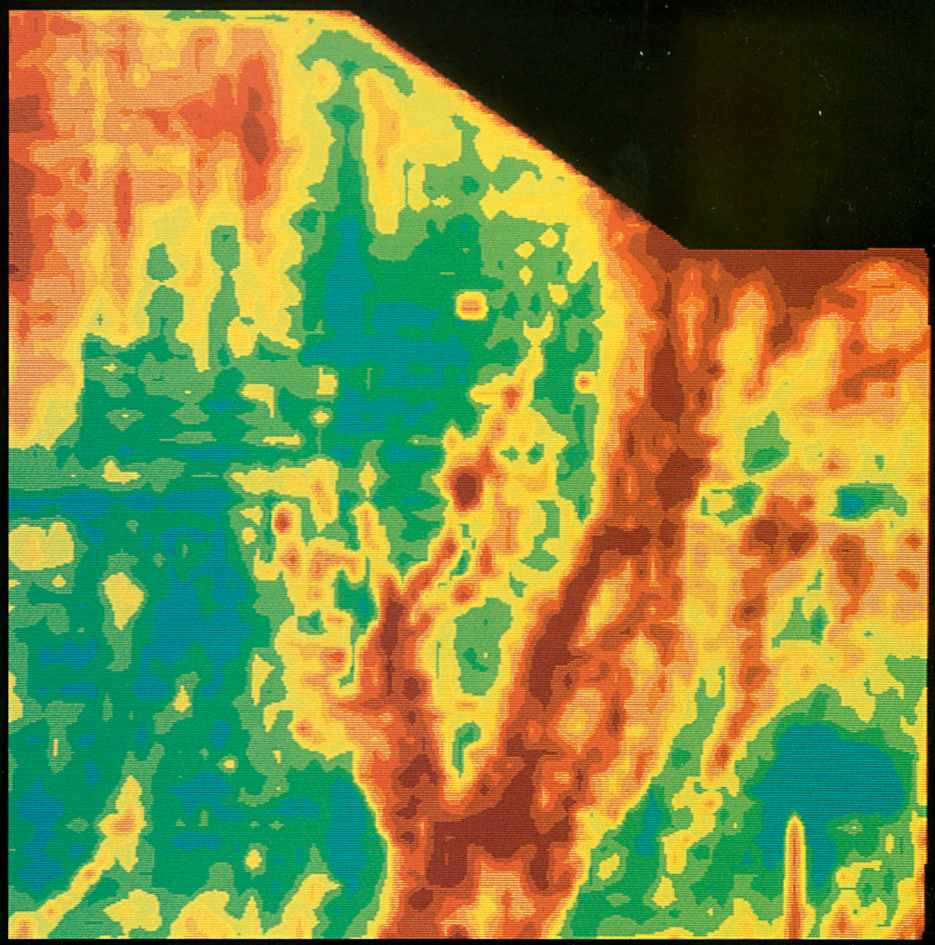
Orbiting Eye Will See Where Crops Need Help

Within 3 years, plans call for launching the first commercial satellites for delivering crop information to farmers within a day after it's obtained. An airplane-carried prototype already flies.

Countdown to the satellite launch began several years ago at an Agricultural Research Service (ARS) laboratory in Weslaco, Texas. By summer 1999, four satellites could eyeball every crop acre on Earth about twice a week, from 450 miles up.

Data from their digital sensors will stream to two receiving stations on the east and west coasts of the United States. From there, computer-processed information will bounce off existing communications satellites and be snagged by small satellite dishes linked to computers.



Above: Potential yield from this cantaloupe field is analyzed from high-flying aircraft. Red indicates the smallest melons, while green shows areas of largest.

Facing page: Computer-generated maps show changes in the health of cantaloupe vegetation before they can be seen in the field.

Farmers and farm advisers will view the images, print out color maps, run statistical analyses—and know exactly where on the farm to find the problems the imagery has spotlighted.

The result should be a fast track to more informed, timely decisions—and fewer regrets along the lines of "if I knew then what I know now...."

Agronomist John LeBoeuf, who is with Fordel, Inc., in Mendota, California, has used the airplane prototype since 1993. RESOURCE21, Inc., which will build and launch the satellites, supplies the service to LeBoeuf and dozens of other farm advisers and growers.

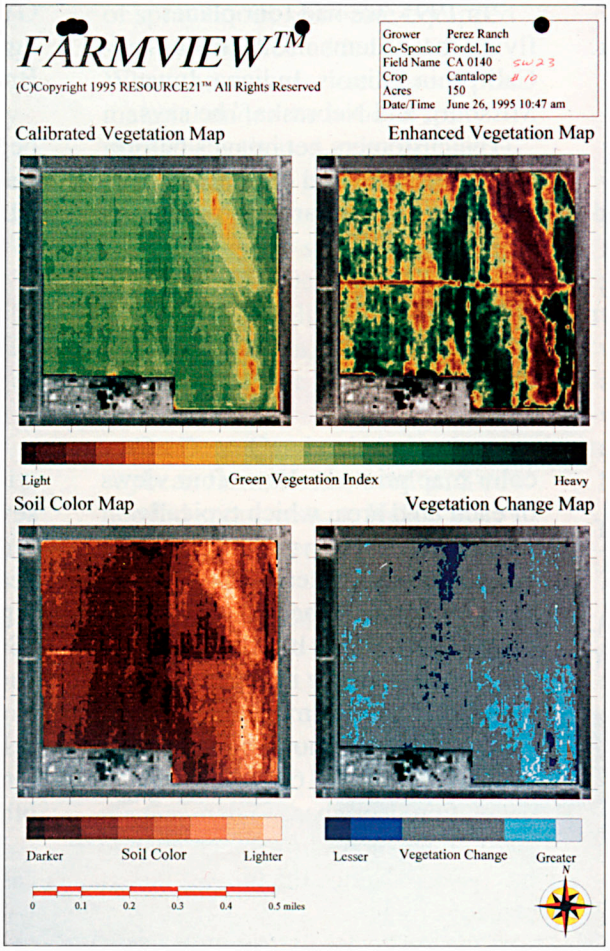
Fordel, a grower, packer, and shipper, has 5,000 owned or leased farm acres in California. The plane-carried prototype of the Earth-orbiting system watches over about 1,700 Fordel acres, mostly in cantaloupe and honeydew melons.

How does the information help? LeBoeuf ticks off some examples.

"It identifies areas getting too much or not enough irrigation water," he says. "It lets us find nutrient deficiencies in the plants, so we can remedy them. It points us straight to weed, nematode, aphid, and salt problems that almost certainly would get worse without attention. We also use the information to pinpoint outbreaks of plant diseases such as *Fusarium* wilt and vine decline."

Is remote sensing something only big farms could use?

"No," LeBoeuf says. "It's conceivable almost any size farm would find it useful. While farmers don't need to know how the cameras and satellites work, they do need to know that the system picks up changes before the human eye can. It usually won't tell what the problem is, but it will tell you where to find it. Then you apply your farming knowledge and experience."



Video Sensing Takes Off

Since 1985, ARS range scientist James H. Everitt and the team he leads at Weslaco's Subtropical Agricultural Research Laboratory have assembled, tested, and refined approaches to using remote sensing for monitoring crops and the environment. Now they're seeing their high-tech dreams played out as part of the everyday business of agriculture.

Most U.S. farms using RESOURCE21's system are in the 1,000- to 2,000-acre range. Farm remote-sensing services are also available in other countries. AGRO-SAT Consulting, Ltd., based in Berlin, Germany, uses the basic system designed by Everitt's team to help German farmers with fertilizer recommendations.

Until recently, turnaround time has been a chief drawback to using satellite data on farms. It took days, weeks, or months to convert imagery to a form that would have been useful—had it reached farmers promptly.

Everitt's team at Weslaco's Remote Sensing Research Unit has long been in the vanguard of developing remote sensing for farms using videotape and low-flying planes. [See "Airborne Video—A Ride on ARS' Own Air Force 1," *Agricultural Research,* February 1991, pp. 4-9.]

In 1991, Weslaco's setup used three video cameras attached to a portable frame and placed so they peered at the land through a port in the plane's floor. Each camera had a different light filter—near-infrared, red, and yellow-green. To human eyes, these video images would look black and white.

But studies by Everitt, remote-sensing specialist David Escobar, and others at Weslaco had established spectral "signatures" for dozens of plant, soil, and water conditions—such as weeds, excess salts, and infestations of plant diseases or insect pests—that showed up best on one or another of the three filters.

The ARS team had also drawn on decades of research on interpreting satellite and aircraft data by others at ARS as well as by the National Aeronautics and Space Administration (NASA), universities, and private industry.

From the three taped images, the ARS scientists produced composites, called color infrared. They could interpret the colors—based on known signatures. They knew, for example, that a color infrared image of a sorghum field would show healthy plants as magenta and areas with chlorosis, an iron deficiency, as pink.

The ARS team made faster progress once higher resolution Super-VHS video recorders became available in the late 1980's. "But," Everitt recalls, "after a flight, we had to spend hours and hours converting videotape images to digital format. Only then could we use the computer to break down the information into useful statistics."

Tuning in a Space Channel

George May knew about the Weslaco research. May is director of the Space Remote Sensing Center, a part of the Institute for Technology Development (ITD). The center is located on the Gulf of Mexico about 20 miles west of Gulfport, Mississippi.

"We went to Weslaco in 1991 to see how their aircraft-based video system operated," May says. "But we wanted to get it up to space. You can't cover the whole world from small airplanes."

A nonprofit company, Space Remote Sensing Center entered a cooperative research and development agreement with ARS in 1988. The center receives some funding from ARS, NASA, and private industry. But its goal was to stimulate creation of a company that would generate its own financing to launch a space enterprise.

"We put together a business plan and created RESOURCE21. To show growers and industry that a space-based farm surveillance system would work, we started with planes—flying basically the same system Jim's team had developed, except we used digital cameras," May explains.

The system's resolution—the area shown by one bit, or pixel, of digital information—is 10 meters, or one-fortieth of an acre, forming a square with sides of 33 feet.

"In 1995, we had four planes flying the systems in six states—California, Illinois, Indiana, Iowa, Missouri, and Nebraska," he says.

The customers get images before planting season and once a week thereafter. A standard 11-by-17-inch color map printout shows four views of each land area, which typically covers 160 acres.

One image—taken before planting but used for reference all season—is the soil color map. It reflects soil differences, mainly in organic matter and ability to hold moisture. Two vegetation maps show crop growth; one discriminates 16 gradients in vegetation, from bare to dense. A fourth map shows how much change has occurred since the time of the previous image.

"The maps and the computer generated statistical analyses let growers make decisions based on comparisons of the same field from week to week and year to year," May says.

When information points to problems in small areas, spot treatments can cut needs for fertilizer, chemicals, and water—or ensure that a deficient area gets the extra it may need.

"Since 1991, about 170 farmers have paid for the service and also invested their time to help improve the products. This year, RESOURCE21 will cover about 50,000 acres," he says. "We anticipate that several hundred million dollars will be invested by the partners that make up RESOURCE21."

The current partners are Agrium Ltd., Boeing Commercial Space Company, Farmland Industries, Inc., GTD Systems, Institute for Technology Development, and Pioneer Hi-Bred International.

Next fall, RESOURCE21 plans to begin building five 1,200-pound, solar-powered satellites—four to launch, plus a spare. Each will grab a wide swath of digital data during its several daily orbits.

In 1995, RESOURCE21 had four planes flying the system in six states.

And in Weslaco, research continues. "We're beginning to study a 12-digital-camera system," says Everitt. "Some bands, such as mid-infrared and thermal infrared, are available from satellite. But agricultural researchers need to find out how to interpret them in ways farmers and others can use."

May notes that the number of cameras deployed on future satellites will depend partly on the Weslaco experiments.

"The RESOURCE21 venture," says May, "coming about because of the achievements of Everitt and his research team, will provide the United States a capability that does not exist anywhere else in the world."—By **Jim De Quattro,** ARS.

James H. Everitt is at the USDA-ARS Subtropical Agricultural Research Laboratory, Remote Sensing Research Unit, 2413 E. Highway 83, Weslaco TX 78596, phone (210) 969-4824, fax (210) 969-4893, e-mail j-everitt@tamu.edu ◆