altered to make crinkled leaves that hold water. And the ability of plants to reflect sunlight can be bolstered biophysically so that less water is lost through evapotranspiration. Rosenberg says he is confident that such technologies can have major impact—over a period of time—in lessening drought's effects.

All seem agreed that the social sciences, the physical sciences and the agricultural sciences all have crucial roles to play. And, concludes Rosenberg, "We need a national strategy to cope with drought." □

Pueblo population explosion

One of the most consistently popular features of each AAAS meeting is the annual public lecture sponsored by the National Geographic Society, which this year adhered to the meeting's regional theme by presenting a film of the first modern excavation of a 14th-century Pueblo in the Rio Grande area. The film was narrated by Douglas W. Schwartz, director of the School of American Research in Santa Fe, who conducted the excavation.

In an interview with SCIENCE NEWS, Schwartz called the northern Rio Grande region near Santa Fe "the stepchild of southwest archaeology." People settling there, he says, were the "country cousins" to Indians in larger, better-known pueblos farther west, like Mesa Verde. Yet, for all the Indians in the area, the 14th century was a critical period, with Mesa Verde being abandoned just as a recently excavated site—Arroyo Hondo, 5 miles south of Santa Fe—was experiencing a population explosion.

After carefully applying four dating techniques, Schwartz concludes that the original village at the site grew from only three families in 1285 to more than 1,000 people 30 years later. "For a primitive population," he says, "that is an amazing increase." The Pueblo eventually grew into a large complex of apartments with three to five rooms each and at its peak in about 1330 would have housed perhaps 1,700 people.

But again the population changed rapidly. By 1350, the site had been completely abandoned; 20 years later it again had a substantial population of 400; and by 1420 it had been permanently abandoned. These changes, Schwartz says, "seem to correlate exactly with the climate changes we see."

The critical factor was water, whose availability can be measured quite accurately by studying tree rings from the time. As water decreased, food became scarce and the very young were the first to suffer. Eventually half the children were dying before they reached the age of five from causes related to malnutrition. Abandonment of the site, Schwartz says, was thus not so much a matter of mass migration as a "fading away," as the population eventually dwindled down to a few old timers. Schwartz hopes to incorporate the knowledge learned at this excavation into a more general model of population explosions.

The film, produced by the National Geographic Society, illustrates four years of the painstaking work needed to draw such conclusions. (The work itself was funded by the National Science Foundation.) In one sequence of time-lapsed photography, the eight days required to excavate a single room is compressed into two minutes, giving the viewer a new appreciation for archaeology as both the most strenuous and most tedious of sciences.

The interdisciplinary nature of the modern archaeological dig is also illustrated. A paleobotanist pieced together clues to the Indians' varied diet. An ecologist tested soil in the area to determine where fields had been and then replanted the crops and raised them. In an experimental dating method magnetic fields frozen into the ashes of ancient fires were correlated with records of the wanderings of the magnetic North Pole.

Schwartz is reluctant to apply the lessons of Arroyo Hondo to the modern population explosion or to threatening changes in climate that some other scientists have said could devastate vulnerable societies. He points out the obvious difficulty of extrapolating from a simple society to a complex one. But then he pauses and begins to talk of the "delicate balance" of nature in drought-stricken northern California. The shrinking of previous societies in response to climate is unmistakable, he says. And then "maybe we will see a contracting in our own day." □

Double challenge of western coal

Reports on studies sponsored by the Council on Environmental Quality and the Environmental Protection Agency indicate that the economic incentives for tapping the vast coal resources in the western United States would be almost irresistible, but that environmental penalties would also certainly be severe. One ray of hope for a "technological fix" comes from an upbeat report of progress in underground coal gasification. The conclusions were reported at the series of symposiums on regional themes at the AAAS meeting this week in Denver.

The CEQ study, by Joyce M. Kelly, presents results of various possible scenarios of development, highlighting the strengths and weaknesses of each. The assumption is that coal mined, say, in Montana, will eventually produce electricity used in some larger city far to the east, for example, Chicago. The electricity could be generated at the mouth of the mine, or coal could be hauled by rail to Chicago or it could be mixed with water and sent as a slurry. Or the coal could be gasified before burning—at the mine in Chicago, or at some intermediate point.

Gasification produces only about 10 percent as much air pollution from sulfur oxides as direct burning, but the process requires more water and more land. Transportation by rail or slurry is efficient, but rail transport generates additional air pollution, while slurrying would require great quantities of water in a region where it is scarce. Producing electricity at the mine mouth and carrying it by wire to Chicago would waste four or five times as much energy as rail or slurry. The question of water availability for some schemes has not yet been solved, and environmentally, "none of the scenarios seem to be clearly preferable."

In considering direct costs, however, there is no contest. "Generating electricity directly from coal at Chicago involves the least dollar cost and . . . it is always less expensive to generate the electricity directly from the coal than to gasify it first."

The EPA-sponsored study was conducted by a team from the University of Oklahoma and from the Radian Corp. Oklahoma zoologist Irvin L. White prepared the report. This study did address the problem of water availability and water pollution, concluding, "Water problems and issues are clearly the single most significant category of problems and issues that policymakers will have to deal with in choosing among energy development alternatives."

Some, though by no means all, of the problems discussed could be eased by gasifying coal while it is still underground. The idea is actually quite an old one—dating back to 1848—and the Soviet Union has been experimenting with *in-situ* gasification since 1927. The report of recent progress in the United States was presented by Andrew W. Decora of the Laramie (Wyoming) Energy Research Center.

"Based on results to date," he concludes, "the potential for underground coal gasification looks extremely promising." The land surface is not disturbed so reclamation is no problem. Sulfur can be removed, reducing air pollution when the gas is eventually burned. Less fresh water is required than other gasification methods. And all the residue is left in the underground seam.

Unfortunately, more development is needed, and a pilot plant for actually generating commercial electricity will not be ready until 1980, or later. Also, the effects on groundwater have not yet been fully explored. Economic feasibility, Decora says, is purely speculative at the moment, but preliminary calculations indicate that underground gasification should eventually become a competitive method of extracting clean energy from coal. □