

A HISTORY OF LEPIDOPTERA CONSERVATION, WITH SPECIAL REFERENCE TO ITS REMINGTONIAN DEBT

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ABSTRACT. In the past half century, the preservation of Lepidoptera and their habitats has risen from relative obscurity to become one of the most active subdisciplines in modern conservation biology. A wide appreciation and popularization of butterflies and moths has resulted. This paper presents an overview of the ascent, with emphasis on the intertwined roles played by scientific research, global growth in awareness of environmental issues, and political/legal action.

The conservation of uncommon species of butterflies and moths and their habitats has become a frequent topic of concern and discussion in the contemporary lepidopterological press. Such was not always the case. When, in 1967, a paper on the subject was first brought before the annual meeting of the Lepidopterists' Society, it was greeted with guarded interest. When the same paper was submitted to the *Journal of the Lepidopterists' Society*, it was rejected, doubtless due to its anecdotal nature and editorial shortcomings. But when it eventually appeared elsewhere in revised form (Pyle 1967) it was one of few citations available on the topic.

A different situation pertains today, when this and related journals routinely contain papers at least partly concerned with biodiversity conservation. Entire journals devoted to the subject, such as *Biological Conservation*, frequently contain papers related to butterflies, moths, and other insects. In just a quarter of a century, Lepidoptera conservation has grown from an arcane topic to a commonplace concern.

Several reasons for this growth suggest themselves. First, there is greater general recognition that the environmental crisis extends to small-scale life: through the writings of E. O. Wilson and others, insects have become respectable in public. Second, population growth has quickened habitat loss, such that no one who pays attention to insects can fail to notice. Third, the number of lepidopterists has grown as well, giving greater witness to these losses and concern for the protection of disappearing populations. Fourth, public interest in natural history and butterflies in particular has grown dramatically. Fifth, teachers and scientists who employ these animals in their research have produced students sophisticated in lepidopteran biology who are prepared to take part in conservation.

Perhaps the most influential of these teachers has been Charles Lee Remington. This paper aims to summarize the major historical developments in Lepidoptera conservation, while suggesting the Remingtonian contribution to the field and its impact.

THE EARLY STAGES

The earliest concern on behalf of insect conservation might have been that of Queen Cristina de Borbon of Spain, who asked Professor Graells to provide a plan for firefly protection around 1835 (Pyle 1976a, Pyle 1976b). Overt butterfly conservation can be thought of as beginning a decade or so later, when *Lycaena dispar dispar* Haw. became extinct in Great Britain due to the drainage of the East Anglian Fens (Ford 1945, Duffey 1968). British collectors mourned this and other losses from the changing landscape. Lord Walter Rothschild unilaterally established some of the earliest butterfly reserves, notably at Woodwalton Fen. In 1925, he was to chair the first butterfly conservation body, an arm of the Royal Entomological Society of London initially known as the Committee for the Protection of British Lepidoptera (this group subsequently became the Insect Protection Committee, and later the Joint Committee for Conservation of British Insects). While many notes of concern appeared in the European literature in the first half of the twentieth century, most of them consisted of allegations of overcollecting of *Parnassius apollo* L. and other rarities, rather than arguments for habitat conservation (Pyle 1976b).

Across the Atlantic, attention drew to the topic almost as early as in England. In a letter to Herman Strecker written on 26 September 1875, H. H. Behr lamented that *Glaucopsyche xerces* Boisduval "is now extinct as regards the neighborhood of San Francisco. The locality where it used to be found is converted into building lots, and between German chickens and Irish hogs no insect can exist besides louse and flea" (Pyle 1976b). *Glaucopsyche xerces* did not in fact become extinct until the early nineteen-forties (Downey & Lange 1956, Emmel & Emmel 1993), though it was preceded into extinction by the nominate subspecies of *Cercyonis sthenele* (Boisduval). Grote (1876) also called early on for protection of the White Mountain butterfly, *Oeneis melissa semidea* (Say), in New Hampshire. However, unlike in Great Britain, no formal committees arose in North America to address these early expressions of alarm.

In 1946, the Joint Committee for Conservation of British Insects (JCCBI) issued its first list of rare and endangered insects, surely the first such list anywhere. By this time there had long been a Committee for the Protection of the Large Blue in England, in recognition of the decline of *Maculinea arion* L. Its work of half a century would eventually prove in vain, due to inadequate knowledge of the insect's requirements (Thomas 1980). This need for solid autecological data upon which to base management was sounded by John Heath, whose studies on the moth *Eustroma reticulata* in the Lake District (Heath 1959)

opened the era of intensive study of threatened species with a view toward their conservation.

Charles Remington entered this rising climate of concern for the British biota when he went to Oxford to work with E. B. Ford on a Guggenheim Fellowship in 1958–59. Ford (1945) had summarized the changes in the British butterfly fauna that led to a general call for its conservation on behalf of lepidopterists. Although Remington's work with Ford primarily concerned ecological genetics, the Oxford don's knowledge of population decline was not lost on the young Remington. It was while Charles was in Britain those years that he acquired, in London auctions and by gift, the nucleus of Yale University's great collection of extinct and endangered insects, and further developed many of his ideas concerning the conservation ecology of rare insects. These concepts were to find expression in a series of papers published before and after Oxford (Remington & Pease 1955, Remington 1958a, 1958b) having to do with the general and specific ecological requirements of lepidopterans in nature.

LEPIDOPTERA CONSERVATION IN MID CENTURY

The 1960s saw a wave of environmental activism, culminating in the first Earth Day on 22 April 1970. During the decade, a number of suggestions appeared in print that lepidopterists should be paying close attention to disappearing habitats and the populations they supported (Rindge 1965, Sieker 1967, Pyle 1967). In 1961, George Rawson attempted a reintroduction of *Eumaeus atala florida* Rober into the Everglades in Florida, an effort defeated by Hurricane Donna. With future introductions of this sort in mind, as well as biological control, Remington (1968) reviewed the population genetics of insect introductions. At the 20th Annual Meeting (1967) of the Lepidopterists' Society in Corvallis, Oregon, at the suggestion of David McCorkle, a Conservation Committee was formed. McCorkle also promoted the establishment of The Nature Conservancy's first rare butterfly preserve for a disjunct population of *Boloria selene atrocotalis* Huard at Moxee Bog, Washington, in the late 1960s (Hendrix 1975). This fecund period saw the establishment of many environmental groups. Following publication of Society member Paul Ehrlich's influential book *The Population Bomb* (Ehrlich, 1968), Ehrlich and Remington co-founded Zero Population Growth (ZPG), in recognition of the fact that burgeoning human numbers underlie all other resource conservation problems, and, indeed, bias our own future.

By the late 1960s, Lepidoptera conservation activities in Great Britain had become numerous and sophisticated. The JCCBI, a new British Butterfly Conservation Society with revered naturalist Sir Peter Scott

as its President, and several other bodies were working on an array of habitat protection issues. The nerve center of this activity was Monks Wood Experimental Station, a field center of the British governmental agency known then as the Nature Conservancy. Monks Wood itself was an early, private insect reserve, and now is a National Nature Reserve (NNR), one of a number established after World War II in response to the Huxley Report, a biotic survey antecedent to our modern-day Natural Heritage Programs. The Experimental Station was set up in 1963 to conduct research to guide management of the NNRs (Steele & Welch 1973). A Nature Conservancy colloquium at Monks Wood (Duffey & Morris 1965) reviewed the state of invertebrate conservation and stressed the importance of further research and survey.

At Monks Wood in 1970, no fewer than eight biologists were employed on research and management projects substantially involving rare insects. Notable among these were Eric Duffey's research on the re-introduced population of *Lycaena dispar* at Woodwalton Fen; Jack Dempster's work on *Papilio machaon britannicus* Sietz; and Jeremy Thomas's investigations of the autecology of *Strymonidia pruni* L., and *Thecla betuli* L. Hall (1981) summarized these and related studies. Also based at Monks Wood were the Insect Recording Schemes of the Biological Records Centre. The late John Heath, one of the most active conservationists among the lepidopterists, had surveyed a century of change in British Lepidoptera (Heath 1974) and began producing atlases of species occurrence based on 10 km square dot maps (Heath et al. 1984). By updating these maps annually, through the efforts of many field volunteers and a professional staff, the Biological Records Centre was able to provide a dynamic picture of population expansion and contraction. Field research could then address the reasons for local extinctions and management needs. In this way both *S. pruni* and *Melitaea athalia* were brought back through a combination of mapping, research, and management (Thomas 1984, Warren 1987). The Butterfly Recording Scheme continues today, directed by Paul Harding at Monks Wood. Certain moth groups and other insects also have been mapped.

In 1971-72, I had the opportunity to pursue studies in Lepidoptera conservation at Monks Wood under the mentorship of John Heath and the other scientists in residence. This experience, and the example of the British large blue (*Maculinea arion*) as a symbol for Lepidoptera conservation, led directly to the founding of the Xerces Society on 9 December 1971. Jo Brewer voiced many parallel concerns in the United States (Brewer 1971) and lent her early support to the embryonic organization. Xerces' goals were to raise positive public awareness of butterflies and other beneficial insects, and to work for the conservation of rare species and their habitats.

The 25th Annual Meeting of the Lepidopterists' Society took place in San Antonio, Texas, in July, 1972. Under the leadership of then-President Charles Remington, a symposium was held on "Endangered and Extinct Lepidoptera." A series of papers outlined the present state of knowledge and action in the field, both in the United States and Great Britain. This meeting served as an effective launching pad for the Xerces Society, which subsequently situated itself at Yale University, in New Haven, Connecticut, at the invitation of Remington.

The first several years of the Society's activity saw the launch of the Fourth of July Butterfly Counts, the journal *Atala*, and the newsletter *Wings*, and involvement in several land-use issues. These included Forest Service management of the habitat of the New Mexico endemic, *Sandia macfarlandi* Ehrlich & Clench; Project Ponceanus on behalf of *Papilio aristodemus ponceanus* Schaus in Florida; conservation of the Karner blue in New York State; and conservation of several western fritillaries (summarized by Pyle 1976a, 1976b, and in early issues of *Atala*). At the same time, I was undertaking graduate studies at Yale with Charles Remington, with a view toward placing the activities of Xerces in an historic, worldwide, and scientific context. It was often said that if John Heath served as midwife to the Xerces Society, then Charles Remington was its godfather. This role was underscored when the first annual meeting of the Xerces Society was held at Yale University in April, 1974. Thanks to Charles' influence, distinguished guests such as Miriam Rothschild and Alexander Klots attended. This lent substance to the occasion and both encouragement and credibility to the young organization.

THE ENDANGERED SPECIES ACT AND BEYOND

The largest event in North American Lepidoptera conservation was the passage of the Endangered Species Act (ESA) in 1973. In 1974, society member Paul Opler was hired by the U.S. Fish & Wildlife Department as Staff Specialist in entomology. In 1975, 41 species and subspecies were proposed as candidates for listing under the ESA. Federal listing of six California lycaenids (*Apodemia mormo langei* J. A. Comstock, *Euphilotes battoides allyni* Shields, *E. enoptes smithi* (Mattoni), *Incisalia fotis bayensis* R. Brown, *Plebejus icarioides missionensis* Hovanitz, and *P. i. pheres* (Boisduval)), and two Florida swallowtails (*Papilio aristodemus ponceanus* Schaus and *P. andraemon bonhotei* (E. M. Sharpe)) soon followed, along with *Speyeria zerene hippolyta* (Edwards). Additional species were listed in later years, and numerous research projects undertaken toward the conservation of these and other endangered species, with a combination of federal, state, and private funding (see for example Arnold 1983, Gall 1984, Reid & Murphy 1986,

McCorkle & Hammond 1988, Powell & Parker 1993). One taxon, the Palos Verdes Blue (*Glaucopsyche lygdamus palosverdesensis* Perkins & Emmel) apparently became extinct in spite of protection from the ESA due to negligence of habitat development for a park (Mattoni 1993) but was subsequently rediscovered by Rudy Mattoni on naval land.

The Endangered Species Act was amended in 1983 in order to permit taking of listed taxa under certain conditions, including the preparation of a conservation plan for the survival and enhancement of the remaining population. This amendment was designed to remove the obstacle that the endangered Mission Blue and several other listed species presented to developers on San Bruno Mountain, south of San Francisco, in California. This was a divisive issue in Lepidoptera conservation circles. Xerces and The International Union for Conservation of Nature (IUCN) opposed it, contending that the expertise to re-create critical habitat did not exist, and the unknowns were too many. Others felt that the survival of the ESA lay in the balance, and supported the compromise. The outcome is as yet unclear, with both development and restoration underway (Bean et al. 1991, Cushman, 1993). Listings of invertebrates under the ESA ceased during the Reagan years until Paul Ehrlich et al. sued the U.S. Fish and Wildlife Service to list *Euphydryas editha bayensis* (Sternitzky) (Murphy & Weiss 1988).

The 1970s and 1980s saw vulnerable-species lists and red data books appear in several countries, including Britain, Spain, and Switzerland. Conservation activity in Europe became intense, chiefly through the offices of the European Invertebrate Survey and the Societas Europaea Lepidopterologica, both co-founded by John Heath, who also performed a European butterfly conservation survey for the Council of Europe (Heath 1981). A spate of papers appeared during this stock-taking period, summarizing the initial wave of activity (Morris 1976, Thomas 1984, Pyle 1976b, Pyle et al. 1981). Kudrna (1986) summarized and analyzed the European Lepidoptera conservation scene in an important book, as did successive symposia held in Karlsruhe and Cambridge (see Heath 1982).

Sir Peter Scott, Chairman of the IUCN Species Survival Commission, created a Lepidoptera Specialist Group under my chairmanship, with Charles Remington as a key charter member. Meeting in Washington, D.C., in 1976, the Group designated the migratory phenomenon of the monarch butterfly as the highest priority in world butterfly conservation (see below). This and my work with the Wildlife Division of Papua New Guinea in 1983 convinced Scott of the need to include invertebrates in global monitoring procedures. The IUCN and World Wildlife Foundation (WWF) concurred, and work was begun in Cambridge at the Species Conservation Monitoring Unit (now World Conservation

Monitoring Centre) on an IUCN *Invertebrate Red Data Book*. The publication contained numerous lepidopteran entries (Wells et al. 1983), and was followed by a red data book devoted to swallowtails of the world (Collins & Morris 1985). Both tomes recognized *Ornithoptera alexandrae* (Rothschild), the largest butterfly in the world and a very narrow Papuan endemic facing powerful economic pressures, as a world conservation priority. IUCN and WWF, as well as the government of Papua New Guinea, subsequently treated it as such, though it is yet far from safe (Parsons 1992a, 1992b). New & Collins (1991) subsequently produced a worldwide Action Plan for swallowtail conservation.

One of the most significant elements of the IUCN *Invertebrate Red Data Book* was the listing of *Danaus plexippus* (L.) in the new category of Threatened Phenomenon, an idea jointly developed by myself and Lincoln Brower, Remington's first doctoral student and onetime E. B. Ford research fellow, and now the primary Monarch investigator in North America. In turn, this led to the founding of The Monarch Project as a unit of the Xerces Society, with myself as Chair, Brower as Scientific Chair, and Remington as an advisor. Xerces, always volunteer-run to this point, now hired Melody Mackey Allen as Executive Director of The Monarch Project and later of the Society as a whole. The Monarch Project sought to protect Monarch wintering grounds in Mexico and California, and migratory corridors throughout North America. These developments came about at the 11th annual Meeting of the Xerces Society, held at Yale University in June 1985, at Remington's invitation. Having overseen the group's early development, he now assisted it into a new era of professional activity.

Additional students and colleagues of Charles Remington carried the influence of Osborn Memorial Laboratory, the Peabody Museum of Natural History, and the Rocky Mountain Biological Laboratory into a variety of conservation arenas. Francie Chew (1977) demonstrated the relationship between introduced and native species of pierids. Larry Gall (1984) discovered a new and narrowly endemic species of North American butterfly, *Boloria acrocneuma* Gall & Sperling, and fostered its way to eventual Federal listing. Dale Schweitzer (1987) extended several state natural heritage and Nature Conservancy programs into a close examination of the butterfly and moth faunas within their bounds. Remington worked with Schweitzer and others to develop management criteria for the Karner blue (*Plebejus melissa samuelis* (Nabokov)) in upstate New York. The most recent candidate for Federal listing, the Karner blue's survival will owe much to these studies as well as to those of the Yale group's Cornell associates, Robert Dirig and John Cryan, who initially pursued this issue through Xerces. The long tradition of butterfly science at Rocky Mountain Biological Laboratory (RMBL) in Gothic, Colorado, continues to contribute basic ecological understand-

ing to a broad array of conservation settings, not the least in its own backyard. Many of the RMBL workers have been influenced by Remington's long, vital and ongoing association with the laboratory, whose new research facility bears his name.

THE PRESENT AND FUTURE OF CONSERVATION EFFORTS

Lepidoptera conservation has recently entered an era of expanded energy worldwide, at a time when environmental pressures have exacerbated and funding for protective measures has diminished. Private contracts, to a degree, have supplemented lost public funding, and non-governmental organizations also have assumed an increased role. Government activities in Great Britain contracted under the unsympathetic Thatcher regime. The Monks Wood collective of scientists already had broken up with the sundering of the Nature Conservancy into separate agencies for research and management. Much of the effort shifted to Furzebrook Research Station of the Institute of Terrestrial Ecology in Dorset, under the direction of M. G. Morris. This was the base for Jeremy Thomas's landmark studies of *Maculinea arion* leading to its effective reintroduction and management following extinction of the British race (Thomas 1980, 1989), and detailed studies of other rare British blues (Thomas 1984, 1985).

The British Butterfly Conservation Society (now called Butterfly Conservation) has grown dramatically, hired a professional director, and established a number of reserves and educational programs. The group celebrated its 25th anniversary by conducting a major symposium on Lepidoptera Conservation at Keele University in September 1993. This followed on the heels of a symposium on insect conservation hosted by the Royal Entomological Society in London, whose proceedings represent a seminal volume in the field. The Xerces Society has grown too, and has spread its influence into Jamaica, on behalf of *Papilio homerus* (Fab.) (Emmel & Garraway 1990), and Madagascar, whose jeopardized forests support many endemic butterflies and other invertebrates (Kremen, 1992). While its journal *Atala* has been suspended, the magazine *Wings* is published regularly in a popular color format that has widely raised interest in arthropods and their needs.

Increasingly, those needs are seen to lie in the tropics. Early efforts at developing butterfly ranching as an economic incentive for conservation in Papua New Guinea (Pyle & Hughes 1978) have been emulated in many tropical and subtropical countries, and a non-profit organization, Wings for the Earth, directed by Olaf Malver, now exists to encourage such projects. M. G. Morris explored prospects for butterfly farming in Oceania as a Churchill Fellow, and Angus Hutton and Mi-

chael Parsons have consulted on similar projects from India to China (Parsons 1992a, 1992b). Both Parsons and Larry Orsak (1993) have worked extensively in Papua New Guinea to strengthen the existing program and its ties to conservation of forest habitats while enhancing local economies. An international conference on butterfly conservation and local utilization was held in September 1993, in Ujung Padang, Indonesia.

Conservation involves more lepidopterists around the world each year. Many of the projects have been synopsisized by the current IUCN Lepidoptera Specialist Group chairman, T. R. New (1990). He also has reviewed Australian insect conservation in depth, edited a volume on lycaenid conservation biology, and summarized the entire field of butterfly conservation in a volume sure to become the standard text in the field (see New 1991). New and his collaborators reviewed butterfly conservation management for the *Annual Review of Entomology* (New et al. 1995).

Pro Monarca, a Mexico City group, leads the campaign to save the Mexican monarchs, a challenging goal in the face of growing pressures from poverty and logging. The Xerces Society, the Lepidopterists' Society, and the Mexican Society of Lepidopterists held a joint symposium on Mexican and Californian Monarch Biology and Conservation in Cocoyoc, Mexico, in 1981. A second symposium was held in Los Angeles under the leadership of Julian Donahue; both led to published proceedings (Pyle 1984, Malcolm & Zalucki 1993). Another gathering was convened by The Monarch Project at the Esalen Center in California in January 1990, to review California monarch needs, research, management, and plans. Alternative income production through eco-tourism seems the most hopeful approach in Mexico, while California monarchs will depend largely on easements, reserves, and growth management. Pacific Grove, California, passed a bond issue in November 1990, to acquire and restore degraded but previously utilized monarch roosting habitat. This brings full-circle the American butterfly conservation movement, whose first official measure might have been a 1950s city ordinance to protect monarchs from public disturbance (but, fatefully, not from habitat loss) in Pacific Grove (Lane 1984). Monarch conservation science also underscores the Remingtonian legacy, in that the co-founders of The Monarch Project, Brower and Pyle, were both graduate students of Remington.

One area of growth in Lepidoptera conservation today is in awareness and education. Butterfly clubs have arisen in several regions, all of them involved to some extent with conservation. Butterfly houses and butterfly gardens are becoming popular wherever they appear. The forty or more butterfly houses in Britain (Collins 1987) have been emulated

by a dozen or more in North America (Emmel & Boender 1991). While few of these have yet taken direct action to breed and release rare species (a moot point, unless wild habitats are first addressed) they no doubt increase the public's lepidopteran literacy. Butterfly gardens, too, are making a major contribution to a heightened consciousness (Xerces Society 1990). When people create or take part in cultivating a butterfly garden, they come to appreciate the needs of individual species. These gardens help to maximize butterfly diversity and abundance in urban and suburban areas, conserving species that might otherwise become less common, while bringing the insects into public awareness.

A divisive issue throughout the history of Lepidoptera conservation has been collecting of specimens. From the earliest days, many of the published alarms have alleged overcollecting. However, most scientists and amateurs alike agree that collecting per se seldom has substantial impact on populations (Pyle et al. 1981, Morris 1976). Dangerously, collecting restrictions often distract attention from serious issues of habitat conservation. A most bizarre example occurred in Germany, where bureaucrats responded to a Council of Europe call for conservation action by banning collecting of almost all Lepidoptera. Rightly, some birdwings and other butterflies, including *Parnassius apollo*, have been placed on Appendix II of the Convention on International Trade in Endangered Species (CITES), in order to monitor trade in them. However, CITES has been misapplied in some instances, preventing trade designed to encourage responsible butterfly ranching and enhance habitat conservation efforts; and imposing unreasonable barriers to the orderly exchange of legally collected or reared specimens (Parsons 1992, New 1991).

Both the Xerces and Lepidopterists' Societies have adopted collecting policies to reinforce responsible collecting practices among their members (Pyle 1992). The British group Butterfly Conservation, however, has adopted an anti-collecting stance that has alienated and tarred many entomologists. I hope that this sort of needless polarization can be avoided among North American collectors and watchers. No instance of extinction by overcollecting has ever been shown unequivocally, although most lepidopterists can recite instances in which they think overcollecting has occurred at least locally. This is most likely where a highly restricted taxon has been ecologically stressed already. The most recent federal listing of a butterfly as endangered (*Euptychia mitchellii* French) for the first time named overcollecting as one of the causes of decline. This coincides with the rise of a general perception of collecting as depreciative and archaic, against which those who wish to continue collecting will have to resist.

At this writing, North American butterfly collectors are deeply con-

cerned over recent attempts by authorities of the U.S. Fish and Wildlife Service to implement the Lacey Act and other punitive laws and regulations in ways they see as arbitrary, unreasonable, or unrelated to conservation (see, for example, *News of the Lepidopterists' Society* from 1992 forward). This has chilled the very exchange of specimens and information that have given the Lepidopterists' Society much of its communicative function. It has also led to sharp debate over the Society's proper role with respect to conservation (Ziegler 1993, Wagner 1993). Clearly, it will be important for the officers of this and other biological societies to arbitrate among public resource agencies and their own memberships in order to arrive at an acceptable understanding; and to educate authorities to the ongoing importance of responsible collecting and the unlikelihood of its doing harm to the resource. Likewise, lepidopterists find themselves needing to become better informed about rules and regulations on public lands, and to be ambassadors for their hobby and science. Collectors will also need to monitor their own activities carefully if they are to avoid outside interference with activities they have long taken for granted. The same population pressures that squeeze wild habitats have also begun to diminish free access to the entomological resource, an unfortunate side effect that might have been predicted by Ehrlich and Remington when they founded Zero Population Growth.

Partly in response to changing attitudes about collecting, butterfly watching is growing dramatically as an outdoor activity (Pyle 1992, Glassberg 1993). The North American Butterfly Association has been formed to promote butterfly watching and butterfly counts, and tours to the tropics and elsewhere are now incorporating butterfly watching as one of their attractions. These developments will no doubt increase the clientele for butterfly appreciation and conservation. Tour participants have led efforts to protect rainforest remnants in Rondonia, Brazil, for example (K. Bagdonas and T. C. Emmel, pers. comm.).

Butterfly watching will augment but not replace collecting in research. Therefore, it is important that watchers be given an understanding of the paramount importance of habitat protection, and a parallel appreciation for the value of intelligent collecting as an activity that seldom harms populations and contributes greatly to biogeographical understanding. Charles Remington has long been an effective voice on this issue.

Perhaps the most active area in butterfly and moth conservation today is the application of ecogeographic data to regional ecosystem management plans. Lepidoptera conservation surveys are now well under way in North America. In some instances, basic survey is being combined with an ecogeographic approach, often employing Geographic

Information Systems (GIS) to define where maximum diversity and conservation planning can most effectively overlap. This "gap" analysis, as it is called, will not encompass every rare taxon, but it is the trend of the future in a climate of increasing need and diminishing resources (Pyle 1982, Scott et al. 1993). Recognizing this, the Xerces Society has entered into such projects in several U.S. states, integrating butterfly distributional data into the overall species data bases. The premiums from energetic survey work already are becoming apparent in increased butterfly and moth preserve activity on the part of The Nature Conservancy in many states, just as John Heath's Butterfly Recording Scheme led to direct on-the-ground conservation in Britain.

For ecogeographic analysis and natural heritage programs to work well, active and empathetic collaboration between watchers, collectors, gardeners and all other brands of butterfly and moth fanciers is necessary. It will require the continuing field work of lepidopterists—both amateurs and professionals, working together in the cooperative, inclusive manner envisioned by Remington and Clench when they launched the Lepidopterists' Society nearly fifty years ago.

Charles Remington's work in conservation carries on at Yale University, where for several years he has taught the graduate course on Biology of Endangered Species in the School of Forestry and Environmental Studies. He has also organized a new exhibit on endangered species at the Yale Peabody Museum, and Charles and I are currently pursuing a book on Lepidoptera conservation (Island Press). But the Remingtonian influence on conservation should not be considered solely in the context of entomology. Many graduate students in Forestry and Environmental Studies have gone on to influential careers with The Nature Conservancy and other conservation organizations (see the introduction to this *Journal* issue). Prominent among these is Spencer B. Beebe, long one of The Nature Conservancy's most effective professionals and later the founder of both Conservation International and Ecotrust. Beebe was among those influenced by the teachings of Remington in evolutionary and conservation biology. So was Thomas E. Lovejoy who is currently a science advisor to President Clinton, and formerly Vice-President for Science of the World Wildlife Fund.

Today one cannot peruse an issue of the *Journal of the Lepidopterists' Society* or the *News* of the Society without reading about habitat conservation needs, concerns, or activities. This owes partly to increased awareness, partly to a deepening crisis in ecosystem maintenance. But the fact that lepidopterists are widely, knowledgeable, and energetically responding to the challenge of Lepidoptera conservation clearly stems largely from the teachings, studies, and dedication of their fellow, Charles Lee Remington.

LITERATURE CITED

- ARNOLD, R. A. 1983. Ecological studies of six endangered butterflies (Lepidoptera, Lycaenidae): island biogeography, patch dynamics, and the design of habitat preserves. *Univ. Calif. Publ. Entomol.* 99:1-161.
- BEAN, M., S. FITZGERALD & M. O'CONNOR. 1991. The San Bruno habitat conservation plan, pp. 52-56. *In* *Reconciling conflicts under the Endangered Species Act*. World Wildlife Fund (US), Washington.
- BREWER, J. 1971. How to kill a butterfly. *Audubon* 74(2):77-88.
- CHEW, F. S. 1977. The effects of introduced mustards (Cruciferae) on some native North American cabbage butterflies (Lepidoptera: Pieridae). *Atala* 5:13-19.
- COLLINS, N. M. & M. G. MORRIS. 1985. Threatened swallowtail butterflies of the world: The IUCN Red Data Book. IUCN, Gland and Cambridge. 401 pp.
- COLLINS, N. M. 1987. Butterfly houses in Britain: The conservation implications. IUCN, Gland and Cambridge. 60 pp.
- CUSHMAN, J. H. 1993. The Mission Blue, *Plebejus icarioides missionensis*, pp. 139-140. *In* New, T. R. (ed.), Conservation biology of Lycaenidae (Butterflies). IUCN Species Survival Commission Occ. Pap. 8.
- DOWNNEY, J. C. & W. H. LANGE, JR. 1956. Analysis of variation in a recently extinct polymorphic lycaenid butterfly, *Glaucopsyche xerces* (Bdv.), with notes on its biology and taxonomy. *Bull. South. Calif. Acad. Sci.* 55:153-170.
- DUFFEY, E. 1968. Ecological studies on the large copper butterfly, *Lycaena dispar* Haw. *batavus* Obth. at Woodwalton Fen National Nature Reserve, Huntingdonshire. *J. Appl. Ecol.* 5:69-96.
- DUFFEY, E. & M. G. MORRIS (eds.). 1965. The conservation of invertebrates. Monks Wood Exper. Sta. Staff Symp. 1:1-93. The Nature Conservancy, London.
- EHRlich, P. R. 1968. The population bomb. Ballantine, New York. 223 pp.
- EMMEL, T. C. & R. BOENDER. 1991. Wings in paradise: Florida's butterfly world. *Wings* 15(3):7-12.
- EMMEL, T. C. & J. F. EMMEL. 1993. The Xerces Blue, *Glaucopsyche xerces* (Boisduval), pp. 137-138. *In*: New, T.R. (ed.), Conservation biology of Lycaenidae (Butterflies). IUCN Species Survival Commission Occ. Pap. 8.
- EMMEL, T. C. & E. GARRAWAY. 1990. Ecology and conservation biology of the homerus swallowtail in Jamaica (Lepidoptera: Papilionidae). *Trop. Lepid.* 1:63-76.
- FORD, E. B. 1945. Butterflies. Collins, London. 368 pp.
- GALL, L. F. 1984. Population structure and conservation of the narrowly endemic alpine butterfly, *Boloria acrocneuma* (Lepidoptera: Nymphalidae). *Biol. Cons.* 28:111-138.
- GLASSBERG, J. 1993. Butterflies through binoculars. Oxford Press. 160 pp.
- GROTE, A. R. 1876. A colony of butterflies. *Am. Nat.* 10:129-132.
- HALL, M. L. 1981. Butterfly research in I.T.E. Inst. Terrest. Ecol., Monks Wood Exper. Sta. Cambridge. 28 pp.
- HEATH, J. 1959. The autecology of *Eustroma reticulata* Schiff. (Lep.: Geometridae) in the Lake District with notes on its protection. *J. Soc. Brit. Entomol.* 6:45-51.
- . 1974. A century of change in the Lepidoptera, pp. 275-292. *In* Hawksworth, D.L. (ed.), The changing flora and fauna of Britain. Academic Press, London.
- . (ed). 1982. Proceedings of the 3rd Congress of European lepidopterology. Cambridge. 211 pp.
- HEATH, J., E. POLLARD & J. A. THOMAS. 1984. An atlas of the butterflies of the British Isles. Viking, London. 158 pp.
- HENDRIX, L. 1975. Relict bog. *Pacif. Discovery* 28(2):1-9.
- KREMEN, C. 1992. Butterflies as ecological and biodiversity indicators. *Wings* 16(3):14-17.
- KUDRNA, O. 1986. Butterflies of Europe. Vol. 8. Aspects of conservation of butterflies in Europe. Weisbaden, Aula-Verlag. 323 pp.
- LANE, J. 1984. The status of monarch butterfly overwintering sites in Alta California. *Atala* 9:17-20.

- MALCOLM, S. B. & M. P. ZALUCKI. 1993. Biology and conservation of the monarch butterfly. *Nat. Hist. Mus. Los Angeles County Sci. Ser.* 38:1-419.
- MATTONI, R. H. T. 1993. The Palos Verdes Blue, *Glaucopsyche lygdamus palosverdesensis* Perkins and Emmel, pp. 135-136. *In* New, T. R. (ed.), *Conservation biology of Lycaenidae (Butterflies)*. IUCN Species Survival Commission Occ. Pap. 8.
- MCCORKLE, D. V. & P. C. HAMMOND. 1988. Observations on the biology of *Speyeria zerene hippolyta* (Nymphalidae) in a marine-modified environment. *J. Lepid. Soc.* 42:184-195.
- MORRIS, M. G. 1976. Conservation and the collector, pp. 107-116. *In* Heath, J. (ed.), *The moths and butterflies of Great Britain and Ireland. I. Micropterigidae-Heliozelidae*. Blackwell (Oxford) and Curwen (London).
- MURPHY, D. D. & S. B. WEISS. 1988. Ecological studies and the conservation of the bay checkerspot butterfly, *Euphydrys editha bayensis*. *Biol. Cons.* 46:183-200.
- NEW, T. R. 1990. Directory of Lepidoptera conservation projects. LaTrobe Univ., Melbourne. 79 pp.
- . 1991. *Butterfly Conservation*. Oxford Univ. Press (Australia). 224 pp.
- NEW, T. R. & N. M. COLLINS. 1991. Swallowtail butterflies: an action plan for their conservation. IUCN, Gland and Cambridge. 36 pp.
- NEW, T. R., R. M. PYLE, J. A. THOMAS, C. D. THOMAS & P. C. HAMMOND. 1995. Butterfly conservation management. *Ann. Rev. Entomol.* 40:57-83.
- ORSAK, L. 1993. Killing butterflies to save butterflies. *News Lepid. Soc.* 3:71-80.
- PARSONS, M. J. 1992a. Butterfly farming and conservation in the Indo-Australian region. *Trop. Lepid.* 3(Suppl. 1):1-31.
- . 1992b. The world's largest butterfly endangered: the ecology, status and conservation of *Ornithoptera alexandrae* (Lepidoptera: Papilionidae). *Trop. Lepid.* 3(Suppl. 1):33-60.
- POWELL, J. A. & M. W. PARKER. 1993. Lange's Metalmark, *Apodemia mormo langei* Comstock, pp. 135-136. *In* New, T. R. (ed.), *Conservation biology of Lycaenidae (Butterflies)*. IUCN Species Survival Commission Occ. Pap. 8.
- PYLE, R. M. 1967. Conservation and the lepidopterist. *Bull. Assoc. Minn. Entomol.* 2:1-5.
- . 1976a. The eco-geographic basis for Lepidoptera conservation. Ph. D. dissertation. Yale University. 369 pp.
- . 1976b. Conservation of Lepidoptera in the United States. *Biol. Cons.* 9:55-75.
- . 1981. Lepidoptera conservation in Great Britain. *Atala* 7:33-72. [1979]
- . 1982. Butterfly ecogeography and biological conservation in Washington. *Atala* 8:1-26.
- . (ed.). 1984. Symposium on the biology and conservation of monarch butterflies. *Atala* 9:1-45. [1981]
- . 1992. *Handbook for butterfly watchers*. Houghton Mifflin, Boston. 280 pp.
- PYLE, R. M., M. BENTZIEN & P. A. OPLER. 1981. Insect conservation. *Ann. Rev. Entomol.* 26:233-258.
- PYLE, R. M. & S. A. HUGHES. 1978. Conservation and utilization of the insect resources of Papua New Guinea. *Consult. Rep. Wildl. Branch, Dept. Nat. Res., Port Moresby, Papua New Guinea*. 157 pp.
- REID, T. S. & MURPHY D. D. 1986. The endangered mission blue butterfly, *Plebejus icarioides missionensis*, pp. 147-167. *In* Wilcox, B. A., P. F. Brussard & B. G. Marcot (eds.), *The management of viable populations: theory, applications, and case studies*. Center for Cons. Biol., Stanford.
- REMINGTON, C. L. 1958a. Genetics of populations of Lepidoptera. *Proc. 10th Intl. Congr. Entomol.* 13:415-426.
- . 1958b. On the autecology of *Megathymus yuccae* in Florida, with notes on foodplant specificity (Hesperioidea). *Lepid. News* 12:175-184.
- . 1968. The population genetics of insect introductions. *Ann. Rev. Entomol.* 13:415-426.
- REMINGTON, C. L. AND R. W. PEASE, JR. 1955. Studies in foodplant specificity. I. The

- suitability of swamp white cedar for *Mitoura gryneus* (Lycaenidae). *Lepid. News* 9:4-6.
- RINDGE, F. H. 1965. The importance of collecting—now. *J. Lepid. Soc.* 19:193-195.
- SCHWEITZER, D. F. 1987. *Catocala pretiosa*, the precious underwing moth: results of a global status survey, with a recommendation for retention in category 2. Status survey report, U.S. Fish & Wildl. Serv. Newton Corner, Massachusetts. 24 pp.
- SCOTT, J. M., F. DAVIS, B. CSUTI, R. NOSS, B. BUTTERFIELD, C. GROVES, H. ANDERSON, S. CAICCO, F. D'ERCHIA, T. C. EDWARDS, JR., J. ULLIMAN, & R. G. WRIGHT. 1993. GAP analysis: a geographical approach to biological diversity. *Wildl. Monographs* 123:1-41.
- SIEKER, W. E. 1967. The importance of preserving natural habitats—NOW. *J. Lepid. Soc.* 21:275-278.
- STEELE, R. C. & R. C. WELCH. 1973. Monks Wood: a nature reserve record. *Nature Conservancy (NERC), Cambridge.* 337 pp.
- THOMAS, C. D. 1985. The status and conservation of the butterfly *Plebejus argus* L. (Lepidoptera: Lycaenidae) in north west Britain. *Biol. Cons.* 33:29-51.
- THOMAS, J. A. 1980. Why did the large blue become extinct in Britain? *Oryx* 15:243-247.
- . 1984. The conservation of butterflies in temperate countries: past efforts and lessons for the future, pp. 333-353. *In* Vane-Wright, R. I. & P. R. Ackery (eds.), *The biology of butterflies.* Academic Press, London.
- . 1989. The return of the large blue butterfly. *Brit. Wildl.* 1:2-13.
- WAGNER, D. L. 1993. More on collecting and the Endangered Species Act: a reply to Ziegler. *News Lepid. Soc.* (July/Aug.):99-100.
- WARREN, M. S. 1987. The ecology and conservation of the heath fritillary butterfly, *Mellicta athalia*. *J. Appl. Ecol.* 24:467-513.
- WELLS, S. M., R. M. PYLE & N. M. COLLINS. 1983. *The IUCN Invertebrate Red Data Book.* IUCN, Gland and Cambridge. 632 pp.
- XERCES SOCIETY & SMITHSONIAN INSTITUTION. 1990. *Butterfly gardening: creating summer magic in your garden.* Sierra Club, San Francisco. 192 pp.
- ZIEGLER, J. B. 1993. Conservation vs. collecting and the role of our Society: a rejoinder. *News Lepid. Soc.* (May/June):83-85.