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Environmental Disaster Control Analysis

Color infrared photography revealed that frost damage to eucalyptus trees was not as great as visual inspection had indicated.

Introduction

Disaster struck the East Bay Regional Park District in December, 1972. However, a stark tragedy was averted in part through the timely use of color infrared aerial photography.

The East Bay Regional Park District encompasses Alameda and Contracosta Counties, California. This region east of San Francisco Bay that includes the cities of Oakland and Berkeley, and the adjoining hills.

The Problem

Disaster arrived in the form of the most severe cold snap since the 1880's. When it struck, much of the lush semi-Mediterranean vegetation in the region suffered severe frost burn.

Imported species of trees currently dominate in the region.

When the Spanish explorers arrived in the San Francisco Bay Region about the time of the American Revolutionary War, the hills were crowned with stands of lofty redwoods. The early Spanish settlers were followed by waves of emigrants from all over Europe and from Asia. The pace of immigration exploded when gold was discovered in 1848. With this discovery, the demand for lumber soared. The early settlers cut, hacked, split, and chopped trees in wild abandon. By the time John Muir, Teddy Roosevelt, and other bright lights in American conservation appeared over history's horizon, it was almost too late.

A few groves of coastal redwoods were saved, but a substitute had to be found. The cry of (and for) timber reverberated from a burgeoning America. Early lumbermen responded with vigor. Responding with more brawn than brain, however, they went to Australia for a replacement rather than attempt to culture the native species and restock the by now nearly bare hills.

Replanting with one of the more than 300 species of Australian eucalyptus went into full speed about 1910. Before operations were over and it was found that the wrong species had been planted, more than 3,000,000 gum eucalyptus were in place.

The wood obtained from the gum eucalyptus is heavy and brittle. It splits easily and burns very slowly. This last characteristic explodes a contradiction which surfaced after the 1972 cold snap, as will be shown.

For every loss there is a compensating gain, if we have but the intelligence and patience to search for it. Planting of the "wrong" kind of eucalyptus three-quarters of a century ago is no exception.

One of the major losses suffered when the redwoods were stripped from the slopes was that it exposed them to severe erosion. Planting trees—any kind of trees—stabilized the soil, retarding erosion. The second value is in part a mixed blessing. Gum eucalyptus trees shed oily leaves, bark, and seed pods. These have a distinctive, not unpleasant odor. The oil has medical values which are well known. It is also an effective antifungicide and pesticide. These properties help cut down the impact of some of the thalophyta which attack native species. The trees grow tall, fast, and straight. Some of them on the campus of the University of California at Berkeley are nearly 200 feet tall.

But there are undesirable side effects also.

The trees shed leaves and bark almost continuously. As they grow, the bark splits and falls off in long strips. Both traits are messy, and the litter could fuel a very hot ground fire.

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When the freeze struck in the winter of 1972, the leaves suffered frost burn. When this occurred, they took on a brown, weathered look. Normally, they remain green all year long, except for those that die naturally and fall to the ground. When the frost burn occurred, the trees turned from dark green to an apparent lifeless brown. This took place almost overnight. The bark-split habit accelerated.

Almost immediately, loud wails and politically motivated shrieks arose. Somehow, some way, opponents of the present local, state, and national administrations screamed, all persons in elective political office were to blame. Either we weren't doing enough to remove the imagined fire hazard, or we were doing too much of the wrong thing.

Had the trees been of an easily ignited fire-prone variety, a serious fire hazard might have existed. The ironic thing, though, is that this species is one rated as a "slow" burner, except under special conditions such as exist in Tasmania. In spite of this, many wailed that the trees are all dead, and that they must be removed.

It is a biological truism that in any time span a given percentage of all living creatures will die off eventually. When environmental stress is exerted, as in the case of the cold snap discussed earlier, normal mortality rates will be altered (usually accelerated).

We conceded that a need existed for accelerated selective cutting and clean-up of forest litter, but *not* for the complete removal of all trees within five miles of San Francisco Bay. This demand was made as part of a $3,000,000 class action suit.

Color Infrared Aerial Photography to the Rescue

Many of the trees did look dead, but several of us, quite independently, wondered.

Dr. Robert N. Colwell at the University of California pleaded caution. So did famed meteorologist Harry Geise whose clients, many of them in the field of agriculture and forestry, pleaded caution. So did I. This was the first case on record where extensive frost burn had been recorded afflicting this species. In local cases it had been noted that several of the apparently seriously injured trees had recovered. Weighing these facts, we agreed, quite independently, that we should adopt a "wait and see" attitude before clear-cut logging operations were undertaken.

This was where the use of color-infrared aerial photography come in.

No evidence of wide-spread tree mortality was noted in ERTS-A imagery of the area taken in March, 1973 at the time when shrieks were loudest. These observations came after earlier perplexing observations in examination of color infrared aerial photography.

The Earth Resources group at NASA Ames Research Center at Moffett Field, California had ordered two U-2 flights over the area as soon as the public clamor had arisen. Color infrared photography was obtained using a Wild RC-10 camera from an altitude of 65,000 feet on 4 January 1973, and again on 22 January.

It had been assumed that the "dead" trees would not reflect infrared energy, and would register in blue-green colors. This was not the case, however. The Eucalyptus groves imaged red-brown. This indicated that in spite of the outward dead appearance of the trees, most might still be alive.

Technology and the Public

Freedom of the press and of the airwaves is a wonderful thing. It must be preserved at all cost. Advocacy reporting rights, however, should carry with them the obligation that the reporting be accurate technically. Unfortunately, some news broadcasters do not agree with this concept.

Several politicians began to scream with renewed vigor for emergency relief from the Federal Office of Emergency Preparedness and the California Office of Emergency Services. The cry was for funds to "cut down all those dead trees before we have a catastrophic fire." California's two U.S. Senators introduced legislation requesting $11,000,000 to finance removal of all Eucalyptus trees on large sections of the watershed.

Early in April it became apparent that further study was needed. Mr. Gary Tate and other foresters in the East Bay Regional Park District were proceeding assiduously with selective cutting operations. Fire lanes were being cleared. Forest litter was being removed. All this was being done as rapidly as possible under a limited budget.

As cutting progressed, though, it became apparent that excessive cutting would accelerate erosion. This would result in accelerated siltation and possible clogging of streams and reservoirs. A major fire would be worse, of course. Had this occurred, not only would siltation be a problem, but charred wood ashes, fire retardant from aerial spray operations, and other materials would have degraded water quality.

Flight Test Operations

Under sponsorship of California Aero Topo, Inc., Environmental Design Center, the Environmental Protection Institute undertook color infrared flight operations over the area, to photograph some of the apparently "dead" eucalyptus groves. Before scheduling large-format vertical photography with the RC-10 camera, it was decided to obtain some low-altitude oblique stereomultiband photographs. These were taken using 35 mm Eastman Kodak Type 2443 film, pairing the Wratten 12 and 15 filters.

The approach was selected because

(1) It was considered likely that if new growth were developed in the eucalyptus trees it would develop at the far ends of the crowns where it may not be visible from the ground. Such budding had been noted in undamaged eucalyptus trees (in the author's yard); and

(2) Spectral response characteristics of the available film were not known.

A flight was made on 3 April, 1973. Color infrared and concurrent natural color aerial photographs were obtained. Color infrared photographs were obtained using Type 2443 film. The natural color photographs were obtained using Kodachrome II.

The film was obtained from the Eastman Kodak processing facility on 8 April. It was examined in stereo immediately.

An initial evaluation indicated that most of the trees showed evidence of budding—conservatively, 75 percent. This was indicated in color infrared, even though evidence of budding was not evident in the concurrent natural color photography.

Method of Analysis

This aerial photography was in the form of 35mm slides. Visual analysis was accomplished in two ways; by direct viewing using a stereo microscope as was demonstrated in one of the author's earlier books, *35mm Aerial Photography*, and by projection. The slides were projected using a very short focal length lens (50mm) and projecting them through a polacoat screen. This was more satisfactory than was an earlier test in which slides were merely projected against a standard projection screen.

The use of an isodensitracer to prepare a themic separation may have yielded more significant results. It is hoped that readers who have access to such equipment will test this approach.

Technical Lessons Learned

Camouflage detection film, the grandfather of type 2443, was designed to detect the scattered few trees which are (or have been) killed or cut for camouflage. Other applications have been to photograph crops to detect disease and insect damage. Here, too, scattered evidence of mortality is expected, and searched for. This is true except in the very rare, fortunately, event of holocaust mortality.

Scattered mortality is expected and acceptable in this case, and it was a relief to find that holocaust mortality had not occurred. Simple observation in the visible portion of the spectrum indicated that holocaust mortality had occurred.

The major lesson learned in this case was that color infrared aerial photography can play a very valuable role in measuring the extent of some forms of natural and semi-natural damage. Potential examples of valuable application are—

(1) Assessing the extent of frost damage, as in this case;

(2) Assessing the extent of salt spray damage after hurricanes. (This occurs to pines and other types of vegetation which have been planted to stabilize dunes along the eastern seaboard.); and

(3) Assessing air pollution damage (both natural and man-created).

A lesson for the environmental control standpoint is go slowly. Had clearcut logging proceeded, as some members of the press and bar demanded, irreparable damage may have occurred.

Sequel

All problems resulting in environmental disaster deserve a happy ending. This one is no exception.

Questions arose about public acceptance of color infrared technology, and how effective it really was in assessing the conditions reported here.

Public acceptance demands public knowledge, and this was extended via the local news media. Through the good offices of local broadcasters, I appeared on TV Channel 7, KGO, through the courtesy of Mr. James Marshall, and showed a color infrared slide. Later, I appeared in a "Friend of the Court" role before the Directors of the East Bay Regional Park District, pleading for selective cutting (and that with caution).

As the growing season progressed, it became apparent that survival was more than 90 percent (perhaps as much as 99 percent),

far greater than the very conservative 75 percent estimate made earlier with the first blush of new crown cover.

The professionals descended with full force, and progress accelerated in reducing fire hazards. With the help of Radio Station KCBS, Mr. Ray Hunter, Director, California Department of Conservation and Dr. John Zivnuska, Dean of the College of Forestry and Conservation, University of California at Berkeley set the record straight for the public.

A fuel break was established and potentially dangerous forest litter was removed (by the California Division of Forestry and the California Ecology Corps, primarily). A re-filling base was established at Napa County Airport so that aerial tankers could re-fill with fire retardant chemicals. In short, a total program of prevention and planning was established.

Congressional action followed also. The bill to provide $11,000,000 passed the U. S. Senate, Congressional financial watchdog Rep. H.R. Gross (Iowa) had seen the color infrared photos and deduced correctly that the trees were not all dead. He succeeded in killing the bill in the House, with the terse comment that if it passed—it should be called the "YOU CLIPPED US" bill. We can conclude proudly, I suggest, that the proper and timely use of color infrared aerial photography saved us tax-payers $11,000,000!

This is a story of how many, many people in several disciplines working together can act in the common good for all. I hope it will stand as a guide to show how our profession of remote sensing, a "tool science," can be of general value in environmental disaster relief operations.

Articles for Next Month

Dr. Marshall D. Ashley, James Rea, and *Linda Wright,* Spruce Budworm Damage Evaluations Using Aerial Photography.

R. M. Batson, Kathleen Edwards, and *E. M. Eliason,* Synthetic Stereo and LANDSAT Pictures.

Cyrus Beck, Inadequacy of the Scattering Coefficient.

Robert E. Brown and *Robert K. Holz,* Land-Use Classification Utilizing Infrared Scanning Imagery.

Toyohisa Kaneko, Evaluation of LANDSAT Image Registration Accuracy.

C. J. Tucker and *E. L. Maxwell,* Biological Criteria in Sensor Design for Monitoring Vegetation Canopies.

Richard S. Williams, Jr., Philip G. Hasell, Jr., Albert N. Sellman, and *Harry W. Smedes,* Thermographic Mosaic of Yellowstone National Park.

Prof. Paul R. Wolf, PhD, and *Richard A. Pearsall,* The Kern PG-2 as a Monocomparator.