The Laborers of Nature

Economic Ornithology and the Role of Birds as Agents of Biological Pest Control in North American Agriculture, ca. 1880–1930

Matthew D. Evenden

Agriculture has been blamed, on occasion, for creating its own pests. In 1864 George Perkins Marsh wrote in *Man and Nature* that "[w]ith the cultivated plants of man come the myriad tribes which feed or breed upon them, and agriculture not only introduces new species, but so multiplies the number of individuals as to defy calculation."[1] Since early in the twentieth century, the solution to insect pests in North American agriculture has been the heavy use of insecticides. Although biological control techniques were important early in the century and have become a focus of attention more recently, the place of insecticides in the twentieth-century history of agricultural pest control is central and remains so.

Over the past twenty years, environmental and agricultural historians have sought to analyze the origin and course of pest control regimes in modern North American agriculture.[2] They have placed particular emphasis on determining why over the course of the past century pesticides came to prevail in pest control regimes. Historians have proposed a variety of possible factors, including the role of agribusiness and state-funded science in institutionalizing and promoting pesticides, the cachet of pesticide research in entomological science following World War II, and the attractiveness of pesticides to farmers. Less attention within this overarching question has been given to the history of biological control, and even when it has been considered, the definition of biological control has been narrowly conceived.[3] With rare exceptions, biological pest control has been understood to be the use of insect predators (whether introduced into an ecosystem or emergent through habitat modification) in the control of insect or weed pests. This definition, although it covers the broad scope of biological control, ignores various other techniques on its margins.

One of these other, marginal techniques is the role of birds as agents of biological control. In the late-nineteenth and early-twentieth centuries, scientific ideas about this method of pest control developed within the context of popular debates over bird preservation and conservation generally. These ideas, although predominantly generated in the United States, were diffused and debated in the Canadian and American agricultural literature, with little respect for political borders.

Avian agent biological control has long been used throughout the world in forestry and has received attention recently in the integrated pest management literature.[4] But in the late-nineteenth and early-twentieth centuries the notion of using birds to help control pests, among the gamut of methods that were proposed and debated within the agricultural literature, commanded significant attention.[5] Growing out of the natural historical concern for teleological design in nature and debates over bird importation, systematic studies of the potential role of birds as pest control agents were first produced

in the 1880s and embodied in the newly named field called economic ornithology. From the late-nineteenth century to the 1930s, when this field practically disappeared, hundreds of studies on the role of birds in agriculture were published. This research had implications for conservation politics and was popularized in the natural historical and agricultural literature through two strands of conservationist discourse. One posited birds as humanlike moral agents; the other constructed birds as natural resources.

By the 1930s, however, depictions of birds as beneficent laborers declined, as did the claims of scientific "knowledge" upon which they were based. The emerging dominance of pesticides was clearly crucial to this change. But economic ornithology also collapsed because of three other important factors: first, economic ornithology did not offer practical methods for harnessing the role of birds as insect eaters; second, debate among ornithologists in the early-twentieth century over data analysis methods destabilized the claims of the field as a whole; and third, the weakening political status of the U.S. Biological Survey in the 1930s undermined economic ornithology's institutional base. It is tempting to blame pesticides for displacing, by the 1940s, biological control research and practice. But the history of economic ornithology demonstrates that internal aspects of the science along with the then-current political context were important factors that weakened the legitimacy of biological control prior to the triumph of pesticides.

The Cultural Background of Economic Ornithology

The proposition that birds are useful agents of insect control has a long history. From the mid-eighteenth century, naturalists ranging from Benjamin Franklin to Bernadin de Saint-Pierre proclaimed the virtue of birds, based upon teleological assumptions about the order and economy of providential nature.[6] "Birds," wrote Swiss naturalist Frederic De Tschudi in the mid-nineteenth century, "are nature's soldiers and keep in subjection the inferior animals."[7] Every aspect of their being, such authors argued, was fitted to a higher purpose, since nature did nothing in vain. In order to control insect pests, De Tschudi continued, "the most essential of [birds'] organs have been adapted—their sight is piercing, and even the very smallest among them possess the most extraordinary powers of digestion—whilst their great activity and lightness enable them to exercise their calling incessantly and where most required."[8] Before Darwin, and even in his wake, natural historians interpreted the economy of nature as a grand set of cycles in which God's magnificence revealed itself.[9] Birds, according to this line of thought, provided an essential function in maintaining the harmonious balance of nature, and deserved human protection and encouragement in their blessed project.

This view of the beneficent role of birds lay behind attempts to propagate foreign species within regions of European settlement in the nineteenth century. Mynas were introduced to Australia to control locusts; starlings were brought to North America to help control shade tree pests; and English sparrows, one the most successful and widespread of the introduced species, were established in Argentina to control moths, in Australia to attack all varieties of insects, and in the United States and Canada to suppress tree pests and cutworms.[10] In the United States starting in the 1850s, such groups as the Society for the Acclimatization of Foreign Birds organized bird importation programs, while commentators trumpeted the cause in the agricultural literature.[11] This enthusiasm for bird importation encompassed both a sincere belief that birds could control insect pests and a sentimental affection for the pastoral European landscapes that imported birds were said to represent. Eugene Scheiffelin, a wealthy New York manufacturer and prominent member of the Acclimatization Society, exemplified such conflated goals through his personal attempts to import all bird species mentioned in Shakespeare.[12] Although few mirrored Scheiffelin's romantic enthusiasm, he personified the "importing mania" that swept the eastern United States in the mid-nineteenth century.[13]

Despite the initial optimism that surrounded bird importation programs, by the 1870s opinion was divided over whether introduction schemes were worthwhile. In particular, questions about the relation of the English sparrow to agricultural economy inspired heated debate in the agricultural press and natural history journals. Between 1867 and 1879, periodicals and newspapers in the United States published almost one hundred ninety articles on the subject.[14] The combatants termed the debate "the Sparrow War," and a literary battle it was indeed. Proponents of the sparrow elevated its noble service as a controller of pests; those who denigrated the bird's performance in this regard blamed it for consuming farmers' grain and driving out native birds from their favored haunts. Those who attempted to discredit the English sparrow painted their attacks in the nativist imagery usually reserved for human immigrants of the period. The English sparrow was thus portrayed as an ungrateful foreigner, taking from America what it did not return; it crowded urban centers and was said to drive out upright avian citizens. If this were not bad enough, the English sparrow immigrant shirked its duties as a "contract laborer" and was hardly better in the eyes of its critics than America's native "black," the crow.[15]

This anthropomorphic appropriation of racist and classist imagery helps to reveal the social background of the natural history literati involved in this political episode, but it also demonstrates the profoundly moral and political terms in which the "sparrow question" was conceived. As scientific investigators were drawn to examine the role of sparrows and other birds in agricultural economy during this period, the moral problem was transferred into the supposedly disinterested and systematic investiga-

tions of scientific economic ornithology. The science of economic ornithology was established to determine the morality of the economy of nature.

Although some early systematic studies in economic ornithology predated the 1870s, it was during and following the Sparrow War that economic ornithology developed as a scientific field with a theoretical basis and an institutional setting. Before the 1880s the concepts underlying economic ornithological investigations were broad and ill defined. Early investigators during the 1860s and 1870s, such as Samuel Aughey and Wilson Flagg, took it for granted that birds "performed certain services in the economy of nature, which [could not] be so well accomplished by any other species."[16] Against this background of studies that demonstrated a conceptual affinity with a natural historical teleology, investigators in the early-1880s submitted such hallowed assumptions to rigorous reinterpretation. The most important new student of the field, who reoriented its theoretical basis, was Stephen Forbes, a polymath entomologist, limnologist, and ornithologist who directed the Illinois State Laboratory of Natural History in the late-nineteenth century.[17] Although other contemporary researchers, such as the Wisconsin-based agronomist Franklin H. King, made important contributions, it was the work of Forbes that economic ornithologists later held out as the theoretical cornerstone of the field.[18]

Birth of a Science

The work of Stephen Forbes, published in a series of papers in the early-1880s, reinterpreted the latest theoretical approaches in population biology and applied those theories to specific empirical case studies.[19] Forbes's work rested on his own theoretical "first principles" laid out in a paper entitled "On Some Interactions of Organisms" published in 1880. Forbes attempted in that paper to synthesize Charles Darwin's theory of natural selection with Herbert Spencer's notion of a "balance of forces" as developed in Spencer's treatise on biology.[20] Forbes's problem was to account for the concept of equilibrium in primeval Nature, in light of evolution and natural selection. He argued that natural selection was a regulative tool that furthered natural equilibrium by adjusting reproductive rates in congruence with mortality rates and weeding out disruptive organisms that disturbed the "common interest" of population maintenance.[21] Put more simply, Forbes theorized that predator species "A," dependent upon prey species "B," would arrive at an optimum balance between its own consumption and reproduction patterns and the reproductive capacity of its prey so that its own population levels could be maintained. Species that did not conform to these rules—either because they consumed too much or reproduced too quickly—would destroy their food base and thereby submit to the harmonizing force of natural selection, which meant that better-adjusted species would squeeze them out of existence. Although Forbes's preliminary understanding helped to establish why populations of organisms supposedly were not in constant stages of flux, and why they supposedly tended toward harmony, it did not account for how occasional disturbances to equilibrium conditions, such as insect outbreaks, were eventually controlled. For, according to Forbes's understanding of the "common interest" it would be impossible to expect predators that were primarily dependent upon a given insect to diminish their prey population beyond a certain threshold since this would undercut their own food supply. To find the natural control for this anomaly relative to the "common interest" principle, Forbes suggested looking to mixed feeders that could flexibly redirect their dietary patterns to dampen population explosions without ineluctably destroying the basis of their own population.[22]

Of the mixed feeders, Forbes suggested that birds, with their locomotive power, were fitted "above all other animals and agencies, to arrest [insect population] disorder at the start,—to head off aspiring and destructive rebellion before it has had time to fairly make head."[23] By deducing the supposed function of birds in nature in relation to contemporary developments in population biology, Forbes provided a rationale for economic ornithology that distanced it from the questioned suppositions of natural history but kept intact the belief in the positive role of birds in nature. However, he did not present his theoretical first principles as laws, and undertook a series of empirical investigations to verify his hypotheses. He understood that the central question of economic ornithology—do birds do ill or good in agriculture?—was of such complexity, relating as it did to the life history of birds, the agricultural geography of different regions, and the characteristics of insect population dynamics, that a holistic conception of natural phenomena was essential. "The first, indispensable requisite," he wrote, "is a thorough knowledge of the natural order, an intelligently conducted natural survey."[24]

Economic Ornithology and the Biological Survey

Although scientists both in the United States and Canada carried out a series of natural and geological surveys before the mid-1880s, few provided a systematic or comprehensive faunal survey.[25] In the United States, some states funded individual projects that related local fauna to agricultural economy, but in Canada government support for this type of research was almost nonexistent.[26] The American Ornithologists' Union (AOU), established in 1883 as the successor to the Nuttal Ornithological Club of Cambridge, Massachusetts, offered the most concerted effort to redress this apparent deficiency. Of the projects that the AOU attempted to organize in its first years, one related to the geographic distribution of birds in North America, another to the study of bird migration, and a third to the economic status of the English sparrow. This third project drew directly on the Sparrow War controversy, and the AOU envisioned

it as the scientific final word on the debate. These projects quickly outstripped the AOU's meager resources, since they entailed collecting and assessing information and specimens from twelve hundred correspondents throughout the United States and Canada. In order to contain this expanded research program, the AOU appealed to Congress in 1885 for funding to support the research. After initial denials, the group secured a modest appropriation through the United States Department of Agriculture (USDA), thanks to political support provided by AOU friends in Congress and government entomologists active in researching the role of birds in insect control. As a result, in 1885 the AOU transferred most of its research, then under the leadership of Clint Hart Merriam, to the USDA under the auspices of the Division of Entomology. The following year, the USDA established a separate Division of Economic Ornithology and Mammalogy (which later became the Division of Biological Survey [in 1896] and then the Bureau of Biological Survey [1905–39]).[27] Although the division had a broad mandate, which wildlife control projects came to dominate in later years, throughout its history it provided institutional legitimacy to the study of the relation of birds to agriculture.

The division's first major study of economic ornithology, published in 1889, was a comprehensive bulletin on the bird that had helped spawn the agency: the English sparrow.[28] It contained a plethora of unfavorable evidence, which more than thirty-three hundred correspondents in the United States and Canada had collected since 1883. Interpretive passages discussed the importation, spread, and natural checks against the bird, as well as the bird's effects on agricultural crops and insects.[29] The bulletin's authors saw such a mammoth display of data and testimony as the only way to dispel what they took to be the irrational remnants of sentimentality for the English sparrow. The bulletin's principal editor and author, Walter B. Barrows, hoped that the bulletin would conclude the Sparrow War. "The history of the Sparrow controversy in America," he wrote,

> shows plainly...that it would be folly to expect all friends of the Sparrow to accept our conclusions as to its characteristics and habits. There are some persons whose minds are so constituted, that nothing is evidence to them except what is derived from their own observation, and as this unfortunate mental infirmity is commonly correlated with the total inability to observe anything which interferes with their theories, it makes little difference whether their opportunities have been good or bad, their position is unassailable. With this class of observers we have nothing to do. No amount of evidence will change their opinion, and fortunately for the good of mankind it makes little difference what that opinion may be.[30]

Barrows was prophetic since the sparrow controversy continued to stir debate in natural history circles until the early-twentieth century, despite the survey's damning analysis.

The study of the English sparrow helped provide the impetus for engaging a research bureaucracy in the tasks of economic ornithology, but the survey's later economic ornithological studies were generally more of a celebratory nature. The bulletin that followed the English sparrow publication was another weighty tome; it related extensive investigations by Albert K. Fisher on the economic relations of hawks and owls and was intended to dispel prevalent popular prejudice against birds of prey.[31] Before the turn of the century the survey published a variety of other studies, ranging from Foster E. L. Beal's and Frederic A. Lucas's study of the food of woodpeckers to Sylvester Judd's work on the role of birds as weed destroyers.[32] Although the survey damned the English sparrow, it often vaunted the sparrow's avian cousins as the laborers of nature.

The scientific judgments that the survey staff developed depended chiefly upon their analysis of a collection of bird stomach contents gathered by survey staff and correspondents from throughout North America. By 1899, after fourteen years of survey work, Theodore S. Palmer reported that the survey had amassed a collection "of about thirty-two thousand bird stomachs of which some fourteen thousand [have] been examined."[33] Analyzing this stomach data was tedious.[34] Researchers organized stomach contents into "good," "bad," or "neutral" categories of animal remains; plant and mineral material received separate designations. Occasionally the partially digested material was difficult to interpret and researchers routinely sought opinions from government entomologists. Once reasonably sure of the character of the stomach contents, survey staff compared the relative quantities of these components by bulk. The reasoning was that if a bird's diet appeared to contain a major portion of bad insects in relation to, for example, plant material, then it could be classified as a useful species. With few exceptions, this mode of analysis prevailed in survey research into the twentieth century. It provided a clear quantitative measure of the morality of birds in the economy of nature, which economic ornithologists mimicked in Canada and to some extent in England. Above all, the method allowed the survey to pronounce decisively and authoritatively on the economic status of birds.

Popularizing Economic Ornithology

A gamut of agencies and individuals in the U.S. and Canada helped disseminate the "knowledge" that economic ornithology generated, although the survey was acknowledged worldwide as the leader in the field. The survey itself carried out propaganda activities by publishing farmers' bulletins and by making contributions to USDA yearbooks. Individual survey members also routinely published articles in popular agricultural and natural history journals and commented in the *Auk*—the official organ of the AOU—on developments in the field.[35] A number of economic ornithologists based in state agriculture departments and experiment stations also contributed to the cause through their own popular

publications.[36] A handful of ornithologists and avid natural historians in Canada reported survey findings and the findings of other distinguished American economic ornithologists within the pages of Canadian journals.[37] Some provincial ministries of agriculture took an interest in diffusing the findings of economic ornithologists. The Ontario Department of Agriculture sponsored the publication of Charles Nash's study, *The Birds of Ontario in Relation to Agriculture;* other ministries funded occasional speakers on economic ornithology or reprinted in Sessional papers relevant American articles.[38] In general the form of presentation in this genre of propaganda literature differed markedly from the dry analyses of stomach data found in the U.S. Biological Survey's official reports.

One style of this literature evinced the moral tenor of didactic nature writing by incorporating the received "knowledge" of economic ornithological science into the discourse of bird morality. Thus, although some authors marshalled the statistics and authority of the survey to make a case for or against various bird species, the mode of delivery bore resemblance to the most emotive writings of the Sparrow War. Along one trajectory, authors praised insectivorous birds as honest, moral workers, dutifully and apparently intentionally fulfilling their natural tasks on behalf of the farmer. For example, C. D. Howe, Vermont's state ornithologist, praised hardy aves in a short 1915 article entitled "Service of the Birds":

> The birds are the farmers' and horticulturists' hired men. They work day and night, seven days in a week, 30 days in a month, 365 days in a year. These hired men do not ask wages, do not ask lodgings, and they board themselves except occasionally they may take a little cultivated fruit. They may take a chicken now and then when they are driven to it by hunger. These hired men which are working for you every day in the year do not ask for a day off to go fishing or to the ball game; they do not go out on strikes or lockouts, and they do not get drunk on Saturday nights. They are perfectly reliable workmen. And do you horticulturists and farmers realize it and do you make a definite concerted effort to protect and attract the birds?[39]

Although Howe was general in his praise of bird service, other authors differentiated among the contributions of different species.

Birds of a less pure variety that composed their diet of almost equal portions of insect and plant matter were described by some writers as mixed personalities that deserved sympathy and support. Despite their propensity to consume grain, these species were said to perform good acts on behalf of some farmers. Albert K. Fisher, a member of the survey, attempted in an 1893 bulletin to convince farmers of the seasonal utility of crows, despite their bad reputation.

> What farmer needs to be told of the unprincipled conduct of Jim Crow at and immediately after corn-planting time. The ever-present scarecrow bears mute witness to the crow's fondness for corn and his thieving habits. But when the corn is past danger the crow changes from an obnoxious to an exemplary member of bird society, and the war he wages on the cutworm earns him no scanty need of praise from the grass farmer.[40]

But although some middle-of-the-road species could be tolerated and even encouraged, there existed a group of intolerable and unrepentant rogues.

Economic ornithology popularizers labeled some species, along with the English sparrow, "good for nothings." In general, imported species were most denigrated, but some native species, which stepped beyond the supposed bounds of avian morality by squabbling with their kinfolk or gorging on grain, were also held up as examples of birds in need of salvation. George F. Atkinson, who the Manitoba government hired as a naturalist in the early-1900s, in a speech on insectivorous birds warned his audience of the "social degenerate" cowbird, which uncooperatively laid its eggs in the nests of other species.

> The depravity of a father, while deplorable, is not as generally injurious to the race where the faithful mother is at hand to counteract it, but where that mother becomes so depraved as to desire to shirk the duties of nature the demoralization is complete. In this case the knowledge of right remains...and nothing is more expressive of conviction of shame than the sneaking, skulking approach of the female cowbird to the nest....The squalling, greedy nestling which afterwards demands all of the attention of the foster parents to the neglect and frequently starvation of the rightful heirs is a striking example of the blubbering, bullying overgrown "booby," whose mother declares she is unable to control him....[I am forced] to exclaim "Oh, for a Luther to regenerate the morals of the cowbird."[41]

Although Atkinson remarked later that the cowbird performed certain important duties in insect control, he was deeply disturbed by the immorality of cowbird family life. In the conflation of economic ornithology and the discourse of bird morality, as Atkinson's concerns demonstrate, the economic was not always privileged over the moral; in some cases idealism prevailed over materialism.[42]

However, another form of discourse that treated birds not as persons writ small but as resources requiring wise management accompanied this style of moralizing as a vehicle for economic ornithological "knowledge." On one level this approach was intended to appeal to readers' common sense. Ontario naturalist William Saunders, for example, eschewed a moralizing tone in his writings on the utility of birds. In a 1938 report of the Ontario Entomological Society discussing the usefulness of owls for controlling rodent pests, Saunders weighed the benefits owls conferred against their propensity for taking farm poultry. After relating the story of an owl found dead with its stomach filled with thirteen field mice, Saunders suggested that:

> if those mice were valued at two cents each, then that owl was worth twenty-six cents a day to the neighborhood, and that amounts to nearly a hundred dollars a year. If that figure were cut in two, and again in two, it would leave the owl still worth twenty-five dollars a year, and if the bird took four turkeys partly grown and worth, perhaps,

> ten dollars for the four, the question arises, would it not be worth while to pay the owl ten dollars for twenty-five dollars of service? The answer seems to be obvious....[43]

A host of writers, generally of a scientific background, who attempted to convey the importance of birds as an economic resource paralleled Saunders's cost-benefit approach.[44]

Although such approaches to popularizing economic ornithology were intended to appeal to readers' intelligence, or at least to their pocketbooks, they also implicitly tied the issue of bird protection to other conservationist programs. According to this point of view, birds should be protected not for their aesthetic appeal but because they are natural resources that ought not be wasted. Some discussions of this subject explicitly linked birds and other natural resources, as part of conservationist politics in general. Canadian Dominion Entomologist C. Gordon Hewitt, for example, included in his book on *The Conservation of Wildlife in Canada* a special chapter on birds in relation to agriculture.[45] Similarly, the provincial agriculture ministers published in 1926 a pamphlet under the cover of the Department of the Interior that contained their views on preserving birds as "a national asset" like any other.[46] Wildlife protection legislation in the United States and Canada embodied this appeal to birds as natural resources. Survey officials helped draft the Lacey Act of 1900 in the U.S., the first national legislation of its kind, which outlined as a resource issue the need for bird protection.[47] The joint Migratory Bird Treaty that the United States and Canada signed in 1916 contained a similar rationale.[48] If birds had souls, as the bird moralists claimed, according to the conservationists they also had a dollar value.

Dual construction of birds as moral agents and as natural resources demonstrates the shifting and competing definitions of wildlife in the discourse that promoted birds as pest control agents. More broadly, birds became one of a number of sites in which dominant strains of conservationist politics could define their object. From this perspective, the vitriolic early-twentieth-century debates over so-called nature-fakery in nature writing—a fight between those who portrayed wildlife as imbued with human personality and those who sought a seemingly more "scientific" approach—can be seen as one episode in a longer dispute. Over the course of the twentieth century, nature writers and bird enthusiasts tended to drop the conception of the bird as a natural resource; the moralizing discourse met a similar fate, although it survived in a more subtle form in some quarters. Part of the reason for the decline in the description of birds as natural resources was related in general terms to the demise of economic ornithology as a science. When economic ornithologists' claims of authority came to be seriously questioned in the early-twentieth century, utility claims on behalf of birds consequently became more tenuous.

The Failure of Economic Ornithology

Environmental historians have identified several crucial factors to account for the general decline in biological control research and application in North American agriculture from 1930–60. Thomas Dunlap has demonstrated the enthusiasm with which farmers and government entomologists in the United States adopted and promoted pesticides that appeared to deal with insect pests in short order.[49] John Perkins has argued that as pesticides came to dominate the pest control literature in the late-1940s and 1950s, scientists who investigated biological control were castigated for being "out of date."[50] Others, like entomologist Robert van den Bosch, have constructed pictures of the close relationships among agribusiness, chemical firms, and government entomologists in promoting pesticides and institutionalizing the pesticide treadmill.[51] However, although increasing pesticide use—particularly after the Second World War—played an important role in undermining the necessity of biological control programs, it is questionable whether biological control offered a viable option for farmers in the early-twentieth century. Although over the last twenty years it has been demonstrated that in some agricultural systems birds can play an important role in pest control, this proposition was unproven in the early-twentieth century.[52] Economic ornithology was impractical, riven by debate over its fundamental methods, and weakened by the waning status of the U.S. Biological Survey, its major institutional sponsor.

An Applied Science?

A body of literature developed in economic ornithology between 1880 and 1930 that in its systematic and popularized forms proposed remarkably little about how one could practically take advantage of the benefits of the laborers of nature. Since the Sparrow War the implicit problem of economic ornithology was to weigh the good or ill effects of birds. Only rarely did field practitioners take the further step of suggesting how this knowledge might be applied. There were publications that advised how to poison and trap the unwanted English sparrow, but there was little advice on how to employ useful birds.[53] The most that economic ornithologists did was to advise people to plant bushes or construct birdhouses in an effort to attract desired species; although there were rare exceptions to this general lack of instruction, they only serve to prove the rule.[54]

This bias toward the observational and away from the practical in economic ornithology's direction and scope was related to the particular political context in which the science arose. From the 1880s economic ornithology served as the utilitarian "knowledge" base for bird conservationists. In advocating the usefulness of various birds, economic ornithologists called for their protection; in advocating the protection of birds, conservationists recommended their utility. In this sense economic ornithology, both in its institutional setting and its political contexts, came

to be more closely related to wildlife management science than to entomology. It is unsurprising therefore that Waldo L. McAtee, one of the survey's most important economic ornithologists in the early-twentieth century, was also the first editor of the *Wildlife Review* and founding editor of the *Journal of Wildlife Management*.[55] When the survey dissolved in 1939, effectively terminating economic ornithology within the USDA, its employees shifted to the U.S. Department of the Interior to help form the U.S. Fish and Wildlife Service.

Debates over Method

What set systematic economic ornithology apart from natural historical observation in the 1880s and after was the use of bird-diet data in formulating judgments about the economic status of birds. The methods employed to study these data and to give them significance were important: the science stood upon the foundation of bird stomach analysis. The survey primarily employed the volumetric method, which compared diet components by bulk. Prior to the survey, researchers employed a variety of methods but two general approaches dominated. One was the bulk comparison method that Stephen Forbes used in combination with careful field observation. This was the approach that the survey later used in an abstracted form. Another was the so-called numerical method, which consisted of the careful listing of the number of occurrences of food items found in bird stomach data. Wisconsin agronomist Franklin H. King favored this method, which was also popular in Britain.[56] A third and generally unpopular approach called the gravimetric method entailed comparing data by weight. Only German economic ornithologist Georg Rorig consistently used this method.[57]

Although late–nineteenth-century economic ornithologists in North America used several methods in their practice, after the survey was established the volumetric method became dominant. The work of Foster E. L. Beal, a senior survey economic ornithologist in the late-nineteenth and early-twentieth centuries who was both a respected and prolific scientist, provides a case in point. British economic ornithologist Walter Collinge described Beal as "the most brilliant economic ornithologist of his day."[58] By the end of his career, Beal had examined 37,825 bird stomachs and authored over twenty publications for the survey.[59] His most popular publication, "Some Common Birds in Their Relation to Agriculture," first published in 1897, was reprinted more than fifty times and had more than a million of its copies distributed.[60] After his death in 1916, Beal's former colleague McAtee claimed that along with Forbes, Beal was cofounder of the scientific approach to economic ornithology. "Professor Forbes dealt with the subject in a broad, philosophical way, but soon gave it up," McAtee wrote, "while Professor Beal devoted himself practically for the remainder of his life to piling up detailed evidence, leaving the general principles to become apparent of themselves."[61] Indeed, Beal's prolific life work was notable for its empiricist zeal and not for its theoretical subtlety.

Beal's one attempt to present the theoretical underpinnings for his methodology was in his 1908 paper called "The Relations Between Birds and Insects."[62] The paper was a condensed reiteration of Forbes's classic "On Some Interactions of Organisms," published twenty-eight years earlier.[63] However, unlike Forbes's theoretical understanding of birds' role in nature, Beal based his argument on the revealed truths of stomach data. At the opening of the paper Beal listed the percentage breakdown of various foodstuffs in the diets of a variety of birds. The data were provided by earlier survey studies and thus contained an indiscriminate collation of stomach data from birds throughout North America, collected over all seasons. The seeming statistical precision of this data (which Beal took to two decimal places), rather than the context from which they were drawn, was as crucial for Beal as it was for the survey in general.[64] The hard statistics offered by the volumetric method provided hard advice; the so-called numerical method, which Beal criticized, provided mere lists of diet components.[65]

Despite the survey's dominance in the field, however, other studies in the first decade of the twentieth century questioned the foundation of the volumetric method. Sylvester Judd, a survey employee, conducted a painstaking study over a number of years of economic ornithology on one farm in Maryland to compare the general statistical results of survey research with the evidence of one locality.[66] To his chagrin, he found that birds on the farm rarely focused their consumption on problem pests but happily spent their days consuming "hordes of harmless insects" on the banks of the Potomac River.[67] This result demonstrated that the general character of bird diet provided little guidance as to the effect of birds in different agricultural systems. Yet in spite of the important implications that Judd's study had for the research strategy of the survey, his contribution created no methodological reflection within the agency. Another line of criticism arising from outside the survey itself questioned the relevance of the volumetric method. C. W. Mason, a proponent of the numerical method developed by fellow Briton Robert Newstead, claimed in 1912 that "comparative bulks of foods, if expressed merely as percentages, are of absolutely no value whatsoever, and cannot give any idea as to the true economic ratio of the food of the bird in question."[68] Unlike Judd's study, Mason's critical aspersions did not go unnoticed.

In the same year as Mason's publication, McAtee, who later became Director of the Biological Survey's Foods Habits Division, wrote a stinging review of numerical methods in the *Auk* and gave Mason's study special condemnation.[69] McAtee's critique, however, was not simply aimed at contemporary approaches; he searched the history of economic ornithology to criticize the methods of ghosts and exorcise their perhaps forgotten influence. Thus he held

up King's forgotten methods to this polemical guillotine, along with the methods of E. V. Wilcox (published in 1892), John Gilmour (published in 1896), and Newstead (the only contemporary study, except Mason's, published in 1908).[70] Part of his criticism was that those who found fault with the volumetric method had adopted no single numerical method. In his view, the variety of numerical methods suggested a state of intellectual hodgepodge.[71] He also argued that numerical methods exaggerated the amount of some animal foods in stomach analysis, since more resistant animal parts remained in the stomach longer than others.[72] The implication was that numerical results were, even before interpretation, distorted, unlike volumetric methods, which smoothed over such difficulties. Most of McAtee's concern, however, centered on the belief that the numerical method provided no basis for quantitative comparison and was thus "powerless to convey an impression of economic values."[73] In contrast, the volumetric method provided data that was easily presented to the public and which incorporated some form of quantitative analysis, a fact he thought crucial. "Lord Kelvin has said," he wrote,

> [that] "when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind..." It follows therefore, that a method of estimating bird food which is powerless to express anything about a considerable portion of the food, has "scarcely advanced to the stage of science."[74]

With a combination of argument and assertion, and liberal use of quoted authorities, McAtee provocatively defended the survey's methodology as the only method that had "advanced to the stage of science."

In the short term, McAtee's review received only admiring responses. In Britain where the numerical method held more sway, Walter E. Collinge wrote a 1918 article that explicitly reiterated McAtee's points and even contained the same Lord Kelvin quotation.[75] In North America, where the volumetric method was generally applied, there were apparently no criticisms of McAtee's critique. The only citations to the paper were favorable, as in Junius Henderson's discussion of "methods of investigation," published a year after McAtee's study. Referring to the volumetric method that the survey employed, Henderson asserted that "from a decision based upon such evidence [volumetric analysis], providing a sufficient number of stomachs are examined with care, there is no appeal."[76] The volumetric method and the survey had their defenders.

There were further criticisms of the survey's economic ornithological methods during the 1920s and 1930s. Scottish scientist James Ritchie offered one of the most cogent of these criticisms in a series of articles in the 1920s that logically dismantled the volumetric approach on its methodological and theoretical bases.[77] But more important developments during this period occurred in entomological science. Entomological advances in the analysis of insect population dynamics and in the factors regulating them served to undermine the bold claims that economic ornithologists made on behalf of their subjects. In 1928, Canadian entomologist Edgar H. Strickland criticized economic ornithologists for their meager understanding of entomology. The simple knowledge, he claimed, that birds consume many insects did not prove their utility in dampening insect outbreaks.[78] C. N. Ainslie of the U.S. Bureau of Entomology later suggested that economic ornithologists overstated the usefulness of birds and ignored more important regulators of insect outbreaks, such as parasitic agents.[79] These arguments paralleled debates concerning population dynamics in mammalogy. Quantitative methods of animal ecology, of which new approaches in entomology were part, challenged the older natural history tradition of collection and qualitative analysis both in ornithology and mammalogy.[80]

Developments in entomology and animal ecology did not necessarily mean the end of economic ornithology. As early as the 1910s some entomologists, such as Harold C. Bryant and George W. Barber, in order to develop a more sophisticated understanding of economic ornithology, applied new techniques of estimating insect populations and the numerical and behavioral responses of birds in outbreak cases.[81] Within the survey, however, which had led economic ornithology since its founding, such a reorientation was not forthcoming. Waldo L. McAtee, who previously defended the volumetric method, in 1926 stated cautiously when referring to the survey's approach that "investigations are for the most part...directed toward learning what birds eat in general, rather than determining the explicit effects of their food habits upon certain insects and other pests."[82] The internal debates about economic ornithology, combined with external developments in the study of population dynamics, served to dampen the enthusiasm with which economic ornithologists trumpeted the utility of certain birds.

A Bureau of Destruction

The declining political reputation of the survey in conservationist circles in the 1920s and 1930s, combined with the weakening of the "science" of economic ornithology, helped undermine the survey's legitimacy as a scientific voice for bird protection in the United States. Although since its founding the survey acted as a major sponsor of basic biological research in North America, beginning in the early-twentieth century wildlife control became one of the agency's major preoccupations. Although the survey took on several tasks after passage of the Lacey Act in 1900, national wildlife control programs steadily gained in importance.[83] Survey historian Jenks Cameron tabulated that by 1928 the survey had spent somewhere around $10,212,353 on predatory animal and rodent control work. This money between 1915 and 1928 helped

account for the killing of 419,443 predatory animals in the United States, helping lead to a discrediting of economic ornithologists in the eyes of some wildlife conservationists.[84] The survey was not only negligent in monitoring sport hunting at sanctuaries in the 1920s, but the institution itself became known as a bureaucratic shell for animal extermination programs.[85] The Emergency Conservation Committee chastised the survey in 1934 as the "United States Bureau of Destruction and Extermination" and published a pamphlet condemning the "misnamed and perverted" institution.[86] The survey's deeds spoke more strongly than the trickle of survey pamphlets on the utility of birds.

Demise of Economic Ornithology

Although by the 1930s internal difficulties may have weakened the biological control project that economic ornithology represented, after the ascendancy of pesticides during and following World War II the idea of the role of birds as agents of biological control fell out of favor. On the scientific side, in entomology the prestige of pesticide research redirected the research and development interests of pest control scientists. Research in biological control and basic field research on insects in the field declined; pesticide research filled the journals of applied entomology.[87] Economic ornithology demonstrated this trend. Over the period that synthetic organic pesticides rose to prominence, research on the beneficial effects of birds in agriculture dropped dramatically. At the same time, investigations of birds as pests experienced a notable increase. In *Wildlife Abstracts* between 1931 and 1951 there were forty-four articles relating to bird diet; twenty were not economic in scope, twenty-two demonstrated the beneficial activities of birds, and two concerned birds as pests. Between 1952 and 1955, by contrast, there was one article on the beneficial activities of birds and fifteen on the subject of birds as pests. In the next four years, there were no articles on the beneficial use of birds and thirty-six on bird pest control.[88] After the decline of economic ornithology, birds were no longer the laborers of nature in the pest control literature; instead they were either irrelevant or pests.

On a material level the possibility of birds as pest-control agents faded with the progress of industrialization in agriculture. This resulted both because the increasing use of pesticides held out the unintended consequence of harming and sometimes killing birds, and because the trend toward monoculture and increased field sizes, two hallmarks of industrialization, reduced bird habitat. The place of birds within such an evolving agroecology became increasingly problematic.

The irony in the story of economic ornithology is that when conservationists and environmentalists questioned this new state of affairs it was within new conceptual terms of reference that industrialization created. When Rachel Carson published *Silent Spring* in 1962, revealing to the public the danger of indiscriminate pesticide use, few people probably stopped to wonder how over the course of more than thirty years the image of the "bird" had been completely transformed.[89] The new environmentalism took birds to be muted victims of progress. Spring was silent because no birds sang; gone was a vision of birds as an alternate form of pest control. The biological control efforts of economic ornithology failed not only because of the rise of pesticides. The internal weaknesses of the science and environmentalists' abandonment of the idea of birds as part of agriculture left the concept of avian agent biological control unthinkable until it was resurrected much later.

Notes

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1. George Perkins Marsh, *Man and Nature*, ed. David Lowenthal (1864; reprint, Cambridge, Massachusetts: Harvard University Press, 1965), pp. 92-93. For Marsh's views on the utility of birds, see pp. 78-88.
2. Some of the most important studies include James Whorton, *Before Silent Spring: Pesticides in Pre-DDT America* (Princeton, New Jersey: Princeton University Press, 1974); Thomas Dunlap, *DDT: Scientists, Citizens and Public Policy* (Princeton, New Jersey: Princeton University Press, 1981); John H. Perkins, *Insects, Experts and the Insecticide Crisis: The Quest for New Pest Management Strategies* (New York: Plenum Press, 1982). On Canadian material, see Paul W. Reigert, *From Arsenic to DDT: A History of Entomology in Western Canada* (Toronto, Ontario: University of Toronto Press, 1980).
3. For consideration of biological control, see Perkins, *Insects;* Richard C. Sawyer, "Monopolizing the Insect Trade: Biological Control in the USDA, 1888-1951," *Agricultural History* 64, no. 2 (Spring 1990): 271-85; Paolo Palladino, "Biological Control in Canada: The Establishment of Biological Control, 1900-1920" (manuscript in author's possession, n.d.). I thank Richard Jarrell for bringing the Palladino paper to my attention. Eric L. Jones has examined the role of birds in agricultural economy, but only in terms of their pestilent activities. See Eric L. Jones, "The Bird Pests of British Agriculture in Recent Centuries," *Agricultural History Review* 20 (1972): 107-25.
4. For reviews of this literature, see Charles H. Buckner, "The Role of Vertebrate Predators in the Biological Control of Forest Insects," *Annual Review of Entomology* 11 (1966): 449-66; Robert W. McFarlane,

"Birds as Agents of Biological Control," *The Biologist* 58, no. 4 (November 1976): 123-40; Imre S. Otvos, "The Effect of Insectivorous Bird Activities in Forest Ecosystems: An Evaluation," in James G. Dickson, Richard N. Connor, Robert R. Fleet, Jerome A. Jackson, and James C. Kroll, eds., *The Role of Insectivorous Birds in Forest Ecosystems* (New York: Academic Press, 1979); David Kirk, Matthew D. Evenden, and Pierre Mineau, "Past and Current Attempts to Evaluate the Role of Birds as Predators of Insect Pests, With Emphasis on Temperate Agroecosystems" (manuscript, Canadian Wildlife Service [National Wildlife Resource Center, Environment Canada, 100 Gamelin Boulevard, Hull, Quebec], 1995). More recent work along this trajectory includes Ada C. Fowler, Richard L. Knight, T. Luke George, and Lowell C. McEwen, "Effects of Avian Predation on Grasshopper Populations in North Dakota Grasslands," *Ecology* 72, no. 5 (October 1991): 1775-81; Lowell C. McEwen, Lawrence R. DeWeese, and Philip Schladweiler, "Bird Predation on Cutworms (Lepidoptera: Noctuidae) in Wheat Fields and Chlorpyrifos Effects on Brain Cholinesterase Activity," *Environmental Entomology* 15, no. 1 (February 1986): 147-51.

5. For a full listing of the primary literature consulted, see Matthew D. Evenden, "An Annotated Bibliography Concerning the Role of Birds in the Control of the Insect Pests of Agriculture" (manuscript, Canadian Wildlife Service, 1992), pp. 1-64. The author produced the bibliography while under contract with Environment Canada.

6. Clarence J. Glacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century* (Berkeley: University of California Press, 1967), p. 693. Peter Kalm remarked upon Franklin's interest in the utility of birds as well. See Peter Kalm, *Travels in North America,* trans. J. R. Foster, 2d ed., 2 vols. (London, England: T. Lowndes, 1772), 1:372. On Saint-Pierre and others, see Frank N. Egerton, "Changing Concepts of the Balance of Nature," *Quarterly Review of Biology* 48, no. 2 (June 1973): 338.

7. Frederic De Tschudi, "Destructive Insects and the Immense Utility of Birds," trans. by H. L. B. Ibbeston, *Journal of the Royal Agricultural Society of England* 23 (1860-64): 233.

8. De Tschudi, "Destructive Insects," p. 233.

9. Glacken, *Traces on the Rhodian Shore;* Egerton, "Changing Concepts"; Carl Berger, *Science, God and Nature in Victorian Canada* (Toronto, Ontario: University of Toronto Press, 1983).

10. John L. Long, *Introduced Birds of the World: The Worldwide History, Distribution and Influence of Birds Introduced to New Environments* (New York: Universe Books, 1981), pp. 11-12; George Laycock, *The Alien Animals* (Garden City, New York: The Natural History Press, 1966), pp. 70-89. On the general process of "biological exchange," or his later term "ecological imperialism," see Alfred Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (Cambridge, England: Cambridge University Press, 1986).

11. Clarence M. Weed and Ned Dearborn, *Birds in Their Relation to Man: A Manual of Economic Ornithology for the United States and Canada,* 3d ed. (1903; reprint, Philadelphia, Pennsylvania: Lippincott, 1924), p. 356. Laycock, *Alien Animals,* pp. 70-73.

12. Felton Gibbons and Deborah Strom, *Neighbors to the Birds: A History of Bird Watching in America* (New York: W. W. Norton, 1988), p. 216.

13. Michael J. Brodhead, "Elliot Coues and the Sparrow War," *New England Quarterly* 44, no. 3 (September 1971): 421.

14. Walter B. Barrows, *The English Sparrow (Passer domesticus) in North America Especially in Its Relations to Agriculture,* United States Department of Agriculture (USDA) Division of Economic Ornithology and Mammalogy, Bulletin no. 1 (Washington, D.C.: Government Printing Office, 1889), p. 303. Barrows, in the process of reviewing the literature, cites a study by Elliot Coues listing the one hundred ninety articles.

15. Brodhead, "Elliot Coues," p. 432; Robin W. Doughty, "Sparrows for America: A Case of Mistaken Identity," *Journal of Popular Culture* 14, no. 2 (Fall 1980): 212-28.

16. Quoted in Weed and Dearborn, *Birds in Their Relation to Man,* p. 18.

17. On other aspects of Stephen Forbes's career, see F. Garvin Davenport, "Natural Scientists and the Farmers of Illinois, 1865-1900," *Illinois State Historical Journal* 58 (1958): 357-79; Robert P. McIntosh, *The Background of Ecology: Concept and Theory* (Cambridge, England: Cambridge University Press, 1985), p. 59; Stephen Bocking, "Stephen Forbes, Jacob Reighard, and the Emergence of Aquatic Ecology in the Great Lakes Region," *Journal of the History of Biology* 23, no. 3 (Fall 1990): 464.

18. Waldo L. McAtee, "Economic Ornithology," in Frank M. Chapman and Theodore S. Palmer, eds., *Fifty Years' Progress in American Ornithology 1883-1933* (Lancaster, Pennsylvania: American Ornithologists' Union, 1933), p. 112; Weed and Dearborn, *Birds in Their Relation to Man,* frontispiece. Another major study in this area was Franklin H. King, "Economic Relations of Wisconsin Birds," *Transactions of the Wisconsin State Agricultural Society* 24 (1886): 372-480.

19. Stephen A. Forbes, "On Some Interactions of Organisms," *Illinois State Natural History Bulletin* 1, no. 3 (November 1880), pp. 3-18; Stephen A. Forbes, "The Food of Birds," *Illinois State Natural History Bulletin* 1, no. 3 (November 1880), pp. 80-148; Stephen A. Forbes, "The Ornithological Balance Wheel," *Transactions of the Illinois Horticultural Society,* n.s., 15 (1881), pp. 120-31; Stephen A. Forbes, "The Regulative Action of Birds on Insect Oscillations," *Illinois State Natural History Bulletin* 1, no. 6 (May 1883), pp. 3-32.

20. Forbes, "Some Interactions," p. 5; Sharon E. Kingsland, "Defining Ecology as a Science," in Leslie A. Real and James H. Brown, eds. *Foundations of Ecology: Classic Papers with Commentaries* (Chicago, Illinois: University of Chicago Press, 1991), pp. 1-13; Herbert Spencer, *The Principles of Biology,* 2 vols. (London, England, and Edinburgh, Scotland: Williams and Norgate, 1884), 2:401.

21. Forbes, "Some Interactions," p. 6.

22. Forbes, "Some Interactions," p. 7.

23. Forbes, "Some Interactions," p. 13.

24. Forbes, "Some Interactions," p. 16.

25. For Canadian surveys, see W. A. Waiser, *The Field Naturalist: John Macoun, the Geological Survey and Natural Science* (Toronto, Ontario: University of Toronto Press, 1989); Suzanne Zeller, *Inventing Canada: Early Victorian Science and the Dream of A Transcontinental Nation* (Toronto, Ontario: University of Toronto Press, 1987).

26. Marianne G. Ainley, "From Natural History to Avian Biology: Canadian Ornithology 1860-1950" (Ph.D. diss., McGill University, 1985), pp. 69-70.

27. Theodore S. Palmer, "A Brief History of the American Ornithologists' Union," in Chapman and Palmer, eds., *Fifty Years' Progress,* pp. 7-13; Jenks Cameron, *The Bureau of Biological Survey: Its History, Activities and Organization* (Baltimore, Maryland: Johns Hopkins Press, 1929), pp. 19-21.

28. Barrows, *The English Sparrow.*

29. Although Barrows wrote most of such discussion in the bulletin, Charles V. Riley, a USDA entomologist, contributed a small section on the insectivorous habits of the bird. See Barrows, *The English Sparrow,* pp. 111-25. Also, Albert K. Fisher wrote on poisoning methods and W. T. Hill discussed trapping methods. See Barrows, *The English Sparrow,* pp. 174-91.

30. Barrows, *The English Sparrow,* p. 13.

31. Albert K. Fisher, *The Hawks and Owls of the United States in Their Relation to Agriculture,* Division of Economic Ornithology and Mammalogy, Bulletin no. 3 (Washington, D.C.: USDA, 1893). Fisher published a number of other articles to popularize the benefits conveyed by predaceous birds. See Albert K. Fisher, *Hawks and Owls from the Farmer's Point of View,* Biological Survey Circular no. 61 (Washington, D.C.: USDA, 1907); Albert K. Fisher, "The Economic Value of Predaceous Birds and Mammals," *The Yearbook of the United States Department of Agriculture, 1908* (Washington, D.C.: USDA, 1909).

32. Foster E. L. Beal and Frederic A. Lucas, *The Food and Tongues of Woodpeckers,* USDA Division of Economic Ornithology and Mammalogy, Bulletin no. 7 (Washington, D.C.: USDA, 1895); Sylvester D. Judd, "Birds as Weed Destroyers," *Yearbook of the United States Department of Agriculture, 1898* (Washington, D.C.: USDA, 1899). For a comprehensive listing of the survey's publications through this period, see Waldo L. McAtee, *Index to Papers Relating to the Food of Birds by Members of the Biological Survey in Publications of the United States Department of Agriculture, 1885-1911,* Biological Survey Bulletin no. 43 (Washington, D.C.: USDA, 1913).

33. Theodore S. Palmer, quoted in Weed and Dearborn, *Birds in Their Relation to Man,* p. 24.

34. Although bulletins commonly provided descriptions of methods, McAtee provided a particularly detailed one in Waldo L. McAtee, "Farm Help from the Birds," *The United States Department of Agriculture Yearbook, 1920* (Washington, D.C.: USDA, 1921).

35. Such literature was extensive; the listing provided in the next two notes is illustrative and not comprehensive. See, for example, Foster E. L. Beal, "Birds as Conservators of the Forest," in *Eighth and Ninth Reports of the Forest, Fish and Game Commission of the State of New York, 1901-1903* (Albany, New York: J. B. Lyon, 1903); Waldo L. McAtee, "Bird Enemies of Forest Insects," *American Forestry* 21, no. 6 (June 1915): 681-91; Waldo L. McAtee, "Birds and Other Checks on Insects," *Science Monthly* 27 (July 1928): 77-80; Edwin R. Kalmbach, "The Crow, Bird Citizen of Every Land: A Feathered Rogue Who Has Many Fascinating Traits and Many Admirable Qualities Despite His Marauding Propensities," *National Geographic* 37, no. 4 (April 1920): 322-37.

36. Clarence M. Weed, *The Winter Food of the Chickadee,* Bulletin 54 (n.p.: New Hampshire College Agricultural Experiment Station, 1898); Frank M. Chapman, *The Economic Value of Birds to the State* (Albany, New York: Lyon, 1903); Edward H. Forbush, *Useful Birds and Their Protection* (Boston: Massachusetts State Board of Agriculture, 1905); C. J. Pennock, "The Value of Birds to the Agriculturist," *The Fifth and Sixth Annual Reports of the Delaware State Board of Agriculture* (Dover: Delawarean Printer, 1906); F. H. Hall, "Birds in Relation to Agriculture," in *Addresses to Farmers' Institutes, 1911-1912,* Bulletin 37 (n.p.: New York State Department of Agriculture, 1912); Junius Henderson, *The Practical Value of Birds,* University of Colorado Bulletin 13, no. 4 (Boulder: University of Colorado, 1913); Weed and Dearborn, *Birds in Their Relation to Man;* "Birds," *Yearbook on Texas Conservation of Wildlife, 1929-1930* (Austin, Texas: Game, Fish and Oyster Commission, 1930).

37. A. B. Ketchen, "The Farmer's Feathered Friends," *Ontario Agricultural College Review* 15, no. 5 (1902-1903): 15-17; Leon A. Provancher, *Les Oiseaux Insectivores* (Quebec, Canada: Dussault & Proulx, 1905) [an extract from a brochure originally published in 1874]; William E. Saunders, "Birds the Farmers Friends," *Ontario Agricultural College Review* 21, no. 8 (1908-1909): 448-50; Lionel E. Taylor, "Economic Ornithology," *Proceedings of the Entomological Society of British Columbia,* n.s., 3 (1913), pp. 37-41; Norman Criddle, "Birds in Relation to Insect Control," *Canadian Field Naturalist* 34, no. 8 (November 1920): 151-53. Criddle, a Dominion entomologist, wrote six economic ornithological articles between 1914 and 1922. See also W. E. Whitehead, "Birds and Insect Control," *The Journal of Agriculture and Horticulture* 33, no. 6 (1 December 1929): 82-83; René Mougeot, "Les Oiseaux, Auxiliaires de l'Homme," *Le Naturaliste Canadien* 58, no. 8-9 (August-September 1931): 153-60; Georges Maheux, "Les Oiseaux Auxiliaires de l'Agriculture," *Le Naturaliste Canadien* 59, no. 12 (December 1932): 242-46.

38. Charles Nash, *The Birds of Ontario in Relation to Agriculture* (Toronto, Ontario: Ontario Department of Agriculture, 1898). Nash's book/pamphlet was reprinted a number of times. See also Ontario Agricultural Commission, "Chapter VI: Insectivorous Birds," *Report of the Commissioners,* vol. 1 (Toronto, Ontario: C. Blackett Robinson, 1881), pp. 206-19, and appendix E of Ontario Agricultural Commission, "Evidence on Insects and Insectivorous Birds," *Report of the Commissioners,* vol. 3 (Toronto, Ontario: C. Blackett Robinson, 1881). The commissioners thought the good deeds of birds were highly overrated. The governments of Manitoba and the Northwest Territories in the late-nineteenth century hired George Atkinson as a consulting naturalist; he published a popular talk on economic ornithology. See George F. Atkinson, "Insectivorous Birds of Manitoba," *The Historical and Scientific Society of Manitoba,* Transaction 60 (Winnipeg, Manitoba: The Stovel Printers, 1903), 1-20. Original and reprinted occasional papers and economic ornithological notes appeared in the Ontario Entomological Society reports and Agricultural Society reports included in the *Ontario Sessional Papers* (ca. 1885-1921). See, for example: Edward H. Forbush, "Birds as Protectors of Orchards," *Ontario Sessional Papers,* no. 19 (1896): 53-63. Forbush was the Massachusetts Department of Agriculture's ornithologist at this time. See also William Lochead, "Inter-Relations in Nature," *Ontario Sessional Papers,* no. 36 (1921): 53-60. Other examples of governmental publications include "Birds," *Sixth Report of the Department of Agriculture of British Columbia, 1900* (Victoria, British Columbia: R. Wolfenden Printer, 1901), pp. 180-86; William P. Fraser, "The Economic Importance of Land Birds," *Fourth Annual Report of the Quebec Society for the Protection of Plants from Insects and Fungous Diseases, 1911-1912* (Quebec, Canada: King's Printer, 1912). The geological survey sponsored one original piece of economic ornithological research, Percy A. Taverner, "The Hawks and Owls of the Canadian Prairie Provinces in Their Relation to Agriculture," *Geological Survey Museum Bulletin,* no. 28, Biological Series no. 7 (August 1918), pp. 1-18.

39. C. D. Howe, "Service of the Birds," in *Seventh Annual Report of the Commissioner of Agriculture for the State of Vermont, 1915* (St. Albans, Vermont: n.p., 1915), p. 71.

40. Fisher, *Hawks and Owls,* p. 9.

41. Atkinson, "Insectivorous Birds," p. 5.

42. For a general discussion of the place of bird "morality" in nature writing of the period, see Peter J. Schmitt, *Back to Nature: The Arcadian Myth in Urban America* (New York: Oxford University Press, 1969), esp. pp. 33-55.

43. William E. Saunders, "The Value of Predatory Birds," in *Sixty-Ninth Annual Report of the Ontario Entomological Society* (Toronto, Ontario: T. E. Bowman Printer, 1938), p. 120.

44. See, for example, Forbush, *Useful Birds.*

45. C. Gordon Hewitt, *The Conservation of Wildlife in Canada* (New York: Charles Scribner's Sons, 1921), pp. 166-92. Hewitt served as entomologist from 1909-20.

46. *Birds A National Asset: Views of the Provincial Ministers of Agriculture* (Ottawa, Ontario: Canada National Parks Branch, Department of the Interior, 1926).

47. Theodore Whaley Cart, "The Lacey Act: America's First Nationwide Wildlife Statute," *Forest History* 17, no. 3 (October 1973): 6.

48. William S. Haskell, "Protection of Migratory Birds," in *Report of the Fifth Annual Meeting of the Commission of Conservation of Canada* (Toronto, Ontario: Bryant Press, 1914); George E. Lawyer, "Federal Protection of Migratory Birds: Bird Protection an Economic Question," in *Yearbook of the United States Department of Agriculture, 1918* (Washington, D.C.: USDA, 1919); Janet Foster, *Working for Wildlife: The Beginning of Preservation in Canada* (Toronto, Ontario: University of Toronto Press, 1978), pp. 120-48. Foster's discussion of the Migratory Bird Treaty is tellingly entitled "Protecting an International Resource."

49. Dunlap, *DDT;* Thomas Dunlap, "The Triumph of Chemical Pesticides in Insect Control," *Environmental Review* 2, no. 5 (May 1978): 19-37. I believe Dunlap's characterization of chemical pesticides as a "triumph" at this early date is premature. See Sawyer, "Monopolizing the Insect Trade."

50. Perkins, *Insects,* p. 13.
51. Robert van den Bosch, *The Pesticide Conspiracy* (Garden City, New York: Doubleday, 1978).
52. See footnote 4 above.
53. One example of this literature is Ned Dearborn, *How to Destroy English Sparrows,* USDA Farmers' Bulletin no. 383 (Washington, D.C.: USDA, 1910).
54. Waldo McAtee authored a number of instructive pamphlets on such matters. See Waldo McAtee, "Plants Useful to Attract Birds and Protect Fruit," in *Yearbook of the United States Department of Agriculture, 1909* (Washington, D.C.: USDA, 1910), pp. 185-96; and Waldo McAtee, *How to Attract Birds in the East Central States,* Farmers' Bulletin no. 912 (Washington, D.C.: USDA, 1918). One could also consider articles written to inspire bird habitat maintenance on farms as part of this limited instructive literature. See E. A. Sterling, "Adirondack Birds in Their Relation to Forestry," *Forest Quarterly* 1, no. 1 (October 1902): 18-25; Ralph K. Day, "Grazing Out the Birds: Studies Reveal Abuse of Farm Woodlots is Speeding Extermination of Bird Life and Inviting Invasion of Crop Destroying Insects," *American Forests and Forest Life* 36, no. 9 (September 1930): 555-57; Johnson A. Neff, "Comments on Birds and Codling Moth Control in the Ozarks," *Wilson Bulletin* 54, no. 1 (March 1942): 21-24.
55. Edwin R. Kalmbach, "In Memoriam: W. L. McAtee," *The Auk* 80 (October 1963), p. 478.
56. King, "Economic Relations." For a review of economic ornithology in England from a volumetricist's point of view, see Walter E. Collinge, *The Food of Some British Wild Birds: A Study in Economic Ornithology,* 2d ed. (York, England: Walter Collinge, 1924-27).
57. Georg Rorig, *Tierwelt und Landwirtschaft: Des Landwirtes Freunde und Feinde Unter den Freilebenden Tieren* (Stuttgart, Germany: Verlagsbuchhandlung Eugen Ulmer, 1906). The title is roughly translated as "The Animal World and Agriculture: Of the Land's Friends and Enemies of the Freeliving Animals."
58. Collinge, *Food of Some British Wild Birds,* frontispiece.
59. Waldo L. McAtee, "Life and Writings of Professor F. E. L. Beal," *The Auk* 34, no. 3 (July 1917): 252.
60. McAtee, "Life and Writings," p. 251. The Department of Agriculture distributed the article in Canada as well. See Foster E. L. Beal, "Some Common Birds in Their Relation to Agriculture," *Bulletin of Foreign Agricultural Intelligence* 5, no. 8 (August 1915): 657-86.
61. McAtee, "Life and Writings," p. 249.
62. Foster E. L. Beal, "The Relations Between Birds and Insects," in *Yearbook of the United States Department of Agriculture, 1908* (Washington, D.C.: USDA, 1909), pp. 343-50.
63. Beal, "Relations," pp. 344-46.
64. For an example of Beal's concern with statistical precision, coupled with ecological imprecision, see Foster E. L. Beal, *Food of Our More Important Flycatchers,* Biological Survey Bulletin no. 44 (Washington, D.C.: USDA, 1909), p. 5.
65. Beal provided an involved criticism in Foster E. L. Beal, "Recent Investigations of the Food of European Birds," *The Auk* 14, no. 1 (January 1897): 8-14. He particularly criticized the numerical method developed by Gilmour in John Gilmour, "Bird Investigation, An Inquiry Concerning the Relation of Certain Birds to the Agricultural Interest as Shown by Their Diet," *Transactions of the Highland and Agricultural Society,* 5th ser., 8 (1896): 21-113.
66. Sylvester D. Judd, *Birds of A Maryland Farm, A Local Study in Economic Ornithology,* Biological Survey Bulletin no. 17 (Washington, D.C.: USDA, 1902).
67. Judd, *Birds of A Maryland Farm,* p. 28.
68. C. W. Mason, "The Food of Birds of India," *Memoirs of the Department of Agriculture, India, Entomological Series,* ed. H. Maxwell-Lefroy, 12 vols. (London, England: Imperial Department of Agriculture, 1906-31), 3:19. Newstead outlined his approach in Robert Newstead, "The Food of Some British Birds," *The Journal of the Board of Agriculture Supplement* 15, no. 9 (December 1908): 1-87.
69. Waldo L. McAtee, "Methods of Estimating the Contents of Bird Stomachs," *The Auk* 29, no. 4 (October 1912): 449-64.
70. King, "Economic Relations"; E. V. Wilcox, "The Food of the Robin," *Ohio Agricultural Experiment Station,* Bulletin 43 (September 1892), pp. 115-31; Gilmour, "Bird Investigation"; and Newstead, "Food of Some British Birds."
71. McAtee, "Methods of Estimating," p. 450.
72. McAtee, "Methods of Estimating," p. 457.
73. McAtee, "Methods of Estimating," p. 453.
74. McAtee, "Methods of Estimating," p. 457.
75. Walter E. Collinge, "On the Value of Different Methods of Estimating the Stomach Contents of Wild Birds," *Scottish Naturalist,* no. 77 (May 1918): 103-108. This paper was republished in his collection, Collinge, *Food of Some British Wild Birds,* pp. 25-36.
76. Henderson, *Practical Value,* p. 18.
77. From 1922 to 1925, Ritchie produced a series of articles under the title, "Farm Pests," in the *Scottish Journal of Agriculture.* Those with particular bearing on economic ornithological methods include James Ritchie, "Farm Pests: Birds," *Scottish Journal of Agriculture* 7, no. 1 (January 1924): 34-39; and James Ritchie, "Farm Pests: Birds," *Scottish Journal of Agriculture* 7, no. 2 (April 1924): 171-79.
78. Edgar H. Strickland, "Can Birds Hold Injurious Insects in Check?" *Science Monthly* 26 (January 1928): 48. Waldo McAtee disagreed with Strickland's emphasis on parasites and cited Stephen Forbes as his authority. See McAtee, "Birds and Other Checks on Insects."
79. C. N. Ainslie, "The Economic Importance of Birds as Insect Predators," *Wilson Bulletin* 42, no. 3 (September 1930): 193-97.
80. Thomas R. Dunlap, *Saving America's Wildlife* (Princeton, New Jersey: Princeton University Press, 1988), pp. 52-53.
81. Harold C. Bryant, "The Relation of Birds to an Insect Outbreak in Northern California During the Spring and Summer of 1911," *Condor* 13, no. 6 (November 1911): 195-208; George W. Barber, "The Efficiency of Birds in Destroying the Over-Wintering Larvae of the European Corn Borer in New England," *Psyche* 32, no. 1 (February 1925): 30-46.
82. Waldo L. McAtee, "The Role of Vertebrates in the Control of Insect Pests," *Smithsonian Institution Annual Report for 1925* (Washington, D.C.: Smithsonian Institute, 1926), p. 417.
83. Cameron, *Bureau of Biological Survey,* p. 315. Survey presentation of data over time definitely shifted, but the fundamental method did not alter substantially.
84. Keir B. Sterling, "Builders of the U.S. Biological Survey, 1885-1930," *Journal of Forest History* 33, no. 4 (October 1989): 187.
85. Regarding the survey's negligence in monitoring sport hunting at sanctuaries, see Thomas R. Dunlap, "'The Coyote Itself'—Ecologists and the Value of the Predators, 1900-1972," in Kendall E. Bailes, ed. *Environmental History: Critical Issues in Comparative Perspective* (Lanham, Maryland: University Press of America and the American Society for Environmental History, 1985), pp. 597-99; and Dunlap, *Saving America's Wildlife.*
86. *The United States Bureau of Destruction and Extermination: The Misnamed and Perverted 'Biological Survey'* (New York: Emergency Conservation Committee, 1934).
87. See Perkins, *Insects,* pp. 11-13.
88. I developed these figures through a tabulation of articles listed in *Wildlife Abstracts* from 1935 to 1960. The organization of these articles within the abstracts was somewhat uneven over time and categories of article classification shifted. From 1935-51, I examined sections on "Birds—Foods; Economics" and "Birds—Management." These categories changed from 1952-55, and I examined the replacement categories "Birds—Economics," "Birds—Protection; Rare and Extinct Species," and "Birds—Control Methods." From 1956-60, I examined the categories "Birds—Economics," "Birds—Protection; Extinct and Vanishing Species," and "Birds—Control Methods." I did not count non-English language articles; the vast majority of articles are American.
89. Rachel Carson, *Silent Spring* (New York: Houghton Mifflin Company, 1962).