as how much clear-cutting to allow in the national forests and how far the SCS should go with its stream channelization projects.

According to Donald T. Donnelly, associate director of the American Farm Bureau's Washington office, many land-grant college people regard Cutler as an "environmental extremist." "Just the mention of his name drives them up the wall," Donnelly says.

Before undertaking graduate studies in resource economics and law at Michigan State University (MSU) in 1969, Cutler had held a succession of jobs with conservation organizations, including the National Wildlife Federation and the Wilderness Society. After receiving his Ph.D. in 1972, he joined the MSU faculty to teach in the fields of forestry, fish and wildlife management, and park and recreation resources. He has been active in extension work and has served as a member of Michigan's Environmental Review Board, a state equivalent to the CEQ.

Despite the dismay felt by some land-grant institution people at the prospect of Cutler's appointment, one strategically placed individual in state university circles told *Science* that he did not think opposition to the appointment would amount to much. To fight a nomination publicly is, he says, "risky as hell, because if you don't succeed, you've got a tiger on your hands." Besides, he added, the objections he had heard raised to Cutler seemed insubstantial.

Return of a Veteran

President Carter has made no new appointments yet at the Energy Research and Development Administration, and, since the departure of Robert C. Seamans, Jr., on 20 January, Seamans' deputy, Robert W. Fri, has been acting administrator. But Carter has appointed a new administrator for the Federal Energy Administration. In some respects the FEA has always been less than meets the eye, but if an able, forceful, and highly experienced administrator can make a difference, it is clear that the new incumbent, John F. O'Leary, will bring this agency greater prominence and respect. O'Leary has served successfully as head of the Federal Power Commission's Bureau of Natural Gas, the Department of the Interior's Bureau of Mines, the old Atomic Energy Commission's reactor-licensing directorate, and, most recently, as the top state energy official in New Mexico. He has gained a widespread reputation as an aggressive and effective administrator in all of these various roles. In the opinion of some, O'Leary's finest hour came when the Nixon White House, apparently doing the bidding of coal operators resentful at O'Leary's key role in the drafting and enforcement of the Coal Mine Safety Act, fired him.

Some environmentalists are unhappy with the O'Leary appointment because they associate him with the drive on the part of the coal industry to develop a big synthetic fuels industry in the Southwest. Yet he is also publicly committed to strict regulation of strip mining. On balance, many environmentalists seem to grant him an at least grudging acceptance. "Our New Mexico people say he isn't too bad," observes Brock Evans, head of the Sierra Club's Washington office.—LUTHER J. CARTER

Aftermath of the New Math: Its Originators Defend It

The "new math" movement, which was extensively promoted during the 1960's, has come under a barrage of criticism and a new movement—"back-to-basics"—has been gaining momentum. People complain that the new math produced a generation of computational cripples who are seriously hindered in their attempts to use mathematics in school and in their daily lives.

Proponents of the back-to-basics movement, which stresses computation and drill, often point to declining test scores in mathematics sections of college board exams and of national standardized tests, such as the Iowa Tests of Basic Skills and the Comprehensive Tests of Basic Skills (CTBS). They also say that the new math movement was pedagogically wrong—that it required students to reason in a way that contradicts what is known about how people learn.

Developers of the new math programs have answers for these charges, but their answers are not often heard. This article is based on their responses to criticism and their assessments of the past 15 years of curriculum reform.

First, the curriculum developers deny that test results demonstrate that students who were counted as being exposed to new math programs were subsequently less able to compute. They argue that the new math programs were, in fact, never properly implemented, so it is impossible to say whether the goals of the movement could have been achieved. Some of these goals were to emphasize concepts rather than rules in mathematics and to introduce topics of modern mathematics that have proved increasingly important in the 20th century. These include probability, statistics, and logic. The desired reforms were incorporated into a number of experimental curriculums written by mathematicians and members of mathematics education departments at universities. Among the better known curriculums were the School Mathematics Study Group (SMSG) and the University of Maryland Mathematics Project (UMMaP). Developers of the new math programs stress that there was no one curriculum that can be identified with this movement. But the curriculums shared many of the same goals, and all are lumped together when the new math is attacked.

Some developers of the new math movement admit that they invited the criticisms and hostility of the general public by their failure to anticipate the major difficulties in implementing radical new curriculums. They fear that the current back-to-basics movement is misdirected but that the social attitudes and economic climate of this country are no longer right for a new round of curriculum reforms.

The most widely cited evidence that the new math programs hindered students' computational abilities is the declining scores on the mathematics sections of the Scholastic Aptitude Tests (SAT). But the declines in mathematics scores from 1962 to 1975 were not as pronounced as those in verbal scores. The scores of Iowa Tests administered in 1963 and in 1970 indicated that students in the lower grades improved in their abilities to solve problems and to grasp concepts. Students in the upper grades did substantially worse in mathematics in 1970 than in 1963, but they also did worse in reading and language skills. A comparison of CTBS scores of 1968 and 1973 indicates that performance on the

mathematics computation sections declined, but that performance on the verbal sections did also, although to a lesser degree. Since these declines in test sources were not limited to mathematics, proponents of the new math programs argue that they are part of a general pattern of lowered academic performance.

Defenders of the new math report that concrete evidence that the new math movement did not hinder students' computational abilities was published more than a year ago but received little notice or was misinterpreted by the popular press. This evidence is contained in results from the first, and so far only, national test of students' mathematical achievement, which was administered by the National Assessment of Educational Progress (NAEP) in 1972–1973. The plan is for the testing to be repeated every 5 years, with the next tests to be given this fall.

The NAEP test of primary school students was given to 9-year-olds and 13-year-olds. The results showed that these students, who presumably had been taught by the new math methods, did well in computing with whole numbers but poorly in other areas, such as understanding topics in geometry and measurement. The investigators who analyzed the results stressed that drill and computation may not be needed so much as emphasis on concepts.

The NAEP study of secondary school students included 13-year-olds and 17-year-olds who were in school or were dropouts or graduates. It also included a set of controls, who were adults between the ages of 26 and 35. These adults had finished high school before the advent of the new math. The results indicated that the 13-year-olds computed nearly as well as the adults, and the 17-year-olds did better. All of the age groups shared the weaknesses of being unable to estimate or check their results. And all age groups tended to try to obtain results through recall or with one-step methods. The analysts of the secondary school results conclude that "these data show the critics and doomsayers wrong with regard to the detrimental effects on computation of the new mathematics programs." Like the primary school results, they indicate people taught by both new math and traditional methods did not learn important concepts.

Analysts have not been able to reach any firm conclusions as to why test scores in mathematics and other areas declined. Television viewing has been blamed, as has the general permissiveness of the school systems during the 1960's—a time when "relevance" was touted and routine drilling was often displaced by more interesting activities. In addition, Alfonse Buccino and Raymond Hannabel of the National Science Foundation (NSF) say that a great deal of classroom time is spent in other than learning activities. The amount of time spent actually learning mathematics is a significant variable in determining how well students perform. The time devoted to mathematics teaching, they believe, may have declined during the 1960's. It is hard to prove that these factors affected achievement test results, and so some analysts are looking to school curriculums for explanations of the trend.

According to David Wiley and Annegret Harnischfeger, who are directors of the ML Group for Policy Studies in Education and are located in Chicago, the most likely explanation of test score declines is related to changes within the schools. They focus on high schools because the trend is most pronounced among students in the upper grades. Their explanation of this trend is based on two observations. First, they find that the total amount of academic work in high school has decreased—that is, high school students take fewer courses. Second, they find that high school students are taking more diversified courses, such as psychology and anthropology, which causes their enrollment in regular courses to decrease. But the subject matter of regular, rather than specialized, courses is covered in achievement tests.

The data from national achievement tests, then, do not give a clear answer to the question of whether the new math hindered students' abilities to compute. But the heart of the defense of the new math programs is the contention that these programs were never really implemented. Unfortunately, there is little detailed information on what is actually taught in classrooms. Most analysts believe, however, that the mathematics taught during the 1960's was far more traditional than is generally believed. Apparently, the developers of the new math programs made some crucial mistakes when they tried to have these programs implemented.

Most developers of mathematics curriculums seem to agree with an analysis, put forth by James Wilson, chairman of the mathematics education department at the University of Georgia, of why these programs were not properly implemented. Wilson, who has been intimately involved in designing curriculums, planning national assessments of student achievement, and analyzing results of these tests, believes that the primary and secondary schools must be considered separately.

Wilson says that primary school teachers were unable or unwilling to implement the new math programs because resources for teacher training were not available. The NSF provided funds for teacher training programs for secondary school mathematics teachers but provided very little for primary school teachers. This was due in part to the fact that there are so many primary school teachers that they are hard to reach.

The problem was compounded, in the eyes of NSF administrators, by the fact that primary school teachers generally had poor mathematics backgrounds. These administrators say that education departments were given low priority by colleges and universities, so training in elementary education was often not adequate to prepare teachers to teach mathematics. Moreover, students with academic talent were discouraged from going into elementary education. The result was that primary school teachers were poorly trained and were drawn from the pool of the least academically talented students. When these teachers were then not specifically trained to teach the new math curriculums, they either ignored these programs and taught in traditional ways or they stressed irrelevancies. For example, they drilled students on the proper spelling of "commutative," "associative," and "distributive," or they insisted that all answers be enclosed in braces. Some of the more important concepts, such as those of geometry, were among the first to be dropped for lack of time.

Schools Resist Changes

The secondary schools, according to Wilson, had a separate set of problems. The new math movement had only minimal effects in these schools because the schools were extremely reluctant to change their basic courses for college-bound students, which consist of algebra, geometry, and trigonometry. James Fey, a developer of the UMMaP curriculum and an analyst of the new math for the National Advisory Committee on Mathematics Education, says that "traditional teaching of algebra, geometry, and trigonometry is a sacred part of American life." As for students who do not plan on college, Wilson says they were mostly ignored. The general math courses for those students essentially never changed and still have not changed.

Part of this problem in implementation of the new math programs stems from an error made by the program developers. According to Fey, they took a cavalier attitude toward the role of the classroom teacher in implementing the programs. They generally failed to comprehend the

importance of adequately preparing teachers to introduce the programs and of involving teachers in developing them. Developers of the programs assumed that if they wrote good books, teachers would use them successfully to teach their programs.

Book publishers made similar mistakes, according to Robert Tompkins, the executive editor of the mathematics school department of Holt, Rinehart and Winston. Tompkins reports that the publishers relied on the word of the authorities—namely, the program developers—that the new curriculums were desirable. The publishers generally overlooked the classroom teachers. Tompkins says that the new math texts were inadequately tested in classrooms. When they were tested, the students, because they were part of an experiment, would try very hard. And the teachers were especially chosen for their mathematics backgrounds.

Other mistakes made by developers of the new math programs affected the attitudes of parents as well as teachers. For example, James Henkelman, a developer of UMMaP, says that the programs were oversold. In their zeal to get them moving, developers of the programs raised the expectations of both teachers and parents so high that disappointment was bound to result. This disappointment turned to hostility as time went on.

Another mistake made when the new math was introduced was to exclude parents from the programs. According to Henkelman, traditional mathematics was often superficially changed and parents were asked not to try to help their children with these "new" concepts. Many parents came to feel alienated from what their children were learning and concluded that they were not learning fundamental concepts and skills.

Some critics say that this focus on mistakes in implementation avoids the true problem with the new math programs, which is that their contents and approaches to learning were inappropriate. For example, the new math programs for elementary schools included the use of number bases other than 10. The idea, according to Henkelman, was that other bases were necessary to teach the general concepts of enumeration. This was confusing to elementary school teachers, Henkelman says, and this goal of teaching enumeration was probably not right. It is not important to teach the general concepts of enumeration in elementary schools, curriculum developers now believe.

Tompkins says that a major pedagogical problem with the new math textbooks is that they demand that students learn by going from the general to the specific and not vice versa. What was finally realized, he reports, is that very bright children can learn that way, but average children cannot. Educational psychologists had been saying for years that people learn by going from the specific to the general, according to Tompkins, but their word was not heeded.

> "Emphasis on computational skills and problem-solving."
> "Clear, direct presentation."
> "Good sequential arrangement."
> "Plenty of practice problems."
> "Single concept on a page."
> "Little reading."
> "Emphasis on drill...back to basics."
> "Wide range of supplementary materials available."
> "Easier for average and below student to use."
> "Adequate material for the gifted."
>
> *Part of an advertisement in* The Arithmetic Teacher *for primary school textbooks of a major publisher. Like most other recent advertisements, this plays up the back-to-basics movement.*

This criticism of the new math programs is somewhat controversial, since many developers of the programs believe that their texts did not require reasoning from the general to the specific. For example, Edward Begle of Stanford University, who was the director of the SMSG, examined the SMSG material and concluded that this criticism does not hold.

Have the Textbooks Changed?

In light of these criticisms, it seems reasonable to ask whether the recent textbooks are different from those of the 1960's. Although publishers claim their current textbooks are changed from the new math texts, some analysts say that the new math texts and the back-to-basics texts are not very different from each other. Henkelman, for example, finds that the major change, in secondary school texts at least, is in the way they are advertised. As one example, he cites the language of sets, one of the best-known aspects of the new math, which remains in the back-to-basics texts.

Although pedagogical mistakes and errors in implementation are most often cited as contributing to the failure of the new math movement, many analysts believe that social factors and the mood of the times also determine the direction of education programs. They say that the current back-to-basics movement did not occur solely as a backlash against the new math but is part of a general social trend. According to Fey, the public was unhappy with many aspects of the education system of the 1960's. These include declining test scores, a breakdown of discipline in the schools, and the rising costs of education. Fey sees the back-to-basics movement as part of a general desire to recapture values of the past.

Because of this social trend and because of the current hostility toward the new math movement, developers of mathematics curriculums and representatives of funding agencies do not believe that the public will support any widespread curriculum reforms in the near future. Many are disturbed by this and agree with Wilson, who feels that the back-to-basics movement is going too far in stressing computation and drill at the expense of other essential skills such as measurement, approximation, and estimation. Ironically, they feel that the increasing use of hand-held calculators makes extensive drilling less necessary. Most believe that a need for curriculum reform exists. For example, they feel that hand-held calculators will inevitably affect mathematics education by leading to an earlier introduction of decimals and an increased emphasis on estimation to see if answers are reasonable. In addition, they believe that students should be introduced to probability and statistics at an early age because some knowledge of these subjects is important to the interpretation of such things as advertising claims, opinion polls, and weather reports. They also believe that new programs should be introduced for high school students who do not plan to attend college so as to enable them to move quickly into vocational training.

Rather than funding projects in curriculum reform, Congress has stressed in-service programs to help teachers who are already in the schools. Administrators at the NSF, such as Buccino and Hannabel, say they believe these in-service programs are the key to improving mathematics education. But some curriculum developers, such as Wilson and Fey, remark that this is a very political response. They point out that the NSF did not request funds for in-service programs in its current budget. Congress added money for these programs to the NSF funds. Fey believes that Congress is fond of such programs because they represent major grants to local institutions. But the value of in-service programs is subject to question. For example, high school teachers have used these programs as a stepping-stone to leaving the high schools according to Fey. Apparently, there is little hard evidence that the NSF in-service programs have had much effect on math education.

Another area that many believe shows room for improvement is mathematics education programs in colleges and universities. Henkelman, for one, does not see many dramatic changes from the programs of a decade ago. In fact, he says, the movement toward allowing college students more electives has worked to the detriment of mathematics education

programs. Most students do not take math courses if they are not required to.

Curriculum developers naturally feel defensive about the criticisms of the new math movement. They also feel frustration at their lack of success in implementing curriculum reform. Although members of mathematics education departments of universities are always devising innovations, few ever catch on. "Despite their fascination with every new fad, local school boards rarely change mathematics curriculums," Fey says. According to Fey, the past 20 years have served to demonstrate that curriculum developers and school systems move in separate orbits. One lesson of the past two decades is that those orbits will have to coalesce if major curriculum reforms are ever to be successfully implemented.—GINA BARI KOLATA

NCAT: Appropriate Technology with a Mission

"Appropriate technology" could be on its way to becoming a household term. The proponents of small, environmentally sound, human-centered technologies have found a Bible of sorts in E. F. Schu-Schumacher's book *Small Is Beautiful*, which has also been widely read by government officials including Jimmy Carter.

Now, appropriate technology is getting a small but significant boost from the federal government which has awarded $3 million to a new National Center for Appropriate Technology (NCAT), located in Butte, Montana.* The money comes from the Community Services Administration (CSA), the agency that has charge of some of the leftovers of the old Office of Economic Opportunity. NCAT hopes to serve as an information clearing-house for the thousands of small groups around the country that are experimenting with appropriate technologies: what makes it unique, however, is that its specific mission is to link these efforts with the needs of low-income people.

The people behind NCAT, many of whom come from a background of community activism, believe the time has come to bring appropriate technology out of the small, experimental places where it has been incubating for some years, and apply it where they believe it is most needed: in ameliorating the food, housing, and energy problems of the poor. They emphasize that what they are looking for is not the development of a "poor people's technology." Rather, they would like to see low-income people become leaders in the adoption of technologies upon which everyone must increasingly rely in the future.

Appropriate technology generally means technology that is small, easy to understand and maintain, cheap, dependent on local resources, and fitted to local needs. It makes heavy use of renewable resources, ranging from labor to garbage, and makes minimal demands on capital and on nonrenewable environmental and energy resources.

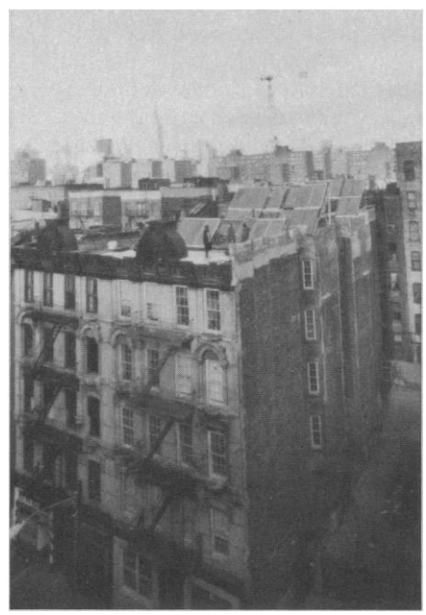
Common examples of such technologies are solar heat collectors, windmills, recycling of waste to produce methane and compost, composting toilets, urban greenhouses, and rooftop hydroponic gardens.

But the term is fast gaining connotations that go beyond development and dissemination of techniques and hardware. Nowadays, appropriate technology implies a constellation of values that emphasize self-reliance, political and economic decentralization, the reduction of peoples' dependency on large institutions over which they have no control, and the development of tools that enhance peoples' relationship with their work, rather than eliminate opportunities for individual creativity.

NCAT is engaged in a perilous undertaking. It involves mobilizing the most demoralized and resource-poor segment of the population, while at the same time developing working relationships between technical professionals and residents of poor communities. That means reorienting professionals to challenges that are more social than technical in nature. Scientists, after all, are fond of envisaging our future in terms of such things as orbiting space colonies (which architect Dennis Holloway, an NCAT board member, calls an extreme example of "inappropriate technology. . . . F--- the earth and then leave").

NCAT's location in Butte is owing to a convergence of circumstances. A few years ago R & D consultant Jerry Plunkett, who now heads the new Montana Energy and Magneto-Hydrodynamics Research Institute (MERDI), wanted to broaden the institute's scope to include alternative and small technologies. He got his senator, Mike Mansfield (who was Senate majority leader), interested in the idea. He later hooked up with people at CSA, who have been putting money into home insulation projects for poor people since the fuel crisis of 1973.

CSA eventually gave MERDI a planning grant to work out the design for an appropriate technology center. The planning committee took over a year to get the idea in final shape. There were great hagglings over the definitions of "low-income" people and of "appropriate technology" (for example, does this



Jon Naar Photo

The building at 519 East 11 Street, Manhattan, with solar collectors and a 2-kilowatt windmill on the roof.

*The U.S. government is slowly shifting some priorities in this direction, perhaps more so in the foreign aid area (where it is also referred to as intermediate technology). The Agency for International Development some years ago decided to shift its emphasis to rural development rather than high technology, and AID now has $20 million which is being put into a semiprivate corporation called Appropriate Technology International. The purpose of this group, according to Ted Owens at AID, will be to beef up local small technology enterprises wherever they can be found. Another glimmer is to be found at the Energy Research and Development Administration, which has a $10 million authorization to include an office of appropriate technology in its office of energy conservation. Maxine Savitz, director of this office, says it plans to do cooperative work with the NCAT. Finally, the National Science Foundation is conducting a study of appropriate technology.