

Celebration of the 50th anniversary of Rachel Carson's Silent Spring

Rachel Carson, sensitive and perceptive interpreter of nature

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Resum. En complir-se els cinquanta anys de la publicació de *Silent Spring* (1962) sembla totalment oportú retre un merescut homenatge a la seva autora, una magnífica escriptora i divulgadora de les meravelles de la natura, i recordar el que va significar per a la consciència ambiental, primer americana i després mundial, la denúncia dels disbarats que la fumigació indiscriminada de diclorodifeniltricloroetà (DDT) i altres biocides va provocar en les espècies, els hàbitats i la salut humana. Mentre que s'ha atribuït, justament, a Rachel Carson el paper de precursora del moviment ecologista, no és tan conegut que la denúncia la feia sobre bases científiques sòlides i amb uns excel·lents coneixements de l'ecologia de les espècies i els ecosistemes, tant els terrestres com els aquàtics.

Paraules clau: contaminació · plaguicides · biocides · DDT · ecologia · divulgació científica · indústria química

Summary. On the occasion of the 50th anniversary of the publication of *Silent Spring* (1962), this well-deserved homage to its author is a particularly timely one. Rachel Carson was a talented writer, able to excellently convey the marvels of nature. But it was her disclosure, first to the American public and afterwards to the whole world, of the havoc wreaked on organisms, habitats, and human health by the indiscriminate spraying of DDT and other biocides, by which she will always be remembered. Rachel Carson is credited, and justly so, as being one of the founder's of the environmentalist movement. What is less well known is that her claims were based on solid science and that she was highly knowledgeable about the ecology of species and ecosystems, both terrestrial and aquatic.

Keywords: pollution · pesticides · biocides · DDT · ecology · scientific popularization · chemical industry

The year 1962 was a momentous one, marked perhaps most famously by the Cuban missile crisis; the launch and operation of *Telstar*, the first communication satellite; the death of Marilyn Monroe; and the first use of silicone breast implants. Despite the significance of these events, the biggest impact on the life of modern societies may well have been the publication of *Silent Spring*, a book that raised an enormous stir at the time. Half a century is perhaps too long for a book to remain useful unless it is a classic. *Silent Spring* is indeed a classic, combining popular science, environmental reportage, and a brilliant and moving literary style.

The author of *Silent Spring*, Rachel Carson (Fig. 1), epitomizes two of the main and antagonistic ingredients that turn historical characters into imperishable myths: to begin with, the respect, admiration, and veneration from one segment of society for the contribution made by that person, whether to science, culture, or the arts, but also, from another segment of society, reactions of scorn, rejection, mockery, and even personal attack in attempts to depreciate or diminish the value of the contribution.



Fig. 1. Rachel Carson, 1940. Fish & Wildlife Service employee photo.

Carson's name can be included in a list of the great American naturalists such as John James Audubon, Henry David Thoreau, Aldo Leopold, Edward O. Wilson and their likes, who studied, described, and defended nature with the weapons of science, the heart, and the pen. If Audubon is considered the first ornithologist and first modern naturalist of the United States; Thoreau as the father of environmental ethics, pacifism, and non-violence; Leopold as the originator of the natural wilderness protection movement; Wilson as the champion of biodiversity in a world from which it is rapidly disappearing, then the person with the foresight to warn the public about the disastrous effects of chemical pollution on the health of both the environment and our species was Carson [21].

Yet, she was also able to convey the beauty of the natural world and to promote the value of the ecological relationships between very disparate organisms, including humans. It is in this triple role—as an exceptional writer, a nature-loving biologist, and an *avant la lettre* ecologist and accuser of the destruction caused by chemical pollution—that she should be remembered, especially given the fact that she wrote in the 1950s and 1960s, a time when the United States was a leader in industry, economics, and politics while also confronting the challenges of a potential nuclear threat and the perceived communist challenge.

It is no exaggeration to say that *Silent Spring's* denunciation of the indiscriminate use of powerful biocides, and of their pernicious effects, first to the American public, and then, following the book's translation into dozens of languages, to the rest of the world, was the first, and, to this day, perhaps the most powerful argument against the widespread elimination of organisms that play a key role in the economy of nature. Rachel Carson presented this argument based on sound scientific knowledge but with the sensitivity of a naturalist and a woman. As such, she directly confronted the powerful postwar American chemical industry and an erratic (if not senseless) environmental policy of the Department of Agriculture of the United States.

Rachel Carson, naturalist and writer

Rachel Louise Carson was born in 1907 in Springdale, Pennsylvania, and died in 1964, before reaching the age of 57, in Silver Spring, Maryland. A gifted writer, a naturalist enthusiast, and a trained marine biologist and zoologist, she combined all these facets in her professional activities: as a columnist for local and state newspapers, editor for the Fisheries Agency and editor-in-chief for the United States Fish and Wildlife service, assistant professor at the University of Maryland, a respected teacher at the summer courses held by Johns Hopkins University, and, later, as a full-time, freelance writer.

She gained a well-deserved reputation for popularizing the natural beauty of the sea, doing so in three books whose un-

precedented success allowed her to leave her job and devote herself entirely to writing, beginning with *Under the Sea Wind* (1941 revised in 1952 [5]), followed by *The Sea Around Us* (in 1951 [6]), and *The Edge of the Sea* (in 1954 [7]) (Fig. 2). Especially in the last two, she provided the reader with an accurate and reliable description of the sea and its inhabitants, written in elegant prose that placed her among the best naturalist storytellers of all times. Carson not only discovered the sea and its wonders (with the help of magnificent illustrations by respected artists) for her readers, but did so with a style that would quickly make her books bestsellers and serve as a model for other popular science writers. Like *Silent Spring*, these earlier books have also been translated into multiple languages and commemorative editions have been revised by renowned scientists. Following the success of *Silent Spring*, all three were published in a single volume, *The Sea*, in 1964 [10].

By the early 1960s, Carson was known to American readers (and to much of the world), for her books, articles in the press, and her affable, lively and engaging style. Whether narrating the adventures of the life cycle of 'Scomber the Mackerel,' in a language suitable for children and adults, describing the living beings that inhabit the coast and the sea, or sharing her interest and knowledge about the ocean's origin, structure, and function, Carson's prose was smooth, precise, and poetic, conveying tranquility and a love of nature. In her own words, by combining a scientific career with that of a writer, she experienced

"... the magic combination of factual knowledge and deeply felt emotional response."

Imagine for a second, then, the blow that American society received with the publication of *Silent Spring* in 1962 [8,12]. The great storyteller was still there, but the natural beauty of the forests, fields, rivers, and coasts was described as battered, poisoned, destroyed by the chemical substances that were used to combat agricultural and forest pests, to clear roadsides, and to eliminate pesky mosquitoes in wetlands and lakes. However, while the American public was stunned at this denunciation of the horrors that the indiscriminate spraying of



Fig. 2. Covers of *Under the Sea Wind*, *The Sea Around Us*, and *The Edge of the Sea*.

biocides caused in the natural environment and to our health, the powerful American chemical industry was prepared to defend its interests at all costs.

The term 'biocides' was suggested by Carson, as pesticides not only affect pest species but also, directly or indirectly, any nearby living species,

"Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called 'insecticides' but 'biocides'." (Chapter 2)

The publication of *Silent Spring* meant a radical change in how American society and the media, but especially the chemical industry, treated Carson. A successful writer, with books that had been on the bestseller lists for months, Rachel Carson was known for the natural wonders she described and the way in which she described them. *Silent Spring*, which exposed the environmental disasters caused by pesticides, changed all that: she was fiercely targeted by the leaders of the country's large chemical corporations, who first attempted to prevent *Silent Spring* from ever seeing the light of day (they were alerted by the prior publication of a chapter in the daily press) and later attempted to discredit her in public. No less aggressive was the US Department of Agriculture, whose forestry and agricultural policies Carson censured for allowing the disasters detailed in the book. Even the press, perhaps under pressure from government and industry, was not only hostile but scathing in its attacks on an author whose literary successes it had celebrated not long before [1,13,22,27,31].

Silent Spring was not Carson's first denunciation of environmental injustices. In an article in the *Washington Post*, for example, she attacked the environmental insensitivity of the new Republican administration (of President Eisenhower), which had replaced a competent Secretary of the Interior for a politician with no environmental knowledge,

"For many years public-spirited citizens throughout the country have been working for the conservation of natural resources, realizing their vital importance to the Nation. Apparently their hard-won progress is to be wiped out, as a politically-minded Administration returns us to the dark ages of unrestrained exploitation and destruction. It is one of the ironies of our time that, while concentrating on the defense of our country against enemies from without, we should be so heedless of those who would destroy it from within." [27]

The media acted as a sounding box for the debate on pesticides, which raged for a whole year before it slowly quieted—when it was finally acknowledged that Carson had been right to denounce the chemical industry and the administration. Vicious criticism and bitter mockery then gave way to more balanced evaluations, and eventually to open praise, honors, and awards. The attacks against Carson and *Silent Spring* have been compared to those suffered by Charles Darwin, a century before, when the Church and the Victorian establishment similarly reacted to the publication of *On the Origin of Species*.

"A sort of war"

Carson was accused of being an alarmist, of not being scientifically informed, of falsifying, in tearful prose, the beneficial reality of the fight against insect pests; of fostering with her 'environmental hysteria' the destruction that pests caused in the agricultural and forestry sectors of the United States and thereby promoting hunger and disease in the world; of thus sinking the American economy and favoring competitor countries in the global agricultural trade; and, of course, of playing along with the communists ("She is probably a communist," former Secretary of Agriculture Ezra T. Benson said in a letter to President Eisenhower). Even the fact that she was unmarried was used against her. The press, always eager for sensationalism, called her a 'bird lover,' 'fish lover,' 'nun of nature,' 'priestess of nature,' 'a fanatic defender of the cult of the balance of nature,' among other derogatory names. Carson had been very aware

"... that by taking up her pen to write honestly about this problem, she had plunged into a sort of war." [20]

Her response to the attacks was firm and balanced: she insisted that she did not proclaim the abolition of chemical pesticides but of a rationalization in their application, e.g., by moderating the disparate doses that were used; that specific pesticides, targeting specific pest organisms should replace the broad-spectrum, general pesticides that simultaneously eliminated harmful and beneficial animals; to differentiate between weeds and non-harmful wild plants; that efforts at biological control, which had already seen some notable successes, be intensified; and that no spraying program be undertaken without previous field studies and a complete knowledge of the ecology of the organisms that might be affected.

She explained that our species is simply one among many in the natural world, and that just like the others it is subject to the damage that we indiscriminately inflict upon it. Newspaper articles, radio interviews, an appearance before Congress (in 1963), and the support of naturalists and scientists gradually quieted the media circus that the chemical industry (Monsanto, DuPont, Velsicol, among other major companies) and different sectors of the administration had used against her, including a leaflet that, mimicking the book's opening chapter, conversely described the misfortunes of a world without pesticides and at the mercy of insects.

The resulting national debate prompted President John F. Kennedy to order the preparation of a comprehensive report on pesticides to an advisory committee. After a long study, it was concluded, in 1963, that while evidence supported the continued use of pesticides against pests that threatened crops and health, these chemicals should no longer be sprayed indiscriminately. The report also recommended more research, especially aimed at the development of specific pesticides, and a study of the chronic effects of pesticides as well as their synergistic effect with other commonly used substances. In addition, the committee advocated limiting the domestic use of insecticides and herbicides and insisted upon extreme care in estimations of the doses applied and in accurate user information.

In other words, Rachel Carson had been right all along, and the chemical industry (and the governmental departments responsible for the spraying programs) had been careless, arrogant, sloppy and, therefore, liable for damages to the environment and for the deaths of people, domestic animals, and wildlife (although this was not mentioned in the report). The political reaction that followed corrected the defective system of granting nearly automatic authorization for new biocides (1964) that Carson had denounced as ineffective. Indeed, the response provided the basis for the creation of the Environmental Protection Agency (EPA, 1970). One of its first acts was to ban DDT as a pesticide in almost all crops, but allowing its use to combat the insect vectors of malaria and other diseases (1972) [29,31]. (Already in 1962, a year before the publication of *Silent Spring* in England, the voluntary ban of aldrin and dieldrin had been promoted there [25,26,28].) Carson had practically no chance to enjoy her vindication, as she had long suffered from breast cancer and died from the disease in 1964.

A partisan book?

Another similarity between Carson and Darwin was the careful preparation of the books that would make them world famous. The preliminary research for *Silent Spring* necessitated more than 4 years of study of published papers (in physiology, ecology, medicine, toxicology, etc.) and internal reports of government agencies and departments and the United States Congress, as well as interviews and consultations with scientists and experts around the world for further information. The extensive list at the end of the book attests to the fact that each of Carson's 'exaggerated' or 'distorted' claims (according to her critics) was based on reliable scientific sources and official reports. Also, as with her earlier books, *Silent Spring* was thoroughly reviewed before the final version was published.

Along with the sound scientific basis of *Silent Spring* and the perfectionism of its prose, two other merits should be added: a scrupulous respect for the truth and a significant personal involvement in the book's underlying subject matter [19]. *Silent Spring* is not just a declaration in defense of nature made by a naturalist, it is a general warning of the dangers to human health that are an inherent side effect of poisoning the environment. This warning came from a woman who underwent a radical mastectomy while writing the book, who was treated with radiotherapy, and who eventually died from the complications of the breast cancer treatment. And while the pathogenesis of breast cancer is multifactorial and not completely understood, the cancer-causing effects of many of the biocides described in her book surely contributed to the urgency Carson felt in presenting her case.

In the book, she clearly identified the underlying reasons for the proliferation of pesticides and their indiscriminate use, sprayed in hedges and gardens or distributed from the air over enormous tracts of forests and wetlands:

"All this has come about because of the sudden rise and prodigious growth of an industry for the production of man-

made or synthetic chemicals with insecticidal properties. This industry is a child of the Second World War. In the course of developing agents of chemical warfare, some of the chemicals created in the laboratory were found to be lethal to insects. The discovery did not come by chance: insects were widely used to test chemicals as agents of death for man." (Chapter 3)

"With the development of the new organic insecticides and the abundance of surplus planes after the Second World War, all this [the prudent use of pesticides] was forgotten." (Chapter 10)

And of course, if the disasters that Carson predicted were to occur, it was because someone allowed them to. Just as *Silent Spring* warned of the damage caused by pesticides to nature and its inhabitants, it also condemned the arrogance, ignorance, and opportunism of the human beings responsible for their use.

"The 'control of nature' is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man. The concepts and practices of applied entomology for the most part date from that Stone Age of science.

It is our alarming misfortune that so primitive a science has armed itself with the most modern and terrible weapons, and that in turning them against the insects it has also turned them against the earth." (Chapter 17)

The chemists, applied entomologists, and other professionals involved in the production of pesticides and in their widespread application, far from showing contrition and making amends, reacted in a derogatory, defensive manner, and—judging from some of their comments—without even having read the book.

Much of the criticism of *Silent Spring* targeted the perceived bias of the author's message: pesticides are bad, nature (including the species we are fighting) is good. Carson's literary style was branded maudlin and alarmist for assigning such great importance to the death of 'some birds and bees.' Of course, her detractors made sure to point out, whether subliminally or directly, the fact that the author was a woman—"with little scientific training," which was not true, or "who does not even have a doctorate," although Carson had a master's thesis on the embryonic development of the catfish kidney [4]—who dared to question the scientific and technical work of experts in the industry and the US government, most of whom were men.

Silent Spring's message is partial, of course; but Carson did nothing more than counter the much greater bias put forward, out of ignorance or greed, by the manufacturers of chemicals and by US state and federal agricultural and forestry agencies in defense of their pesticides and spraying programs. Perhaps the best reply to her critics' charges was in the review of the

book by LaMont Cole, Professor of Ecology at Cornell University,

“Errors of fact are so infrequent, trivial, and irrelevant to the main theme that it would be ungallant to dwell on them.” [11]

The accusation of the book’s ‘maudlin’ sentiments was undeserved [21]. One of Carson’s great gifts as a naturalist was her feminine sensitivity, not sentimentality, which freed her to movingly describe (as she did in her previous books) both the wonders of the living world and the damage being inflicted on it. Nor is she alarmist when pointing out this aggression and its effects; rather, her concern stems from an awareness of the interrelationships between living beings and their ecosystem. It cannot be denied, however, that *Silent Spring* was written when Carson herself was in very poor health, which surely influenced the literary style, clouding the joy and euphoria for nature and life expressed in her previous books and replacing it with a dismal view of the future.

While one might argue that the charges of bias, sentimentality, and alarmism were not entirely unfounded, the counterattack mounted by the chemical industry was not only very powerful, but cruel and ruthless... and equally biased [18,27]. To the consternation of the deniers of Carson’s thesis, both radio and TV presented to the public a shy yet confident woman who stood her ground and, through her candor and with well-argued reasons, was able to present and defend her case. One of the harshest critics was the biochemist Robert White-Stevens, who in a televised interview dared to say that,

“The major claims of Miss Rachel Carson’s book, *Silent Spring*, are gross distortions of the actual facts, completely unsupported by scientific, experimental evidence, and general practical experience in the field. Her suggestion that pesticides are in fact biocides destroying all life is obviously absurd in the light of the fact that without selective biologicals these compounds would be completely useless ... If man were to 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... Miss Carson is a fanatic defender of the cult of the balance of nature.

The real threat to the survival of man is not chemical but biological, in the shape of hordes of insects that can denude our forests, sweep over our crop lands, ravage our food supply and leave in their wake a train of destitution and hunger, conveying to an undernourished population the major diseases scourges of mankind.”

This excerpt is typical of the argument’s put forward by proponents of continued, indiscriminate chemical warfare against pests. It should be kept in mind that this debate took place during an unprecedented boom in the creation of synthetic substances, especially in the United States, and the false belief that our species, unchallenged, could dominate nature. White-Stevens himself made the following statement, which today, given our planet’s deplorable state, can be easily interpreted as the height of arrogance and male chauvinism:

“The crux of the matter, the fulcrum on which the argument primarily rests, is that Miss Carson maintains that the balance of nature is a fundamental force in human survival, whereas the modern chemist, biologist and scientific believe that man firmly controls nature.” [33]

It remains unresolved whether White-Stevens and other scientists advocating the safety of pesticides were convinced of their position or simply felt obliged to respond to a generalized accusation made by Carson in her book and that, *mutatis mutandis*, can be applied today to many other fields of applied research in every developed country of the world:

“The major chemical companies are pouring money into the universities to support research on insecticides. This creates attractive fellowships for graduate students and attractive staff positions. Biological-control studies, on the other hand, are never so endowed—for the simple reason that they do not promise anyone the fortunes that are to be made in the chemical industry. These are left to state and federal agencies, where the salaries paid are far less.

This situation also explains the otherwise mystifying fact that certain outstanding entomologists are among the leading advocates of chemical control. Enquiry into the background of some of these men reveals that their entire research programme is supported by the chemical industry. Their professional prestige, sometimes their very jobs, depends 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 the protests that insecticides are harmless?” (Chapter 15)

In any case, a bitter aftertaste of *Silent Spring*’s denunciations remained among the professionals of the chemical industry, and it is difficult to find a statement from them, even recently, that does not convey, either succinctly or protractedly, the message that Carson grossly exaggerated the disasters that pesticides could create in the living world [15,16,23,24,26,34].

Silent Spring

The book that made Rachel Carson world famous begins with a short chapter, “A Fable for Tomorrow” which describes an imaginary city that had simultaneously suffered all the disasters that had thus far actually been detected in various towns and cities throughout the United States, and which the author in subsequent chapters would explain in detail. After this devastating image, in the next two chapters (“The Obligation to Endure” and “Elixirs of Death”) Carson raises the issue of the chemical fight against pests and describes the main pesticides used at the time (today, even a brief description of the vast spectrum of biocide substances currently in use would require several extensive chapters) (Fig. 3).

She goes on to describe the effects of these toxic substances in various environments (“Surface Waters and Underground Seas,” “Realms of the Soil,” “Earth’s Green Mantle”). It should

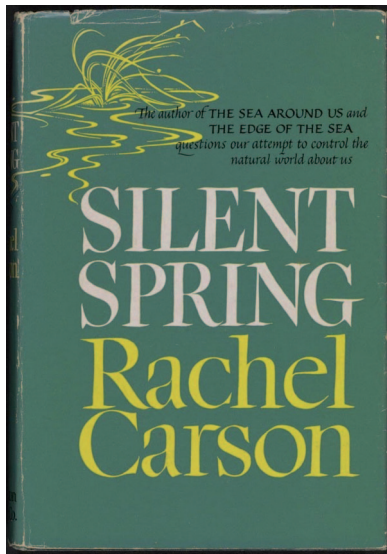


Fig. 3. Cover of *Silent Spring* (1962). Credit: Library of Congress, USA.

be noted that Carson was most likely the first person to draw the general public's attention to the interaction of the various compartments of the biosphere, all linked and immensely important and thus particularly vulnerable to the consequences of our ignorance (her explanation on the role of the soil is brilliant).

In the following two chapters ("Needless Havoc," and "And No Birds Sing"), the reader is confronted with the lethal results on the fauna, especially birds, of fumigation and various pest eradication programs. Fish inhabiting forest rivers do not fare any better ("Rivers of Death"), nor do domestic and farm animals, as a result of a genuine spraying frenzy ("Indiscriminately from the Skies"). The subsequent chapters describe the impact of pesticides on our species ("Beyond the Dreams of the Borgias" and "The Human Price"). Carson acknowledges that,

"Probably no person is immune to contact with this spreading contamination unless he lives in the most isolated situation imaginable." (Chapter 11)

She then speculates on the physiological cause of poisoning ("Through the Narrow Window"), in a commendable effort to explain scientifically yet simply the biochemical and cellular mechanisms leading to the death of the affected organisms. The following chapter (with the ominous title of "One in Every Four," an allusion to the prevalence of cancer among us) is dedicated to unraveling what in her time was known about the causes of various diseases, highlighting those that could be environmentally related, thus making it clear that it was our health, and not just that of the environment, that would be severely impacted by environmental pollution.

The three final chapters show Carson's gifts as a naturalist. "Nature Fights Back" and "The Rumbblings of an Avalanche" explain one of the evolutionary consequences of the application of biocides, one that remains relevant today, i.e., the fact that pests eventually become resistant. The author also highlights the impact on an ecosystem of the mortality of the spe-

cies that normally control the targeted pests, i.e., predators and parasitoids, making it clear that the cascading effects of their disappearance usually cause worse (and more persisting) damage than the pests themselves. Finally, "The Other Road," is a complete (for its time) catalogue of alternative methods of pest elimination, based on biological control or the selective application of chemical pesticides. Carson encourages the relevant agencies to use these methods (which the book helped to promote) and to abandon indiscriminate chemical warfare, with its resultant accumulation of toxic substances in the environment and in our bodies in addition to irreparable damage to nature. The book concludes with an extensive list of the main sources of information the author used in preparing her documented report.

As usual, science has confirmed some of Carson's warnings (for example, the effect of the bioaccumulation of several biocides in living organisms, and the biomagnification of these effects along food chains); has clarified others (such as the carcinogenic activity of pesticides); and has questioned some (release of toxins into the bloodstream when the body fat in which they are stored is metabolized). Last but not least, in addition to drawing attention to the dangers of the indiscriminate use of pesticides in our environment, one of the merits of *Silent Spring* was that it provided an important incentive to the scientific study of the effects of DDT (and other pesticides) on living organisms. Whether it was to deny or to support Carson's thesis, all kinds of research (toxicological, epidemiological, ecological, etc.) would, in the following years, fill in the bibliographic gap that existed at the time the book was written [21]. For the most part, the results of these studies confirmed all of the author's fears, and they would eventually lead to the prohibition of the use of DDT and to other safety measures controlling the use of pesticides.

The ecology of *Silent Spring*

Carson's biological and ecological knowledge make *Silent Spring* one of the major popular science books in the field of ecology. While the number of such books would increase steadily throughout the second half of the 20th century, they were extremely rare at that time. For Nicholson, the book is

"... probably the biggest single contribution, and the most effective up to that moment, aimed at informing the public opinion of the true nature and importance of ecology." [28]

As an ecologist myself, what I like most about Carson's book is the aforementioned fact that she considers what environmental disruptions occur, or may occur, linked to the mortality of some organisms due to poisoning by toxic pesticides [21]. It is not just about making a census of the number of sprayed hectares or dead birds as a consequence of spraying; rather, it explains the ecological consequences of these deaths (or the reduction of fertility, etc.) on the whole ecosystem, i.e., the 'cascading effects' of which ecologists have only been aware in the last couple of decades. Thus, not only is the target

species affected, but also many that naturally control it, such that the cumulative result is often not the desired one. For reasons that have to do with the relative position of species in food chains or webs, the controlling species (usually predators) suffer more damage than the pest species (which are usually herbivores), as do other species, including those that are beneficial to us. Carson cited these cases in her book several times and demonstrated irrefutably and objectively the consequential, multiple damage to organisms in an ecosystem, and thus, to our crops, our forests, and our health (Fig. 4).

These and other aspects of the workings of nature, which today we take for granted, were first described in a widely circulated book aimed at non-experts and thus able to deliver its message to society. Carson was up-to-date in what was known at that time, in the mid-twentieth century, about the ecology of organisms (for example, on several occasions she cites Elton's essential book [14]). In the 1950s and early 1960s, this was a poorly developed field but ecology would develop dramatically, precisely in the United States, albeit not until the second half of the century.

The most popular message of *Silent Spring*, stated in its very title, is complemented by another, more substantial one that has gone relatively unmentioned. Thus, while Carson predicted a silent spring, without the singing of insectivorous birds and in which the bees would not be buzzing among the flowers, she also foresaw autumns in which there would be no pollination or fruit. There were two reasons for her prediction of an infertile American countryside, and she set poetry aside to introduce the observations of a naturalist:

“... a bee may carry poisonous nectar back to its hive and presently produce poisonous honey.” (Chapter 3)

This has proven to be the case, and it has led to many efforts to reduce the poisoning of honeybees by pesticides and herbicides. But the same efforts to protect wild pollinators, both in agricultural and in natural environments [3], were lacking, and that was Carson's second warning,

“Without insect pollination, most of the soil-holding and soil-enriching plants of uncultivated areas would die out, with far-reaching consequences to the ecology of the whole region. Many herbs, shrubs, and trees of forests and range

depend on native insects for their reproduction; without these plants many wild animals and range stock would find little food. Now clean cultivation and the chemical destruction of hedgerows and weeds are eliminating the last sanctuaries of these pollinating insects and breaking the threads that bind life to life.” (Chapter 6)

Carson also cited two consequences related to the incorporation of toxic substances by organisms. While nowadays both are well-established, they were recent discoveries at the time *Silent Spring* was published, and the book greatly helped to highlight them. (1) In plants, through the uptake of soil nutrients and in animals, through either the ingestion of food or direct passage through the integument of the body (or blood of the mother in eggs and fetuses), the bioaccumulation of toxins is such that they reach higher concentrations than in the surrounding external environment. (2) Moreover, since some organisms are prey for others, along food webs biomagnification further increases the levels of these poisons and causes super-predators (birds of prey, carnivores, etc.) to accumulate them in their tissues in concentrations that are several orders of magnitude higher than the original one, with deleterious effects that would not happen at lower concentrations.

As a biologist, Carson unequivocally accepted evolution (another target of criticism in a country in which, then and now, arguments are made in the courts about the right to teach evolution in the classroom). The ability of organisms to resist poisons devised by humans provided her with a great example of evolution in action:

“If Darwin were alive today the insect world would delight and astound him with its impressive verification of his theories of the survival of the fittest. Under the stress of intensive chemical spraying, the weaker members of the insect populations are being weeded out [...] Only the strong and fit remain to defy our efforts to control them [...] Darwin himself could scarcely have found a better example of the operation of natural selection than is provided by the way the mechanism of resistance operates. Out of an original population, the members of which vary greatly in qualities of structure, behaviour, or physiology, it is the ‘tough’ insects that survive chemical attack. Spraying kills off the weaklings. The only survivors are insects that have some inherent quality that al-

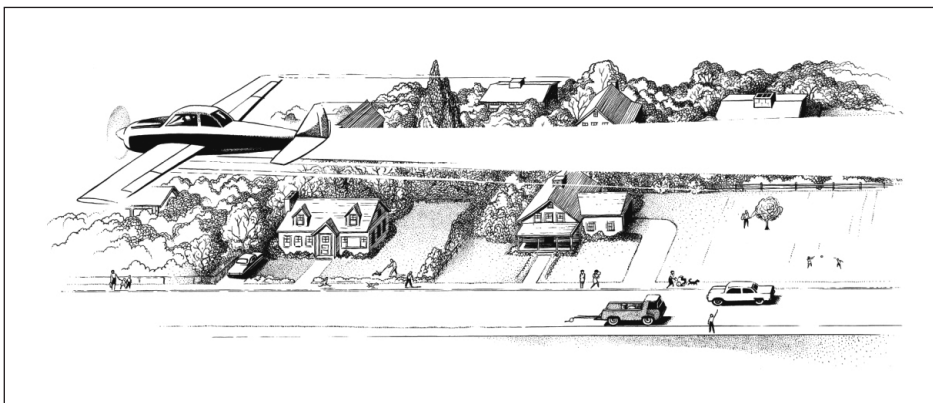


Fig. 4. Example of illustrations from *Silent Spring*'s first printing.

lows them to escape harm. These are the parents of the new generation, which, by simple inheritance, possesses all the qualities of ‘toughness’ inherent in its forebears. (Chapter 16)

Another aspect of Carson’s overall environmental vision is that, in an era of American economic expansion, she clearly advocated sustainable agricultural production,

“Yet is our real problem not one of *overproduction*? Our farms, despite measures to remove acreages from production and to pay farmers *not* to produce, have yielded such a staggering excess of crops that the American taxpayer in 1962 is paying out more than one billion dollars a year as the total carrying cost of the surplus-food storage programme.” (Chapter 2)

Thus, Carson was asking the public to consider all the costs of production, including costs to the environment and similar costs that even today are rarely considered, the so-called externalities:

“It is cheaper [to spray the weeds with pesticides] than mowing, is the cry. So, perhaps, it appears in the neat rows of figures in the official books; but were the true costs entered, the costs not only in dollars but in the many equally valid debits we shall presently consider, the wholesale broadcasting of chemicals would be seen to be more costly in dollars as well as infinitely damaging to the long-range health of the landscape and to all the varied interests that depend on it.” (Chapter 6)

“We are told that inoculation with milky spore disease [to fight the Japanese beetle] is ‘too expensive’—although no one found it in the fourteen eastern states in the 1940s. And by what sort of accounting was the ‘too expensive’ judgment reached? Certainly not by any that assessed the true costs of the total destruction wrought by such programmes as the Sheldon spraying.” (Chapter 7)

Consequently, when explaining the damage caused by pesticides, she evaluates it in ecological but also in financial terms, often appealing to those sectors of society that will be forced to accept the greatest share of the consequences: farmers, fishermen, hunters, hikers, tourists, naturalists and bird-watchers. All in all, *Silent Spring* is, among other things, a very good ecology textbook [21].

Carson, conservationist

Carson’s concern about the abuse of new chemical pesticides, such as DDT, with the apparent blessing of the American government, was awakened early on. Already in 1945 she tried to publish an article on the subject in *Reader’s Digest*, but the magazine rejected it. Carson then turned to her marine trilogy and it was not until its completions that she again tried to get

the article into print. By then, more than a decade later, the list of pesticides had significantly grown, as had their destructive power, with the use of agents several times more potent than DDT. Carson recalled,

“The more I learned about the use of pesticides, the more appalled I became, and I realized that there was the material for a book. What I discovered was that everything which meant most to me as a naturalist was being threatened, and that nothing I could do would be more important.” [9]

Although Carson was not a typical activist, *Silent Spring* served as her proxy and had the distinction of being the catalyst for the organization of the first American and, later, global environmental associations. It can even be argued that without Carson’s book, organizations such as Greenpeace probably would not exist today. The acknowledgement of the potential for environmental disasters associated with the indiscriminate use of biocides confirmed some of the public’s worst fears. But what was probably most important for the public was that the book also offered a solution that went beyond simply banning certain pesticides.

Carson explained that we had treated nature as a set of disconnected pieces, when the truth is that all the elements of nature (ourselves included) are connected in a ‘web of life’ and that any attack on one of these elements reverberates across the whole, with unexpected, almost always negative consequences. Therefore, the best strategy was not the use of ‘brute force’ methods (such as indiscriminate spraying of biocides), worsened by the creation of new chemicals at an increasing rate, but to live by the laws of nature (which implies the need to study them) and adapt to them. Our attempts to dominate nature are not only sure to be futile, they will almost certainly backfire.

Some have seen the origin of the environmental movement in Carson’s challenge to ‘progress at any cost’ and the ‘conquest of nature,’ and in her demands for new paths, new ideas, and new policies (Robert Frost’s poem “The Road Not Taken,” cited by the author in the last chapter of the book) [2,13,25,30]. Before *Silent Spring*, conservation had not aroused much interest among American society; few people genuinely cared about the disappearance of nature, especially in such a large country with its pioneer spirit and its success in “conquering the West.”

But Rachel Carson forced Americans to consider an environmental drama too terrible to disregard, in which the annihilation of beautiful (and useful) species was compounded by the contamination of food chains, genetic damage, and cancer. (The contemporary and widespread awareness of the horrors of thalidomide, which caused severe defects in newborns, contributed to the book’s impact.) For the first time, North American society deemed it necessary to regulate industry in order to protect the environment, and thus environmentalism was born.

Carson’s *Silent Spring* has been compared with the abolitionist Harriet Beecher Stowe’s *Uncle Tom’s Cabin* (1852), a novel that also denounced an injustice, in that case one perpe-

trated by the actions of American society in its support of slavery, and actively promoted a solution, i.e., abolition. But Carson did not intend to establish herself as standard bearer of the green crusade. She was an environmentalist *malgré soi*.

As noted above, Carson did not just reveal the evils of pesticides, she also proposed knowledge-based alternatives, for example,

“A truly extraordinary variety of alternatives to the chemical control of insects is available. Some are already in use and have achieved brilliant success. Others are in the stage of laboratory testing. Still others are little more than ideas in the minds of imaginative scientists, waiting for the opportunity to put them to the test. All have this in common: they are *biological* solutions, based on understanding of the living organisms they seek to control, and of the whole fabric of life to which these organisms belong.” (Chapter 17)

These words seem very modern and not just relevant to the time in which they were written. Dr. Wilhelm Hueper, of the National Cancer Institute, one of the researchers who was most concerned about the environmental causes of cancer and one of Carson’s main informants, summarized in the following brief description of *Silent Spring*’s author, what is probably the best definition of an environmentalist:

“... she is a sincere, unusually well-informed scientist possessing not only an unusual degree of social responsibility but also having the courage and ability to express and fight for her convictions and principles.”

“Sensitive and perceptive interpreter of the ways of nature”

Edward O. Wilson wrote an afterword to a commemorative edition of *Silent Spring* that also featured a preface by Al Gore [19]. He wondered what Rachel Carson would have thought, had she been alive, about the current environmental situation. According to Wilson,

“... she’d give America a mixed grade. The increased public awareness of the environment would please the educator in her; the ranking of her book as a literary classic would astonish the writer; and the existence of new regulatory [environmental] laws would gratify the frustrated government bureaucrat.” [35]

Even so, she would have been quite aware that “the war between environmentalists and exploiters, local and national, is far from over,” and that many other environmental problems have since been added to the list of our planet’s woes: problems affecting the fields and forests of industrialized countries, the jungles of developing countries, and the seas that Carson so well described. But there have also been events, unthinkable in her day (the Earth Summit in Rio de Janeiro, which produced the Convention on Biodiversity, the various international



Fig. 5. 17 cent Rachel Carson U.S. postage stamps (1981) and Gill Craft First Day Cover.

meetings to reduce greenhouse gas emissions, and the attempts to strengthen policies to mitigate climate change), that despite their partial results would have encouraged her.

However, the unbridled growth of the world’s population and the number of developing countries whose booming economies have further strained energy resources while assaulting nature would have been issues of deep concern to the ‘lady from Maryland.’ According to Wilson, the battle led by Rachel Carson to the benefit of nature has not yet been won, rather, we continue

“... poisoning the air and water and eroding the biosphere, albeit less so than if Rachel Carson had not written.” [35]

Rachel Carson received many awards and honors, both throughout her literary career as well as posthumously (Fig. 5). Among them are the National Book Award, for *The Sea Around Us*; gold medals from the Zoological Society of New York and the National Geographic Society, for her merits both as a naturalist and a writer; and the Auduborn Society medal, for which she was the first woman recipient (1963) but unfortunately when she was already very ill. Its inscription could serve as an epitaph to a naturalist who, probably unwittingly, forever changed the way we perceive the nature that surrounds us and which we are a part of,

“Distinguished scientist, gifted writer,
Sensitive and perceptive interpreter of the ways of nature,
Who authored a book called *Silent Spring*;
Through it she alerted and aroused the public about
Needless and dangerous chemical pollution of our environment
And sounded a timely warning that technology,
Run away from science, can be a threat to man.” [32]

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