Dan Quiring

History of Forest Entomology at the Canadian Forest Service - Atlantic Forestry Centre (Fredericton) from 1911-1985: A celebration of the first 75 years of this institution on its 100-year anniversary

Canada has a distinguished heritage of groundbreaking research in entomology. One of the areas for which we are best known is research in forest entomology. Research carried out by staff at the Canadian Forest Service's research facility (hereafter known as CFS-Atlantic) in Fredericton, New Brunswick, which is currently celebrating its 100 year anniversary, played a major role in establishing this reputation. I am honored to provide a short synopsis of some of the research that was carried out during the first 75 years of this institution, 1911-1985. Much of the information that I used for this article was taken from Simpson (1999), and from various biographies and other reports prepared by Doug Eidt, a former editor of *The Canadian Entomologist* and the *Memoirs*, who worked tirelessly for Canadian entomology throughout his life. In 1911, the Dominion Department of Agriculture's Entomology Division began a cooperative effort with the Forestry Branch of the Department of the Interior to address outbreaks of forest insects. Provincial outposts were established to study insect pests and their control, and to carry out educational work. In New Brunswick, R.C. Treherne and G.E. Sanders carried out surveys of brown-tail moth populations from June to October in 1911. They were joined in November 1911, by J.D. Tothill, who was appointed Field Officer by the Division of Entomology and placed in charge of field work on the ecology of the brown-tail moth and its eradication from New Brunswick.

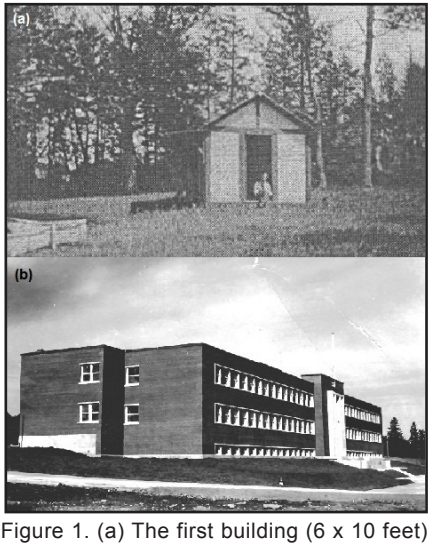

Figure 1. (a) The first building (6 x 10 feet) of the Canadian Forest Service-Atlantic in Fredericton, built in 1912, with John Tothill sitting in the entrance; and (b) building constructed in 1953. Both buildings were located on the campus of the University of New Brunswick.

The first CFS-Atlantic building was a very small two-room structure that was built on the campus of the University of New Brunswick in Fredericton in 1912 (Fig. 1a). A much larger two-storey structure was built on the same campus in 1915, and was enlarged with an addition in 1937. With increasing

Dan Quiring (quiring@unb.ca) is a professor in the Faculty of Forestry and Environmental Management at the University of New Brunswick, Fredericton, where he teaches ecology, insect ecology, forest entomology and insect pest management. Much of Dan's research has focused on elucidating the population ecology of major pests in forests (and some in agriculture) and using this information to develop monitoring systems and suppression tactics.

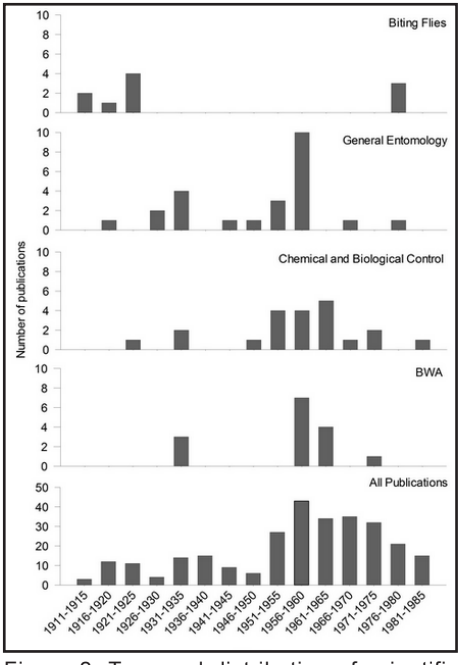

Figure 2. Temporal distribution of scientific publications from CFS-Atlantic (Fredericton) between 1911 and 1985 on biting flies, general articles on entomology, chemical and biological control (not including papers on European spruce sawfly and winter moth), balsam woolly adelgid (BWA), and all entomological topics combined, including many not mentioned above.

two classic biocontrol studies that are discussed below) (Fig. 2, authored by Reginald Balch, Ed Kettela, Charlie Miller, Murray Neilson, Malcolm Prebble, Bill Varty and Frank Webb); off-target effects of biological and chemical insecticides (Doug Eidt and Bill Varty); elaterid ecology (Doug Eidt and Frank Morris); aphids and adelgids (Reginald Balch, Reginald Underwood and Bill Varty), especially the balsam woolly adelgid (Fig. 2, authored by Reginald Balch, R.C. Clark and David Greenbank); mountain ash sawfly (Bob Forbes); red pine sawfly (Reginald Underwood); spruce bud moth (Murray Neilson); bark beetles (Malcolm Prebble); and the blackheaded budworm (Charlie Miller and Leonard Mook).

Under John Tothill (Officer-in-charge from 1911-1924) and Lee Simpson (Acting Officer-numbers of employees and research projects, the research centre moved to a large new building on the University of New Brunswick campus in 1953 (Fig. 1b).

Forest entomologists at CFS-Atlantic were very productive, as can be seen by the number of peer-reviewed publications that they produced during the institution's first 75 years (Fig. 2, bottom histogram). Researchers published 3 to 15 publications per 5-year period from 1911 to 1950 and averaged just over 25 per 5-year period from 1951 to 1985. Slight reductions in publication rates were associated with the Great Depression (1929-1933) and the end of the Second World War. A searchable database of research publications can be accessed on the CFS-Atlantic website at https://cfs.nrcan.gc.ca/publications.

Due to space limitations, I will not be able to comment on many studies, including: general entomology articles (Fig. 2, authored by Reginald Balch, Doug Eidt, Frank Morris, John Tothill and Frank Webb); biological and chemical control of insect pests (excluding

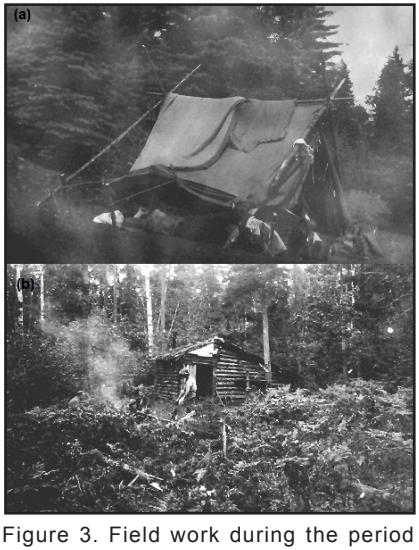

Figure 3. Field work during the period 1911-1932. (a) Temporary field station in Upsalquitch, New Brunswick, made from small tree trunks and blankets; (b) clearing and construction of a more permanent (log cabin) station.

in-charge until Reginald Balch took over in 1930), many field studies were carried out to elucidate the ecology of biting flies (Fig. 2) as well as the ecology and possible eradication of the brown-tail and gypsy moths. There were few forest roads during this period and much of the travel inside the forest was by canoe and by foot, with overnight accommodations ranging from "lean-tos" constructed with large sticks and blankets to small log cabins (Fig. 3). Two of the first entomologists to work with John Tothill were Alfred Baird, who later became director of the biocontrol centre in Belleville, and Leonard McLaine, who left for Ottawa where he eventually rose to become Dominion Entomologist.

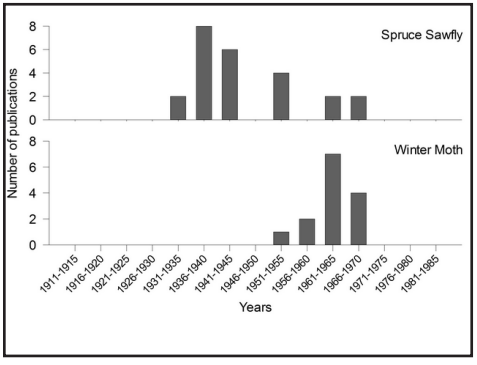

Figure 4. Temporal distribution of scientific publications from CFS-Atlantic (Fredericton) between 1911 and 1985 on classical biological control of the European spruce sawfly and the winter moth.

Probably the best-known studies from this early period were those on the ecology and successful classical biological control of the European spruce sawfly (Fig. 4, authored by Reginald Balch, Ed Reeks, Murray Neilson and Malcolm Prebble). Accidentally introduced from Europe in 1922, by 1936 the sawfly had caused "severe damage" in > 2.5 million ha in all eastern provinces of Canada and in the north-eastern U.S.A. Approximately 30 people collected 0.5 million eggs and 0.5 million cocoons (all parasitoids, except egg parasitoids, overwintered in cocoons) in Europe and sent them to Canada. Almost 900 million parasitoids were either directly imported or lab reared (primarily in Belleville under the direction of Alfred Baird) and released by 1951.

Unfortunately, only a few of the 27 parasitoid species released became well established. Fortunately, however, a nucleopolyhedrovirus (*Borrelinavirus hercyniae*) that was accidentally introduced from Europe caused an epizootic in 1939-1940, and European sawfly populations have never since reached unacceptably high densities, presumably due to the NPV and two parasitoids.

Another major success story in classical biological control occurred several decades later when several parasitoids were introduced from Europe to suppress epidemic populations of the winter moth, a pest of many deciduous trees that was introduced into Nova Scotia (Embree 1965). Although Ed Reeks, Doug Eidt and Frank Morris also carried out studies on the winter moth, a classic study was carried out by Doug Embree, during which he followed winter moth populations, using the life-table approach pioneered at Green River, for 10 years, including years before and after the introduction of a tachinid and ichneumonid wasp that suppressed winter moth densities (Fig. 4). He later collaborated with Jens Roland to write a review (Roland and Embree 1995) that harmonized his results with those of Jens, who had demonstrated that pupal predation by indigenous species was an important factor in the suppression of winter moth populations in British Columbia.

Two other CFS-Atlantic projects that made outstanding contributions to forest entomology are briefly described below. Whereas the Green River project is well known and still frequently cited, the contributions of the studies on fall webworm have probably not received the attention they deserve.

Green River Project

The Green River project, which was carried out in north-western New Brunswick from 1944 to 1973, was one of the most influential studies ever carried out in forest entomology. Approxi-

mately 106,000 ha of spruce-and balsam fir-dominated forest were included in the study, which was supported by two federal departments, one provincial department, and Fraser Companies Ltd. The goal of the project was to examine "natural" and "applied" control of epidemic spruce budworm populations by comparing the dynamics of spruce budworm in a continuous forest without insecticide spraying or harvesting to that in mixed forests with sprayed and unsprayed blocks.

The large main camp of the Green River project usually housed 30-40 people (Fig. 5a, b)during spring and summer, and contained a large number of laboratories and storage facilities. Life at the main camp is delightfully described by Muriel Miller in a previous issue of the *Bulletin* (Miller 1984).

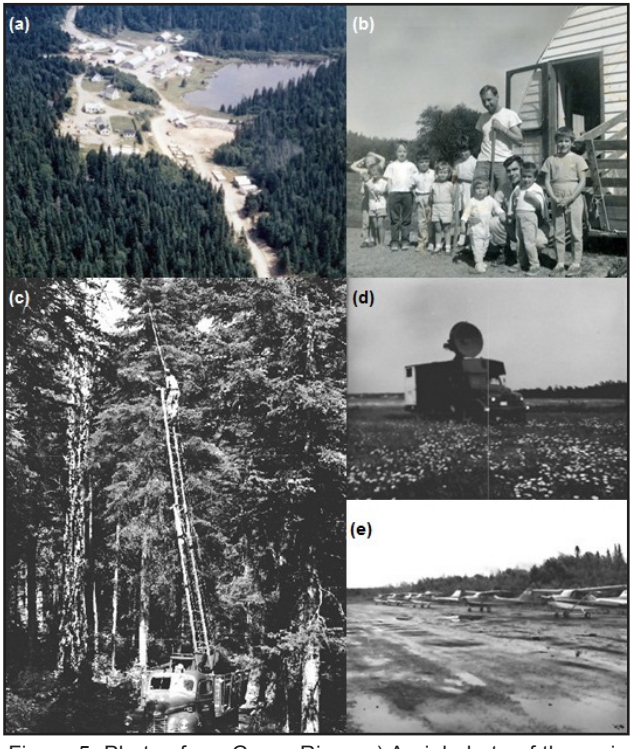

Figure 5. Photos from Green River. a) Aerial photo of the main compound; b) some of the "Green River children" (see letter by Muriel Miller), accompanied by Thaddée Renault (crouching) and a summer student; c) man using a pole-pruner while standing at the top of a revolving ladder that was fastened to a truck; d) a travelling laboratory used to monitor adult budworm dispersal using radar; and e) some of the planes used to catch juvenile budworm at different altitudes.

Under the direction of Frank Morris, a life-table approach was devised to tabulate changes in the abundance of the different development stages and in the number of eggs produced per adult during the years that spruce budworm populations increased, peaked and declined. A large team of researchers, including, but not limited to, Gordon Baskerville, David Greenbank, Ed Kettela, Charlie Miller, Leonard Mook, Frank Morris, Murray Neilson, Ian Outram, Tom Royama, George Shaw, Tony Thomas and Bill Varty, carried out research on all aspects of the population dynamics of the spruce budworm. Whereas pole-pruners were used to collect juvenile stages from trees, planes with traps or radar and a radar-equipped truck were used to sample dispersing budworm (Fig. 5c, d, e).

The conclusions of the Green River study were summarized in many publications (Fig. 6), the most famous of which was a *Memoir of the Entomological Society of Canada* that was edited by Frank Morris (Morris 1963). The memoir was over 300 pages in length and contained 40 chapters by 12 authors. Although there was much debate about many points, the major conclusions of the study were that: the life-table approach pioneered at Green River, along with regression and key-factor analyses, were useful to elucidate mechanisms influencing population dynamics; budworm outbreaks were associated with maturing of extensive areas of balsam fir and climatic variation; three or four summers of clear, dry weather "seemed" to release populations; dispersal

from epicentres and starvation were important influences on budworm dynamics; parasites and predators did not exert a large influence on budworm populations during the outbreak; stand structure had a large influence on budworm dynamics and could be manipulated to "prevent" high defoliation; and insecticides or sex pheromones could be used to reduce densities in incipient outbreaks.

The need for new analytical tools to elucidate the role of the many factors influencing spruce budworm population dynamics led to a large increase in the number of theoretical papers on analytical techniques for studying population dynamics (Fig. 6). The Green River project also stimulated subsequent theoretical and field work in various systems. Using only the eastern spruce budworm as an example, a reanalysis of the Green River data by Tom Royama resulted in a new method of analysis and in different conclusions regarding the underlying factors determining the second-order process (i.e., variations in survival of old larvae and pupae and in the egg:moth ratio). It also formed a good portion of his subsequent book on analytical population dynamics (Royama 1992). The Green River study also helped stimulate long-term and detailed studies of the dynamics of spruce budworm in New Brunswick (Eldon Eveleigh and Tom Royama), Quebec (David Perry and Jacques Regnière) and Ontario (Jacques Regnière and Vince Nealis).

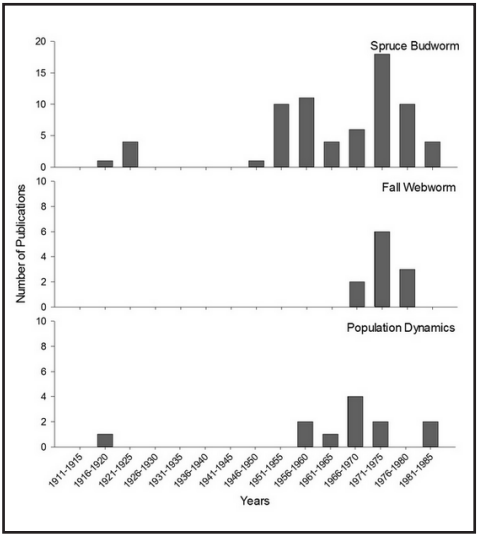

Figure 6. Temporal distribution of scientific publications from CFS-Atlantic (Fredericton) between 1911 and 1985 on the spruce budworm, fall webworm, and population dynamics.

Fall Webworm Studies

The population dynamics of the spruce budworm were difficult to elucidate for many reasons, not the least of which were the long length of budworm cycles (approximately one outbreak every 35 years) and the difficulty of sampling and estimating dispersal. Consequently, Frank Morris decided to hone his analytical skills by studying the population dynamics of the fall webworm, which had four outbreaks in eastern Canada between 1939 and 1974. Defoliation by webworm larvae, which feed on a large variety of deciduous trees, occurs at the end of summer, and so has a minimal effect on hosts. Larvae are easy to locate because they make large webs that can enclose entire trees. Frank Morris carried out a large series of surveys and manipulative field experiments on the fall webworm (Fig. 6). Peter Price (2003; page 36), who obtained his masters degree at the University of New Brunswick and who greatly appreciated his interactions with Frank Morris, articulated his evaluation of Morris's webworm research in the following way: "*He noted the improved explanatory power of his process studies compared with field studies alone and correlational interpretations. He was also examining the role of density dependence, the genetic quality of populations, and intrinsic mechanisms in population regulation. Host plant phenology and quality variation were constituents of the model, as was the geographic variation of land use and climate. Morris's legacy is a vastly more comprehensive enquiry into the distribution, abundance, and population dynamics of a species than had been achieved up to his time and remains to this day as an example we can all benefit from*."

Conclusion

Research at CFS-Atlantic during its first 75 years was dominated by entomologists, who published almost half of the scientific publications from the research centre. The large number of publications was not as impressive as the quality of the published works, and the large impact they had on forest entomology, forest management, and insect ecology. To mention just a few of their accomplishments, forest entomologists at CFS-Atlantic: pioneered biological control in Canada (John Tothill and Alfred Baird); were responsible for two of the greatest success stories in classical biological control (European spruce sawfly and the winter moth); were the first (Morris et al.), along with independent studies in Britain (e.g., Richards and Waloff 1954; Varley and Gradwell 1958), to develop the use of life-tables for insects; were among the first to promote (Morris) and then discourage (Royama) the use of key-factor analysis; were among the first to incorporate "process studies" and evolutionary ecology into population dynamics studies (e.g., Morris's work on the fall webworm); and developed more rigorous models for predator-prey interactions and population dynamics (Royama). The incredible creativity and productivity of forest entomologists at CFS-Atlantic during the first 75 years of the institution may be unparalleled and constitute one of the most important components in Canada's rich entomological heritage.

Acknowledgements

I thank Caroline Simpson, Doug Eidt, Doug Embree, Suzanne Renault and Taddy Renault for historical information, Caroline Simpson, Suzanne Renault and Taddy Renault for photos, Lindsay May and Allen Graves for scanning photos and organizing publication data, and Caroline Simpson and Cedric Gillott for comments on an earlier version of the manuscript. I am especially grateful to Doug Eidt for the many biographies of forest entomologists that he prepared and to Caroline Simpson and Gerritt Van Ralte, who previously summarized some of the early history of CFS-Atlantic in a short publication. Finally, I thank Muriel Miller for her humorous and insightful story that was published in the Bulletin of the Entomological Society of Canada 28 years ago. All photographs were obtained from Thaddée and Suzanne Renault and from photos stored at CFS-Atlantic (Fredericton).

References

Embree, D.G. 1965. The population dynamics of the winter moth in Nova Scotia, 1954-1962. Memoirs of the Entomological Society of Canada, No. **46** (57pp.).

Miller, M.E. 1984. My life with the spruce budworm. Bulletin of the Entomological Society of Canada **16**:70-73.

Morris, R.F. 1963. The dynamics of epidemic spruce budworm populations. Memoirs of the Entomological Society of Canada, No. **31** (332pp.)

Price, P. 2003. Macroevolutionary Theory on Macroecological Patterns. Cambridge University Press, Cambridge, United Kingdom.

Richards, O.W., and Waloff, N. 1954. Studies on the biology and population dynamics of British grasshoppers. Anti-Locust Bulletin **17**: 1-182.

Roland, J., and Embree, D.G. 1995. Biological control of the winter moth. Annual Review of Entomology **40**:475-492.

Royama, T. 1992. Analytical Population Dynamics. Chapman and Hall, London.

Simpson, C.M. 1999. Our history... Selected musings on events, people, and places. Canadian Forest Service-Atlantic publication, Fredericton, New Brunswick.

Varley, G.C., and G.R. Gradwell. 1958. Oak defoliators in England. Proceedings of the 10th International Congress of Entomology **4**:133-136.