

Perspective

Prescribed Burns in California: A historical Case Study of the Integration of Scientific Research and Policy

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Abstract: Over the past century, scientific understanding of prescribed burns in California's forests transitioned from being interpreted as ecologically harmful to highly beneficial. The state's prescribed burn policies mirrored this evolution. Harold Biswell, a University of California at Berkeley ecologist, studied prescribed burns and became a major advocate for their use during the 1950s and 1960s. Drawing primarily on archival materials from Biswell and the state government, this historical case study presents an example of how a scientist successfully contributed to integrating research into policy and practice through consistent and targeted science communication to gain allies among environmental organizations, local stakeholders, and governments. Though at first isolated by his academic peers for proposing that fire could provide environmental benefits in forests, Biswell continued conducting and sharing his research and findings with academic and non-academic audiences. Over several decades, Biswell engaged in conversations which ultimately advanced policy changes at the state level to expand the use of prescribed burns. Despite lacking a formal role in government, Biswell used his academic platform to promote the policy implications of his research. Current and future researchers can draw on these lessons to advocate effectively for other science-informed policies.

Keywords: prescribed burn; controlled burn; wildfire; California; science policy; environmental policy; environmental history

1. Introduction

The proper approach to managing wildfire has long occupied the minds of government officials in California. Historically, management has been synonymous with wildfire suppression, the result of early ecological studies and subsequent federal policies mandating the absence of fire on the landscape [1,2]. However, excluding fire resulted in overgrown and unhealthy forests, littered with fuels when wildfires inevitably ignited [2,3]. Alternative scientific conclusions emerging in the mid-twentieth century—which echoed the wisdom of millennia of Indigenous nations' land management practices—recognized that fire played a critical role in the natural environment [2,4,5]. Drawing on their field experiments, some ecologists became early proponents of prescribed burns, intentionally-set fires that clear surface fuels under carefully controlled conditions [4,6]. Although widely recognized today as an effective means of mitigating wildfire risk, prescribed burns remain underutilized in California [7]. Understanding this transition to scientific and policy support for prescribed burns in forest ecosystems between the 1950s and 1970s offers an important lesson both specifically in why prescribed burns were slow to enter California's repertoire of fire management options and generally in how advances in and communication of academic research can influence environmental policies.

The scientific consensus surrounding prescribed burns closely matched the policies governing their use on public lands. With the primary exception of experimental burns, prior to 1968, prescribed burning typically occurred on private property for either agricultural clearing or fuel reduction, rather than on state or federal lands. Conducting a prescribed burn in the mid-twentieth century in California involved multiple steps, which interested burners often interpreted as overly restrictive [8]. First, burners needed (1) a permit from the California Division of Forestry (CDF; now the California Department of Forestry and Fire Protection, or CAL FIRE), (2) confirmation from the CDF of safe local weather conditions on the day of the planned burn to prevent any escapes, and (3) approval from the local air quality board or district, if regionally applicable [8,9]. Air quality boards in California monitor local air quality and determine whether prescribed burns or other emissions releases can occur; the first air district in California was established in 1947 in Los Angeles in response to smog, with other districts forming in subsequent decades [10]. Would-be burners complained that the CDF distributed permits inadequately, mandated statewide burn bans unnecessarily, and failed to recognize local expertise and burning successes [8].

Harold Biswell, a University of California at Berkeley ecologist, entered the state's scientific and policy debate over prescribed burns. Biswell, along with several other likeminded researchers, staked his academic reputation on demonstrating that prescribed burns improved ecosystem health and reduced wildfire threats. In his early career, this research earned him chastisement from department chairs and dismissive insults from state government officials [11]. The CDF employed many forest managers who believed that prescribed burns, and fire in general, caused environmental deterioration and overall destruction [4].

Between the 1950s and 1970s, California had strong conservative representation at both the state and federal level, resulting in forestry conversations dominated by utility and development rather than preservation. During this period, fiscally conservative state leaders contributed to important advancements in environmental policies and protections, even as the logging and forestry industry enjoyed tremendous growth. Tasked with protecting California's natural resources for future generations, the CDF tended toward caution in its recommendations rather than promoting dramatic revisions of longstanding forestry practices.

Drawing primarily on CDF records and Biswell's personal archives, this paper explores the complex social and political contributors to the underlying controversy over prescribed burns and the battles over prescribed burn research, policies, and implementation in California. Biswell's book and semi-autobiography, *Prescribed Burning in California Wildlands Vegetation Management*, constitutes a particularly important source. Written in 1989, the book offers Biswell's comments on prescribed fire techniques as well as his own reflections on his role in the prescribed burn debate decades earlier. Whereas Biswell's archival records depict his contemporary thoughts, his book represents a more reflective perspective with the benefit of hindsight, as prescribed burn policies had changed by its publication, while also allowing Biswell to present himself as a coherent voice and informed narrator on the subject [11]. Using historical methods of reviewing and evaluating thousands of pages of archival documents, including Biswell's book, this article explores how prescribed burns entered modern wildfire management practice in California, primarily by using Harold Biswell and his efforts as narrative drivers.

Here, I use Biswell's accomplishments and pitfalls to identify lessons relevant for a modern researcher based on Biswell's conflicts with the CDF and his department at UC Berkeley. I present background into wildfire research in the early twentieth century to provide important context before exploring Biswell's career, criticism, and, ultimately, successes; this narrative approach incorporating both contemporary correspondence and broader reflections reveals subtly emerging themes and societal changes over thirty years which helped shape long-term policies. These findings broadly demonstrate the role that scientific advances may play in the crafting and implementation of science policies, particularly when government officials and non-governmental stakeholders recognize the important role of science in science-related policy. As a historic case study describing Biswell's experiences and

approach, these findings may offer strategies for how scientists today can use their applied research to recommend policies, with important implications for wildfire and other environmental policies.

2. Wildfire Research in the Early Twentieth Century

In the early twentieth century, federal forest managers often criticized the concept of prescribed burning (then called “light burning”) for damaging trees and preventing the resource from flourishing [11]. For example, Richard Boerker, a U.S. Forest Service (USFS) forester, described light burning in the *Journal of Forestry* in 1912 as “most undesirable and the most mischievous . . . [It] was not forest protection . . . , it was forest devastation pure and simple” [12] (p. 185). He noted that light burning would lead to “extinction of the forest,” and that preventing timber growth would result in profit losses of USD 50 to 100 (approximately USD 1300 to 2600 today) per acre across two million acres in California [12] (p. 185). In 1920, USFS Chief Forester Henry Graves wrote that “fire has no such values . . . as a remedy for bark beetle attacks, but . . . even if it did, its use would not be justified . . . [Light burning] would mean . . . a disastrous sacrifice of all that we have gained in improved conditions through fifteen years of protection” provided by the USFS [13] (p. 88). Others from the USFS in California, including regional forester Stuart Show and experimental station director Edward Kotok, were similarly vocal in their conclusions that fire threatened timber production; deviation from this perspective was not condoned [14]. The USFS dismissed any rebuttals in favor of light burning and instead instituted a national policy of wildfire suppression both to promote forest health and to sustain a commercial resource [4,11].

Wildfire suppression became orthodoxy in the public discourse during World War II, when the USFS linked its message of fire prevention to the war effort [15]. Propaganda explicitly connected fire prevention with victory and educated the public through government-produced banners, posters, billboards, flyers, and campaign icon Smokey Bear [16–19]. Following World War II, Americans seeking the calm and comfortable promise of suburban life exploded into the wildland–urban interface, or WUI [20]. The growth of the WUI resulted in more people moving into high-risk fire areas such as overgrown forests. Suburban newcomers to the WUI were likely less personally familiar with fuel reduction practices like light burning [21]. More established rural communities recognized their higher risk of wildfires and supported practices like light burning [8]. However, contemporary forestry research often focused on the danger wildfires posed to the environment, rather than to communities or society [22–24].

Forestry experts were siloed into natural science frameworks, enabling the isolation of the “wildfire problem” as a forest management issue, with only occasional recognition of fire’s societal impacts. Forest managers frequently conflated wildfires with light burning in their critiques, arguing that any fire was dangerous, regardless of size, purpose, or intensity. E.A. Colman, at the California Forest and Range Experimental Station (located near Berkeley and since renamed the USFS’ Pacific Southwest Research Station), declared that “fire is a destructive agent . . . measured directly by the value of the property burned, and indirectly by the series of events it starts. Wildland fires destroy or damage timber, forage, and improvements” [22] (p. 4). Colman emphasized fire’s threat to a forest’s utility. His thirty-page report from May 1947 titled “Wildland Fire and Wildland Use in California” lists the detriments associated with fire based on an extensive review of USFS experimental plots: erosion, burned vegetation, unattractive vistas, water quality degradation, and increased flooding. Despite the emphasis on environmental rather than human impacts, Colman concluded that “public agencies in California must consider fire as a menace to public welfare unless or until, in specific instances, it is proved otherwise” [22] (p. 29).

However, Colman may have only been able to review experiments with findings that supported agency policy. The USFS prevented publication of studies that indicated that fire suppression was detrimental, including studies that frequent light burning in forestlands, essentially prescribed burns, removed flammable vegetation and reduced fire risk [25] (p. 19). In suppressing these divergent studies, the USFS, as the lead fire science agency in the country, promulgated the notion that all fire was

dangerous. Though California consists of numerous landowning and land management organizations, each with its own approach to fire management, the USFS' perspective strongly influenced how other federal agencies viewed fire and deeply informed both federal and state forest management policy and practice [5].

3. Prescribed Burn Research into Practice

3.1. Harold Biswell

Born in 1905 in the Ozark foothills of Missouri, Harold Biswell grew up working on his family's farm, which he later cited as his first instructor in land management. Biswell drew on his farming background as an undergraduate majoring in zoology and in his graduate degrees in botany and ecology. After earning his doctorate in plant ecology from the University of Nebraska, Biswell joined the USFS and spent six years as an Assistant Range Examiner on foothill woodland-savanna in two experimental rangeland stations in California before joining the Southeastern Forest and Range Experiment Station in Asheville, North Carolina, in 1940, where he spent seven years overseeing rangeland research [11] (p. 10–13).

Biswell would later claim that when he first moved to Asheville he viewed “fire as the arch enemy of forests”, but changed his mind after observing how low-intensity fire on Georgia's coastal plains actually increased the growth of timber and forage within pine forests [11,26] (p. 293 from [26]). Unlike California, the Southeastern United States enjoyed a long history of state-sanctioned prescribed burns. Generations of private landowners had adopted the traditional burning practices among Indigenous peoples in the region, which, in addition to a humid climate and comparatively lenient liability laws, enabled extensive burning throughout southeastern states. Although the Southeast also made slow progress toward expanding the use of prescribed burns, its favorable climatic conditions and long history of burning on one's own property facilitated more burning than in California during the same time period [2,27]. On a work trip to Georgia, Biswell observed an elderly forester burning on a company's timberlands, patiently moving through the trees and guiding the fire. Biswell later declared that “my observations during this one day were sufficient to convince me that prescribed fires can be used beneficially in forestland management,” contrary to his employer's established policy [11] (p. 13).

In 1947, Biswell accepted an offer to become an Assistant Professor at the University of California at Berkeley in its Department of Forestry and Conservation (then called the School of Forestry and split between forestry and range management, though primarily tasked with supporting the agriculture and timber industries) [28]. Encouraged by Edward Kotok, his early research at Berkeley focused on range management and covered the effects of controlled burns on livestock grazing and wildlife in the foothill woodland savanna in the Sierra Nevada, but Biswell expanded from controlled burns on grasslands into prescribed burns on forestlands within a few years. Based on his observations of prescribed burns in Georgia, Biswell believed that prescribed burns might be able to reduce the severity and frequency of wildfires in California. In 1951, Biswell began conducting research on ponderosa pine forests in northern and central California at Teaford Forest in Madera County and at Hoberg's Resort in Lake County [11].

Although research on prescribed burns in forests was unusual at the time, another Harold—Harold Weaver—informed many of Biswell's early academic pursuits. An area forester for the Bureau of Indian Affairs, Weaver published articles on his experiments with prescribed burns in ponderosa pine forests [29–36]. However, the Bureau of Indian Affairs had adopted the USFS' fire exclusion policy (an illustration of the practice's spread in other federal government agencies and particularly ironic given widespread traditional Native American practices of controlled burning), and forced Weaver to issue statements in his publications noting that the agency did not support his conclusions [36,37]. Weaver's colleagues complimented his courage in pursuing this research, even as his critics derided him [4] (p. 61–63). The two Harolds became close friends and colleagues, and frequently reviewed each other's draft articles [11,38–42].

Weaver and Biswell dominated the academic literature on prescribed burns during the 1950s. Other scholars examined controlled burns on rangelands (as Biswell initially had) but avoided the more controversial study of prescribed fires in forests [4,11]. By contrast, Biswell wrote articles such as “Reduction of wildfire hazard: removal of dead fuel reduced damage by wildfire in treated portion of experimental second growth ponderosa pine range” or “Removal of tinder in ponderosa: Prescribed burning of forest brush during the wet season by tested methods effectively reduces hazard of wildfire” [43,44]. His experimental results confirmed his original suspicions that prescribed burns could reduce fuels, but Biswell remained isolated as a researcher for the topic.

Biswell’s isolation stemmed in part from the opposition of commercial interests on burning on timberlands. Whereas controlled burns were widely accepted among range management professionals, throughout the mid-twentieth century the timber industry condemned his beliefs about the potential of prescribed burns [45]. A 1948 letter from a representative of the California Fruit Growers Exchange declared that “nearly all lumbermen [are] opposed to burning while the stockmen [for cattle] are in favor of it. I have yet to see what is commonly referred to as controlled burning success[,] for when it is safe to burn it is impossible to get good results” [46]. He contrasted controlled burning on rangelands, which was generally supported by CDF officials and ecologists alike, with that in forestlands, where it was opposed by both groups. Similarly, a 1955 review of state forest policies recognized that “the responsible owners of the important timberlands did not recommend the practice [of prescribed burning] themselves” [47] (p. 5). By 1961, an internal CDF memo specifically targeted Biswell, claiming that “the research done to date has been too limited, most commercial timber owners do not accept prescribed burning as being practical or desirable, and the forestry profession (including UC faculty) is not generally in agreement on the value of prescribed burning in timber [There is] a need for the Division to be constantly on guard in respect to the promotion of burning from certain University quarters [e.g. Biswell]. It is essential that we take a firm stand on these matters at every opportunity in order to keep views on burning in balance” [48].

Despite the discouragement of his peers and the forestry industry, Biswell wanted to show them that prescribed burns could be valuable in reducing wildfire risk. As Biswell described in his book, he organized a field day at Hoberg’s Resort in Lake County in April 1952 to demonstrate how a prescribed burn works, with attendance from Fred Baker (Dean of the School of Forestry), other Berkeley faculty, and CDF staff. Few participants at the event voiced comments or provided feedback. Biswell attributed this silence to embarrassment or ignorance in how prescribed burns could support ponderosa pine ecosystems and constituted the day as an overall success [11].

Unfortunately, this perspective proved short-lived. A few days after the demonstration, Dean Baker sent Biswell a letter expressing his dismay at the assistant professor’s research and demonstration activities. He wrote, “You should exercise the greatest of care in plunging into as uncertain a field as that of the use of fire in forest protection You know very well the traditional viewpoint of foresters regarding the use of fire in the woods I feel you should be more conservative in the material which you are presenting It is your own work, and does not necessarily carry the okay of the School of Forestry as a whole. Also, I would like to have you work carefully to make sure your points of view are not given too much publicity and are not considered as proven or okayed by any of the forestry agencies, such as the School, the State, or Forest Service here in California” [49]. Baker warned that Biswell’s training as an ecologist did not make him a qualified “forester,” and instructed Biswell to distance himself from forest policy matters. Baker shared carbon copies of his letter with the state forester, a USFS manager overseeing fire research, and the chairman of the State Board of Forestry (the policy arm of the CDF) [49].

Rather than acquiesce to Baker’s subtle threats, Biswell contacted his own powerful allies. Faculty supporters from the University of California at Davis assembled in Berkeley to ask the dean of the College of Agriculture to promise that he would not sign dismissal papers for the fledgling academic [11] (p. 69). Paul Sharp, director of the Berkeley University Agricultural Experiment Station, scolded Baker for distributing his letter beyond the university because research-related controversies should be

managed internally. Baker offered a weak apology, but justified his actions to Biswell because “I had received so much adverse comment from these men, not as individuals, but as channels through which others sent criticisms to me, that I thought it might be a good thing to show them rather definitely that the viewpoints . . . were your own” [11] (p. 106). He continued, “Don’t let my viewpoints bother you too much. The main thing is that you have not persuaded me personally in the correctness of your viewpoints The situation, I think, is such that it would seem wise to proceed with the greatest of care and with full cooperation with your co-workers who are involved in allied problems” [11] (p. 106). Baker explained his earlier behavior as a combination of professional distancing from and advice to Biswell, though his role as an ex-officio member of the Board of Forestry may have also contributed to his scathing remarks [50]. Baker sought to differentiate his own research and the university from Biswell’s unusual and unpopular opinions, claiming that forest management should be left to the more conservative and knowledgeable forestry professionals and agencies that favored timber growth and harvesting.

3.2. *Communication with the Public*

In his opening line in his 1953 proposal for “A National Research Program for Mass Fire Control,” DeWitt Nelson, then Director of the California Department of Natural Resources, the parent agency of the CDF, described fire as “the greatest single threat to the adequate production of forest products, the protection of watersheds and other reproducible wild-land resources” [51]. Wildfires were dangerous, deadly, and destructive to the environment, economy, and society, but suppression alone was not the solution. Instead, as the Deputy State Forester recommended, “a brand new tool in firefighting is what we really need, one when properly applied would prevent a buildup of the fire storm or blowup which is the great destroyer in major fires” [52]. CDF staff wanted a fire prevention tool to clear out the fuels that contributed to massive fires and called for national research on reducing catastrophic wildfires [51]; though not recognized as a potential solution by name, prescribed burns could—and ultimately would—help fill this niche gap.

Via careful experiments, frequent press coverage, and demonstration burns, Biswell slowly gained converts, who subsequently helped distribute his research. For example, a farm advisor to the Director of Agricultural Extension in Madera County in central California wrote to Biswell in 1958, “I have read and reread the copies of the two speeches you sent me. They are excellent. You need to have some ‘disciples’ to go forth to the four corners of the country and spread the ‘truth.’ It is a story that has to be told and retold before it is too late. Maybe it is too late already in some parts of the hills” [53]. After a successful demonstration burn in 1961, the Assistant State Director of the UC Agricultural Extension Service thanked Biswell for the experience. He wrote, “I do know that some of this research has been written up in various farm and forestry journals; however it occurred to me that possibly it has not been given as wide-spread release as you would like,” before offering a contact for Biswell to distribute his information to a wider scientific audience [54].

Biswell frequently discussed his research with the media and at invited talks with both forestry professionals and the general public, which helped to propel his conclusions into popular science and discussion. He often repeated the same speech for each audience, rarely tailoring it beyond the introductory remarks. He compared the state’s overgrown forests with the park-like environment John Muir had described in his writings, illustrating the detrimental impacts of long-term fire suppression and presenting a narrative that prescribed burns could return California to its original, natural landscape [11,55–59]. Biswell capitalized on the new constituency of preservation-minded activists emerging in this period. Concerns about deteriorating air, water, and land steadily were becoming mainstream political issues [60]. The Sierra Club’s membership increased by a factor of seven between 1960 and 1970, exploding from 16,000 to 114,000 active members [61]. Biswell’s claim that prescribed burns would support ecosystem health spoke to this rising interest in environmental stewardship [60]. He and his graduate students, many of whom continued this work in their later careers, advocated for prescribed burns to anyone who would listen. This audience included local government officials,

reporters, or local residents, some of whom had never before heard of prescribed burns, while others were already frustrated by their limited use.

Though his attempts to appeal to traditional high-level political or policy-making figures proved ineffective, Biswell's practice of sharing his research with any possible source turned readers and listeners into advocates. His use of direct appeals to a public clamoring for environmental protection is analogous to the approach used by muckrakers around the turn of the twentieth century to expose unseen dangers or wretched conditions and then educate the populace. Muckrakers like Upton Sinclair and Jacob Riis inspired public lobbying for new institutions and policies that improved public health and well-being through publications intended for a mass audience [62]. Similarly, Biswell gained supporters and "lobbyists" for prescribed burns through non-academic venues like speeches and interviews for the public. For example, an article in *Parks Management* featured his work in ponderosa pine ecosystems and recommendations for frequent light fire in forests [63]. In the San Francisco Bay Area, the Chief of Parks of the East Bay Regional Park District read the article and implored the director of the Department of Parks and Recreation to invest in research on prescribed burns [64]. The director deputized DeWitt Nelson, who had previously recognized the need for a new tool for fire risk reduction, to respond. Nelson appeared cautiously optimistic that prescribed burning "might be worth trying on a small scale," but he remained skeptical. He wrote, "Dr. Biswell's proposal when applied to the state, as a whole, is highly theoretical. On the other hand, when applied to individual properties of reasonable extent, his theories can be applied within certain economic limitations" [65].

However, communicating the science behind prescribed burns drew criticism from Biswell's colleagues precisely because it attracted public attention. A Berkeley Forestry faculty member, who did agree with Biswell's conclusions, suggested that "for your own protection and to prevent the general public from getting the wrong ideas, I personally hope you will keep the results of your experiments within professional journals and out of the general press for the present" [4] (p. 76). He argued that Biswell's findings should be restricted to "progressive" forest managers familiar with land management rather than confused Californians who might set fire to their property (regardless of the unlikely nature of that outcome) [4] (p. 76). This recommendation, akin to Baker's reprimand, could also represent a strong hint to Biswell that undesirable public attention from the legislature over his controversial findings might prompt future research funding cuts, a viable threat for research sponsored by a more conservative state focused on resources and economics.

Regardless of the feedback from his colleagues, Biswell became confident that his and Weaver's conclusions were fundamental to future forest management. Throughout the 1950s, Biswell continued his regular demonstration events, regularly spoke before Rotary Clubs and other interested parties, and published his findings in reputable journals [4,11]. He became so well-known for his outspoken perspective that the House of Representatives Subcommittee on Interior and Insular Affairs invited him to speak on October 8, 1957, for an investigation into USFS firefighting. In his presentation entitled "Wildfires in Forest and Brush," he emphasized fire as "a natural force" in "forests which burned under natural conditions" such that suppression of fire is "fighting nature" (emphasis in original) [66] (p. 1). Instead, wildfire management could "conform to the laws of nature" [66] (p. 3). The preceding half-century's policy of fire suppression had resulted in enormous fuel accumulation and heightened fire risk. An alternative option, prescribed burns, "although given little attention thus far, offered a solution to the problem" [66] (p. 4). Biswell could demonstrate the value of prescribed burns via his experiments, but the challenge remained in convincing forest managers and government officials that he was right.

3.3. Targeting the Right Audience: Forest Managers

Fortunately for Biswell, he gained a new supporter within his department when Henry J. Vaux replaced Baker as the Dean of the School of Forestry in 1955. Vaux believed that forest practices and policies should be based on scientific findings, with Biswell's prescribed burn research exemplifying this potential [67,68]. In 1960, he identified the major barrier Biswell faced in transitioning from prescribed

burn experiments to statewide policies: the forest managers did not fully accept his conclusions. Biswell, as a range management researcher focused on chaparral and grassland ecosystems [69,70], struggled to find acceptance for his work on prescribed burns in forests among forestry researchers and professionals. Vaux wrote, “Before the results of any research are widely adopted in practice, it is necessary to get ‘acceptance’ of the ideas by the potential users,” namely, the foresters [67]. Vaux believed that making progress toward implementing prescribed burns required convincing lifelong foresters and managers of its benefits, in large part because they had the most to gain or lose from the practice. However, he cautioned against offering broad generalizations on the benefits of prescribed burns in forested ecosystems, as these would ignore generations of research and practice. Instead, he recommended that Biswell partner with individuals interested in hazard reduction in order to test theories of prescribed burns and their viability together [67].

Vaux’s suggestions stemmed from prior interactions with respected ecologists and the forest management community, which differentiated between acceptable burning in rangelands and controversial burning in forests. For example, the conservative California Forest Practice Committee of the Western Pine Association contacted Vaux to express dismay over the growing popularity of Biswell’s conclusions among local stakeholders, because “the theoretical benefits are far outweighed by the practical and proved disadvantages in cost, damage, and risk Public enthusiasm for use of fire in land management can be very costly to timber production, not only from well-meaning application but from incendiaryism” [71]. Biswell wanted to spread the message that certain types of fire were beneficial, while others were dangerous, but only in specific areas under precise conditions. These caveats proved confusing for the public, and thus alarming for forest managers and interested parties, like Keep California Green, Inc., a group dedicated to preventing wildland fires, whose directors primarily represented lumber and ranching companies [72,73]. Keep California Green was concerned when the media misconstrued Biswell’s research to mean that wildfires should burn unmitigated. However, when Biswell shared his actual recommendation—burn low-intensity and safe fires in wet seasons under wet conditions—Keep California Green’s leadership acknowledged that implementing his suggestion might even benefit their own timber and forestry interests [72,73]. Biswell recognized the challenges of science communication, particularly when he was not personally communicating, so he invited Keep California Green leadership to a demonstration burn. As Biswell wrote to the leadership, “the research is too important to quarrel about! My thought is that misunderstanding leads to controversy and can only retard progress, while knowledge and understanding can greatly accelerate it” [74].

Yet even as Biswell gained supporters from the general public and some forest managers, the CDF remained a major barrier. According to the Assistant Deputy State Forester in 1962, it was a “fact that sound research information . . . to conduct burning safely, to predict results accurately, and to assess its economic values correctly, simply does not exist” [4] (p. 108). The Deputy State Forester voiced similar distaste in a letter to *California Monthly* in 1961: prescribed burning was not “accepted by practicing professional foresters or more important, by timberland owners and managers who have the largest stakes in the matter In my opinion there has emanated too much publicity from Dr. Biswell on this subject which is based on inadequate research and practice” [4] (p. 106–107). Representatives from both forestry groups and professionals expressed concern that Biswell’s proposals would upset their efforts to increase timber and expand resource development and use.

Despite continued misgivings from CDF leadership, rural and WUI communities familiar with prescribed burning demanded greater freedom to burn, without stringent state oversight. A 1962 editorial in the northern California paper *The Lake County Record-Bee* offered a scathing critique of the state for its unenthusiastic regard for prescribed burns. The editorial opened, “While we’re still attempting to wheeze out some of the smoke we’ve eaten for breakfast, lunch and dinner the past several days as a result of the nostril-twanging Widow Creek Fire on Cobb, now would be a most momentous time to replant an oft sought thought—that of control burning—with the State Division of Forestry [M]ost of the brush and timber fires like last week’s would cause little, if any, damage if

Sacramento-squatted policy-makers would allow the many more-than-willing property owners to get rid of the mounting, hazardous fuel through burning during non-fire season periods" [8]. The CDF's restrictive permitting process prevented locals from obtaining a burn permit, which left residents feeling powerless: "IF THE STATE, as we've been told, indeed has plans for increased controlled burn activities, we say get with it! You're years late already While the fire burned, local residents could be heard muttering, 'If they'd have let us control burn . . . ' " [8]. The older, more conservative professional and state foresters remained unconvinced of the potential role for prescribed burns, even as more dynamic foresters, ecologists, and WUI residents implored the state to make policy changes to enable more burning on private lands.

Local governments in new WUI areas also forced the CDF to account for its inaction in the mid-1960s. Suburbanites and exurbanites represented new and emerging constituencies with rising political clout. Rachel Carson's *Silent Spring* became a bestseller after its publication in 1962, with its evocative first chapter of an imaginary small town reminiscent of many suburbs encountering the nightmarish impacts of pesticides [75]. Concerns that environmental degradation in their own backyards was, in turn, harming their own health inspired suburban residents to demand greater environmental protection and oversight [20]. Growing suburban WUI counties independently requested hearings and testimony on the subject of wildfire prevention from Sacramento officials, especially after personally experiencing a wildfire. Between 1960 and 1965, Santa Barbara County in Southern California more than doubled its population. WUI development and expansion there prompted new conversations on fire risk, particularly after the Coyote Fire of 1964 [76,77]. In response to local concerns, the County Board of Supervisors hosted a meeting of the Committee to Study Controlled Burning in 1965 and invited State Forester F.H. Raymond, local fire chiefs, USFS employees, and local stakeholders to attend [78].

In the Committee meeting, Raymond acknowledged that fire could play in a role in ecosystem management but was not a panacea. He claimed that "there appear to be adequate laws to meet the [fuel] problem. If this is not so then stronger and better laws should be enacted" [79]. While Raymond recognized that individuals planning to conduct a burn faced requirements (such as permits or good weather conditions), he dismissed these as insignificant because "there are no general laws to my knowledge which prohibit the use of fire by landowners for land management and fire protection purposes" [79]. Raymond left Santa Barbara before Biswell's speech on the last day of the hearings. Projecting slide images of prescribed burns in ponderosa pine forests, Biswell explained that these forests enjoyed suitable burning conditions between 47 and 74 days per year. He also boasted that prescribed burns from one of his experiments had enabled greater control over a wildfire that occurred in the region a few years later. Raymond's representative at the meeting, the Deputy State Forester, reported his review of Biswell's presentation back to Raymond. He disparaged the research and implied that Biswell claimed responsibility for reducing the severity and spread of wildfires through his burning experiments "by innuendo," rather than fact [80]. The Committee concluded its session with a request for a new hazard reduction program focused on forestlands to protect its population and region, even as the CDF leadership remained unconvinced of Biswell's claims [81]. Despite these continued setbacks from the state government, Biswell's research on and advocacy on behalf of prescribed burns helped to create the opportunity for them to become a land and wildfire management tool in California, although they first received this approval from the federal government.

4. State and Federal Prescribed Burn Policies

Broad national trends in favor of environmental protection contributed to federal and state policy changes in favor of prescribed burns. The environmental movement, most closely associated with the 1970s, had its roots in the prior decade, which saw an evolving appreciation for the fragility and interconnectedness of the biosphere [82]. Concerns about the environment's degradation precipitated increased respect and funding for ecological research. In the late 1950s and early 1960s, "systems biology" emerged as a subfield that examines ecosystems in their entirety, rather than as many

individual parts. Systems biologists calculated the influences of both abiotic and biotic (including human) factors in ecosystems through mathematical models. By the late 1970s, systems biology advocates had convinced the federal government and the public that advances in systems biology could allow better applications of ecological findings to society. The holistic approach to ecological systems endorsed by systems biologists promised to restore balance to an environment in crisis [83].

Systems biology provided ecology-backed credence to using prescribed burns. A committee commissioned by the Secretary of the Interior Stewart Udall to examine wildlife management in the National Parks submitted its final report in 1963 and concluded that wildfire exclusion, in effect for decades before and since the National Park Service's founding in 1916, had deleterious effects on plant and animal diversity. As a result, the ecosystem as a whole was suffering. The committee offered prescribed burns as an effective and less expensive means to improve biodiversity and bring renewed splendor to the National Parks. In the mid-1960s, Biswell and other ecologists, experimenting near Kings Canyon National Park in the Sierra Nevada Mountains, concluded that the giant sequoia could not germinate without fire, a devastating realization for the future of the California state tree amidst a burgeoning national environmental movement [11] (p. 108–111). In 1968, Sequoia-Kings Canyon subsequently became the first National Park with institutional prescribed burns, with the agency's official fire policy changed to read: "The presence or absence of natural fire within a given habitat is recognized as one of the ecological factors contributing to the perpetuation of plants and animals native to that habitat Prescribed burning to achieve approved vegetation and/or wildlife management objectives may be employed as a substitute for natural fires" [11] (p. 108–110). By 1970, Yosemite, Kings Canyon, and Sequoia National Parks all had established prescribed burning programs [11] (p. 110). Over the next decade, several other National Parks, primarily in the American West, began using prescribed burns, although the vast majority of these occurred in either California or Florida [84].

Introducing prescribed fire onto state lands prompted serious debate due to concerns that anthropogenic burning would destroy the "ethic of preservation upon which our State Park System was founded" [4] (p. 159). Montaña de Oro, located along the central Californian coast, became a State Park in 1965 and featured native grasslands that had coexisted with fire for thousands of years. Without fire, "natural" or prescribed, the grassland ecosystem would disappear; good management required fire. The Department of Parks and Recreation approved a controlled burn there in June 1973 [4] (p. 160–161). Two years later, the government reintroduced fire onto forested state parks with Calaveras Big Trees State Park in the Sierra Nevada. Unfortunately, in the absence of fire at Calaveras, vegetation had accumulated to such a degree that burning safely became a fresh challenge. In a sign of the CDF's internal transformation over the role of prescribed burns, Biswell served as a special consultant for the Division between 1975 and 1982 and organized field seminars to teach appropriate burn practices and establish training standards [4,11]. Burning on a California state park required at least twelve days of classroom and laboratory training in basic fire ecology and an additional sixty days of supervised field experience, more than for any other state or federal agency in the country, and a mark of Biswell's enduring legacy [11]. On both state and federal lands, interest in preserving—rather than managing or exploiting—natural resources guided initial policies toward implementing prescribed burns in California, a further sign of the rise of environmentalism. Although Biswell did not personally oversee these changes, his professional advocacy over several decades helped change perceptions and policies surrounding prescribed burns at the state and federal levels.

By the early 1970s, USFS employees began to admit that suppressing fires had incidentally increased their severity, with prescribed burning acknowledged as viable, if not fully embraced, by the USFS in California by 1974. Rather than pursue its traditional strategy of "fire control," the USFS transitioned to a policy of "fire management," recognizing its own culpability in exacerbating the fire threat by forcing fire suppression. In 1978, fire as a management tool became an official policy throughout all National Forests [4] (p. 175–181). Only when leadership finally acknowledged that the absence of fire actually reduced overall forest stock and health did prescribed burns gain traction and acceptance agency wide.

In addition, prescribed burns gained a new stronghold in California in 1980, when Governor Jerry Brown signed Senate Bill 1704, “Prescribed Burning: Brush Covered Lands” and established the Vegetation Management Program (VMP). The VMP enabled the CDF to partner with private landowners who wanted to conduct burns on their property. Although originally established for rangelands rather than forests, it has since evolved to support landowners using fire for ecological or management purposes across the state [11] (p. 114–115). Today, the VMP and the newly established Vegetation Treatment Program (CalVTP) in California promise to treat fuels using ecologically appropriate methods, including prescribed burns, across hundreds of thousands of the state’s most overgrown acres [85].

5. Discussion and Conclusions

More than half a century after Biswell became a professor, prescribed burns are recognized as a critical tool for fuel management, alongside mechanical thinning and managed wildfire, to reduce the severity of wildfires. Modern ecological studies in California examining fire frequently cite its numerous benefits, whether revitalization of wildlife habitat or increased growing space for vegetation. Much of this research concludes with pleas for more fire to restore natural ecosystem balances [86–90]. Unfortunately, many of the challenges that plagued their use throughout the second half of the twentieth century—including financial barriers, limited training, and fears that burns would escape—continue to slow the deployment of prescribed burns in California [7]. By contrast, other states like Florida have longstanding legislation that protects landowners and encourages more prescribed burning, particularly for private sector interests such as ranching, gaming, and sugarcane production [91]. More than 2.1 million acres across Florida were prescribed burned in 2017, compared to under 50,000 acres in California, a state over 2.6 times larger than the Sunshine State [92]. Successful fuel management policies should consider local geographies and climates, as California’s drier heat inherently makes prescribed burns more challenging than in Florida’s humidity. Recent sessions within the California State Legislature have focused on expanding fuel treatments, and particularly prescribed burns [7]. As such policies continue to evolve in California, it is important to balance scientific findings with management opportunities, with possible roles for current wildfire scientists and researchers to influence policies.

The transition in prescribed burn policies in California at the federal and state level from abject rejection to grudging acceptance and now broad approval (although not broad deployment) occurred painstakingly and across research, policy, and practice. This historical case study presents an example of how researchers can present their experimental findings and conclusions and ultimately contribute to policy changes. However, scientists engaging in policy-relevant conversations and advocacy have a moral obligation to present facts rather than spread false or biased information, particularly given the trend toward misinformation and fake scientific news [93–96]. Biswell’s experiences offer important lessons for modern research scientists who seek to influence environmental policies. Specifically, his strategies of (1) extensive public science communication, (2) targeted communications to and engagement with influential stakeholders, (3) continued perseverance despite pushback from within and outside of his institution, and (4) active description of his own role contributed to his professional successes and positioning as a hero for the movement.

First, Biswell altered the prescribed burn policy landscape through his role as a science communicator, translating his experimental research for lay and professional audiences alike. A disconnect often exists between basic or applied research and its practical applications. Biswell did not personally spur the federal and state prescribed burn policy changes. Instead, he used his authority and platform as a research scientist to promote his findings and their policy-relevant implications via public speeches, academic journals, and conversations with key stakeholders, who subsequently enacted policy changes.

Biswell’s approach to sharing his findings consisted of frequent public talks and regular demonstration days at Whitaker’s Forest near Kings Canyon National Park. His research contributed

to the fire-positive narrative in place today, an example of how science and policy can and should be flexible enough to improve and be revised based on new findings over time. Biswell and others like Harold Weaver demonstrated courage in advancing their research to an often unfriendly audience. They also illustrate the importance of strong science communication skills, the absence of which is frequently lamented among academic researchers [97–100]. Using scientific findings in his journal articles, prepared speeches, and live demonstrations of prescribed burns, Biswell slowly converted skeptics to his point of view. This approach parallels that of modern scientists who use their research and its implications to promote environmental action in media beyond journal articles among the public and policymakers [101,102].

Second, for scientists to present their research as policy relevant, it is critical to focus on and engage with the most important audience [103,104]. Harold Biswell and his likeminded colleagues often tried appealing to ecologists through academic journal articles rather than directly convincing the public or the foresters with ecosystem management responsibilities. Policies change when policymakers and implementers become convinced of the need for modification based on support from either elite groups (such as lobbyists or professionals in that field) or the general public. Gaining public support and establishing positive relationships with organizations like Keep California Green or with managers like the Chief of Parks for the East Bay Regional Park District proved beneficial for Biswell's prescribed burns advocacy. After Dean Vaux encouraged Biswell to share his work and findings with more forestry-minded professionals, Biswell received more positive feedback from them, which helped overturn their conservative, utility-focused mindsets to recognize that good forest management required fire. This progress was not solely the result of Biswell's efforts to champion prescribed burns. Instead, it occurred alongside a broader backdrop of a growing environmental movement supported by fears of public health impacts and advances in ecology during the 1960s and 1970s.

While this paper primarily focuses on Biswell, he did not work alone. Many other research scientists and prescribed burn advocates played a role in the adoption of prescribed burns as a fuel treatment option throughout California. Harold Weaver, Bruce Kilgore, Emanuel Fritz, Ed and Roy Komarek, the leadership and organizers for the Tall Timbers Fire Ecology Conferences, and dozens more contributed to this outcome [4]. Many of Biswell's graduate students and advisees—including Jan van Wagtendonk, Jim Agee, Bruce Kilgore, and David Graber—subsequently pursued extensive and active careers in wildfire and prescribed burn ecology that further contributed to scientific understanding of the role and importance of fire in ecosystems, with subsequent impacts on policy [105,106]. Policy change does not occur within a vacuum but results from the collective work of many passionate people working toward a shared goal both within and outside of institutions and agencies with the power to enact policy change [101,107]. Ultimately, Biswell did not personally compel or convince the state government to enact prescribed burn policies, which occurred in response to federal changes in the wake of environmental degradation, but his work as an outspoken advocate contributed to that outcome. However, centering this narrative around Biswell offers guidance for how other individual scientists working on controversial or policy-relevant research can bring their findings to bear on local, state, or federal policy. Scientists today can similarly work with stakeholder organizations and take advantage of current wildfire or environmental movements to use their platform and expertise for advocacy [108,109].

Third, scientific progress often entails steady, slow steps, which require long-term dedication before they may subsequently impact science policy, just as the development of systems biology influenced interest in a holistic approach to environmental stewardship and policy [110,111]. Advancements in science may be driven by those in policy, and vice versa, based on funding allocations, exciting and new discoveries, and external crises, among other influencing factors. The interface between science and policy encompasses both scientific and policy actors, whose stakeholders or actions are rarely fully comprehensible to the other. The complexities and caveats that abound in scientific research parallel those within policy and politics, further complicating efforts to combine the two [112].

During the first half of the twentieth century, scientific literature tended to classify fire as dangerous and destructive, and ecologists had few reasons to cast aside these preconceived and repeatedly-proven conclusions based on the results of a few experiments conducted by a lowly assistant professor and some of his colleagues. The CDF was composed of trained foresters, sworn to protect California's natural resources and public lands. From their perspectives, they were managing the forests, just as today we know that they were increasing wildfire risk by preventing any fires, large or small, from burning [4]. As Biswell's research became more widely accepted by foresters and local governments and stakeholders, so too did it gain tolerance among state forestry leadership and elected officials, but not before he received significant pushback and scorn both from within UC Berkeley and from CDF officials. Determination in the face of opposition proved critical for Biswell's success. Researchers drawing potentially controversial conclusions with environmental or wildfire policy implications may find themselves in an analogous position to Biswell; in both cases, extraordinary persistence is required, making strong communication skills and partnerships all the more beneficial [102,104,113].

Finally, Biswell actively pursued public engagement which presented his side of the prescribed burn argument. His book commentary indicates his awareness of the martyr-like nature of his efforts. Recent examinations of Biswell and his legacy frequently admire or quote his self-reflections from his book [105,114]. After describing the incident with Dean Baker in his book, Biswell acknowledged on his own courage in continuing to pursue this research, noting that the controversy involved would have driven away most researchers. Instead, he wrote, "I have always reasoned that if there is controversy about something, it indicates a need for investigation and research. All through the fifties, I was the only person in California doing research on prescribed burning in the understory of trees" [11] (p. 107). Such comments illustrate Biswell's active awareness of his role as a champion of prescribed burns and his ability to manifest the public's opinion of himself as this champion through his speeches and written work. Biswell's last graduate student, Jim Agee, described Biswell as "kind of a hero" by the time Agee graduated in 1973 [115]. Nearly two decades before Biswell wrote his book, he had already become a tremendous figure in the prescribed burn movement through his dynamic approach to gaining supporters. Environmental scientists can actively promote their positions and opinions, relying on research to defend their claims, and become a symbol [116,117]. While this approach can be highly successful, as for Biswell, it also risks ridicule, abuse, or slander, particularly given the ubiquity of mass media and social media [118,119].

Biswell appeared cognizant of his own important role in prescribed burn policy and presented himself as the solitary, and ultimately correct, researcher that he was. As he recounts in his book, the director of USFS research wrote in a 1956 private letter that he had "little sympathy with Harold Biswell so far because he has made so little effort to be responsible and constructive. Biswell, I feel, is very headstrong and very much an extremist" [11] (p. 107). When reflecting back decades later over how he had maintained the drive to research and defend a practice so reviled by his colleagues, Biswell offered a simple answer guided by his scientific training and curiosity: "The concept of studying nature and working in harmony with it, not against it, made for interesting work; each year I could see a growing interest in prescribed burning; opposition made it challenging; and many sensible people strongly supported the research and showed it by coming to the field days" [11] (p. 107–108).

Intellectual curiosity in an unusual fuel treatment option may have guided his work, but this unassuming response belies his decades of labor, dozens of demonstration days, and hours of sworn testimony. Biswell organized field days at Whitaker's Forest each August between 1965 and 1973, when he retired from the university. Attendance increased each year such that 175 people attended the final demonstration. In 1980, during a field day at the Calaveras Big Trees State Park, a representative from the CDF noted that "in the fifties we were all making fun of Harold and fighting him. Now, 30 years later, we are all working for him. This represents quite a change in philosophy and action" [11] (p. 108). Among prescribed burners in California, Biswell is revered a hero, an interpretation that also comes from the benefit of hindsight [106,115,120]. By the end of his career, Biswell finally proved to state and federal government that his conclusions were worthwhile, practical, and, most importantly,

correct. Researchers today can learn from his mistakes and successes in transforming their own research with policy implications to actual policy: communicate well, speak to the right audience, form alliances, persevere, and take an active role in advocacy and the narrative.

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