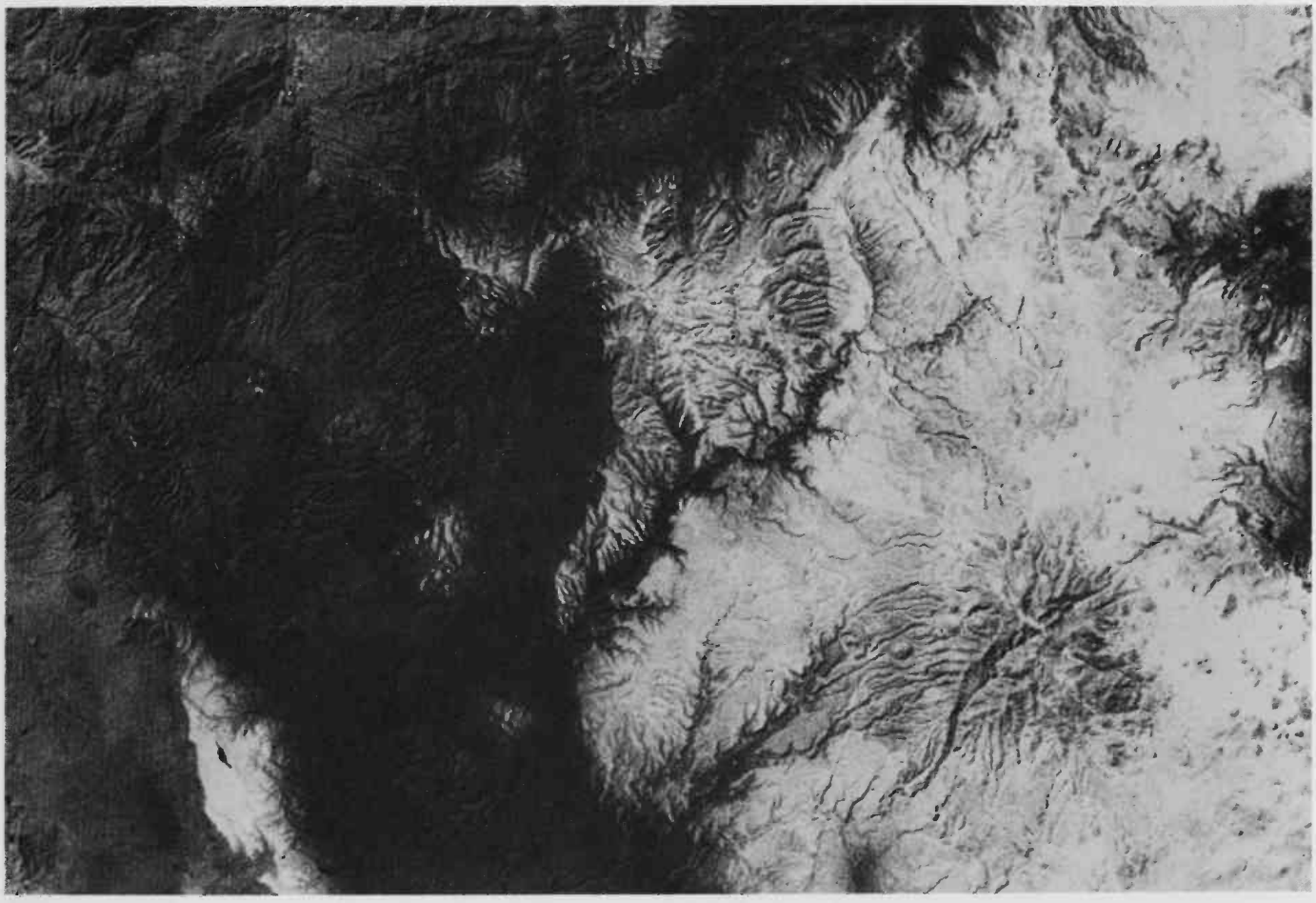


NASA PHOTO

(above) Arizona's many cloud-free days make for clear satellite pictures of northern Arizona's snow country. (right) Chief snow researcher Dr. Peter Ffolliott, at the computer, and hydrologist Dr. D. Phillip Guertin have taken field research and incorporated it into a computerized teaching tool.

Harvesting Snow In Water Shy Arizona

Snow is a critical part of the water picture in Arizona. Up to 70 percent of the water in the state's reservoirs comes from the snowfall.

By Lorraine B. Kingdon

It's 4 a.m. on a cold winter morning in the mountains. Snow glistens under the moonlight as Dr. Peter Ffolliott and his students climb into snowmobiles and, later, put on snowshoes.

It's two in the afternoon before they wearily stop taking measurements of snow depth and weight in the White Mountains, the Coconino National Forest or along the Mogollon Rim.

For 15 years, measuring snow every winter was part of Ffolliott's life at the University of Arizona. The watershed management professor led 60 graduate students in what was one of the largest snow research projects in the United States.

A serious study of snow from Tucson, Arizona, may seem as unlikely as mountain climbing in Kansas. Yet, snow is a critical part of the water picture in Arizona, Ffolliott says. Up to 70 percent of the water in the state's reservoirs comes from the snowfall.

"If snowmelt water yields were increased by 10 percent, an additional 150,000 to 350,000 acre-feet of water might be realized annually to help meet the growing needs of downstream users," Ffolliott believes.

Before central and southern Arizona could benefit from the extra water, Ffolliott and the graduate students had to study the physical properties of the snowpack firsthand. They worked in cooperation with the U.S Forest Service learning how the forest could be managed to increase water run off from snow.

Eighty percent of their work was done in the Salt and Verde River Basins, in cooperation with the Salt River project.

Although snow measurements had been taken in other parts of the world, Arizona's snow was—and is—different. The snowpacks are intermittent; the sunshine is more constant; snow depth is more variable; and snowfall that lands on trees is not necessarily lost to the run off as it is in most other states, Ffolliott explains.

The tools for their field measurements were simple: a series of 30-inch-long tubes that could be coupled together to measure snow depth and a scale to measure snow weight (which determines the amount of water in the snow). And, snowshoes for everybody.

Snowshoes were a necessity. Snowfall in Flagstaff averages between 100 and 200 inches in a season, usually from November until April. Of course, Ffolliott still remembers 1973 when 300 inches fell.

At least one student took some convincing about the need to wear snowshoes, Ffolliott remembers. A young man from the Philippines had never seen snow, and he thought snowshoes clumsy and inconvenient—until he took two steps away from the snowmobile and fell, head over heels, into snow deeper than he was tall.

His plight, along with a picture taken before he was quickly rescued, made headlines in newspapers across the Philippines, Ffolliott tells. Needless to say, the student became an instant convert to the use of snowshoes.

Snowshoeing takes a lot of energy; by the end of the winter, Ffolliott says the snow research team were in as good a condition as the UA football team.

"I spent some of the best times of my life on showshoes," he remembers.

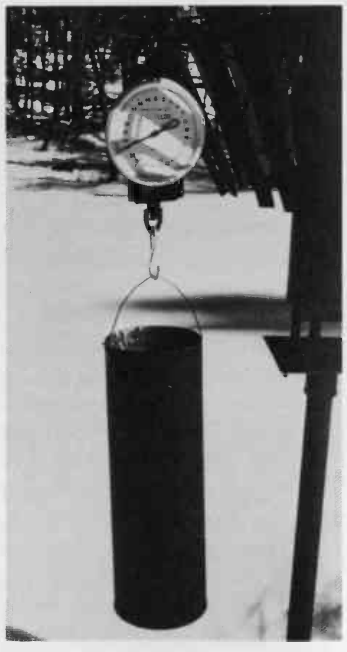
Of course, he also remembers those weekends when it snowed; snow can't be measured while it's still falling. "We'd leave Tucson on a Friday after-

LYNN KETCHUM

25 Years of Snow Research

"Back in 1961 we developed a chart of what should be done to predict snow melt; 25 years later, I can say, 'we did it.'"

PHOTOS BY PETER FFOLLIOTT



Tools of the snow researcher's trade. Connecting tubes (upper left) are used to check snow depth, a movie camera (above) records temperature and the rate of snowmelt, a scale (right) is used to measure snow weight, in turn the amount of water in the snow. (far right) A permanent monitoring station measures actual runoff from melting snow.

noon, stay at a motel overnight and sometimes we'd end up spending Saturday watching basketball games on the TV," he reminisces.

For safety, they traveled in teams of two between transects, areas marked off for taking measurements earlier in the fall before snow started.

The transects could look entirely different after it started snowing, Ffolliott says. Only one student actually got lost when he wandered over a ridge into an unfamiliar watershed and didn't "find himself" until he bumped into a hunter's shack about 10 that evening. "Usually, we might not have known exactly where we were, but the snow mobile was lost, we weren't," Ffolliott laughs.

What good did all their measurements do?

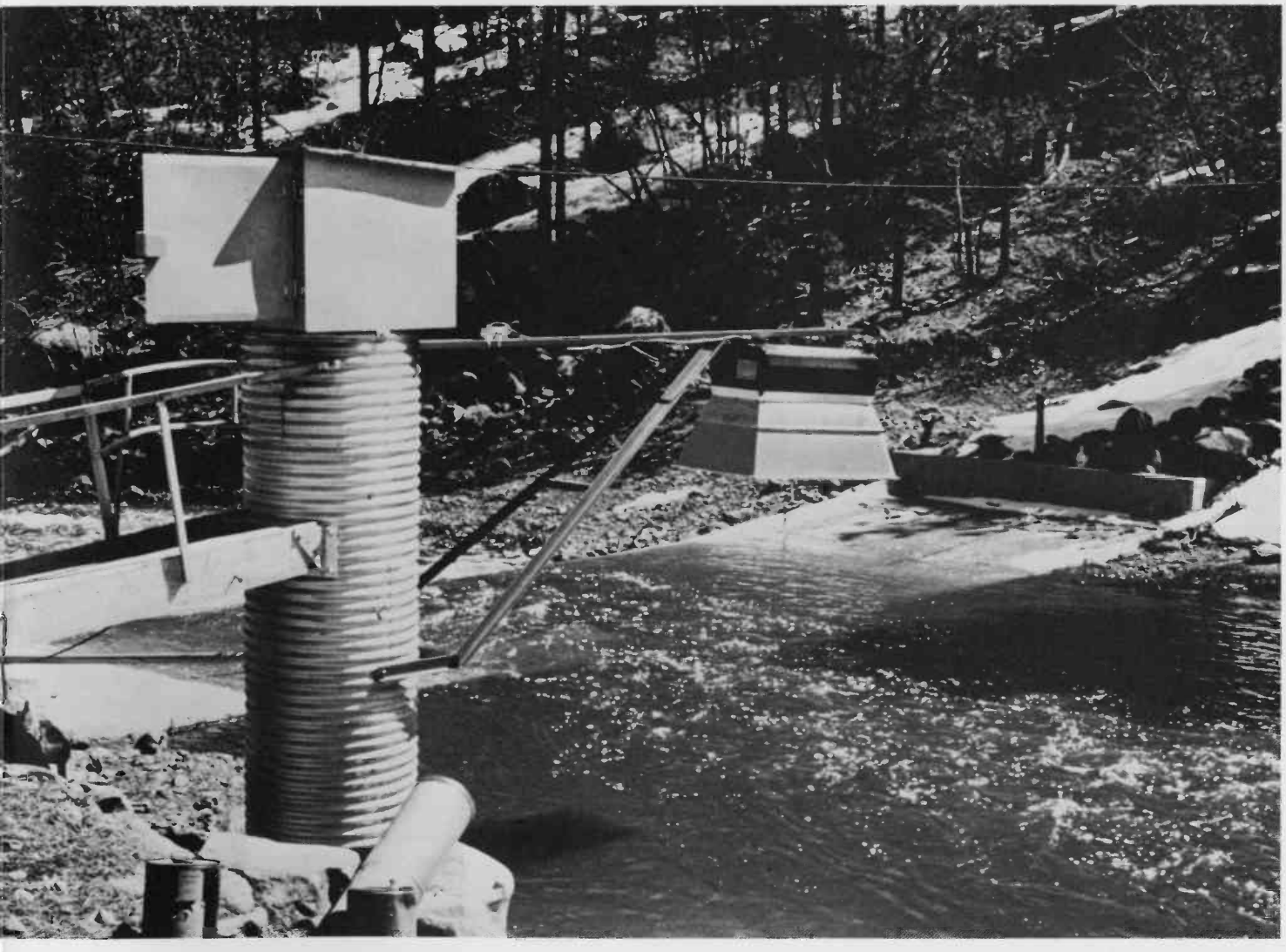
They determined that snow becomes denser as it changes from a fluffy pack to an icepack as it "ripens" just before melting. They calculated what conditions affected ripening. They found what factors influence the timing of snowmelts.

"In most situations, higher snowpack densities occurred under sparsely stocked forest stands, suggesting using forest management to ripen snowpacks," Ffolliott reports. He measured the snowpack along power line right-of-ways to check the theories that developed.

He theorized that foresters might be able to increase the water yield from the snowpack by making sure the snow accumulated, without melting, until spring.

Research shows that either thinning the trees or clearing the forest in various opening patterns can work.

The watershed management professor led 60 graduate students in what was one of the largest snow research projects in the United States.



25 Years of Snow Research

The UA is still doing snow research, but it has moved from the snow field to the computer laboratory.

Clear-cutting, or removing all the trees in a stand of timber at once, is not as beneficial.

Ffolliott admits that foresters won't be cutting or thinning trees solely to affect the snow runoff. "But, we're now able to say what effect timber cutting will have; we can prescribe timber management," he says.

UA snow research has involved more than getting out in the snow with tubes, scales and snowshoes, enjoyable as Ffolliott and his crew found the exercise. Satellites were used, and now computers play a leading role in the research.

Back in the early '70s, the UA cooperated with NASA to determine the feasibility of using satellite imagery in snow hydrology research. Ffolliott found that Arizona's snow country is uniquely suited to getting snowpack information from the satellite.

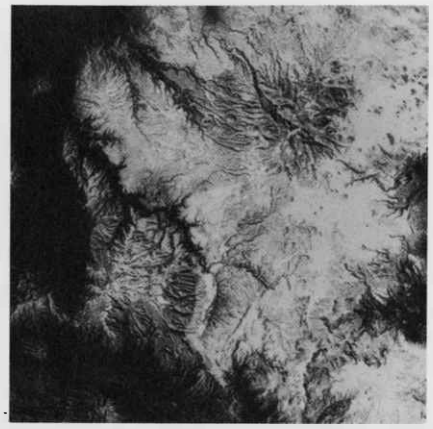
It's as simple as this: the sun shines more often. There's a greater number of cloud-free days. What looks like snow in the satellite photos is actually snow. Ffolliott explains that it's hard to tell clouds from snow in a photo taken from a satellite 100 miles up in the sky.

Using satellite imagery and his ground level measurements, Ffolliott found a close correlation between the extent of the snow cover, the water content and subsequent run off into the watershed.

The UA is still doing snow research, but it has moved from the snow field to the computer laboratory. He and Dr. William Rasmussen, UA director of the Western Computer Consortium, have designed computer simulation models that predict daily snowmelt for forest and watershed managers.

UA-designed programs for the computer do more, however. Ffolliott and other snow hydrologists can use the computer programs to predict the effects of managing the forest in alternative ways. They can evaluate how much water would be released to the watershed before a specific management technique is tried.

"The computer helps provide a basis for making decisions," Ffolliott says. The work continues. "We're adding new computer subroutines to better predict the results from a wider variety of alternative."



NASA PHOTO

The framework of the UA simulation models are being modified for use almost around the world, wherever information about multiple-use forest planning has become important. Ffolliott and UA hydrologist Dr. D. Philip Guertin have gone one step further.

Approximately 150 students have used the computer snowmelt model in a course, "Simulation of Renewable Natural Resources," to input their own ideas about forest management — to see what happens as a result.

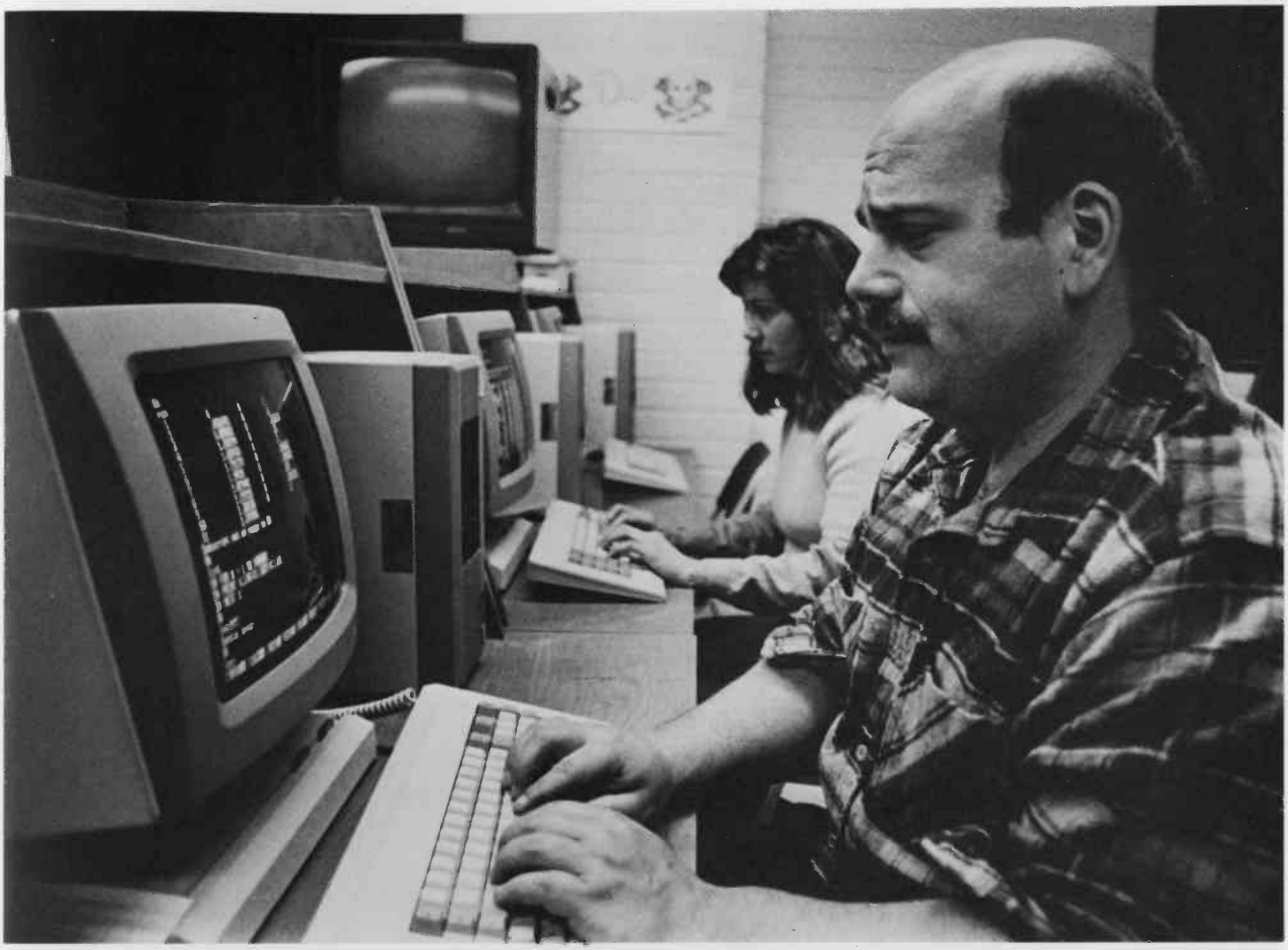
"You don't have to be a computer whiz to use the snowmelt model," Ffolliott comments. He and Guertin plan to take computer terminals to public land use meetings so people could answer their own questions about, "What would happen if...?"

Ffolliott believes, "Importantly, it seems possible that forest management activities can be designed to increase the amount of recoverable water from snowpacks, and at the same time, furnish the timber, forage, wildlife and amenity values required by the people of Arizona."

When he looks back at the 25 years of snow research he has conducted, Ffolliott is pleased. "Back in 1961 we developed a chart of what should be done to predict snow melt; 25 years later, I can say, 'we did it.'"

Snow research has moved to the computer laboratory, but Ffolliott still makes a point of doing a few studies out in the snow. "...Because, it's fun."

LYNN KETCHUM



Renewable natural resources students study forest management with the help of a computer snowmelt model designed by Ffolliott and Dr. William Rasmussen.