



PARK SCIENCE

A Resource Management Bulletin

Volume 14 - Number 4

National Park Service U.S. Department of the Interior

Fall 1994

Sequoia National Park Hosts 'Pulse II' And the Beat Goes On. . .

By Jean Matthews; photographs by the editor

Eleven years after their first "pulse study" in Sequoia/Kings Canyon National Parks (SEKI), Dr. Jerry Franklin, Professor of Ecosystems Analysis at the University of Washington (UW), and a 65-member group of researchers returned to the original sites at the 7000-foot level to see what the passage of time afforded in the way of a stereoscopic view. The scientific disciplines represented by the research team covered the broad range of study angles involved in discerning a total picture. As team members picked up on the ecosystem beat that was first pulsed in 1982-83, what struck the observer was the remarkable evolution of the pulse itself.

The data gathered between June 20 and 25 must await analysis, but the dynamic, generative nature of the pulsing process was immediately apparent. Like a strong eddy, the pulse attracts not only individual researchers (see companion article), but whole long-range research programs. Several of the latter either held overlapping meetings at the SEKI pulse campsite or were represented by individuals, who spun in and out of the action--making their own inquiries and sharing their findings.

Hear Oregon State University (OSU) ecologist (and rotten log maestro) Mark Harmon, holding forth at the pulse group's closing campfire:

"The original pulse studies were a spark that ignited a paradigm shift in research--from single species and single problems in individual parks to an awareness of biotic communities and ecosystem functioning over broader areas that extend beyond park boundaries."

Back in 1980, when Franklin organized a pulse at the Hoh River drainage at Olympic NP (see *Pacific Park Science* Vol. 1, No. 1), he was working for the USFS out of the Corvallis, Oregon Forestry Sciences Lab. A corps of scientists and associates with a tradition of inte-

grated, ecosystem-oriented research had developed around programs centered there. Baseline data to serve managerial and scientific purposes within Olympic Na-



Oregon State University Ph.D. candidate and big tree climber Steven Sillett shoots a monofilament line-trailing arrow over a giant sequoia branch 180 feet above ground in preparation for climbing the behemoth. Albeit difficult, canopy research in the sequoias provides an unequalled opportunity for investigating the interactions between the hard-to-reach epiphytes and their hosts. Sillett and his partners collected over 15 different lichens and other epiphytes in four days of intensive research as part of Pulse II.

tional Park (NP), especially the South Fork of the Hoh River drainage, were needed. One objective was to describe the role of vegetation in landform development and the formation of different aquatic habitats. Another was to develop baseline descriptions of the valley bottom forest; another was to analyze the role of dead and down wood and the regeneration of trees in valley bottom forests; another to describe and analyze aquatic habitats and their use by fish; and finally to examine the interactions between Roosevelt elk and vegetation.

Seven scientific papers grew out of the Hoh River pulse study. A summary by Franklin stated the major conclusions and described the interrelationships among ecosystem components.

The Pulse I study at SEKI, was described in the Fall 1983 issue of *Park Science*. The study involved plant ecology, geomorphology, hydrology, entomology (aquatic and terrestrial), aquatic biology, forestry, and geography. The focus was largely on collections of basic descriptive data on the stream, riparian, and forest systems at the selected study sites.

In the decade-plus since Pulse I, SEKI's original 6 research plots grew to 23. Nine acid deposition plots were added, as were 8 global change plots (5 in SEKI, 3 in nearby Yosemite NP). Many of the same people were back. Sequoia NP science personnel--Wildlife Ecologist Dave Graber, Ecologists Nate Stephenson and Annie Esperanza, and Larry Bancroft, Chief of Resource Management--were still keeping sweaty fingers crossed as to what the future under the new National Biological Survey (NBS) might hold. Jeff Manley, Natural Resource Specialist; Mary Beth Keifer, park Staff Ecologist; and Dan Driscoll, Forestry Technician,

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Sequoia Pulse . . . and the beat goes on (cont'd from p. 1)

completed the SEKI staff on hand. Long-time Senior Scientist Dave Parsons attended Pulse II as a final farewell. He was leaving not just the park, but the Park Service (See article on page 8).

Stream ecology studies begun in 1983 were on hold because their personnel were needed for intensive aquatic sampling for the Coastal Oregon Productivity Enhancement. But two new strings to the pulse bow were the canopy architecture and epiphyte ecology study begun in the permanent reference stands, led respectively by Robert Van Pelt of UW and Steven Sillett of OSU, and the forest floor epiphyte study, led by Dave Shaw.

OSU Research Associate Steve Acker led the team investigating changes in three reference stands (riparian, white fir, and mixed conifer), and found pronounced evidence of mortality. Gregg Riegel, a major organizer of the 1983-84 Pulse I study at SEKI, reported that almost 30 percent of the sugar pines tagged in 1983 had died and a much higher percentage of the remaining trees are infected with white pine blister rust, paving the way for beetles as the proximate cause of death. Acker's team also recorded what was found in the Jeffrey pine and the two giant sequoia reference stands. All these data will be reviewed, verified, and entered by Acker into OSU's Forest Science Data Bank, whose establishment was supported in large part by the National Science Foundation (NSF).

Ruth Kern, Duke University graduate student working with the Global Change Program, reported on her investigations into regeneration in mixed conifer zones at the 5000- to 7000 foot elevational level. In one approach, she enters the permanent reference stands and plots seedling patterns of regeneration in relation to light patterns. Baseline information useful to the parks will come from models that predict seedlings survival and that show whether there is a repeatable pattern for success or whether the reality is too random to make a difference. So far, her results indicate that survival and growth are strongly related to light, but almost not at all to water.

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In the shadows of huge sugar pines (*Pinus lambertiana*), this sapling struggles to compete for limited sunlight. Researcher Gregg Riegel, with the OSU Silviculture Lab in Bend, Oregon, documents the tree's vital statistics, noting poor general health and the presence of white pine blister rust (*Cronartium ribicola*), a nonnative fungus and pathogen that has become more prevalent in the ten years since Pulse I.



Pulse pioneer Jerry Franklin chips in with the basic pulse work: remeasuring trees from the six permanent study plots originally laid out and surveyed as part of Pulse I and assessing them for growth, vigor, disease, and causes of death. Researchers hope to learn more about the health of the mixed pine forests and sequoia groves nearby and the factors responsible for any changes of the past decade. Preliminary findings suggested greater mortality in the Jeffrey and sugar pine forests than ten years earlier.

Sequoia Pulse (cont'd)

Art McKee, Site Director at the USFS H.J. Andrews Experimental Forest in Oregon, who sampled the original riparian plots for vegetation diversity (along belt transects on three streams), was back to measure changes. In 1994, in addition to resampling streamside vegetation, for comparison his team sampled species richness in surrounding uplands. A somewhat surprising early indication is that vascular plant species, while they are more diverse as expected in riparian zones, are not more than two- to three-fold richer than upland zones. The four- to five-fold greater diversity that had been expected for plants *did* hold true for riparian "critters" compared to critter numbers in upland situations.

Mark Harmon, author of "Ecology of Coarse Woody Debris in Temperate Ecosystems" (in *Advances in Ecological Research*, Vol. 15, 1986) began investigating SEKI "dead" wood during the 1982-83 pulse. Harmon revels in decomposition. "Sequoia National Park," he said approvingly, "is a very rotten place." He points out that the "so-called 'live' trees consist of no more than five to ten percent living tissue—a biological desert. Now a *dead* tree," he says, his eyes beginning to sparkle, "is about half living matter."

Harmon and his rotten loggers found in 1994 that downed sequoias had remained almost as they were 11 years before, whereas white and red fir logs showed such rapid deterioration that some previously recorded simply no longer existed. Carpenter ants, termites, and white and brown rot fungi

can't get a meal out of sequoias, but fir logs decay so fast "they almost vaporize" in Harmon's words.

The Sierra Nevada sequoia stands offer an unparalleled opportunity to study the swings of climate over thousands of years, and such a magnet is drawing top drawer scientists into the pulse. Malcolm Hughes, Director, and Lisa Graumlich and Thomas Swetnam, associate professors, all from the Tree Ring Lab at the University of Arizona, reported findings from dendrochronology and fire scar studies that make possible reconstruction of the spatial and temporal patterns of surface fires in five giant sequoia groves for the past 1,500 years. The extent, the intensity, and the seasons of fire in general correlate with the climate. Multidimensional disturbance (fire) patterns now in hand show fire regimes by elevation. Beginning with the chaparral level, fires occur every four years or so, becoming less and less frequent at higher elevations. The upper tree line also has moved up and down over the years in response to climate changes.

Sequoia regeneration is spotty, according to the findings of the tree ring people. Sometimes decades go by with none at all, followed by a flurry of successes; disturbance, such as fire, would be a key factor in such an event. The pollen record in the meadows suggests that sequoias may have become established only 4,000 years ago, "which means," Swetnam said, "that these groves are only two tree-lifetimes old."

Malcolm Hughes looked around the campfire and beamed: "I love people who actually go out and *measure*, instead of just having wonderful evolutionary thoughts.



"Rotten logging" is the interest of OSU researcher Mark Harmon who reexamines the decay process in logs studied a decade ago at Pulse I. Since then, many specimens have been all but reclaimed by the forest ecosystem. Among the most important factors in their speedy demise is moisture content: too wet or too dry and decay is retarded; just right, as in SEKI, and mechanisms, such as brown and white rot (fungi), termites and ants, and other creatures from bacteria to black bears, efficiently redistribute log nutrients.

My joy is reading the ancient past through tree ring records. In every giant sequoia, the A.D. 500-year growth ring is either entirely missing or very, very thin. Some particular climatic event is indicated here—probably drought. We find that in the past 80 years, thin rings match a climate of *severe* drought. We're now using that relationship to establish the dates of such severe droughts in California for the last 2,000 years."

Lisa Graumlich's research looks at long-lived trees for what they can tell her about past climate and atmospheric composition, helping her formulate more realistic hypotheses. Data from the ancient past about subalpine forest dynamics (tree rings and fire scars) have provided the basis for a more complex model of past climate. She has found temperatures in the past (A.D. 1100 to 1300) exceeding those of the 20th Century, showing that this century's temperatures, while warmer than average, "are within the envelope of natural variability."



OSU research assistant and sawyer Jay Sexton prepares "cookies" or crosssections of decaying pine for evaluation by his Pulse Study teammates. After measuring diameter and thickness of the sections and then weighing them, the team evaluates the means and rate of decay by comparing samples from the two studies.

"Our investigators at the upper treeline," she continued, "find dead trees; dating these trees shows that the upper tree line retreated around A.D. 1,000--a time of regional drought." She described tree ring evidence for century-long drought in the past. "A drought-stressed tree hunkers down," she said, "so that its bole consists of a mere strip of live cambium, as opposed to a cambial sheath that normally surrounds the entire bole." Then she wondered aloud: "Do they sort of hibernate?"

At the opposite end of the research scale lies the microsite work of Pat Halpin. Halpin's studies overlap with the pulse at Log Creek near the Giant Forest. They address the theoretical question of where the dividing line lies between the large (e.g., climate) actions and the tree-to-tree interactions in a particular plot. How long can established local interactions outweigh the effects of major global climate change?

Halpin and his wife spent six weeks in the summer of 1993 in the Log Creek site, charting water flow paths and flow accumulations "at a ridiculously small scale" on three 2-ha sites. They report that they found tree-to-tree interactions more important at the microscale level, but that the larger physical controls are beginning to make themselves felt, even there. Hidden water storage in many giant sequoia groves seems to be acting as a drought survival agent, mainly to downstream trees. Halpin also has found roots much deeper than the 200 cm depths thought to be usual for sequoias--some as far down as 500 cm.

Depressions that once may have been the bases of mature sequoias, now long gone, are holding water up to three weeks longer than the surrounding ground, "and sequoia seedlings are popping out in the flow routes and on the catchments downslope from the mature trees," Halpin reported.

On Friday, the last full day of Pulse II, members of the Global Change Research Program arrived. This formerly NPS program was transferred in its entirety in November 1993 to the National Biological Survey. Global change in the Sierra Nevada poses such potential problems as loss of biotic diversity, increase in frequency and severity of wildfire, increased tree and shrub mortality from drought and pollution, shifts of treeline and other vegetation to higher elevations, changes in species distribution, increased stress on rare plant and animal species, and decreased snowpack with earlier runoff.

Objectives of the Global Change Research Program are to understand and



Professor Jerry Franklin hosted traditional evening information exchange campfires where pulse takers compared their preliminary findings from the day's hard work with data logged ten years earlier. Carried over from Pulse I, the nightly gathering was also a venue for discussions on the next stage in SEKI's prescribed burning program and reports on Global Change projects.

predict changes in the structure and function of the Sierra Nevada ecosystems, with emphasis on the effects of climate on forest ecosystems (including disturbance regimes), species-habitat relationships, and hydrology. The program provided support for a number of individual research projects and for long-term study plots, data management activities, and cooperative outreach activities. Members of the Global Change project attended the Thursday and Friday night campfires, and several pulse study people sat in on the Saturday meetings of the Global Change group.

Early Recognition

The importance of the earlier pulse study was first sounded when then-Superintendent Boyd Evison wrote in the Spring 1983 issue of *Park Science*:

"A remarkable team of 30 scientists, students, and technicians from Oregon State University [arrived at the park in September 1982 and worked for 10 days] from dawn to dusk, carrying out intensive field studies of stream, riparian, and forest systems in a mixed-conifer forest, a giant sequoia forest, and a meadow." Evison described the nightly campfire sessions held by the group and led by Jerry Franklin as "structured, but very lively discussions of project objectives, progress, and applications to Park needs . . . open to Park staff, who were able frequently to provide valuable insights."

Evison applauded the pulse for its attention to "assuring maximum applicability of the findings to on-going Park programs such as basic resources inventory, acid rain research, and long-term moni-

toring of vegetation changes, the effects of fire, and water quality." He credited the pulse with "providing interdisciplinary information of the kind that most parks unfortunately seem to have little hope of obtaining."

In 1994, the scene of the repeat pulse was a park with no superintendent. Tom Ritter, its latest leader and once head of the NPS Western Region's Science Advisory Task Force, had retired to a cabin in the Puget Sound area. The future of park management was a hazy question mark, but the pulse beat went on. The ecosystem continued to adapt to its own inner and outer conditions; the park research team continued to gather information about how the ecosystems work--struggling to refine their research methodologies, sharpen their focus, and deepen their understanding of both the work they must do on behalf of the systems, and the work they must do to assure their own continued support.

The results of SEKI Pulse I largely dominated the 1984 conference at the University of California/Davis on Research in California's parks, but the papers given there were mostly descriptive and only a very few were published in journals. A dozen years ago, in order to get one's results into the mainstream of science literature, it was necessary to publish in the journals--a process whose timeliness has been aptly described as "proceeding with glacial dignity." Today, the flood of data coming out of pulse and pulse-related research is being fed into data banks--there to await bright hypothesizers who can devise models to test alternative futures.

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Sequoia Pulse Study . . . (cont'd from page 5)

The emerging genius of the pulse lies in this new approach to resource management. No longer will we have to rely on what Nate Stephenson calls "the lumbering, limping, ancient equations of 1988" that give one or two recommendations for park management to accept or reject. Today's scientists are looking confidently toward the day when they can run off a host of "what if" scenarios, using the numbers laboriously collected in the field. From these models they anticipate being able to give management a score of "outcomes" to choose from. However, Sarah Greene, USFS ecologist at the Forestry Sciences Lab in Corvallis, Oregon, cautions that much more data remain to be collected before we can confidently predict ecosystem futures. "A model is still only a weak attempt at best to second guess nature," she warned.

"Models are tools for thinkers, not crutches for the thoughtless."

M.E. Soule'

Given the enormous array of variables inherent in, and affecting, ecosystems, just where the SEKI study plots are heading in the long term is still guesswork. But the pulse crews carrying on the "work" are chipping away at the "guess" in guesswork. Meanwhile, social science research is becoming an increasing necessity, as management is faced with such additional questions as, What do people conceive of as "natural wilderness?" What do they come to parks to experience (and thus what are they willing to support)? How much personal freedom are people willing to forego and how much money are they willing to spend to shape nature to the preferences of *human* nature? (And once we have *that* answer, do we really want to let it guide resource management?)

Franklin's answer, voiced during an evening campfire: "I suspect that the next century will find the 'naturalness' issue to have pretty much gone by the boards. You'll be choosing how you want your parks to look, and managing them to look like that. At Sequoia/Kings Canyon, air pollution from the valley and a couple of degrees of climate warming will make the whole question of 'naturalness' irrelevant."

Or, as a University of Montana philosophy professor fondly remembered by Dave Graber observed some years ago: "We're about to enter an era in which we



Vital to any research project, data recording was accomplished at Pulse II through the skillful use of electronic data recorders. Sarah Greene tirelessly translated the shouts of distant and near forest pulse takers into keystrokes that accurately portrayed the trees' vital signs, i.e., identification numbers, species, diameter, general health, and prominence in the forest canopy. The data were then downloaded to computers for deferred analysis in Corvallis.

will treat nature--once lively, vigorous, and stronger than any of us--as a doddering, beloved old aunty, requiring our thoughtful, loving care."

Even as the ecosystem is showing signs of stress and change, so too is the stewardship system. At precisely the time that land managers (e.g., the National Park Service) need the most careful and continuing research, the rug is being rearranged under their science capability. "The transfer of the NPS's Global Change Research Program to the new National Bio-

logical Survey," says the 1993 SEKI Annual Report, "leaves many questions regarding the funding and direction of the Sierra Nevada Global Change Research Program." From resource managers across the entire National Park System can be heard a shaky "Amen."

As the latest chapter in the Hairbreadth Harry story of science and the parks is written, two quotations come to mind. The first is from Shakespeare: "... tongues in trees, books in the running brooks, sermons in stones, and good in everything. I would not change it." The other is from John Muir, one of the most eloquent tongues the trees ever had: "We all travel the milky way together--trees and men."

And when we have mulled all this, we can pick up the next issue of the George Wright Society's *Forum* and read William E. Brown's latest "Letter from Gustavus," in which he writes:

"No discussion of wildlife, habitat, or ecosystem preservation has any long-term meaning unless the human condition of overpopulation and its amelioration and eventual solution is the overarching context of discourse. All else is fiddling while Rome burns--playing games with research plots, taking record photos before assured destruction. Assuredly all these things must go on, but if they go on in other than a context of human population control, they will have no bearing on coming realities."

Sequoia Ecologist Annie Esperanza may not be as eloquent as the immortal bard, but her words at a Pulse II campfire are as appropriate an epilogue as can be said at this uncertain moment in park history:

"The pulse payoff for the park is the short-term labor force it affords us, the collection of a mountain of data, the stimulation and excitement of the participants who work in this important place and who know they are doing important work here. The long-term payoff is the way it helps us keep long-term research alive here. The tone of acceptance from management is so much better than it was when the pulsing began. We still get resistance, but it's *friendly* resistance."

"Research has become more institutionalized than ever it was before. We've proved our worth to management. And we did it by 'swarming' them. We dug ourselves deep into the fabric of the park until our work has become as much a part of park management as cleaning the toilets."

Matthews recently retired as editor of *Park Science*. She now makes her home in Vancouver, WA., where her address is 6010 Riverside Dr., Vancouver, WA 98661, (206) 690-8568.