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Teaching natural history at the Museum of Vertebrate Zoology

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Abstract. During its centennial celebrations in 2008, the Museum of Vertebrate Zoology (MVZ) at the University of California, Berkeley paid homage to its founding director, Joseph Grinnell. Recognized as a leading scientific institution, the MVZ managed to grow throughout the twentieth century, a period often characterized by the decline of natural history. To understand how and why research flourished at the MVZ, this paper looks closely at Grinnell's undergraduate course, the Natural History of the Vertebrates (NHV). Taught by MVZ affiliates since 1914, the NHV offers an important window on Grinnell's approach and legacy. This paper argues that the NHV contributed to the MVZ's long-term success by acting as, first, a gateway to natural history; second, a vector for the MVZ's research programme; and third, a shared faculty responsibility. Grinnell's significance in the history of science is understated, in part because his writing style de-emphasized the importance of his theoretical contributions, including his development of the niche concept, his emphasis on population thinking and geographic isolation in studies of evolution, and his effort to integrate speciation questions and genetics. Studying the NHV highlights these contributions because Grinnell freely communicated his ideas to his students. An analysis of Grinnell's course material shows that his theoretical and methodological approach pre-dated the evolutionary synthesis and inspired natural-history research throughout the past century.

Established in 1908, the Museum of Vertebrate Zoology (MVZ) at the University of California, Berkeley, recently celebrated its centennial. There was much to celebrate. The twentieth century was not generally kind to natural history, yet the MVZ managed to flourish. While many natural-history museums were forced to shut their doors and/or significantly realign their objectives, the MVZ upheld the core scientific approach of its founding director, Joseph Grinnell. The centennial provided an ideal opportunity to commemorate Grinnell, who launched a remarkably successful research programme that

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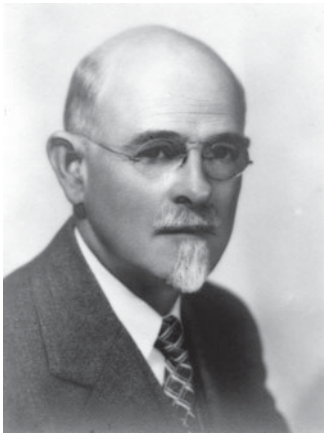

Figure 1. Joseph Grinnell. This portrait hangs prominently in the Museum of Vertebrate Zoology. Museum of Vertebrate Zoology, photograph collection, *c.*1935.

paved the way for a century of investigations.[1] A celebration of the MVZ is a celebration of Grinnell.[2] MVZ newcomers are quickly introduced to the man behind the museum, but it is not uncommon for this to be a first introduction (see Figure 1).

Although Grinnell is well known by ornithologists and mammalogists, his significance is not often recognized outside these communities. Unlike some of his contemporaries and correspondents, Grinnell did not write a major treatise, popularize his ideas or emphasize his theoretical contributions. This does not mean that his ideas did not become widespread; indeed, Grinnell managed to build something of a natural-history empire, but he does not always receive proper credit for his innovations. The niche concept, for example, is most often associated with the mid-twentieth-century work of Charles Elton and/or George Evelyn Hutchinson, even though Grinnell first published

1 For more on the history of the Museum of Vertebrate Zoology see Elihu M. Gerson, 'The American system of research: evolutionary biology, 1890–1950', PhD dissertation, University of Chicago, 1998; Elihu M. Gerson and James R. Griesemer, 'Collaboration in the Museum of Vertebrate Zoology', *Journal of the History of Biology* (1993) 26, pp. 185–203; James R. Griesemer, 'Modeling in the museum: on the role of remnant models in the work of Joseph Grinnell', *Biology and Philosophy* (1990) 5, pp. 3–36; *idem*, 'Material models in biology', in Arthur Fine, Micky Forbes and Linda Wessels (eds.), *PSA 1990, v.2*, East Lansing: Philosophy of Science Association, 1991, pp. 79–93; *idem*, 'Niche: historical perspectives', in Evelyn Fox Keller and Elisabeth A. Lloyd (eds.), *Key Words in Evolutionary Biology*, Cambridge, MA: Harvard University Press, 1992, pp. 231–240; Javier A. Rodriguez-Robles, David A. Good and David B. Wake, *Brief History of Herpetology in the Museum of Vertebrate Zoology, University of California Berkeley, with a List of Type Specimens of Recent Amphibians and Reptiles*, Berkeley: University of California Press, 2003; Barbara Stein, *On Her Own Terms: Annie Montague Alexander and the Rise of Science in the American West*, Berkeley: University of California Press, 2001; Robert Kohler, *All Creatures: Naturalists, Collectors, and Biodiversity, 1850–1950*, Princeton: Princeton University Press, 2006.

2 On the problematic nature of commemorative practices see Pnina Abir-Am, 'Commemorative practices in science: historical perspectives on the politics of collective memory', *Osiris* (1999) 7, pp. 1–33. This paper recognizes the biased perspective of commemorative agendas, but does not explore the ramifications of the MVZ's centennial celebrations in depth.

on the concept in 1913.[3] An emphasis on population thinking and geographic isolation in evolutionary studies, and the integration of speciation questions with genetics, are usually attributed to Ernst Mayr and Theodosius Dobzhansky and associated with the evolutionary synthesis period, even though this theoretical framework is evident in Grinnell's early publications and in his teaching materials.[4]

Disdainful of self-promotion, and reluctant to publish theoretical interpretations prematurely, Grinnell freely shared his views in the classroom. In fact, Grinnell's colleague, Eugene Raymond Hall, suggested that the 'breadth of his interests, the depth of his knowledge of natural history, and his comprehension of ecological relationships probably were better known to his pupils than to his readers'.[5] As a result, students have been significant vectors for Grinnell's philosophy. Many students were first introduced to field and museum work in the Natural History of the Vertebrates (NHV), a course that Grinnell began teaching in Berkeley's zoology department in 1914 and which is still offered today through the Integrative Biology programme.[6] Although not all students were taught directly by Grinnell, many were taught by his academic descendants, or by those who embraced key aspects of his philosophy.

Grinnell's philosophy is embodied in the MVZ. He built practices into the museum that continue to be associated with his name. The 'Grinnellian' method involves a variety of standardized practices (e.g. 'Grinnellian' field notes) that embed museum specimens in a network of associated data; it was this prototypical relational database that facilitated the MVZ's early digitization of its records. Grinnell set up the MVZ as a research tool to enable long-term studies of evolution and predicted that the data he was collecting would not reach its full value for many years to come. This systematic, research-oriented approach to building specimen collections required specially trained workers and set the MVZ apart from other natural-history museums. During the pre-Darwinian period, collections were assembled largely by professional collectors who were usually rewarded

3 Griesemer, 'Niche: historical perspectives', op. cit. (1); Joseph Grinnell and H. Swarth, 'An account of the birds and mammals of the San Jacinto area of Southern California with remarks upon the behavior of geographic races on the margins of their habitats', *University of California Publications in Zoology* (1913) 10, pp. 197–406.

4 Joel B. Hagen, *An Entangled Bank: The Origins of Ecosystem Ecology*, New Brunswick: Rutgers University Press, 1992; Sharon Kingsland, *Modeling Nature: Episodes in the History of Population Ecology*, Chicago: Chicago University Press, 1995; Ernst Mayr, 'Prologue: some thoughts on the history of the Evolutionary Synthesis', in Ernst Mayr and William B. Provine, *The Evolutionary Synthesis: Perspectives on the Unification of Biology*, Cambridge, MA: Harvard University Press, fourth printing, 1998 (first published 1980), pp. 1–50. Grinnell's early thinking about populations and isolation is evident in Grinnell, 'The origin and distribution of the chestnut-backed chickadee', *The Auk* (1904) 21, pp. 364–382. Grinnell's incorporation of genetics with questions of speciation is evident in his handout on 'Speciation' – discussed later in the paper. Joseph Grinnell, 8 April 1937, 'Speciation: Things entering the problem of species-making in vertebrate animals', Joseph and Hilda Wood Grinnell Papers, Bancroft Library, Berkeley (subsequently JHGP), Box 9, Folder 8.

5 E.R. Hall, 'Joseph Grinnell (1877 to 1939)', *Journal of Mammalogy* (1939) 20, pp. 400–417, 412.

6 Carla Cicero, staff curator of birds at the MVZ, first learned about the MVZ when she took the NHV course in 1981. Cicero completed her PhD at the MVZ in 1993 and was then hired as the staff curator of genetic resources (1994). Monica Albe, a senior museum specialist at the MVZ, also learned about the MVZ through the NHV in 2000. Hired as a curatorial assistant in 2001, Albe transitioned into her current position in 2004.

for the volume and/or uniqueness of their specimens, rather than for the quality of their field notes (i.e. the data associated with each specimen). Furthermore, before population thinking became widespread, museums focused on gathering single type specimens rather than amassing populations to display individual variability, as exemplified in the MVZ. Founded on a firm conceptual basis, committed to investigating the relationship between biogeography and evolution, and situated within a research university, the MVZ was uniquely poised to contribute to evolutionary biology. Through the NHV, Grinnell trained students to generate data that would build the MVZ into an unparalleled resource for studying evolutionary change over time.

While Grinnell's research programme thrived at the MVZ, the biological sciences underwent a transformation.[7] Cellular and molecular biology gained prominence on university campuses, professional societies followed suit, and funding agencies promoted laboratory-oriented approaches to biological problems.[8] Although many American universities had developed natural-history museums as centres of research and teaching in the nineteenth century, their emphases shifted towards public displays as the twentieth century progressed.[9] A few university-based natural-history museums retained research reputations, but their respective research programmes were significantly reoriented under changing directors and institutional contexts.[10] The MVZ is an outlier of this general trend.[11] By reaching a wide community of students, many of whom pursued graduate studies away from the MVZ, the NHV generated interest in field, laboratory and museum work while facilitating the dispersal of Grinnell's approach to natural history.[12]

7 Garland E. Allen, *Life Science in the Twentieth Century*, London: Wiley, 1975; Ronald Rainger, Keith Benson and Jane Maienschein (eds.), *The American Development of Biology*, Philadelphia: University of Pennsylvania Press, 1988; and Jane Maienschein, *Transforming Traditions in American Biology, 1880–1915*, Baltimore: Johns Hopkins University Press, 1991.

8 Toby A. Appel, 'Organizing biology: the American Society of Naturalists and its "Affiliated Societies," 1883–1923', in Rainger, Benson and Maienschein, op. cit. (7), pp. 87–120; Keith Benson, 'From museum research to laboratory research: the transformation of natural history into academic biology', in Rainger, Benson and Maienschein, op. cit. (7), pp. 49–86; and P. Henson, 'The Comstock research school in evolutionary entomology', *Osiris* (1993) 8, pp. 158–177.

9 Sally Kohlstedt, 'Museums on campus: a tradition of inquiry and teaching', in Rainger, Benson and Maienschein, op. cit. (7), pp. 15–48.

10 Mary P. Winsor, *Reading the Shape of Nature: Comparative Zoology at the Agassiz Museum*, Chicago: University of Chicago Press, 1991.

11 Although there are additional university-based natural history museums that have retained active research programmes, such as Harvard's Museum of Comparative Zoology, the Museum of Vertebrate Zoology stands out in the sense that its current research programme is the realization of its long-standing research goal to monitor faunal change over time in California. For more on the Museum of Comparative Zoology see Winsor, op. cit. (10).

12 Diffusion of the Grinnellian approach is worth noting because his influence is often acknowledged, especially in the mammalogy and ornithology communities; see Ned K. Johnson, 'Ornithology at the Museum of Vertebrate Zoology, University of California, Berkeley', in W.E. Davis Jr and J.A. Jackson (eds.), *Memoirs of the Nuttall Ornithological Club*, Cambridge, MA: Nuttall Ornithological Club, 1995, pp. 183–221; Frank Pitelka, 'Academic family tree for Loye and Alden Miller', *The Condor* (1993), pp. 1065–1067; J.O. Whitaker, 'Academic propinquity: III. The Joseph Grinnell/E.R. Hall group (Berkeley and Kansas)', in Elmer C. Birney and Jerry R. Choate (eds.), *Seventy-Five Years of Mammalogy, 1919–1994*, Provo: American Society of Mammalogists, 1994, pp. 129–134; J. Knox Jones Jr, 'Genealogy of twentieth-century systematic

Training shapes the way that scientists approach problems, generate data and formulate answers, yet questions of education and teaching have not taken centre stage in the history of science.[13] This paper shows that transmitting Grinnell's approach to studying evolutionary biology in the classroom contributed to the long-term success of the MVZ's research programme. Resurvey work exemplifies the stability of the MVZ research programme. Grinnell intended students 'of the future' to conduct '[c]omparative studies of the conditions in the same area at different successive times', and thereby 'bring important generalizations in the field of evolution'.[14] The MVZ's current flagship study involves resurveying Grinnell's pioneering field studies of California to document patterns of change in the fauna and flora and is aptly titled The Grinnell Resurvey Project.[15]

mammalogists in North America: the descendants of Joseph Grinnell', in Michael A. Mares and David J. Schmidly (eds.), *Latin American Mammalogy: History, Biodiversity, and Conservation*, Oklahoma: University of Oklahoma Press, 1991, pp. 48–56. After Grinnell served as president of the American Society of Mammalogists (1937–1938), many of his students, grand-students, and great-grand-students followed suit, including Walter P. Taylor (1940–1942), E. Raymond Hall (1944–1946), Tracy Storer (1949–1951), William H. Burt (1953–1955), William B. Davis (1955–1958), Robert T. Orr (1958–1960), Stephen D. Durrant (1960–1962), Emmet T. Hooper (1962–1964), Donald F. Hoffmeister (1964–1966); Randolph L. Peterson (1966–1968), Richard G. Van Gelder (1968–1970), J. Knox Jones Jr (1972–1974); Sydney Anderson (1974–1976), William Z. Lidicker (1976–1978), Robert S. Hoffmann (1978–1980), James S. Findley (1980–1982), J. Mary Taylor (1982–1984, who graduated from the MVZ under Alden Miller and became the first female president of the ASM), Hugh Genoways (1984–1986), Don E. Wilson (1986–1988), Elmer C. Birney (1988–1990), James H. Brown (1990–1992), Robert J. Baker (1994–1996), O. James Reichman (1998–2000), Thomas H. Kunz (2002–2004), Guy N. Cameron (2006–2008) and Michael A. Mares (2010–2012). Since Grinnell 73% of the ASM presidents have had a Grinnellian lineage. Thanks to William Z. Lidicker who compiled this information and presented it in a talk titled 'Mammalogy at MVZ: a brief overview' at the MVZ Centennial Celebrations, 12 December 2008. Grinnell also served as president of the American Ornithologists' Union, as did his student Alden Miller and grand-students Charles Gald Sibley (1986–1988) and Ned K. Johnson (1996–1998), among others.

13 The important relationship between teaching and research has been explored in the physical sciences and engineering; see David Kaiser (ed.), *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives*, Cambridge, MA: MIT Press, 2005; *idem*, *Drawing Theories Apart: The Dispersion of Feynman Diagrams in Postwar Physics*, Chicago: University of Chicago Press, 2005; Kathryn Olesko, *Physics as a Calling: Discipline and Practice in the Königsberg Seminar for Physics*, Ithaca: Cornell University Press, 1991; and Andrew Warwick, *Masters of Theory: Cambridge and the Rise of Mathematical Physics*, Chicago: University of Chicago Press, 2004. Studies of research schools have explored the role of teaching in chemistry and physiology research; see Frederic L. Holmes, 'The complementarity of teaching and research in Liebig's laboratory', *Osiris* (1993) 5, pp. 121–164; Gerald L. Geison, *Michael Foster and the Cambridge School of Physiology*, Princeton: Princeton University Press, 1978; Gerald L. Geison and Frederic L. Holmes (eds.), 'Research schools: historical appraisals', *Osiris* (1993) 8; and Jack B. Morrell, 'The chemist breeders: the research schools of Liebig and Thomas Thomson', *Ambix* (1972) 19, pp. 1–46.

14 Joseph Grinnell to Benjamin Wheeler, 1 July 1910, President Correspondence 1908–1919, Museum of Vertebrate Zoology, Berkeley (subsequently PC).

15 For an analysis of the Grinnell Resurvey Project see Michelle Nijhuis, 'The ghosts of Yosemite', *High Country News*, 17 October 2005; Kenneth Brower, 'Disturbing Yosemite', *California Magazine* (2006) 117, pp. 14–21, 41–44; Avelet Shavit and James R. Griesemer, 'There and back again, or, the problem of locality in biodiversity surveys', *Philosophy of Science* (2009) 76, pp. 273–294; Shavit and Griesemer, 'Transforming objects into data: how minute technicalities of recording "species location" entrench a basic challenge for biodiversity', in Alfred Nordmann and Martin Carrier (eds.), *Science in the Context of Application*, forthcoming. For published results from the Grinnell Resurvey Project see Craig Moritz *et al.*, 'Impact of a century of climate change on small-mammal communities in Yosemite National Park, USA', *Science* (2008) 322, pp. 261–264.

Exploring how the MVZ prospered during an era of profound change in the life sciences highlights factors that contribute to the long-term success of research programmes.[16] The term 'research programme' is used to refer to an organized research approach that utilizes a defined collection of theories, concepts, terminology, techniques, tools and methods to answer an overarching set of questions.[17] Previous analyses have attributed research success, or stability, to a variety of factors, including leadership qualities of the research director, general characteristics of the research group, institutional and financial contexts and pedagogy.[18] Most efforts to extend analyses of research programmes have centred on work that takes place exclusively in laboratories, while little attention has been paid to the kind of work that occurs in museums, herbariums, marine stations and field stations, which usually involves a combination of laboratory work, fieldwork and/or collections work.[19] By exploring the interplay of research and teaching at the MVZ, this essay shows that the long-term stability of the NHV is closely intertwined with the MVZ's institutional success. Instruction in the NHV has consistently facilitated the transmission of the conceptually informed practices that form the backbone of the MVZ's research programme to generations of students.

This paper shows how the NHV has acted as, first, a gateway to 'Grinnellian' natural history; second, a vector for the MVZ's research programme; and third, a shared faculty responsibility. The first section provides an overview of Grinnell's research vision and describes how the NHV course acted both as an introduction to natural history and as a gateway to the MVZ research community. The NHV succeeded in recruiting students to natural history in an environment that became increasingly hostile to field and museum practices, especially in the latter part of the twentieth century. The second section examines the interplay of the MVZ's research approach and the NHV's content through a close study of the NHV's changing course description. With a focus on the Grinnellian period, this section looks closely at how Grinnell taught students to study speciation, a central topic of his research programme, and reveals that his approach anticipated the evolutionary synthesis period. The third section profiles previous NHV instructors and explores their role in transmitting the MVZ's approach to

16 Previous efforts to evaluate the success of research programmes have focused primarily on research schools, which Geison defined as 'small groups of mature scientists pursuing a reasonably coherent program of research *side-by-side* with *advanced students* in the same institutional context and engaging in direct, continuous social and intellectual interaction'. Gerald Geison, 'Scientific change, emerging specialties, and research schools', *History of Science* (1981) 19, pp. 20–40, 23, original emphasis.

17 Henson, op. cit. (8).

18 Geison, op. cit. (13); Geison and Holmes, op. cit. (13); Morrell, op. cit. (13).

19 Gerald L. Geison, 'Research schools and new directions in the historiography of science', *Osiris* (1993) 8, pp. 226–238, 232; Robert E. Kohler, *Lords of the Fly: Drosophila Genetics and the Experimental Life*, Chicago: University of Chicago Press, 1994. In contrast, the role of training in research that involves work beyond the laboratory remains largely uncharted, with the exception of David Kushner, 'Sir George Darwin and a British school of geophysics', *Osiris* (1993) 8, pp. 196–223; Joel B. Hagen, 'Clementsian ecologists: the internal dynamics of a research school', *Osiris* (1993) 8, pp. 178–195; Ronald Rainger, 'Adaptation and the importance of local culture: creating a research school at the Scripps Institution of Oceanography', *Journal of the History of Biology* (2003) 36, pp. 461–500.

generations of students. Nurturing common ground amongst the faculty, especially during times of increasing research specialization, promoted long-term stability in the MVZ.

A gateway to 'Grinnellian' natural history

Although it has primarily been an undergraduate course, Grinnell made the NHV a requirement for new graduate students affiliated with the MVZ.[20] Even students with substantial fieldwork experience were not exempt. By teaching the theories, concepts and practices that comprised his research approach, Grinnell equipped students with the skills to turn observations into scientific data – and not just any data, but data that could contribute to the MVZ's overarching research programme. Using the MVZ's research to introduce the questions, practices and tools of natural history, the NHV has infused students with a Grinnellian perspective and functioned as a gateway both to the MVZ and to natural history more generally. This section introduces Grinnell and the MVZ, and explores their significance in this history of biology. Grinnell's standardization of natural-history practices was central to his research and a key component of the NHV's curriculum. The latter part of this section looks closely at how Grinnell taught students to take accurate, scientifically credible and theoretically interesting field notes.

As a graduate student at Stanford, Grinnell encountered ichthyologist David Starr Jordan, who championed the fundamental role of isolation in evolution, and ran a zoology department where taxonomy, field studies and embryology coexisted.[21] Shaped by Jordan (and perhaps even anticipating his views about isolation), Grinnell emphasized the role of geography in evolution and asked how species variation was correlated to specific habitat features.[22] Grinnell wondered how physical barriers in the environment, like a river or a mountain, affected the amount of variation and the creation of new species.[23] It was important, therefore, to gather a great variety of each species from a multitude of different habitats. This approach of measuring and analysing diversity within a species was quite different to previous collecting approaches that had

20 This is confirmed by a variety of sources, including conversations with Professor Emeritus Dale McCullough, who was required to take the NHV by his PhD supervisor, Aldo Starker Leopold, and conversations with Professors Emeriti William Z. Lidicker and James L. Patton, who indicated that new graduate students in both the MVZ and the Department of Zoology were expected to participate in the NHV if they were without prior organismal training. A letter from Joseph Grinnell to Annie Alexander indicates that half of the students enrolled in the NHV were graduate students. Joseph Grinnell to Annie M. Alexander, 20 April 1929, Annie Alexander papers, 1929, Museum of Vertebrate Zoology, Berkeley (subsequently AA).

21 For more on Grinnell's life see H.W. Grinnell, 'Joseph Grinnell: 1877–1939', *The Condor* (1940) 42, pp. 3–34; Juan Ilerbaig, 'Pride in place: fieldwork, geography, and American field zoology, 1850–1920', PhD dissertation, University of Minnesota, 2002; A. Miller, 'Joseph Grinnell', *Systematic Zoology* (1964) 13, pp. 235–242; Hall, op. cit. (5).

22 Grinnell and Swarth, op. cit. (3). Ilerbaig pointed out that Grinnell actually tried to use the chickadee work for his doctorate, but his major professor, Charles Gilbert, judged it to be too short and speculative (Ilerbaig, op. cit. (21), p. 253).

23 Joseph Grinnell, *Joseph Grinnell's Philosophy of Nature: Selected Writings of a Western Naturalist*, Berkeley: University of California Press, 1943.

sought to obtain a single specimen that was representative of the whole species group (type).[24] Furthermore, since Grinnell was interested in the relationship of each specimen to its environment it was necessary to document habitat details. He built the MVZ to address these interests.

Grinnell's vision to build a research institution for the long-term study of evolution was shared and supported by Annie Montague Alexander, whose generous donations and tenacious drive led to the establishment of the MVZ. An avid collector and naturalist, Alexander was heir to the California and Hawaiian Sugar Refining Company fortune. With her money, she aspired to build a museum of natural history on the West Coast that could rival those on the East, and she selected Grinnell as the director to help realize her dream.[25] Both Grinnell and Alexander recognized an opportunity to create a West Coast-oriented natural-history museum that centred on California.[26]

Surveying the fauna of California was appealing to Grinnell for a number of reasons: it was strikingly diverse, it was rapidly undergoing dramatic changes due to development of the West Coast, and its fauna was relatively undocumented, or at least had not been surveyed systematically in a way that enabled proper scientific analysis (according to Grinnell). Furthermore, the geography of California provided Grinnell with an opportunity to conduct an in-depth study of the role of barriers and isolation in speciation – hot topics in natural history at the turn of the twentieth century.[27] The Californian landscape presented itself as a natural, ongoing experiment and Grinnell seized the opportunity to gather as much data as possible.

Together, Grinnell and Alexander agreed that the MVZ should be primarily a research institution with the following functions:

> Collecting and preserving animals of certain groups from a limited region [California]; recording in permanent form all obtainable information in regard to their distribution, variation, economic status and habits; serving as a bureau of popular information as regards the animals of the region worked in; the description and analysis of ecologic and faunal conditions as they are today; the publication of the immediately important data obtained, calling attention to whatever generalizations may be indicated by these facts; participation in the teaching of vertebrate zoology in the University; the preparation of exhibition groups to lead the public to recognize the meaning and value of animal life.[28]

Since this original statement of functions was first recorded in 1910, a few changes have occurred, such as the abandonment of public displays due to the exorbitant associated costs, coupled with the decisions to focus entirely on research and education, and the expansion of the MVZ's geographic scope beyond California and the Pacific West Coast to become more global. Despite these changes, the main objectives of the MVZ

24 Joseph Grinnell, 1 July 1930, Museum of Vertebrate Zoology Annual Report, Museum of Vertebrate Zoology, Berkeley, Folder: Annual Reports, Miscellaneous History cabinet (Subsequently AR-MVZ).

25 Grinnell, op. cit. (21); Gerson and Griesemer, op. cit. (1), pp. 186–187; Stein, op. cit. (1), p. 75.

26 Sally G. Kohlstedt, 'Review: museums: revisiting sites in the history of the natural sciences', *Journal of the History of Biology* (1995) 28, pp. 151–166; Stein, op. cit. (1), pp. 76–87.

27 Grinnell, op. cit. (23).

28 Joseph Grinnell to Benjamin Wheeler, op. cit. (14).

have remained constant. This continuity is indicated by the programme description provided on the MVZ's website today, which explains,

> The superb collections are at the heart of the MVZ program, where methods of field biology are combined with modern laboratory techniques and analytical methods in a comprehensive, synthetic approach. Our goals are to remain at the forefront of international research on evolutionary biology from the perspectives of systematics, ecology, behavior, functional and developmental morphology, population biology, and evolutionary genomics, and to lead the way in developing and using major natural-history collections for research, education, and solving problems in biodiversity conservation.[29]

Comparing these two descriptions reveals the MVZ's prevailing focus on the specimen collection, and dedication to research. Although Grinnell's original statement did not list 'contributing to evolutionary biology' as one of the MVZ's functions, he made it clear that the MVZ's ultimate purpose was to 'bring important generalizations in the field of evolution'.[30] Accordingly, Grinnell built the MVZ to facilitate long-term studies of evolution.

A discernible force in the American ornithology and mammalogy communities, Grinnell convinced many of his students and colleagues to conduct more rigorous experimental work during a period of important change in the life sciences. While the desire to exert control over experimental conditions led many scientists to study evolution via heredity in the laboratory, Grinnell asserted the advantages of studying evolution in the field. Charles Davenport, for example, established the Station for Experimental Evolution at Cold Spring Harbor in 1904 with funding from the Carnegie Institute of Washington, and, as their main zoology adviser, preferentially supported laboratory-centric work.[31] Like Davenport, Grinnell built a technically sophisticated and highly organized research institution, but rather than setting up the MVZ in opposition to places like the Station for Experimental Evolution, he envisioned them as complementary. Although Grinnell argued for the reliability of natural over artificial experiments in evolution, he simultaneously encouraged his students to conduct breeding experiments that might inform their field observations and further test their interpretations.[32]

Both Grinnell and Alexander wanted to address important scientific issues; at the beginning of the twentieth century, this meant contributing to overlapping debates about the role of mutation versus isolation, and the role of mutation versus selection in

29 'The Museum of Vertebrate Zoology at Berkeley, what we do, and why', at http://mvz.berkeley.edu/General_Information.html, accessed 9 June 2009.

30 Joseph Grinnell to Benjamin Wheeler, op. cit. (14).

31 Juan Ilerbaig, 'The view-point of a naturalist', in Joe Cain and Michael Ruse (eds.), *Descended from Darwin*, Philadelphia: American Philosophical Society, 2009, pp. 23–48.

32 The laboratory–field distinction has been a productive topic of scholarship in the history and philosophy of sciences, but it is not addressed in depth here. See Robert E. Kohler, *Landscapes and Labscapes*, Chicago: University of Chicago Press, 2002; and *idem*, op. cit. (19). The naturalist–experimentalist dichotomy was introduced by Garland Allen, in Allen, op. cit. (7), and has had staying power, in part, because of the reinforcing field–laboratory distinction. Work at the MVZ challenges these distinctions. For an in depth discussion see Mary Sunderland, 'Collections-based research at the Museum of Vertebrate Zoology', forthcoming.

evolution.[33] Although the American scientific community had generally accepted Darwin's theory of evolution by the late nineteenth century, many were sceptical of natural selection and of the kinds of evidence provided by natural history. The publication of Hugo de Vries's *Mutation Theory* challenged the mechanism of natural selection with evidence from breeding experiments that suggested new species could arise in a single generation via mutation. Naturalists, like Grinnell, were highly doubtful of this interpretation because data from museum specimens offered overwhelming support for natural selection.[34] Fresh data from the field were needed to elucidate evolutionary mechanisms; isolation was a problem that evolutionary theory had to address.[35] To encourage this, Grinnell implemented an elaborate standardized system for data collection and organization.

Detailed procedures were implemented in the MVZ regarding taking of field notes, labelling specimens and photographing. Each specimen was only as valuable as its associated data; indeed, it was the lack of data that made evolutionary research difficult in many of the older natural-history museums. Numerous specimens that populated existing museums had been acquired by donation, or collected by professional collectors who were paid by the quantity of specimens, not by the quality of their field notes, hence the specific locality of a particular specimen was often ambiguous. For Grinnell, this was a serious flaw because he was motivated by questions about biogeography and evolution and sought information about the geographic distribution of species.[36] During the MVZ's early planning stages Grinnell predicted, 'Our field-records will be perhaps the most valuable of all our results'.[37] Rather than employ professionals to build the MVZ's collection, Grinnell preferentially hired and trained students to do the kind of fieldwork that could address questions about geographic distribution, variation and speciation.[38]

Grinnell's formalized note-taking procedures responded and conformed to the general trend towards methodological standardization in the life sciences.[39] Field notes were stressed as an integral component of each specimen. Without field notes, without data, specimens were worthless to the MVZ's research programme. Field notes provided the context for each animal that was collected. Grinnell was not simply interested in amassing specimens, he was equally interested in gathering precise data about the locality, habitat and behaviour of each species. Describing habitats required accurate recordings of weather conditions, temperature, elevation and flora, as well as any geographic features.[40] Documenting this large quantity of data involved a substantial

33 Gerson, op. cit. (1), p. 31.

34 Hugo de Vries, *Die Mutationstheorie. Versuche und Beobachtungen über die Entstehung von Arten im Pflanzenreich*, 2 vols., Leipzig: Veit, 1901–1903; Joseph Grinnell, 7 May 1925, speech notes 'To Doctor Gilbert and Professor Price', JHGP, Box 9, Folder 5.

35 John E. Lesch, 'The role of isolation in evolution: George J. Romanes and John T. Gulick', *Isis* (1975) 66, pp. 483–503; Gerson, op. cit. (1).

36 Gerson and Griesemer, op. cit. (1), pp. 193–196.

37 Joseph Grinnell to Annie M. Alexander, 14 November 1907, as cited in Stein, op. cit. (1), p. 77.

38 Stein, op. cit. (1); Ilerbaig, op. cit. (21).

39 Angela Creager and Hannah Landecker, 'Technical matters: method, knowledge and infrastructure in twentieth-century life science', *Nature Methods* (2009), pp. 701–705.

40 Joseph Grinnell, 'Suggestions for field notes', JHGP, Box 9, folder 8.

amount of writing; a day in the field might fill thirty notebook pages.[41] To deal with such a large quantity of information, Grinnell established procedures that facilitated data extraction from the narrative. Proven effective, Grinnell's procedures spread far and wide. Although Grinnell never wrote a laboratory manual, he did write a number of short descriptions of how to take field notes that have been adapted, readapted and promulgated.[42]

Keeping field notes was not a simple task. Teaching students to write and maintain them was a central focus of Grinnell's NHV, and has continued to be a major course activity. In the MVZ, field notes determine the value of the specimen, and in the NHV, field notes often determine a student's final academic standing. Examining the field-note-taking rules that Grinnell distributed to the NHV class is informative because the same rules were applied throughout the MVZ, and continue to be taught in the NHV class today. Furthermore, the instructions for taking field notes that were provided in the 2008 NHV laboratory manual remain nearly identical to the instructions that Grinnell provided to his students.[43] Taking field notes is a central craft skill that has been transmitted through the NHV. To this day, students' notes are evaluated and re-evaluated on multiple occasions to ensure that they are acquiring the proper skills to conduct meaningful field observations. It is through this iterative process that students learn how to appropriately record their experiences in the field.

To ensure accuracy, Grinnell instructed students to record observations 'at once' because 'memory is treacherous'.[44] Field notes followed a specific form that ensured that notes would retain their maximum value over time, both for the user and for potential readers in the distant future.[45] Learning how to take the right kind of field notes was important for doing any kind of natural history, but essential for the kind of work that was under way in the MVZ.[46]

Students were instructed to follow very specific directions, which required them to write on loose-leaf pages that could easily be rearranged. Constant rearrangement was important because Grinnell demanded a separation between the general field notes and the species accounts. In a species account, students were instructed to document everything about a particular animal under observation. Each species was subsequently assigned its own section, where many pages that related to the same species could be

41 Cathryn Carson, 'Writing, writing, writing: the natural field journal as literary text', *Townsend Newsletter* (2007), pp. 6–8.

42 Joseph Grinnell, 'Suggestions as to collecting', revised by Alden H. Miller, 2 July 1942, Museum of Vertebrate Zoology, Berkeley, Drawer – Miscellaneous History cabinet, Folder – Methods; E. Raymond Hall, *Collecting and Preparing Study Specimens of Vertebrates*, Lawrence: University of Kansas Museum of Natural History, 1962; *idem*, *The Mammals of North America*, 2nd edn, New York: Wiley, 1981; Steven G. Herman, *The Naturalists Field Journal*, Vermillion: Buteo, 1986; J.V. Remsen Jr, 'On taking field notes', *American Birds* (1977) 31, pp. 946–953.

43 Grinnell, op. cit. (34); N. Johnson, M.J. Mahoney, J.L. Patton and R.C. Stebbins, *Vertebrate Natural History Laboratory and Field Syllabus*, University of California, Berkeley, 2003, p. 118.

44 Grinnell, op. cit. (42), underlining in original.

45 Herman, op. cit. (42); Johnson *et al.*, op. cit. (43).

46 Carson, op. cit. (41); J.D. Perrine and J.L. Patton, 'Letters to the future: field notes and the Grinnell resurvey project', in Michael Canfield (ed.), *Field Notes on Science and Nature*, Cambridge, MA: Harvard University Press, 2011, pp. 211–250.

compiled. In fact, Grinnell never actually followed this rule himself, which suggests that grading ease and data extraction were perhaps the motivations behind this rule.[47] Students were further instructed to record the 'general and exact locality, date, and hour of the day', along with 'facts as observed for that species at the moment' and 'also any inferences that seem logically to be made from them'. For example, he provided a list of possible observations, including 'field characters, mannerisms, behavior, voice, reactions to danger, forage habits, mating actions, nesting habits, etc.' He emphasized, 'Every sort of fact definitely observed should be recorded; and observations even of the very same nature should be repeated again and again, as opportunity permits, for each species.'[48] No field observations were redundant.

In the 'general' section of field notes, students were instructed to provide the 'route of travel, hours of observation, weather conditions, nominal list of birds seen, and general impressions such as apply to all the species en masse.' When evaluating the field notes, Grinnell warned students that he would be looking for the 'development of powers of observation, and increase of ability to record accurately, and to infer correctly from, what is seen and heard'.[49] Although much effort was placed on standardizing the practice of taking notes in the field, Grinnell emphasized, 'Thoughtful, complete notes require thinking in the field and making inferences – not only recording of observations.'[50] Grinnell wanted his students to think about life-zones and niches.

Inspired by the life-zone descriptions of C. Hart Merriam that used temperature ranges to determine different habitat regions, or life-zones, Grinnell expanded the idea to consider how humidity, vegetation and other geographic characteristics impacted the ranges of different species.[51] Rather than using temperature as the main predictor of general life-zone areas, Grinnell worked with botanist Harvey Monroe Hall, from Berkeley's Department of Biology and Herbarium, to refine the concept in the Californian context. Together, they concluded that it was most effective to use animals and plants as 'indicators' of particular life-zones. Using Merriam's work as a guide, Grinnell and Hall provided a list of species that were associated with each zone.[52] For example, the Lower Sonoran zone could be recognized by the presence of Washington palm, mesquite, Fremont cottonwood, barrel cactus, desert quail, gilded flicker, Costa hummingbird, leaf-nosed bat, kangaroo rat, grasshopper mouse and desert sheep. In contrast, Hutton's vireo, Anna's hummingbird, brush rabbit, blue oak and California juniper characterized the Upper Sonoran zone.[53]

Students were provided with a list of indicator species for each life-zone and required to memorize what belonged where.[54] This was important because Grinnell was teaching

47 Carson, op. cit. (41); Perrine and Patton, op. cit. (46).

48 Grinnell, op. cit. (40).

49 Grinnell, op. cit. (40), underlining in original.

50 Grinnell, op. cit. (40), underlining in original.

51 C. Hart Merriam, *Life Zones and Crop Zones of the United States*, US Department of Agriculture Division of Biological Survey Bulletin No. 10, 1898; Joseph Grinnell and H.M. Hall, 'Life-zone indicators in California', *Proceedings of the California Academy of Sciences* (1919) 9, pp. 37–67.

52 Grinnell and Hall, op. cit. (51).

53 Joseph Grinnell, 6 April 1937, 'Some life-zone indicators for California', JHGP, Box 9, Folder 8.

54 Grinnell, op. cit. (53).

them how to make scientifically interesting observations. While observing a desert quail beside a barrel cactus was expected, finding a desert quail amongst California juniper warranted special notice. The movement of species into new life-zones interested Grinnell because it suggested the possibility of a natural experiment as the transported organism would soon need to adapt to new surroundings. Animals that were observed on the edges of their life-zones, or inhabiting unusual life-zones, were most likely to be in the process of speciation. Grinnell hoped to detect evolution in action.

Elaborate descriptions of different life-zones informed Grinnell's development of the niche concept, which held that a distinct environmental unit (niche) could be defined by a set of factors, including temperature, humidity, vegetation (i.e. food supply, shelter), soil composition and competition. Each species occupied only one niche. Any alternation of a niche therefore forced adaptation, which often meant leaving one niche for another. Grinnell was in search of the environmental factors that influenced 'species-making';[55] thinking in terms of ranges and niches was central to his approach.[56] Griesemer has pointed out that Grinnell's niche concept allowed him to think taxonomically about the environment wherein niches could be 'considered in groups' which together formed 'associations' which could then be 'grouped into faunal areas' and 'considered in series called life-zones, which subdivide continents; and life-zones may be grouped into regions, and these into world realms'.[57]

Along with life-zones, Grinnell taught the niche concept to his students early in the course because it informed their ability to record accurate, interesting, relevant field notes. These concepts impressed the importance of each organism's relation to its environment and drew attention to scenarios where evolution was under way. Looking at the NHV's examination questions reveals additional terms that students were expected to learn. In 1928, students were asked to define 'furcula, sternum, culmen, calamus, pteryla, secondaries, ecological niche, plumage, tomia, gonys'.[58] Most of these words refer to bird anatomy that enabled accurate field descriptions. For example, the terms tomia, gonys and culmen refer to different parts of a bird's bill. Rather than simply referring to a bird's bill, is was important to know how to describe the bill in detail, especially because the bill is often used as a way to distinguish between different species with a similar appearance. Once students had learned the necessary language to describe birds, they next had to learn how to distinguish between similar-looking birds at different times of the year because the colouring of many birds depends on both the season and age.

55 Joseph Grinnell, 8 April 1937, 'Speciation: things entering the problem of species-making in vertebrate animals', JHGP, Box 9, Folder 8.

56 Joseph Grinnell, 'An account of the mammals and birds of the Lower Colorado Valley with especial reference to the distributional problems presented', *University of California Publications in Zoology* (1914) 12, pp. 51–294; *idem*, 'Barriers to distribution as regards birds and mammals', *American Naturalist* (1914) 48, pp. 248–254; Griesemer, 'Niche: historical perspectives', op. cit. (1).

57 Joseph Grinnell, 'Significance of faunal analysis for general biology', selection from 'A distributional summation of the ornithology of Lower California', *University of California Publications in Zoology* (1928) 32, pp. 1–300, 13–18, reprinted in *idem*, op. cit. (23), p. 143, as cited in Griesemer, 'Modeling in the museum', op. cit. (1), p. 17. See also *idem*, 'Niche: historical perspectives', op. cit. (1).

58 Joseph Grinnell, 9 February 1928, 'Mid-term Examination Zool. 113', JHGP, Box 9, Folder 8.

To evaluate if students had grasped the idea of life-zones and the ecological niche, Grinnell asked them to 'name and explain five factors that limit the distribution of a land vertebrate'.[59] Answering the exam question required students to think critically about how new species were made. Thinking about the problem of 'species-making'[60] required students to think in terms of ranges, life-zones and niches. First and foremost it was important for students' observations to be accurate, hence the emphasis on terminology. But the long-term goal was to teach students how to recognize particularly interesting observations, such as noticing an animal in an unusual habitat, or performing an atypical behaviour. The cultivation of this skill is illustrated by a final examination question that asked, 'Given an association of live oak and low chaparral in the bottom of Strawberry Canyon, list the species of birds one would expect to find there at this season of the year.'[61] Students were learning how to predict and interpret the presence and absence of species.[62]

Understanding Grinnell's theoretical framework is key to understanding the role of the NHV, since he structured the course to teach students how to see and study the natural world from this perspective. The ability to see previously undetectable details has invited students into the MVZ community who are defined, in part, by this shared perspective. Although recognizing and describing detail in nature might seem like an easily acquirable skill, attainable through reading field guides, the NHV has impressed that this is not the case. Instead, the NHV has portrayed the ability to make valuable scientific observations as a professional skill that includes the capacity to recognize what is interesting and to make informed inferences.

A vector for the MVZ's research programme

Examining the origins and development of the NHV reveals how Grinnell shaped the course to reflect work in the MVZ. In addition to communicating the general research programme and note-taking practices of the MVZ, the NHV taught a broad skill set that was necessary to do museum work. Teaching the MVZ's core research questions and methods in the NHV nurtured the MVZ's research programme by educating the next generation of mammalogists, ornithologists and herpetologists, not just within the MVZ but also within the general research community. This section begins with an examination of the NHV's origins and explores how changes to the course description map onto changes in evolutionary biology and ecology during the first half of the twentieth century. The second half of the section looks at how Grinnell taught students to study speciation – the central topic of his research programme that continues to shape research today. A close analysis of Grinnell's class material on speciation reveals that he advocated a synthetic approach to studying evolution much before the evolutionary synthesis period.

59 Grinnell, op. cit. (58).
60 Grinnell, op. cit. (40).
61 Joseph Grinnell, 7 May 1935, 'Final Examination Zoology 113', JHGP, Box 9, Folder 8.
62 Grinnell, op. cit. (24).

In his first Annual Report (1910) to the university's president, Benjamin Wheeler, Grinnell indicated that although MVZ staff had not been involved 'extensively and directly in teaching', the museum had indeed played an important educational role by rendering 'aid in the way of material or information to the departments of Palaeontology, Zoology, Anthropology and Botany'.[63] He also highlighted his involvement with the free summer course, General Lectures on Local Zoology, which was open to the public. Offered from 1910 to 1917, these public education efforts focused on 'various aspects of the animal life of Berkeley and the Bay region',[64] a topic that was prominently featured in the growing MVZ. These well-attended summer courses informed the development of Grinnell's Natural History of the Vertebrates course and 'proved the demand for teaching in this line'.[65]

Despite the demand, Grinnell was unsuccessful in his attempts to convince Wheeler that the museum needed more human resources for teaching.[66] It was necessary for Grinnell to request additional support from the university because his primary responsibility was to research and management of the museum.[67] Responsibilities were dictated by his contract with Alexander, who paid Grinnell's salary and was firmly convinced that his time should not be spent teaching. Alexander frowned upon any teaching by MVZ staff; she reasoned that the university should pay for the service of teaching, since she paid the salary of each and every museum staff.[68]

Grinnell, however, was already beginning to recognize students as a valuable resource. Although he admitted that students initially consumed quite a bit of his valuable research time, he also believed that their contributions ultimately increased his productivity, and, more importantly, the productivity of the museum as a whole. He wrote to Alexander, 'I make it my business, by drilling in the technique of scientific writing, as well as in those matters that have to do with the research itself, to render their output creditable as contributions from MVZ.'[69] It was with this argument that Grinnell finally managed to convince Alexander that teaching was not a waste of his time.

By the time Grinnell started teaching Advanced Vertebrate Zoology in 1914 he had given much thought to the MVZ's educational role. With a newly minted PhD, Grinnell took over the teaching of Advanced General Vertebrate Zoology from William Emerson Ritter and Charles Atwood Kofoid. Along with his MVZ colleagues Harold C. Bryant and Walter P. Taylor, Grinnell began to mould Advanced General Vertebrate Zoology (Zoology 113) into what would become Natural History of the Vertebrates. Under Ritter and Kofoid's direction the course had been described as a 'systematic and ecological study of the vertebrate fauna of California' that was 'confined to the study of

63 Joseph Grinnell to Benjamin Wheeler, op. cit. (14).

64 *Announcement of Courses, 1910–1911*, Berkeley, 1910, 130, CCC-B.

65 Joseph Grinnell to Benjamin Wheeler, op. cit. (14).

66 Joseph Grinnell to Benjamin Wheeler, 1 April 11, PC; Benjamin Wheeler to Joseph Grinnell, 10 April 1911, PC.

67 Gerson and Griesemer, op. cit. (1); Stein, op. cit. (1); Joseph Grinnell, 1 July 1926, Museum of Vertebrate Zoology Annual Report, AR-MVZ.

68 Annie M. Alexander to Joseph Grinnell, 8 April 1929, AA.

69 Joseph Grinnell to Annie M. Alexander, op. cit. (20), underlining in original.

the mammals, birds, reptiles and amphibians of the Pacific Coast'. The course included: 'Lectures, field and laboratory and museum work, and papers on assigned topics'.[70] Studying the evolution of the course description under Grinnell illustrates how he incorporated the museum's objectives into the curriculum, ultimately forming the core emphasis.

During twenty-three years of teaching, Grinnell had various co-instructors and changed the course description five times. Renowned for his careful word choice and attention to detail, Grinnell's pointed edits can be interpreted as a meaningful representation of the skills and concepts that were identified as essential to doing work in the MVZ.

Grinnell's first subtle amendments to the course description in 1913 reduced the attention paid to amphibians (which were not a key focus of the MVZ's collection at the time) and changed the emphasis from 'ecological' to 'faunistic', which highlighted the MVZ's central aim of studying the geographic distribution of animals.[71] The next alteration occurred in 1918; a 'systematic and faunistic study' became a 'faunal and economic' study.[72] This minor yet significant word change points to Grinnell's increasing focus on the 'economy' of vertebrates, which referred to vertebrate animals' 'relation to human beings from the selfish standpoint of the humans'.[73] Economic zoology was distinguished from ecology; according to class notes that were taken by his wife, Hilda Wood Grinnell, Grinnell described ecology as the 'study of: food of first importance, proper temperature, proper degree of humidity, safe breeding places, safe refuges for adults during rest and sleep'. He went on to note that animals were 'an important part of their own environment' and that it was therefore necessary to consider 'competition among a species' and 'between species'.[74]

Distinguishing between ecology and economic zoology was necessary for Grinnell because ecology was in the early stages of its development and already accumulating multiple definitions, while economic zoology was more of an applied science that informed natural-resource management in important ways.[75] Grinnell's approach in the NHV was ecological, especially its focus on organism–environment interactions, yet he did not publicize his approach as such. Correspondence between Grinnell and pioneering ecologists like Victor Shelford and Charles Elton point to Grinnell's influence in early ecology in both American and European contexts.[76]

The removal of the word 'economic' in 1921 does not indicate a shift away from applied problems, but rather points to the museum's increasingly important role in economic and policy issues during a period in American history concerned with the

70 *Announcement of Courses, 1911–1912*, Berkeley, 1911, p. 134, CCC-B.

71 *Announcement of Courses, 1913–1914*, Berkeley, 1913, p. 232, CCC-B.

72 *Announcement of Courses, 1918–1919*, Berkeley, 1919, p. 262, CCC-B.

73 Hilda Wood Grinnell, 22 August 1922, 'Mr Grinnell Zool 116', JHGP-B, Box 9, Folder 12.

74 Grinnell, op. cit. (73).

75 Although a history of American ecology is beyond the scope of this article, see Hagen, op. cit. (4); Kingsland, op. cit. (4); and *idem*, *The Evolution of American Ecology 1890–2000*, Baltimore: Johns Hopkins University Press, 2005; Hunter Duprée, *Science in the Federal Government: A History of Policies and Activities to 1940*, Cambridge, MA: Belknap Press, 1957.

76 Grinnell correspondence, Museum of Vertebrate Zoology correspondence files, Berkeley, CA.

conservation of natural resources. In fact, 'economic' was removed from the description because that same year Grinnell introduced a stand-alone course, 'Economic Vertebrate Zoology', that addressed how knowledge of natural history could inform policy decisions, especially regarding 'important useful and injurious species'.[77] As the public realized that natural resources were limited and at risk of exhaustion, they looked to the government for protection, and the government increasingly looked to scientific experts for advice. Although he avoided direct political involvement, Grinnell trained many leading figures in the establishment and growth of the National Park Service.[78] Providing scientifically informed advice about the management of natural resources was an early function of the MVZ. Grinnell and his research associates interacted often with the California Division of Fish and Game to advise about predator and pest control, among other topics.[79] Instead of trying to cover vertebrate economics and natural history in one course, Economic Vertebrate Zoology trained students to apply their knowledge of vertebrate animals to regulatory problems. The course emphasized that a sound knowledge of natural history was necessary to inform effective management practices and emphasized how much money could be saved by paying attention to organism–environment interactions. Organizing the applications of the NHV into a stand-alone course had important long-lasting impacts for the MVZ, ultimately ensuring that the NHV course remained in the zoology department amidst disciplinary rearrangements that separated pure and applied science into different areas of the university.[80]

Playing an advisory role to the state of California earned the MVZ its place as an economically important institution. Students who were interested in the public service enrolled in Economic Vertebrate Zoology; indeed, enrolment surpassed the NHV's numbers. By separating the two courses, Grinnell distinguished the applications of natural history and made them a distinct undertaking. At the same time, he communicated the academic importance of studying animals in their environment to understand evolution. Categorizing scientific work as pure/basic or applied became increasingly important throughout the twentieth century. As physics gained prominence on the university and world stages, biologists sought to make their work comparable. Zoology departments increasingly focused their resources on genetics and on cellular and molecular biology, and steered away from the applied work associated with wildlife and conservation.[81] Sensitive to the distinct standards, demands and needs of the

77 *Announcement of Courses, 1920–1921*, Berkeley, 1920, 232, CCC-B.

78 Duprée, op. cit. (75); Hall, op. cit. (5).

79 California Division of Fish and Game correspondence folder, Museum of Vertebrate Zoology, Berkeley.

80 Henson, op. cit. (8), tells a version of this story in her study of John Henry Comstock's schools of entomology at Cornell and Stanford, but, unlike Grinnell's programme, Comstock's school did not last long after his death in 1931. Henson attributes the fall of Comstock's research school to 'competing fields in biology'. After his retirement, many of Comstock's entomology courses were moved to the School of Agriculture, where their focus was shifted from evolution to economics.

81 After Grinnell's death in 1939, Aldo Starker Leopold, son of the famous Aldo Leopold, was hired in 1946 as the MVZ's first official 'conservationist' (*General Catalogue, Fall and Spring Semesters, 1946–47*, Berkeley, 1946, 429, CCC-B). Under Leopold, Grinnell's Economic Vertebrate Zoology (which Grinnell changed to 'Applied Vertebrate Zoology' in 1937) became Introduction to Wildlife Conservation (1947). Although conservation was recognized as an applied science with economic and political dimensions, it

University of California and the state of California, Grinnell provided training for students with different career aspirations and at the same time established the MVZ as an important institution in a variety of different communities.

The study of 'habitat preferences, distribution, behaviour, and classification'[82] was added to the 1921 description of NHV, which mirrored the museum's focus on the relationship between geographic distribution and speciation. 1932 marked a change in focus from 'classification' to 'phylogeny'.[83] Although some used the two terms interchangeably, they were not equivalent. Emphasizing phylogeny over classification, Grinnell indicated the MVZ's motivations to generate a better understanding of the evolutionary relationships among species. Subtle changes to the course description culminated in 1937 when Grinnell made the final amendments before his untimely death in 1939. Changes were implemented not only to the description, but also to the course title: Advanced Vertebrate Zoology finally became Natural History of the Vertebrates, which has ever since remained the same. The description read, 'The birds, mammals, reptiles, and amphibians, chiefly of California; identification of species; observational methods in study of behavior and habitat relations; systematics, distribution, and speciation. Field work emphasized'.[84]

In 1948 the course description was changed for the first time since Grinnell's death: 'The birds, mammals, reptiles, and amphibians, chiefly of California; identification of species; observational methods in study of behavior and habitat relations; systematics. Field work emphasized'.[85] It is interesting to note that although the description remained largely similar, there was one significant change that involved the removal of two key Grinnellian words: 'distribution' and 'speciation'. However, the laboratory notebooks from this period suggest that distribution and speciation remained a central conceptual focus; in fact, it had become redundant to indicate that systematists were interested in distribution and speciation because it was assumed that they owned these topics.[86] Perhaps the removal was merely an effort to simplify course descriptions in the growing

retained a place in the increasingly molecular-oriented Zoology Department throughout most of the 1960s. In 1969, when Leopold transferred his faculty position from Zoology to the Department of Forestry and Conservation, the course moved with him, along with four other courses that had formally been in the Zoology Department and taught by MVZ faculty. Although Applied Vertebrate Zoology lost its original departmental affiliation, the NHV remained a core course within the Zoology Department. Although the NHV was not officially a required course within the Zoology Department, the majority of zoology majors enrolled because the NHV simultaneously fulfilled multiple general course requirements. The NHV retained high enrolment until 1998, a decade after the Zoology Department became the Department of Integrative Biology, in response to curriculum changes. The reorganization of the biological sciences at Berkeley is described in the *General Catalog, 1989–90*, Berkeley, 1989, p. 89, CCC-B. Thanks to James L. Patton for describing the changing enrolment trends in the NHV during the 1970s, 1980s and 1990s during a conversation at the MVZ, 13 December 2009.

82 *Announcement of Courses, 1920–21*, Berkeley, 1920, p. 232, CCC-B.

83 *Announcement of Courses, 1931–32*, Berkeley, 1931, p. 299, CCC-B; *Announcement of Courses, 1932–33*, Berkeley, 1932, p. 305, CCC-B.

84 *General Catalogue, 1937–38*, Berkeley, 1937, p. 400, CCC-B.

85 *General Catalogue, 1948–49*, Berkeley, 1948, p. 491, CCC-B.

86 Julian Huxley, *The New Systematics*, Oxford: Clarendon Press, 1940; Ernst Mayr, 'Speciation phenomena in birds', *American Naturalist* (1940) 74, pp. 249–278; *idem*, *Systematics and the Origin of Species*, New York: Columbia University Press, 1942.

course catalogue. Simplification certainly drove the changes to the course description that took place in 1961, which resulted in the concise 'Lectures, field trips, and laboratory. Vertebrates, exclusive of fishes'. The same basic course description remains today.[87]

Weekly field trips have always been at the core of the NHV, often making an indelible impression on students. Over fifty years after taking Grinnell's field course, one of his students fondly remembered the 'highlight of the week was the Saturday morning field trip with Professor Grinnell up Strawberry Canyon. He was a wonderful teacher. His students learned to develop their powers of observation. Details of movement of body, wings and flights and especially vocalisation were taught'.[88] Students were encouraged to develop their observational skills with the aim of acquiring a perspective that would enable them to study evolutionary processes and think about 'species-making' as a 'problem'.[89] Grinnell's course material on studying speciation in the field emphasized the importance of combining natural history and genetic data, mapped out the basics of allopatric speciation, and anticipated many of the innovations that are attributed to Ernst Mayr and the evolutionary synthesis period.[90] Looking at the NHV speciation material in depth shows that Grinnell promulgated many approaches that were fundamental to the synthesis period, including the value of jointly considering both systematics and genetics.[91]

When studying how new species evolved, Grinnell underscored the importance of 'the facts of geographic distribution and limitation',[92] which referred to thinking in terms of life-zones, ecological niches and geographical barriers. Additional considerations included reproduction rates, the outward movement of populations from a dense centre, barriers, shifting barriers over time, forced species movement and the difference between species and subspecies. The contentious term 'species' was interpreted as 'merely one stage in progressive modification, but nevertheless, as regards the present time-plane a real entity, definable, and for the handling of a great number of important considerations, necessary to recognize through some system of accurate designation'.[93] Subspecies were indicators of the 'varying adaptability of animals' since 'some groups modify more easily in response to environmental change, as evidenced by the number of subspecies'.[94]

87 *General Catalogue, Fall and Spring Semesters, 1961–62*, Berkeley, 1961, p. 572, CCC-B.

88 Robert T. Orr, 26 December 1991, personal written recollections, OPPOH, main folder.

89 Grinnell, 1937, op. cit. (53).

90 Mayr, op. cit. (86).

91 For more on the evolutionary synthesis see Vassiliki Betty Smocovitis, *Unifying Biology: The Evolutionary Synthesis and Evolutionary Biology*, Princeton: Princeton University Press, 1996; Ernst Mayr and William Provine (eds.), *The Evolutionary Synthesis: Perspectives on the Unification of Biology*, Cambridge, MA: Harvard University Press, 1980; and more recently Joe Cain, 'Rethinking the Synthesis period in evolutionary studies', *Journal of the History of Biology* (2009) 42, pp. 621–648; and Ilerbaig, op. cit. (31).

92 Grinnell, op. cit. (55).

93 Grinnell, op. cit. (55).

94 Grinnell, op. cit. (55).

To think about 'species-making',[95] Grinnell advised an analysis of characters and their inheritance. According to Grinnell, inheritance mechanisms functioned to ensure 'stability within narrow margins of modifiability'.[96] Those characters that varied geographically were assumed to be 'essential to existence, either in themselves or indirectly, as when genetically linked with others that are'.[97] He went on to describe how the forced movement of populations led to 'phases of geographic behavior' that involved the '[i]nvasion of new territory by [a] portion of [the] population, isolation of this stock, differentiation, and re-invasion of original territory'.[98] This point was of particular importance since Grinnell was looking to collect specimens from different points of this process. Acquiring such a series would allow a demonstration and in-depth investigation of change over time. California was changing so rapidly that potentially every animal in the state was a candidate for becoming a useful series.

Just as it was important to consider the movement and change of populations, it was equally important to study the '[c]ontinual migration, modification, and multiplication of environments (niches and habitats)'.[99] Students were instructed to consider '[t]erritories, ecologic niches, habitats, subfaunal areas, faunal areas, life-zones, regions and realms – as arenas of differentiation'.[100] Conditions in the field were constantly changing, thus providing ample opportunity to study change over time, or evolution. Studying the problem of 'species-making' has taken many forms within the museum. Grinnell's speciation material illustrates how he incorporated the MVZ's overarching questions in the NHV's curriculum: how are new species formed? How do speciation mechanisms inform our understanding of evolution? Moreover, the NHV's speciation material reveals the synthetic nature of Grinnell's approach and places it well ahead of the evolutionary synthesis period.[101]

A shared responsibility

In the MVZ's 1977–1978 Annual Report, director David Wake noted that although the NHV course had been listed each year as a standard course in the Zoology Department, the MVZ had 'accepted primary responsibility' for the 'course that introduces undergraduate students to the principles of field biology'. Wake further observed, 'to a large degree, it is this course that conveys the philosophy of the Museum to students'.[102] This section explores how the teaching responsibility has engendered a common natural-history perspective amongst the MVZ faculty. Commitment to the NHV has resulted in an extraordinary amount of instructor stability and the collaborative nature of the course has facilitated overlap between new and old instructors. Surveying the academic

95 Grinnell, op. cit. (55).
96 Grinnell, op. cit. (55).
97 Grinnell, op. cit. (55).
98 Grinnell, op. cit. (55).
99 Grinnell, op. cit. (55).
100 Grinnell, op. cit. (55).
101 Ilerbaig, op. cit. (31).
102 David Wake, 8 September 1978, 'Annual Report July 1, 1977–June 30, 1978', ARF.

genealogy of instructors, this section also illustrates the NHV's sustained connection to Grinnell.

Scientists take pride in acknowledging their academic lineage.[103] Creating academic family trees identifies and reifies associations with important people and places, legitimates approaches, and acknowledges the lasting influence of an original research programme, despite changes that might have occurred.[104] In the MVZ, detailed 'intellectual genealogies' have been constructed for both Grinnell and Miller.[105] The sequence of instructors within the NHV and their academic lineages shows Grinnell's pervasive voice in the classroom and also within the MVZ.

After Grinnell's death in 1939, Alden Miller, Grinnell's student and eventual successor, started to teach the NHV along with the acting director, E.R. Hall. A dispute over the directorship led to Hall's departure in 1944.[106] In the following years the NHV's three sections were taught by a trio of MVZ curators: an ornithologist, a mammalogist and a herpetologist.[107] Between 1914 and 2002 there were approximately four different instructors in the ornithology section, six in the mammalogy section and three in the herpetology section.[108] Significant overlap between the different section instructors has meant that someone was usually able to pass on the course traditions, often someone who had been trained, directly or indirectly, by Grinnell. Because of this, Grinnell's influence in the NHV continued to be felt long after his death.

Since 1939 the ornithology section has been taught primarily by individuals with a Grinnellian lineage. Miller began teaching the course after Grinnell's death in 1939 and continued to teach it until 1959, with the exception of his sabbatical year (1958), in which his student, John Davis (PhD 1950) took over teaching. Ned Johnson began teaching the NHV in 1960, shortly before he received his PhD under Miller's supervision (1961), and continued to teach the course until his death in 2003. In his lecture notes Johnson explained, 'Patterns in nature must be described before the processes responsible for those patterns can be understood', and credited these sentiments to his 'academic grandfather', Grinnell, who was the 'first to take the "old natural history" out of the realm of mythology and put it on a firm scientific footing'.[109] After Rauri Bowie was hired as a bird curator (2006), he began teaching the NHV in 2008. Bowie can also claim a Grinnellian lineage, since he worked with one of Grinnell's academic

103 Geison, op. cit. (13), p. 237; Hans A. Krebs, 'The making of a scientist', *Nature* (1967) 215, pp. 1441–1445.

104 Geison, op. cit. (13), p. 237.

105 Johnson, op. cit. (12), p. 8; Pitelka, op. cit. (12), p. 95; Jones, op. cit. (12).

106 Alden Holmes Miller to Robert G. Sproul, 13 December 1943, Alden H. Miller Papers, Bancroft Library, University of California, Berkeley (subsequently AHMP-B), Carton 3, folder Correspondence Rec'd.

107 CCC-B, 1914–2005.

108 The turnover of instructors increased substantially after 2002 for a number of reasons, including Harry Greene's departure from the MVZ in 1998, James Patton's retirement in 2002, and the death of Ned Johnson in 2003. Jim McGuire was hired as a new curator of herpetology in 2003 and has since been teaching the NHV course. Rauri Bowie was hired as a new bird curator and began teaching the NHV in 2008. During this transitional period within the MVZ there have been a number of different instructors involved with the NHV, usually MVZ advanced graduate students and postdoctoral fellows.

109 Ned Johnson, 'Introduction to Integrative Biology 104', Ned Johnson Teaching Files, Museum of Vertebrate Zoology, Berkeley (Subsequently NJ-MVZ), folder: Vertebrate Speciation, underlining in original.

great-great-grandchildren, Shannon Hackett, during his postdoctoral training at Chicago's Field Museum of Natural History.

The mammalogy section has also been taught by a significant number of individuals with ties to Grinnell. E.R. Hall, who taught from 1929 to 1942, and Seth B. Benson, who taught from 1944 to 1968 (with the exception of 1945), were both students of Grinnell who had participated in the NHV course before they taught it. Although Oliver P. Pearson, who taught the course in 1949 and again from 1969 to 1971, did not have a direct Grinnellian lineage (having studied reproductive physiology at Harvard under Frederick L. Hisaw), he first taught the course alongside Miller and therefore received an authentic introduction/indoctrination. Shortly after joining the MVZ as an assistant curator of mammals, James L. Patton began teaching the mammalogy section in 1972, which he continued to do until 2002. Between 1974 and 1993 Patton alternated teaching the NHV with William Z. Lidicker, who taught the course again in 2004 and 2005. Lidicker, curator of mammals, joined the MVZ in 1957 after earning his PhD under Donald F. Hoffmeister at the University of Illinois. Hoffmeister took the NHV course with Grinnell while he was studying for his PhD at the MVZ.[110]

The herpetology section has been taught by Tracy Storer, who was one of the first graduate students to receive a PhD under Grinnell, and later by Robert Stebbins, who was hired as the first curator of herpetology in the MVZ in 1945. Stebbins was hired by Alden Miller, but had been recommended to the post by Miller's father, Loye Miller, Grinnell's colleague and a long-time MVZ affiliate. After Stebbins's retirement Harry Greene was hired as a herpetology curator within the MVZ (1978); however, he was also hired because of his ability to teach the NHV. In the late 1970s the NHV course was perceived within the Zoology Department as a core course both to the MVZ and to the department and therefore the ability to teach the field-oriented NHV course played an important role during the hiring process.[111] After Greene's departure from the MVZ, Jim McGuire was hired as curator of herpetology. McGuire began the NHV course in 2004 alongside Lidicker, who introduced McGuire to the course's traditions. McGuire continues to teach and organize the NHV today.

The NHV has served as an important interdisciplinary space. Planning, managing and participating in a team-taught course provides everyone involved with the opportunity to learn more about their colleagues' research and scientific perspective. Mutual instruction leads to many types of collaboration. Instructors interact systematically, formally and informally. Shared commitment to the MVZ's overarching goals is evident in the final field study, which has always held a central place in the NHV.

Rather than relying entirely on examinations, Grinnell created an independent field project in which students had to ask a scientific question of animals in their environment, gather data in the form of field notes, and submit a written report of their findings.

110 Donald Hoffmeister to Oliver P. Pearson, 6 December 1992, Oliver P. Pearson Papers, Pearson home, Orinda, California.

111 Personal communication with James L. Patton, 14 December 2009, Museum of Vertebrate Zoology, Berkeley, California. Information about instructors was gathered by systematically surveying the University of California, Berkeley, Course Catalogues (1905–2005) in the Bancroft Library, University of California, Berkeley, and corroborated by personal discussions with William Z. Lidicker and James L. Patton.

Conducting the independent field study required a Grinnellian skill set, including formulating a meaningful problem, recording scientific observations in field notes, analysing and interpreting the data and writing a scientific report. The basic skill set has remained constant since Grinnell first assigned the project, and it continues to be assigned today in virtually the same format that Grinnell designed. Originally, Grinnell instructed students to choose an accessible location where they could conduct 'entirely original' work that was based on their 'own watching and thinking' with 'no resort to be made to books or to other second-hand sources of information'.[112] To do this, it was important for students to carefully 'keep "raw" notes' in the field notebooks.[113] Students were encouraged to make the project their own, and were able to choose any topic – although consultation with Grinnell about the feasibility of the project was encouraged.[114] To this day, the objectives of the project remain the same and much of the course is geared toward the independent field study, which continues to determine a significant component of the students' final grade. The longevity of the project demonstrates that regardless of a particular faculty member's research specialty, it has remained necessary to cultivate the practices and perspective needed to make scientific observations in the field.

The NHV curriculum has unfailingly emphasized the valuable work of the naturalist. To the NHV class, Johnson explained, 'Naturalists and descriptive ecologists study by direct observation what organisms do', and he went on to say, 'There is no such thing as a good ecologist who is not also first a good naturalist.'[115] Studying natural history meant studying animals in their environments, but that was just the first step. MVZ research has involved using a variety of techniques from gel electrophoresis to DNA sequencing to birdsong analysis. While teaching the NHV in the 1950s, Miller underscored that naturalists, or ecologists, were well equipped to address the following: 'What is the fate of the mutation? How are mutations preserved and assembled? How are the individuals with the mutations segregated in nature into species?'[116] In contrast, he placed the study of the 'hereditary basis of differences, mutations' and 'methods of transmitted attributes' in the geneticist's field.[117] But this did not mean that genetics could not be done in the museum – just not extensively during Grinnell's (1908–1939) or Miller's (1940–1965) directorships. The MVZ was one of the first natural-history museums to establish an evolutionary genetics laboratory with gel electrophoresis equipment able to deal with museum specimens.[118]

Despite independent research goals, personalities and research approaches, faculty have shared the effort of instilling an appreciation for the value of studying animals in

112 Joseph Grinnell, 15 February 1937, 'Individual field project in ornithology', JHGP-B, Box 9, Folder 8.

113 Grinnell, op. cit. (112).

114 Grinnell, op. cit. (112).

115 Johnson, op. cit. (109).

116 Alden H. Miller, '1957 Zoology 113 Speciation', NJ-MVZ, folder: Vertebrate Speciation, underlining in original.

117 Miller, op. cit. (116).

118 David Wake, 20 September 1973, 'Annual Report July 1, 1972–June 30, 1973', Annual Report Files, Museum of Vertebrate Zoology, Reprint Room, Berkeley (Subsequently ARF); Wake, 26 September 1974 'Annual Report July 1, 1973–June 30, 1974', ARF.

their natural environment in conjunction with prepared specimens in the museum and laboratory. As individual research programmes within the MVZ have become more specialized, this shared value has become increasingly relevant. Regardless of the degree of a particular faculty member's specialized knowledge, it remained desirable to cultivate the general knowledge that is required to teach the NHV. The field section of the course has always encouraged students to learn all of the many local vertebrates. Grinnell possessed an almost mythical ability to identify any vertebrate species from the slightest of information and students learn to both admire and aspire toward his legendary talent.

Conclusion

Grinnell's significance in the history of biology is understated and relatively understudied, in part because of the way he communicated his approach.[119] One of Grinnell's first graduate students, Hall, who co-taught the NHV with Grinnell for many years, pointed out that although Grinnell made many contributions to evolutionary thinking, his theoretical analyses were scattered throughout many papers.[120] Grinnell received many requests to put the 'substance of his lectures' into a book, but decided to save book writing for retirement because 'there still were too many other interesting things to do in natural history'.[121] Although Grinnell never wrote his great book, we can learn much about his contributions to evolutionary biology by studying the ideas, methods and research strategies that he communicated to his students.

The NHV has steadily taught the MVZ's central practices and promoted the value of observing animals in their natural environment. By demonstrating how the NHV has transmitted Grinnell's vision and methods to generations of students and MVZ faculty, this paper provides an example of how an educational programme has functioned to stabilize a research programme. The NHV course materials show that Grinnell advocated fieldwork that was theoretically grounded, encouraged population thinking and instructed students to think about the role of genetics and isolation in speciation, thereby anticipating developments that are often associated with the evolutionary synthesis. Aligning the MVZ's philosophy and practices with the NHV curriculum allowed Grinnell to successfully train a workforce to realize his research programme.[122] Emphasizing the interdependence of fieldwork and laboratory analysis seduced many to pursue evolutionary research in the field and contribute to the MVZ's greater goal of understanding evolutionary change over time.

The NHV has been a shared faculty responsibility in the sense that members of the MVZ community have regarded and continue to regard the NHV as an important

119 Ernst Mayr, 'Alden Holmes Miller', *Biographical Memoirs of the National Academy of Sciences* (1973) 43, pp. 177–214.

120 Hall, op. cit. (5).

121 Hall, op. cit. (5), p. 412.

122 Among many others, Storer, Hall, Benson and Miller promoted the Grinnellian approach in the MVZ and also later at the University of California, Davis (Storer) and the University of Kansas (Hall), and more broadly within the American Society of Mammalogists and the American Ornithological Union. See footnote 12 above.

course that warrants substantial effort. Although the course could theoretically have been taught by anyone selected by the chair of the Zoology Department, and later the chair of the Department of Integrative Biology, the MVZ's curatorial faculty has assumed that responsibility. The academic lineages of previous instructors and their long-term commitment to the NHV indicate Grinnell's influence in the classroom, long after his departure. Looking at the NHV speciation material in depth shows that Grinnell pioneered many of the approaches credited to the evolutionary synthesis, including the value of jointly considering both systematics and genetics.

The fieldwork component of the NHV course requires students to engage with their instructors, with each other and with the environment. Cold, rainy mornings are a litmus test for future natural historians where students quickly learn their capacity for fieldwork. According to Grinnell, teaching was important to ensure the future of the MVZ.[123] Studying the history of the NHV provides valuable insight into both the MVZ and the history of twentieth-century biology, while also revealing the critical role that teaching has played in the long-term success of a research programme.

123 Grinnell to Alexander, op. cit. (20).