROCESSING

As research continued into post-burn regeneration and causal models began to be developed, it became desirable to understand, in greater detail, the history of change within the plant communities. Five different sets of aerial photographs, spanning a 36 year period, were available to do a study of the historic distribution of the canopy, chaparral and grasslands that cover the site. (Fig. 3). With the addition of large amounts of new data, it became clear that interpretation of each set of photographs by hand, as had been done to plot the canopy before, would be prohibitive in terms of time and money.

In order to accomplish the goal we explored the use of computer assisted image processing to provide the needed information. This technique was used to identify and map thousands of trees that could not be reached on foot. The image

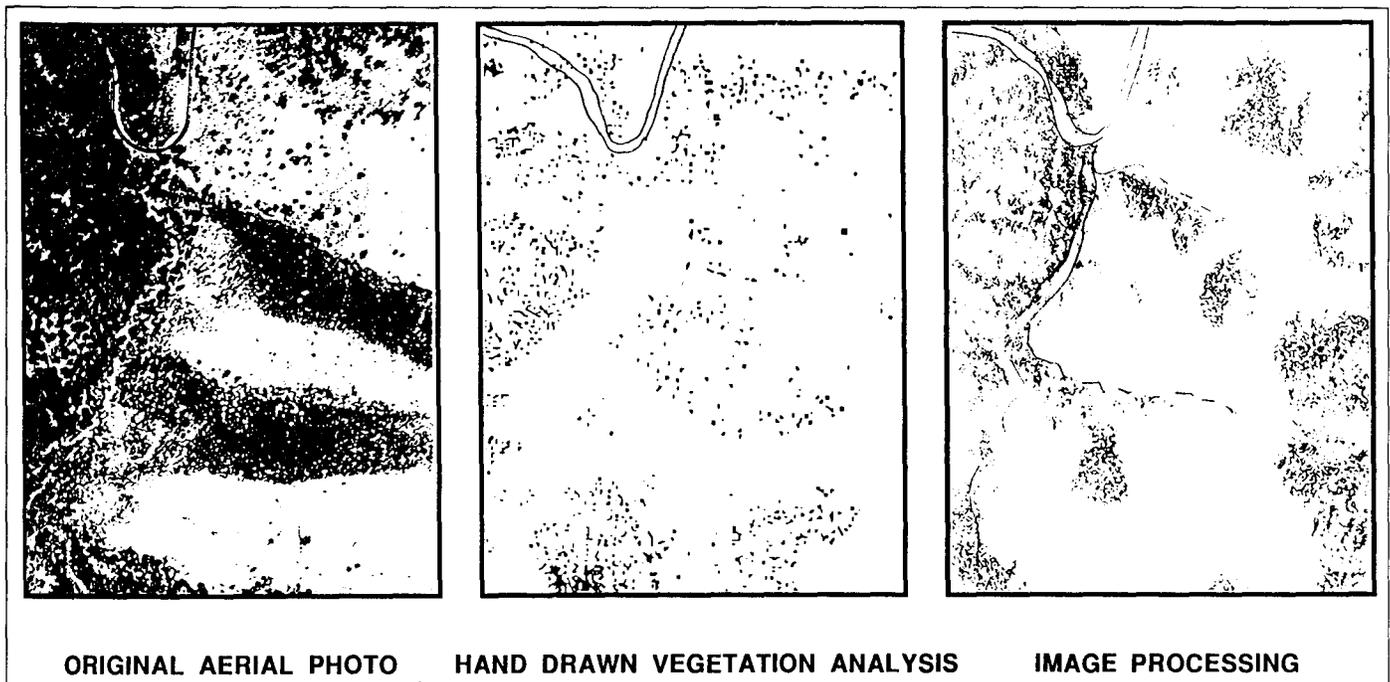


Figure 2—Stebbins Cold Canyon Reserve Vegetation Inventory. A comparison of two methods for inventorying hardwood canopy from aerial photographs.

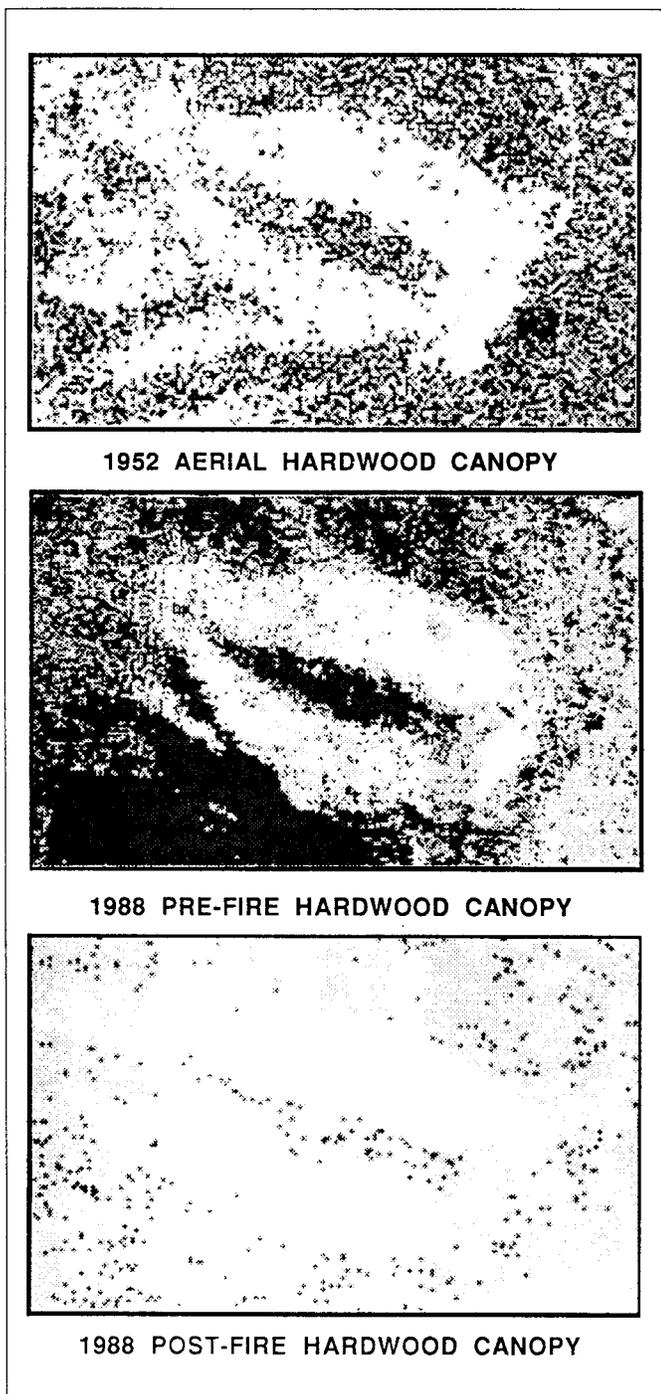


Figure 3—Change in Canopy Over a 36 Year Period in Stebbins Cold Canyon Reserve. Comparisons of canopy coverage as revealed through image processing shows a net gain in canopy between 1952 and pre-fire 1988 images. The 1988 post-fire image reveals the devastation to hardwoods in this particular area.

processing techniques that were developed used false color enhancement of aerial photographs to identify each canopy tree, chaparral area and grassland.

An aerial photo was first scanned into the computer using a half tone setting that yielded 27 shades of gray. Scanning was accomplished on a flat bed 400 dots per inch (dpi) scanner. There is a trade-off to be made with most scanners between the number of shades of gray recorded and the resolution of the image. Since the majority of the scans we used were half-tones and not true gray scale images, we learned to optimize the number of shades recorded to around 27 with a resulting resolution of 300 dpi and a 4 by 4 matrix. The TIFF files were then imported into Studio 8™, a medium priced paint and photo retouching application, for processing.

General associations were outlined in the field by drawing an overlay by hand on a mylar sheet, as was done originally. However, this vegetation association map was drawn with more accuracy and sensitivity to variations in the size and outline of each tree or stand. A botanist walked the accessible portions of the site and developed a species list for each general mapping zone. At the same time he recorded significant examples of individual trees of known species and located them on copies of the photos. Based on the color or tonal signature of the known tree which the botanist had identified in the field, Studio 8™ was used to highlight all other occurrences of the identical color or tonal signature. For example, on the photos, the indicator trees for valley oaks were made up of four shades of gray. All other occurrences of these four shades of gray were enhanced on the computer image by turning them dark green.

Theoretically, the resulting image located all valley oaks automatically. However, it was found that it took some careful examination of the photos and some additional tweaking of shades of gray to finally arrive at a reasonable estimation of the canopy. This additional tweaking was required because of subtle variations in shadows and atmospheric conditions when the photographs were taken. The results were of reasonable accuracy and consistency to allow us to perform the time series analyses. Although this system does not ensure 100 percent accuracy, it does provide reasonably accurate information where detailed site surveys are prohibitive for physical or financial reasons.

PHOTOREALISTIC SIMULATIONS

During the process of urbanization, clearing land to make way for new construction takes a heavy toll on oaks. While many hardwoods have been lost to development, better planning and education can save the oaks that exist today. One way is to develop new urban forms and alternative methods for retention and mitigation of impacts. In pursuit of this goal, Sacramento and other California communities have adopted legislation

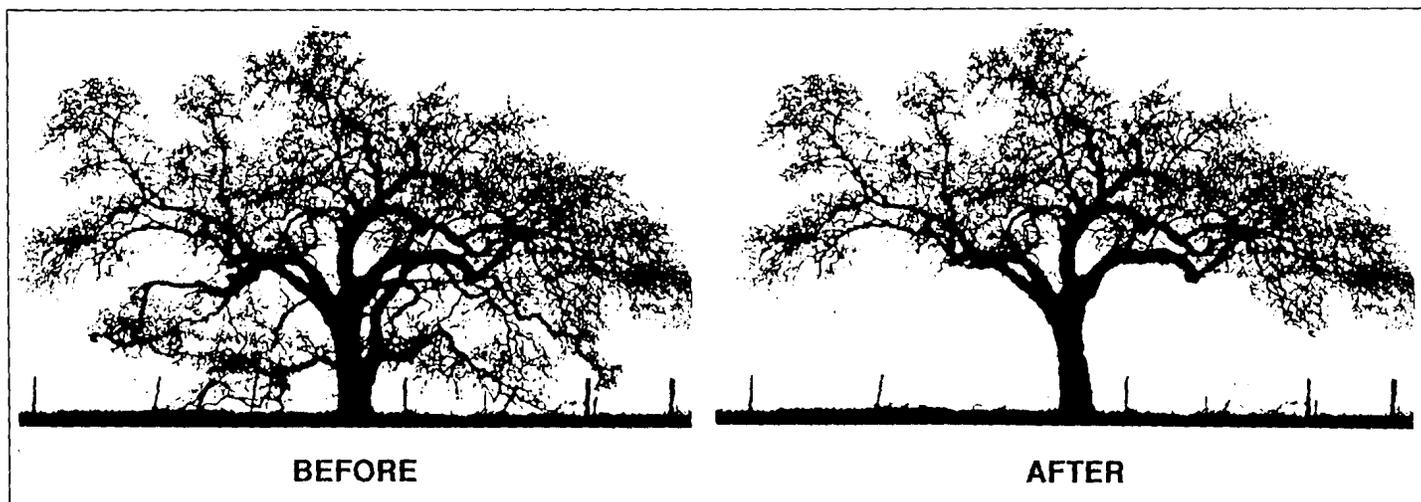


Figure 4—Pruning Simulation. This computer simulation illustrates the result of recommended pruning of the lower branches of an ancient oak tree. It was generated from a slide image using a slide scanner and photoretouching software.

intended to protect existing trees. However, preservation of individual trees will not ensure a stand of trees in the future. Only the conservation of intact wooded areas, seedlings and large tracts of open space, along with a rigorous replanting program on some sites, will guarantee oaks for the future.

In Amador County, suburban growth is beginning to occur at alarming rates and threatens to cover the oak woodlands and pastoral ridge tops with development if a new urban form, protecting these resources, is not adopted. At a recent public meeting photorealistic simulations of future development, under current policies, were used to illustrate the advantages of protecting all ridge tops and riparian zones from development. These simulations were based on actual color photographs that were scanned into the computer and modified with photo retouching software to achieve a final image. Computer simulations require expensive hardware and software but are a very effective visual aid. We use a Macintosh II with 5 to 8 MB of RAM and a 24 bit color video card and monitor. The original scanning is accomplished with a Truevision NuVista™ video digitizer board or a Barneyscan™ slide scanner. The slide scanner provides a much higher resolution image and is preferable to video imagery. Manipulation of images is accomplished with Barneyscan XP™, Photoshop™ or Pixelpaint Professional™ software. There are many other software choices in this area but all are expensive at the present time. Despite current costs, simulations communicating desired visual effects, technical specifications and impending impacts have proven extremely effective when presented to public officials, developers, contractors and citizens.

The computer has also been employed to facilitate the management and mitigation process. Using digital simulations of pruning effects and cabling diagrams helps avoid surprises and misunderstandings between the arborist and the maintenance contractor. These are created in the same way as the Amador County simulations, using photographs, slides or video tape to capture the original image. Output can be in the form of black and white or color paper printouts, slides, video tape or

direct projection from the computer onto a screen. (Fig. 4).

In conclusion, the capability of the Macintosh to support high resolution graphics and the availability of software applications such as Filevision IV™ and Studio 8™ provides a relatively inexpensive tool that can be purchased and used by public agencies, special interest groups and individual citizens to help conserve hardwood resources. While the combination of software used here cost just over \$1,600, comparable software normally used for GIS, image processing and photorealistic simulations can cost over \$30,000 for each application. The most expensive, single application used in these projects was Photoshop™, selling for approximately \$500. It is true, that the Macintosh software cannot do everything the \$30,000 packages can, but those things the software can do, constitute the vast majority of what is needed to inventory and manage land and hardwood resources. The real savings come in the form of ease of use and learning. Learning times can be measured in hours for these Macintosh programs as opposed to days, weeks and even years for some of the higher end computer software available on other platforms. Filevision IV™ requires approximately 1-4 hours while Studio 8™ requires only about 30 minutes in order to become productive. In doing photorealistic simulations, sophisticated software like Photoshop™ can be learned in a half hour, but requires closer to 4 hours to master.

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SOFTWARE

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