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The early years of Sequoia and Kings Canyon science: Building a research program

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Abstract

This paper provides a history of the development of the scientific research program at Sequoia and Kings Canyon National Parks (SEKI) during the period 1968–1994 from the perspective of one of the scientists involved. The years following the 1968 hiring of Bruce Kilgore as the first park-based research scientist at SEKI saw the growth of a research program that included three permanent research-grade scientists and their support staff. This nucleus was successful in attracting both outside funding and leading university and government scientists to work on issues of importance to the parks and to society at large, topics that included fire ecology and management, black bears, wilderness impacts, acid deposition, and climate change. During this time the SEKI scientists' role expanded from one focused primarily on the personal research on issues of immediate importance to the park, to increasing responsibilities for marketing and coordinating a growing program of collaborative research that also addressed regional and national priorities. This, in turn, required that the park scientists increasingly become generalists, able to converse in a number of scientific disciplines as well as communicate with non-scientists. Finally, keys to success and lessons learned are discussed.

Introduction

In November 2018, the US National Park Service (NPS), US Geological Survey (USGS), and Sequoia Parks Conservancy organized a two-day symposium to recognize the 50th anniversary of the science (research) program at Sequoia and Kings Canyon National Parks (SEKI). Yet, whereas 1968 was the first year that a formal research "program" existed at SEKI (i.e., an NPS researcher was assigned to and stationed in the parks, to both conduct and coordinate scientific studies), SEKI already had a rich history of scientific observation and data collection. This can be found in published (e.g., Adams 1925; Coleman 1925; Fry and White 1938; Sumner and Leonard 1947; Sumner and Dixon 1953) and unpublished form (numerous unpublished reports dating from the first half of the 20th century can be found in the SEKI archives; see, for example: Sumner 1941; Armstrong 1942; Hallock and Briggle 1959). Additional details regarding resource conditions and management issues can be found in early park management plans (e.g., National Park Service 1963). In addition, valuable natural history observations for what is now Sequoia and Kings Canyon can be found in early issues of the *Sierra Club Bulletin* (dating from the 1890s), the Nature Guide Services series produced 1922 to 1937 by Sequoia National Park, and *Los Tulares,* the bulletin of the Tulare County Historical Society (e.g., Brown 1900; Farquhar 1941; Jones 1950; Brown 1969). In addition, Dilsaver and Tweed (1990) review early scientific studies, while Sumner et al. (1966) and Parsons and King (1980) provide more thorough listings of early studies relating to SEKI.

The 1963 publication of a special report to the Secretary of the Interior on wildlife conditions in the national parks (Leopold et al. 1963, commonly known as the Leopold Report) raised significant questions about policies and practices focused on the protection of parks, including the elimination of predators and the suppression of natural fires. The Leopold Report emphasized the importance of managing parks in a way that would preserve them in as "natural" a state as possible, "as nearly as possible in the condition that prevailed" prior to European settlement. The authors recognized the difficulties of such an approach, emphasizing the need for sound science upon which to base management decisions. This was at a time when the science of ecology was in its infancy, and NPS did not have even a semblance of a research *program*.

In September 1965, a group of scientists met at Giant Forest over several days for the purpose of identifying natural science research needs for SEKI. Scientists from the US Forest Service (USFS), USGS, and universities met with NPS biologists from the agency's Washington and Regional offices and park staff to address the types of information that would be most useful to park management in facing "the problems of preserving and managing nature." The discussions recognized the value of California's universities and colleges as well as other state and federal agencies in addressing these needs. They also recognized the importance of viewing parks not as biological islands, but in the context of the surrounding lands. They acknowledged the value that could be gained by using the relatively undisturbed park lands as a base from which to measure and evaluate future change. The report of the meeting (Sumner et al. 1966) provides valuable insight into the state of knowledge about park resources and information priorities as seen in the 1960s.

In an effort to address the science needs of the national parks at the national level, A. Starker Leopold, the primary author of the Leopold Report, accepted an appointment in 1967 as the first chief scientist of the National Park Service. Although he continued to work from his office at the University of California (UC) in Berkeley, Leopold advocated for an in-house research program for NPS. Although he soon became disillusioned with what he perceived as a lack of commitment, both within the agency and by Congress, to fund such a program, Leopold was successful in getting several initiatives started. One of these was the hiring of PhD researchers to address the myriad challenges faced by the national parks. Sequoia and Kings Canyon were among the first beneficiaries of this effort.

The Kilgore Era: 1968–1972

The first research scientist hired by Leopold to work in a national park was Bruce Kilgore. Kilgore had recently finished his PhD at UC Berkeley on the effects of fire on bird populations in sequoia mixed-conifer forests. Leopold was his major professor and his study sites were at Whitakers Forest, a UC field station on Redwood Mountain, immediately adjacent to Kings Canyon National Park. Elaine Kilgore, Bruce's wife, recalls answering the phone in early 1968 to find Leopold on the other end of the line. He said "Elaine, pack your bags, you're moving to Sequoia. . . ." Bruce's arrival at Sequoia, in March 1968, marked the first time an NPS researcher had been permanently stationed at SEKI (though Lowell Sumner had spent several years at SEKI as park biologist prior to this; see Dilsaver and Tweed 1990). Kilgore reported to the park superintendent.

Fire. During the next several years Kilgore's research focused on documenting the importance of reintroducing fire into the forested ecosystems of SEKI. His work built on the continuing studies by a team of scientists from San Jose State University. Richard Hartesveldt and his co-investigators, H. Thomas Harvey, Howard Shellhammer, and Ronald Stecker, had been studying the ecology of giant sequoia since the early 1960s (Hartesveldt et al. 1975). Their work documented the dependence of the giant sequoia on periodic low-intensity fire for its reproduction (Hartesveldt and Harvey 1967), factors affecting its survival and growth, as well as the insects, birds, and mammals associated with the species (Harvey et.al. 1980). Kilgore built on this work by studying the fire history and fire ecology of sequoia

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The first park-based research scientist at Sequoia–Kings Canyon National Parks was Bruce Kilgore, who was hired by Starker Leopold in 1968. The modern era of research at the parks dates to Kilgore's arrival.

mixed-conifer forests (Kilgore 1973; Kilgore and Taylor 1979), including the effects of prescribed burns of varying intensity conducted by park staff on vegetation and fuels (Kilgore 1972a). These studies laid important groundwork for the acceptance of the idea of restoring fire as a natural part of park ecosystems. During this time Kilgore was assisted by two field assistants, Dan Taylor and Dean Taylor.

In addition to his important research studies, Kilgore was a prolific writer and skilled communicator. Many of his written papers, as well as oral presentations to both park and outside groups, effectively communicated the important role of fire in Sierra Nevada forests (Kilgore 1972b). In addition to his work in the middle-elevation sequoia mixed-conifer forest, Kilgore was the driving force behind a program to allow naturally ignited fires to burn in the parks' higher-elevation red fir and subalpine forests (Kilgore and Briggs 1972), a program that was to become widely accepted in western parks and forests as the "prescribed natural fire" program.

During these years there were also several outside scientists working in the parks. Their research included studies of giant sequoia ecology (Phil Rundel, UC Irvine), spatial patterning of mixed-conifer forests (Thomas Bonnicksen, UC Berkeley), shorthair sedge meadows (Ray Ratliff, USFS), vegetation change as measured from repeat photos (John Vankat, UC Davis), and the mapping of Lilburn Cave in Redwood Canyon (The Cave Research Foundation).

In 1972, Bruce Kilgore accepted the position of regional chief scientist in the NPS Western Regional Office in San Francisco. By this time it was generally believed that the importance of restoring fire to SEKI's forested ecosystems was well established and the responsibility for managing fire (both human- and naturally ignited) was now largely in the hands of park managers. Management of fire in the middle-elevation forests of SEKI was viewed as an *operational* program. It was thought the research necessary to support this program had been largely completed.

The Parsons Era: 1973–1980

In the spring of 1973 as I was finishing my PhD studies in plant ecology at Stanford University, my major professor, Harold Mooney, showed me a letter from the National Park Service announcing recruitment to fill a position as research biologist at Sequoia and Kings Canyon National Parks. The announcement stated that they were looking for someone to undertake a research agenda focused on two primary areas: backcountry visitor use impacts and foothill fire ecology. I was interviewed for the position by Superintendent Hank Schmidt, assisted by Regional Chief Scientist Bruce Kilgore and Chief Ranger Bob Smith (at the time the natural resources management staff was under the Ranger Division). I was offered and accepted the position. I reported to work in early July 1973, reporting directly to the superintendent. Over the next several years I developed research projects in both of the priority areas. A permanent biological technician support position was established (briefly filled by Belinda Norall and later by Steven DeBenedetti) and a small project budget provided.

Foothill chaparral. Building on my graduate studies on vegetation in Mediterranean climate ecosystems, my initial emphasis was on the lower-elevation foothill zone, characterized primarily by chaparral and oak woodlands. This work focused on characterizing the vegetation communities and articulating the threats posed to them by decades of fire exclusion (Parsons 1976). Project funding was used to attract cooperative studies with Phil Rundel (UC Irvine), including structural and nutrient changes along a fire-induced age gradient (Rundel and Parsons 1979), shrub phenology, growth and drought survival (Parsons et al. 1981a; Baker et al. 1982), and oak woodland ecology (Baker et al. 1981). It was in 1977 that Nate Stephenson, as a volunteer undergraduate working with Rundel, began his many years of working at SEKI. Additional studies of chaparral population structure and postfire demography were continued with university cooperators into the 1980s (e.g., Stohlgren et al. 1984; Rundel et al. 1987). Yet, while understanding of the foothill communities was greatly improved (Parsons and Stohlgren 1986), SEKI fire managers accomplished little in terms of reintroducing fire into the foothill zone.

Backcountry use and impacts. The second major research initiative undertaken in the 1970s was an effort to improve understanding of the impacts of backcountry users and to provide a basis for park managers to develop restrictions as might be needed. For a number of years there had been increasing concern about the accelerating levels and impacts of backcountry use, both by hikers and pack stock (Hallock and Briggle 1959). SEKI's first backcountry use restrictions were imposed along the heavily used Rae Lakes Loop in Kings Canyon. First, concerns about the heavy use and associated impacts at Bullfrog Lake led to that area being closed to all camping in 1961. In 1963 the Rae Lakes Basin was closed to grazing by pack and saddle stock, followed in 1970 by a one-night camping limit and closure to wood fires. In 1972 the popular Rae Lakes Loop was put under a daily trailhead quota (see Parsons 1983 for a more detailed discussion of the Rae Lakes Loop use restriction history). Then, in 1973 the rest of the trailheads into Kings Canyon were placed under daily quotas, followed in 1975 by those in Sequoia. These quotas required the cooperation of USFS as many of the trailheads contributing use to the parks were located on adjacent national forests. The trailhead quotas were intended to hold use at approximately the levels experienced in the early 1970s until a more quantitative (and defensible) basis for determining appropriate use levels could be developed.

The research program that was developed to address backcountry use and impacts included characterization of past impacts and management (Parsons 1979, 1983) as well as development of a system to quantify impacts associated with campsites, which are the primary focus of most visitor activity (Parsons and MacLeod 1980). The campsite inventory system that was developed utilized eight criteria to be measured in the field. Using these criteria, a detailed field inventory of all the backcountry campsites in the two parks was carried out between 1977 and 1981. A total of over 8,100 campsites were located, mapped, and classified. Steven DeBenedetti and, later, Tom Stohlgren served as field leaders for this project. This was also the project in which Nate Stephenson first worked for SEKI research. The campsite inventory data were then used, together with information derived from wilderness permits as to how people dispersed from each trailhead, along with assessments of park staff (scientists, resource managers, and backcountry rangers), to establish acceptable maximum use levels for different areas of the parks (50 travel zones were demarcated to assist this process). These were then translated into daily trailhead quotas using a computer model developed in Yosemite National Park that relates zone use to trailhead use (van Wagtendonk and Coho 1986). Examples of the application of this approach, which is still in use today, can be found in Parsons et al. (1981) and Parsons (1986). Additional work during this period included studies of campsite recovery (Stohlgren and Parsons 1986), wilderness permit accuracy (Parsons et al. 1982), and visitor impacts on high-elevation lakes (Taylor and Erman 1979). Van Wagtendonk and Parsons (1996) provide a review the wilderness research and management programs of the Sierra Nevada parks.

In hindsight it is clear that the trailhead quota system was established at a time when public input was not as big a factor as it would later become. Efforts in the 1980s and beyond to develop new wilderness management plans, including stock use management, became quite contentious, being appealed by both hiker and stock user groups on a regular basis. Often this delayed finalization of plans for years. The increase in user groups' attention to any proposed restrictions on use resulted from the view that they were threatening or restricting traditional uses (e.g., pack stock) and personal rights, or from concerns over threats to the "wilderness values" of SEKI's backcountry. Interestingly, whereas the 1984 designation by Congress of much of SEKI as a wilderness area may have gone largely unnoticed by park staff (there was a feeling that the parks were already being managed as wilderness and thus few, if any, changes were needed), that action helped focus outside attention on SEKI's wilderness values.

Meadows. A third significant in-house research program, focused on mountain meadows, started in the 1970s and continued into the 1980s. This work was coordinated by Steven DeBenedetti. It included studies documenting the occurrence of fire and post-fire succession in a subalpine meadow in Kings Canyon (DeBenedetti and Parsons 1979a, 1984) as well as the physical and biological impacts of pack and saddle stock on high-elevation meadows. The stock impact studies included developing a better understanding of the effects of the timing of stock use (both trampling and grazing) on soil stability (erosion), species composition, and forage production (DeBenedetti and Parsons 1979b; Stohlgren et al 1989). These studies provided a basis for implementing a grazing management plan that included opening dates and limits on animal numbers for different meadow types (DeBenedetti and Parsons 1983). The work provided the basis for the meadow monitoring program that SEKI continues to support.

Summary. While in-house studies on chaparral, backcountry use, and meadows were the primary focus of SEKI research during the 1970s, there was also a growing number of outside projects being conducted in the parks. Some of these were in response to park-identified needs (as with the studies conducted by the SEKI research staff, these might be called "science for parks"), but more commonly they were initiated by the interests of outside investigators ("parks for science"). Such work included studies of bighorn sheep, winter surveys of wolverines and other mammalian predators, survival of yellow-legged frogs in high-elevation lakes, black bear ecology, causes of giant sequoia tree failure, ozone impacts on conifers, and the effects of fire on soil nutrients in mixed-conifer forests. The park research staff provided oversight, coordination with other staff, and occasionally logistical support to this work. During this period supervision of park-based scientists in the NPS Western Region was transferred from park superintendents to the regional chief scientist in San Francisco (several years later supervision was moved to the Cooperative Park Studies Unit, or CPSU, at UC Davis). This change was intended to increase the independence of the park scientists by having them report to another scientist rather than a manager who might have a stake in influencing the research findings. Despite this change in oversight it is important to note that it had become increasingly clear that there were significant advantages to having a research staff physically based in the parks. The regular interaction this allowed with park management was critical to the success of the program. The SEKI science staff felt particularly fortunate to work with a park staff that understood and supported the importance of a scientific basis for management decisions.

The Parsons/Graber Era: 1980–1990

Bears. In the late 1970s Superintendent Stan Albright, and later his successor Dave Thomson, became increasingly concerned about the high numbers of incidents between black bears and park visitors. They were aware that a multi-year research program on this topic was wrapping up in Yosemite and wanted to have similar studies done at SEKI. To address this need they created a term research scientist position into which David Graber, the lead researcher on the Yosemite project, was hired in 1980. Graber had recently completed his PhD at UC Berkeley under A. Starker Leopold and was happy to continue his work with the National Park Service. From the beginning Graber felt that the focus on keeping human food away from the bears that had proved so successful in Yosemite was also the answer to SEKI's problems. His field studies provided the justification the parks needed to put food storage lockers in the frontcountry campgrounds as well as address means to keep backpackers' food away from bears in the more remote areas of the parks (Graber 1986a, 1986b; Ayers et al. 1988). Concern over the ineffectiveness of traditional counterbalancing and other methods, including bear poles (which were briefly tested in the Kearsarge Lakes Basin) and bear boxes that had been placed in strategic backcountry locations (there were questions about the appropriateness of the boxes in designated wilderness and their effect on concentrating use) led to experiments with the backpacker food cannisters that continue to be used to this day. SEKI Biologist Harold Werner was instrumental in testing different cannister designs on bears in the Fresno Zoo. As time passed, Graber pursued additional questions regarding black bear behavior, such as differences between bears who spend their time away from humans in the backcountry and those who frequent developed areas. He also was able to radio-collar bears that were relocated out of the developed areas and track their movements and propensity to return to where they had been captured. The frequency and rapidity with which the bears returned further confirmed the importance of separating them from human food sources.

Watershed/acid precipitation. In 1982 Sequoia National Park was selected through a competitive process to be one of three national parks (with Rocky Mountain and Isle Royale, later expanded to include Olympic)

Mminimizing conflicts between human visitors and bears is a perennial challenge at SEKI. The development of tools such as educational signage (left) and innovations in equipment, among them bearproof trash containers (right), have been informed by the park's scientific research program.

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to participate in a long-term watershed research and monitoring program that was being developed through the NPS Division of Air and Water Quality. The program was funded through an allocation to NPS from the National Acid Precipitation Program. The goal was to measure atmospheric inputs and then monitor ecosystem parameters potentially sensitive to acid precipitation. The southern Sierra Nevada was of interest because of its poorly buffered granitic bedrock and low-alkalinity lakes, both of which lead to high sensitivity to acidic inputs. We saw this as an opportunity to contribute to a major national research priority while at the same time obtaining data necessary to better understand and monitor the long-term health of key park ecosystems (Parsons and Graber 1985).

Our initial study design was to utilize SEKI's elevation gradient, establishing three primary study sites (foothill chaparral, middle-elevation mixed-conifer forest, and a high-elevation subalpine lake basin) where

Solar-powered meteorological station at Emerald Lake.

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aspects of hydrological and chemical budgets as well as key ecosystem elements and processes could be measured. In reaching out to scientists outside the parks it became apparent that others were interested in contributing to the effort and eager to submit ideas that strengthened the overall SEKI proposal and could later be developed into more detailed project proposals. Whether interested in the impacts of acid precipitation or oxidant air pollutants, or in particular structural or process elements of natural ecosystems, we found a significant number of university scientists who were attracted to both the undisturbed aspect of the parks' ecosystems and the benefits of being part of a larger, cooperative effort.

Over the next several years Sequoia became a center for long-term ecological research focused on the three primary study sites (Elk Creek, Log Meadow, and Emerald Lake). The NPS funds were used in-house to establish and provide core measurements for the three primary watersheds, including inputs from rain and snow, the quantity and chemistry of stream outputs, basic meteorological parameters, and establishment of permanent vegetation plots. The core funds also supported work by outside cooperators on additional priorities (e.g., soils mapping and chemistry, aquatic biology, lake chemistry) by providing project funding as well as on-site support staff to assist with field and lab sampling. USGS constructed a gauging station at the outlet of Emerald Lake, the high-elevation site. Other studies were supported by the National Aeronautics and Space Administration (NASA), Electric Power Research Institute (EPRI), Southern California Edison, and USFS (Parsons and Graber 1985). SEKI used the growth of this program as justification for the 1983 conversion of Graber's term position into that of a permanent NPS research scientist. At the same time, Superintendent Boyd Evison made the decision to convert what had been the superintendent's residence into the Southern Sierra Research Center. In addition to providing office and computer space and living quarters for visiting researchers and office space for Graber, the garage was converted into a first-class wet laboratory. The lab, by providing a means for rapid chemical analysis of water samples, became critically important to the success of the growing program.

As the SEKI watershed research program developed, it attracted the attention of the state of California's Air Resources Board (CARB). They were looking for a location for a new research initiative on acidic deposition in the Sierra Nevada. The infrastructure provided at SEKI (lab, lodging, baseline data collection, and assistance with field sampling and logistics), together with ongoing studies by other groups, provided an opportunity to leverage CARB's funds. In 1984 CARB selected the Emerald Lake watershed to be the focal point for a ten-year acid deposition research and monitoring program. With a primary focus on the areas of snow hydrology and chemistry, aquatic biology, and soil processes, CARB (through the coordination of Kathy Tonnessen) funded over $8 million of research over the next ten years, much of it contracted to scientists at UC Santa Barbara (John Melack, Jeff Dozier, Scott Cooper, Jim Sickman, Mark Williams, Danny Marks) and other universities and agencies (Tonnessen 1991, 1992). Although less intensive and mostly supported by other funding sources (e.g., NPS, USFS, UC), additional studies were carried out at the Elk Creek and Log Meadow sites. These included work on nitrogen cycling and soil solution chemistry (Peter Vitousek and Pamela Matson, Stanford University; Jon Chorover, UC Berkeley) and establishment of permanent reference stands for description of forest communities (Jerry Franklin, Mark Harmon, and co-workers, USFS and Oregon State University). All of this work emphasized studies of park ecosystems as "natural laboratories," providing an opportunity to study entire ecosystems, as opposed to earlier research, which had generally focused on single species or processes.

The acid precipitation research program, with its focus on attracting outside scientists to address issues of importance to the park as well as society as a whole, marked the start of a new emphasis on leveraging NPS resources (money, facilities, and staff) to attract both researchers and additional research funds. This was critical to expanding the amount of research that could be accomplished. It had become clear that research conducted by park staff alone was inadequate to address the growing list of information needs. As a result, the SEKI science staff played an increasingly important role in prioritizing, coordinating, facilitating, and otherwise overseeing research conducted by university and other outside scientists. Both Tom Stohlgren and Annie Esperanza transitioned into permanent research support positions during this time.

Complementing the acid precipitation research program were continuing studies by USFS scientists on the effects of ozone on conifers. For years concern had been growing over the effects of air pollution on park ecosystems. Summer inversions over the Central Valley concentrated pollutants derived from vehicles and agricultural chemicals on the western slopes of the Sierra Nevada, highlighting SEKI's vulnerability to influences originating outside park boundaries. Forest Service scientists from the agency's lab in Riverside, California, had been studying the effects of ozone on needle mottling on ponderosa pine for a number of years (Paul Miller, Nancy Grulke). This work was expanded to include experimental fumigation of ozone and its effects on photosynthesis rates and seedling survival in giant sequoia.

Sequoia mixed-conifer fire. By the early 1980s it was widely accepted that the background research needed to justify and provide guidance for the restoration of fire as a natural process to sequoia mixed-conifer forests had largely been completed. It was clear from fire history studies (Kilgore and Taylor 1979) as well as general observation that the suppression of fires through the 20th century had resulted in high ground fuel accumulation, a lack of giant sequoia reproduction, and the growth of a dense understory of young conifers (Parsons 1978; Parsons and DeBenedetti 1979). For the most part the parks' fire management program was considered to be "operational." One or two fuel reduction burns to reduce ground fuels and thin the understory were thought to be adequate before a "natural" fire regime (one with the frequency and intensity characteristic of pre-settlement times) could be restored, through a combination of management


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Experimental nutrient additions at Emerald Lake.

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Fire-scarred sequoia.

(prescribed) and natural (lightning) ignitions. Monitoring the effects of the prescribed burn program was the responsibility of the park natural resource management staff, under the direction of Larry Bancroft as the chief and Tom Nichols as the fire specialist.

Yet, as the fire management program in the sequoia mixed-conifer forest zone was implemented, questions—both philosophical and practical—began to emerge. For example, if the goal was to restore "natural" fire regimes, should this include fires ignited by Native Americans? Or, were only lightning-ignited fires "natural"? Fire scar records did not distinguish between the two ignition sources. Other questions included whether one or two rounds of management burns were sufficient to restore the forest to a state where fire alone would maintain a "natural" forest. Whereas the park's goal was to use an initial burn (or two) to reduce fuels to the point that naturally ignited fires could be allowed to burn (or, as necessary, supplemented with management ignitions), criticism from UC Berkeley scientists maintained that selective cutting of trees was first required to restore the forest structure to a state that had occurred at some point in the past (Bonnicksen and Stone 1982). Park staff (scientists as well as the fire and natural resource management staffs) felt that the suppression of fire over the past 80+ years had not altered the forests enough such that, with time, the reintroduction of fire alone—with no mechanical thinning—would allow them to re-equilibrate to a state that would be close to what would have existed without suppression. They argued that, even if the fit wasn't perfect, allowing the natural process of fire to operate was preferable to artificially manipulating the vegetation (Parsons et. al. 1986). These differences, often referred to as the "structure vs. process debate," led to an exchange in the literature that seemed to only harden the views of those involved (Bonnicksen and Stone 1985; Parsons et. al. 1986; Bonnicksen 1989). In retrospect, the terminology/semantics used hindered effective dialogue between the two views. However, it was clear that additional information was needed; and this was more than the existing park research staff could accomplish. Additional funding would be required.

Other questions, which would only become more important with time, included concern whether it would be possible to burn enough acreage to ever restore even a semblance of pre-settlement fire regimes (Caprio and Graber 2000). Funding and personnel constraints, along with a growing concern from local communities and state and county air quality boards over the impacts of smoke from management burns, presented significant challenges. The fire program was also constrained by the necessity to conduct most burning in the spring or fall (due to concern over both possible escape and smoke production), rather than during the hot, dry, late-summer months when historic fires most often occurred. It was uncertain what the long-term effects of a change in the seasonality of burning might be. Finally, questions were raised as to how much "management" (e.g., management ignitions) was appropriate. These types of questions occupied many hours of discussion among park staff. The restoration of fire to park ecosystems was clearly not as straightforward as we had once thought.

Questions about the fire management program in the sequoia mixed-conifer forests were further highlighted when concerns were raised about the aesthetic impacts of burning on giant sequoia. In the fall of 1985 a longtime local resident expressed concerns about the bark char, foliage scorch, and fire scar enlargement resulting from management burns in Giant Forest. Initially, this criticism focused on the 110-acre Broken Arrow burn of 1985. Charges were made that the park was burning too much and too hot, and not doing enough to protect the large trees. The park was accused of not considering the interests of park visitors. Soon, claims of "sequoias in flames," "scenery crisis," and "professional vandalism" appeared in articles in newspapers such as the *Los Angeles Times, San Francisco Chronicle, Fresno Bee*, and *Visalia Times Delta*. The Save the Redwoods League, renowned conservationist David Brower, and others weighed in with concerns over what they considered an overly aggressive prescribed fire program. These concerns led Western Regional Director Howard Chapman to appoint an external panel of scientists to conduct a review and assessment of the policies and practices of the SEKI and Yosemite sequoia mixed-conifer forest fire programs. The panel was chaired by Norm Christensen of Duke University and consisted of individuals with expertise ranging from fire and forest ecology to landscape architecture. A public review with opportunities to testify before the panel was held in Giant Forest, June 30–July 1, 1986. Meanwhile Superintendent Jack Davis imposed a moratorium on all prescribed burning in SEKI for the 1986 fire season, pending recommendations of the review panel. (Copies of the extensive correspondence related to this controversy, and the proceedings of the review panel, can be found in the SEKI archives. These include letters to and from the review panel, NPS Director William Penn Mott, Jr., conservation organizations, academics, and concerned individuals, including extensive correspondence with the person who raised the initial concerns.)

The review panel issued a final report dated February 22, 1987 (Christensen et. al. 1987). The report generally supported the goals of the fire program, but also made a number of recommendations to improve both operational aspects of and the scientific basis for the program. Operational recommendations included that management burns should be classified as either "restoration fires" or "simulated natural fires." In the case of restoration fires, judicious pre-burn cutting of live trees should be permitted and multiple spot ignitions used. They also recommended that burn plans be formulated in consultation with landscape architects so that aesthetic impacts could be considered. This was especially important in so-called "showcase" areas, such in the heart of the Giant Forest and Grant Grove, where there was high visitor use. Pre- and post-burn monitoring to evaluate both the short- and long- term effects of individual burns was considered critical. The report also recommended expanded investment in the parks' research program related to the role and effects of fire in the sequoia mixed-conifer forest zone. It specifically recommended investment in improving the understanding of fire history; demography and life history of trees; effects of burning on shrub and herb species; fuel dynamics; the effects of varying fire regimes on pathogens, nutrient cycling, and litter dynamics; and visitor response and public understanding of the program. This was clearly a call for a significant investment in an expanded research program.

The SEKI fire management program was reactivated in 1987 with direction to use the review panel's report as guidance. Over the succeeding months funds to support the needed research were provided by the NPS Washington Office, the Regional Office, Omnibus Fee legislation funding, as well as from park base funds (both SEKI and Yosemite). Additional funds to support selected studies came from USFS and the Sequoia Natural History Association. With this significant increase in funding, a suite of new studies was undertaken. Together, they contributed significant new understanding of key park resources, understanding that provided important guidance for the fire program, but that also made important contributions to the expanding knowledge base on the history and dynamics of park ecosystems. As with the acid precipitation program, many of these studies were conducted by some of the most distinguished scientists in their fields. It was clear that SEKI was becoming known as a good place to work—a place where there was a supportive management structure as well as valuable opportunities for important collaboration with scientists from other disciplines. Among the studies supported by these funds were the following (see also Parsons 1990):

- Biogeography and disturbance history of giant sequoias. Studies of pollen, macrofossils, and charcoal from meadows within sequoia groves documented significant changes in sequoia distribution and fire over the past 10,000 years. (R. Scott Anderson, Northern Arizona University.)
- Reconstruction of giant sequoia fire history using tree rings and fire scars to document changes in fire occurrence over the past several thousand years. This work received extremely wide coverage, including a cover article in *Science* (Swetnam 1993). (Tom Swetnam, University of Arizona.)
- Paleoclimate reconstruction from tree rings of tree line conifers documented significant changes in past climate. (Lisa Graumlich, University of Arizona.)
- Giant sequoia seedling establishment and survival following fire. (Stephanie Gebauer, Duke University.)
- Forest age structure (recruitment and death), including the importance of "hot" fires (Stephenson et al. 1991). (Nate Stephenson, NPS.)
- Fuel accumulation rates and fire behavior modeling. (Jan van Wagtendonk, NPS.)
- Forest pathogens associated with fire scars and roots. (J.R. Parmenter, UC Berkeley and Doug Piirto, Cal Poly San Luis Obispo.)
- Soil and cambium temperatures during fires. (Steve Sackett and Sally Haase, USFS.)
- Visual resource management to plan burn units. (Kerry Dawson, UC Davis.)
- Visitor perceptions of the fire program.(Joyce Quinn, Cal State University Fresno.)

With time, some of these projects were expanded to address additional information needs that were identified as the fire program progressed. These included expanded fire and climate history and tree demography studies to address concerns over impending climate change. Parsons and van Wagtendonk (1996) provide a summary of the prescribed and natural fire programs and associated research in the Sierra Nevada parks.

Natural resources inventory. With the rapid increase in information being derived from the expanding research program it became clear that there were both other types of basic data that SEKI did not have (e.g., up-to-date soil and vegetation maps, animal sighting records, etc.) and that a system was needed to effectively catalogue this growing base of information. With this background, in the mid-1980s Graber started a natural resources inventory project with the goal of establishing and inventorying several thousand permanent plots systematically located throughout SEKI. And, although only something over 600 plots were actually completed (Graber 1987; Graber et al. 1993), the data collected were integrated into the beginnings of a park GIS (van Wagtendonk and Graber 1986). Judy Fessenden and Sylvia Haultain provided field leadership in establishing the inventory plots. Graber also became involved in an effort to convince NPS of the importance of long-term monitoring as a means of understanding the status of park resources. These efforts provided much of the genesis for the NPS Inventory and Monitoring program that many years later would become a key component of the agency's 1999 Natural Resources Challenge. Among the projects supported through these programs were studies of the status of the mountain yellow-legged frogs, which successfully used the park's wilderness rangers to help collect critical observations (Bradford et. al 1994).

Naturalness. Throughout the 1980s SEKI research staff spent considerable time brainstorming just how to implement the Leopold Report's direction to maintain, or where necessary, recreate biotic associations in their pre-settlement condition—what became commonly referred to as "natural." For example, should the activities of Native Americans (e.g., hunting, burning, collecting of acorns and berries) be considered as "natural," and thus replicated? How should "natural" be defined when ecosystems are continually changing? How much active management (manipulation) is appropriate, much less practical? These questions became increasingly important, and complicated, the more that was learned about park ecosystems and the species inhabiting them. In addition to a number of published papers in which park scientists addressed such questions (Graber 1983, 1995; Parsons et al. 1986), SEKI requested a meeting with Starker Leopold to question him about just what had been meant by various statements in the 1963 Leopold Report. The meeting, which was held in Berkeley in the spring of 1983, was attended by Boyd Evison, David Graber, Tom Nichols, and myself. Leopold followed up in a June 9, 1983, letter to Superintendent Evison. Leopold emphasized that he felt the parks were taking the report's wording too literally, especially when it came to the interpretation of "naturalness" and how to achieve it. He stated that hands-on, often subjective management actions are absolutely required to achieve park goals. And, depending on the situation, such goals might be to restore more natural fire regimes, vegetation structure, animal populations, or, in the case of invading conifers in Yosemite Valley, even scenic vistas. He emphasized the need to use "judgement, followed by action," and that simply "allowing natural ecosystem process to operate" is "not sufficient." He concluded with this statement: "I still espouse the idea of active manipulation to maintain a more or less natural aspect to the park as seen by the visitor." He claimed that this was what they were trying to say in the 1963 Leopold report. It seemed to us that we, and NPS in general, had not fully understood the recommendations of the Leopold Report. Fisher Smith (2016, Chapter 32) reviews this issue in his analysis of NPS's struggle to maintain "naturalness" in parks.

Wilderness. One other topic which occupied much of our time in the 1980s was debating the appropriate role of research activities in designated wilderness. The bulk of SEKI had been officially designated as wilderness in 1984. And, whereas this new designation was felt by some to be unnecessary for large natural-area parks, it did require some changes in what activities were to be permitted. Boyd Evison was superintendent in 1984 and he took the designation seriously. Graber found he could no longer use a truck to position bear traps on a road now included in wilderness. Researchers mapping Lilburn Cave in Redwood Canyon could no longer use an old road to drive to their study site. Similarly, backcountry trail crews, rangers, and even scientists were forced to provide strong justifications for any activities involving the use of mechanized equipment (e.g., helicopters, chain saws), installation of meteorological stations, or even the marking of study plots (Parsons and Graber 1991).

Summary. The 1980s saw a significant shift in SEKI research from the relatively narrowly focused in-house studies of the 1970s to a conscious effort to attract outside funding and scientists to conduct studies focused on ecosystem or even regional questions. Both the watershed/acid precipitation and fire research programs provided this opportunity. As noted above, the funding that came with those programs allowed SEKI to build a laboratory, provide both work and living space to visiting scientists, as well as hire an additional park scientist and additional support staff Together, these provided a level of logistical support, including both field sampling and lab analysis, that allowed a leveraging of funds and staff to maximize the information to be gained. As the research program grew, the synergy provided by the growing number of respected scientists working in SEKI created a snowball effect, attracting both additional funding and scientists. While the park scientists were able to continue personal research, they were also developing a true research *program*, as opposed to a collection of individual studies. This required that an increasing amount of their time be given to marketing, oversight and coordination. Yet this was the best way to maximize benefit to the parks.

The Parsons/Graber/Stephenson Era: 1990–1994

Global change. Efforts to build a comprehensive SEKI research program received a further boost with the NPS Global Change Research initiative, part of the US Global Change Research Program. In 1990 the NPS Washington Office solicited proposals from parks for research to address the potential effects of global climate change. Proposals were to be based on a biogeographic area (BGA) approach with parks as the core of each BGA. The SEKI scientists solicited interest from Yosemite as well as potential university cooperators to work together to prepare a conceptual proposal for what we called the Southern and Central Sierra Nevada Biogeographic Area. We proposed a combination of paleo-ecological, modern, and predictive studies to understand and predict biotic and hydrologic changes across the climatic and topographic gradients represented in the Sierra Nevada (Parsons et. al. 1990). The projects proposed would build on the rich assortment of relevant, ongoing research in the parks.

The Sierra Nevada proposal, titled "Understanding and Predicting Change in Biota and Hydrology with Changing Climates" was accepted as one of six BGAs to be funded, starting in 1991. Twelve related projects were proposed. Nate Stephenson, who had been working in SEKI since the late 1970s, and had recently completed his PhD at Cornell University on understanding climatic control of vegetation distribution in Sequoia, took the lead in developing the program. And, the new global change funding allowed for creation in 1991 of a third permanent research scientist position into which Nate was hired. He was to serve both as a researcher and as the BGA coordinator. During the initial two years of the global change program the following projects were undertaken (Stephenson and Parsons 1993), with all but those noted otherwise paid for with NPS global change funding (note that several of the projects were extensions of ongoing studies):

- Paleo-climate as determined from subalpine tree-ring chronologies. (Lisa Graumlich and Malcolm Hughes, University of Arizona.)
- Paleo-fire from giant sequoia tree-rings. (Tom Swetnam, University of Arizona.)
- Paleo-fire from charcoal, and paleo vegetation from plant remains in meadow cores. (R. Scott Anderson, Northern Arizona University.)
- Forest demography, including both tree mortality

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Coring a meadow for charcoal and pollen analysis.

and seedling dynamics. (Nate Stephenson, NPS; Ruth Kern and Norm Christensen, Duke University.)

- Conifer physiology (funded jointly with USFS). (Nancy Grulke, US Forest Service.)
- Climate and tree growth. (Lisa Graumlich, University of Arizona.)
- Species–environment relationships. (David Graber and Jan van Wagtendonk, NPS; Frank Davis, UC Santa Barbara.)
- Forest dynamics modeling (ZELIG). (Dean Urban and Carol Miller, Colorado State University.)
- Fuel dynamics modeling (funded by NPS Western Regional Office and Boise Interagency Fire Center.) (Jan van Wagtendonk, NPS.)
- Fire behavior and fire spread modeling. (Mark Finney, NPS; Pat Andrews, USFS; Colin Bevins, Systems for Environmental Management.)
- Tree growth modeling (funded by EPRI). (David Weinstein and Ruth Yanai, Cornell University.)

As with the acid precipitation and fire research programs, NPS "seed money" and SEKI's reputation for supporting quality science attracted a cadre of reputable scientists as well as additional funding from other agencies and institutions (e.g., USFS, EPRI, NASA, Environmental Protection Agency). NASA, for example, soon chose the SEKI alpine region as part of a worldwide study of the effect of climate change on seasonal snowpack.

The knowledge base that has been developed from SEKI global change research studies is impressive. The investigators have been active in giving presentations at national meetings, participating in workshops, providing briefing materials to park staff (interpreters, resource managers, rangers, etc.) as well as publishing their findings in scientific journals. Listings of the publications produced can be found in the Sierra Nevada Global Change Research Program annual reports (the first such annual report was for 1992). Copies of these reports and individual papers are in the SEKI files.

It should be noted that Mark Finney, who, following completion of his PhD at UC Berkeley, was hired by Nate Stephenson to work on the SEKI forest demography global change project, so impressed us with his creative approach to modeling fire spread that we allowed him time to further develop those ideas. This led to Finney collaborating with other fire scientists and eventually taking on co-leadership on a fire spread and modeling project. Finney was soon hired away from SEKI by the USFS Fire Lab in Missoula, Montana, where he developed FARSITE, a state-of-the-art fire growth simulation model that continues to be widely used by fire managers throughout the world. In 2019 Mark Finney, widely acknowledged as the father of FARSITE, was awarded the Ember Award from the International Association of Wildland Fire (IAWF) to acknowledge his sustained achievement in wildland fire science. Mark credits his early years at SEKI as providing him the opportunity to develop the ideas that led to his later success.

During the early 1990s Graber and I were appointed to the science team in support of the congressionally funded Sierra Nevada Ecosystem Project (SNEP). This activity focused on a broad assessment of the natural resource and social conditions characterizing the greater Sierra Nevada, including projections for alternative future scenarios. Extensive reports produced by SNEP can be found in the park files.

The transition to USGS: 1993–1994

Significant changes to the NPS research program, including at SEKI, began in 1993. On October 1, all NPS research staff and funding were transferred to the National Biological Survey (NBS), a newly created agency

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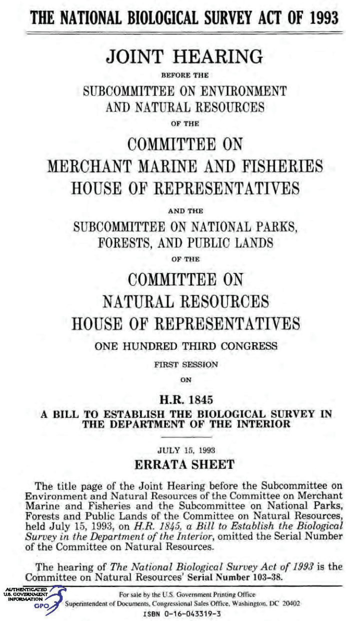

THE NATIONAL BIOLOGICAL SURVEY ACT OF 1993

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON ENVIRONMENT
AND NATURAL RESOURCES

OF THE

COMMITTEE ON
MERCHANT MARINE AND FISHERIES
HOUSE OF REPRESENTATIVES

AND THE

SUBCOMMITTEE ON NATIONAL PARKS,
FORESTS, AND PUBLIC LANDS

OF THE

COMMITTEE ON
NATURAL RESOURCES
HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

ON

H.R. 1845

A BILL TO ESTABLISH THE BIOLOGICAL SURVEY IN THE DEPARTMENT OF THE INTERIOR

JULY 15, 1993

ERRATA SHEET

The title page of the Joint Hearing before the Subcommittee on Environment and Natural Resources of the Committee on Merchant Marine and Fisheries and the Subcommittee on National Parks, Forests and Public Lands of the Committee on Natural Resources, held July 15, 1993, on *H.R. 1845, a Bill to Establish the Biological Survey in the Department of the Interior*, omitted the Serial Number of the Committee on Natural Resources.

The hearing of *The National Biological Survey Act of 1993* is the Committee on Natural Resources' **Serial Number 103–38.**

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The creation of the National Biological Survey brought major changes to the SEKI research program.

in the Department of the Interior. Despite the excellent relationships that had been developed between the SEKI researchers and other park staff, there were suddenly new obstacles to be faced. While SEKI continued to do its best to support the NBS researchers stationed in the park, the fact that those individuals now reported to a different agency, and one that was struggling to figure out what its own role would be and how it was going to operate, posed a suite of new challenges.

It wasn't long before I felt frustrated enough with the new bureaucracy, a bureaucracy that seemed to have little interest in park needs, that I started to look at other options. In February 1994, I accepted a position with USFS as director of the fledgling interagency Aldo Leopold Wilderness Research Institute in Missoula. The institute was designed to provide the research needed by the four land management agencies responsible for designated wilderness (Bureau of Land Management, US Fish and Wildlife Service, NPS, and USFS). I left SEKI in May 1994. Two years later Graber was hired back into NPS as a senior science advisor, giving up his research position and RGE (research grade evaluation) status by which he was evaluated on his personal scientific contributions. He continued to be stationed at SEKI, reporting to the superintendent but with advisory responsibilities across the Western (later the Pacific West) Region of NPS. For much of next several years he served as the lead in developing a new general management plan for SEKI. Stephenson continued as a research biologist for NBS, which in 1996 became the Biological Research Division (BRD) of USGS. Annie Esperanza continued in her support position with the BRD until hired by SEKI as the branch chief for physical sciences, overseeing the park's air, water, and cave programs.

Reflections on the first 25 years: Keys to success

In the years from 1968 to 1993, a park-based research program grew steadily at SEKI. Starting with a lone researcher (Kilgore), 25 years later the park had an office staffed by three permanent research grade (RGE) scientists supported by a cadre of permanent, term, and seasonal staff. During this time the SEKI scientists' role expanded from one focused primarily on the personal research of individual scientists on issues of immediate importance to the park, to increasing responsibilities for marketing and coordinating a growing program of collaborative research that also addressed regional and national priorities. This, in turn, required that the park scientists increasingly become generalists, able to converse in a number of scientific disciplines as well as communicate with non-scientists. This time also saw the SEKI resources management staff transition from specialists reporting through the Ranger Division to a separate Division of Resources Management consisting of scientifically trained staff that reported directly to the superintendent.

In reflecting on the growth of the SEKI science program, there are a number of keys to our success:

Relationships between scientists and park managers were critical to the success of the SEKI science program. This included effective two-way communication between the research staff (often including outside researchers), the superintendent, and the various division chiefs. This was facilitated through inclusion of both Graber and I in weekly squad meetings and on yearly team-building trips into the backcountry. It also included outreach by the scientists in the form of orientations given to the interpretation, ranger, fire, resources management, and even the maintenance staffs to ensure that other park employees understood the purpose and importance of the park's research program. The mutual respect, trust, and feeling of ownership developed through these interactions paid tremendous dividends when assistance was needed, such as in managing bear traps, or constructing the lab or new research office buildings that were so critical to the growing program. Being able to demonstrate such parkwide support was also important in successfully competing for outside funding.

Relationships with other scientists were critical to attracting quality researchers to work at SEKI. These facilitated the successful involvement of a large number of university scientists in working with the SEKI scientists in developing program proposals (e.g., on acid precipitation, fire, and global change). These relationships were built through the active participation of the park scientists in professional societies, including speaking and organizing sessions at conferences and meetings and serving on editorial boards of scientific journals. For example, I was active in the Ecological Society of America (ESA), organizing sessions at annual conferences, participating on various ESA committees, and serving as an editor for ESA publications. Graber was similarly involved in several wildlife-focused professional societies. Through these means academic and other agency scientists became familiar with SEKI and the opportunities it provided. In turn, the park scientists were frequently invited to present papers on park science at various national symposia (Parsons 2004), serve on national and international panels and teams, and serve as reviewers of national programs. These activities, coupled with the quality of the outside scientists attracted to work at SEKI, resulted in an impressive array of publications related to the parks (e.g., Anderson 1990; Sickman and Melack 1992; Graumlich 1993; Swetnam 1993; Lloyd and Graumlich 1997). In addition, the entire research staff actively participated in the biennial George Wright Society conferences, which brought together scientists and managers from across the NPS. The benefits from such interactions, including with the numerous participants from academia and other federal and state agencies, were significant. In later years both Graber and I served on the Board of Directors of the George Wright Society.

There were tremendous advantages to having the park scientists physically stationed within SEKI. This allowed us to become familiar with the park resources and to develop the close relationships with other park staff that were so important in building a research program that was responsive to park needs. Often referred to as "place-based" science, the location of the scientists within the parks was in contrast to the model typically found in other federal agencies, such as USFS and USGS, where scientists are generally located in central locations away from the resource to be studied. Furthermore, each of the three SEKI research scientists saw their highest passion as being the protection and preservation of the parks. They saw science as the way they could best contribute to that interest. This was in contrast with some scientists who saw themselves as scientists first, and parks as simply convenient places to work.

A high priority was given to encouraging (in some cases requiring) researchers working in SEKI to put their findings in forms that were both understandable and useful to the broader park staff. This included briefings and materials that could be used by managers developing plans and programs, and by the interpretive staff in presentations to the public or as displays to be used in the visitor centers. For example, the cross section of a giant sequoia with past fire scars labeled by year that was placed near the General Sherman Tree was the result of cooperation between an outside researcher (Tom Swetnam) and the SEKI Maintenance Division.

The professionalization of the SEKI resources management staff that occurred starting in the late 1970s facilitated communication and mutual understanding between researchers and those responsible for carrying out the park's natural resource management programs. This, in turn, helped maximize the usefulness and application of research findings. Larry Bancroft's hiring as the SEKI chief of resources management facilitated this transition.

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Preparing a giant sequoia cross-section showing fire scars for display in Giant Forest.

Limited in-park funds were leveraged as seed money to attract other funding (both from NPS and outside). The augmented funding was then used for improving facilities and hiring of a third research scientist and support (technician) staff, which was critical to building the SEKI research program. These outside funds also provided the support for many of the researchers who came to work at SEKI.

Lessons learned

Among the many lessons learned as the SEKI research program developed were (1) an understanding of the dynamic nature of ecosystems and the challenges they pose for managing for "naturalness"; (2) the importance of looking beyond park boundaries; (3) the importance of effective communication; (4) that research conducted in national parks can provide multiple values; and (5) the need for an effective means to track changes in species and ecosystems over time.

(1) The paleo-historical studies (of fire scar and tree ring dating, and of pollen and macrofossils) provided an eye-opening understanding of the importance of past changes in vegetation and climate. What had been generally thought of as stable communities of plants and animals were shown to have changed significantly over just the past several millennia. Fire frequency, species composition, and tree line have all changed in close concert with changing climates. For example, we now know that giant sequoia has only occurred in its present locations in the Sierra Nevada for the last 10,000 years or so, which is only several generations of that long-lived tree. Understanding of such changes raises questions as to just what the management goals for national parks such as SEKI should be. What does it mean to manage for "natural" ecosystems or to leave "unimpaired for future generations" when those systems are constantly changing? These questions have become even more critical in an era of accelerating global (climatic) change. Furthermore, how is success evaluated? And, ultimately, how much manipulation (management intervention) is appropriate (e.g., Tweed 2010; Stephenson 2014)? What were once seen as relatively straightforward management goals became increasingly uncertain.

(2) The atmospheric transport of pollutants is a clear demonstration of why parks cannot be managed in isolation from their surroundings. Similarly, animals and fires do not recognize administrative boundaries. Thus, cooperation in both planning and management with surrounding lands, be they USFS, BLM, or private lands, is critical. In the case of SEKI, varying degrees of such cooperation can be found in wilderness management (working together on the issuance of wilderness permits), fire planning and management, smoke impacts on surrounding communities, and collaborative planning and studies on the effects of air pollution and climate change.

(3) Effective communication, within the parks (e.g., scientists with interpreters and park managers), between the parks and the public (visitors as well as surrounding communities), and with outside scientists, is critical. The importance of the social (human dimension) aspects of all phases of park operations has become increasingly apparent. For example, special interests (e.g., hiker groups, stock users) have learned how they can stall, if not block, proposed park management actions through legal challenges. It is critical that such groups be involved in the early stages of planning, including their being provided the scientific basis for proposals in a form that is easily understandable. The SEKI scientists felt particularly fortunate to work with a park staff (interpreters, managers, and planners) that understood the importance of a scientific basis for management decisions and was committed to communicating that understanding to outside interests. Further, such support from park management was critical to the development of lab and office facilities within the park.

(4) Research conducted in parks can provide answers to specific questions important to park managers, such as informing backcountry use quotas or the means of separating human food from bears. Such "science for

Three NPS researchers: (l–r) the author, David Graber, and Jan van Wagtendonk, ca. mid-1990s. Parsons and Graber were based in SEKI, while van Wagtendonk works from Yosemite National Park.

parks" is the traditional and probably most common type of research supported by the NPS. However, park-based research—that funded both by the NPS and outside entities—can also lead to important new understandings (what Nate Stephenson has called "epiphanies"), sometimes making us realize that our initial assumptions or beliefs were incorrect. An example of this is our coming to understand that patches of high-intensity fire were part of the historic fire regime and may actually be necessary for successful giant sequoia reproduction (Stephenson et al. 1991). In time we also came to realize that the parks' fire program wasn't coming close to restoring pre-Euroamerican fire regimes, leading to a reassessment of what the appropriate goals for park management should be (Parsons et al. 1986; Caprio and Graber 2000).

(5) It didn't take long to realize that there was a need for a modern, comprehensive resource database of the various aspects of SEKI ecosystems that could be used as a basis against which change could be tracked. Since such a system was not likely to be competitive through normal budget processes, the park found ways to capitalize on its various research initiatives (acid precipitation, fire, wildlife, global change) to build the data storage and processing capabilities needed to track change in park ecosystems. One example of where baseline data has already proven valuable is in a 30-year resurvey of the distribution and impact of wilderness campsites. Carried out as a cooperative effort between researchers and the park wilderness staff, the resurvey documented definitive changes in the distribution of campsites along with an overall marked improvement in conditions (Cole and Parsons 2013). The change in distribution can be attributed to a change in visitor use patterns, where through hikes along "classic" trails such as the John Muir and High Sierra trails have increased dramatically but use of side trails into canyons and lake basins away from the primary trails has decreased. This change is reflected in the changing numbers and impact levels of campsites. The overall improvement of conditions (decreased impacts) can be attributed to the improved etiquette of wilderness users (e.g., gas stoves replacing wood fires) and the extraordinary efforts of SEKI's wilderness rangers to both educate users and rehabilitate or remove large numbers of campsites, especially the largest, most impacted sites.

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