

# Professional Entomology

and the 44 Noisy Years since

## *Silent Spring*

### Part 2: Response to *Silent Spring*

Christian H. Krupke, Renée Priya Prasad,  
and Carol M. Anelli

Davis (1964) astutely observed that *Silent Spring* (Carson 1962) embodies an impassioned attack and thus “tends to elicit enthusiastic support or else outright condemnation.” The book’s opening chapter, “A Fable for Tomorrow,” comprises a mere 11 paragraphs spanning two pages, but Carson’s biographer contends that it “elicited more controversy than almost any other part of the book” (Lear 1997a). The chapter relates an allegory of an imaginary town whose idyllic natural beauty is transformed into a devastatingly lifeless, silent landscape because of environmental pesticide pollution.

Carson devised the fable to entice the general public, whom she felt would be put off by the scientific content that became Chapter 2 (Lear 1997a). Although Carson’s approach earned the acclaim of most literary critics, many scientists were appalled by her use of allegory, a device without place in scientific writing (Lear 1997a). Thus Darby (1962) denounced Carson’s “dramatic” fable chapter and impugned her credentials, advising responsible scientists to read the book to “understand the ignorance of those writing on the subject and the educational task which lies ahead.” Similarly, Stare (1963) called her book an “emotional picture” and criticized her for writing “with passion and with beauty, but with very little scientific detachment.” He saw “no evidence in *Silent Spring* which justifies calling Miss Carson a scientist.”

In sharp contrast, the ecologist F. R. Fosberg posed the query, “If *Silent Spring* is not a scientific book, then one may fairly ask of what interest it is

to ecologists and why it is being reviewed in *Ecology*.” He continued,

When it can be pointed out that economic entomologists, whose proper concern is with insects that affect crops, medical entomologists, whose proper concern is with insects that affect man, and agricultural scientists, whose proper concern is with anything that affects agricultural production, have been making decisions about the treatment with poisonous chemicals of millions of acres of the land on which man depends, it may be properly asked, where were the ecologists, whose proper concern is with the environment in which we live? Ought they not to have a voice in these decisions? (Fosberg 1963)

#### **Agrochemical Industry, NACA, NPCA**

The serialization and publication of *Silent Spring* provoked wholesale furor among agrochemical companies, who responded swiftly (Fig. 1) and sometimes with *ad hominem* attacks. Velsicol, sole producer of chlordane and heptachlor, threatened the *New Yorker* with a lawsuit and intimated to Houghton Mifflin that Carson might be part of a Cold War conspiracy that sought to “reduce the use of agricultural chemicals in the [United States and western Europe] so that our supply of food will be reduced to East-curtain parity” (Graham 1970, Lear 1997a, Walker 1999). Velsicol also advised the National Audubon Society to reconsider publishing excerpts of the book, as “everyone had wives and children to feed, and it would be a shame...to jeopardize their financial security for a muckraking article containing unwarranted assertions about

Velsicol pesticides” (Lear 1997a).

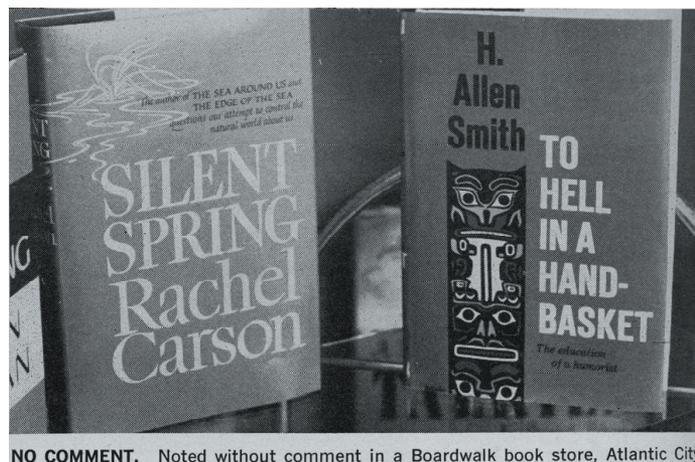
In October 1962, Monsanto distributed 5,000 copies of “The Desolate Year” (see Fig. 1), which parodied Carson’s fable by portraying a future world devastated by famine and disease due to the banning of chemical pesticides (Graham 1970, Lear 1997a). An editorial parody in the *American Agriculturist* followed suit (Brooks 1972). Robert White-Stevens, an executive with American Cyanamid, painted a catastrophic tableau in a nationally televised CBS interview that included Carson and high-ranking officials from industry and the U.S. federal government. White-Stevens asserted that, “If man were to faithfully follow the teachings of Miss Carson, we would return to the Dark Ages; and the insects and diseases and vermin would once again inherit the earth” (Lear 1997a, p. 449).

White-Stevens became the agrochemical industry’s chief spokesman, denouncing *Silent Spring* in numerous speeches and calling Carson “a fanatic defender of the cult of the balance of nature” (Lear 1997a). The president of Montrose Chemical Corporation, largest producer of DDT, made the same pronouncement (Lee 1962). A photograph that appeared in the American Chemical Society’s weekly, *Chemical and Engineering News*, evidences the chemical industry’s disdain for Carson’s book (Fig. 2).

The agrochemical companies joined forces under the National Agricultural Chemical Association (NACA) and employed a public relations firm to attack *Silent Spring*. NACA spent more than \$250,000 in the effort, which included issuing warnings to newspaper and magazine editors that favorable reviews of the book could prove detrimental to future advertisements (Lear 1997a).



**Fig. 1.** This montage appeared in *Chemical Week* the month following the publication of *Silent Spring*. The caption and opening byline read: “Bracing for Broadside. Manufacturers of pesticides this week are bracing for the full impact of public opinion following publication of Rachel Carson’s controversial ‘*Silent Spring*,’ a deftly written, 368-page polemic against large-scale use of chemical pest killers.” (Courtesy *Chemical Week*; publication date 6 Oct. 1962)



**Fig. 2.** When *Silent Spring* first appeared in bookstores, the national meeting of the American Chemical Society was underway in Atlantic City, NJ, where this photograph was taken. The image, together with the “No Comment” statement, was published in *Chemical and Engineering News*, 24 Sept. 1962. (Courtesy American Chemical Society)

NACA also supported distribution of a brochure of the *County Agent and VoAg Teacher*, titled “How to Answer Rachel Carson.” The brochure stated that “while residues of DDT *do* build up in stored fat in humans, they aren’t permanent, and with no additional intake, they will disappear in 90 days” (Lear 1997a, p. 432). The National Pest Control Association (NPCA) also generated a packet of anti-Carson propaganda (Lear 1997a).

NACA put a positive spin on the antipesticide publicity, predicting that gains in pesticide sales were “promising,” given that only 15% of U.S.-planted acreage received pesticide applications, and 95% or more of forests and permanent grasslands were as yet untreated (Anon. 1962).

### Strange Bedfellows

The view of *Silent Spring* as a seditious tract was hardly extreme 40 years ago and made for some bizarre professional partnerships. For example, the most scathing reviews, written by two highly influential human nutritionists (Darby 1962, Stare 1963), were reprinted and distributed by the Manufacturing Chemists’ Association (MCA) in collaboration with the American Nutrition Foundation (Brooks 1972). The foundation, which received support from 54 chemical and industrial food companies, dispensed a “Fact Kit” on *Silent Spring* to “thousands of public officials, university departments, doctors and citizens” (Walker 1999). The kit included a letter from the foundation’s president that stated,

...publicists and [Carson’s] adherents among the food faddists, health quacks and special interest groups are promoting her book as if it were scientifically irreproachable and written by a scientist. (Walker 1999, p. 324)

The anti-Carson position was reinforced by unlikely ties between other professional groups

White-Stevens asserted that, “If man were to faithfully follow the teachings of Miss Carson, we would return to the Dark Ages; and the insects and diseases and vermin would once again inherit the earth”

Elger (1966) argued vehemently that Carson had been assailed unfairly on nonscientific grounds. He cited the critics' muted response to Rudd (1964), who had drawn the same conclusions as Carson in his *Pesticides and the Living Landscape*

who saw pesticides as vital for human health and the food supply. Thus, the American Medical Association referred its constituents to NACA for an information kit on the effects of pesticides on humans (Brooks 1972). Of this, Carson stated, "I am sure physicians have a need for information on this subject. But I would like to see them referred to authoritative scientific or medical literature—not to a trade organization whose business it is to promote the sale of pesticides" (Carson 1998).

The USDA-ARS also opposed Carson, who had roundly condemned the agency's massive pest eradication programs, particularly its fire ant effort, as in this passage:

It is an outstanding example of an ill-conceived, badly executed, and thoroughly detrimental experiment...so expensive in dollars, in destruction of animal life, and in loss of public confidence in the Agriculture Department that it is incomprehensible that any funds should still be devoted to it. (Carson 1962, p. 162)

At first, ARS spokesman E. G. Moore glibly dismissed *Silent Spring*:

The balance of nature is a wonderful thing for people who sit back and write books or want to go out to Walden Pond and live as Thoreau did. But I don't know a housewife today who will buy the type of wormy apples we had before pesticides. (Lear 1997a, p. 413)

One month later, ARS issued a more tempered response, stating that it shared Carson's concerns for "real and potential dangers of misusing chemical pesticides" (Lear 1997a, p. 413). Despite this outward show of alignment, the agency covertly supplied anti-Carson information to NACA, the NPCA, state extension groups, and others (Lear 1992). As head of Agricultural Research Service-Entomological Research Division, Knippling circulated an 8-page memo for internal use that vigorously defended insecticides, although his research division was then exploring avenues of nonchemical control (Perkins 1982).

### Wildlife Biologists, Ecologists

Carson received widespread support among biologists studying fish, birds, and mammals, evidenced throughout *Silent Spring* as cited publications and personal communications to her. Ecologists also were generally favorable toward *Silent Spring*, but not without criticism. Cole (1962) called *Silent Spring* "a highly partisan selection of examples and interpretations" but argued that the "extreme opposite" had been impressed upon the public, whose awareness to pesticide dangers needed to be heightened. He also opined that her errors were infrequent and trivial, and that pesticides represented a mixed blessing.

Davis (1964) provided a thoughtful review, stating that Carson had omitted the "remarkable successes" in agriculture, forestry, and public health attributable to chemical pest control efforts, a criticism echoed by Baldwin (1962). Davis also checked 23 of Carson's "more striking examples

and figures" for errors and concluded, "The facts quoted are essentially correct even if there has been a very considerable selection of facts and interpretation of them has sometimes been rather elastic" (Davis 1964).

Elger (1966) argued vehemently that Carson had been assailed unfairly on nonscientific grounds. He cited the critics' muted response to Rudd (1964), who had drawn the same conclusions as Carson in his *Pesticides and the Living Landscape*, written for a scientific audience: "It is interesting—and damning—that the opposition, unable to attack Rudd on grounds of his professional status, his style of writing and the public for which he aimed, have largely chosen to ignore him" (Elger 1966, p. 1077). (In fact, Rudd experienced formidable difficulties publishing his book because of its then controversial content [Graham 1970].)

### Popular Press

*Silent Spring* received unfavorable reviews from much of the popular press (e.g., *Time* and *Newsweek* magazines, *The Economist*, *The Reader's Digest*, *Sports Illustrated*, and numerous U.S. newspapers) (Lear 1997a). The media criticized Carson for presenting an exaggerated, one-sided, emotional, and alarmist view of pesticides. Many reviews reflected gender biases (Graham 1970, Lear 1997a, Smith 2001), an unfair if not unsurprising occurrence, given the tenor of the times and the scant number of women in science in 1962.

### ENTOMOLOGISTS AND SILENT SPRING Carson Critical of Entomologists

Carson consistently berated and demeaned entomologists in *Silent Spring*, particularly those engaged in applied work. These excerpts are typical:

The entomologist...is not so qualified by training and is not psychologically disposed to look for undesirable side effects of his control programs. (Carson 1962, p. 86)

It is the public that is being asked to assume the risks that the insect controllers calculate. (Carson 1962, p. 13)

F. H. Jacob in England has declared that "the activities of so-called economic entomologists would make it appear that they operate in the belief that salvation lies at the end of a spray nozzle...that when they have created problems of resurgence or resistance or mammalian toxicity, the chemist will be ready with another pill." (Carson 1962, p. 259)

Carson's criticisms were founded on three main premises: entomologists focus on chemical control of insect pests and consequently ignore biological control. Entomological research is suspect because it is heavily funded by chemical companies. Economic entomologists are not bona fide biologists because they do not consider the harmful side effects of pesticides on nontarget organisms. We consider each of these in turn.

To Carson, economic entomologists empha-

sized chemical controls at the expense of biotic or “natural” controls. She argued that for every insect pest being treated with large quantities of insecticides, a number of nonchemical controls were or could become available. Today many entomologists would question the feasibility of some of her proposed control methods, particularly when pest populations reach outbreak levels. Her biographer asserts that Carson underestimated the formidable cost and time required to develop biocontrol measures and failed to appreciate that farmers could ill afford the risk of abandoning cheap and effective pesticides to experiment with nonchemical strategies (Lear 1997b). Nevertheless, the extensive list of control alternatives in the final chapter of *Silent Spring* informed the public of nonchemical options, of which they likely had little or no knowledge.

According to Carson, biological control was under-exploited, in part because of inadequate research funds and near-exclusionary reliance on chemical control:

It was reported in 1960 that only 2 per cent [*sic*] of all the economic entomologists in the country were then working in the field of biological controls. A substantial number of the remaining 98 per cent were engaged in research on chemical insecticides. (Carson 1962, p. 258)

This led logically to her second criticism, whereby she impugned the integrity and objectivity of entomological research:

...certain outstanding entomologists are among the leading advocates of chemical control. Inquiry into the background of some of these men reveals that their entire research program is supported by the chemical industry. Their professional prestige, sometimes their very jobs depend on the perpetuation of chemical methods. Can we expect them to bite the hand that literally feeds them? But knowing their bias, how much credence can we give to their protests that insecticides are harmless?” (Carson 1962, p. 258–259)

The link between entomologists and the agrochemical industry is underscored elsewhere in the book and was reiterated in some of Carson’s public addresses after the publication of *Silent Spring*. For example, in her address to the Woman’s National Press Club in December 1962, Carson asked, “When the scientific organization speaks, whose voice do we hear—that of science? or of the sustaining industry?” (Carson 1998, p. 209). To illustrate her point, she cited four examples of then-recent studies published in the *Journal of Economic Entomology* that acknowledged chemical industry support for the research. (It should be noted that Carson, who died in April 1964, did not publish evidence showing that funding source influenced the results reported by scientists working with pesticides.)

Carson’s third criticism held that economic entomologists were not bona fide biologists be-

cause they did not study insects as an integral part of the environment and were unmindful of the ecological consequences and public risks that insecticides pose:

The plain truth is that this critically important subject of the ecology of the soil has been largely neglected even by scientists and almost completely ignored by control men. (Carson 1962, p. 56)

...nothing must get in the way of the man with the spray gun. The incidental victims of his crusade against insects count as nothing; if robins, pheasants, raccoons, cats, or even livestock happen to inhabit the same bit of earth as the target insects and to be hit by the rain of insect-killing poisons no one must protest. (Carson 1962, pp. 85–86)

Carson acknowledged the efforts of a few “basic” entomologists, albeit in a tone that seems almost reluctant:

Amid the general acclaim for chemicals as the principal method of insect control, minority reports have occasionally been filed by those few entomologists who have not lost sight of the fact that they are neither chemists nor engineers, but biologists. (Carson 1962, p. 259)

#### Damage Control: Entomologists Respond to Carson

Given Carson’s indictment of the entomological community, it is perhaps surprising that entomologists were not more vocal in their criticism of *Silent Spring* and Carson herself. An exception was G. C. Decker (1964), who, as discussed in Part 1, came to extol the benefits of pesticides to the exclusion of their deleterious effects. Decker wrote, “In her reckless misinterpretation of scientific facts, Miss Carson has done irreparable harm to the orderly processes of protecting human life from hazards far worse than the ogres she conjures up” (Lear 1997a, p. 573, fn 9). Cynthia Westcott, who was prominently active in the Entomological Society of America at the time (Lear 1997a), wrote about protecting plants from insects for home gardening magazines and penned several articles for popular magazines that disputed *Silent Spring* (Westcott 1963, 1965).

The efforts of Decker and Westcott in this regard have been reviewed extensively (Graham 1970, Lear 1997a). Here we focus on the official response of ESA, the professional body representing U.S. entomologists.

In his historical review of ESA, Smith (1989) states, “The issues raised [by *Silent Spring*], while widely discussed informally, did not occupy a prominent place on the ESA agenda, and the book was not reviewed in ESA publications.” Indeed, perusal of the *Bulletin of the Entomological Society of America* from 1962 through 1965 indicates that neither Rachel Carson’s name nor *Silent Spring* is ever acknowledged directly. However, a few poorly disguised comments (see the box, “On the

According to Carson, biological control was under-exploited, in part because of inadequate research funds and near-exclusionary reliance on chemical control

Edge”) made it clear that the view of Carson was not favorable.

Instead of addressing Carson’s criticisms directly, ESA focused on creating a positive image of itself and the science of entomology, and its Public Information Committee assumed a central role after *Silent Spring*’s publication. The committee made the following recommendation during the final business meeting for 1963:

#### ON THE EDGE

Says a lady who writes of the sea  
“I’ve espoused a new cause—DDT.  
It’s sprayed all around us  
By those pest control bounders,  
And threatens my bonnet’s pet bee”

—Hector Monro (1963)  
*Bulletin of the  
Entomological Society of America,*  
1963. 9(1): 2

That this Society continues to avoid direct participation in the “Poisons in Our Environment” controversy. Experience during the past 18 months now shows the wisdom of this determination. Our surveys prove this controversy caused no statistical change in the opinion of the general public in relation to need for insect control or use of insecticides. (Hall et al. 1963)

The survey mentioned above was conducted first in 1962 and again in 1963 and showed that the public still experienced pest problems and wanted those pests to be controlled (Hall et al. 1963).

The opening plenary address of the 1962 annual meeting was entitled, “What and Why of Professional Public Relations,” by Stanley Baar, president of Barber and Baar Associates of New York. Baar first summarized the public view of entomologists post-*Silent Spring*.

Here’s a situation in which the public believes, rightly or wrongly, that you, the public health guardian are linked with big business—the chemical processing business. (Baar 1962)

Baar then offered guidelines on how the ESA should redefine itself in the eyes of the public. He stressed that the society should not ignore the impact of the recent negative publicity (i.e., in response to *Silent Spring*) and encouraged entomologists to be pro-active in presenting a positive image of the profession to society at large.

Expand your story to schools, to women’s clubs, to elected officials. It is your duty to tell the public the truth about your profession and your accomplishments.... (Baar 1962)

Barr’s invitation and the prominent placement of his address is notable and may be viewed as an

indication that Carson’s condemnation of entomologists had been registered by ESA, and that the society wished to improve its public image.

In his address as ESA President for 1962, E. Steinhaus offered a redefinition of the profession in the wake of *Silent Spring*. He addressed several of Carson’s criticisms without mentioning her name or the book. He referred to the perception that entomologists focus solely on killing insects with insecticides, and he argued that the true entomologist possesses a more holistic view:

...to control harmful insects is not our only task. We must promote the activities of useful and beneficial insects....

...this gives us no license to think of our task as only that of killing insects. The entomologist who does not find in an insect a thing of beauty, who does not marvel at its symmetry and biological intricacies, and who does not wonder concerning the innumerable instances of unbelievable behavior—such a man, in my opinion, is not truly an entomologist, and in a very real sense is not the scientist...he should be. (Steinhaus 1963)

Steinhaus underscored the altruism and societal impact of entomological research, rebutting Carson’s claim that entomologists do not care about the public:

Fortunately, the Entomological Society of America can hold its head high because of the multitude of its contributions to man’s welfare and to public service. (Steinhaus 1963)

In addition to focusing on public perception of entomologists, ESA also made efforts to present a more balanced view of pesticides and their utility to society. A “Statement on Pesticides,” adopted by the Governing Board in 1963, addressed the benefit and continued need for pesticides and emphasized the role of regulation and research in further advancing pesticide safety. The “Statement” also acknowledged unintended and negative impacts of pesticides on wildlife, including residue accumulation. It underscored commitment to research on biological, alternative control and mitigating negative impacts of pesticides, and concluded with a pledge to support research, cooperation, and education (ESA 1963).

Despite ESA’s reasoned “Statement” of 1963, the following year ESA members passed a resolution denouncing an article by Elger (1964), in which he had criticized the pesticide infrastructure, with its strong ties to industry and academe (ESA 1965). Of this ESA action, Smith (1989) opined,

Rather than respond to the Elger charge by the time-honored route of distinguished journalism, a paragraph-by-paragraph rebuttal...the matter was handled by resolution [that] cited “slandorous statements that insult all scientists” and protested the lax editorial policy... that permitted the publication of such a “vicious attack,”

Van den Bosch (1978) also was highly critical of ESA for passage of this resolution. Six years hence, the ESA Governing Board issued a second statement regarding pesticides (ESA 1970) which, according to Smith (1989), “never became a landmark policy declaration and was largely ignored.”

ESA continued to be dogged by its reticence on the pesticide debate. As Smith (1989) notes, in 1971 President E. A. Ritcher “reviewed the growing regulatory burden spawned by pesticide use and ruefully addressed the issue that would not go away... ‘[W]hy doesn’t the ESA take a united stand on the pesticide issue? We represent so many points of view in our society’.” ESA President W. G. Eden echoed this explanation two years later (Eden 1973).

Smith and Smith (2003) summarized the majority response to the pesticide debate provoked by Carson (1962):

Economic entomologists...viewed *Silent Spring* as an attack on their professional competence and integrity. Since the late 19th century, they had cultivated a self-image of dedicated public servants...This explains in part their emotional response and sense of hurt that has lingered among entomologists of the DDT era. (Smith and Smith 2003, p. 517)

**Journal of Economic Entomology:  
A Case Study**

One of Carson’s main criticisms of entomology was its emphasis on chemical control of insects at the expense of biotic control. The entomological journal most heavily referenced in *Silent Spring* is the *Journal of Economic Entomology (JEE)*. We examined the articles published in *JEE* in 1962, 1982, and 2002 to generate three “snapshots” for a perspective of the kind of control research being conducted over this 40-year span. Our findings reveal a dramatic chronological decrease in studies that emphasize chemical control, from 35.2% (1962) to 19.1% (1982) to 2.7% (2002); these percentages were accompanied by a chronological increase in articles on biotic control and integrated control (Table 1).

Of the articles published in 2002, we found an almost equal distribution of biotic and integrated control, 14% vs. 12.9%, respectively, which together make up 26.9% of the total published articles in 2002. In contrast, 2.7% of the total published articles in 2002 focused on traditional chemical control. Moreover, 74% of the chemical control publications (14 of 19) for 2002 reported on alternatives to conventional insecticides, such as botanicals, insect growth regulators, and selective insecticides.

It is important to point out that this finding may be due, at least in part, to the development of the new ESA publication *Insecticide and Acaricide Tests* in 1976 (Sorensen 1976). This publication is now familiar to entomologists under its new name, *Arthropod Management Tests*, and is published annually serving primarily as a non-peer-reviewed repository for efficacy testing data—the

very information that Rachel Carson found fault with in *JEE*. The development and success of *Arthropod Management Tests* are emblematic of a move within the peer-reviewed publications of the society toward more nonchemical insect control research, while maintaining an outlet for crucial chemical data. Though not all of this can be attributed to the publication of *Silent Spring* in 1962, there is no doubt that a marked shift has occurred in the material being presented in the *Journal of Economic Entomology* over the past 45 years.

Jones (1973) examined publications in *JEE* from 1927 to 1962. He found that the percentage of articles that focused on the general biology of insect pests decreased from 45% in 1927 to 16% in 1962; the same 35-year span saw a concomitant rise in articles on insecticide testing, from 44 to 62%. Jones (1973) also stated that the biological content of *JEE* increased greatly in the 1960s. His findings speak to Carson’s third major complaint, i.e., that her contemporary economic entomologists overlooked the harmful side effects of pesticides on wildlife and the environment. Since *Silent Spring*, the research trend toward integrated pest management (IPM) represents an underlying goal of minimizing pesticide impact on nontarget organisms and the environment. In this regard, we note the emergence of journals devoted exclusively to biological control research (e.g., *Biological Control*), which were largely nonexistent in 1962.

Carson criticized entomologists for their substantial reliance on research funds from agrochemical companies because she felt it promoted bias toward chemical control. This has been called the “corruption hypothesis” (Perkins 1982); and van den Bosch (1978) and Ehrlich (1978) offered a vitriolic assessment of those purportedly involved, whom they labeled the pro-pesticide “Mafia.” Regarding the “corruption hypothesis,” Perkins (1982, pp. 259–260) wrote that, although it may

One of Carson’s main criticisms of entomology was its emphasis on chemical control of insects at the expense of biotic control.

**Table 1. Summary of research focus of articles published in the *Journal of Economic Entomology* in 1962 (year *Silent Spring* published), 1982 and 2002.<sup>a</sup>**

| Year | Total no. articles <sup>b</sup> | Articles on chemical control <sup>c</sup> |      | Articles on biotic control <sup>d</sup> |      | Articles on integrated control <sup>e</sup> |      |
|------|---------------------------------|---|------|---|------|---|------|
|      |                                 | No.                                       | %    | No.                                     | %    | No.   | %    |
| 1962 | 361                             | 127 (1)                                   | 35.2 | 16                                      | 4.4  | 23  | 6.4  |
| 1982 | 283                             | 54 (6)                                    | 19.1 | 20                                      | 7.1  | 40  | 14.1 |
| 2002 | 186                             | 5 (14)                                    | 2.7  | 26 (6)                                  | 14.0 | 24  | 12.9 |

<sup>a</sup>Articles were categorized based on review of title and abstract.

<sup>b</sup>Includes Scientific Notes and Technique articles.

<sup>c</sup>Does not include insecticide residue or resistance studies, unless some aspect of control with insecticide was also evaluated. Numbers in parentheses are for studies on botanical/selective insecticides.

<sup>d</sup>Includes surveys for biocontrol agents and studies in which aspects of biocontrol agents biology were examined, for purpose of rearing or efficacy determination. Does not include insecticide toxicity studies against biocontrol agents. Numbers in parentheses are for studies with transgenic control.

<sup>e</sup>Includes other control methods such as cultural or mechanical control, sterile male, monitoring methods, and sampling designs.

Writing in 1989, Smith indicated that ESA's Sustaining Associates category largely comprised companies in the pesticide industry, but the funds they contributed amounted to less than 1% of ESA's annual budget.

have some veracity, “to attribute overriding importance to any such corrupting effect represents a serious and complete misreading of the dominant forces motivating creative work in entomology.” Furthermore, he contends that entomologists were driven foremost by their loyalty to farmers and the desire to solve their insect problems, and that the chemical industry served merely as “handmaidens” in the process. Writing in 1989, Smith indicated that ESA's Sustaining Associates category largely comprised companies in the pesticide industry, but the funds they contributed amounted to less than 1% of ESA's annual budget.

We know of no studies showing that entomologists biased their scientific results to favor the interests of their funding source(s). Van den Bosch (1978) accused U.S. land grant universities and certain units within the USDA (i.e., Agricultural Research Service, Forest Service) of unprincipled transgressions; however, his attacks singled out administrators, whom he saw as duplicitous and greedy when presented with funds from pesticide manufacturers or pressure from politicians. He believed that economic entomologists were mostly “outstanding insect ecologists and developers of rational pest-control programs” (van den Bosch 1978, p. 71), whose administrators harassed, censured, and demoralized them when they attempted to publish data disagreeable to the agrochemical company that funded their research.

#### **INITIAL IMPACT AND LEGACY OF *SILENT SPRING*—President's Science Advisory Committee (PSAC) and Senatorial Committees**

In November 1962, DuPont's public relations team reported its press analysis findings on *Silent Spring* and concluded that a national debate on pesticide safety was certain (Lear 1997a). History has proven the prescience of this statement. In response to the clamor incited by *Silent Spring*, President John F. Kennedy convened a committee to study the pesticide situation, and in May 1963, the President's Science Advisory Committee (PSAC) issued its report (Lear 1997a). It began with recognition of the continuing need for pesticides, used properly, to safeguard the country's food supply and suppress disease vectors. But it enumerated many serious problems about the establishment of residue tolerances, pesticide certification, administration of pesticide regulation, and the massive USDA efforts aimed at pest eradication (e.g., gypsy moth, Japanese beetle, fire ant). In the journal *Science*, Greenberg summarized the PSAC report, commenting that,

...it is a temperate document...carefully balanced in its assessments of risks versus benefits [and] adds up to a fairly thorough-going vindication of Rachel Carson's *Silent Spring* thesis....Carson can be legitimately charged with having exceeded the bounds of scientific knowledge for the purpose of achieving shock; but her principal point—that pesticides are being used in

massive quantities with little regard for undesirable side effects—permeates the PSAC report and is the basis for a series of recommendations aimed at minimizing risks and maximizing the benefits of pesticide use. (Greenberg 1963)

It is instructive to recall that when the PSAC report was published, the 1958 Delaney Clause was the sole piece of federal environmental legislation in existence. Shortly after the PSAC report appeared, Carson testified before the Senate Commerce Committee, to whom she recommended the creation of an independent commission to examine pesticide issues and make policy decisions. She further recommended that its members have expertise in medicine, genetics, biology, and conservation, and that none be representatives of government or the chemical industry (Anon. 1963a).

Carson was also called before the Senate Subcommittee on Reorganization, which was investigating environmental hazards. As Carson prepared to testify, Committee Chair Senator Abraham Ribicoff remarked to her, “Miss Carson,...you are the lady who started all this” (Lear 1997a).

Carson called for immediate action on two fronts: strict control of aerial pesticide spraying, and reduction and eventual elimination of use of persistent pesticides (Anon. 1963a). Meanwhile, in other testimony before the Ribicoff Committee, William J. Darby, chair of the Department of Biochemistry at Vanderbilt University, maintained that persistent pesticides, used properly, posed no health hazards, and argued for better education and monitoring rather than restrictive legislation (Anon. 1963b). Wayland Hayes, a USPHS toxicologist, echoed this view, saying that some persistent pesticides, e.g., those used to control termites and malaria, should stay on the market indefinitely. The President of NACA, who also represented MCA and Chemical Specialties Manufacturers Association, adamantly opposed further legislative controls and disagreed with PSAC's recommendation that highly toxic, persistent pesticides be replaced with equally effective, less toxic ones (Anon. 1963c). He testified that “all indications to date are that the pesticide residues in the environment and body burden are without effect” (Anon. 1963c).

W. C. Hueper, chief of the Environmental Cancer Section at the National Cancer Institute, presented a different view on the issue of human health. In his testimony to the Ribicoff Committee, Hueper expressed concern that so many carcinogenic pesticides were readily available on the open market and pointed out that certain combinations of pesticides could act synergistically (Anon. 1963d). He recommended that use of highly toxic pesticides be limited to trained, licensed operators, and that carcinogenic pesticides be prohibited if non-carcinogenic substitutes were available. He also recommended that all pesticides be tested in several animal models for both acute and chronic toxicity.

## Since *Silent Spring*

*Silent Spring* made the connection between environmental and human health, placing environmental issues in the mainstream of politics. Several benchmarks can be noted.

In 1969, the U.S. Commission on Pesticides and their Relationship to Environmental Health, chaired by Emil Mrak, issued a 577-page report that recommended elimination of DDT in the United States within two years, except when deemed essential for human health and welfare (USHEW 1969).

In 1970, the U.S. National Environmental Policy Act (NEPA) was enacted, enabling articulation of a national policy that promoted harmony between human activity and the environment, and the U.S. Environmental Protection Agency (EPA) was established, charged with setting and enforcing environmental protection standards and conducting environmental research (Lewis 1985). In accordance with EPA's mission to "protect human health and the environment," the toxicity and research requirements implemented by EPA address many concerns articulated by Carson, e.g., chronic toxicity, developmental toxicity, carcinogenicity, cumulative risk, and environmental fate (EPA 2006).

In 1996, the Food Quality Protection Act (FQPA) introduced fundamental changes to EPA's pesticide registration process. The FQPA acknowledges concerns first raised by Carson about aggregate or multiple exposures to pesticides, and includes specific provisions regarding the potential risk of pesticide exposure to infants and children (EPA 2003).

*Silent Spring* has been translated into 22 languages and continues to sell more than 27,000 copies each year (Lear 1998). It has appeared on lists of the most significant/influential books of the 20th century by various journals, newspapers, and organizations, eg., *American Scientist* (Morrison and Morrison 1999), *Atlanta Journal-Constitution* (Skube 1996), *Boston Public Library* (Boston Public Library 2005), *BioScience* (DiSilvestro 1997), *Foreign Affairs* (Cooper 1997), *Modern Library* (2002), and *National Review* (Booklist Center 2005). Carson herself was named one of *Time* magazine's 100 most influential people of the 20th century (Houghton Mifflin 2005).

Nevertheless, the controversy her book spawned persists to the present day. Elizabeth Whelan, president of the American Council on Science and Health, cited *Silent Spring* in her list of "Twenty Greatest Unfounded Health Scares of Present Times" (see Liebermann and Kwon 2002). Edwards (1992) provides a lengthy list documenting what he calls the "lies" that appear in *Silent Spring*.

## Conclusions

Since the 1960s, detectable human serum concentrations of DDT and its metabolites have decreased significantly in the U.S. population (Longnecker et al., 1997). p,p'-DDE, the primary

degradation product of DDT (Metcalf 1973), has a much longer half-life than DDT and is detectable in 99.5% of the U.S. population (12.6 ppb) (Longnecker et al. 1997). Exposure continues as a result of release into the atmosphere from countries where DDT is still manufactured and used (e.g., Mexico), persistence, and bioaccumulation, but there is no unequivocal epidemiological evidence that DDT poses a cancer risk (Ames and Gold 1997, Longnecker et al. 1997). However, DDT and its derivatives are highly toxic to many aquatic invertebrates and fish and can cause eggshell thinning, egg breakage, and embryo death in predatory birds; gallinaceous birds are largely insensitive (WHO 1989, Matsumura 2003).

Tremendous advances have been made in our understanding, formulation, use, and regulation of pesticides. *Silent Spring* makes frequent reference to 12 pesticides then commonly used. Since then, 8 of these have been banned for use in the United States (DDT, chlordane, dieldrin, aldrin, endrin, pentachlorophenol, toxaphene, benzene hexachloride), 2 are severely restricted in use (heptachlor, lindane), and 1 is considered severely hazardous (parathion) (EPA 2004). Malathion remains as a registered pesticide. DDT is still used in indoor residual spraying for malaria vector control in many parts of the world (WHO 2004).

Did *Silent Spring* have an impact on the practice of professional entomology? If we judge from the shift in research related to insect control before *vs.* after the book's publication, the answer appears to be a qualified "yes." Entomologists, toxicologists, and epidemiologists generally concur with this view (Lewis 1985, Longnecker et al. 1997, Casida and Quistad 1998). Perkins (1982) argues that the science of entomology would have changed regardless of Carson or *Silent Spring* because the widespread development of resistance, pest resurgence, destruction of natural enemies, and hazards associated with broad spectrum, persistent pesticides would have demanded it. Others similarly cite the significant impact of these factors (Graham 1970, Jones 1973, Luckmann and Metcalf 1982, Casida and Quistad 1998).

What of the practice of pest management, the realm of entomology that was the focus of Carson's work? As we survey the pest management landscape, it is clear that although strides have been made, most modern pest management is still overwhelmingly based on chemical pesticides. This is despite the fact that from 1985 to 1995, more than \$100 million a year in U.S. government funding was dedicated to biologically based pest management technologies (OTA 1995). Despite a \$1.3 billion investment, the commercial impact of these technologies was only 1% of the \$8.5 billion annual economic value of synthetic chemical pesticide sales during this period (Winston 1997). Though part of this shortfall may be attributable to the time lag between research and application, it is clear that chemical control methods will not be wholly supplanted by biological methods in the near term. While well-known examples of success-

ful classical biological control programs, such as cottony cushion scale (*Icerya purchasi* Maskell) and the prickly pear cactus (*Opuntia* spp.) are outstanding demonstrations of the potential for nonchemical control (Caltigrone 1981), overall, the estimated success rates of classical biological control programs against weeds is around 33% worldwide (Culliney 2005) and against arthropod pests less than 10% (Gurr and Wratten 1999). The use of augmentative biological control is widespread in some agricultural commodities, for example, greenhouse vegetables, but of limited use in others, such as field vegetables.

There is no doubt that *Silent Spring* threw entomology and its practitioners under the microscope of public scrutiny to an extent that had never been experienced before or since. In the words of Smith and Smith (2003), "Overnight...[entomologists] were in the public eye, viewed as allies with the corporate giants, poisoners of robins and the earth." Although the connection between the science of entomology and industry funding remains strong, that connection has now been made plain for all who care to examine it, and the debate over the merits of this close connection will likely continue as long as industry-funded research is conducted. The strong representation of topics such as biological control at more recent ESA annual meetings, particularly among student presentations, reflects a marked departure of the discipline from the pesticide-based research of 1960s. By illuminating important issues about pesticide use in a manner accessible to the layperson, *Silent Spring* had far-reaching ramifications for the entomological community, the agrochemical industry, and legislative policy makers, all of which impact society at large.

#### Acknowledgements

We are grateful to S. Fisher, C. Sadof, and A. York for helpful comments on earlier versions of the manuscript, and to the two reviewers for *American Entomologist*.

#### References Cited

Ames, B. N., and L. S. Gold. 1997. Environmental pollution, pesticides, and the prevention of cancer: misconceptions. *FASEB Journal* 11: 1041–1052.

Anonymous. 1962. Antipesticide wave may help industry. *Chem. Eng. News* 40: 14.

Anonymous. 1963a. Rachel Carson recites details on pesticide problems and backs a partial solution. *Chem. Eng. News* 41: 36–37.

Anonymous. 1963b. Proposed ban on persistent pesticides hit. *Chem. Eng. News* 41: 36–37.

Anonymous. 1963c. Industry blasts pesticides report. *Chem. Eng. News* 41: 32–34.

Anonymous. 1963d. Pesticides called biological dynamite. *Chem. Eng. News* 41: 34–35.

Baldwin, I. L. 1962. Chemicals and pests [book review]. *Science* 137:1042–1043.

Baar, S. 1962. The what and why of professional public relations. Plenary Session address, ESA Annual Meeting for 1962. *Bull. Entomol. Soc. Am.* 9:24–27.

Booklist Center. 2005. 100 best nonfiction books of the twentieth century. National Review. <http://home.com-cast.net/~dwtaylor1/natreviewnonfiction.html>

Boston Public Library. 2005. 100 most influential books of the century; booklists for adults. <http://www/bpl.org/research/AdultBooklists/influential.htm>

Brooks, P. 1972. Rachel Carson: the writer at work. Sierra Club Books, San Francisco.

Caltigrone, L. E. 1981. Landmark examples in classical biological control. *Annu. Rev. Entomol.* 26: 213–232.

Carson, R. 1962. *Silent Spring*, 40th anniversary edition. Houghton Mifflin, Boston.

Carson, R. 1998. *Lost woods: the discovered writing of Rachel Carson*. L. Lear, Editor. Beacon Press, Boston.

Casida, J. E., and G. B. Quistad. 1998. Golden age of insecticide research: past, present, or future? *Annu. Rev. Entomol.* 43: 1–16.

Cole, L. C. 1962. Rachel Carson's indictment of the wide use of pesticides. *Sci. Am.* 207(12): 173–180.

Cooper, R. N. 1997. Significant books of the last 75 years. *Foreign Affairs* 76: 218–219.

Culliney, T. W. 2005. Benefits of classical biological control for managing invasive plants. *Crit. Rev. Plant Sci.* 24: 131–150.

Darby, W. J. 1962. Silence, Miss Carson. [Book review]. *Chem. Eng. News* 40: 60–63.

Davis, B. N. K. 1964. Reviews. [Book review]. *J. Ecol.* 52: 447–448.

Decker, G. C. 1964. Agricultural applications of DDT, with special reference to the importance of residues. *J. Econ. Entomol.* 30: 557–562.

DiSilvestro, R. L. 1997. Special book article: books to remember. *BioScience* 47: 609–613.

Eden, W. G. 1973. Presidential address: challenges in entomology. *Bull. Entomol. Soc. Am.* 19: 7–8.

Edwards, J. G. 1992. The lies of Rachel Carson. <http://www.21stcenturysciencetech.com/articles/summ02/Carson.html>

Ehrlich, P. 1978. Preface. *In* R. van den Bosch. *The pesticide conspiracy*. Garden City, NY. pp. vii–viii.

Elger, F. E. 1964. Pesticides in our ecosystem: communication II. *Bioscience* 14: 29–36.

Elger, F. E. 1966. Pointed perspectives: pesticides in our ecosystem. *Ecology* 47: 1077–1084.

EPA (U.S. Environmental Protection Agency). 2003. Food Quality Protection Act (FQPA) of 1996. H.R. 1627. Public Law 104-170. <http://www.epa.gov/pesticides/regulating/laws/fqpa/>

EPA (U.S. Environmental Protection Agency). 2004. U.N. PIC [prior informed consent] and U.S. PIC-nominated pesticides list. <http://www.epa.gov/oppfead1/international/piclist.htm>

EPA (U.S. Environmental Protection Agency). 2006. About EPA. <http://www.epa.gov/epahome/aboutepa.htm>

ESA (Entomological Society of America). 1963. Statement on pesticides. *Bull. Entomol. Soc. Am.* 9: 18.

ESA (Entomological Society of America). 1965. Final business meeting, December 2, 1964. Report of the Resolutions Committee. *Bull. Entomol. Soc. Am.* 11: 33.

ESA (Entomological Society of America). 1970. ESA policy statement on insect control. *Bull. Entomol. Soc. Am.* 16:170.

- Fosberg, F. R. 1963. Reviews: pesticides and ecology. *Ecology* 44: 624.
- Graham, F. 1970. Since *Silent Spring*. Houghton Mifflin, Boston.
- Greenberg, D. S. 1963. Pesticides: White House advisory body issues report recommending steps to reduce hazard to public. *Science* 140: 878–879.
- Gurr, G. M., and S. D. Wratten. 1999. Integrated biological control: A proposal for enhancing success in biological control. *Int. J. Pest Manage.* 45(2): 81–84.
- Hall, D. G., M. R. Budd, R. B. Rathbone, and R. G. Richmond. 1963. Report of the Committee on Public Information. *Bull. Entomol. Soc. Am.* 9(3): 36–37.
- Houghton Mifflin. 2005. *Silent Spring* by Rachel Carson. <http://www.houghtonmifflinbooks.com/catalog/title-detail.cfm?titleNumber=688329>
- Jones, D. P. 1973. Agricultural entomology, pp. 307–329. *In* R. F. Smith, T. E. Mittler, C. N. Smith [Eds.]. *History of entomology*. Annual Reviews, Palo Alto, CA.
- Lear, L. 1992. Bombshell in Beltsville: The USDA and the challenges of *Silent Spring*. *Agric. Hist.* 66: 151–170.
- Lear, L. 1997a. Rachel Carson: witness for nature. Henry Holt, New York.
- Lear, L. 1997b. The world took a new direction: Rachel Carson's legacy. *History News* (Summer): 10–13.
- Lear, L. 1998. Endangered legacy: reclaiming the significance of Rachel Carson's life and work. *People, Land, Water*. Jul/Aug: 16–17.
- Lee, J. M. 1962. "Silent Spring" is now noisy summer. *New York Times*. 22 July. Section F, p. 1.
- Lewis, J. 1985. The birth of EPA. *EPA J.* November. <http://www.epa.gov/history/topics/epa/15c.htm>
- Liebermann, A. J. and S. C. Kwon. 2002. The greatest unfounded health scares of recent times. Part I: DDT. *National Policy Analysis*, January, No. 396. National Center for Public Policy Research. <http://www.nationalcenter.org/NPA386.html>
- Longnecker, M. P., W. J. Rogan, and G. Lucier. 1997. The human health effects of DDT (dichlorodiphenyl-trichloroethane) and BCBS (polychlorinated biphenyls) and an overview of organochlorines in public health. *Annu. Rev. Public Health* 18: 211–244.
- Luckmann W. H., and R. L. Metcalf. 1982. The pest-management concept, pp. 1–31. *In* R. L. Metcalf and W. H. Luckman [Eds.]. *Introduction to insect pest management*. John Wiley and Sons, New York.
- Matsumura, F. 2003. Insecticides, pp. 566–569. *In* V. H. Resh and R. T. Cardé [Eds.] *Encyclopedia of insects*. Academic Press, Boston.
- Metcalf, R. L. 1973. A century of DDT. *J. Agric. Food Chem.* 21: 511–519.
- Modern Library. 2002. 100 best nonfiction books, board's list. <http://www.randomhouse.com/modernlibrary/100bestnonfiction.html>
- Monro, Hector. 1963. "On the edge." *Bull. Entomol. Soc. Am.* 9(1): 2.
- Morrison P., and P. Morrison. 1999. 100 or so books that shaped a century of science. *Am. Sci.* 87: 542–547.
- OTA (Office of Technology Assessment, U.S. Congress). 1995. Biologically based technologies for pest control. OTA-ENV-636. OTA, Washington, DC.
- Perkins, J. H. 1982. *Insects, experts, and the insecticide crisis: The quest for new pest management strategies*. Plenum Press. New York.
- Rudd, R. L. 1964. *Pesticides and the living landscape*. University of Wisconsin Press, Madison.
- Skube, M. 1996. Book reviews and opinion books that defined the 20<sup>th</sup> century. *Atlanta Journal-Constitution*, 5 May, p. L12.
- Smith, E. H. 1989. The Entomological Society of America: the first hundred years, 1889–1989. *Bull. Entomol. Soc. Am.* 35: 10–32.
- Smith, E. H., and J. R. Smith. 2003. History of entomology, pp. 509–519. *In* V. H. Resh and R. T. Cardé [Eds.]. *Encyclopedia of insects*. Academic Press, Boston.
- Smith, M. B. 2001. "Silence, Miss Carson!" Science, gender, and the reception of *Silent Spring*. *Feminist Studies* 27: 733–752.
- Sorensen, K. A. 1976. Origin of insecticide and acaricide tests. *Insectic. Acaricide Tests* 1: 1.
- Stare, F. J. 1963. Some comments on *Silent Spring*. [Book review]. *Nutrit. Rev.* 21: 1–4.
- Steinhaus, E. 1963. The day is at hand. *Bull. Entomol. Soc. Am.* 9(1): 1–2.
- U.S. HEW (U.S. Department of Health, Education and Welfare). 1969. Report of the Secretary's commission on pesticides and their relationship to environmental health. U.S. Printing Office, Washington, DC.
- van den Bosch, R. 1978. *The pesticide conspiracy*. Doubleday. Garden City, NY.
- Walker, M. J. 1999. The unquiet voice of "*Silent Spring*": The legacy of Rachel Carson. *Ecologist* 29: 322–325.
- Westcott, C. 1963. Spray chemicals: Are they really dangerous. *Am. Home* 12: 86–88.
- Westcott, C. 1965. Experts review pesticide progress. *New York Times*, 17 January 1965. Section II, p. 27.
- WHO (World Health Organization). 1989. Environmental health criteria for DDT and its derivatives—environmental aspects. <http://www.inchem.org/documents/ehc/ehc/ehc83.htm>
- WHO (World Health Organization). 2004. Frequently asked questions on DDT use for disease vector control. <http://www.who.int/malaria/docs/FAQonDDT.pdf>
- Winston, M. L. 1997. *Nature wars*. Harvard University Press, Cambridge, MA.

**Christian H. Krupke** has been an Assistant Professor at Purdue University in West Lafayette, IN, since January 2005. He teaches graduate and undergraduate level Insect IPM, and conducts research within the broad area of insect pests of field crops, primarily corn and soybeans. **Renée Priya Prasad**, who specializes in sustainable agriculture and biocontrol by natural enemies, is a Research Scientist with E.S. Cropconsult Ltd, Vancouver, B.C., Canada. **Carol M. Anelli**, is an Associate Professor of Entomology and Honors College Faculty member at Washington State University, Pullman. She teaches courses on the history of biology and the historical and current impacts of science on society.

