Richard Hull complains that the program analysis measured only profitability, not quality or usefulness: "We have one of the best entomology programs in New England. We are extremely strong in vector-borne diseases and pest management. Those quality things don't translate into dollars per faculty."

Other faculty members argue with the numbers. Grant income and student enrollments in the geology department were unusually low in 1994–95, the year of the analysis's financial snapshot, and the department's aging quarters showed up as a $300,000 expense in the analysis even though the building is "literally crumbling," says geology Chair Don Hermes. Real costs are lower, he says, and revenues are higher.

Still other URI faculty members, including accounting Professor Richard Vangermeersch, point to inconsistencies in the assumptions behind the analysis. For example, the analysis spread the costs of university-wide services among departments according to the number of students each taught. It spread those costs among programs within departments, however, according to the amount of time faculty members devoted to courses in each program. As a result, in departments such as psychology—where faculty members teach a few large undergraduate courses but spend most of their time teaching small graduate courses—each graduate program appeared to suffer "unbelievable deficits," says Vangermeersch.

Not everyone is displeased, however. "After years of living with financial instability," says paleontologist David Fastovsky of URI's geology department, which lost its master's degree program, "many faculty members were open to the fact that some changes do need to take place." And at the faculty senate's request, Carothers gave each department a chance to review the program analysis and make an argument against proposed suspensions. Several programs, including biochemistry and microbiology, won reversals.

This drama is likely to be played out again on other stages, as variations on URI's efficiency experiment are under way in many states. As part of its Priorities, Quality, and Productivity project, or "PQP," the Illinois Board of Higher Education is comparing instructional costs at each of Illinois's state universities to state averages for each discipline and recommending specific cost-cutting measures and program shutdowns. Private research universities, including the University of Rochester, Duke University, and Washington University in St. Louis, are now gauging the productivity of their own faculty members through a similar comparison of departmental data.

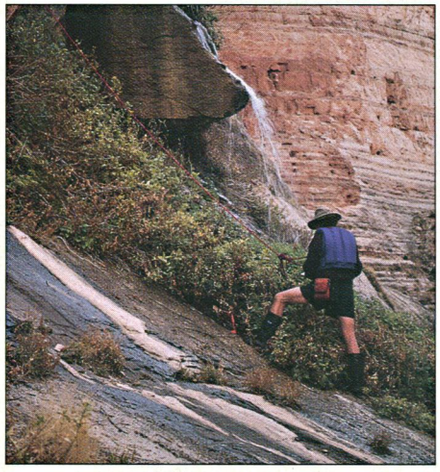
Whether research universities can push faculty productivity upward fast enough to offset continuing decreases in funding will mainly be a matter of ingenuity and clever coaching. It's unclear, however, how long faculty members will remain willing pawns in all this money-minded strategizing. "When someone working more than full-time is asked to account for his time as if he's not working hard enough, it's a little demoralizing," says URI's Fastovsky. "Ultimately you have to ask yourself whether education is a business, and whether business management practices reflect what it's about."

–Wade Roush

ECOLOGY

Deliberate Flood Renews Habitats

The Colorado River at Vesey's Paradise, Arizona, where waterfalls cascade down limestone walls, is usually a clear emerald green. But beginning on 26 March, it turned the color of chocolate milk as a flood wave deliberately released from Glen Canyon Dam surged downstream, lifting and churning river-bottom sediments. The flood was a challenge for experienced boaters, who rode the river at nearly triple its average flow. But the week-long surge was actually a $1.5 million ecological experiment designed to test the idea that controlled floods are to river ecosystems what prescribed fires are to forests—a means of rejuvenation. "This is the first time, on a large river, that we have actually attempted to restore some of the dynamic range of flows for the protection and maintenance of ecological resources," says Edmund Andrews, chief of the River Mechanics Project for the U.S. Geological Survey (USGS).



JEFF SORENSEN/ARIZONA GAME AND FISH

Snails' place. Biologist prepares to gather and move amber snails before the flood.

Some 100 scientists were stationed along a 390-kilometer stretch of river from the dam through the Grand Canyon, and they quickly tallied early results: Sediment swept up by the flood built or rejuvenated hundreds of sand bars, adding anywhere from 0.5 to 3 meters to their height. Now the waiting game begins, as researchers see whether the resculpted riverbanks prove more hospitable to the Colorado's endangered species—and how long the new habitats persist.

Glen Canyon Dam began impounding water in 1963, transforming the Colorado River from a muddy, turbulent, desert river into one that is clear, cold, and controlled. It cut the river's annual peak discharge from nearly 2700 cubic meters per second to a quarter of that today. These unnaturally low flows have drastically reduced the river's ability to carry sediment. Before the dam, floods would periodically sweep up sediment deposited in the Colorado's main channel by its headwaters and tributaries. As the high water subsided, the sediment would settle out to form beaches and sandbars. But without the floods, these deposits and the slack backwaters they created—the nurseries for native fish—have slowly vanished.

Beach growth. Before and after photos show sand deposition.

Scientists at the USGS figured that a controlled flood, created by running all of the dam's eight turbines at full throttle and opening its four jet tube outlets, could churn up the sediments again and rejuvenate the beach habitats. In collaboration with the Bureau of Reclamation and the National Park Service, they released 1200 cubic meters per second from Lake Powell for seven straight days. As the flood wave traveled downstream, the USGS monitored water velocity, river rise, sediment transport, erosion, and water chemistry.

One surprise, said senior USGS hydrologist Mark Anderson, was how quickly the beaches were rebuilt. While computer models had suggested that the beaches might grow steadily for 6 days, most of the deposition took place within the first 40 hours. That's an exciting find, says Anderson, because it means that future floods could be much shorter and still rebuild beaches. "We now have more tools in the management box," he says.

Now scientists want to see whether endangered species—in particular a fish called the humpback chub—move into the rejuvenated habitats. The chub is the only native fish that persists as a reproducing population in the Grand Canyon. But it faces a hostile environment: The dam has cooled the river, and the sun-warmed backwaters that young chub rely

on are in short supply. The flood recreated those habitats, in particular near the inflow of the Little Colorado River, where the largest population of the fish is found. "In one place where there was no sand whatsoever, there is now a great wide beach with a backwater that can be used by humpback chub," reports Larry Stevens, an ecologist with the Bureau of Reclamation's Glen Canyon Environmental Studies Office.

Even if the flood turns out to be a boon to the humpback chub—not to mention to boaters who camp on the Colorado's beaches—there's the question of how long these rejuvenated habitats will last, says Dave Wegner, program manager at the environmental studies office. "How stable are [the beaches]? Do we need to do this every five or every 10 years?" To answer that question he and his colleagues will spend the next 8 months closely monitoring physical and biological changes along the flood route.

Ecologists are hoping that the rebuilt beaches will last, because it won't be possible to turn the floodwaters back on anytime they're needed. For one thing, in the complex world of ecosystem management, what benefits one species can harm another. Take the endangered Kanab amber snail, which slimes along cardinal monkey-flowers and watercress at Vesey's Paradise, 75 kilometers from the dam. The population, one of only two known, was threatened by rising flood waters, so the U.S. Fish and Wildlife Service (FWS) devised a plan to lessen the flood's impact. Four biologists spent days roped to the canyon wall, moving 1300 snails up above the inundation zone. "Picking snails is kind of like picking blueberries. You find good patches and pick a lot of them pretty quick," says Stevens. Next time a flood is needed to rebuild the chub's habitat, however, the snail could stand in the way. Before the Colorado is allowed to flood again, FWS has stipulated that a third population of snails either be found or established, says Vicky Meretsky, an FWS biologist.

What's more, water allowed to rush downstream means lost revenue from the dam's electric dynamos—$1.5 million over the 7 days of the flood, says Tony Morton, an environmental specialist with the Western Area Power Administration, which helps manage dam operation. Still, says Morton, the cost would be acceptable if a flood were staged only every 7 to 10 years.

Even if the Colorado isn't unleashed again any time soon, the flood of results could have ripple effects elsewhere, says Wegner: "The results will be applied not only to Glen Canyon, but potentially to every other dam that controls water releases downstream"—which means dams on every major river system in the United States.

–Bernice Wuethrich

Bernice Wuethrich is a free-lance writer in Washington, D.C.

UNDERGRADUATE EDUCATION

Report Urges NSF to Promote Teaching

It's not easy to change a system 50 years in the making, admits Melvin George, former president of St. Olaf (Minnesota) College. But as chair of an advisory panel that will deliver its recommendations next month to the National Science Foundation (NSF), George hopes the group's proposals will start a revolution in undergraduate education. The panel believes NSF has helped contribute to an imbalance between research and teaching on most college campuses by promoting specialized research careers. What's needed, it says, is for NSF to tell scientists that what they do in the classroom is as important as what they do in the lab.

The committee, which has been deliberating for more than a year, undertook its study at the request of NSF's education chief, Luther Williams.* To bring about the change, the draft report recommends that universities revise their approach to teaching to address the needs of all students. For example, it suggests that departments should set goals for what their students should learn, hold faculty members accountable for students' performance, change the academic reward system to incorporate good teaching, and give science faculty members a bigger role in training kindergarten through grade 12 (K-12) teachers. To achieve these goals, says the report, NSF will need to double its $180 million budget for undergraduate education. But even more important, says George, is a greater commitment to educating students.

"NSF was part of the problem, and so it has an obligation to be part of the solution," says George, who summarized his group's finding earlier this month at a meeting of the advisory committee to NSF's Education and Human Resources directorate.

The "problem" to which George refers is the government's decision after World War II to have universities carry out the bulk of the nation's basic research. That decision has fostered a network of more than 100 research-intensive universities—NSF's primary customers—that is the envy of the world. But George and other advocates of reform point out that 65% of all undergraduates, including some who will become the nation's primary- and secondary-school teachers, attend schools that don't even receive NSF research funds. This has created a system that—according to Harvard University historian of science Gerald Holton—leaves students "homeless" in a world of growing technical complexity.

The panel wants NSF to redress this imbalance by shifting more of its resources into undergraduate programs that focus on teaching. The current lineup grew out of the recommendations of a review in 1986, which focused on how NSF could help science majors. Advisory board members who attended the briefing endorsed the panel's approach. In fact, they suggested several changes to broaden its scope: Integrate the report with the new national K-12 science education standards, address the importance of curriculum reform, acknowledge an increasingly diverse student body on campus, and encourage dissemination of good teaching models. But panelist David Sanchez, vice chancellor for academic affairs at Texas A&M University, believes that these technical issues are not as important as changing how individual departments feel about undergraduate instruction.

"When I meet with departments and ask them, 'What do you expect from your students?' they talk about what students need to know to continue in the field," says Sanchez, a former head of NSF's math and physical sciences directorate. "But I say, 'No, I'm talking about the majority of your students, the ones taking only one science course but who may want to be teachers.' "

NSF's Williams says he appreciates the panel's broad analysis but warns that NSF's ability to bring about change is limited. "The problem, fundamentally, is that a system created to serve 10% of the population is now being asked to serve everybody," he says. "We can be a catalyst, but we're only one of many voices in a national debate." Even so, George and his panel hope the agency will sing out loud and clear: "If NSF sends a message that teaching is important," he says, "universities will start to change their behavior."

–Jeffrey Mervis

NSF'S UNDERGRADUATE PROGRAMS
(FY '95 Budget in Millions)

Instruction-oriented activities	
Teacher preparation	$23.2
Support for minority institutions	$22.1
Instrumentation, lab development	$19.7
Advanced technological education	$18.0
Curriculum development	$17.1
Faculty enhancement	$7.1
Research-oriented activities	
Research experiences for undergraduates	$27.8
Research at undergraduate institutions	$25.0
Support for minority institutions	$20.8

SOURCE: NSF

* "Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology."