Distribution and Stratigraphic Correlation of Upper Paleocene and Lower Eocene Fossil Mammal and Plant Localities of the Fort Union, Willwood, and Tatman Formations, Southern Bighorn Basin, Wyoming

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1540

Cover. A member of the American Museum of Natural History 1896 expedition entering the badlands of the Willwood Formation on Dorsey Creek, Wyoming, near what is now U.S. Geological Survey fossil vertebrate locality D1691 (Wardel Reservoir quadrangle). View to the southwest. Photograph by Walter Granger, courtesy of the Department of Library Services, American Museum of Natural History, New York, negative no. 35957.

DISTRIBUTION AND STRATIGRAPHIC CORRELATION OF UPPER PALEOCENE AND LOWER EOCENE FOSSIL MAMMAL AND PLANT LOCALITIES OF THE FORT UNION, WILLWOOD, AND TATMAN FORMATIONS, SOUTHERN BIGHORN BASIN, WYOMING

Upper part of the Willwood Formation on East Ridge, Middle Fork of Fifteenmile Creek, southern Bighorn Basin, Wyoming. The Kirwin intrusive complex of the Absaroka Range is in the background. View to the west.

Distribution and Stratigraphic Correlation of Upper Paleocene and Lower Eocene Fossil Mammal and Plant Localities of the Fort Union, Willwood, and Tatman Formations, Southern Bighorn Basin, Wyoming

By Thomas M. Bown, Kenneth D. Rose,
Elwyn L. Simons, *and* Scott L. Wing

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1540

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1994

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Robert M. Hirsch, Acting Director

For sale by U.S. Geological Survey, Map Distribution
Box 25286, MS 306, Federal Center
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Distribution and stratigraphic correlation of Upper Paleocene and Lower Eocene fossil mammal and plant localities of the Fort Union, Willwood, and Tatman Formations, Southern Bighorn Basin, Wyoming / by Thomas M. Bown ... [et al.].
p. cm. — (U.S. Geological Survey professional paper ; 1540)
Includes bibliographical references.
Supt. of Docs. no.: I 19-16: 1540
1. Mammals, Fossil—Wyoming. 2. Plants, Fossil—Wyoming. 3. Paleobiogeography—Wyoming. 4. Paleontology, Stratigraphic. 5. Paleontology—Wyoming. 6. Paleontology—Paleocene. 7. Paleontology—Eocene. 8. Bighorn Basin (Mont. and Wyo.) I. Series.
QE881.D57 1993 93-21628
569'.09787—dc20 CIP

CONTENTS

PLATES

[Plates are in pocket]

FIGURES

TABLES

Distribution and Stratigraphic Correlation of Upper Paleocene and Lower Eocene Fossil Mammal and Plant Localities of the Fort Union, Willwood, and Tatman Formations, Southern Bighorn Basin, Wyoming

By Thomas M. Bown, Kenneth D. Rose[1], Elwyn L. Simons[2], *and* Scott L. Wing[3]

ABSTRACT

The fossil mammals of the lower Eocene part of the Willwood Formation in the southern Bighorn Basin of northwest Wyoming constitute by far the largest sample of stratigraphically documented fossil mammals of any age from anywhere in the world. For this reason, the southern Bighorn Basin Willwood sample of fossil vertebrates has become the most important for empirically derived paleontological studies of tempo and mode of evolution in Mammalia. Locality data for 1,472 Willwood fossil mammal sites (about 1,146 hitherto unpublished) and the detailed stratigraphic correlation of 941 of them into measured stratigraphic sections (700 newly correlated) afford a framework for the biostratigraphic integration of nearly 80,000 catalogued and at least 30,000 uncatalogued specimens. Earlier published and unpublished measured sections of the Willwood Formation of the central and southern Bighorn Basin that related fossil mammal localities to one another are partly revised; all are tied to a new master section. Revisions to earlier sections do not materially affect published accounts of the principally gradual nature of evolution of Willwood mammals. A preliminary list of the Willwood mammal fauna of the south-central and southeast Bighorn Basin and mammalian compositions for some of the most important sites are presented. Locality and stratigraphic correlations are also provided for 37 fossil plant localities in the Fort Union, Willwood, and Tatman Formations, data that offer considerable potential for correlation of late Paleocene and early Eocene plant and mammal biostratigraphies. Fossil pollen also permits direct correlation of Willwood rocks with standard marine zonations.

[1]Johns Hopkins University School of Medicine, Baltimore, Md.
[2]Duke University Primate Center, Durham, N.C.
[3]Smithsonian Institution, Washington, D.C.

INTRODUCTION

The first fossil vertebrates from the lower Eocene part of the Willwood Formation of the Bighorn Basin, northwest Wyoming, were collected within the study area (fig. 1) by J.L. Wortman in 1880 (Cope, 1882a, 1882b). Since that time, perhaps as many as 120,000 catalogued museum specimens have been recovered from Willwood rocks, the results of more than 75 major expeditions spanning more than a century. The bulk of these specimens are upper and lower jaw fragments; however, many more complete specimens are also represented. The principal recent sustained field endeavors, by the Yale Peabody Museum (1961–66, 1968–72, 1974–78), the University of Wyoming (1973–76); the U.S. Geological Survey-Johns Hopkins University School of Medicine (U.S. Geological Survey, 1977–79; with the Johns Hopkins University School of Medicine, 1980–present), and the University of Michigan Museum of Paleontology (1974–present), account for more than 100,000 specimens recovered on 45 expeditions in the last 31 years.

Important collections of Willwood mammals, including some very fine specimens, also are catalogued at many other institutions, among them the American Museum of Natural History (New York, N.Y.), the Carnegie Museum of Natural History (Pittsburgh, Pa.), the Duke University Primate Facility (Durham, N.C.), the Los Angeles County Museum (Los Angeles, Calif.), the Museum of Comparative Zoology (Cambridge, Mass.), the National Museum of Natural History (Washington, D.C.), the Pratt Museum (Amherst, Mass.), the Princeton University Museum (specimens now at the Yale Peabody Museum), the Raymond M. Alf Museum (Claremont, Calif.), the Royal Ontario Museum (Toronto, Canada), the University of California Museum of Paleontology (Berkeley, Calif.), the University of Colorado Museum (Boulder, Colo.), the University of Kansas Museum of

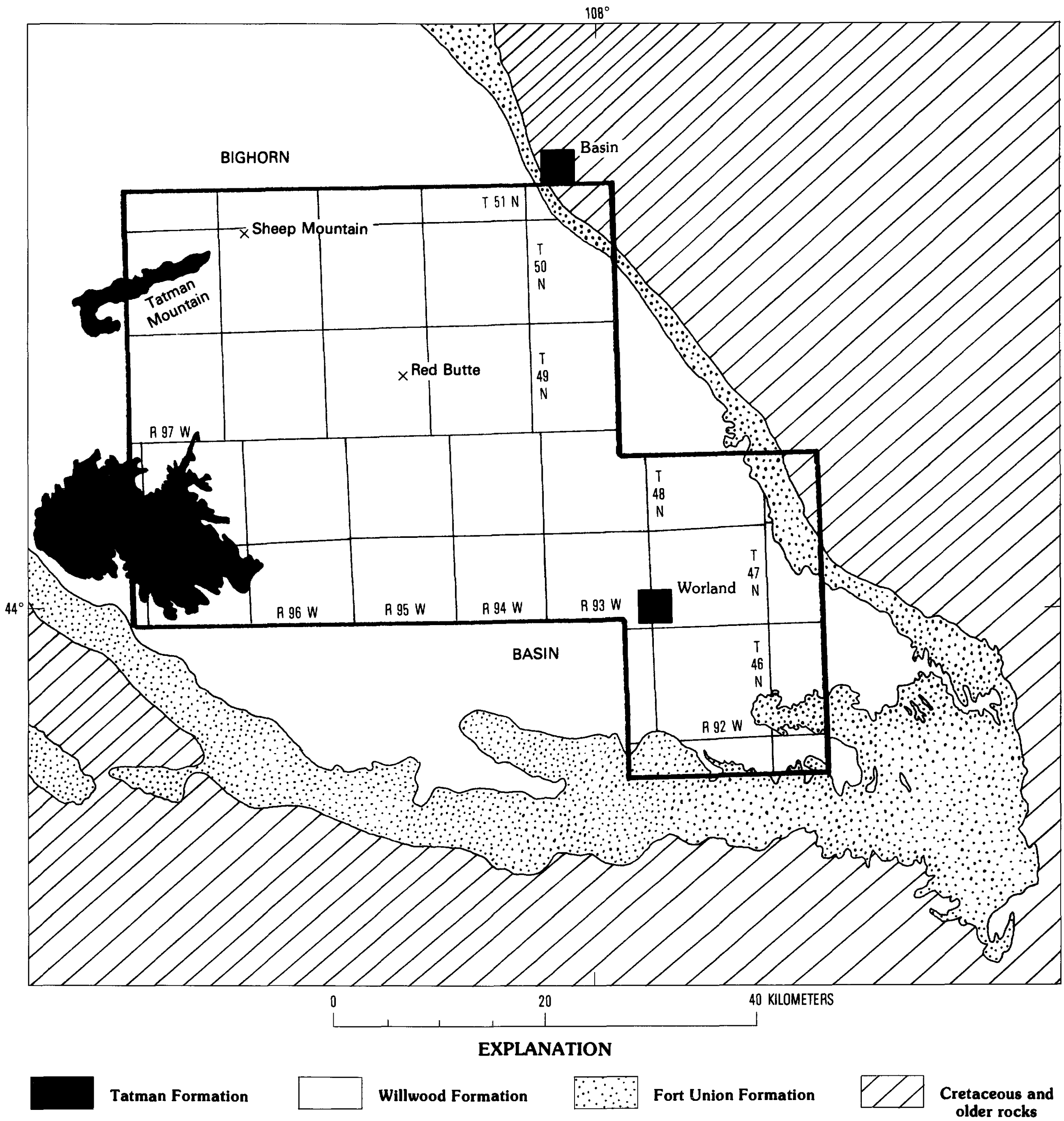


Figure 1. Map showing location of study area in the Bighorn Basin of northwest Wyoming. Geology by T.M. Bown (1975 and unpub. data) and Love and Christiansen (1985).

Natural History (Lawrence, Kans.), and the University of Nebraska State Museum (Lincoln, Neb.).

This report is concerned with what is known of fossil mammal and plant localities and their stratigraphic correlation in the south-central and southeast parts of the Bighorn Basin (south of the Greybull River). Similar contributions to these subjects have been presented for the mammals of the Clarks Fork area of the northern Bighorn Basin by Rose (1981a) and Gingerich and Klitz (1985). Gingerich (1980a) reviewed the history of vertebrate fossil collecting in Tertiary deposits of the Bighorn Basin. Between World War I and about 1960, there were no sustained vertebrate paleontological collecting efforts in the vast badland area between the Greybull River on the north and Gooseberry Creek on the south. E.L. Simons (then at Yale University) initiated the first sustained expeditions to the region in 1961. The Simons expeditions established 477 fossil vertebrate localities in the Willwood Formation and explored paleontologically

virtually all of this region between Meeteetse and Worland, Wyo. From 1979 through 1992, Simons has made significant collections from the Willwood Formation under the auspices of the Duke University Primate Facility.

From 1973 to 1976, T.M. Bown (then at the University of Wyoming) led expeditions in search of Willwood mammals in the Sand Creek-No Water Creek area, southeast of Worland, and in the more extensive badlands northwest of Worland as far as Red Butte and the Elk Creek Rim (pls. 1 and 2). These expeditions continued uninterrupted, first with the U.S. Geological Survey (1977–79), and then with the joint U.S. Geological Survey-Johns Hopkins University School of Medicine field efforts (1980–present). A small but important group of localities was established in the region of Red Butte in 1976 and on the east margin of Sheep Mountain in 1981 by University of Michigan field parties under the direction of P.D. Gingerich.

The first plant fossils recovered from Willwood strata were reported by Hewett (1926) from the Oregon Basin near Cody, Wyo., approximately 10 m (meters) above the base of the formation. Brown (1962) reported several fossil plant localities of probable Wasatchian age from the upper part of the Fort Union Formation west of Greybull, Wyo., and Erling Dorf made several small collections of Willwood plants for Princeton University during the 1950's and 1960's in the area south of Burlington. Dorf also collected plants from tuffaceous shales immediately overlying the Willwood Formation west of Meeteetse, but more recently Bown (1982) correlated those deposits with the Tatman Formation. Dorf's collections of these Eocene plants now reside at the U.S. National Museum. Systematic investigations of early Eocene fossil plants were begun by S.L. Wing at Yale in 1978 and have continued through 1992, now under the auspices of the Smithsonian Institution. Resulting field work has established more than 100 localities, dispersed in the upper part of the Fort Union Formation and in the Willwood and Tatman Formations of the central and southern Bighorn Basin. The collection consists of more than 15,000 specimens, most of which are held at the U.S. National Museum. A small collection is housed at the Yale Peabody Museum.

Willwood fossil mammals are important because they include many representatives of archaic groups, more characteristic of Paleocene faunas, coexisting with some of the earliest known members of extant higher taxa (table 1). Research on these fossils, perhaps more so than studies of mammals from any other single formation, has contributed substantially to almost every aspect of paleobiological inquiry for the Paleogene. The fossils constitute a very important source of information about: (1) mammalian taphonomy on a formation-wide scale (Bown and Kraus, 1981b; Bown, 1987; Bown and Beard, 1990); (2) comparative and functional anatomy (for example, Osborn, 1898, 1900; Matthew, 1915, 1918; Rose, 1982, 1985, 1987, 1990 and references therein; Rose and Walker, 1985); (3) tempo and mode of mammalian evolution (for example, Gingerich, 1974, 1976, 1977, 1980b, 1983a; Bookstein and others, 1977; Rose and Bown, 1984, 1986, 1991; Bown and Rose, 1987, 1991; Bown and Beard, 1990); and (4) phylogenetic diversity among early Eocene mammals (for example, Cope, 1884; Matthew, 1915, 1918; Jepsen, 1930; Van Houten, 1945; Radinsky, 1963, 1964; Gingerich, 1981, 1982, 1983c, 1986; Gunnell and Gingerich, 1981; Gingerich and Gunnell, 1979; Bown, 1974, 1979, 1980; Schankler, 1980; Rose, 1981a, 1981b; Rose and Bown, 1984; Rose and others, 1977; Bown and Rose, 1976, 1979, 1984, 1987, 1991). Concomitant studies of the stratigraphic contexts of Willwood mammals (for example, Gingerich, 1974, 1976, 1977; Gingerich and Simons, 1977; Gingerich and Gunnell, 1979; Bown, 1979; Schankler, 1980, 1981; Rose, 1981a, 1981b; Rose and Bown, 1986; Bown and Rose, 1987; Bown and Beard, 1990) have facilitated the construction of a denser, more comprehensive empirical picture of mammalian evolution than has hitherto been obtainable by traditional studies of samples from separate and disparate localities (or even basins), with little or no stratigraphic or paleoenvironmental control. Studies of Willwood turtles (Hutchison, 1980), plants (Wing, 1980, 1984a, 1984b), and trace fossils (Bown and Kraus, 1983) from the study area have substantially supplemented studies of the fossil mammals.

Some advantages that study of the Willwood mammalian fauna has conferred on paleobiology have been the result of the extraordinarily rich Willwood vertebrate fossil accumulations and unusually extensive and continuous Willwood exposures. Paleontological studies have also been augmented considerably by sustained paleobotanical, sedimentological, and paleopedological investigations during the past 25 years (for example, Neasham, 1967, 1970; Neasham and Vondra, 1972; Bown, 1979, 1985; Bown and Kraus, 1981a, 1981b, 1987, 1993; Bown and others, 1991; Kraus, 1980, 1985; Butler and others, 1981; Kraus and Bown, 1986, 1988, and in press; Wing, 1980, 1984a; Wing and Bown, 1985). Most recently, the extraordinary Willwood record of fossil mammal associations in paleosols has led to empirically testable means by which to examine temporally controlled small-scale geographic differences in fossil mammal composition, evolution, and taphonomy (Bown, 1987; Bown and Beard, 1990).

Vertebrate paleontology has differed from invertebrate paleontology in that the origin, development, and evolution of its biostratigraphy were accomplished with little reference to the empirical control of measured stratigraphic sections. The reasons for this dichotomy appear to be historical: (1) From the beginning, vertebrate paleontologists tended to emphasize the biological rather than the geological aspects of their discipline; (2) most early collecting was done by museum scientists interested more in obtaining quality museum specimens than in recording detailed stratigraphic information; (3) vertebrate fossils were often thought (to some extent erroneously) to be too rare to be of much biostratigraphic value; (4) paleontological exploration of the

Table 1. Provisional list of fossil mammals from the Willwood Formation of the south-central and southeastern Bighorn Basin, central Wyoming.

[List based on collections at the U.S. Geological Survey and the Yale Peabody Museum]

Class Mammalia
  Subclass Allotheria
      Order Multituberculata
        Suborder Ptilodontoidea
          Family Neoplagiaulacidae
            Ectypodus tardus (Jepsen)
            Parectypodus lunatus Krause
            Parectypodus simpsoni Jepsen
        Suborder Taeniolabidoidea
          Family Eucosmodontidae
            Neoliotomus ultimus (Granger and Simpson)
  Subclass Theria
    Infraclass Metatheria
      Order Marsupialia
        Suborder Didelphoidea
          Family Didelphidae
            Peratherium macgrewi Bown
            Peratherium marsupium Troxell
            Peradectes chesteri (Gazin)
            Mimoperadectes labrus Bown and Rose
    Infraclass Eutheria
      Magnorder Ernotheria
        Grandorder Ictopsia
          Family Leptictidae
            Prodiacodon tauricinerei (Jepsen)
            Prodiacodon, sp. nov.
            Palaeictops bicuspis (Cope)
        Grandorder Anagalida?
          Order cf. Macroscelidea?
            Haplomylus speirianus (Cope)
            Haplomylus, sp. nov.
      Magnorder Preptotheria
        Order Cimolesta
          Suborder Palaeoryctoidea
            Family Palaeoryctidae
              Palaeoryctes sp., cf. *P. punctatus* Van Valen
              Pararyctes, sp. nov.
              Pararyctes sp.
            Family Didelphodontidae
              Didelphodus absarokae (Cope)
              Didelphodus sp., cf. *D. ventanus* Matthew
          Suborder Pantolesta
            Family Pantolestidae
              Palaeosinopa incerta Bown and Schankler
              Palaeosinopa lutreola Matthew
              Palaeosinopa veterrima Matthew
          Suborder Apatotheria
            Family Apatemyidae
              Labidolemur kayi Simpson
              Labidolemur sp., cf. *L. serus* Gingerich
              Apatemys chardini (Jepsen)
              Apatemys bellus Marsh
              Apatemys bellulus Marsh
              Apatemys rodens Troxell
        Order Creodonta
          Family Hyaenodontidae
            Arfia opisthotoma (Matthew)
            Arfia shoshoniensis (Matthew)
            Tritemnodon hians (Cope)
            Tritemnodon strenua (Cope)

Class Mammalia—Continued
  Subclass Theria—Continued
    Infraclass Eutheria—Continued
      Magnorder Preptotheria—Continued
        Order Creodonta—Continued
          Family Hyaenodontidae—Continued
            Tritemnodon, sp. nov.
            Prototomus mordax (Matthew)
            Prototomus sp., cf. *P. multicuspis* (Cope)
            Prototomus sp., cf. *P. vulpecula* (Matthew)
          Family Limnocyonidae
            Prolimnocyon atavus Matthew
            Prolimnocyon sp., cf. *P. robustus* Matthew
          Family Oxyaenidae
            Oxyaena transiens Matthew
            Oxyaena forcipata Cope
            Oxyaena gulo Matthew
            Oxyaena sp., cf. *O. lupina* Cope
            Dipsalidictides amplus (Jepsen)
            Palaeonictis sp., cf. *P. occidentalis* (Osborn)
            Ambloctonus sp.
        Order Arctocyonia
          Family Arctocyonidae
            Thryptacodon antiquus Matthew
            Thryptacodon sp., cf. *T. loisi* Kelley and Wood
            Chriacus, sp. nov. 1
            Chriacus, sp. nov. 2
            Chriacus sp.
            cf. *Tricentes* sp.
          Family incertae sedis
            Anacodon ursidens Cope
            Anacodon sp., cf. *A. cultridens* Matthew
            Anacodon, sp. nov.
        Order Mesonychia
          Family Mesonychidae
            cf. *Dissacus* sp.
            Pachyaena gracilis Matthew
            Pachyaena gigantea Osborn
            Pachyaena ossifraga Cope
            Hapalodectes leptognathus (Osborn)
            Hapalodectes, sp. nov.
        Order Carnivora
          Family Viverravidae
            Viverravus acutus (Matthew)
            Viverravus bowni Gingerich
            Viverravus politus Matthew
            Viverravus lutosus Gazin
            Viverravus, sp. nov.
            Didymictis protenus (Cope)
            Didymictis lysitensis Matthew
            Didymictis, sp. nov.
          Family Miacidae
            Vulpavus australis Matthew
            Vulpavus canavus (Cope)
            Miacis exiguus Matthew
            Miacis petilus Gingerich
            Uintacyon masseterićus (Cope)
            Uintacyon rudis Matthew
            Uintacyon sp., cf. *U. asodes* Gazin
            Vassacyon promicrodon (Wortman)

Table 1. Provisional list of fossil mammals from the Willwood Formation of the south-central and southeastern Bighorn Basin, central Wyoming—Continued.

- Class Mammalia—Continued
  - Subclass Theria—Continued
    - Infraclass Eutheria—Continued
      - Magnorder Preptotheria—Continued
        - Order Creodonta—Continued
          - Family Miacidae—Continued
            - cf. *Oödectes*, sp. nov.
            - miacine, gen. et sp. nov.
        - Order Erinaceomorpha
          - Family Dormaaliidae
            - *Macrocranion nitens* (Matthew)
            - *Scenopagus hewettensis* Bown and Schankler
            - *Scenopagus* sp.
            - dormaaliid, sp. nov.
          - Family Erinaceidae
            - *Leipsanolestes* sp.
            - *Eolestes simpsoni* (Bown)
            - *Dartonius jepseni* (McKenna)
        - Order Erinaceomorpha, *incertae sedis*
          - *Talpavoides dartoni* Bown and Schankler
        - Order Soricomorpha
          - Family Nyctitheriidae
            - *Pontifactor* sp.
            - *Plagioctenodon krausae* Bown
            - *Plagioctenodon savagei* Bown and Schankler
            - *Plagioctenoides microlestes* Bown
          - Family Geolabididae
            - *Centetodon patratus* Bown and Schankler
            - *Centetodon neashami* Bown and Schankler
          - Family Apternodontidae
            - *Parapternodus antiquus* Bown and Schankler
        - Order Plesiadapiformes
          - Suborder Mixodectoidea
            - Family Plagiomenidae
              - *Plagiomene multicuspis* Matthew
              - *Worlandia inusitata* Bown and Rose
          - Suborder Microsyopoidea
            - Family Microsyopidae
              - Subfamily Microsyopinae
                - *Arctodontomys wilsoni* (Szalay)
                - *Arctodontomys nuptus* (Cope)
                - *Microsyops angustidens* Matthew
                - *Microsyops latidens* (Cope)
                - *Microsyops cardiorestes* Gunnell
              - Subfamily Uintasoricinae
                - *Niptomomys doreenae* Mckenna
                - *Niptomomys thelmae* Gunnell and Gingerich
                - *Niptomomys*, sp. nov.
            - Family Paromomyidae
              - *Ignacius graybullianus* Bown and Rose
              - *Phenacolemur simonsi* Bown and Rose
              - *Phenacolemur praecox* Matthew
              - *Phenacolemur* sp., cf. *P. jepseni*
              - *Phenacolemur*, sp. nov. 1
              - *Phenacolemur*, sp. nov. 2
              - *Phenacolemur*, sp. nov. 3
              - *paromomyid*, gen. et sp. nov.

- Class Mammalia—Continued
  - Subclass Theria—Continued
    - Infraclass Eutheria—Continued
      - Magnorder Preptotheria—Continued
        - Order Plesiadapiformes—Continued
          - Suborder Mixodectoidea—Continued
            - Family, *incertae sedis*
              - *Tinimomys greybulliensis* Szalay
              - *Micromomys willwoodensis* Rose and Bown
              - *Chalichomomys antilucanus* Beard
        - Order Primates
          - Infraorder Omomyiformes
            - Family Omomyidae
              - Subfamily Anaptomorphinae
                - *Teilhardina americana* Bown
                - *Teilhardina crassidens* Bown and Rose
                - *Teilhardina tenuicula* (Jepsen)
                - ?*Teilhardina*, sp. nov.
                - *Chlororhysis incomptus* Bown and Rose
                - *Anemorhysis pattersoni* Bown and Rose
                - *Anemorhysis wortmani* Bown and Rose
                - *Anemorhysis* sp., cf. *A. pearcei* Gazin
                - *Arapahovius advena* Bown and Rose
                - *Tetonius matthewi* Bown and Rose
                - *Tetonius homunculus* (Cope)
                - *Tetonius* sp.
                - *Pseudotetonius ambiguus* (Matthew)
                - *Tatmanius szalayi* Bown and Rose
                - *Absarokius metoecus* Bown and Rose
                - *Absarokius abbotti* (Loomis)
                - *Strigorhysis* sp., cf. *S. bridgerensis* Bown
              - Subfamily Omomyinae
                - *Steinius vespertinus* (Matthew)
                - *Steinius annectens* Bown and Rose
          - Infraorder Adapiformes
            - Family Notharctidae
              - *Cantius torresi* Gingerich
              - *Cantius ralstoni* Matthew
              - *Cantius mckennai* Gingerich and Simons
              - *Cantius trigonodus* Matthew
              - *Cantius abditus* Gingerich and Simons
              - *Cantius frugivorus* (Cope)
              - *Cantius*, sp. nov.
              - *Pelycodus jarrovii* (Cope)
              - cf. *Copelemur* sp.
              - cf. *Notharctus* sp.
        - Order Palaeanodonta
          - Family Metacheiromyidae
            - *Palaeanodon ignavus* Matthew
            - *Palaeanodon*, sp. nov.
          - Family Epoicotheriidae
            - *Alocodontulum atopum* (Rose, Bown, and Simons)
            - *Alocodontulum*, sp. nov.
        - Order Rodentia
          - Family Ischyromyidae
            - *Paramys excavatus* Loomis
            - *Paramys* sp., cf. *P. francesi* Wood
            - cf. *Paramys*, very large sp.
            - *Reithroparamys* sp., cf. *R. atwateri* (Loomis)
            - *Franimys* sp.

Table 1. Provisional list of fossil mammals from the Willwood Formation of the south-central and southeastern Bighorn Basin, central Wyoming—Continued.

- Class Mammalia—Continued
  - Subclass Theria—Continued
    - Infraclass Eutheria—Continued
      - Magnorder Preptotheria—Continued
        - Order Rodentia—Continued
          - Family Ischyromyidae—Continued
            - cf. *Microparamys* sp.
            - ischyromyid, medium sp.
            - ischyromyid, very small sp.
            - ischyromyid, minute sp.
        - Order Tillodontia
          - Family Esthonychidae
            - *Esthonyx grangeri* Simpson
            - *Esthonyx spatularius* Cope
            - *Esthonyx bisulcatus* Cope
            - *Esthonyx acutidens* Cope
            - *Megalesthonyx hopsoni* Rose
        - Order Taeniodonta
          - Family Stylinodontidae
            - *Ectoganus* sp., cf. *E. gliriformis* Cope
            - stylinodontid, indet. sp.
        - Order Pantodonta
          - Family Coryphodontidae
            - *Coryphodon*, sp. 1
            - *Coryphodon*, sp. 2
            - *Coryphodon*, sp. 3
            - *Coryphodon*, sp. 4
        - Order Dinocerata
            - *Probathyopsis*? *lysitensis* Kelley and Wood
            - dinoceratan, gen. et sp. nov.
        - Order Condylarthra
          - Family Phenacodontidae
            - *Ectocion osbornianus* Cope
            - *Ectocion*, sp. nov.
            - *Phenacodus primaevus* Cope
            - *Phenacodus vortmani* Cope
            - *Copecion brachypternus* (Cope)
            - *Phenacodus*, sp. nov.
          - Family Hyopsodontidae
            - *Hyopsodus* sp., cf. *H. loomisi* McKenna
            - *Hyopsodus miticulus* (Cope)
            - *Hyopsodus minor* (Loomis)
            - *Hyopsodus* sp., cf. *H. latidens* Denison
            - *Hyopsodus* sp., cf. *H. lysitensis* Matthew
            - *Hyopsodus*, sp. nov.
            - *"Hyopsodus" powellianus* Cope
            - *Apheliscus* sp., cf. *A. nitidus* Simpson

- Class Mammalia—Continued
  - Subclass Theria—Continued
    - Infraclass Eutheria—Continued
      - Magnorder Preptotheria—Continued
        - Order Condylarthra—Continued
          - Family Pentacodontidae
            - *Apheliscus wapitiensis* (Van Valen)
            - *Apheliscus* sp., cf. *A. insidiosus* (Cope)
            - *Apheliscus*, sp. nov. 1
        - Order Perissodactyla
          - Suborder Hippomorpha
          - Family Hyracotheriidae
            - *Hyracotherium* sp., cf. *H. angustidens* (Cope)
            - *Hyracotherium* sp., cf. *H. etsagicum* (Cope)
            - *Hyracotherium* sp., cf. *H. borealis* Granger
            - *Hyracotherium* sp., cf. *H. craspidotum* (Cope)
            - *Hyracotherium*, sp. nov.
            - *Xenicohippus grangeri* Bown and Kihm
          - Family Palaeotheriidae
            - *Lambdotherium popoagicum* Cope
          - Suborder Tapiroidea
          - Family Isectolophidae
            - *Homogalax protapirinus* (Wortman)
            - *Homogalax* sp., cf. *H. semihians* (Cope)
            - *Homogalax*, sp. nov.
            - isectolophid, gen. et sp. nov.
          - Family Helaletidae
            - *Heptodon calciculus* Cope
            - *Heptodon posticus* (Cope)
            - helaletid?, gen. et sp. nov.
        - Order Artiodactyla
          - Family Dichobunidae
            - *Diacodexis metsiacus* Cope
            - *Diacodexis*, sp. nov.
            - *Diacodexis robustus* Sinclair
            - cf. *Hexacodus* sp.
            - "*Bunophorus*," small sp.
            - "*Bunophorus*," large sp.
            - *Wasatchia grangeri* Sinclair
            - *Wasatchia sinclairi* Guthrie
      - Magnorder Preptotheria, incertae sedis
            - *Creotarsus lepidus* Matthew

American West was linked to geographic exploration, and logistical support was too small for continuous field seasons or time-consuming section measuring; and (5) vertebrate paleontology did not have the stratigraphically directed economic incentive afforded invertebrate paleontology by the rapid expansion of the American oil industry from about 1880 to 1920 (see also discussions in Tedford, 1970; International Subcommission on Stratigraphic Classification, 1976).

Three of the first synopses of general mammalian biostratigraphy for the Tertiary of North America were published by Matthew (1899) and Osborn (1909, 1929). These were commendable early efforts that, although lacking explicit section information, approximated closely the occurrences of fossil mammals in rock units. The Wood committee report (Wood and others, 1941) offered the first real hope for advancing North American mammal biostratigraphy and was used as a general reference on the subject for about 50 years. Even so, it appeared about a century after detailed, section-controlled invertebrate biostratigraphies first began to appear in Europe.

Woodburne (1987) is a substantial improvement over Wood and others (1941), but it remains curious to us that there is yet so little general interest in a vertebrate

biostratigraphy based on measured sections and in one more detailed than the rather crude, somewhat anachronistic resolution afforded by land-mammal ages. This is not to say that there has been no interest (see, for example, Rensberger, 1971, 1973; Savage and others, 1972; Emry, 1973; West, 1973, 1979; Skinner and others, 1977; Wilson, 1977, 1986; Stevens and others, 1984; Skinner and Johnson, 1984; Stucky, 1984a, 1984b); however, progress toward this worthy goal has been very slow for vertebrate fossils and, in many instances, still lacks not only detailed sections but a reliable systematic base for the mammals as well.

Earlier general efforts toward developing a section-controlled biostratigraphy of the Willwood Formation include work on the basal Willwood Formation of the southeast Bighorn Basin (Bown, 1979, 1980), on the lower and middle parts of the Willwood Formation in the Clarks Fork region of the northern Bighorn Basin (for example, Gingerich and others, 1980; Rose, 1981a, 1981b; Gingerich and Klitz, 1985), and on the complete Willwood section of the south-central and southern Bighorn Basin (Schankler, 1980; Bown, 1980; and this paper). Though most groups of Willwood mammals still require considerable systematic revision, Schankler's (1980) work remains the most useful and comprehensive effort at a general Willwood mammal biostratigraphy for the Wasatchian of the central Bighorn Basin. It was complemented in 1981 by Rose's biostratigraphic documentation of Clarkforkian rocks of the northern Bighorn Basin, and by Gingerich (1983b).

In the study of the evolution of the omomyid primates (Rose and Bown, 1984, 1986; Bown and Rose, 1987) and other groups of Willwood mammals, it has become increasingly obvious that precise locality information, preferably coupled with good stratigraphic documentation, is essential to conduct meaningful investigations of tempo and mode of mammalian evolution as well as to pursue systematic and phylogenetic studies. Publication at this time of all current Willwood mammal locality and stratigraphic information will relieve future students of Willwood mammals of many of the vexing data gaps and quandaries earlier experienced. Paramount among these problems are instances in which fossils (including types and many outstanding specimens) have no or inadequate locality data and, therefore, no biostratigraphic data. Moreover, with the advent of paleontological studies involving correlation of fossil vertebrates with pedofacies (Bown, 1987; Bown and Beard, 1990; Bown and others, 1992), and concomitant knowledge of the differential distributions of fossil mammals in paleosols, even more precise field documentation is necessary now and in the future in order to determine exactly which kinds of paleosols yield which kinds of fossils. Such documentation requires considerable time to perform in the field, and the consequent decrease in collecting time decreases the size of samples that can be recovered in a field season. However, most necessary field information is now of such a nature that it cannot be reliably reconstructed now that the majority of the exceptionally rich fossil lag concentrations in the Willwood Formation have been exhausted.

Although it seems true that the fossil mammal resources in Willwood paleosols are virtually infinite using current collecting and sediment-processing techniques (Bown, 1979), the largest samples of fossils have been recovered from erosional-surface lag accumulations that appear to have required many hundreds or even thousands of years to form. Consequently, thorough site documentation at this time is important, even more than for the initial studies involving mammalian evolutionary mechanisms in light of the pedofacies and other as yet untested innovations. We also hope, by the stratigraphic documentation of numerous additional Willwood fossil-mammal sites in the present work, to assist in placing vertebrate and plant biostratigraphies on firmer and more respectable footings relative to those of the invertebrates, and to provide a dense stratigraphic data framework from which to pursue empirical studies of mammalian evolution. Studies of the reconstructed time stratigraphy of the Willwood Formation are also well underway (Bown and others, 1992; Bown and Kraus, 1993; Kraus and Bown, in press).

Willwood plant fossils document a number of important patterns. First, like the mammalian faunas that occur in the same sections, Willwood floras demonstrate the transition from Paleocene assemblages of archaic appearance to assemblages dominated by more modern forms. Floristically, this transition involves a decrease in the diversity and importance of conifers and increase in the diversity and eventual dominance of various angiosperm groups, including many species attributable to extant genera. Second, plant megafossils from the Willwood Formation indicate a vegetational shift from essentially deciduous forests in the latest Paleocene to mixed evergreen and deciduous broad-leaved forests by the end of Willwood time (Wing and others, 1991). This vegetational shift is significant both as a context for compositional change in the mammalian fauna and as a proxy for climatic change in this region during the early Eocene. In general, the floral trends are consistent with increasing warmth through the early Eocene, perhaps a reflection of the globally warmer climate inferred from paleobotanical data and oxygen isotope studies of marine microfossils (for example, Wolfe and Poore, 1982). A third pattern, visible within single strata for tens to hundreds of meters, appears to relate to small-scale variation in the original composition of the flood-plain vegetation (Wing, 1984a). The preservation of compositional information at this small scale permits some reconstruction of forest heterogeneity, species-area relationships, and successional processes, ecological characteristics that cannot commonly be inferred for vegetation of this age. As a result, Willwood floras may have the potential to play an important role in understanding the evolution of forest structure over geologically long periods of time.

Abbreviations used within the text.—DPC, Duke University Primate Facility (Durham, N.C.); NM, National Museum of Natural History, Smithsonian Institution (Washington, D.C.); UM, University of Michigan Museum of Paleontology (Ann Arbor, Mich.); U.S. Geological Survey (Denver, Colo.; D in tables and plates); UW, University of Wyoming Geological Museum (Laramie, Wyo.; W in tables and plates); YPM, Yale Peabody Museum (New Haven, Conn.; Y in tables and plates); m, meters; MNI, minimum number of individuals.

Acknowledgments.—The authors thank H.H. Covert and R.K. Stucky for review of an earlier version of this manuscript, and M.J. Kraus and David Schankler for discussion. G.F. Gunnell contributed locality information regarding University of Michigan vertebrate localities. K.C. McKinney assisted considerably with the organization of Willwood fossils in the U.S. Geological Survey collections. We are grateful to A.L. Isom for drafting the block diagram (fig. 12) showing the geometry of pedofacies.

This study owes considerable debt to all of those who contributed to the recovery of Willwood vertebrate fossils from the southern Bighorn Basin, especially those who collected specimens now in the three largest institutional collections of fossil vertebrates from this region, the collections of the Yale Peabody Museum, the University of Wyoming Geological Museum, and the U.S. Geological Survey. The principal Yale Peabody Museum field-party members in 1961–74 were: Joe Alpert, Friderun Ankel-Simons, Ernie Bonebaker, Bruce E. Bowen, Thomas M. Bown, Hal Brown, Prithijit S. Chatrath, John G. Fleagle, Hal Frank, Michael F. Gibbons, Jr., Leonard Greenfield, Karen Hiiemae, Richard F. Kay, Troy Krieger, Paul Lemke, Jim Meade, Deborah Meinke, Grant E. Meyer, Marty Meyer, Wayne Meyer, Pete Parks, Dennis W. Powers, Leonard Radinsky, Terry Radinsky, Stanley J. Riel, Kenneth D. Rose, Jeffrey Schweitzer, Richard Sheldon, Elwyn L. Simons (director), Ian M. Tattersall, Tom Westermeier, Tom Walsh, Paul Whitehead, Scott L. Wing, Roy Winslow, Claire Zwell, and Michael Zwell. The principal University of Wyoming field-party members in 1973–76 were: Thomas M. Bown (director), Arliss Burtis, Malcolm C. Campbell, Ruth Henritze, Mary J. Kraus, Kenneth D. Rose, Eleanor Saunders, and Jeffrey Schweitzer. The principal U.S. Geological Survey field-party members in 1977–92 (jointly with the Johns Hopkins University School of Medicine after 1980) were: Andres Aslan, Kenneth C. Beard, Michael Bell, Brandon Bown, Thomas M. Bown (director), Mark Brown, Malcolm C. Campbell, Silvia E. Cornero, Robert Costello, Marian Dagosto, Michael Diamond, David Dunn, Al Fraser, Carolyn Garman, Daniel Gebo, Marc Godinot, Paul V. Gold, Ron Heinrich, Inés Horovitz, John Hunter, Howard Hutchison, Scott Johnson, Mary J. Kraus, Robert Kraus, John Kurtz, Lewis Ladocsi, Abd-el A. Latief-Houdab, Alexandra Ledesma, J. David Love, Richard Madden, Andrew C. McKenna, Bruce McKenna, John D. McPhee, Kevin C. McKinney, Adéle Oakley, Fredericka Oakley, John Oakley, Robert W. O'Donnell, Maureen O'Leary, Charlotte Otts, Kathy Rafferty, D. Tab Rasmussen, Kenneth D. Rose (director), Jennie J. Rose, Sue Rose, Callum Ross, Jackie Runestad, Elise Schloeder, Sam Senturia, Myron Shekelle, Masako Shimamura, David Simons, Elwyn L. Simons, Amy Verreault, Gustav Winterfeld, Virginia J. Yingling, Naoko Yokoyama, and Pan Yuerong. The principal Duke University Primate Center field-party members from 1979–90 were: Herbert H. Covert, Mario Gagnon, Pat Holroyd-Vychodil, David Simons, Elwyn L. Simons (director), Verne Simons, Michael Stuart, and Chris Tilden. We were assisted greatly in 1980 and 1981 by J. Howard Hutchison and in various other seasons by visiting crews directed by J. David Archibald (San Diego State University), William S. Bartels (Albion College), Grant E. Meyer (Raymond M. Alf Museum), Michael J. Novacek (American Museum of Natural History), Charles Schaff (Agassiz Museum), Wighart von Koenigsvald (Institut für Palaontologie, Bonn, Germany), and Craig B. Wood (Providence College).

The senior author was assisted in measurement of stratigraphic sections of the Willwood Formation for the U.S. Geological Survey from 1981 to 1986 by Scott Johnson, Virginia J. Yingling, and especially Bruce Mckenna. The Yale sections of the Willwood Formation utilized here were measured by David Schankler and Scott L. Wing in 1976–78. In developing the fossil plant localities, Scott L. Wing was assisted in 1978–87 by Natasha Atkins, David D'Argenio, Kevin C. McKinney, Arnold Powell, Ben Rose, Bruce H. Tiffney, and Steven B. Wing, and by visiting field parties directed by Bruce H. Tiffney. Mary J. Kraus contributed considerable geologic information from her unpublished sections of the Willwood Formation along the Elk Creek Rim.

In the initial stages, much of Bown's work was supported by a G.K. Gilbert Professional Fellowship with the U.S. Geological Survey, and later work was supported largely by National Geographic Society Grant 3985–89. Kenneth D. Rose acknowledges support from National Geographic Society Grant 2366–81, John J. Hopkins Fund and U.S. National Institute of Health Biomedical Research Support Grant #RR5378 (through the Johns Hopkins University), and National Science Foundation Grants BSR–8215099 and BSR–8500732. Elwyn L. Simons was supported by grants from the J.T. Doneghy Fund (Yale University), The Boise Fund (Oxford University), and grants from the Duke University Research Council. Scott L. Wing acknowledges grants from Sigma Xi, the Smithsonian Scholarly Studies Fund, the Smithsonian Research Opportunities Fund, the Roland Brown Fund (Smithsonian Institution), and a National Research Council Postdoctoral Fellowship with the U.S. Geological Survey. David Schankler was assisted by grants from the J.T. Doneghy Fund and Sigma Xi.

FOSSIL VERTEBRATE LOCALITIES

GEOGRAPHIC LOCALITIES

There is considerable variety of opinion as to just what constitutes a fossil vertebrate locality. This circumstance results less from conflicting opinions than from different field experience, commonly dictated by the natural disposition of the fossils in different rocks in different basins. In the Willwood Formation of the south-central and southeast Bighorn Basin, all known sites are in one or more of the following categories, regardless of the mechanism responsible for concentrating the fossils: (1) Surface localities; (2) quarries; (3) wash sites; and (4) unusual concentrations of fossils that do not qualify as quarries, surface localities, or as wash sites.

Surface localities are delimited by the areal extent of lag concentrations of fossils on hills, on slopes, in runnels and rills, and on flats at the bases of hills or surrounding them. They vary in size from about 1 square meter to several hectares (fig. 2). Quarries (figs. 3 and 4) and wash sites (fig. 5) generally occupy a few to several square meters in size and delimit places of high local concentration of fossils. Unusual concentrations specifically include calcareous steinkerns (fig. 6) of the boles of trees (Kraus, 1985, 1988) that are known to contain vertebrate remains in a number of sequences (for example, Carroll, 1967; Walker and others, 1986; Gingerich, 1987; Walker and Teaford, 1989), and thin (<3 cm) concentrations of fossils over but a few cubic centimeters of surface exposure (for example, one area in locality D1830).

All of these different kinds of localities are now recorded geographically by demarcating their areas as precisely as possible on the best available maps (pls. 1 and 2) and, after 1992, will be recorded with a Magellan locating device; however, prior to about 1950, reliable large-scale topographic maps of the more remote badland areas of Willwood Formation exposure in the Bighorn Basin were not available. No reliable locality mapping exists for most Willwood localities established prior to about the middle of this century, except for sites known by tradition or by collecting continuity that have been, long after their discovery, recorded on maps. Lamentably, sites with poor, unreliable, or no recorded locality data include all of the principal localities of the early Cope expeditions and those of the American Museum of Natural History in the decade preceding World War I, from which important type materials were obtained (see discussions in Gingerich (1980a) and Bown and Rose (1987)). Although some localities were recorded on existing maps by Princeton University field parties under the direction of W.J. Sinclair and G.L. Jepsen, many of those were inaccurately plotted, and the majority appear to have never been recorded.

Therefore, the first reliable and systematically kept map records of the geographical situation of Willwood fossil mammal localities were maintained by E.L. Simons, who directed several Yale Peabody Museum expeditions in the Bighorn Basin from 1961 to 1975. In this endeavor, he was assisted by G.E. Meyer from 1963 to 1971, and by the senior author from 1970 to 1972. These Yale localities possessed little geographic or stratigraphic control other than what could be obtained by circumscribing a general location on a map. Nonetheless, this information was recorded faithfully every collecting day, and at least as early as 1968 (and probably earlier), the considerable time necessary to pinpoint new sites on maps became as important a part of the collecting routine as prospecting for fossils. Even so, the Yale localities commonly incorporated rather large geographic areas with only modest control on stratigraphic position. They are here termed geographic localities and, as shown in Schankler's (1980) correlation of YPM sites in the south-central Bighorn Basin, most cannot be stratigraphically correlated more accurately than to the nearest 10 m.

STRATIGRAPHIC LOCALITIES

In the area of exposure of the Willwood Formation, as in most badland areas where fossils commonly accumulate in surficial lags, it can be very difficult to determine from exactly where in a sequence an exposed fossil came. In the Willwood Formation, the majority of fossils were collected from lag accumulations on flats or at the bases of hills, accumulations that were produced over many years of weathering, erosion, and concentration. Only rarely, or when productive beds have been located (Bown, 1979), are remains found in place (fig. 7). Although it is commonplace procedure for paleontologists to follow the strike of the producing beds in outcrop in search of more fossils, during the Yale expeditions little attempt was made to either discern or to limit the stratigraphic provenance of fossils collected, except to constrain collecting efforts to the circumscribed geographic localities. Even so, great care was normally taken to prevent wandering of crew members in steep topography in the interest of stratigraphic conservation.

In 1974, it was discovered that a suite of geographic localities in the Sand Creek-No Water Creek area of Willwood badlands (pl. 2) yielded abundant vertebrate fossils from a single, exceptionally continuous bed (Bown, 1975, 1979). Further collecting in that area in 1975 demonstrated that the vast majority of Willwood fossils there could be precisely related to the beds that produced them, and several localities were given names to reflect this discovery (for example, Slick Creek quarry beds, Two Head Hill quarry beds, Supersite quarry beds; Bown, 1979). All of these important units are geographically widespread within that part of the Bighorn Basin, and all produce abundant fossil vertebrates throughout their area of exposure. Shortly thereafter, other exceptionally productive, stratigraphically explicit fossil occurrences were also discovered in Willwood rocks exposed in the drainages of Elk and Fifteenmile

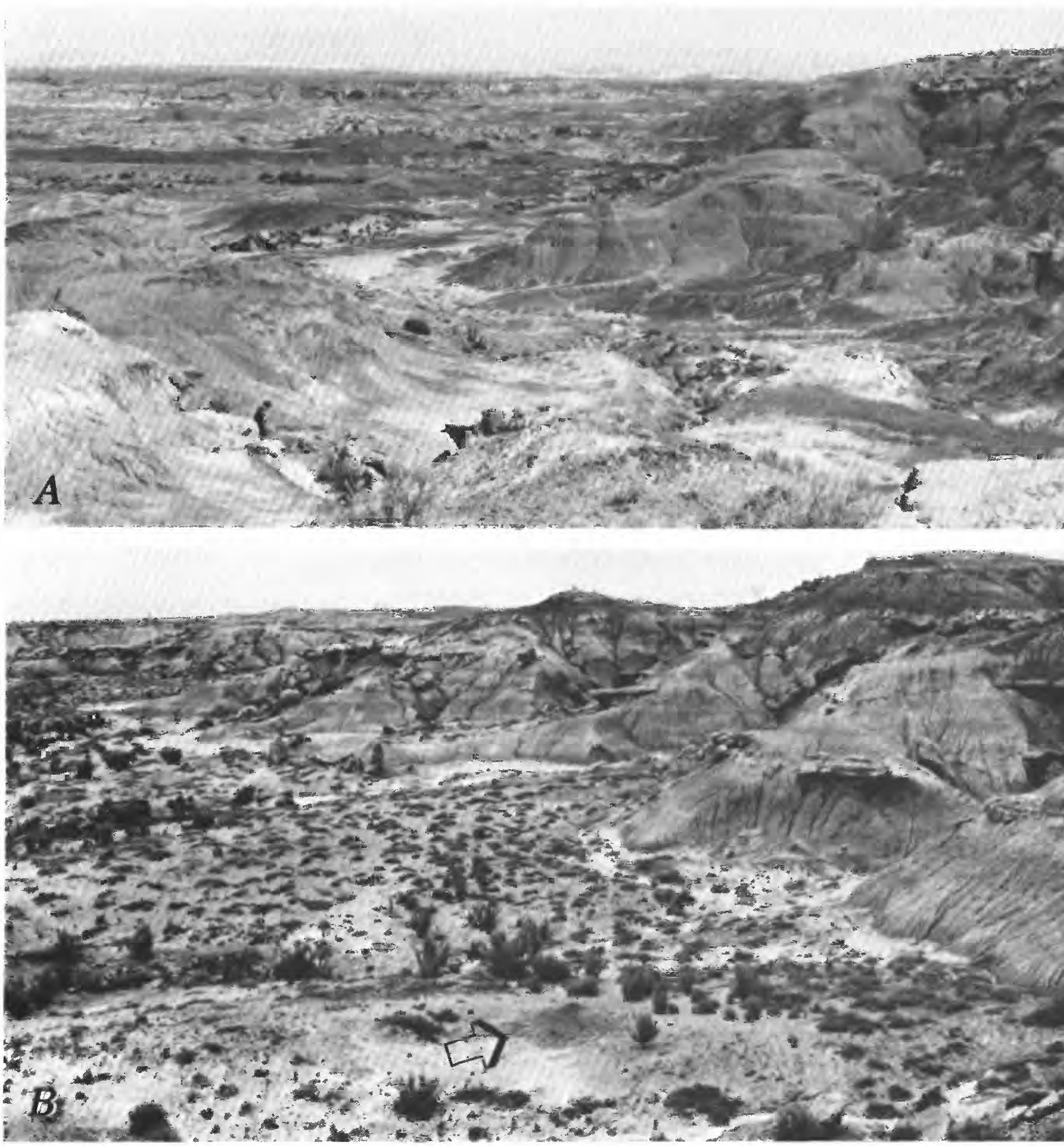


Figure 2. Surface (geographic) localities, Willwood Formation, southern Bighorn Basin, Wyoming. *A*. U.S. Geological Survey locality D1473, 556-m level. Locality has a sequence of levee deposits and immature paleosols at the floor of the valley and extending to the base of badland hills in the far distance. View to the north. *B*. Yale Peabody Museum locality Y104, 140-m level. Locality has a paleosol immediately above the flats at the base of the exposure, as well as several anthills (arrow). View to the north.

Creeks (pl. 1), and it was found that their origin was due to passive paleosol lag accumulations (Bown, 1977, 1979, 1980; Bown and Kraus, 1981a, 1981b).

Recent collecting operations in the Fifteenmile Creek drainage, beginning under University of Wyoming auspices in late 1973 and continuing with the U.S. Geological Survey and joint U.S. Geological Survey-Johns Hopkins University School of Medicine expeditions through 1992, were undertaken, following the 1974 season, with the specific goal of collecting large samples of Willwood vertebrates with tight stratigraphic controls tied to fossil provenances in paleosols. Field collecting began to be consciously restricted to specific

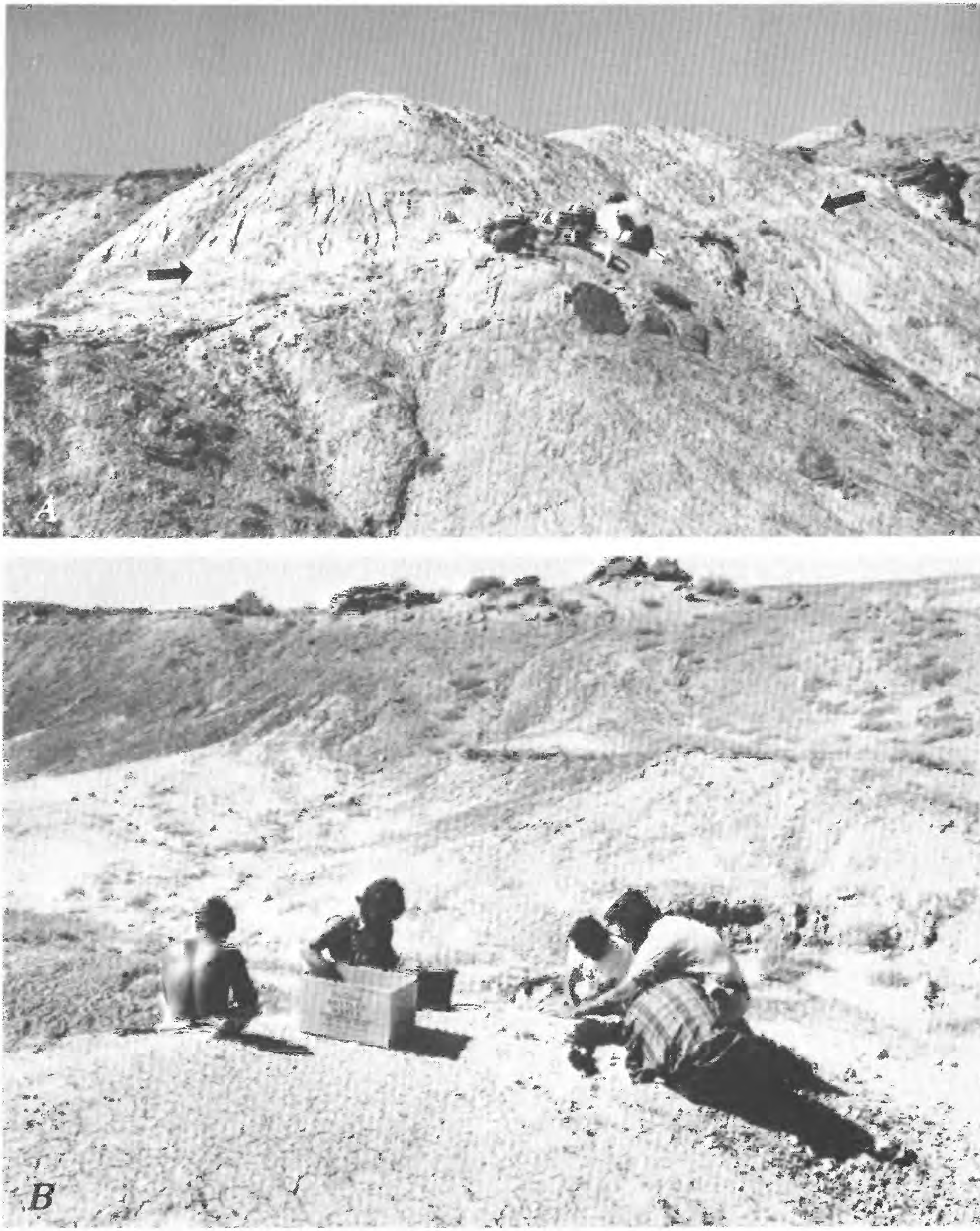


Figure 3. Fossil vertebrate quarry sites, Willwood Formation, southern Bighorn Basin, Wyoming. *A*. U.S. Geological Survey locality D1340Q, 364-m level. Fossils are concentrated in intraclastic mudrock conglomerate above the base of the scour (arrows). View to the south. *B*. U.S. Geological Survey locality D1762Q, estimated at the 414-m level. Fossils are in whitish sandy mudrock filling the scour throughout the small valley but are most abundant at the edge of the hill where the people are digging. View to the north.

Figure 4. Rose quarry, U.S. Geological Survey locality D1460Q, 411-m level ofthe Willwood Formation. *A*. View to the southeast of the entire quarry site; more than 1,000 specimens of small mammals were found in the area bounded by the men and the arrows. *B*. Close view of quarry operations and working surface in 1983. The site is so small (about 9 m^2) that it was difficult to apply the efforts of more than a few people at a time.

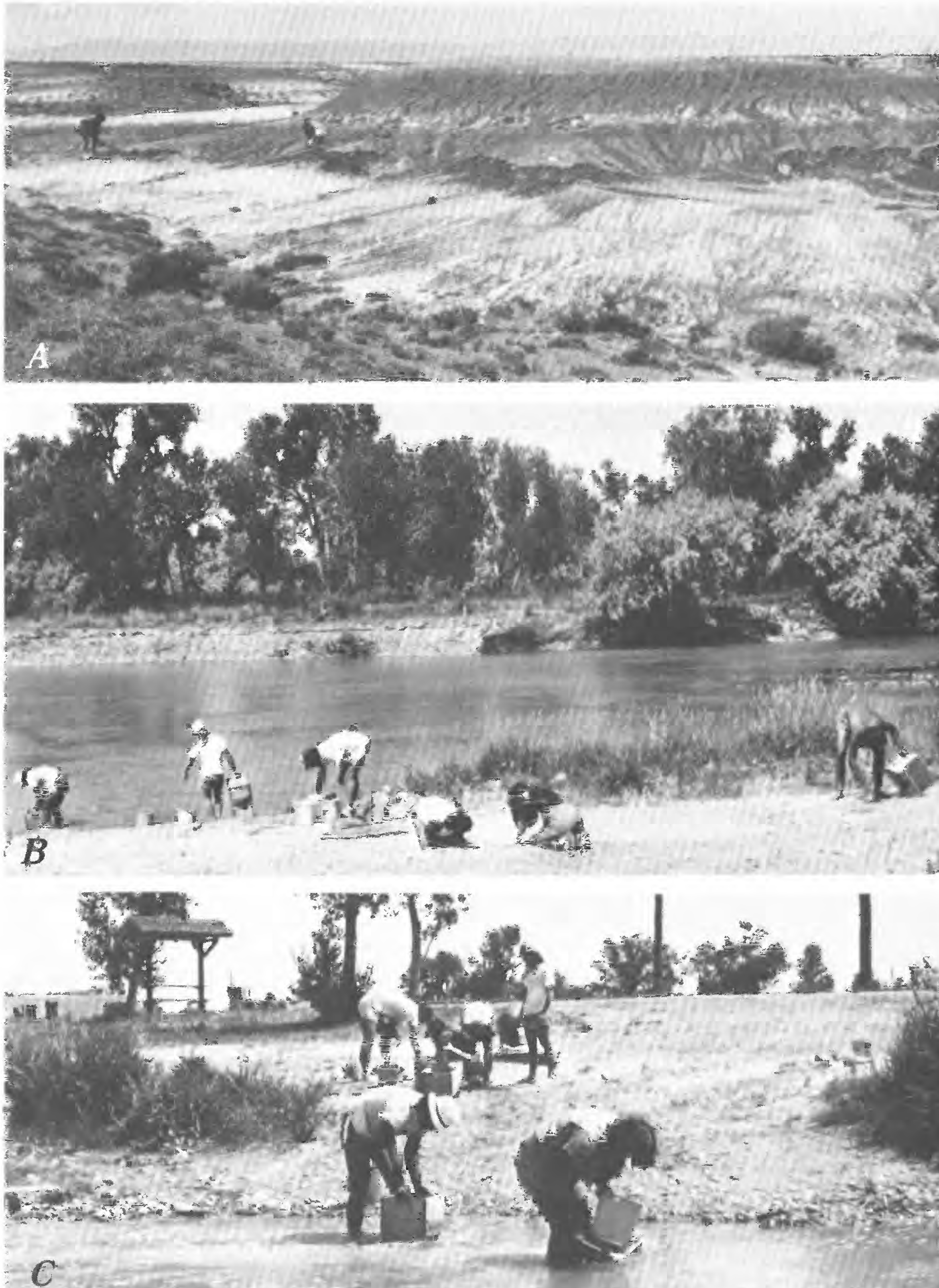


Figure 5. Teakettle Hill, Yale Peabody Museum locality 363, 190-m level of the Willwood Formation, southern Bighorn Basin, Wyoming. *A*. Chopping the A horizon of the productive paleosol and gathering matrix; view to the east-northeast. *B* and *C*. Screen-washing operations on the Bighorn River at Worland, Wyo., in 1984. Sediment was soaked in buckets (*B*), then poured in a slurry through screens and washed in river water (*C*). Concentrate was picked initially while drying (*B*), then packed for transport to the laboratory.

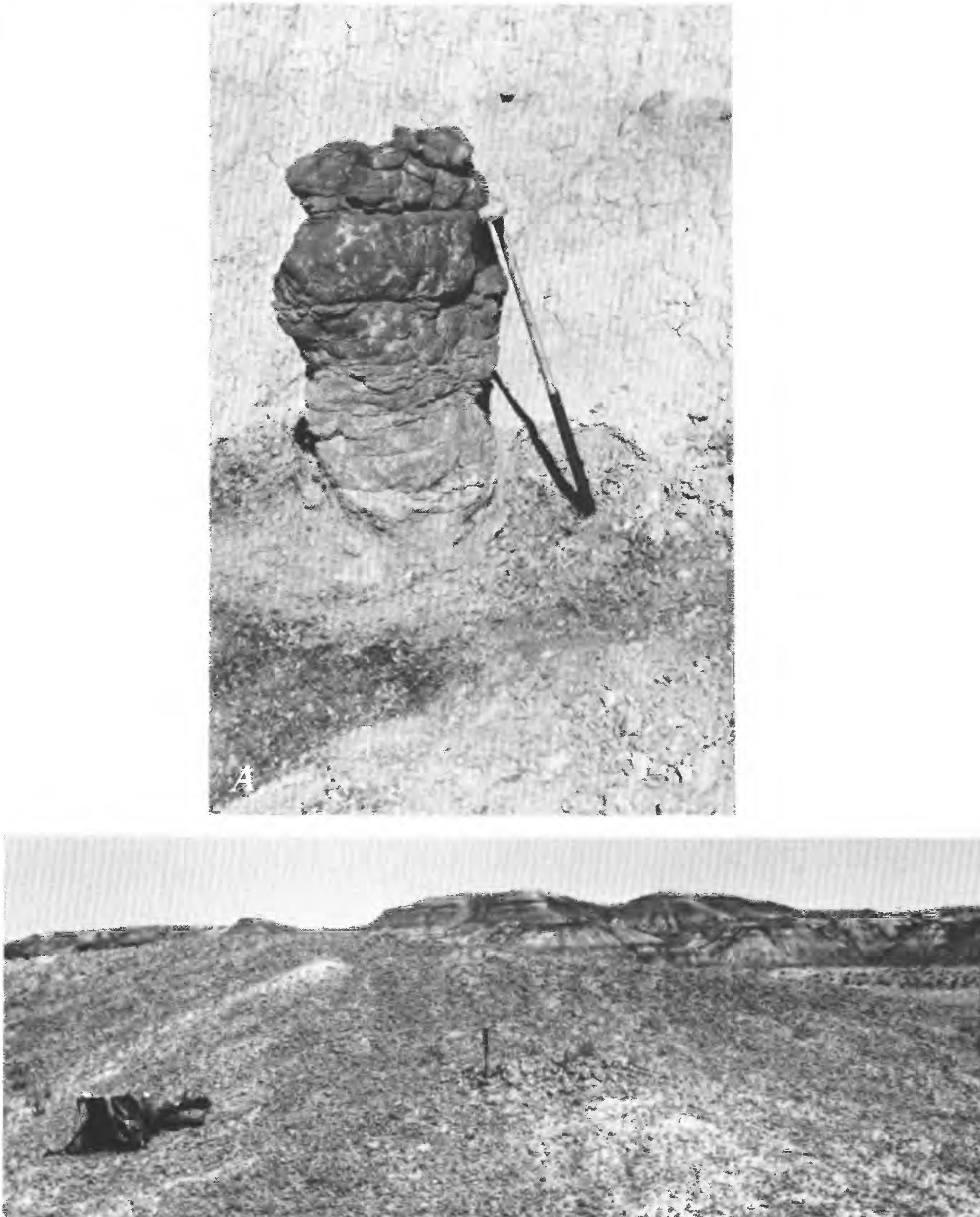


Figure 6. Calcareous steinkerns of the boles of trees. *A*, in the Fort Union Formation, on the Polecat Bench north of Powell, Wyo., and *B*, at U.S. Geological Survey locality D1799, Willwood Formation, at geology pick. Specimen in *B* is rich in fossil vertebrate remains. *A* is courtesy of M.J. Kraus.

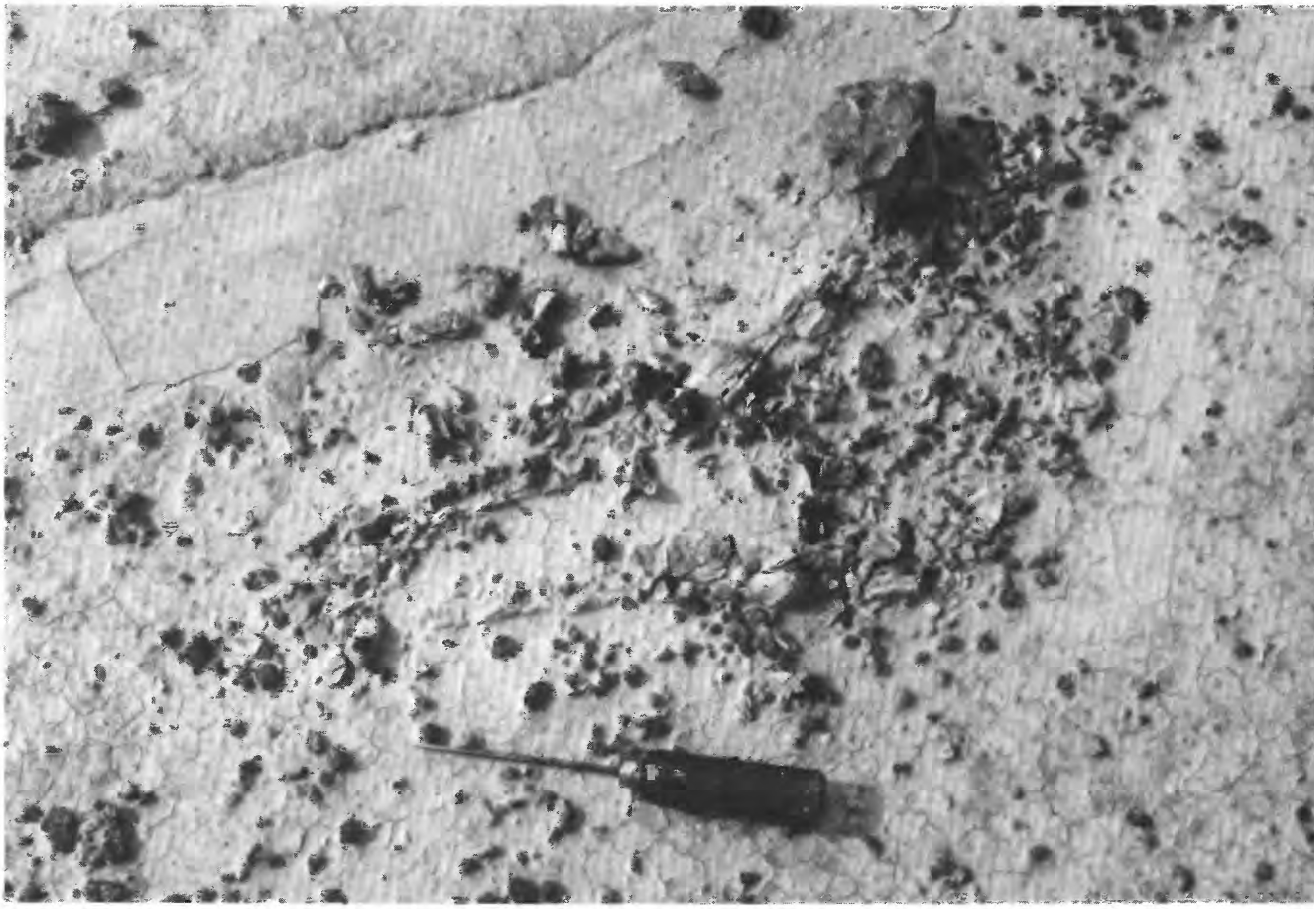


Figure 7. Mandible of a small species of *Coryphodon* (Mammalia, Pantodonta) in place in mudrock at U.S. Geological Survey locality D1583, 556-m level of the Willwood Formation, southern Bighorn Basin, Wyoming.

stratigraphic intervals that could be related to fossil provenances, and these are almost invariably in paleosols. Thus, since 1974, Willwood specimens in the University of Wyoming and U.S. Geological Survey collections have, for the most part, been collected stratigraphically, the producing beds sought out and recorded at the time of collection. This technique has afforded greater stratigraphic resolution than was possible in the study of Schankler (1980), in his correlation of the strictly geographic YPM localities (nearest 1.0 m instead of 10.0 m), for which bed provenance was unknown and commonly could not be reconstructed. The UW and U.S. Geological Survey localities, therefore, are both geographic and stratigraphic localities (fig. 8). The complete listing for U.S. Geological Survey, YPM, DPC, UM, and UW geographic and stratigraphic localities is presented in tables 2–6 (following "References Cited").

SEDIMENTOLOGIC LOCALITIES

With increasing knowledge of Willwood Formation depositional mechanisms and temporal-depositional controls on Willwood sediment-accumulation rates (Bown and others, 1991, 1992; Bown and Kraus, 1993; Kraus and Bown, in press), it has also become important to qualify geographic and stratigraphic localities in the field by some measure of their sedimentologic attributes. It became clear that it was necessary to establish a new type of fossil vertebrate locality after recognition that the various fossil-bearing Willwood paleosols are all basically the same kind of paleosol and that their morphological differences reflect considerably varying amounts of time required to form them (that is, some are more mature than others). Bown (1985) and Bown and Kraus (1987) designated five stages of maturation in Willwood paleosols, numbered 1–5 in order of increasing maturity. A sixth and least mature stage (numbered 0) was added by Kraus (1987) for Willwood sediment that was relatively unaltered pedogenetically, and to this scheme Bown and Kraus (1993) have added stage 6 for the most mature Willwood paleosols.

The relative maturities of the paleosols were discovered to be more or less directly proportional to their relative lateral distances from contemporary stream-channel deposits; that is, very immature stage 0 and stage 1 paleosols are typical of more proximal channel, levee, and meander-belt deposits, whereas stages 5 and 6 paleosols (the most mature)

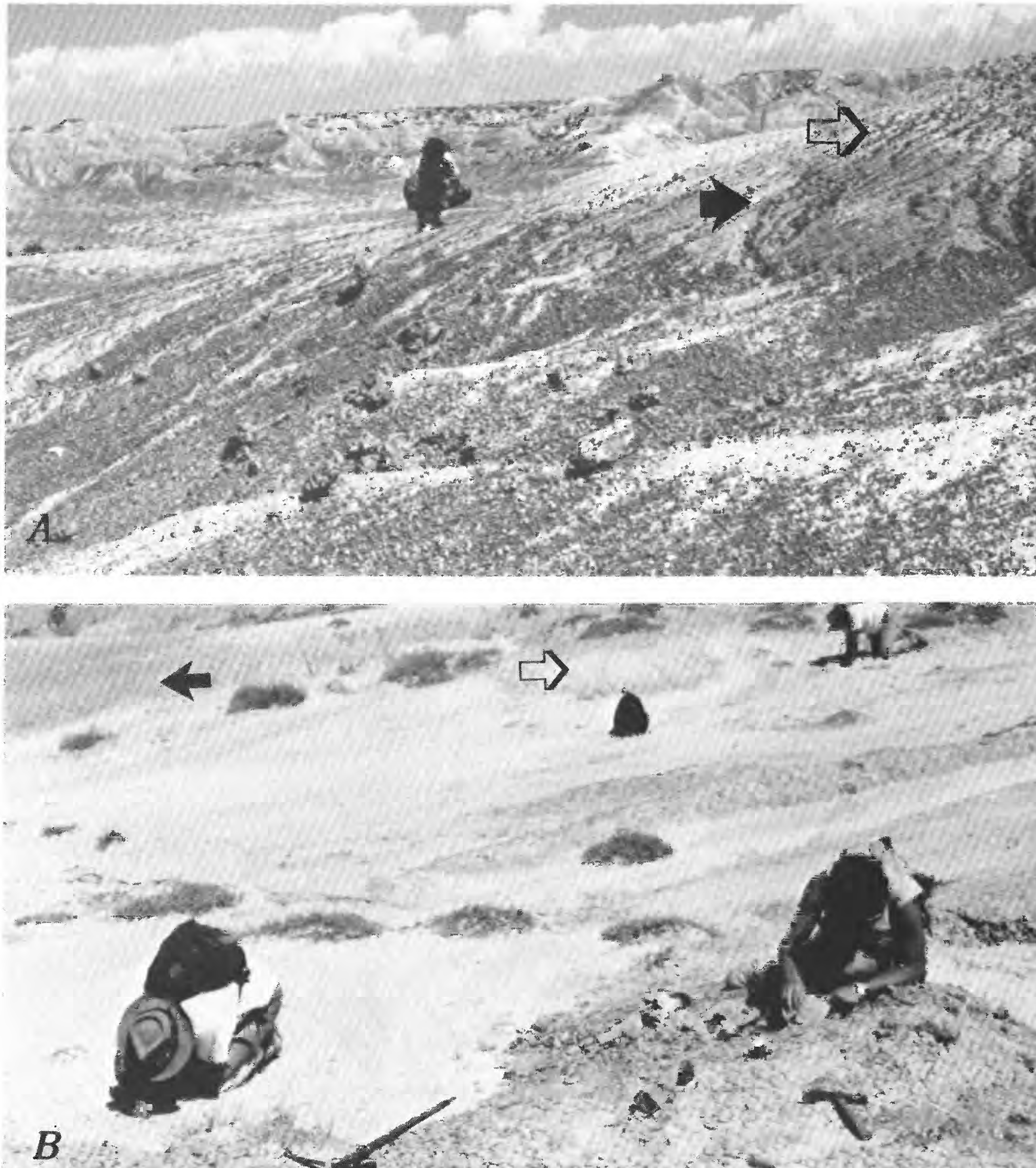


Figure 8. Stratigraphic fossil vertebrate localities, Willwood Formation, southern Bighorn Basin, Wyoming. *A*, U.S. Geological Survey locality D1454, 409-m level; man is collecting vertebrate fossils from surface lag accumulations derived from a stage 3 paleosol. Open arrow, A horizon; black arrow, upper part of B horizon of paleosol. *B*, Surface collecting and quarrying fossil vertebrates from stage 5 paleosol at University of Wyoming locality W44, 57-m level. Open arrow, A horizon, black arrow, upper part of B horizon of paleosol.

typically formed on sediments on the most distal part of the contiguous flood plain. Stages 2, 3, and 4 paleosols occupy areas intermediate between the proximal deposits proper and the most distal flood plain. Because maturity of Willwood paleosols was controlled by deposition, a means had therefore been found by which to integrate paleosols and paleosol time with deposition and sediment-accumulation time. Those means were embodied in the concept of the pedofacies (Bown and Kraus, 1987; Kraus, 1987), and the time-stratigraphic reconstruction of the Willwood Formation (Bown and others, 1992; Bown and Kraus, 1993; Kraus and Bown, in press).

Studies of evolution in lineages of the adapid primates *Cantius* and "Copelemur" and different species of the hyopsodontid condylarth *Hyopsodus* were undertaken in paleosol sequences with exceptionally rich fossil localities at the 438–442-m and 546-m levels of the Willwood Formation. It was discovered that the differential MNI abundances of temporally sympatric species are directly related to the different maturation stages of the paleosols in which they occur (Bown, 1987; Bown and Beard, 1990). Because, by the pedofacies concept, paleosol stage reflects proximity to nearby coeval stream channels (Bown and Kraus, 1987), the abundance differences between temporally sympatric species appear to record small-scale, intrabasinal geographic (and probably floral) controls on faunal composition.

Further examination of fossil mammal and pedofacies associations suggests that it is necessary to record even more locality information in the field to refine evolutionary studies further. Thus, beginning in 1987, the U.S. Geological Survey-Johns Hopkins University expeditions have recorded paleosol stage and other sedimentological and pedofacies information for all new localities and have begun a program of reconstructing this information from all older localities for which sufficient geographic and stratigraphic data exist to make such a reconstruction plausible. These are new types of localities for the Willwood Formation, localities whose documentation includes not only geographic area and stratigraphic provenance, but also sufficient information to assign paleosol stage and position in the local pedofacies complex. These sites are best termed sedimentologic localities (fig. 9). Sedimentologic locality information was published for various sites at the 438–442-m, 546-m, and 556-m levels by Bown (1987) and Bown and Beard (1990), and has now been compiled for about 1,000 additional localities. Some sedimentologic locality information is presented in tables accompanying the following section.

AVERAGE AND NOTEWORTHY LOCALITIES

All numbered fossil vertebrate localities in the Willwood Formation yield isolated jaws, teeth, and bones in variable abundance and in various stages of preservation. The most commonly encountered elements are teeth, followed first by jaw fragments and second by identifiable bone fragments. Associations of several bones, of dental remains and bones of the same individual, or of associated right and left rami or maxillae are relatively uncommon. Skulls and partial skeletons are quite rare. Although the outcome of prospecting for fossils in the Willwood Formation cannot be predicted with precision, the following estimates can be made, based on data compiled by the senior author for more than 22,000 specimens (partial listings occur in Bown and Kraus (1981b) and Bown and Beard (1990)). An average locality, after an average day of collecting by a party of six persons, might yield 50 teeth and one-tooth jaw fragments, 50 jaw fragments with two or more teeth, and perhaps 15 identifiable fragments of postcranial bones. Our field crews also might expect to find a group of associated bones of one individual fossil animal (or an association of teeth and bones) once a week; two partial skulls might surface in a field season; and a substantial part of a skeleton appears, on the average, slightly more often than once per eight-week season. For the past 10 seasons, a single yearly 8-week expedition has found an average of about 3,000 teeth and one-tooth jaw fragments, 2,200 jaw fragments with two or more teeth, 930 identifiable postcranial bone fragments, 9 noteworthy postcranial or dental-postcranial associations, 2 partial skulls, and 1–2 partial skeletons.

The vast majority of Willwood fossil-mammal sites are average surface localities in which the whole known sample was taken in one or two days, and the locality is not revisited unless: (1) Particularly significant or unusual mammals are later found to have come from there; (2) there is evidence that the site is richer than could be demonstrated when found; (3) there is evidence that the productive unit or units at the locality is more or equally productive farther afield (in areas in which the locality might be geographically extended); or (4) after relating the site to the measured stratigraphic section, the site is found to occupy a stratigraphic position for which little (or not enough) material is known. Other localities, however, have yielded enough fossils and(or) sufficient unusual fossils that they are quite extraordinary. Still others are so large and(or) so productive that they continue to yield excellent fossil material season after season and are revisited to increase sample sizes for studies of anatomical variability and faunal diversity. Data for the most important of these highly significant localities are given in table 7, and mammalian faunal lists and compositions for some of them are provided in tables 8–14.

FAUNAL COMPOSITION

A detailed analysis of the composition of Willwood mammalian assemblages is beyond the scope of this report, but a few remarks based on a preliminary assessment of the data at hand seem worthwhile. Basic data and diversity indices are given in table 15 for the assemblages summarized in

Figure 9. Sedimentologic fossil vertebrate locality complex, Willwood Formation, southern Bighorn Basin, Wyoming. *A*, Yale Peabody Museum locality Y192, 546 m-level; fossils come from an approximately 10-m-thick levee sequence containing stage 0–1 paleosols and bounded by crevasse-splay and crevasse-channel deposits. Meter levels for localities in such levee sequences are determined by recording the stratigraphic position of the middle of the sequence (bounded by arrows in figure). *B*, U.S. Geological Survey locality D1583, 551-m level; most fossils come from the A horizon of a stage 3 paleosol (arrows), from which the men are collecting. Both localities Y192 and D1583 are in the same pedofacies; however, Y192 is proximal to the channel system that formed the deposit, and D1583 is considerably distal to it. Both localities are part of the D1256 locality complex, and both are sedimentologic localities because their pedofacies positions have been determined, in addition to their geographic and stratigraphic positions.

tables 8–14. As indications of mammalian faunal diversity, we employ species richness (the number of species present), the Whittaker index (chiefly a measure of species evenness), and the Shannon-Wiener index (a commonly used measure of mixed diversity, that is, evenness and species richness). (For the use of these measures of diversity, see Whittaker, 1972, 1977; Peet, 1974; May, 1976; Rose, 1981b.)

Sufficient samples are known for all the faunal assemblages so that all but the rarest species likely have been recorded. An exception is the rarity of species with very small body size, but because all these samples were collected primarily by surface prospecting, this bias should be about the same for all.

Although screen washing at some sites may significantly affect the composition by revealing an unsuspected abundance of microfaunal taxa (for example, Winkler, 1983), it is unlikely that this procedure would fundamentally alter the diversity indices in table 15. Still, the assemblages display quite a large range in species richness, and one that is generally proportional to sample size. This range indicates that even the relatively large samples from the Willwood Formation are probably incomplete with regard to species, and smaller samples may provide an inadequate impression of species richness. It is probable, however, that as sample size increases, the only species added are the rarest elements of the fauna.

The diversity indices, despite generally larger samples than previously analyzed for Wasatchian assemblages, are surprisingly low compared to those of previously analyzed faunas (Rose, 1981a, 1981b). In relative diversity, the less diverse assemblages are more comparable with that of Clarkforkian faunas than with Wasatchian ones. Whether this lower diversity reflects local differences in ecological stability or local habitat has yet to be investigated.

STRATIGRAPHIC SECTIONS

MEYER-RADINSKY SECTION (1965)

The abundance of fossil vertebrates in the Willwood Formation of the Bighorn Basin was apparent as early as the Princeton University and American Museum of Natural History expeditions led by W.J. Sinclair and Walter Granger (Sinclair and Granger, 1911, 1912; Granger, 1914); however, it was not until more than a half-century later that the first large numbers of fossil localities were related to one another in a stratigraphic section. In 1965, G.E. Meyer and L.B. Radinsky (both then at Yale University) measured a section at the base of the formation along Antelope Creek, south of Basin, Wyo. (pl. 1). This (unpublished) section terminated at the contact of the Willwood Formation with the overlying Tatman Formation on the Squaw Teats Divide, and related 83 localities to one another through a measured thickness of 1,690 feet (515 m). Although there now appears to have been a rather severe error in measuring the formation (it is the thinnest of the complete measured sections of the formation by about 600 feet (183 m)), the Meyer-Radinsky section was the first of several attempts to relate the hundreds of early Eocene fossil vertebrate sites in the southern Bighorn Basin. Even though later studies have demonstrated that the actual meter levels recorded in the Meyer-Radinsky section are incorrect, their section did provide a relatively accurate stratigraphic arrangement of the localities with respect to one another, and it was utilized by Gingerich (1974) in his seminal study of dental evolution in the condylarth *Hyopsodus*.

NEASHAM-VONDRA SECTION (1966–69)

From 1966 to 1969, J.W. Neasham and C.F. Vondra of Iowa State University measured sections of the Willwood Formation. One of their sections was begun at the contact with the underlying Fort Union Formation on Antelope Creek but, rather than turning south at the Elk Creek Rim and crossing the Buffalo Basin as did the Meyer-Radinsky section, they instead brought their line of section westward up the drainage of Elk Creek, crossed the south face of Sheep Mountain, and culminated with a thickness of 2,300 feet (701 m) at the Willwood Formation-Tatman Formation contact on the east side of Tatman Mountain (pl. 1). This section was measured partly in cooperation with E.L. Simons' 1968 Yale Peabody Museum expedition to the Willwood Formation, and 37 YPM fossil vertebrate localities were related to it, including 19 not correlated previously by Meyer and Radinsky (Neasham, 1970). It was also in the course of this field work that Willwood paleosols were first recognized (Neasham, 1967, 1970; Neasham and Vondra, 1972).

In 1976, Gingerich published a second account of his *Hyopsodus* study in conjunction with other work. This new study utilized nearly all fossil localities correlated by the combined Meyer-Radinsky and Neasham-Vondra sections and added stratigraphic plots of tooth dimensions in the diminutive mammal *Haplomylus* and the adapid primate *Pelycodus* (=*Cantius*). In these and several later depictions of stratigraphically correlated dental dimensions of Willwood mammals from the central and southern Bighorn Basin (for example, Gingerich, 1977, 1980b, 1983a; Gingerich and Simons, 1977), Gingerich utilized data for fossils from 114 additional localities that were "***interpolated into measured sections on basis of geographic proximity to a locality in the measured sections and/or the morphology of the *Hyopsodus* from that locality" (Gingerich, 1976, p. 8). As observed by Bown (1979, p. 135), Willwood rocks throughout most of the central Bighorn Basin are not flat lying, as had been assumed by Gingerich, and an error of a single degree of dip from the actual rock inclination produces a stratigraphic error of more than 17 m/km (kilometer). Moreover, the procedure of utilizing tooth-size data to infer

Table 7. The most significant fossil vertebrate localities in the Willwood Formation of the southern Bighorn Basin, Wyoming, and synopsis of stratigraphic position, paleosol maturation stage (if known), and vertebrate remains.

[Sample sizes given include only identified remains; number of mammalian jaws given are mostly dentary or maxillary fragments with two or more teeth. MNI, minimum number of individuals; USGS, U.S. Geological Survey]

Locality number, name, and year of discovery: D1162, *Chriacus* locality, 1979.
Stratigraphic position: 481 m.
Paleosol stage: 1 and 2.
Sample size: 1,346 specimens, including 447 mammal jaw fragments.
Significant specimens: *Chriacus* sp., nearly complete articulated skeleton (USGS 2353; Rose, 1987); *Esthonyx* sp., cf. *E. bisulcatus*, skull and mandible (USGS 5285); *Palaeosinopa veterrima*, skull and jaw fragments (USGS 302).
Remarks: See faunal list, table 8. Locality Y40, nearby, represents the same level.

Locality number, name, and year of discovery: D1177, Purple Hills, 1976.
Stratigraphic position: 481 m.
Paleosol stage: 4.
Sample size: 1,014 specimens, including 257 mammalian jaw fragments.
Significant specimens: *Vulpavus* sp., cf. *V. canavus*, skull and jaws (USGS 206); *Xenicohippus grangeri*, holotype mandible (USGS 292).
Remarks: D1177 is stratigraphically the highest known richly fossiliferous stage 4 paleosol in the southern Bighorn Basin. Other nearby localities in the same paleosol are D1315, D1316, Y253, UMRB1, and UMRB2. See faunal list, table 9.

Locality number, name, and year of discovery: D1198 complex, Reservoir Creek Bonanza (includes Y45 and Y45S), 1962, as Y45.
Stratigraphic position: Levee deposits; median position is 470 m.
Paleosol stage: 1 and 2.
Sample size: 4,865 specimens, including 1,629 mammalian jaw fragments.
Significant specimens: Cf. *Prodiacodon*, dentaries and partial skeleton (USGS 16493); *Anemorhysis pattersoni*, holotype dentary (USGS 476; Bown and Rose, 1984); *Absarokius metoecus*, holotype dentary (USGS 492; Bown and Rose, 1987); *Miacis* sp., cf. *M. exiguus*, dentary and partial skeleton (USGS 7161).
Remarks: D1198 consists of eight separate sites, D1198A through D1198H, all in the same sequence of levee deposits extensively exposed along the drainage of Reservoir Creek. D1198A is the same as Y45, and D1198C is the same as Y45S; the remaining localities are U.S. Geological Survey extensions in equivalent beds and are accorded the same locality number. Other sites that produce fossil mammals from the same levee deposits are D1160, D1160N, D1244, and D1314. The D1198 complex is dominated faunally by *Hyopsodus*, two species comprising almost 50 percent (MNI) of the fauna. See faunal list, table 10.

Locality number, name, and year of discovery: D1204, Kraus Flats, 1976.
Stratigraphic position: 438–444 m.
Paleosol stage: 3 and 3+ (3 paleosols).
Sample size: More than 1,800 specimens, including about 750 mammalian jaw fragments.
Significant specimens: *Oxyaena gulo*, partial skull and skeleton (USGS 7186); *Steinius vespertinus*, best known upper dentition (USGS 502; Bown and Rose, 1984).
Remarks: D1204 is the richest fossil vertebrate site in the upper part of the *Bunophorus* Interval Zone of Schankler (1980). D1204 is characterized by an abundance of *Hyopsodus* and *Cantius*, both of which are represented by two species and were utilized by Bown and Beard (1990) in their study of fossil vertebrate distribution in paleosols. *Hyopsodus* constitutes nearly 40 percent of the fossil mammal fauna at D1204. Nearby localities in the same paleosols are D1203, D1693, and Y338. See faunal list, table 11.

Locality number, name, and year of discovery: D1230, Fossil Hollow Bonanza (equal to UMRB10), 1976.
Stratigraphic position: 490 m.
Paleosol stage: Unknown.
Sample size: More than 300 specimens, including more than 200 mammalian jaw fragments.
Significant specimens: Many jaws of small mammals that are rare at this level of the Willwood Formation, including *Apatemys*, *Phenacolemur*, and *Didelphodus*.
Remarks: D1230 is locally extremely rich in vertebrate remains. The locality was established by a joint University of Wyoming-University of Michigan field party as UMRB10.

Locality number, name, and year of discovery: D1256 complex, Bobcat Draw Bonanza (fig. 9*A*) 1971 as Y192.
Stratigraphic position: 541–551 m.
Paleosol stage: 1 through 3+ (Bown and Beard, 1990).
Sample size: 5,537 specimens, including more than 2,400 mammalian lower jaws.
Significant specimens: *Hapalodectes leptognathus*, dentition and associated postcrania (USGS 5912); numerous mandibular and maxillary associations and some dental and postcranial associations.
Remarks: The D1256 complex is developed at the richest fossil vertebrate horizon known in the southern Bighorn Basin. This pedofacies complex includes: D1256 proper, D1464, D1467, D1574, D1575, D1576, D1581, D1582, D1583, DPC15, DPC16, Y181, Y190, Y192, Y193, and Y315. The discovery site in the principal collecting area was Y192. Y181 and Y190 were discovered earlier but not extended; the remaining sites are extensions of Y192. See faunal list, table 12.

Locality number, name, and year of discovery: D1326, Dry Cottonwood Bonanza, 1980.
Stratigraphic position: 425 m.
Paleosol stage: 3.
Sample size: About 650 specimens, including 327 mammalian jaw fragments.
Significant specimens: *Microsyops angustidens*, snout and dentary (USGS 3793); *Didymictis* sp., cf. *D. protenus*, dentaries and partial skeleton (USGS 5024).

Table 7. The most significant fossil vertebrate localities in the Willwood Formation of the southern Bighorn Basin, Wyoming, and synopsis of stratigraphic position, paleosol maturation stage (if known), and vertebrate remains—Continued.

Remarks: D1326 is dominated by one species of *Hyracotherium* (MNI 21 percent), and two species of *Hyopsodus* (MNI 15 percent and 14 percent, respectively). The locality yields the stratigraphically lowest occurrences of *Absarokius* (*A. metoecus*), *Anacodon* (*A. ursidens*), and *Xenicohippus* (*X. grangeri*). See faunal list, table 13.

Locality number, name, and year of discovery: D1350, Gill Locality, 1976.
Stratigraphic position: 408–410 m.
Paleosol stage: 1 and 2.
Sample size: 57 specimens.
Significant specimens: *Hyracotherium* sp., partial articulated skeleton (USGS 5901); *Palaeanodon ignavus*, dentaries and partial skeleton (USGS 7209).
Remarks: Although D1350 is not a rich site, it is noteworthy for skeletal associations noted above and for a small quarry (D1350Q) at the southern margin of the site, which has yielded a small mammal fauna (including a new species of *Phenacolemur*) from a stage-1 paleosol.

Locality number, name, and year of discovery: D1389, no name, 1981.
Stratigraphic position: 264 m.
Paleosol stage: 4.
Sample size: 117 specimens, including 65 jaw fragments of very small mammals.
Significant specimens: *Tetonius-Pseudotetonius* intermediate (stage 2), complete dentary (USGS 3841; Bown and Rose, 1987); several well-preserved lower jaw fragments of didelphid marsupials and lipotyphlans.
Remarks: D1389 is stratigraphically the lowest locality above Biohorizon A (Schankler, 1980) that yields a diverse microfauna.

Locality number, name, and year of discovery: D1454, Potala Bonanza (fig. 8*A*), 1982.
Stratigraphic position: 409 m.
Paleosol stage: 3.
Sample size: 1,687 specimens, including 776 mammalian jaw fragments and numerous associations of dentitions with postcranial bones (sample size includes fossils from nearby D1460, which produces from the same paleosol).
Significant specimens: cf. *Prodiacodon* sp., 3 nearly complete skulls; *Cantius trigonodus*, snout and partial skeleton (USGS 5900; Rose and Walker, 1985); *Cantius trigonodus*, partial skeleton (USGS 21832); *Palaeanodon ignavus*, dentaries and partial skeleton (USGS 16471); *Esthonyx bisulcatus*, skull, mandible, and associated bones (USGS 7551, juvenile); *Hyracotherium* sp., jaw fragments and partial skeleton (USGS 21858); 14 mandibular fragments of *Apatemys* sp.; 8 unusually complete lower jaws of *Cantius trigonodus* (at D1460). See faunal list, table 14.
Remarks: The productive level at D1454 is exceptionally rich and extensive.

Locality number, name, and year of discovery: D1460Q, Rose quarry (fig. 4), 1982.
Stratigraphic position: 411 m.
Paleosol stage: 1.
Sample size: More than 1,000 specimens, including 150 mammalian jaw fragments.
Significant specimens: Numerous well-preserved dentitions of very small mammals, including *Apheliscus*, *Macrocranion*, *Talpavoides*, and *Peradectes*.
Remarks: The fauna of D1460Q is dominated by the jaws of very small mammals, of which the otherwise rare *Macrocranion nitens* and *Apheliscus* sp. nov. predominate (more than 20 jaws each). Faunal composition at D1460 differs considerably from that of the surrounding stage-3 paleosol (D1460 proper).

Locality number, name, and year of discovery: D1473, Hoover Renner Reservoir Bonanza (fig. 2*A*), 1983.
Stratigraphic position: 556 m.
Paleosol stage: 0–1.
Sample size: 1,119 specimens, including more than 750 mammalian jaw fragments.
Significant specimens: *Anemorhysis wortmani* holotype, USGS 6554).
Remarks: Locality D1473 produced more than 500 mammalian jaws in the first two days. D1504 and D1781 to the south have yielded large numbers of fossil mammals from the same levee sequence.

Locality number, name, and year of discovery: D1510, Crooked Creek Bonanza, 1983.
Stratigraphic position: 482 m.
Paleosol stage: 1.
Sample size: At least 1,000 specimens, including more than 800 mammalian jaw fragments.
Significant specimens: *Vulpavus canavus*, skull and partial skeleton (USGS 16488).
Remarks: Locality D1510 was locally extremely rich. In the first two days at the site, five collectors discovered 602 mammal jaws with two or more teeth (175 the first day, 427 the second day); during the next season 200 additional jaws were collected there. The fauna is dominated by *Hyopsodus*.

Locality number, name, and year of discovery: D1583, Bownanza (figs. 7, 9*B*), 1984.
Stratigraphic position: 551 m.
Paleosol stage: 3+.
Sample size: 1,186 specimens, including at least 800 mammalian jaw fragments.
Significant specimens: *Didymictis protenus*, snout and dentary (USGS 5909); very rich in a rare adapid primate similar to *Copelemur*.
Remarks: Locally very productive; five collectors found more than 300 jaw fragments the first day in 1984, and 200 additional jaws were collected in one day the following season.

Locality number, name, and year of discovery: D1651, Gooseberry Creek quarry, 1986.
Stratigraphic position: Approximately 636 m.
Paleosol stage: 1.
Sample size: 315 specimens, including 75 mammalian jaw fragments.

Table 7. The most significant fossil vertebrate localities in the Willwood Formation of the southern Bighorn Basin, Wyoming, and synopsis of stratigraphic position, paleosol maturation stage (if known), and vertebrate remains—Continued.

Significant specimens: *Phenacolemur* sp., dentaries and partial skeleton (USGS 17847).
Remarks: Locality D1651 is stratigraphically the highest known productive small-mammal locality in the Willwood Formation of the southern Bighorn Basin and yields a late Wasatchian fauna. Locality D1651Q is a small hill within the locality that yielded more than 200 specimens, including more than 50 jaw fragments of small mammals.

Locality number, name, and year of discovery: D1675Q, Elk Creek Rim quarry, 1986.
Stratigraphic position: 493 m.
Paleosol stage: 3.
Sample size: About 30 specimens, including 15 mammalian jaw fragments.
Significant specimens: *Microsyops* sp., partial skull and complete dentary (USGS 28050); several well-preserved lower jaws of *Microsyops* and *Apheliscus*; partial skull of small hyaenodontid creodont.
Remarks: Locality D1675Q is an important site because it yields well-preserved small mammals of middle Wasatchian age. The quarry site is contained within locality D1563, which yielded a partial skull and skeleton of *Oxyaena* sp., cf. *O. forcipata* (USGS 16484) from the same bed.

Locality number, name, and year of discovery: D1699, no name, 1986.
Stratigraphic position: 463 m.
Paleosol stage: 1.
Sample size: 558 specimens, including 373 mammalian jaw fragments.
Significant specimens: *Hadrianus majusculus*, most of carapace, plastron, and postcranial skeleton (University of California Museum of Paleontology 134931); *Prototomus* sp., dentaries and partial skeleton (USGS 16475); *Anacodon ursidens*, partial forelimb (USGS 21857).
Remarks: Localities D1737, D1776, D1776N, D1833, and D1881 (see separate entry for D1737) are also very rich and occur in the same levee deposits farther north.

Locality number, name, and year of discovery: D1717, no name, 1987.
Stratigraphic position: Unknown; above 636 m.
Paleosol stage: 0.
Sample size: 48 specimens.
Significant specimens: Three partial skulls of *Coryphodon* and several well-preserved upper and lower jaws of *Heptodon* and *Lambdotherium* (all uncatalogued).
Remarks: Stratigraphically one of the highest productive vertebrate localities in the Willwood Formation. Considerable future promise, especially for more remains of *Coryphodon*. Productive unit (proximal levees with splay sands) extends to the north and includes locality D1718.

Locality number, name, and year of discovery: D1737, no name, 1987.
Stratigraphic position: 463 m and 469 m.
Paleosol stage: 1 (lower) and 3 (upper).
Sample size: 236 specimens, including 111 mammalian jaw fragments.
Significant specimens: *Pararyctes* sp., skull (USGS 23824); *Didymictis* sp., cf. *D. protenus*, skull and mandible (USGS 21864); *Hyracotherium* sp., partial hind-limb skeleton (USGS 21860).
Remarks: Localities D1699 (to the northeast) and D1776 and D1776N (to the north of D1737) yield mammals from the same levee deposits (see separate entry for loc. D1699). Locality D1776 produced two partial skeletons of *Palaeanodon ignavus* (USGS 21876 and 21930) and a partial skeleton of *Coryphodon* (USGS 21935). Locality Y100, just to the southeast, lies in a stage-4 paleosol below locality D1737 (455-m level), and produced an important partial skeleton of *Anacodon ursidens* (USGS 21856).

Locality number, name, and year of discovery: D1762Q, McKinney quarry (fig. 3*B*), 1988.
Stratigraphic position: Approximately 414 m.
Paleosol stage: 0.
Sample size: About 1,000 specimens, including 73 mammalian jaw fragments.
Significant specimens: Several well-preserved lower jaws of lipotyphlans, didelphid marsupials, and the omomyids *Steinius vespertinus* and *Arapahovius advena* (Bown and Rose, 1991; Rose and Bown, 1991).
Remarks: Locality D1762Q has considerable potential as a micromammal quarry. It is notable in that it has yielded several specimens of the rare omomyids *Arapahovius* and *Steinius* at a stratigraphic level at which all omomyids are quite rare.

Locality number, name, and year of discovery: Y55, Howard's Hill and *Diacodexis* locality, 1962.
Stratigraphic position: Approximately 501 m.
Paleosol stage: 1 and 2.
Sample size: 168 specimens, including about 110 mammalian jaw fragments.
Significant specimens: *Diacodexis metsiacus* skeleton (USGS 2352; Rose, 1982, 1985); Howard's Hill, a small pocket in a stage 2 paleosol in the Y55 levee sequence, yielded 40 micromammal jaws, more than 150 teeth, and about 200 bones.

Locality number, name, and year of discovery: Y104 (fig. 2*B*), no name, 1963.
Stratigraphic position: 140 m.
Paleosol stage: 4.
Sample size: 79 specimens in U.S. Geological Survey collection, and a significant collection (sample size unknown) at the Yale Peabody Museum.
Significant specimens: *Teilhardina, T. americana-T. crassidens* intermediate, only complete anterior dentition of *Teilhardina* (USGS 512; Bown and Rose, 1987); *Pachyaena ossifraga*, palatal dentition (USGS 7185, from loc. D1640, a site to the east developed in the same paleosol); *Plagioctenodon savagei*, holotype dentary (YPM 34257; Bown and Schankler, 1982).

Locality number, name, and year of discovery: Y356, *Hyopsodus* Hill, 1972.

Table 7. The most significant fossil vertebrate localities in the Willwood Formation of the southern Bighorn Basin, Wyoming, and synopsis of stratigraphic position, paleosol maturation stage (if known), and vertebrate remains—Continued.

Stratigraphic position: Approximately 360 m.
Paleosol stage: 2.
Sample size: Unknown; probably more than 200 mammalian jaw fragments.
Significant specimens: Unknown.
Remarks: This site is noteworthy for its remarkable concentration of jaw fragments of *Hyopsodus* and *Microsyops* (most of the collection from the site) collected from a small hill by the 1972 Yale Peabody Museum field crew. About 60 more jaws were recovered by the U.S. Geological Survey-Johns Hopkins University School of Medicine field party in 1981, but the locality now appears to be worked out.

Locality number, name, and year of discovery: Y363, Teakettle Hill (fig. 5*A*), 1972.
Stratigraphic position: 190 m.
Paleosol stage: 4.
Sample size: Unknown, but probably well in excess of 400 mammalian jaw fragments.
Significant specimens: Unknown.
Remarks: Locality Y363 has produced one of the most important samples of small mammals in the upper part of the lower *Haplomylus-Ectocion* Zone (Schankler, 1980). It is especially rich in omomyid primates and is one of very few sites in the Willwood Formation that yield three contemporaneous omomyid species *Teilhardina crassidens*, *Tetonius matthewi*, *Tetonius* sp.; Bown and Rose, 1987).

Locality number, name, and year of discovery: Y370A, Banjo Quarry, 1972.
Stratigraphic position: 70 m.
Paleosol stage: 0.
Sample size: Unknown but probably exceeds 100 mammalian jaw fragments and 500 teeth.
Significant specimens: *Parapternodus antiquus*, holotype dentary (YPM 31169; Bown and Schankler, 1982); numerous specimens of small lipotyphlans, neoplagiaulacid multituberculates, didelphid marsupials, and primates.
Remarks: Locality Y370 was the first major micromammal quarry, whose location is known, to be developed in the Willwood Formation.

Locality number, name, and year of discovery: W22, Slick Creek quarry beds, 1974.
Stratigraphic position: 46 m.
Paleosol stage: 4.
Sample size: Unknown but exceeds 400 mammalian jaw fragments and 1,000 teeth.
Significant specimens: *Teilhardina americana* (holotype dentary, UW 6896; Bown, 1976; Bown and Rose, 1987); *Talpavoides dartoni*, holotype dentary (UW 9624; Bown and Schankler, 1982); numerous mandibular and maxillary fragments of lipotyphlans, didelphid marsupials, and other small mammals.
Remarks: Locality W22 is quite extensive areally and yields fossils throughout. Slick Creek Quarry was an exceptionally productive pocket in the paleosol.

Locality number, name, and year of discovery: W27, Stonehenge quarry beds, 1974.
Stratigraphic position: 30 m.
Paleosol stage: 4+.
Sample size: Unknown but exceeds 300 mammalian jaw fragments and 800 teeth.
Significant specimens: Numerous jaw fragments and teeth of very small mammals.
Remarks: Locality W27 is areally limited but remains an exceptionally rich locality. Stonehenge Quarry was a highly productive pocket in the paleosol. Locality D1296, just to the southwest, is in the same paleosol.

Locality number, name, and year of discovery: W37, Supersite quarry beds, 1975.
Stratigraphic position: 34 m.
Paleosol stage: 5.
Sample size: More than 4,000 identified specimens, including more than 900 mammalian jaw fragments and 2,500 teeth.
Significant specimens: *Plagioctenoides microlestes*, holotype dentary (UW 9694; Bown, 1979); several mandibular and maxillary specimens of the minute, rare plesiadapiformes *Niptomomys* and *Tinimomys*.
Remarks: Locality W37 is the richest known site in the southern Bighorn Basin for small mammals, and it is by far the most productive site in the *Haplomylus-Ectocion* zone and in the lower part of the Willwood Formation. It has almost limitless opportunities for development as a wash site. Locality W34 (Two Head Hill quarry beds) and extensions are farther south in the same paleosol and yielded the holotype dentary of *Peratherium macgrewi* (UW 9564; Bown, 1979).

Locality number, name, and year of discovery: W44, Wadi Kraus Quarry (fig. 8*B*), 1975.
Stratigraphic position: 57 m.
Paleosol stage: 5.
Sample size: Approximately 150 mammalian jaw fragments and 500 teeth.
Significant specimens: Jaw fragments of many lipotyphlans, primates, and other small mammals, including holotype dentary of *Plagioctenodon krausae* (UW 9682; Bown, 1979)
Remarks: Though of limited area, locality W44 is an exceptionally rich site. For its size, it is the most productive locality in the Sand Creek-No Water Creek area, both as a quarry and as a wash locality.

Locality number, name, and year of discovery: W125, Big W, 1976.
Stratigraphic position: 180 m.
Paleosol stage: 4+.
Sample size: Approximately 600 specimens, including about 150 mammalian jaw fragments.
Significant specimens: *Teilhardina crassidens*, holotype dentary (USGS 8959; Bown and Rose, 1987); numerous jaws of small mammals, especially lipotyphlans and omomyid primates.
Remarks: Locality W125 is stratigraphically the highest productive site in the lower *Haplomylus-Ectocion* zone in the Fifteenmile Creek section and, like Y363, yields three species of contemporaneous omomyid primates (*Teilhardina crassidens*, *Tetonius matthewi*, and *Tetonius* sp.).

Table 8. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1162 (includes locality Y40), 481-m level of the Willwood Formation, southern Bighorn Basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1983]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	858	100.05	241	99.88
Magnorder Preptotheria	858	100.05	241	99.88
Order Cimolesta	16	1.87	9	3.81
Suborder Pantolesta	13	1.52	7	2.90
Family Pantolestidae	13	1.52	7	2.90
Palaeosinopa veterrima	13	1.52	7	2.90
Suborder Apatotheria	1	.12	1	.41
Family Apatemyidae	1	.12	1	.41
Apatemys rodens	1	.12	1	.41
Suborder Palaeoryctoidea	2	.23	1	.50
Family Didelphodontidae	2	.23	1	.50
Didelphodus absarokae	2	.23	1	.50
Order Creodonta	7	.82	5	2.07
Family Hyaenodontidae	2	.24	2	.82
Tritemnodon sp., cf. *T. hians*	1	.12	1	.41
Prototomus sp.	1	.12	1	.41
Family Limnocyonidae	1	.12	1	.41
Prolimnocyon sp.	1	.12	1	.41
Family Oxyaenidae	4	.47	2	.83
Oxyaena sp.	4	.47	2	.83
Order Arctocyonia	10	1.17	5	2.07
Family Arctocyonidae	10	1.17	5	2.07
Thryptacodon sp., cf. *T. loisi*	47	.47	2	.83
Chriacus, sp. nov.	2	.23	2	.83
Anacodon ursidens	4	.47	1	.41
Order Carnivora	21	2.45	11	4.46
Family Miacidae	21	2.45	11	4.56
Didymictis sp.	7	.82	2	.83
Viverravus sp., cf. *V. acutus*	5	.58	3	1.24
Vulpavus sp.	8	.93	5	2.07
Miacis sp., cf. *M. exiguus*	1	.12	1	.41
Order Erinaceomorpha	1	.12	1	.41
Family Dormaaliidae	1	.12	1	.41
Macrocranion nitens	1	.12	1	.41
Order Plesiadapiformes	10	1.17	8	3.31
Family Microsyopidae	9	1.05	7	2.90
Microsyops latidens	9	1.05	7	2.90
Family Paromomyidae	1	.12	1	.41
Phenacolemur, sp. nov.	1	.12	1	.41
Order Primates	43	5.01	19	7.87
Infraorder Omomyiformes	16	1.86	7	2.90
Family Omomyidae	16	1.86	7	2.90
Absarokius abbotti	16	1.86	7	2.90
Infraorder Adapiformes	27	3.15	12	4.97
Family Notharctidae	27	3.15	12	4.97
Cantius abditus	26	3.03	11	4.56
cf. *Copelemur* sp.	1	.12	1	.41

Table 8. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1162 (includes locality Y40), 481-m level of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Palaeanodonta	4	.47	2	.83
Family Metacheiromyidae	4	.47	2	.83
Palaeanodon ignavus	4	.47	2	.83
Order Rodentia	19	2.21	7	2.90
Family Ischyromyidae	19	2.21	7	2.90
cf. *Paramys*, large sp.	4	.47	2	.83
cf. *Paramys*, medium sp.	4	.47	2	.83
cf. *Paramys*, small sp.	9	1.05	2	.83
ischyromyid, very small sp.	2	.23	1	.41
Order Tillodontia	24	2.80	8	3.32
Family Esthonychidae	24	2.80	8	3.32
Esthonyx bisulcatus	24	2.80	8	3.32
Order Pantodonta	3	.35	1	.41
Family Coryphodontidae	3	.35	1	.41
Coryphodon sp.	3	.35	1	.41
Order Dinocerata	1	.12	1	.41
dinoceratan, gen. et sp. nov.	1	.12	1	.41
Order Condylarthra	252	29.37	80	33.20
Family Hyopsodontidae	224	26.11	66	27.38
Hyopsodus sp., cf. *H. miticulus*	169	19.70	53	21.99
Hyopsodus sp., cf. *H. minor*	55	6.41	13	5.39
Family Pentacodontidae	3	.35	3	1.24
Apheliscus, sp. nov.	3	.35	3	1.24
Family Phenacodontidae	25	2.92	11	4.56
Phenacodus vortmani	24	2.80	10	4.15
Phenacodus brachypternus	1	.12	1	.41
Order Perissodactyla	396	46.15	62	25.73
Family Hyracotheriidae	376	43.83	51	21.16
Hyracotherium, large sp.	53	6.18	8	3.32
Hyracotherium, small sp.	323	37.65	43	17.84
Family Helaletidae	20	2.33	11	4.56
Heptodon calciculus.	16	1.86	9	3.73
helaletid, gen. et sp. nov.	4	.47	2	.83
Order Artiodactyla	54	6.29	24	9.96
Family Dichobunidae	54	6.29	24	9.96
Diacodexis metsiacus	48	5.59	21	8.71
"*Bunophorus*", small sp.	6	.70	3	1.24

stratigraphic position and then using the stratigraphy so derived to plot tooth size and infer evolutionary patterns is inherently circular. Nonetheless, Gingerich's work was instrumental in documenting the importance of tight stratigraphic control in empirical evolutionary studies using fossil mammals. It was also the first study to demonstrate the potential of the Willwood fauna in that regard.

What was really needed was a major new measured section of the Willwood Formation, measured with the specific purpose of correlating as many fossil localities as accurately as possible. Such sections were published for Willwood localities in the Sand Creek-No Water Creek area and the central Bighorn Basin only three and four years later, respectively.

Table 9. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1177 (includes localities D1315, D1316, Y253, UMRB1, and UMRB2), 481-m level of the Willwood Formation, southern Bighorn Basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1983]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	459	100.24	136	100.75
Magnorder Ernotheria	3	.66	2	1.47
Grandorder Ictopsia	3	.66	2	1.47
Family Leptictidae	3	.66	2	1.47
Palaeictops bicuspis	3	.66	2	1.47
Magnorder Preptotheria	456	99.35	134	98.53
Order Cimolesta	2	.44	2	1.47
Suborder Pantolesta	1	.22	1	.74
Family Pantolestidae	1	.22	1	.74
Palaeosinopa veterrima	1	.22	1	.74
Suborder Palaeoryctoidea	1	.22	1	.74
Family Didelphodontidae	1	.22	1	.74
Didelphodus absarokae	1	.22	1	.74
Order Creodonta	5	1.09	3	2.22
Family Hyaenodontidae	4	.87	2	1.47
Tritemnodon sp., cf. *T. hians*	2	.44	1	.74
cf. *Prototomus* sp.	2	.44	1	.74
Family Oxyaenidae	1	.22	1	.74
Oxyaena sp.	1	.22	1	.74
Order Arctocyonia	4	.87	2	1.47
Family Arctocyonidae	4	.87	2	1.47
Chriacus, sp. nov.	1	.22	1	.74
Anacodon ursidens	3	.66	1	.74
Order Carnivora	26	5.68	12	8.82
Family Miacidae	26	5.68	12	8.82
Didymictis sp.	8	1.75	2	1.47
Viverravus acutus	3	.66	2	1.47
Vulpavus australis	1	.22	1	.74
Vulpavus canavus	6	1.31	2	1.47
Miacis exiguus	3	.66	2	1.47
Vassacyon sp., cf. *V. promicrodon*	1	.22	1	.74
Uintacyon sp.	4	.87	2	1.47
Order Plesiadapiformes	17	17.72	6	4.42
Family Microsyopidae	15	3.28	5	3.68
Microsyops latidens	15	3.28	5	3.68
Family Paromomyidae	2	.44	1	.74
Phenacolemur, sp. nov.	2	.44	1	.74
Order Primates	31	6.77	16	11.77
Infraorder Omomyiformes	2	.44	1	.74
Family Omomyidae	2	.44	1	.74
Absarokius metoecus	2	.44	1	.74
Infraorder Adapiformes	29	6.33	15	11.03
Family Notharctidae	29	6.33	15	11.03
Cantius abditus	29	6.33	15	11.03

Table 9. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1177 (includes localities D1315, D1316, Y253, UMRB1, and UMRB2), 481-m level of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Rodentia	9	1.97	6	4.41
Family Ischyromyidae	9	1.97	6	4.41
ischyromyid, large sp.	1	.22	1	.74
ischyromyid, medium sp.	2	.44	2	1.47
ischyromyid, small sp.	6	1.31	3	2.21
Order Tillodontia	9	1.97	4	2.94
Family Esthonychidae	9	1.97	4	2.94
Esthonyx sp.	9	1.97	4	2.94
Order Pantodonta	2	.44	2	1.47
Family Coryphodontidae	2	.44	2	1.47
Coryphodon sp.	2	.44	2	1.47
Order Condylarthra	121	26.42	41	30.15
Family Hyopsodontidae	95	20.74	35	25.73
Hyopsodus sp., cf. *H. miticulus*	85	18.56	31	22.79
Hyopsodus sp., cf. *H. minor*	10	2.18	4	2.94
Family Phenacodontidae	26	5.68	6	4.42
Phenacodus vortmani	24	5.24	5	3.68
Phenacodus brachypternus	2	.44	1	.74
Order Perissodactyla	200	43.67	32	23.53
Family Hyracotheriidae	199	43.45	31	22.80
Hyracotherium, large sp.	27	5.90	7	5.15
Hyracotherium, small sp.	161	35.15	20	14.71
Xenicohippus grangeri	11	2.40	4	2.94
Family Helaletidae	1	.22	1	.74
helaletid, gen. et sp. nov.	1	.22	1	.74
Order Artiodactyla	30	6.55	9	6.62
Family Dichobunidae	30	6.55	9	6.62
Diacodexis metsiacus	26	5.68	7	5.15
"*Bunophorus*", small sp.	4	.87	2	1.47

SAND CREEK-NO WATER CREEK (BOWN) SECTIONS (1974–75)

In 1973 the senior author, then with the University of Wyoming Geological Museum (UW), began collecting operations in the extensive Willwood badlands southeast of Worland, Wyo., largely from exposures along the drainages of Sand Creek, Slick Creek, and the East Fork of No Water Creek (pl. 2). That region had earlier been prospected by Yale Peabody Museum field parties in 1964 and 1972; however, no very productive sites had been found, except for Banjo quarry (Y370A, pl. 2) in 1972. The University of Wyoming expeditions established 76 fossil vertebrate localities. These incorporated the then richest known and best documented basal Willwood sites in the Bighorn Basin (including 35 sites below the stratigraphically lowest correlated YPM locality at the 50-m level). Stratigraphic sections relating 60 of the UW sites were published by Bown (1979), and the occurrence of most Willwood fossil vertebrates as lag accumulations in paleosols was first recognized (Bown, 1975, 1977, 1979).

The University of Wyoming expeditions also initiated new collecting operations between Gooseberry Creek and the Greybull River (pl. 1), beginning in 1973. UW sites W124–W127 at the 180-m level of the Willwood Formation west of the Bighorn River were related to the 60 correlated sites in the Sand Creek-No Water Creek area east of the Bighorn River by well logs (Wyoming Geological Association, 1968; Bown, 1979). This correlation of clusters of Willwood localities on either side of the Bighorn River valley provided an accurate datum for the base of the Fifteenmile Creek sections measured later and set the stage for the eventual integration of the Sand Creek-No Water Creek sections with the Schankler-Wing section, discussed below.

Table 10. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1198 (includes localities D1160, D1160N, D1244, D1314, Y45, and Y45S), 470-m level of the Willwood Formation, southern Bighorn basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1983]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	2,972	99.97	797	100.05
Magnorder Ernotheria	9	.30	4	.51
Grandorder Ictopsia	9	.30	4	4.51
Family Leptictidae	9	.30	4	.51
Palaeictops bicuspis	9	.30	4	.51
Magnorder Preptotheria	2,963	99.70	793	99.49
Order Cimolesta	18	.60	7	.89
Suborder Apatotheria	2	.06	2	.26
Family Apatemyidae	2	.06	2	.26
Apatemys bellulus	1	.03	1	.13
Apatemys rodens	1	.03	1	.13
Suborder Palaeoryctoidea	16	.54	5	.63
Family Didelphodontidae	16	.54	5	.63
Didelphodus sp.	16	.54	5	.63
Order Creodonta	37	1.24	17	2.13
Family Hyaenodontidae	23	.77	11	1.39
Tritemnodon sp., cf. *T. hians*	11	.37	7	.88
Prototomus vulpecula	6	.20	3	.38
Prototomus sp.	6	.20	1	.13
Family Limnocyonidae	5	.17	2	.25
Prolimnocyon sp.	5	.17	2	.25
Family Oxyaenidae	9	.30	4	.50
Oxyaena sp., cf. *O. forcipata*	9	.30	4	.50
Order Arctocyonia	3	.10	3	.38
Family Arctocyonidae	3	.10	3	.38
Thryptacodon sp., cf. *T. loisi*	1	.03	1	.13
Chriacus, sp. nov.	1	.03	1	.13
Anacodon ursidens	1	.03	1	.13
Order Carnivora	107	3.60	38	4.77
Family Miacidae	107	3.68	38	4.77
Didymictis sp.	42	1.41	10	1.25
Viverravus sp., cf. *V. acutus*	30	1.01	12	1.51
Viverravus lutosus	3	.10	2	.25
Vulpavus australis	15	.50	5	.63
Vulpavus canavus	3	.10	2	.25
Miacis exiguus	5	.17	2	.25
Vassacyon promicrodon	5	.17	2	.25
Uintacyon sp., cf. *U. asodes*	2	.07	1	.13
cf. *Oodectes* sp.	2	.07	2	.25
Order Erinaceomorpha	1	.03	1	.13
Family Dormaaliidae	1	.03	1	.13
Macrocranion nitens	1	.03	1	.13
Order Plesiadapiformes	86	2.90	28	3.52
Family Microsyopidae	73	2.46	25	3.14
Microsyops latidens	73	2.46	25	3.14
Family Paromomyidae	13	.44	3	.38
Phenacolemur, sp. nov.	13	.44	3	.38

Table 10. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1198 (includes localities D1160, D1160N, D1244, D1314, Y45, and Y45S), 470-m level of the Willwood Formation, southern Bighorn basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Primates	182	6.13	55	6.90
Infraorder Omomyiformes	12	.41	7	.88
Family Omomyidae	12	.41	7	.88
Anemorhysis pattersoni	2	.07	1	.13
Absarokius metoecus	10	.34	6	.75
Infraorder Adapiformes	170	5.72	48	6.02
Family Notharctidae	170	5.72	48	6.02
Cantius abditus	170	5.72	48	6.02
Order Palaeanodonta	2	.07	2	.25
Family Metacheiromyidae	2	.07	2	.25
Palaeanodon ignavus	2	.07	2	.25
Order Rodentia	65	2.19	24	3.01
Family Ischyromyidae	65	2.19	24	3.01
ischyromyid, large sp.	16	.54	4	.50
ischyromyid, medium sp.	43	1.45	17	2.13
ischyromyid, very small sp.	6	.20	3	.38
Order Tillodontia	36	1.21	6	.75
Family Esthonychidae	36	1.21	6	.75
Esthonyx sp.	36	1.21	6	.75
Order Taeniodonta	1	.03	1	.13
Family Stylinodontidae	1	.03	1	.13
Ectoganus sp., cf. *E. gliriformis*	1	.03	1	.13
Order Pantodonta	19	.64	5	.26
Family Coryphodontidae	19	.64	5	.26
Coryphodon, large sp.	16	.54	3	.38
Coryphodon, small sp.	3	.10	2	.25
Order Condylarthra	1,295	43.57	402	50.44
Family Hyopsodontidae	1,253	42.16	392	49.18
Hyopsodus sp., cf. *H. miticulus*	741	24.93	236	29.61
Hyopsodus sp., cf. *H. minor*	512	17.23	156	19.57
Family Phenacodontidae	42	1.41	10	1.25
Phenacodus vortmani	42	1.41	10	1.25
Order Perissodactyla	961	32.34	140	17.57
Family Hyracotheriidae	862	29.00	113	14.18
Hyracotherium, very large sp.	2	.07	1	.13
Hyracotherium, large sp.	200	6.73	26	3.26
Hyracotherium, small sp.	651	21.90	82	10.29
Xenicohippus grangeri	9	.30	4	.50
Family Isectolophidae	1	.30	1	.13
cf. *Homogalax* sp.	1	.30	1	.13
Family Helaletidae	38	1.28	8	1.00
Heptodon calciculus	38	1.28	8	1.00
Order Artiodactyla	153	.15	64	8.03
Family Dichobunidae	153	.15	64	8.03
Diacodexis metsiacus	124	4.17	55	6.90
Diacodexis robustus	4	.13	2	.25
"*Bunophorus*", large sp.	22	.74	7	.88

Table 11. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1204 (includes localities D1203, D1208, and Y338), 438–444-m levels of the Willwood Formation, southern Bighorn Basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1987]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	984	99.72	308	99.95
Magnorder Ernotheria	8	.81	5	1.62
Grandorder Ictopsia	7	.71	4	1.30
Family Leptictidae	7	.71	4	1.30
Prodiacodon tauricinerei	7	.71	4	1.30
Grandorder Anagalida	1	.71	1	.32
Order cf. Macroscelidea	1	.10	1	.32
Haplomylus sp.	1	.10	1	.32
Magnorder Preptotheria	976	99.19	303	98.38
Order Cimolesta	1	.10	1	.32
Suborder Apatotheria	1	.10	1	.32
Family Apatemyidae	1	.10	1	.32
Apatemys rodens	1	.10	1	.32
Order Creodonta	16	2.74	8	2.60
Family Hyaenodontidae	20	2.03	9	2.92
Tritemnodon sp.	4	.41	2	.65
Tritemnodon, sp. nov.	2	.20	2	.65
Prototomus sp.	14	1.42	5	1.62
Family Limnocyonidae	3	.30	2	.65
Prolimnocyon atavus	3	.30	2	.65
Family Oxyaenidae	4	.41	2	.65
Oxyaena sp.	4	.41	2	.65
Order Carnivora	53	5.39	20	6.49
Family Miacidae	53	5.39	20	6.49
Didymictis sp.	11	1.11	2	.65
Viverravus acutus	9	.91	6	1.95
Viverravus politus	1	.10	1	.32
Vulpavus australis	20	2.03	5	1.62
Vulpavus canavus	2	.20	1	.32
Miacis *exiguus*	8	.81	3	.97
cf. *Oodectes* sp.	1	.10	1	.32
cf. *Uintacyon* sp.	1	.10	1	.32
Order Erinaceomorpha	1	.10	1	.32
Family Geolabididae	1	.10	1	.32
Centetodon neashami	1	.10	1	.32
Order Plesiadapiformes	7	.71	4	1.30
Family Microsyopidae	3	.30	3	.97
Microsyops angustidens	3	.30	3	.97
Family Paromomyidae	4	.41	1	.32
Phenacolemur sp.	4	.41	1	.32

Table 11. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1204 (includes localities D1203, D1208, and Y338), 438–444-m levels of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Primates	108	10.98	38	12.34
Infraorder Omomyiformes	1	.10	1	.32
Family Omomyidae	1	.10	1	.32
Steinius vespertinus	1	.10	1	.32
Infraorder Adapiformes	107	10.87	37	12.01
Family Notharctidae	107	10.87	37	12.01
Cantius trigonodus	104	10.57	35	11.36
Cantius sp., cf. *C. abditus*	3	.30	2	.65
Order Palaeanodonta	3	.30	2	.65
Family Metacheiromyidae	3	.30	2	.65
Palaeanodon sp., cf. *P. ignavus*	3	.30	2	.65
Order Rodentia	5	.51	3	.97
Family Ischyromyidae	5	.51	3	.97
ischyromyid, large sp.	2	.20	1	.32
ischyromyid, medium sp.	3	.30	2	.65
Order Tillodontia	5	.51	2	.65
Family Esthonychidae	5	.51	2	.65
Esthonyx sp.	5	.51	2	.65
Order Taeniodonta	2	.20	2	.65
Family Stylinodontidae	2	.20	2	.65
stylinodontid sp.	2	.20	2	.65
Order Pantodonta	13	1.32	4	1.30
Family Coryphodontidae	13	1.32	4	1.30
Coryphodon sp.	13	1.32	4	1.30
Order Condylarthra	362	36.69	127	41.24
Family Hyopsodontidae	361	36.49	126	40.92
Hyopsodus sp., cf. *H. latidens*	361	36.49	126	40.92
Family Pentacodontidae	1	.10	1	.32
Apheliscus, sp. nov.	1	.10	1	.32
Order Perissodactyla	289	29.37	56	18.18
Family Hyracotheriidae	266	27.03	43	13.96
Hyracotherium, large sp.	50	5.08	7	2.27
Hyracotherium, small sp.	216	21.95	36	11.69
Family Helaletidae	23	2.34	13	4.22
helaletid, gen. et sp. nov.	23	2.34	13	4.22
Order Artiodactyla	97	9.86	29	9.42
Family Dichobunidae	97	9.86	29	9.42
Diacodexis metsiacus	73	7.42	22	7.14
Diacodexis robustus	24	2.44	7	2.27

Table 12. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1256 (includes localities D1463, D1583, Y192, Y193, and Y315), 546-m level of the Willwood Formation, southern Bighorn Basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1984]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	3,216	99.99	788	100.02
Magnorder Ernotheria	8	.25	4	.51
Grandorder Ictopsia	8	.25	4	.51
Family Leptictidae	8	.25	4	.51
Palaeictops multicuspis	8	.25	4	.51
Magnorder Preptotheria	3,208	99.75	784	99.49
Order Cimolesta	7	.22	4	.51
Suborder Apatotheria	2	.06	2	.25
Family Apatemyidae	2	.06	2	.25
Apatemys sp., cf. *A. bellulus*	2	.06	2	.25
Suborder Palaeoryctoidea	5	.16	2	.25
Family Didelphodontidae	5	.16	2	.25
Didelphodus sp.	5	.16	2	.25
Order Creodonta	30	.93	12	1.52
Family Hyaenodontidae	17	.53	8	1.01
cf. *Tritemnodon* sp.	11	.34	5	.63
Prototomus sp.	6	.19	3	.38
Family Limnocyonidae	2	.06	1	.13
Prolimnocyon sp.	2	.06	1	.13
Family Oxyaenidae	11	.34	3	.38
Oxyaena sp.	11	.34	3	.38
Order Mesonychia	3	.09	2	.25
Family Mesonychidae	3	.09	2	.25
cf. *Dissacus* sp.	1	.03	1	.13
Hapalodectes leptognathus	2	.06	1	.13
Order Arctocyonia	1	.03	1	.13
Family Arctocyonidae	1	.03	1	.13
Chriacus sp.	1	.03	1	.13
Order Carnivora	83	2.58	26	3.30
Family Miacidae	83	2.58	26	3.30
Didymictis lysitensis	50	1.55	10	1.27
Viverravus acutus	6	.19	6	.76
Vulpavus australis	3	.09	1	.13
Vulpavus canavus	18	.56	6	.76
Miacis sp.	2	.06	1	.13
Uintacyon sp., cf. *U. asodes*	4	.12	2	.25
miacine, gen. et sp. nov.	1	.03	1	.13
Order Plesiadapiformes	100	3.11	36	4.56
Family Microsyopidae	91	2.83	34	4.31
Microsyops latidens	91	2.83	34	4.31
Family Paromomyidae	9	.28	2	.25
Phenacolemur, sp. nov.	9	.28	2	.25

Table 12. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1256 (includes localities D1463, D1583, Y192, Y193, and Y315), 546-m level of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Primates	205	6.38	63	1.54
Infraorder Omomyiformes	16	.50	8	1.02
Family Omomyidae	16	.50	8	1.02
Anemorhysis wortmani	1	.03	1	.13
Absarokius abbotti	15	.47	7	.89
Infraorder Adapiformes	189	5.88	55	6.98
Family Notharctidae	189	5.88	55	6.98
Order Palaeanodonta	1	.03	1	.13
Family Metacheiromyidae	1	.03	1	.13
Palaeanodon sp.	1	.03	1	.13
Order Rodentia	7	2.21	20	2.54
Family Ischyromyidae	71	2.21	20	2.54
ischyromyid, large sp.	7	.22	2	.25
ischyromyid, medium sp.	41	1.27	8	1.02
ischyromyid, small sp.	18	.56	8	1.02
ischyromyid, very small sp.	4	.12	1	.13
ischyromyid, minute sp.	1	.03	1	.13
Order Tillodontia	41	1.27	7	.89
Family Esthonychidae	41	1.27	7	.89
Esthonyx sp.	41	1.27	7	.89
Order Pantodonta	13	.40	3	.38
Family Coryphodontidae	13	.48	3	.38
Coryphodon, large sp.	12	.37	2	.25
Coryphodon, very small sp.	1	.03	1	.13
Order Condylarthra	1,147	35.67	350	44.42
Family Hyopsodontidae	1,132	35.20	342	43.40
"*Hyopsodus*" powellianus	495	15.39	134	17.01
Hyopsodus sp., cf. *H. lysitensis*	630	19.59	202	25.63
Hyopsodus, sp. nov.	7	.22	6	.76
Family Phenacodontidae	15	.46	8	1.02
Phenacodus sp., cf. *P. vortmani*	12	.37	6	.76
Phenacodus sp., cf. *P. primaevus*	1	.03	1	.13
Phenacodus brachypternus	2	.06	1	.13
Order Perissodactyla	1,302	40.49	192	24.37
Family Hyracotheriidae	1,143	35.54	146	18.53
Hyracotherium, large sp.	177	5.50	30	3.81
Hyracotherium, small sp.	966	30.04	116	14.72
Family Helaletidae	159	4.94	46	5.84
Heptodon sp.	59	1.83	17	2.16
helaletid, gen. et sp. nov.	100	3.11	29	3.68
Order Artiodactyla	203	6.31	66	8.38
Family Dichobunidae	203	6.31	66	8.38
Diacodexis sp., cf. *D. metsiacus*	173	5.38	57	7.23
"*Bunophorus*" sp.	27	.84	8	1.02
Wasatchia sp.	3	.09	1	.13

Table 13. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1326, 425-m level of the Willwood Formation, southern Bighorn Basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1989]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	662	100.02	194	99.99
Magnorder Preptotheria	662	100.02	194	99.99
Order Cimolesta	3	.45	3	1.55
Suborder Pantolesta	2	.30	2	1.03
Family Pantolestidae	2	.30	2	1.03
Palaeosinopa veterrima	2	.30	2	1.03
Suborder Palaeoryctoidea	1	.15	1	.52
Family Didelphodontidae	1	.15	1	.52
Didelphodus absarokae	1	.15	1	.52
Order Creodonta	6	.91	2	1.03
Family Hyaenodontidae	6	.91	2	1.03
Tritemnodon sp.	4	.60	1	.52
Prototomus mordax	2	.30	1	.52
Order Arctocyonia	2	.30	2	1.03
Family Arctocyonidae	2	.30	2	1.03
Chriacus, sp. nov.	1	.15	1	.52
Anacodon ursidens	1	.15	1	.52
Order Carnivora	18	2.72	10	5.15
Family Miacidae	18	2.72	10	5.15
Didymictis sp., cf. *D. protenus*	3	.45	1	.52
Viverravus sp.	7	1.06	3	1.55
Vulpavus sp.	5	.76	3	1.55
Miacis sp., cf. *M. exiguus*	2	.30	2	1.03
cf. *Uintacyon* sp.	1	.15	1	.52
Order Plesiadapiformes	32	4.83	10	5.15
Family Microsyopidae	32	4.83	10	5.15
Microsyops latidens	32	4.83	10	5.15
Order Primates	54	8.15	23	11.85
Infraorder Omomyiformes	3	.45	2	1.03
Family Omomyidae	3	.45	2	1.03
Absarokius metoecus	3	.45	2	1.03
Infraorder Adapiformes	51	7.70	21	10.82
Family Notharctidae	51	7.70	21	10.82
Order Rodentia	15	2.27	7	3.61
Family Ischyromyidae	15	2.27	7	3.61
ischyromyid, large sp.	4	.60	2	1.03
ischyromyid, medium sp.	10	1.51	4	2.06
ischyromyid, small sp.	1	.15	1	.52
Order Tillodontia	24	3.63	9	4.64
Family Esthonychidae	24	3.63	9	4.64
Esthonyx sp., cf. *E. bisulcatus*	24	3.63	9	4.64
Order Pantodonta	7	1.06	2	1.03
Family Coryphodontidae	7	1.06	2	1.03
Coryphodon sp.	7	1.06	2	1.03

Table 13. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1326, 425-m level of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Condylarthra	206	31.12	3	32.47
Family Hyopsodontidae	185	27.95	56	28.87
Hyopsodus sp., cf. *H. miticulus*	111	16.77	29	14.95
Hyopsodus sp., cf. *H. minor*	74	11.18	22	13.92
Family Phenacodontidae	21	3.17	7	3.61
Phenacodus vortmani	21	3.17	7	3.61
Order Perissodactyla	252	38.07	5	25.77
Family Hyracotheriidae	241	36.41	47	24.23
Hyracotherium, large sp.	1	.15	1	.52
Hyracotherium, small sp.	232	35.05	41	21.13
Xenicohippus grangeri	8	1.21	5	2.58
Family Helaletidae	11	1.66	3	1.55
helaletid, gen. et sp. nov.	11	1.66	3	1.55
Order Artiodactyla	43	6.50	13	6.70
Family Dichobunidae	43	6.50	13	6.70
Diacodexis metsiacus	37	5.59	11	5.67
Diacodexis robustus	1	.15	1	.52
"*Bunophorus*", large sp.	5	.76	1	.52

SCHANKLER-WING SECTION (1976–78)

For his dissertation work at Yale University, David Schankler investigated the mammalian biostratigraphy of the central Bighorn Basin Willwood Formation, using the then largest fossil samples from the formation (at the Yale Peabody Museum) and the best controlled locality data then available (the 477 YPM localities). Schankler recognized early in his studies that measuring a new Willwood section was necessary, both to resolve conflicts between the Meyer-Radinsky and Neasham-Vondra sections and to correlate substantially more of the YPM sites to obtain denser biostratigraphic control. Assisted by S.L. Wing, Schankler began in 1976 and completed his new section of the Willwood Formation in 1978, having related 243 YPM sites to a 773-m Willwood section. Schankler's (1980) section and locality correlations permitted him to produce the first section-controlled vertebrate biostratigraphy of the Willwood Formation and perhaps the most detailed stratigraphic documentation of the ranges of fossil vertebrate taxa ever published.

By virtue of both the number of localities correlated and the admirable constraint of the author, Schankler's Willwood biostratigraphy remains quite useful despite knowledge that most groups of Willwood mammals still require considerable systematic revision. Schankler adeptly sidestepped the archaic, largely unsubstantiated, and putatively biostratigraphic terminology that had been retained for Willwood rocks and faunas by Wood and others (1941) by refusing to endorse Granger's (1914) traditional Willwood Formation subdivisions (Sand Coulee and Gray Bull beds), or the borrowed Wind River Formation rock and faunal subdivisions (Lysite and Lost Cabin Members or Lysitean and Lostcabinian age). Using approved biostratigraphic procedure and nomenclature, Schankler (1980) instead applied new names to three biostratigraphic zones: The *Haplomylus-Ectocion* Range Zone (lower and upper); the *Bunophorus* Interval Zone; and the *Heptodon* Range Zone (lower, middle, and upper). These zones were properly based on the stratigraphic occurrences of taxa characterizing them and were separated by Schankler by three so-called horizons apparently recording marked faunal change: Biohorizon A, Biohorizon B, and Biohorizon C. As shown by Bown and others (1991) and Bown and Kraus (1993), Biohorizons B and C as viewed by Schankler almost certainly document the same episode of faunal turnover.

The Schankler-Wing section was a marked improvement over earlier sections in terms of detail and density of fossil localities and contributed a novel and still useful biostratigraphic zonation as well as preliminary faunal analysis based on this new biostratigraphy. Nonetheless, this section is not without problems, some of which will affect its future utility. Paramount among these is that a map recording the lines of his sections has not been published. Moreover, "***The localities were grouped into ten-meter intervals, the maximum resolution thought possible" (Schankler, 1980, p. 102). The latter (10-m-interval) manipulation is both good and bad; by honest implication

Table 14. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1454 (includes locality D1460 but not D1460Q), 409-m level of the Willwood Formation, southern Bighorn Basin, Wyoming.

[MNI, minimum number of individuals. Includes data through 1983]

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Class Mammalia	831	100.01	251	100.02
Magnorder Ernotheria	2	.24	2	.80
Grandorder Ictopsia	2	.24	2	.80
Family Leptictidae	2	.24	2	.80
Prodiacodon tauricinerei	2	.24	2	.80
Magnorder Preptotheria	829	99.76	249	99.20
Order Cimolesta	8	.96	6	2.39
Suborder Apatotheria	6	.72	4	1.59
Family Apatemyidae	6	.72	4	1.59
Apatemys sp.	6	.72	4	1.59
Suborder Palaeoryctoidea	2	.24	2	.80
Family Didelphodontidae	2	.24	2	.80
Didelphodus absarokae	2	.24	2	.80
Order Creodonta	15	1.81	9	3.59
Family Hyaenodontidae	3	.36	3	1.20
Tritemnodon sp.	1	.12	1	.40
Prototomus sp.	2	.24	2	.80
Family Limnocyonidae	7	.84	4	1.59
Prolimnocyon sp.	7	.84	4	1.59
Family Oxyaenidae	5	.60	2	.80
Oxyaena sp.	5	.60	2	.80
Order Arctocyonia	2	.24	2	.80
Family Arctocyonidae	2	.24	2	.80
Thryptacodon sp., cf. *T. antiquus*	1	.12	1	1.40
Chriacus sp.	1	.12	1	.40
Order Carnivora	47	5.66	21	8.37
Family Miacidae	47	5.66	21	8.37
Didymictis protenus	19	2.29	6	2.39
Viverravus acutus	6	.72	3	1.20
Vulpavus australis	15	1.81	8	3.19
Vulpavus canavus	1	.12	1	.40
Miacis exiguus	3	.36	1	.40
Vassacyon promicrodon	1	.12	1	.40
Uintacyon rudis	2	.24	1	.40
Order Plesiadapiformes	25	3.01	10	3.99
Family Microsyopidae	21	2.53	8	3.19
Microsyops sp. cf. *M. angustidens*	20	2.41	7	2.80
Microsyops minuta	1	.12	1	.40
Family Paromomyidae	4	.48	2	.80
Phenacolemur, sp. nov.	4	.48	2	.80
Order Primates	84	10.11	32	12.75
Infraorder Adapiformes	84	10.11	32	12.75
Family Notharctidae	84	10.11	32	12.75
Cantius abditus	82	9.87	31	12.35
cf. *Copelemur* sp.	2	.24	1	.40

Table 14. Provisional faunal list and fossil mammal composition, U.S. Geological Survey locality D1454 (includes locality D1460 but not D1460Q), 409-m level of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

Fauna	Identified elements	Percent of total elements	MNI	MNI as percent of fauna
Order Palaeanodonta	3	.36	2	.80
Family Metacheiromyidae	3	.36	2	.80
Palaeanodon ignavus	3	.36	2	.80
Order Rodentia	32	3.85	7	2.79
Family Ischyromyidae	32	3.85	7	2.79
ischyromyid, large sp.	10	1.20	1	.40
ischyromyid, medium sp.	16	1.93	3	1.20
ischyromyid, small sp.	3	.36	1	.40
ischyromyid, minute sp.	3	.36	2	.80
Order Tillodontia	33	3.97	9	3.59
Family Esthonychidae	33	3.97	9	3.59
Esthonyx sp., cf. *E. bisulcatus*	33	3.97	9	3.59
Order Pantodonta	4	.48	1	.40
Family Coryphodontidae	4	.48	1	.40
Coryphodon sp.	4	.48	1	.40
Order Condylarthra	224	26.96	71	28.29
Family Hyopsodontidae	214	25.75	67	26.69
Hyopsodus sp., cf. *H. latidens*	214	25.75	67	26.69
Family Phenacodontidae	10	1.20	4	1.59
Phenacodus primaevus	10	1.20	4	1.59
Order Perissodactyla	218	26.23	38	15.14
Family Hyracotheriidae	212	25.51	36	14.35
Hyracotherium, large sp.	39	4.69	8	3.19
Hyracotherium, small sp.	173	20.82	28	11.16
Family Isectolophidae	6	.72	2	.80
Homogalax sp., cf. *H. protapirinus*	6	.72	2	.80
Order Artiodactyla	134	16.13	42	16.73
Family Dichobunidae	134	16.13	42	16.73
Diacodexis sp., cf. *D. metsiacus*	130	15.64	40	15.94
Diacodexis robustus	2	.24	1	.40
"*Bunophorus*", large sp.	2	.24	1	.40

that more precise resolution may not be possible (all of the YPM localities are geographic localities, as defined above), the actual measured record was sacrificed. That record was positively a more accurate empirical stratigraphic documentation of localities, whether the precision was on the order of 1 m or 10 m. Lacking publication of the original section, the lines of section, and the record of bed correlations, the Schankler-Wing section offers nothing to assist future biostratigraphic correlations of the Willwood Formation other than by use of what exists in Schankler (1980). Inability to cross reference exact beds in the Schankler-Wing section has led to some difficulty in correlating that section with the Fifteenmile Creek section, especially in the region of the Elk Creek Rim, as discussed below.

FIFTEENMILE CREEK (BOWN) SECTIONS (1980–92)

GENERAL CONSIDERATIONS

FORT UNION-WILLWOOD CONTACT

Pedofacies relations (Bown and Kraus, 1987) and a variety of paleogeomorphological attributes of Willwood sediment accumulation present a suite of problems for correlation of Willwood vertebrate fossil localities that have rarely or never received attention. Some problems that were encountered almost daily in the field were treated in the course of section studies (see below), but others of broader

Table 15. Diversity indices for mammalian faunal assemblages listed in tables 8–14, southern Bighorn Basin, Wyoming.

[Rankings of relative diversity are shown in parentheses. Numbers in parentheses are MNI, minimum number of individuals]

Assemblage (meter level)	Number of specimens	MNI	Number of species	Whittaker index	Shannon-Wiener index
D1162 (481 m)	858	241	39	22.56 (2)	2.87 (1)
D1177 (481 m)	459	157	34	22.85 (1)	2.87 (1)
D1198 (470 m)	2,972	797	47	19.95 (3)	2.44 (6)
D1204 (438-444 m)	984	308	35	16.67 (7)	2.30 (7)
D1256 (546 m)	3,216	788	45	19.60 (5)	2.57 (5)
D1326 (425 m)	662	194	29	18.13 (6)	2.61 (3)
D1454 (409 m)	831	251	36	19.67 (4)	2.60 (4)

import cannot yet be resolved. For example, little is known about the nature of the pre-Willwood paleotopography and relative rates of sediment accumulation, and their relationship to each other, between the base of the Willwood section in the Antelope Creek drainage (the area of the base of the Meyer-Radinsky, Neasham-Vondra, and Schankler-Wing sections) and the base of the Willwood section in the Sand Creek-No Water Creek area. Differences in either of these parameters would affect relative thicknesses of Willwood sections begun in different places. Development of a time-stratigraphic section of the Willwood Formation for the southern Bighorn Basin (Bown and Kraus, 1993; Kraus and Bown, in press) has partly resolved these problems.

Although it has long been known that the Fort Union Formation-Willwood Formation contact is time transgressive, correlation of the contact from one area to another is not a simple matter of correlating time-transgressive strata in one direction or another. For example, the stratigraphic contact lies well beneath the Clarkforkian-Wasatchian faunal boundary in the Clarks Fork area (in the north; Rose, 1981a), and well above it in the Gould Butte area (in the middle; Wing and Bown, 1985), whereas the formation contact and the faunal boundary appear to be essentially coincident in the Sand Creek-No Water Creek area (in the south; Bown, 1979). The reasons for these complex and varying boundaries might become known with more knowledge of the causes of the geographically disparate distributions and temporally diachronous onsets of Willwood-type soil (paleosol) formation. A particular kind of paleosol development produced varicolored beds, which are, by definition (Van Houten, 1944, 1948; Bown, 1979), typical of the Willwood Formation in contrast to Fort Union rocks. At present (1992), the causes of onset of soil formation producing paleosols typical of the Willwood Formation are simply unknown but are probably indicative of both climatic change and decreased sediment-accumulation rates (Bown and Kraus, 1993; Kraus and Bown, in press). They may also have been related to relative original (early Eocene) paleotopography and drainage or to geographic position with respect to the evolving early Eocene Bighorn Basin axis (hence, resulting in different sediment-accumulation rates in different areas). There is currently no way to determine or judge the relative effects of either factor.

Kraus (in press) documented basement lineament control on sedimentation and sedimentary facies development in Willwood rocks in the central and southeast Bighorn Basin in which adjacent lineament-bounded regions contain different Willwood facies and different suites of paleosols. Because some of the facies differences are differences in paleosol development, movement along basin lineaments and resulting different sediment-accumulation rates might well have been responsible for the geographically and temporally disjunct onsets of characteristic Willwood paleosol development around the Bighorn Basin.

CUT-AND-FILL SEQUENCES

To the extent now possible, principles of time and rock stratigraphy must also be applied to the correlation of the fossil-mammal localities of the Willwood Formation. Where they are directly and most commonly applicable to Willwood sections is in the stratigraphic resolution of cut-and-fill sequences, hereafter termed "cuts" (Bown and others, 1983; Kraus and Middleton, 1987).

Willwood cuts are of two kinds. Sandstone-floored cuts (fig. 10*A*) formed by excavation and subsequent channel filling during stream relocation (probably avulsion) and by crevasse channeling. Mudstone-floored cuts (fig. 10*B*) formed by excavation of generally distal flood-plain areas by erosive streams, followed by rapid fill of the cuts with fine-grained sediment. Some preliminary evidence suggests that whereas the excavation of cuts with sandstone floors is obviously a normal part of the depositional alluvial regime, the excavation of cuts with mudstone floors (or at least many of them) was associated with temporary intervals of lowered base levels and degradational regimes. Both types of cuts vary in breadth and profundity. Sandstone-floored cuts in the Willwood Formation range from a few meters wide and 1 m deep to more than 1 km wide and 30 m deep. Mudstone cuts have a similar lower limit in size; however, although they rarely attain more than 10 m in depth, some of them (or zones of

Figure 10. Depositional and erosional cuts in the Willwood Formation, southern Bighorn Basin, Wyoming. *A*, Depositional (sandstone-floored) cut; SW ¼ sec. 15, T. 49 N., R. 95 W. (pl. 1). *B*, Erosional (mudstone-floored) cut; SE ¼ sec. 16, T. 48 N., R. 94 W. (pl. 1). Bases of scours emphasized in places with arrows.

such cuts) reach a width of several kilometers (Kraus and Bown, in press).

Both sandstone- and mudstone-floored cuts are common in the Willwood Formation, even though they have received little attention in the literature (for example, Bown, 1984). Their occurrence in nearly every measured section directs that their stratigraphic and temporal effects must be resolved to correctly and completely situate fossil vertebrate localities with respect to one another, both in terms of simple meter-level determinations and geologic time. Given current levels of resolution, meter levels are an adequate base from which to construct section-controlled biostratigraphies (for example, Bown, 1979; Schankler, 1980; Rose, 1981a). However, meter levels alone are not sufficient for estimating evolutionary rates, because rates are dependent on sediment-accumulation rates and relative time, and relative time requires some control on temporal resolution. Adequate temporal resolution is not available from simple meter-level biostratigraphies because there are no controls on varying sediment-accumulation rates in different geographic areas and in different parts of the rock column. A preliminary time-stratigraphic reconstruction of Willwood deposition was presented by Bown and Kraus (1993).

All units in alluvial sequences might be considered to have unconformable or, at the very least, paraconformable contacts because alluvial sediment accumulation is sporadic (see discussion in Kraus and Bown (1986) and references therein). Of interest to biostratigraphers concerned with precise correlations is the magnitude of time represented by deposition of the sediments making up the rocks and the time represented by hiatuses and lacunae separating rock bodies (for example, Wheeler, 1958). Bown (1985), Kraus and Bown (1986), and Bown and Kraus (1987) suggested that most geologic time bound up in the development of alluvial rock sequences was occupied by soil formation and that relatively little of the geologic time required to form alluvial sequences was expended during active sedimentation. That is, the prior and traditional view that soils (paleosols in the rock record) are rare and record pauses in a more-or-less continuous process of sediment accumulation is incorrect. Rather, alluvial sediment accumulation is rare, of short duration, and punctuates lengthy intervals of soil development. Kraus and Bown (1986) and Bown and Larriestra (1990) indicated that stages of maturity of paleosols offer means of establishing relative temporal correlations in alluvial rocks. These means also apply to the reconstruction of hiatal and lacunal time (Bown and Larriestra, 1990; Bown and Kraus, 1993; Kraus and Bown, in press).

To return to the problem of cuts in the Willwood Formation, it is clear from figure 10 that simple meter-level relations of sites lying in and adjacent to cuts produce erroneous stratigraphic correlations and potentially even more serious relative temporal correlations. The relative temporal picture of cuts is complicated even further by the fact that paleosols developed on the fill in most (but not all) of them are dominated by immature forms. The relative temporal resolution of the Willwood fossil vertebrate localities by holostrome reconstruction using paleosols (see Bown and Larriestra, 1990, for method) is well beyond the scope of this report and was published by Bown and Kraus (1993). However, for the Willwood sections discussed here, localities affected by cuts are completely resolved stratigraphically (fig. 11) but incompletely restored temporally (see temporal restoration of Willwood meter-level stratigraphy in Bown and Kraus, 1993).

PEDOFACIES SECTION MEASUREMENT

The identification of sedimentologic localities in the field based on pedofacies relationships has necessitated development of a consistent procedure for identifying stratigraphic positions of fossil vertebrate localities in paleosols occurring in different parts of local pedofacies. Pedofacies are prismatic rock bodies containing paleosols (fig. 12). The thickest part of the pedofacies rock prism is on the alluvial ridge, which contains numerous superposed immature paleosols. The thinnest part of the pedofacies prism is on the distal flood plain, which generally contains one or two very mature paleosols. Therefore, although there is temporal equivalence between proximal and distal parts of the pedofacies prism (the few mature distal paleosols being the time equivalent of the many immature proximal ones), there is no stratigraphic equivalence (in terms of meter levels) across the pedofacies because the alluvial ridge sediments are thicker than those of the distal flood plain.

Alluvial ridge sediments are dominated by channel-belt, levee, crevasse-channel, and crevasse-splay deposits. Pedologically, Willwood channel-belt and levee deposits are generally characterized by stage 0–2 paleosols and are dominated by stage 1 paleosols (fig. 12). Other alluvial-ridge deposits are overwhelmingly dominated by stage 0 paleosols. Though they are cut by crevasse channels and intertongue with crevasse-splay deposits, fining-upwards sequences of sand and mud are the volumetrically predominant component of Willwood channel-belt and levee deposits. Because of the sporadic nature of alluvial overbank deposition, each major fining upwards sequence in most Willwood channel-belt and levee deposits has an immature paleosol (generally stage 1) developed on it, and the sandy base of the succeeding fining-upwards sequence marks the base of the parent sediment for the succeeding, younger paleosol.

Levee and channel-belt deposits, consisting of several fining-upwards sequences and their paleosols, typically weather into steep ridges. Therefore, it is very difficult to find areas in which faunas can be reliably attributed to specifically one or another of the levee and channel-belt paleosols. In areas in which the specific paleosol from which a fossil vertebrate sample came cannot be determined, the meter level of the middle of the sequence is used for

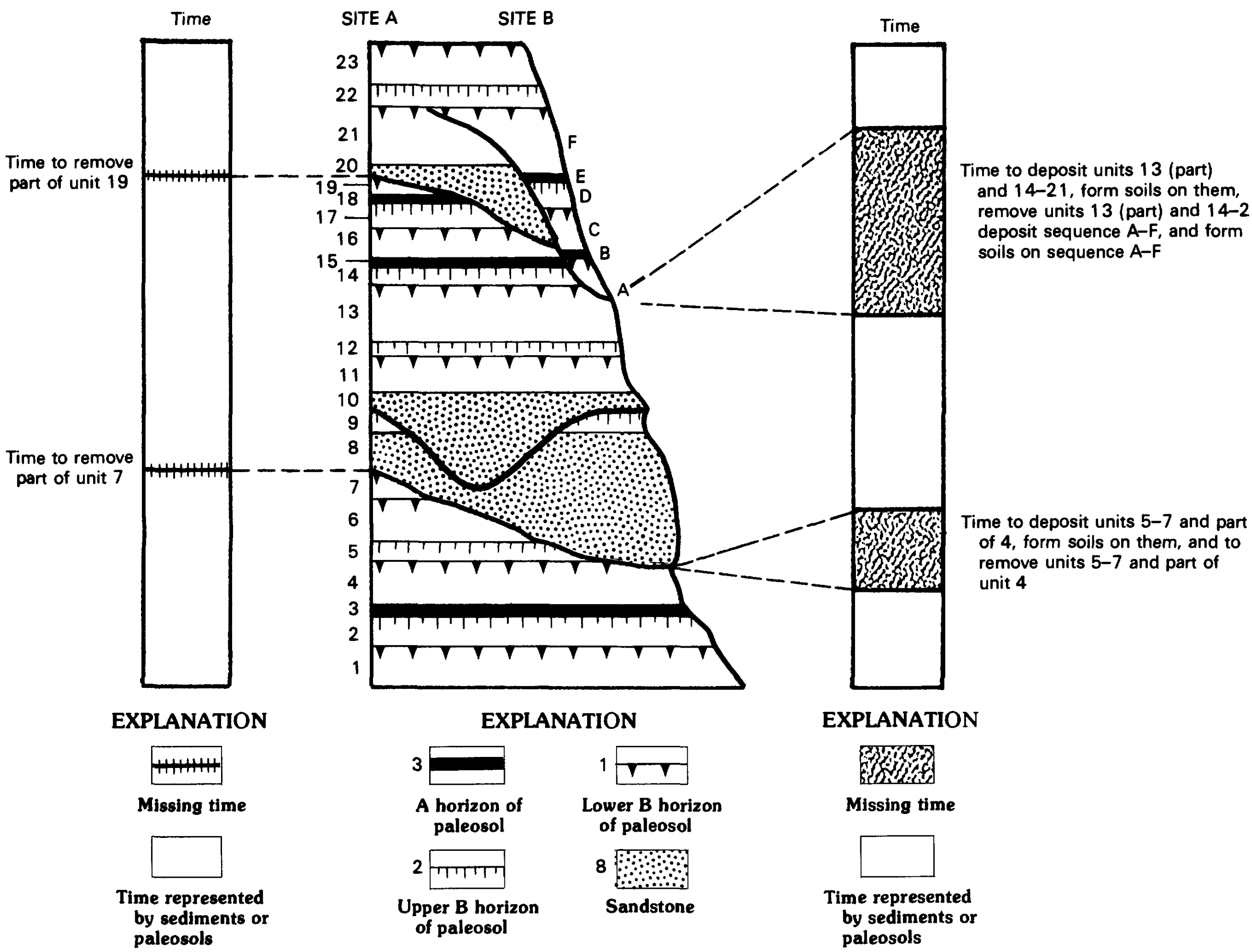


Figure 11. Effects of paleosols and cuts on Willwood biostratigraphy in two different exposures of Willwood Formation sandstone and mudrock in the same stratigraphic interval. Note that in such areas, simple meter levels record very different temporal stratigraphy at sites A and B. Numbers are bed numbers.

stratigraphic correlation (fig. 9*A*). Weathering poses little problem for identifying stratigraphic positions of fossils from very mature paleosols (stages 4 and 5), because these soils are generally confined, both above and below, by boundaries of the preceding and succeeding pedofacies. Temporal resolution, however, is affected; faunas from channel-belt and levee deposits generally cannot be resolved temporally at levels finer than that of the whole sequence containing them. Using the pedofacies model, whole channel-belt sequences represent the same amount of time as the most mature paleosols of the distal floodbasin, or, for the Willwood paleosols, about 25,000–100,000 years (stages 4–6). Therefore, except in extraordinary localities (where individual paleosols might be resolved at an order of magnitude of about 1,000 years), fossil mammals from channel-belt and levee deposits with very immature paleosols are resolvable only at levels comparable to those of the most mature paleosols. The most precise temporal resolution is possible in paleosols of intermediate maturities (stages 2–3+), at intermediate lateral positions (distal alluvial ridge and proximal flood plain, Bown and Kraus, 1987) in the pedofacies sequence.

UNRESOLVED AGGRADATIONAL BIOSTRATIGRAPHY

In examining the mechanisms by which sediment accumulated during Willwood time, it is clear that the mechanisms have introduced an inherent element that precludes determinations of precise relative temporal positions of localities based on relative meter-level correlations. In aggrading meandering stream systems, continued overbank deposition during flooding builds up raised prisms of sediment flanking channels—the natural levees. During extreme flooding, the levees may be breached by the flooded channel, so that (1) the active channel is relocated to a lower, more distal position on the flood plain, and (2) that part of the hitherto active channel downstream from the breach in the levee is stranded above the flood plain and only rarely (or much

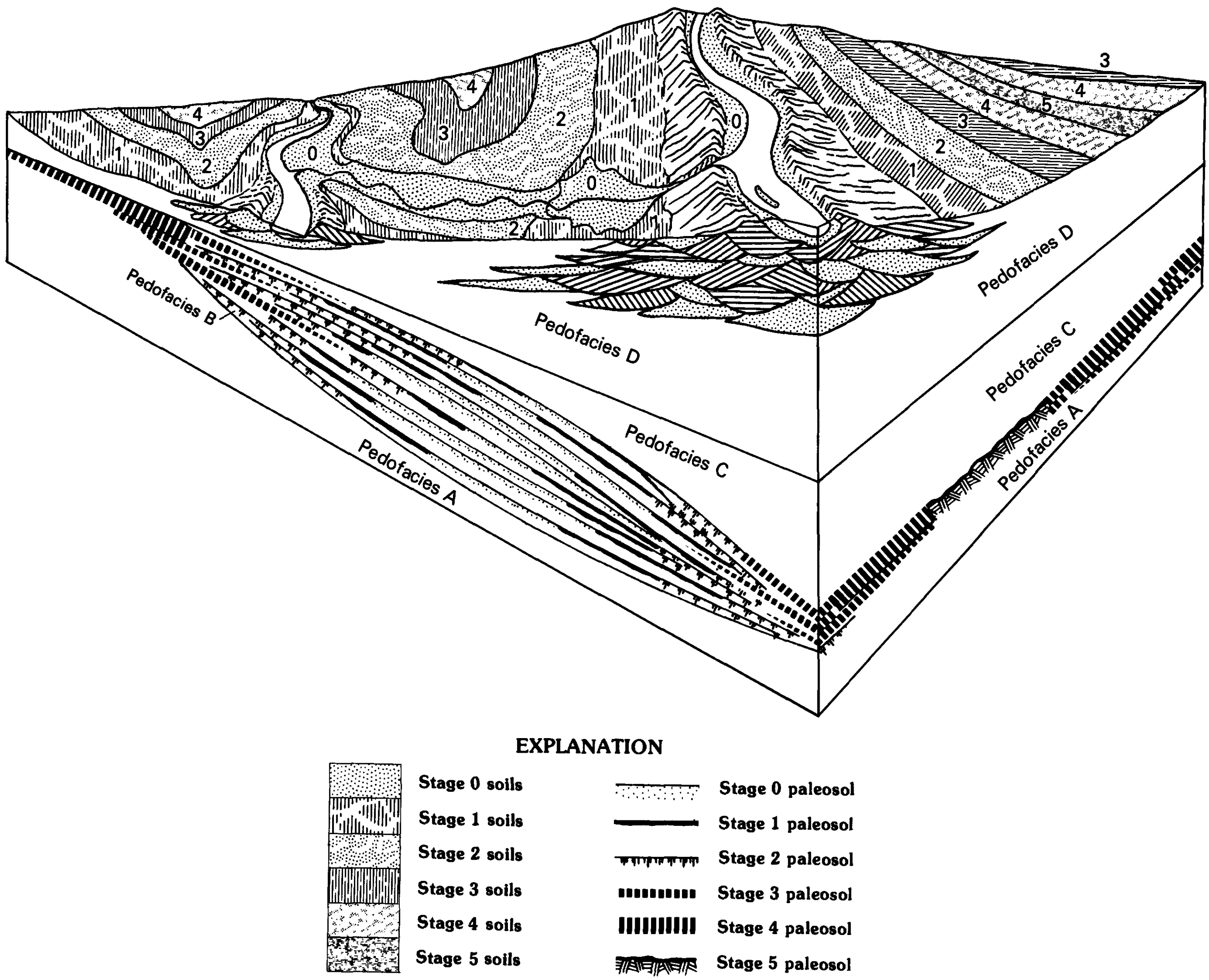


Figure 12. Relationships of five hypothetical Willwood Formation pedofacies (pedofacies A through D; pedofacies B is detailed in cross section). The fifth pedofacies is being developed at the surface. The block diagram is schematic and highly idealized. The width of the left face of the diagram is about 20 km; height of the diagram axis is about 70 m; the vertical exaggeration is about X150.

later) receives additional sediment. The new and topographically lower part of the active channel begins to form channel-belt deposits and levees of its own, so that the channel-belt, levee, and flood-plain deposits associated with the new channel position lie topographically lower than the old. Initially, this meter-level disparity might be as much as 20 m (fig. 13). With continued sediment accumulation, the original channel deposits become engulfed by those of the new channel and are juxtaposed against them laterally.

In such a rock sequence, it is clear that measured sections will include some deposits of both the older and younger channels in the same meter interval. Thus, on a small scale, the faunas of the Willwood Formation and like alluvial systems are partly superposed and partly juxtaposed. This phenomenon may have played a role in causing the oscillation of the mean of tooth area plots of Willwood mammals that are plotted against a stratigraphic (and putatively temporal) axis (for example, Bookstein and others, 1978, figs. 4 and 7). Detailed pedofacies analysis likely can resolve such inherent small-scale temporal biostratigraphic problems; however, the field work involved would be formidable.

SECTION CORRELATIONS

The Fifteenmile Creek master section was begun in 1980 at locality W125 (equal to D1224) and was carried to the spud of the Gulf-Teeters well, in sec. 28, T. 47 N., R. 93 W., in which was recorded a thickness of 790 feet (240 m) of Willwood rocks. This initial section (*C–C′*, pl. 1) established W125 at the base of the Fifteenmile Creek section at the

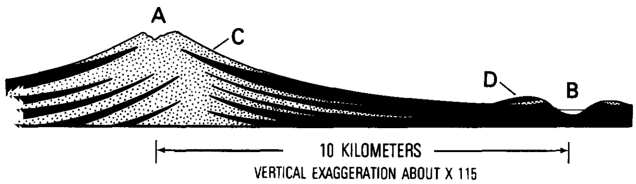


Figure 13. Diagram showing how sediment accumulation in an aggrading regime accommodating avulsion from an alluvial ridge constrains meter-level alluvial stratigraphy. Relocation of drainage A to a lower position (B) on the distal floodbasin results in older alluvial-ridge sediments (C) at higher meter-level positions than alluvial deposits (D) being formed by the younger channel. By the Willwood Formation pedofacies model, the inherent stratigraphic error would not exceed the height of the alluvial ridge, or about 20 m. Patterns show highly schematic bed geometries.

180-m level, approximately 50 m higher than any Willwood localities in the Sand Creek-No Water Creek area studied by Bown (1975, 1979). The U.S. Geological Survey Willwood expeditions (1977–79) and the joint U.S. Geological Survey-Johns Hopkins University School of Medicine expeditions (1980–1992) continued the intensive collecting operations in the lowest part of the Willwood section exposed along Fifteenmile Creek (pl. 1), near the confluence of Fifteenmile Creek with the Bighorn River, begun in 1973. In general, collecting emphasis from 1980–84 was directed farther westward each succeeding field season to allow fossil prospecting and the establishment of new localities to be in advance of the measured section.

Sections were measured using a Jacob's staff in areas characterized by high or variable dips, and(or) in regions with a great density of localities. Localities correlated by this procedure include about 96 percent of all sites correlated. A few extraneous localities were correlated in areas with a low density of localities or with little variability of low dips, and across poorly exposed areas, where dips could be estimated from peripheral exposures and section position calculated by solving three-point problems (for example, Billings, 1965). Locality position was determined to the nearest meter for stratigraphic and sedimentologic localities. For geographic localities at which fossil provenance could not be established with confidence, the locality meter level was determined by averaging the lowest and highest meter levels occurring within the circumscribed geographic areas. All sites that were correlated without use of estimated meter levels (tables 2–5) were related to one another by walking out the beds, and beds were also walked out to relate the 44 Fifteenmile Creek spur sections (table 16) to one another.

U.S. Geological Survey localities established in 1977–79 are, like all the YPM localities, strictly geographic localities. They were established by circumscribing areas on maps without recording data necessary to later place them precisely in measured sections. These are sites D1128 through D1252. Several of those sites were exceptionally rich and were revisited frequently enough that sufficient stratigraphic and sedimentologic information was gathered some years after the sites were discovered. The most important of such localities are D1162, D1177, D1198, D1204, and D1230. At localities established between 1980 and 1984 (D1253–D1584), records were kept regarding which beds at the sites actually produced the fossils, and most 1985–92 localities (D1585–D1986) have documentation of both paleosol stage and pedofacies position.

As of this writing (1992), 1,474 fossil vertebrate localities have been established by the five major institutions working in the Willwood Formation in the central and southern Bighorn Basin since 1961. Most of those in the area south of the Greybull River are depicted on plates 1 and 2, and all of the localities known to us are listed in tables 2–6 at the end of this report. Nine hundred and twenty-eight localities are tied to the composite measured sections of the Willwood Formation in the central and southern Bighorn Basin. Of these, 678 localities have been related directly to the section, whereas the positions of 250 additional sites have been estimated using incomplete section data or using broader paleosol (that is, pedofacies; Bown and Kraus, 1987) correlations for short distances in poorly exposed areas. A synopsis of these localities by institution, depicting their correlation status, is presented in table 17, and the stratigraphic distribution of all correlated sites is depicted in table 18.

CORRELATION WITH THE SCHANKLER-WING SECTION

In his portrayal of the Schankler-Wing section, Schankler (1980) placed localities Y45 and Y227 at the 530-m level. In correlating localities in the Fifteenmile Creek drainage, it was found that these sites lay at 470 and 457 m, respectively, in the sections measured by Bown. The Schankler-Wing and Bown sections are confluent near Y227 at the top of the Elk Creek Rim. The Schankler-Wing section recorded two localities at the bottom of the rim (Y226 and Y269) at 410 m and 420 m, respectively, whereas the Bown section places Y226 at 385 m and Y269 at 394 m. The discrepancy in meter levels (barring human error and considerations of the Fort Union-Willwood contact discussed above) was due to differences in measuring the Willwood section on the Elk Creek Rim. Accordingly, two sections (at ECR–ECR', pl. 1) were measured up the rim between localities Y226 and Y227 and between Y269 and Y227 by U.S. Geological Survey personnel in 1986 and 1989. Those sections record thicknesses of 63 and 71 m, respectively, 57 m and 49 m less than in the Schankler-Wing section.

The 457-m stratigraphic level was adopted for Y227, resulting in a discrepancy of 49–57 m between all Schankler-Wing localities and all Bown localities lying stratigraphically higher than Y227. These include numerous localities lying along the high topographic outliers west of Y227

Table 16. Names and locations of measured spur stratigraphic sections of the Fifteenmile Creek master section of the Willwood Formation, south-central and southeast Bighorn Basin, Wyoming.

[Locations given to quarter sections; exact locations appear on plates 1 and 2. USGS, U.S. Geological Survey section; UW, University of Wyoming section; YPM, Yale Peabody Museum section (probable lines of section reconstructed by T.M. Bown)]

Section symbol and name: AC–AC′—Antelope Creek section (YPM).
Location of bases: NW 1/4 sec. 32, T. 51 N., R. 93 W.; NE 1/4 sec. 36, T.51 N., R. 94 W.; and NE 1/4 sec. 1, T. 50 N., R. 94 W., Orchard Bench quadrangle.
Location of tops: SW 1/4 sec. 7, T. 50 N., R. 93 W.; and NE 1/4 sec. 12, T. 50 N., R. 94 W., Orchard Bench quadrangle.

Section symbol and name: BB–BB′—Buffalo Basin section (YPM).
Location of bases: NE 1/4 sec. 21, SW 1/4 sec. 21, NE 1/4 sec. 28, and NW 1/4 sec. 30, T. 49 N., R. 97 W.; NE 1/4 sec. 26 and NE 1/4 sec. 22, T. 49 N., R. 98 W., Dutch Nick Flat NW quadrangle.
Location of tops: NW 1/4 sec. 16, T. 49 N., R. 97 W.; NE 1/4 sec. 1, SE 1/4 sec. 14, and NE 1/4 sec. 22, T. 49 N., R. 98 W., Dutch Nick Flat NW quadrangle.

Section symbol and name: BD–BD′—Bobcat Draw section (YPM).
Location of bases: SW 1/4 sec. 6 and SW 1/4 sec. 8, T. 48 N., R. 96 W.; SW 1/4 sec. 6, T. 48 N., R. 97 W., Dutch Nick Flat NW quadrangle.
Location of tops: NW 1/4 sec. 20, T. 48 N., R. 96 W.; SE 1/4 sec. 11 and SW 1/4 sec. 24, T. 48 N., R. 97 W., Dutch Nick Flat NW quadrangle.

Section symbol and name: BJ–BJ′—Banjo section (UW).
Location of bases: SW 1/4 sec. 16 and NE 1/4 sec. 33, T. 47 N., R. 91 W., Worland SE quadrangle; NE 1/4 sec. 9, T. 46 N., R. 91 W., Banjo Flats East quadrangle.
Location of top: NW 1/4 sec. 6, T. 46 N., R. 91 W., Banjo Flats East quadrangle.

Section symbol and name: BW–BW′—Brinkerhoff Well section (USGS).
Location of bases: SW 1/4 sec. 2, T. 48 N., R. 95 W. and SE 1/4 sec. 36, T. 49 N., R. 95 W., Schuster Flats NW quadrangle.
Location of top: SE 1/4 sec. 15, T. 49 N., R. 95 W., Sucker Dam quadrangle.

Section symbol and name: C–C′—Canal section (USGS).
Location of bases: SW 1/4 sec. 21 and SE 1/4 sec. 27, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: SE 1/4 sec. 28, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.

Section symbol and name: CD–CD′—Crooked Draw section (USGS).
Location of base: NE 1/4 sec. 21, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: SW 1/4 sec. 9, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.

Section symbol and name: CDW–CDW′—Crooked Draw West section (USGS).
Location of base: SW 1/4 sec. 8, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: SW 1/4 sec. 6, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.

Section symbol and name: CR–CR′—Crooked Creek section (USGS).
Location of bases: NW 1/4 sec. 26, T. 48 N., R. 96 W., Dutch Nick Flat quadrangle; SW 1/4 sec. 14, T. 48 N., R. 96 W., Sucker Dam quadrangle.
Location of top: SW 1/4 sec. 19, T. 48 N., R. 96 W., Dutch Nick Flat SW quadrangle.

Section symbol and name: D–D′—Divide section (USGS).
Location of base: SE 1/4 sec. 29, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: NE 1/4 sec. 31, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.

Section symbol and name: DC–DC′—Dorsey Creek section (YPM).
Location of base: SE 1/4 sec. 26, T. 51 N., R. 95 W., Jones Reservoir quadrangle.
Location of tops: NW 1/4 sec. 5, T. 50 N., R. 94 W.; SE 1/4 sec. 2, NE 1/4 sec. 11, NW 1/4 sec. 11, NW 1/4 sec. 14, and center sec. 10, T. 50 N., R. 95 W., Jones Reservoir quadrangle; SW 1/4 sec. 6, T. 50 N., R. 95 W., Wardel Reservoir quadrangle.

Section symbol and name: DN–DN′—Dutch Nick section (USGS).
Location of base: SW 1/4 sec. 2, T. 47 N., R. 96 W., Dutch Nick Flat quadrangle.
Location of top: SW 1/4 sec. 32, T. 48 N., R. 96 W., Dutch Nick Flat SW quadrangle.

Section symbol and name: EC–EC′—Elk Creek section (YPM).
Location of base: SE 1/4 sec. 17, T. 50 N., R. 93 W., Orchard Bench quadrangle.
Location of tops: NE 1/4 sec. 16 and NW 1/4 sec. 28, T. 50 N., R. 93 W., SE 1/4 sec. 23, T. 50 N., R. 94 W., Orchard Bench quadrangle; NW 1/4 sec. 6, SE 1/4 sec. 7, NE 1/4 sec. 10, SE 1/4 sec. 22, NW 1/4 sec. 27, T. 50 N., R. 94 W., NW 1/4 sec. 12, T. 50 N., R. 95 W., Jones Reservoir quadrangle.

Section symbol and name: ECR–ECR′—Elk Creek Rim section (USGS).
Location of base: SW 1/4 sec. 30, T. 50 N., R. 95 W., Wardel Reservoir quadrangle.
Location of top: NE 1/4 sec. 35, T. 50 N., R. 96 W., Wardel Reservoir quadrangle.

Section symbol and name: ECW–ECW′—Elk Creek West section (YPM? and USGS).

Table 16. Names and locations of measured spur stratigraphic sections of the Fifteenmile Creek master section of the Willwood Formation, south-central and southeast Bighorn Basin, Wyoming—Continued.

Location of base: SW 1/4 sec. 13, T. 50 N., R. 95 W., Jones Reservoir quadrangle.
Location of top: SE 1/4 sec. 29, T. 50 N., R. 95 W., Wardel Reservoir quadrangle.

Section symbol and name: ER–ER′—Elk Creek Rim East section (USGS).
Location of base: SW 1/4 sec. 29, T. 50 N., R. 95 W., Wardel Reservoir quadrangle.
Location of top: SW 1/4 sec. 33, T. 50 N., R. 95 W., Wardel Reservoir quadrangle.

Section symbol and name: ERD–ERD′—East Ridge section (USGS).
Location of base: SE 1/4 sec. 26, T. 47 N., R. 97 W., Dutch Nick Flat SW quadrangle.
Location of top: NE 1/4 sec. 21, T. 47 N., R. 97 W., Dutch Nick Flat quadrangle.

Section symbol and name: FM–FM′—Fifteenmile section (YPM).
Location of base: NW 1/4 sec. 5, T. 48 N., R. 96 W., Dutch Nick Flat NW quadrangle.
Location of tops: NW 1/4 sec. 26 and SE 1/4 sec. 36, T. 49 N., R. 97 W., Dutch Nick Flat NW quadrangle.

Section symbol and name: NF–NF′—North Fork Fifteenmile Creek section (USGS).
Location of base: NE 1/4 sec. 24, T. 48 N., R. 95 W., Schuster Flats NW quadrangle.
Location of top: NE 1/4 sec. 31, T. 49 N., R. 94 W., Schuster Flats NW quadrangle.

Section symbol and name: NFE–NFE′—North Fork Fifteenmile Creek East section (USGS).
Location of base: Center sec. 19, T. 48 N., R. 94 W., Schuster Flats NW quadrangle.
Location of top: NW 1/4 sec. 31, T. 49 N., R. 94 W., Schuster Flats NW quadrangle.

Section symbol and name: NT–NT′—North Fork Tenmile Creek section (USGS).
Location of bases: SW 1/4 sec. 6 and SW 1/4 sec. 8, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.
Location of top: SW 1/4 sec. 31, T. 49 N., R. 93 W., Schuster Flats NE quadrangle.

Section symbol and name: PD–PD′—Phelp's Drift section (YPM and USGS).
Location of bases: SW 1/4 sec. 3, T. 48 N., R. 96 W., Sucker Dam quadrangle; and NE 1/4 sec. 30, T. 49 N., R. 96 W., Dutch Nick Flat NW quadrangle.
Location of top: SE 1/4 sec. 7, T. 49 N., R. 96 W., Dutch Nick Flat NW quadrangle.

Section symbol and name: PSB–PSB′—Peterson School Bus section (USGS).
Location of base: NE 1/4 sec. 13, T. 49 N., R. 96 W., Sucker Dam quadrangle.
Location of top: SE 1/4 sec. 26, T. 50 N., R. 96 W., Wardel Reservoir quadrangle.

Section symbol and name: RB–RB′—Red Butte section (USGS).
Location of base: SW 1/4 sec. 15, T. 49 N., R. 95 W., Sucker Dam quadrangle.
Location of top: SW 1/4 sec. 33, T. 50 N., R. 95 W., Wardel Reservoir quadrangle.

Section symbol and name: RBS–RBS′—Red Butte South section (USGS).
Location of base: Center sec. 21, T. 49 N., R. 95 W., Sucker Dam quadrangle.
Location of top: SE 1/4 sec. 15, T. 49 N., R. 95 W., Sucker Dam quadrangle.

Section symbol and name: RC–RC′—Reservoir Creek section (USGS).
Location of base: SE 1/4 sec. 33, T. 49 N., R. 95 W., Sucker Dam quadrangle.
Location of top: SW 1/4 sec. 22, T. 49 N., R. 95 W., Sucker Dam quadrangle.

Section symbol and name: RS–RS′—Red Spires section (USGS)
Location of bases: NE 1/4 sec. 9 and SE 1/4 sec. 10, T. 49 N., R. 96 W., Dutch Nick Flat NW quadrangle.
Location of top: SW 1/4 sec. 8, T. 49 N., R. 96 W., Dutch Nick Flat NW quadrangle.

Section symbol and name: RSA–RSA′—Red Spires Approach section (USGS).
Location of base: NW 1/4 sec. 31, T. 49 N., R. 95 W., Sucker Dam quadrangle.
Location of tops: NW 1/4 sec. 33, T. 50 N., R. 96 W., Sheep Mountain quadrangle.

Section symbol and name: RWC-RWC′—Rock Waterhole Creek section (USGS).
Location of base: SE 1/4 sec. 24, T. 49 N., R. 97 W., Dutch Nick Flat NW quadrangle.
Location of tops: SE 1/4 sec. 1 and SE 1/4 sec. 11, T. 49 N., R. 97 W., Dutch Nick Flat NW quadrangle.

Section symbol and name: S–S′—Schuster section (USGS).
Location of base: NE 1/4 sec. 3, T. 47 N., R. 94 W., Schuster Flats quadrangle.
Location of top: SW 1/4 sec. 32, T. 49 N., R. 94 W., Schuster Flats NW quadrangle.

Section symbol and name: SD–SD′—Sucker Dam section (USGS).
Location of base: SE 1/4 sec. 16, T. 48 N., R. 95 W., Sucker Dam quadrangle.

Table 16. Names and locations of measured spur stratigraphic sections of the Fifteenmile Creek master section of the Willwood Formation, south-central and southeast Bighorn Basin, Wyoming—Continued.

Location of top: SW 1/4 sec. 34, T. 49 N., R. 95 W., Sucker Dam quadrangle.

Section symbol and name: SF–SF′—Schuster Flats section (USGS).
Location of base: NW 1/4 sec. 4, T. 47 N., R. 94 W., Schuster Flats quadrangle.
Location of tops: NE 1/4 sec. 18, T. 47 N., R. 94 W., and SE 1/4 sec. 12, T. 47 N., R. 95 W., Schuster Flats quadrangle.

Section symbol and name: SFE–SFE′—South Fork Elk Creek section (YPM and USGS).
Location of bases: SW 1/4 sec. 28, NW 1/4 sec. 33, and SW 1/4 sec. 34, T. 50 N., R. 93 W., Orchard Bench quadrangle.
Location of tops: SW 1/4 sec. 26 and SE 1/4 sec. 34, T. 50 N., R. 94 W., Jones Reservoir quadrangle.

Section symbol and name: SL–SL′—Slick Creek section (UW).
Location of bases: SW 1/4 sec. 1, T. 46 N., R. 92 W.; SE 1/4 sec. 26 and NW 1/4 sec. 35, T. 47 N., R. 92 W., Banjo Flats East quadrangle.
Location of tops: NE 1/4 sec. 6, T. 46 N., R. 91 W., Banjo Flats East quadrangle; and SE 1/4 sec. 30, T. 47 N., R. 91 W., Worland SE quadrangle.

Section symbol and name: SM–SM′—Sixmile Creek section (USGS).
Location of base: SE 1/4 sec. 8, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.
Location of top: NE 1/4 sec. 6, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.

Section symbol and name: SMW–SMW′—Sixmile Creek West section (USGS).
Location of base: NW 1/4 sec. 8, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.
Location of top: NE 1/4 sec. 6, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.

Section symbol and name: ST–ST′—South Fork Tenmile Creek section (USGS).
Location of base: SW 1/4 sec. 29, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.
Location of top: SE 1/4 sec. 30, T. 48 N., R. 93 W., Schuster Flats NE quadrangle.

Section symbol and name: TC–TC′—Triple Catch section (USGS).
Location of base: SE 1/4 sec. 3, T. 47 N., R. 94 W., Schuster Flats SE quadrangle.
Location of top: NE 1/4 sec. 2, T. 47 N., R. 94 W., Schuster Flats SE quadrangle.

Section symbol and name: TM–TM′—Tenmile section (USGS).
Location of bases: NE 1/4 sec. 16, T. 48 N., R. 93 W., Schuster Flats NE quadrangle, and NE 1/4 sec. 30, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: NE 1/4 sec. 2, T. 48 N., R. 94 W., Schuster Flats NE quadrangle.

Section symbol and name: TW–TW′—Triple Catch West section (USGS).
Location of base: NW 1/4 sec. 2, T. 47 N., R. 94 W., Schuster Flats SE quadrangle.
Location of top: NW 1/4 sec. 2, T. 47 N., R. 94 W., Schuster Flats SE quadrangle.

Section symbol and name: UD–UD′—Upper Divide section (USGS).
Location of base: SE 1/4 sec. 31, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: NE 1/4 sec. 31, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.

Section symbol and name: W–W′—Wardel section (USGS extensions of M.J. Kraus sections).
Location of bases: NW 1/4 sec. 23 and NE 1/4 sec. 25, T. 50 N., R. 96 W., Wardel Reservoir quadrangle.
Location of tops: SE 1/4 sec. 19, T. 50 N., R. 95 W.; NE 1/4 sec. 14 and SE 1/4 sec. 24, T. 50 N., R. 96 W., Wardel Reservoir quadrangle.

Section symbol and name: WG–WG′—Worland Gulch section (USGS).
Location of base: SW 1/4 sec. 7, T. 47 N., R. 93 W., Schuster Flats SE quadrangle.
Location of top: SW 1/4 sec. 31, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.

Section symbol and name: WW–WW′—Worland Gulch West section (USGS).
Location of base: SW 1/4 sec. 2, T. 47 N., R. 94 W., Schuster Flats SE quadrangle.
Location of top: NW 1/4 sec. 31, T. 48 N., R. 93 W., Schuster Flats SE quadrangle.

known as Red Spires, as well as most localities in the Buffalo Basin (between Tatman Mountain and the Squaw Teats Table), and those lying between Gooseberry Creek and the Buffalo Basin. The Bown section along Red Spires adjusted this discrepancy to 79 m; thus most sites in the Schankler-Wing section recorded by Schankler (1980) as lying at 530 m and above are here recorded at meter levels given by Schankler (1980) minus 79 m. Section measuring of the Willwood Formation and correlation of localities in the Elk Creek, South Fork of Elk Creek, Buffalo Basin, and Squaw Teats Table areas reveal only insignificant differences in meter levels between the two sections in those areas.

Table 17. Fossil vertebrate localities related to measured sections of the Willwood Formation in the southern Bighorn Basin, Wyoming, with respect to institutions housing the fossils.

[DPC, Duke University Primate Center, Durham, N.C. (localities founded by expeditions directed by E.L. Simons); UM, University of Michigan Museum of Paleontology, Ann Arbor, Mich. (localities founded by expeditions directed by P.D. Gingerich); USGS, U.S. Geological Survey, Denver, Colo. (localities founded by expeditions directed by T.M. Bown and K.D. Rose); UW, University of Wyoming Geological Museum, Laramie, Wyo. (localities founded by expeditions directed by T.M. Bown); YPM, Yale Peabody Museum, New Haven, Conn. (localities founded by expeditions directed by E.L. Simons). Data included through 1992 field season]

	DPC	UM	USGS	UW	YPM	Total
Total localities	19	29	843	86	495	1,472
Uncorrelated	11	17	325	12	166	531
Directly correlated	5	11	359	66	238	679
Total correlated	8	12	518	74	329	941
Estimated within 10 m	3	1	124	8	66	202
Estimated within 20 m	0	0	35	0	24	59
Total estimated	3	1	159	8	90	261
Cataloged specimens	[1]1,000	[1]1,500	[2]45,418	4,300	[1]20,400	72,618

[1]Estimated; less than 2 percent are isolated teeth and most are jaw fragments with two or more teeth.
[2]Does not include an estimated 30,000 additional uncatalogued specimens.

Bown and Rose (1987) published a study of the evolution of Willwood anaptomorphine primates, using meter levels from both Bown's Fifteenmile Creek section and the Schankler-Wing section for biostratigraphic control. The plot of the area of the lower second molar of these primates is depicted in figure 14, as it appeared in their figure 54. A second plot of the area of the same tooth, using the revised section data, is presented in figure 15. It is clear from examination of the two plots that the picture of gradual evolution of dental characters in the Bighorn Basin omomyid primates is not changed by the information from the revised section. Rather, the effect of replotting the omomyid tooth dimensions has simply been to contract the plots stratigraphically (temporally), resulting in an even denser distribution of the biostratigraphic data.

CORRELATION WITH THE CLARKS FORK BASIN SECTIONS

During much of the time that UW, YPM, and U.S. Geological Survey localities were being correlated to measured sections in the south-central and southeast Bighorn Basin, similar and equally important developments were taking place in the Clarks Fork region of the northern Bighorn Basin. In 1974, a program of vertebrate fossil collecting was initiated there by the University of Michigan Museum of Paleontology (UM), under the direction of P.D. Gingerich. Rose (1981a) published a map locating 249 localities in the Fort Union and Willwood Formations and stratigraphic sections correlating 194 of those localities (161 in the Willwood Formation, 62 of which are of Wasatchian age). Gingerich and Klitz (1985) later published a map recording all localities, including those established between 1981 and 1984.

The fossil mammals from the Clarks Fork area have been instrumental in the empirical documentation of tempo and mode of evolution in late Paleocene and early Eocene mammals (see, for example, papers by Gingerich and Rose cited in the "Introduction" of this report) and in definition of the Clarkforkian land-mammal age (Rose, 1981a). The Clarks Fork lower Tertiary section is additionally important because it is there that Paleocene fossil mammals were first known in some abundance beneath the lower Eocene section. Moreover, because they are geographically somewhat extraneous with respect to Willwood fossil mammal localities of the south-central and southeast Bighorn Basin, Willwood mammal sites in the Clarks Fork area have also proven important in corroborating evolutionary patterns seen in Willwood mammals with the records from farther south (for example, Bown and Rose, 1987).

There is no continuous exposure of Willwood rocks between the Clarks Fork area and the south-central Bighorn Basin, and adequate Tertiary well-log data do not exist. Nonetheless, precise correlation between the Willwood sections of the south-central and southeast Bighorn Basin and the Clarks Fork area is of obvious interest because of the abundance of vertebrate fossils from these areas and their prominent role in investigation of rates and modes of mammal evolution. Because Wasatchian mammals of the greater Bighorn Basin (including the Clarks Fork area) were part of a regional fauna existing in a single depositional basin (Gingerich, 1983a), biostratigraphic correlation based on mammals holds the most promise.

Although existing collections are probably quite adequate to produce a relatively precise correlation, few groups or lineages have yet been studied in the detail necessary to provide a compelling correlation. However, we offer a preliminary attempt here (fig. 16, table 19) based on several taxa

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming.

[Position is shown in meter levels above the base of the Willwood Formation. Localities from three separate master sections are represented: (1) the Sand Creek-Banjo section southeast of Worland, Wyo. (Bown, 1979); (2) the Fifteenmile Creek section in the south-central Bighorn Basin (all new data, section measured and localities correlated by T.M. Bown); and (3) the Antelope Creek-Elk Creek-Buffalo Basin section measured by David Schankler and S.L. Wing in 1976–78 (Schankler, 1980). Localities in the Sand Creek-Banjo section include all University of Wyoming localities, except W124–W127. All localities originally in Schankler's (1980) Antelope Creek-Elk Creek-Buffalo Basin section are shown underlined, as are DPC, UMRB, and USGS localities that are in the line of this section and which were added in their appropriate places by Bown. Note that Schankler's stratigraphic sections along the Elk Creek Rim have been considerably modified, based on new sections by Bown and by M.J. Kraus. All other localities are in the Fifteenmile Creek master section, measured by Bown in 1981–92. D, U.S. Geological Survey (USGS) localities; DPC, Duke Primate Center localities; NM, U.S. National Museum fossil plant localities; UMRB, University of Michigan Red Butte localities; W, University of Wyoming Geological Museum (UW) localities; Y, Yale Peabody Museum (YPM) localities; *, stratigraphic position estimated and probably within 10 m; **, stratigraphic position estimated and probably within 20 m. The letters A through H following locality names designate different areas assigned to the same locality. N, S, E, and W indicate compass direction. U, M, and L indicate stratigraphic positions recognized within individual localities (upper, middle, and lower, respectively), and Q designates a quarry site]

Meter level	Localities
	Tatman Formation
740	NM37686, NM37687.
	Willwood Formation
719	NM37682, NM37683, NM37684, NM37685.
706	NM37679, NM37680.
641	Y7.
636	D1651**, D1651Q**.
626	Y172**, NM37677.
621	NM37669, NM37672, NM37673, NM37674, NM37675.
611	Y24, Y32.
601	Y3, Y33, Y163, Y166, Y195, Y198, NM37667, NM37668.
591	D1596**, D1646**, D1647**, D1686**, Y8, Y160, Y162A, Y162B, Y162C, Y196, Y197, Y199.
571	Y1, Y2, Y161.
566	D1772.
561	D1735*, Y17*, Y165, Y183.
559	D1622*.
556	D1172*, D1473, D1504, D1558*, D1781, D1860, Y187, DPC14.
553	D1674.
551	D1583, Y9, Y10, Y22, Y188, DPC12*.
550	D1503, D1505, D1506.
546	D1212*, D1256, D1463, D1464, D1465*, D1467, D1481*, D1574, D1575, D1576, D1581*, D1582*, D1828, D1890, Y192, Y192S, Y193, Y193E, Y315, Y316*, DPC15, DPC16.
544	D1918.
543	D1945.
542	D1764*.
541	D1482*, D1613, Y13, Y15, Y16, Y167, Y179, Y180, Y181, Y184, Y189, Y190.
539	D1919.
537	D1765*.
536	D1173*, D1534*, DPC11*.
531	D1170*, D1567*, D1673, Y174, Y175, Y176, Y178, Y185, Y191.
530	D1920.
529	D1831, D1914.
528	D1566*, D1843, DPC17*.
526	D1171*.
521	D1170*, Y18B, Y19, Y36.
516	D1176*, D1304, D1438, D1466*, D1608**, D1625, D1985.
513	D1623*, Y256*.
511	D1167, D1176, D1375*, D1437*, D1573*, D1754, D1834, Y20, Y23, Y171*, Y173, Y177, Y186, Y314.
510	D1769*.
509	D1285, D1513, D1986.
507	D1624*, Y257*.
505	D1609**, D1612*, UMRB5.
504	D1984.

that are: (1) Known well enough that their taxonomy is consistent and reliable; (2) common or distinct enough to be readily and unambiguously identified in both areas; and (3) restricted in temporal range or with abrupt first or last appearances. We consider first and last appearances to be equally useful for intrabasinal correlation, assuming that species had potentially unrestricted and geologically instantaneous dispersal throughout the basin. Under this assumption, it is very unlikely that a species' first or last appearance would be widely discordant in the two parts of the basin. It is acknowledged that first or last appearances could be misleading if they are tied to certain local paleoenvironments. For example, if paleosols indicate that local habitats differed in the two parts of the basin, this method of correlation would be inappropriate.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
501	D1174*, D1175, D1431, D1432, D1433, D1435, D1468, D1755, D1829, D1830, Y21, Y25, Y39, Y55*, Y56*, Y71A, Y75, Y76, Y77, Y168, DPC13.
499	D1337*.
496	D1434*, D1474*, D1475*, D1782.
495	D1672.
494	D1408, D1507, D1508, D1910.
493	D1563, D1675Q.
492	D1436, D1982.
491	D1163*, D1169*, D1338*, D1338N*, D1344*, D1345, D1346, D1469, D1470, D1471, D1773, D1966, Y18A, Y26A, Y26B, Y26C, Y27, Y28, Y59, Y66, Y70, Y71B, Y73, Y74, Y317.
490	D1230, D1255**, D1426*, D1562, Y49**, UMRB10.
489	D1286, D1734*, D1825, Y47, Y47A, UMRB6.
488	D1983.
486	D1165*, D1257, D1305, D1491.
485	D1531*, D1532*, D1552, D1564*, D1565*, UMRB4.
483	D1307, D1312, D1317, D1331, D1397, D1586, Y14A.
482	D1156, D1158, D1159, D1246, D1510, UMRB12.
481	D1162, D1166*, D1177, D1197, D1229, D1316, D1336, Y40, Y41, Y42, Y43*, Y72, Y253, UMRB1, UMRB1A.
480	Y249**.
479	D1826.
478	D1157, D1511, D1605, D1727, Y99, Y318.
477	D1245.
476	D1164, D1667.
475	D1617, D1767*.
474	D1490, D1671, D1777, D1778, D1783, D1885*, Y61.
472	D1161*, D1889*.
471	D1670.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
470	D1128, D1160, D1160N, D1198A, D1198B, D1198C, D1198D, D1198E, D1198F, D1198G, D1198H, D1244, D1314, D1315, D1662, D1663, D1677*, Y45, Y45S, Y52*, UMRB2, UMRB3.
469	D1737(U), Y34.
468	NM37560.
466	D1592*.
465	D1425*.
464	D1495, D1669, D1676.
463	D1462**, D1602, D1603, D1604, D1699, D1726, D1737(L), D1776, D1833, D1881, D1890, D1936, Y44.
461	D1250.
460	D1668, UMRB9*.
458	D1210*.
457	Y227, Y227N.
455	D1409, D1430, D1698, D1784, Y100.
454	Y353.
452	D1209, D1339, D1497, Y339.
450	D1536*, Y427*.
449	D1537, D1599.
448	D1207, D1308, D1451*.
446	D1429, D1439, Y340*.
445	D1629**, Y270**.
444	D1204(U), D1587.
443	D1657.
442	D1204(M), D1310, D1311, D1407, D1588, D1659, D1660, D1682, D1688*, D1937*.
440	D1428, D1452*, D1684, Y250*, Y252*.
438	D1203, D1204(L), D1206*, D1208, D1319, D1320, D1321, D1322, D1323, D1325, D1398, D1400, D1401, D1404, D1405, D1459*, D1687*, D1693, D1748, D1899*, Y338, Y448*, DPC1.
436	D1377, D1406, UMRB7.
435	D1570**, D1571**, D1628**, D1694, D1742, D1876**, D1883*, Y224*, Y225*, Y325**.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
434	D1399.
433	D1749.
432	D1487.
431	D1347.
430	D1348, D1349, D1376, D1378, D1379, D1380, D1381, D1382, D1486, D1545*, D1689, Y83, Y86, Y222*, Y223, Y236*, Y248*, Y251*, Y261*, Y321, Y325**, Y330**, Y361**.
428	D1598, D1330, D1897*.
426	D1309, D1822.
425	D1234, D1326, D1550*, Y247, Y268*, UMRB8.
424	D1295, D1324.
423	Y320*, D1848*, D1866*, NM37662.
422	D1946.
420	D1396, D1402, D1403, D1443, D1529**, D1530**, D1597, Y68, Y324**, NM37661.
418	D1410(U), D1526**.
416	D1410(M), D1484*, D1554, D1821, Y51.
415	D1483*, D1747*.
414	D1235*, D1528**, D1541, D1680*, D1762**, D1762Q**, D1863, Y69*, Y85*.
413	D1774**.
412	D1217, D1411, D1779*, Y221, Y237, Y319*.
411	D1460Q, D1804*.
410	D1261*, D1306, D1350(U), D1350Q, D1410(L), D1527**, D1539, D1549*, D1658, D1859*, Y234, Y463.
409	D1454, D1460, D1524**, D1823, D1895*, Y267.
408	D1240**, D1350(L), Y266.
407	D1894*, D1896*, D1947, Y230A, Y230B.
406	D1824.
405	D1538, D1547*, D1559*, D1805*, Y78, Y220, Y461.
404	D1744, Y235.
402	D1951.
400	D1222, D1458, D1551*, D1952, Y324*, Y348*, Y271, Y462.
399	D1540.
397	D1556, D1716*, Y219, Y262, Y263.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
394	D1555, D1864*, Y50, Y265, Y269.
392	D1218, D1219, D1385, D1413, D1560, Y460.
390	D1342, D1548*, D1712*, D1745*, Y80, Y127, Y421*.
385	D1743, D1792*, D1803*, Y226, Y264.
384	D1221, D1341, D1370, D1421(U).
383	D1741.
382	D1652.
380	D1216, D1259**, D1514*, Y67, Y84, Y152, Y152N*.
379	D1242, D1421(L).
378	D1251, D1300, D1301, D1414, D1453.
377	D1553*.
376	D1293*.
374	D1283.
370	D1200, D1220, D1371, D1422, D1494, D1635, Y82A, Y126*, Y142, Y277, Y280, Y282, Y283, Y298, Y299, Y334, Y360*, Y419*.
368	D1292*.
364	D1340Q, D1412.
362	D1561, D1923*.
361	D1636*.
360	D1303, D1332, D1333, D1334, D1387, D1388, D1417, D1420, Y81, Y132, Y149, Y150*, Y151*, Y278, Y279, Y281, Y284, Y356*.
359	Y136.
357	D1653, D1924, D1967.
356	D1205, D1372, D1391, D1557, Y447, Y449.
354	D1415*, D1416*, Y158**.
353	D1950, NM37656.
352	D1282, D1299, Y274.
351	D1700.
348	D1243*, Y131(U).
346	D1287, D1335(U), D1850.
345	D1882*.
344	D1201, D1201N, D1386, D1449**, D1493, D1498*, D1811, Y131(L).
343	Y135, Y157(U).
342	D1289, D1294, D1313, D1384.
340	Y125*, Y216*.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
338	D1284, D1373(U).
336	D1288(U), D1[illegible](L). D1373(L) D1374, Y157(M).
335	Y335*.
334	D1302**, D1499*.
332	D1288(L), Y459.
329	D1775.
324	D1202**, D1395**, Y133**, Y458.
322	D1500**, Y157(L)*.
315	D1931*.
312	NM37655.
311	D1577**, NM37654.
310	D1938*, D1880*, Y156**, Y365.
305	Y349*.
300	D1145*, D1146*.
296	D1393, D1441.
292	D1328, D1369, D1392.
290	D1141*, D1183*, D1501**, Y287, Y288, Y296, Y297, Y350.
288	D1258*.
285	D1144*, D1266*.
282	D1290, D1418.
280	D1143*, Y285, Y289, Y295, Y301.
278	D1298, D1390, D1678*.
275	D1142*.
270	D1241, D1383, Y286, Y294.
264	D1389.
262	D1297(U).
260	D1291, D1297(M+L), D1419, D1711*.
255	D1644*.
250	D1709*, D1935*, Y373.
245	D1710*.
240	D1645, Y143, Y351, Y354, Y355.
230	Y212, Y302*, Y386**, Y387**.
227	Y300.
220	Y108, Y113, Y213, Y372.
215	Y368**.
213	D1872**, Y412.
210	Y112*, Y215, Y290**, Y344**, Y367**.
205	Y416**.
200	D1631*.
195	Y323**.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
190	D1630*, D1847**, Y111, Y214, Y215W*, Y363.
182	Y347*.
180	D1224, D1461*, D1816**, W124, W125, W126, W127, Y87, Y88, Y98, Y101, Y144, Y345, Y369**, Y377, Y388, Y408.
175	D1189*.
170	D1192, D1193, Y89, Y389.
165	Y404*, Y410*.
160	D1178, Y91, Y145, Y146, Y327, Y362, Y374, Y396*, Y406*, Y411*.
155	Y110**.
150	Y109, Y121**, Y148**, Y359, Y393*, Y394, Y395*, Y397*.
149	D1633.
145	Y407*.
140	D1188**, D1194*, D1195*, D1262, D1640, Y92, Y93, Y94, Y96, Y97, Y104, Y106*, Y206, Y207, Y337, Y341, Y346, Y358, Y364, Y382, Y383.
130	D1190, D1191*, D1632*, D1648, W30, Y305.
124	NM37650.
119	W55, W84.
115	Y381*.
113	D1447*, W29, W54, W61, W111, Y342, Y343*.
112	NM37639, NM37640, NM37641, NM37643, NM37645, NM37648.
100	Y90B, Y119, Y120, Y201, Y202, Y203, Y204, Y205, NM37638.
97	W20, W20A, W20B, W52, Y137*.
95	Y399*.
94	W87.
90	Y90A.
88	W49, W51, W82.
82	Y276*.
81	W83, W129.
80	Y200.
77	W81, Y139*.
75	W46.
70	W16A, Y370A.
66	W50.
64	W16B, W17.

Table 18. Stratigraphic distribution of fossil vertebrate and plant localities in the Fort Union, Willwood, and Tatman Formations of the southern Bighorn Basin, Wyoming—Continued.

Meter level	Localities
63	W48.
61	W16C, W86.
57	W44, W90*, W91*, Y48*.
50	Y95.
48	W24, W24A.
46	W22, W32, W45, W63, W78*, W80, W92*.
41	W38, Y138*.
40	W35, W110.
39	W53, W60.
36	W36.
34	W33, W34, W34N1, W34N2, W37, W77.
31	W23, W66, W130.
30	D1296*, W27, W41*, W76, Y115*, Y306*.
27	W62.
26	W67*, W105.
24	W25, W26, W42*.
23	W39, W85.
20	W43*, W96.
18	D1485*, W28.
10	D1199*, W95, Y275*.
9	W19.
5	D1579, D1887.
4	W59.
3	D1888.
Base of Willwood Formation	
Fort Union Formation	
-20	NM37627.
-24	Y307*.
-25	D1578.

Willwood Formation deposition began much earlier in the northern Bighorn Basin than in the south; hence the Willwood section in the Clarks Fork area includes several hundred meters of sediment of Clarkforkian age as well as overlying deposits of Wasatchian age. The Wasatchian part of the Clarks Fork Basin Willwood Formation section (which represents only the earlier Wasatchian) is about the same thickness (about 720 m) as the entire Willwood section of the central Bighorn Basin, a section that represents the entire Wasatchian. The events and ranges used for our correlation show comparable offsets in the two sections (as indicated by the roughly parallel correlation lines in fig. 16). Most biostratigraphic events occur at meter levels 50–75 percent higher relative to the beginning of the Wasatchian in the Clarks Fork section; that is, the Clarks Fork section is generally at least 50 percent thicker per unit of time than the combined sections from the southern Bighorn Basin. This greater thickness reflects a more rapid (though not necessarily constant) rate of sediment accumulation in the Clarks Fork area, which probably was controlled by its closer proximity to the basin depositional axis (Kraus, 1980; Gingerich, 1983b). These data also suggest that sediment accumulation there was more rapid earlier in Wasatchian time than later.

It is also evident from our correlation (fig. 16) that the Clarks Fork area Wasatchian section is essentially restricted to the *Haplomylus-Ectocion* Range Zone of Schankler (1980). Only a few relatively poor localities, at the top of the Clarks Fork section and succeeding an unfossiliferous interval of about 100 m (from about 2,100–2,240 m), have produced a fauna belonging to Schankler's *Bunophorus* Interval Zone. Because of the gap, the level of the beginning of the *Bunophorus* Interval Zone, as well as the first and last appearances of several taxa (that occur in the 360–400 m interval in the southern Bighorn Basin) cannot yet be determined with any precision.

Reliability of biostratigraphic events used in correlation is enhanced if two or more events coincide in both sections. Of the events listed in table 19, probably the most reliable for correlating the two sections more precisely are the coincident events at 190 m in the southern Bighorn Basin section involving two lineages of omomyid primates and one of a microsyopid plesiadapiform. As currently understood, the last occurrence of the microsyopid *Arctodontomys wilsoni* (Gunnell, 1985) in the southern part of the basin (190 m) was synchronous with the last occurrence of the omomyid *Teilhardina crassidens* and the transition from stage 1 to stage 2 in the *Tetonius matthewi-Pseudotetonius ambiguus* transition (a nonarbitrary transition marked by the loss of the second lower premolar, documented to have occurred in a 10-m interval, Bown and Rose, 1987). In the Clarks Fork section, *Teilhardina crassidens* last appears at 330 m (1,850 m in Gingerich's 1982 section), coinciding with the first known stage 2 *Tetonius* and possibly with the last stage 1 *Tetonius matthewi*. Unfortunately, the record is too sparse for confidence; the stage 1-stage 2 transition could have occurred slightly earlier. The last occurrence of *Arctodontomys wilsoni*, however, is conspicuously lower (at 240 m) in the Clarks Fork section. Although *A. wilsoni* may have persisted much longer in the southern Bighorn Basin than in the north, our correlation suggests that its range was similar in the Clarks Fork area, and that it may eventually be found in beds as high as 1,850 m. In either case, it seems very improbable that two separate lineages of omomyid primates would contemporaneously show identical temporally restricted morphologic stages at a much later time in the Clarks Fork area.

The events just discussed are approximately synchronous with an apparent extinction-immigration event termed Biohorizon A by Schankler (1980). In a critical examination

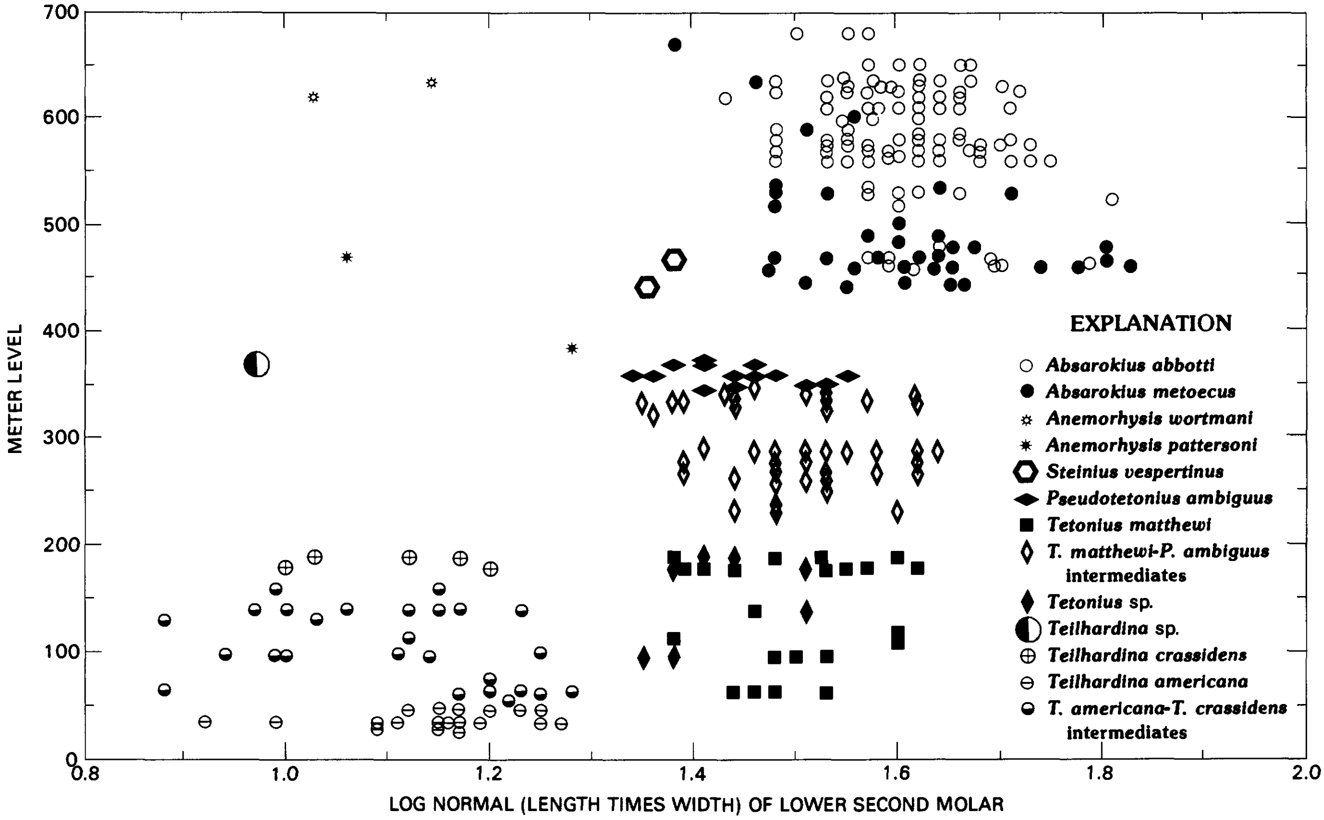


Figure 14. Plot of area of second lower molar in omomyid primates from the Willwood Formation of the south-central and southeast Bighorn Basin, using stratigraphic data from Schankler (1980) and Bown and Rose (1987, table 2 and fig. 54).

of Biohorizon A in the Clarks Fork area, Badgley and Gingerich (1988) correctly portrayed the Biohorizon A events as embracing an interval (1,750–1,790 m) but questioned its validity, suggesting that it could be an artifact of sampling. More recently, Badgley (1989) concluded (partly on the basis of the omomyid primate correlation summarized above) that Biohorizon A may occur higher in the Clarks Fork area, about 1,860 m. The latter assessment conforms much better with the correlation proposed here.

Certain other distinctive taxa have restricted stratigraphic ranges that appear to be useful in the correlation of the two areas. We regard omomyids and microsyopids to be particularly useful because of recent studies (cited above) that place specimens into both sections and relate characteristic morphologies to specific stratigraphic levels. The ranges of stage 5 *Pseudotetonius ambiguus* and of the microsyopids *Arctodontomys nuptus* and *Microsyops angustidens* are temporally quite restricted and suggest a correlation consistent with that based on the events discussed above. Approximately coincident with the last appearance of *Pseudotetonius* in the southern Bighorn Basin were the last occurrences of the hyaenodontid creodont *Arfia* and the phenacodontid condylarth *Ectocion*, as well as the first occurrence of the dichobunid artiodactyl *Bunophorus* (all events occur in a 20-m interval). Although these events all appear to have taken place at 2,100 m or above in the Clarks Fork area (*Bunophorus* is unknown below 2,240 m), it is impossible to be precise because of the very poor record above this level. Based on the other data in table 18, *Bunophorus* almost certainly was present much earlier than the record indicates. It will probably be found eventually as low as 2,100 m.

If the correlation shown in figure 16 is correct, the meter level of a Wasatchian event in the Clarks Fork section may be estimated as 1.50–1.75 times its stratigraphic level in meters in the southern Bighorn Basin sections, the larger factor evidently applicable in the lower two-thirds of the section (a factor of 2 may be a better estimate for the lowest 200 m of the section).

More precise correlation should be possible when certain other groups are known in more detail. We believe the most useful taxa for better correlation will be rodents, the adapiform primate *Cantius*, *Phenacodus*, and, especially, the hyracotheriid perissodactyl *Hyracotherium* and the hyopsodontid condylarth *Hyopsodus*. The study of *Cantius* by Gingerich and Simons (1977) allows a general correlation, but much new evidence (specimens and new taxa as well as revised stratigraphic data) is now available. Detailed correlation is dependent on knowledge of precise meter levels or intervals associated with recognizable morphologic shifts or transitions.

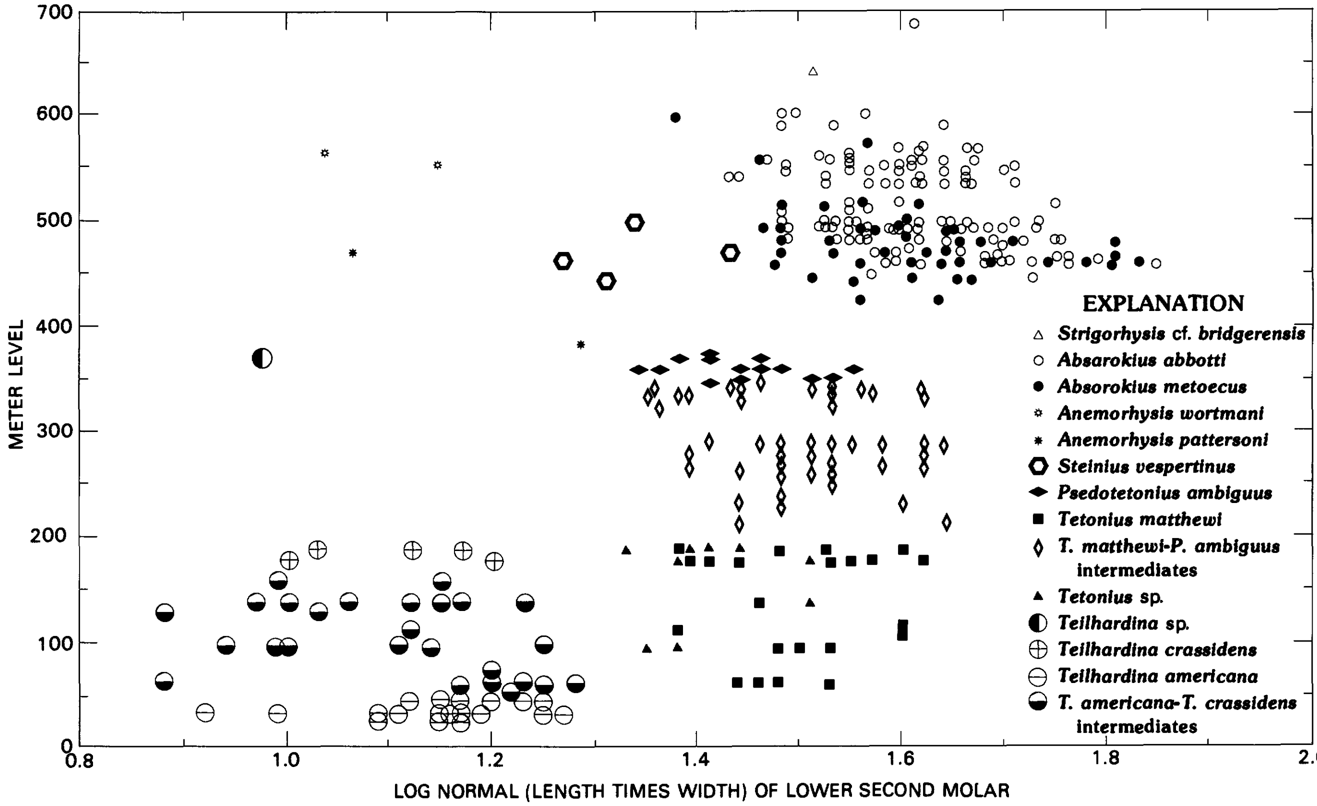


Figure 15. Plot of area of second lower molar in omomyid primates from the Willwood Formation of the south-central and southeast Bighorn Basin, using new and revised sections presented in this report. Note that the overall gradual picture of omomyid evolution presented by Bown and Rose (1987) is unchanged; the net effect has been to compress stratigraphically the points from localities in the Schankler-Wing section above the 530-m level. Information for omomyid specimens collected in 1987 and 1988 has been added.

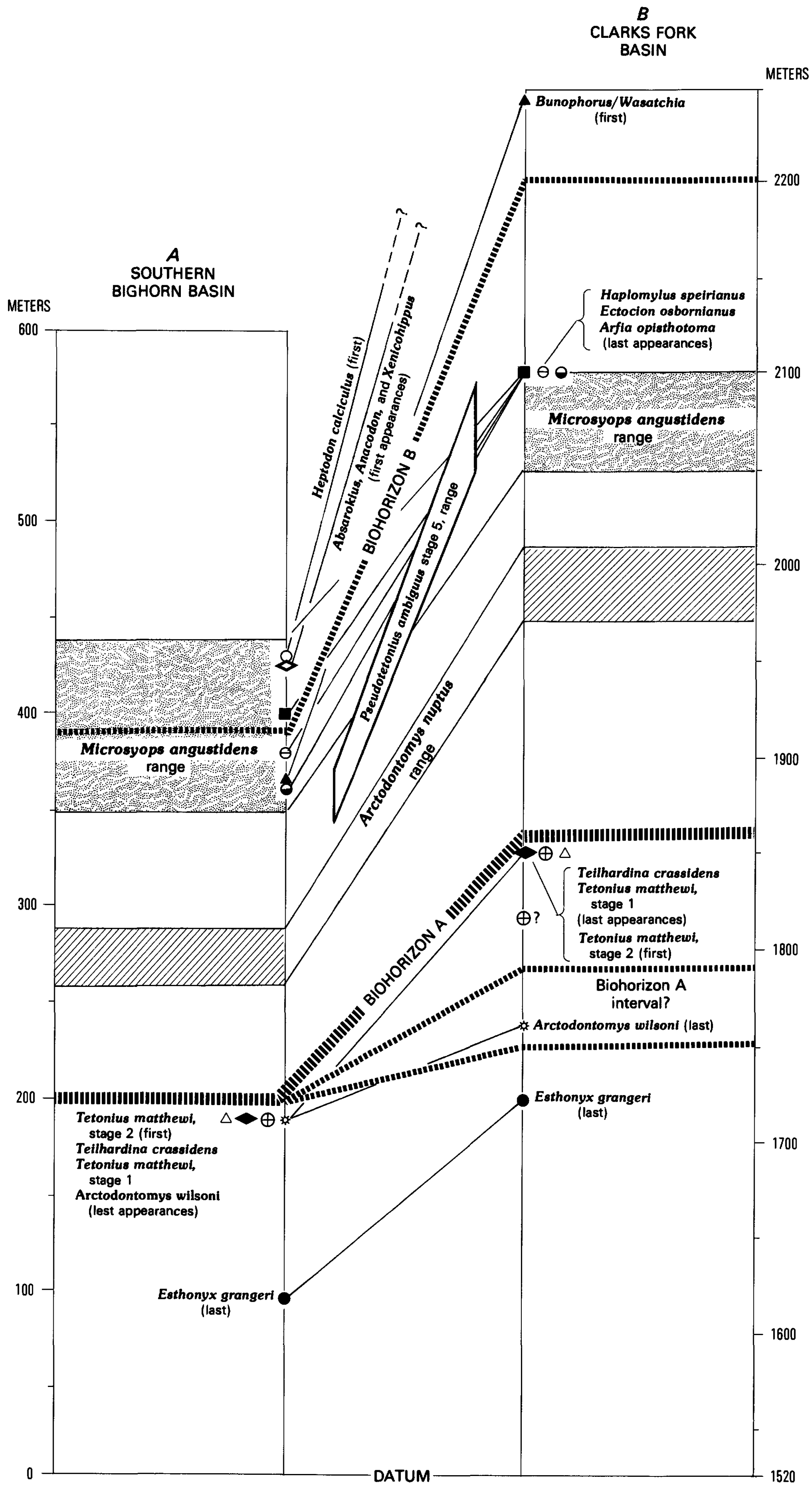
FOSSIL PLANT LOCALITIES

PALEOBOTANICAL SAMPLING

As is clear from the foregoing discussion of vertebrate localities, the predominant lithologies of the Willwood Formation are pedogenically modified mudstone and various kinds of sandstone. Carbonaceous debris is rare, probably comprising 2–5 percent of the formation as a whole, but carbonaceous sediments are locally abundant in the lower and upper parts of the formation (figs. 17 and 18).

Unlike vertebrate fossils, plant remains in the Willwood Formation do not accumulate in lags at the bottom of fossiliferous exposures. The necessity of quarrying for plant remains (fig. 19), in addition to the specific and clearly identifiable horizons, has from the beginning forced collectors to be aware of precise geographic position, stratigraphic position, and sedimentological context. The geographic position of all plant localities has been recorded on topographic quadrangle maps to the maximum degree of accuracy thought possible for the local terrain and the map scale. Beginning in 1989, some localities have been mapped on 1:20,000-scale aerial photographs. The stratigraphic position of each locality is known to whatever level of accuracy the bed containing it can be correlated with the established measured sections. Finally, virtually all of the approximately 100 latest Paleocene-early Eocene plant localities in the Bighorn Basin are "sedimentological" localities, as the term is informally used above. That is, the physical characteristics of the fossiliferous sediment are noted with the locality information, and for most localities lithological descriptions of fresh (man-made) exposures are accomplished for the 1–3-m thick interval enclosing the locality. Because of the small-scale lateral

Figure 16 (facing page). Relative correlation of Willwood Formation sedimentary rocks and time between *A*, the study area, and *B*, the Clarks Fork Basin area of the Bighorn Basin, northwest Wyoming, using fossil mammal distributions. Datum (base of diagram) is base of Willwood Formation (0-m level) in the southern Bighorn Basin and is the 1,520-m level of the Tertiary (Gingerich, 1983c) in the Clarks Fork area. The datum represents the base of the Wasatchian land-mammal age in both areas (Clarksforkian-Wasatchian boundary). Note that the net Willwood sediment-accumulation rate in the Clarks Fork area is about 1.5–2.0 times that of the study area for most of the interval studied. Correlation lines dashed and queried where uncertain.



EXPLANATION

- ■ *Haplomylus speirianus*
- ⊖ *Ectocion osbornianus*
- ◒ *Arfia opisthotoma*
- ▲ *Bunophorus/Wasatchia*
- ◇ *Absarokius, Anacodon,* and *Xenicohippus*
- ⊕ *Tetonius matthewi,* stage 1
- △ *Tetonius matthewi,* stage 2
- ○ *Heptodon calciculus*
- ● *Esthonyx grangeri*
- ✲ *Arctodontomys wilsoni*
- ◆ *Teilhardina crassidens*

Table 19. Mammalian taxa of potential biostratigraphic significance for correlating Willwood Formation measured sections of the southern Bighorn Basin and the Clarks Fork area in the northern Bighorn Basin, Wyoming.

[Clarks Fork levels are in sections of Gingerich (1982) and Badgley and Gingerich (1988); figures in parentheses are meter levels in Wasatchian part of Clarks Fork section; ?, uncertain meter level]

Taxon and event	Meter level: Southern Bighorn Basin	Meter level: Clarks Fork area
Esthonyx grangeri, last	97[1]	1,720[2] (200)
Arctodontomys wilsoni, last	190[3]	1,760[3] (240)
Teilhardina crassidens, last	190[4]	1,850[4] (330)
Tetonius matthewi, last stage 1	190[4]	1,815,?1,850[4] (295, ?330).
Tetonius matthewi, first stage 2	190[4]	1,850[4] (330)
"Biohorizon A"	About 200[5] (195-210[1])	1,750-1,790[6] (230-270) 1,860[7] (340).
Arctodontomys nuptus, range	260-290[3]	1,970-2,010[3] (450-490).
Pseudotetonius ambiguus, range of stage 5	346-374[4]	?2050-2095[4] (?530-575).
Microsyops angustidens, range	350-410[3] (1 specimen, 440)[3]	2,050-2,100[3] (530-580).
Arfia opisthotoma, last	360[5]	2,100[2] (580)
Bunophorus/Wasatchia, first	365[1]	2,240[8] (720)
Ectocion, last	379[1]	2,100[2] (580)
"Biohorizon B"	About 390[5] (380[1])	About 2,200[3] (680).
Haplomylus, last	400[1]	2,100[2] (580)
Absarokius, Anacodon, Xenicohippus, first	425[1]	Not present.
Heptodon, first	430[1]	Not present.

[1]T.M. Bown and K.D. Rose, unpublished data.
[2]P.D. Gingerich, written commun., May, 1989: new record (UM78944) extends range 80 m higher than indicated by Badgley and Gingerich (1988).
[3]Gunnell (1986), using section data provided by T.M. Bown.
[4]Bown and Rose (1987).
[5]Schankler (1980).
[6]Badgley and Gingerich (1988).
[7]Badgley (1989).
[8]P.D. Gingerich and G.F. Gunnell, written commun., 1989.

variations in floral composition, localities more than 3 m apart in the same bed are given separate designations.

Given the great abundance of plant fossils where they are preserved at all, it is not practical to collect all identifiable specimens. Most museum collections result from a compromise collecting strategy that tries to represent the relative abundances of the species at a locality but that favors well-preserved specimens and rare species. To preserve accurate information about relative abundances, censuses have been made at about 20 of the Willwood localities. In these censuses only leaves are counted, and each identifiable specimen complete enough to represent more than half a leaf is assigned to the appropriate species. Studies of untransported leaf litter in living forests show that such counts reflect the surrounding forest with considerable accuracy, both in terms of composition and relative abundance of species (Burnham and Wing, 1989; Johnson, 1989).

DEPOSITIONAL SETTINGS OF PLANT FOSSILS

Wing (1980, 1984a) defined two kinds of carbonaceous units: (1) Lenticular deposits (fig. 17) representing the accumulation of plant debris in abandoned channel scours, and

Figure 17. Lenticular carbonaceous shale, locality NM37560, 468-m level of the Willwood Formation, southern Bighorn Basin, Wyoming. Carbonaceous shale (the black unit in the middle distance) is underlain by a poorly consolidated medium-grained sandstone. The sinuous form of the ridge top apparently conforms to the original shape of the abandoned channel segment.

Figure 18. Tabular carbonaceous shale, 621-m level of the Willwood Formation, southern Bighorn Basin, Wyoming. This exposure of carbonaceous shale is part of an outcrop area of at least 52 km^2.

Figure 19. Plant-fossil quarry and trench at locality NM37656, southern Bighorn Basin, Wyoming, in a tabular carbonaceous shale unit at the 353-m level of the Willwood Formation, southern Bighorn Basin, Wyoming. Note underclay subunit (below whisk broom), carbonaceous shale subunit (above whisk broom), and overlying drab mudstone (immediately above hammer). The 353-m level is the approximate top of the range for many Paleocene-earliest Eocene plants, and the bottom of the range for several late early and middle Eocene species.

(2) widespread tabular deposits (fig. 18), representing plant debris accumulating in extensive floodbasin backswamps. Most lenticular deposits were thought to occur in the 270–457-m interval (270–530-m interval of the Schankler-Wing section; Wing, 1980), but subsequent work has shown that they are present throughout the formation and that they are also abundant between 621 m and the contact with the Tatman Formation.

The two types of carbonaceous units represent different kinds of samples of the original flood-plain vegetation. The numerically predominant floral elements in lenticular deposits are generally aquatic and(or) riparian species. Typically, the aquatic element includes floating plants such as *Salvinia* and *Azolla*, and emergent aquatics such as species of the families Alismataceae and Typhaceae. These are plants that probably colonized oxbow ponds following stream abandonment. The other abundant elements in these assemblages are stream-side trees or shrubs typical of disturbed sites, for example *Platanus*, *Averrhoites*, and *Populus*. The high abundance and common occurrence of these taxa in lenticular deposits probably reflects their abundance on point bars of meander bends before abandonment. The better known lenticular deposit assemblages each contain perhaps 20–40 other species, but many of these are unique to particular sites, and some are represented by only one specimen each. These species were probably derived from the cutbank or levee side of the oxbow and are the best record we have of the vegetation of the typical oxidized Willwood flood plain. Such species include a diversity of Leguminosae and a large number of forms not yet identified even at the familial level. The palynofloras of lenticular units are characterized by a higher level of pine pollen and reworked Cretaceous marine dinoflagellates than is seen in the tabular units of the Willwood (Farley, 1987, and in press). There are also substantial compositional differences between different lenticular unit palynofloras, probably reflecting the diversity and heterogeneity of the vegetation on the cutbank sides of the oxbow ponds.

The floral assemblages derived from tabular deposits represent a wider array of depositional settings and local floras than do those of the lenticular deposits. Two lithologic types within the tabular units produce identifiable plant fossils: carbonaceous shale, and interlaminated fine sand and silt. The carbonaceous shale lithology was interpreted by Wing (1984a) as representing deposition in flood-plain backswamps distal to the channel belt. The large quantity of apparently unsorted plant debris, such as compressed leaves, flowers, seeds, and horizontal trunks and branches, was taken as evidence that these assemblages were essentially autochthonous, or untransported. This interpretation is also consistent with the fine grain size of the shale (mostly clay), the delicate nature of much of the plant debris, and the small-scale lateral variations in the composition of the flora of individual depositional units. Tree trunks and stumps have been observed rooted in or on similar carbonaceous shales in various parts of the Willwood and Fort Union Formations (Kraus, 1988, and personal observation) but have not yet been detected in association with carbonaceous shales producing compression fossil assemblages. The apparent absence of trees in place in most Willwood carbonaceous shales is surprising if the compression assemblages are indeed autochthonous—how were leaves preserved while trunks decayed? At least two possible explanations exist. One, modern weathering may make the trunk casts difficult to detect, because the carbonaceous shales commonly crop out as ledges, whereas the mudstones above them into which the trunks would project are more deeply weathered. Second, the carbonaceous shale assemblages may represent deposition in laterally extensive but very shallow lakes, the plant material having been derived from trees growing on the shoreline. The latter explanation is not consistent with the observed small-scale lateral variation in floral composition but is consistent with the fine grain size of the deposits, their tabular form, and the presence of abundant unsorted plant matter.

Regardless of the genesis of carbonaceous shale, megafloras and microfloras found in it are distinct from those recovered from lenticular units. Typical localities in the carbonaceous shale produce 10–20 species, commonly with strongly predominant taxodiaceous conifers *Glyptostrobus* or *Metasequoia*, or the broad-leaved trees *Alnus*, *Platycarya*, or *Dombeya*. Several species of ferns and the gingerlike monocot *Zingiberopsis* are also locally abundant. Floating aquatic and emergent aquatic plants are rare in the carbonaceous shale. Palynofloras from this depositional setting reflect the composition of the megaflora reasonably well, being dominated by pollen of Taxodicaeae, the broad-leaved genera mentioned above, and fern spores. Reworked palynomorphs and those possibly derived from more distant vegetation (for example, *Pinus*) are relatively rare in the carbonaceous shale (Farley, 1987, and in press).

The interlaminated silt and sand was interpreted by Wing (1984a) as representing deposition in regions closer to the channel, for example upper point bars, levees, or splays. Recent field work has shown that some of the bedforms preserved in this lithology were generated by oscillatory ripples (Erik Kvale, written commun., 1989). This genesis again raises the possibility of deposition in a body of standing water, although waves within a channel could have been responsible. Whatever the depositional environment of this lithology, it preserves floras distinct from those of carbonaceous shales at equivalent stratigraphic levels. Generally taxodiaceous conifers are less important, and a variety of taxa that today occupy streamside habitats are predominant (for example, *Platanus*, *Populus*, *Cercidiphyllum*). As with the carbonaceous shale assemblages, floating aquatic plants are quite rare. Presumably assemblages derived from this depositional environment reflect vegetation growing in coarser, less inundated soils than those of the distal flood-plain backswamp.

EXCEPTIONAL LOCALITIES

Several levels within the Willwood Formation have been especially productive of plant megafossils. A tabular carbonaceous shale at the 112-m level of the Schankler-Wing section is exposed along the east side of the South Fork of Elk Creek. The collections made from this unit (from localities NM37639–NM37650, pl. 1) are the best sample of the earliest Eocene flora of North America. Palynologically, this level is considered to be just above the Paleocene-Eocene boundary because it is the first appearance datum for *Platycarya* pollen (Wing, 1984b). The composition of the flora at this level is very similar to typical Paleocene floras reported from the upper part of the Fort Union Formation (Brown, 1962; Hickey, 1977), with the addition of a few Eocene megafloral indicators such as *Lygodium kaulfussi* and *Cnemadaria magna*. The flora of this bed also clearly shows the effect of depositional environment on megafloral and palynofloral composition (Wing, 1981; Farley, 1987).

Four especially productive lenticular deposits are at localities NM37654 (311 m), NM37661 and SW882 (429 m), and NM37560 (468 m). Each of these floras has the floating aquatic species characteristic of pond assemblages as well as riparian elements. The number of species preserved in these deposits rises up through the section from 22 at the 311-m level, to 25 or 30 at the 429-m level, to approximately 35 at the 468-m level. As yet there are too few lenticular unit localities at each stratigraphic level to know if this relationship represents a true up-section increase in floral diversity.

A 1–3-m-thick tabular carbonaceous unit that crops out on the south side of Fifteenmile Creek (localities NM37669–NM37675, SW8826–SW8828, and others; 621-m level) is the most productive plant-fossil bed in the Willwood Formation. As of 1989 this bed had been traced to the east side of the Squaw Buttes Divide (pl. 1), documenting an east-west lateral extent of more than 11 km. The bed extends north-south at least 4.8 km, and if a similar bed on Tatman Mountain (pl. 1) proves to be the same unit, the north-south dimension would be increased to about 13 km. Over most of the outcrop area, this layer produces plant megafossils, and in some regions the preservation is excellent, with both cuticle and fine venation present on many specimens. Overall, the geometry and lithology of this bed are similar to those of tabular carbonaceous units in the lower part of the Willwood Formation, although the bed is thicker and more laterally extensive. The flora of the Fifteenmile Creek carbonaceous shale has more species than those of shale lower in the formation, both at individual localities and for the combined floras of whole beds. As with the lenticular beds, there is an indication of up-section increase in number of species even within similar depositional environments. The flora of this level includes several species (*Populus wyomingiana, Platycarya castaneopsis, Dalbergia* sp., and *Eugenia americana*) known from parts of the Wind River Formation (Wind River Basin) and Green River Formation (Green River Basin) in central and southern Wyoming that produce late Wasatchian mammal faunas.

The location and stratigraphic distribution of the most important Paleocene and Eocene fossil plant localities in the southern Bighorn Basin are given in table 20, and a preliminary list of the Willwood megaflora is presented in table 21.

REFERENCES CITED

Badgley, Catherine, 1989, A statistical assessment of last appearances in the fossil record of Eocene mammals, *in* Bown, T.M., and Rose, K.D., eds., Dawn of the age of mammals in the northern part of the Rocky Mountain interior, North America: Geological Society of America Special Paper 243, p. 153-168.

Badgley, Catherine, and Gingerich, P.D., 1988, Sampling and faunal turnover in Early Eocene mammals: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 63, p. 41–57.

Billings, M.P., 1965, Structural geology (2nd ed.): Englewood Cliffs, N.J., Prentice-Hall, 514 p.

Bookstein, F.L., Gingerich, P.D., and Kluge, A.G., 1977, Hierarchical linear modeling of the tempo and mode of evolution: Paleobiology, v. 4, p. 120–134.

Bown, T.M., 1974, Notes on some early Eocene anaptomorphine primates: Contributions to Geology, v. 13, p. 19–26.

_____1975, Paleocene and lower Eocene rocks in the Sand Creek-No Water Creek area, Washakie County, Wyoming: Wyoming Geological Association, 27th Annual Field Conference Guidebook, p. 55–61.

_____1977, Geology and mammalian paleontology of the Sand Creek facies, lower Willwood Formation (lower Eocene), Washakie County, Wyoming [abs.]: Dissertation Abstracts International, v. 38, p. 597.

_____1979, Geology and mammalian paleontology of the Sand Creek facies, lower Willwood Formation (lower Eocene), Washakie County, Wyoming: Geological Survey of Wyoming Memoir 2, 151 p.

_____1980, The Willwood Formation (lower Eocene) of the southern Bighorn Basin, Wyoming, and its mammalian fauna, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming: University of Michigan Museum Papers on Paleontology 24, p. 127–138.

_____1982, Geology, paleontology, and correlation of Eocene volcaniclastic rocks, southeast Absaroka Range, Hot Springs County, Wyoming: U.S. Geological Survey Professional Paper 1201-A, 75 p.

_____1984, Biostratigraphic significance of baselevel changes during deposition of the Willwood Formation (lower Eocene), Bighorn Basin, Wyoming [abs.]: Geological Society of America, Rocky Mountain Section Annual Meeting, Abstracts, v. 16, p. 216.

_____1985, Maturation sequences in lower Eocene alluvial paleosols, Willwood Formation, *in* Flores, R.M., and Harvey, M., eds., Field guidebook to modern and ancient fluvial systems in the United States: Third International Fluvial Sedimentology Conference, Fort Collins, Colo., Guidebook, p. 20–26.

Table 20. U.S. National Museum fossil plant localities in the Fort Union and Willwood Formations of the south-central Bighorn Basin, Wyoming.

[Localities NM37686 and NM37687 are in the Tatman Formation, and locality NM37627 is in the Fort Union Formation; all other localities are in the Willwood Formation. m, meter level; B, Bown section; S, Schankler-Wing section; K, Kraus section; EB, estimated into Bown section; ?, unknown. Localities are given to the nearest quarter section and shown on plate 1. All quadrangles have U.S. Geological Survey 7 ½-minute topographic maps at scale 1:24,000. Localities represent collecting efforts by S.L. Wing from 1976 to 1990]

Locality No.	Stratigraphic position	Location	Topographic quadrangle
NM37560	457 m B	SW¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
NM37627	-20 m S	SW¼ sec. 29, T. 51 N., R. 93 W.	Orchard Bench.
NM37638	100 m S	NE¼ sec. 31, T. 51 N., R. 93 W.	Orchard Bench.
NM37639	112 m S	SW¼ sec. 16, T. 50 N., R. 93 W.	Orchard Bench.
NM37640	112 m S	NE¼ sec. 29, T. 50 N., R. 93 W.	Orchard Bench.
NM37641	112 m S	SE¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench.
NM37643	112 m S	NE¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench.
NM37645	112 m S	NE¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench.
NM37648	112 m S	SE¼ sec. 17, T. 50 N., R. 93 W.	Orchard Bench.
NM37650	124 m S	SW¼ sec. 21, T. 50 N., R. 93 W.	Orchard Bench.
NM37654	311 m S	SE¼ sec. 34, T. 50 N., R. 94 W.	Jones Reservoir.
NM37655	312 m S	SW¼ sec. 25, T. 51 N., R. 95 W.	Jones Reservoir.
NM37656	353 m S	NW¼ sec. 1, T. 50 N., R. 95 W.	Jones Reservoir.
NM37661	420 m S	SE¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
NM37662	423 m K	NE¼ sec. 3, T. 50 N., R. 96 W.	Sheep Mountain.
NM37667	601 m S	NE¼ sec. 26, T. 49 N., R. 98 W.	Dead Indian Hill.
NM37668	601 m S	NE¼ sec. 26, T. 49 N., R. 98 W.	Dead Indian Hill.
NM37669	621 m S	SW¼ sec. 25, T. 49 N., R. 98 W.	Dead Indian Hill.
NM37672	621 m S	SE¼ sec. 31, T. 49 N., R. 97 W.	Dead Indian Hill.
NM37673	621 m S	SW¼ sec. 25, T. 49 N., R. 98 W.	Dead Indian Hill.
NM37674	621 m S	NE¼ sec. 35, T. 49 N., R. 98 W.	Dead Indian Hill.
NM37675	621 m S	SW¼ sec. 25, T. 49 N., R. 98 W.	Dead Indian Hill.
NM37677	626 m S	NW¼ sec. 6, T. 48 N., R. 97 W.	Dead Indian Hill.
NM37679	706 m S	SE¼ sec. 1, T. 48 N., R. 97 W.	Dead Indian Hill.
NM37680	706 m S	SE¼ sec. 1, T. 48 N., R. 97 W.	Dead Indian Hill.
NM37682	719 m S	SW¼ sec. 35, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
NM37683	719 m S	SE¼ sec. 35, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
NM37684	719 m S	SE¼ sec. 35, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
NM37685	719 m S	SW¼ sec. 35, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
NM37686	740 m S	SW¼ sec. 6, T. 49 N., R. 97 W.	Dead Indian Hill.
NM37687	740 m S	SW¼ sec. 6, T. 49 N., R. 97 W.	Dead Indian Hill.
SW881	?m	NE¼ sec. 31, T. 49 N., R. 97 W.	Dead Indian Hill.
SW882	?m	SW¼ sec. 15, T. 48 N., R. 94 W.	Schuster Flats NW.
SW8826	?m	NE¼ sec. 31, T. 49 N., R. 97 W.	Dead Indian Hill.
SW8827	?m	SE¼ sec. 31, T. 49 N., R. 97 W.	Dead Indian Hill.
SW8828	?m	SE¼ sec. 31, T. 49 N., R. 97 W.	Dead Indian Hill.
SW8831	344 m EB	NE¼ sec. 32, T. 48 N., R. 93 W.	Schuster Flats SE.

Table 21. Provisional megafloral taxa of the Willwood Formation, southern Bighorn Basin, Wyoming.

[Range is in meters above the contact of the Willwood Formation and the Fort Union Formation. A range bottom of 0 is assigned to species known to occur in rocks stratigraphically below the base of the Willwood Formation. Binomials within quotation marks refer to informal designations in Wing (1981) and are not validly published binomials. Generic names followed by queries indicate that the name is valid but the generic assignment is questionable; names in parentheses indicate alternative generic assignments that reflect other authors' interpretations of generic boundaries; and names within quotation marks are valid, but the assignment to this genus is incorrect. Taxa assigned to Roman numerals were cited as *incertae sedis* forms by Wing (1981), and names in parentheses following the Roman numerals are best guesses at familial assignments. Species names with an asterisk were not mentioned by Wing (1981). Continued collection of the flora of the Willwood Formation has resulted in an ever-increasing number of species. This list does not include at least 20 species of dicotyledonous leaves alone, and if fruits and flowers represent species not seen in the leaf flora, the total number of species not represented in this list could be as many as 50]

	Species	Range
1	Alismataceae? sp. ("Sparganium" stygium)	0-740
2	*Allantoidiopsis erosa*	0-719
3	*Alnus* sp. ("*Alnus atkinsii*" of Wing, 1981)	0-740
4	*Ampelopsis*? *acerifolia*	0-112
5	Apocynaceae sp. ("*Apocynophyllum palustrum*" of Wing, 1981)	621
6	*Averrhoites affinis*	0-706
7	*Azolla* sp.*	420
8	Betulaceae sp. ("*Catryla schankleri*" of Wing, 1981)	112-420
9	*Cercidiphyllum* (*Joffrea*?) genetrix	0-621
10	*Cnemidaria* (*Hemitelia*) *magna*	15-719
11	*Cornus hyperborea*	0-20
12	*Dalbergia*? sp. (Leguminosae)	
	Dicotyledones *incertae sedis*	468-621
13	I (Annonaceae?)	621-740
14	II	621
15	III (Magnoliaceae?)	601-719
16	IV	112
17	V	150
18	VI (Burseraceae?)	112-311
19	X	621-706
20	XI	621
21	XII (Magnoliaceae?)	621
22	XIV (Menispermaceae?)	468
23	XV (Cucurbitaceae?)	311
24	XVI (Sapindaceae?, Anacardiaceae?, Juglandaceae?)	420
25	XVII (Lauraceae?)	353-621
26	XVIII	150
27	XIX	420
28	XX (Leguminosae?, Sapindaceae?, Burseraceae?)	20-311
29	XXI (Tiliaceae?)	112
30	XXII (Lauraceae?)	621
31	XXIII (aff. *Zizyphus*)	353
32	XXIV (Aquifoliaceae?, Monimiaceae?)	150
33	XXV (Icacinaceae?, Malpighiaceae?)	621-719
34	XXVI	112
35	XXVII (Malvaceae?, Tiliaceae?, Sterculiaceae?)	621
36	*Dombeya*? *novi-mundi* (Malvaceae, Sterculiaceae, Tiliaceae)	311-740

Table 21. Provisional megafloral taxa of the Willwood Formation, southern Bighorn Basin, Wyoming—Continued.

	Species	Range
37	*Equisetum* sp.	0-740
38	*Eugenia*? *americana** (Myrtaceae)	621
39	*Fagopsis* cf. *undulata**	60-740
40	Flacourtiaceae sp. 1 ("*Idesia canutaurensis*" of Wing, 1981)	150
41	Flacourtiaceae sp. 2 ("*Populus*" *wyomingiana*)*	621
42	Flacourtiaceae sp. 3 ("*Salix paucisecondaria*" of Wing, 1981)	420
43	*Ginkgo adiantoides*	0-420
44	*Glyptostrobus europaeus*	0-621
45	Hamamelidaceae sp. ("*Churchillia crenata*" of Wing, 1981)	0-353
46	Juglandaceae sp. 1 (aff. "*Carya*" *antiquorum*)	0-353
47	Juglandaceae sp. 2 ("*Vinea basinensis*" of Wing (1981)	420
48	Leguminosae sp. 1 ("*Leguminosites alcerivalis*" of Wing, 1981)	420
49	Leguminosae sp. 2 (DICOT IX of Wing, 1981)	468
50	Leguminosae sp. 3 (DICOT VIII of Wing, 1981)	468
51	Leguminosae sp. 4 (DICOT VII of Wing, 1981)	420
52	Leguminosae sp. 5 (microphyllous)*	468
53	*Lygodium kaulfussi*	112-740
54	"*Meliosma*" *longifolia* (Platanaceae)	0-311
55	Menispermaceae sp. ("*Menispermites afevius*" of Wing, 1981)	150
56	*Menispermites parvareolatus*	0-429
57	*Metasequoia occidentalis*	0-353
58	Palmae *incertae sedis* (indeterminable palm)	0-740
59	Palmae *incertae sedis* (indeterminable fan palm)	0-740
60	*Penosphyllum cordatum*	0-30
61	*Persites arqutus*	0-112
62	*Phoebe*? sp. (Lauraceae)	10-353
63	*Platanus* (*Macqinitiea*) *brownii*	420
64	*Platanus* cf. *quillelmae*	420-601?
65	*Platanus* (*Macqinitiea*) *gracilis*	0-621
66	*Platanus raynoldsii*	0-626
67	*Platycarya castaneopsis*	621-740
68	*Polyptera* sp.*	100
69	*Populus* cf. *meeqsii*	112-740
70	*Potamogeton* sp. 1	10
71	*Potamogeton* sp. 2*	420-468
72	Pteropsida *incertae sedis* (indeterminate fern of Wing, 1981)	621
73	*Salvinia preauriculata*	100-621
74	Sapindaceae sp. (*Acer*-like samaras)	0-353
75	*Schoepfia*? cf. *republicensis* (*Acrovena laevis* of Wing, 1981)	621
76	*Spirodela magna*	420
77	Theaceae sp. 1 (DICOT XXVIII of Wing, 1981)	621
78	*Thelypteris iddingsii*	621-740
79	*Thelypteris weedii**	621-740
80	aff. *Typha*	0-740
81	*Ulmus* (*Chaetoptelea*) *microphyllum*	0-353
82	*Woodwardia gravida*	0-112
83	*Zingiberopsis isonervosa*	0-740

_____1987, The mammalian pedofacies; a novel approach to detailed vertico-lateral and temporal controls in vertebrate facies distribution and mammalian evolution [abs.]: Geological Society of America, Rocky Mountain Section, 40th Annual Meeting, Abstracts with Programs, v. 19, no. 5, p. 262.

Bown, T.M., and Beard, K.C., 1990, Systematic lateral variation in the distribution of fossil mammals in alluvial paleosols, lower Eocene Willwood Formation, Wyoming: *in* Bown, T.M., and Rose, K.D., eds., Dawn of the age of mammals in the northern part of the Rocky Mountain interior, North America: Geological Society of America Special Paper 243, p. 135–151.

Bown, T.M., and Kraus, M.J., 1981a, Lower Eocene alluvial paleosols (Willwood Formation, northwest Wyoming, U.S.A.) and their significance for paleoecology, paleoclimatology, and basin analysis: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 34, no. 1–2, p. 1–30.

_____1981b, Vertebrate fossil-bearing paleosol units (Willwood Formation, lower Eocene, northwest Wyoming, U.S.A.)—Implications for taphonomy, biostratigraphy, and assemblage analysis: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 34, p. 31–56.

_____1983, Ichnofossils of the alluvial Willwood Formation (lower Eocene), Bighorn Basin, northwest Wyoming, U.S.A.: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 43, p. 95–128.

_____1987, Integration of channel and floodplain suites, I. Developmental sequence and lateral relations of alluvial paleosols: Journal of Sedimentary Petrology, v. 57, p. 587–601.

_____ 1993, Time-stratigraphic reconstruction and integration of paleopedologic, sedimentologic, and biotic events (Willwood Formation, lower Eocene, northwest Wyoming, U.S.A.): Palaios, v. 8, p. 68–80.

Bown, T.M., Kraus, M.J., and Middleton, L.T., 1983, Triassic fluvial systems, Chinle Formation, Petrified Forest National Park, Arizona [abs]: Museum of Northern Arizona, Abstract Symposium on Southwestern Geology and Paleontology, p. 2.

Bown, T.M., Kraus, M.J., and Rose, K.D., 1991, Temporal holostrome reconstruction of the Willwood Formation and the reapportionment of paleopedologic, sedimentologic, and paleobiologic events in time [abs.]: Journal of Vertebrate Paleontology, v. 11 (supplement to no. 3), p. 17A.

Bown, T.M., and Larriestra, C.N., 1990, Sedimentary paleoenvironments of fossil platyrrhine localities, Miocene Pinturas Formation, Santa Cruz Province, Argentina: Journal of Human Evolution, v. 19, p. 87–119.

Bown, T.M., and Rose, K.D., 1976, New Early Tertiary primates and a reappraisal of some Plesiadapiformes: Folia Primatologica, v. 26, p. 109–138.

_____1979, *Mimoperadectes*, a new marsupial, and *Worlandia*, a new dermopteran, from the lower part of the Willwood Formation (early Eocene), Bighorn Basin, Wyoming: University of Michigan Museum of Paleontology Contributions, v. 25, no. 4, p. 89–104.

_____1984, Reassessment of some early Eocene Omomyidae, with description of a new genus and three new species: Folia Primatologica, v. 43, p. 97–112.

_____1987, Patterns of dental evolution in early Eocene Anaptomorphine primates (Omomyidae) from the Bighorn Basin, Wyoming: Paleontological Society Memoir 23, 162 p.

_____1991, Evolutionary relationships of a new genus and three new species of omomyid primates (Willwood Formation, lower Eocene, Bighorn Basin, Wyoming): Journal of Human Evolution, v. 20, p. 465-480.

Bown, T.M., Rose, K.D., and Kraus, M.J., 1992, Relation of extinctions and immigrations of Omomyidae and other mammals to paleosol type, sediment accumulation rates, and tectonics [abs.]: American Journal of Physical Anthropology, v. 87 (supplement to no. 4), p. 52.

Bown, T.M., and Schankler, David, 1982, A review of the Proteutheria and Insectivora of the Willwood Formation (lower Eocene), Bighorn Basin, Wyoming: U.S. Geological Survey Bulletin 1523, 79 p.

Brown, R.W., 1962, Paleocene flora of the Rocky Mountains and Great Plains: U.S. Geological Survey Professional Paper 375, 119 p.

Burnham, R.J., and Wing, S.L., 1989, Temperate forest litter accurately reflects stand composition and structure: American Journal of Botany, v. 76, p. 159.

Butler, R.F., Gingerich, P.D., and Lindsay, E.H., 1981, Magnetic polarity stratigraphy and biostratigraphy of Paleocene and lower Eocene continental deposits, Clark's Fork Basin, Wyoming: Journal of Geology, v. 89, p. 299–316.

Carroll, R.L., 1967, Labyrinthodonts from the Joggins Formation: Journal of Paleontology, v. 41, p. 111–142.

Cope, E.D., 1882a, Contributions to the history of the Vertebrata of the lower Eocene of Wyoming and New Mexico, made during 1881—I. The fauna of the Wasatch beds of the Big Horn River. II. The fauna of the *Catathlaeus* beds, or lowest Eocene, New Mexico: American Philosophical Society Proceedings, v. 20, p. 139–197.

_____1882b, Notes on Eocene Mammalia: American Naturalist, v. 16, p. 522.

_____1884, The Vertebrata of the Tertiary Formations of the West, Book I: Washington, D.C., United States Geological and Geographical Survey of the Territories (Hayden), Report 3, 1,009 p.

Emry, R.J., 1973, Stratigraphy and preliminary biostratigraphy of the Flagstaff Rim area, Natrona County, Wyoming: Smithsonian Contributions to Paleobiology 12, 43 p.

Farley, M.B., 1987, Sedimentological and paleoecologic importance of palynomorphs in Paleogene nonmarine depositional environments, central Bighorn Basin, Wyoming: University Park, Pa., Pennsylvania State University Ph.D. dissertation, 215 p.

_____1989, Palynological facies fossils in nonmarine environments in the Paleogene of the Bighorn Basin, Wyoming: Palaios, v. 4, p. 565–573.

Gingerich, P.D., 1974, Stratigraphic record of early Eocene *Hyopsodus* and the geometry of mammalian phylogeny: Nature, v. 248, p. 107–109.

_____1976, Paleontology and phylogeny—Patterns of evolution at the species level in Early Tertiary mammals: American Journal of Science, v. 276, p. 1–28.

_____1977, Patterns of evolution in the mammalian fossil record, *in* Hallam, A., ed., Patterns of evolution: Amsterdam, Elsevier Scientific Publishing Co., p. 469–500.

_____1980a, History of Early Cenozoic vertebrate paleontology in the Bighorn Basin, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin,

Wyoming: University of Michigan Museum, Papers on Paleontology 24, p. 1–6.

_____1980b, Evolutionary patterns in Early Cenozoic mammals: Annual Review of Earth and Planetary Sciences, v. 8, p. 407–424.

_____1981, Early Cenozoic Omomyidae and the evolutionary history of Tarsiiform primates: Journal of Human Evolution, v. 10, p. 345–374.

_____1982, Studies on Paleocene and early Eocene Apatemyidae (Mammalia, Insectivora), II. *Labidolemur* and *Apatemys* from the early Wasatchian of the Clarks Fork Basin, Wyoming: University of Michigan Museum of Paleontology Contributions, v. 26, p. 49–69.

_____1983a, Origin and evolution of species—Evidence from the fossil record, *in* Chaline, J., ed., Prétirage/Modalités, rythmes, et mécanismes de l'évolution biologique: France, Colloques internationaux du C.N.R.S., no. 33, p. 85–92.

_____1983b, Paleocene-Eocene faunal zones and a preliminary analysis of Laramide structural deformation in the Clarks Fork Basin, Wyoming: Wyoming Geological Association, 34th Annual Field Conference Guidebook, p. 185–195.

_____1983c, Systematics of early Eocene Miacidae (Mammalia, Carnivora) in the Clarks Fork Basin, Wyoming: University of Michigan Museum of Paleontology Contributions, v. 26, p. 197–225.

_____1986, Early Eocene *Cantius torresi*—oldest primate of modern aspect from North America: Nature, v. 319, p. 319–321.

_____1987, Early Eocene bats (Mammalia, Chiroptera) and other vertebrates in freshwater limestones of the Willwood Formation, Clark's Fork Basin, Wyoming: University of Michigan Museum of Paleontology Contributions, v. 27, p. 275–320.

Gingerich, P.D., and Gunnell, G.F., 1979, Systematics and evolution of the genus *Esthonyx* (Mammalia, Tillodontia) in the early Eocene of North America: University of Michigan Museum of Paleontology Contributions, v. 25, p. 125–153.

Gingerich, P.D., and Klitz, Karen, 1985, University of Michigan Paleocene and Eocene fossil localities in the Fort Union and Willwood Formations, Clark's Fork Basin, Wyoming: University of Michigan Museum of Paleontology, map, 1 sheet, scale approximately 1:62,500.

Gingerich, P.D., Rose, K.D., and Krause, D.W., 1980, Early Cenozoic mammalian faunas of the Clark's Fork Basin-Polecat Bench area, northwestern Wyoming, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming: University of Michigan Museum, Papers on Paleontology 24, p. 51–68.

Gingerich, P.D., and Simons, E.L., 1977, Systematics, phylogeny, and evolution of early Eocene Adapidae (Mammalia, Primates) in North America: University of Michigan Museum of Paleontology Contributions, v. 24, p. 245–279.

Granger, Walter, 1914, On the names of lower Eocene faunal horizons of Wyoming and New Mexico: American Museum of Natural History Bulletin, v. 33, p. 201–207.

Gunnell, G.F., 1985, Systematics of early Eocene Microsyopinae (Mammalia, Primates) in the Clark's Fork Basin, Wyoming: University of Michigan Museum of Paleontology Contributions, v. 27, p. 51–71.

_____1986, Evolutionary history of Microsyopoidea (Mammalia, Primates?) and the relationship of Plesiadapiformes to Primates. Volume 1: Ann Arbor, University of Michigan Ph.D. dissertation, 612 p.

Gunnell, G.F., and Gingerich, P.D., 1981, A new species of *Niptomomys* (Microsyopidae) from the early Eocene of Wyoming: Folia Primatologica, v. 36, p. 128–137.

Hewett, D.F., 1926, Geology and oil and coal resources of the Oregon Basin, Meeteetse, and Grass Creek Basin quadrangles, Wyoming: U.S. Geological Survey Professional Paper 145, 111 p.

Hickey, L.J., 1977, Stratigraphy and paleobotany of the Golden Valley Formation (early Tertiary) of western North Dakota: Geological Society of America Memoir 150, 181 p.

Hutchison, J.H., 1980, Turtle stratigraphy of the Willwood Formation, Wyoming, preliminary results, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming: University of Michigan Museum, Papers on Paleontology 24, p. 115–118.

International Subcommission on Stratigraphic Classification of IUGS Commission on Stratigraphy, H.D. Hedberg, ed., 1976, International stratigraphic guide: New York, John Wiley and Sons, 200 p.

Jepsen, G.L., 1930, New vertebrate fossils from the lower Eocene of the Bighorn Basin, Wyoming: American Philosophical Society Proceedings, v. 69, p. 117–131.

Johnson, K.R., 1989, A high-resolution megafloral biostratigraphy spanning the Cretaceous-Tertiary boundary in the northern Great Plains: New Haven, Conn., Yale University Ph.D. dissertation, 556 p.

Kraus, M.J., 1980, Genesis of a fluvial sheet sandstone, Willwood Formation, northwest Wyoming, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming: University of Michigan Museum, Papers on Paleontology 24, p. 87–94.

_____1985, Sedimentology of Early Tertiary rocks, northern Bighorn Basin, *in* Flores, R.M., and Harvey, M., eds., Field guidebook to modern and ancient fluvial systems in the United States: Third International Fluvial Sedimentology Conference, Fort Collins, Colo., Guidebook, p. 26–33.

_____1987, Integration of channel and floodplain suites, II. Vertical relations of alluvial paleosols: Journal of Sedimentary Petrology, v. 57, p. 602–612.

_____1988, Nodular remains of Early Tertiary forests, Bighorn Basin, Wyoming: Journal of Sedimentary Petrology, v. 58, p. 888–893.

_____in press, Lineament control on fluvial sedimentation patterns as determined from remote-sensing: Sedimentology.

Kraus, M.J., and Bown, T.M., 1986, Paleosols and time resolution in alluvial stratigraphy, *in* V.P. Wright, ed., Paleosols—Their recognition and interpretation: London, Blackwell Scientific Publications, p. 180–207.

_____1988, Pedofacies analysis; a new approach to reconstructing ancient fluvial sequences, *in* Reinhardt, J., and Siglio, W.R., eds., Paleosols and weathering through geologic time: Geological Society of America Special Paper 216, p. 143–152.

_____ 1993, Short-term sediment accumulation rates determined from Eocene alluvial paleosols: Geology, v. 21, p. 743–746.

Kraus, M.J., and Middleton, L.T., 1987, Dissected paleotopography and base-level changes in a Triassic fluvial sequence: Geology, v. 15, p. 18–21.

Love, J.D., and Christiansen, A.C., compilers, 1985, Geologic map of Wyoming: Washington, D.C., U.S. Geological Survey, scale 1:500,000, 3 sheets.

Matthew, W.D., 1899, A provisional classification of the fresh-water Tertiary of the West: American Museum of Natural History Bulletin, v. 12, p. 19–75.

Matthew W.D., and Granger, Walter, 1915, A revision of the lower Eocene Wasatch and Wind River faunas. Part I. Order Ferae (Carnivora). Suborder Creodonta; Part II. Order Condylarthra, Family Hyopsodontidae; Part IV. Entelonychia, Primates, Insectivora (part): American Museum of Natural History Bulletin, v. 34, p. 4–103, 311–328, 429–483.

_____1918, A revision of the lower Eocene Wasatch and Wind River faunas. Part V. Insectivora (continued), Glires, Edentata: American Museum of Natural History Bulletin, v. 38, p. 565–660.

May, R.M., 1976, Patterns in multi-species communities, *in* May, R.M., ed., Theoretical ecology: Oxford, England, Blackwell Scientific Publications, p. 142–162.

Neasham, J.W., 1967, The stratigraphy of the Willwood Formation in the vicinity of Sheep Mountain, southwestern Big Horn County, Wyoming: Ames, Iowa, Iowa State University M.S. thesis, 74 p.

_____1970, Sedimentology of the Willwood Formation (lower Eocene); an alluvial molasse facies in northwestern Wyoming: Ames, Iowa, Iowa State University Ph.D. dissertation, 98 p.

Neasham, J.W., and Vondra, C.F., 1972, Stratigraphy and petrology of the lower Eocene Willwood Formation, Bighorn Basin, Wyoming: Geological Society of America Bulletin, v. 83, p. 2167–2180.

Osborn, H.F., 1898, A complete skeleton of *Coryphodon radians*; notes upon the locomotion of this animal: American Museum of Natural History Bulletin, v. 10, p. 81–91.

_____1900, Correlation between Tertiary mammal horizons of Europe and America; an introduction to the more exact investigation of Tertiary zoogeography: New York Academy of Sciences Annals, v. 13, p. 1–72.

_____1909, Cenozoic mammal horizons of western North America: U.S. Geological Survey Bulletin 361, 138 p.

_____1929, The titanotheres of ancient Wyoming, Dakota, and Nebraska: U.S. Geological Survey Monograph 55 (2 v.), 953 p.

Peet, R.K., 1974, The measurement of species diversity: Annual Review of Ecology and Systematics, v. 5, p. 285–307.

Radinsky, L.B., 1963, Origin and early evolution of North American Tapiroidea: Yale Peabody Museum of Natural History Bulletin 17, 106 p.

_____1964, *Paleomoropus*, a new early Eocene chalicothere (Mammalia, Perissodactyla), and a revision of Eocene chalicotheres: American Museum Novitates, no. 2179, 28 p.

Rensberger, J.M., 1971, Entoptychine pocket gophers (Mammalia, Geomyoidea) of the early Miocene John Day Formation, Oregon: University of California Publications in Geological Sciences, v. 90, 209 p.

_____1973, Pleurolicine rodents (Geomyoidea) of the John Day Formation, Oregon, and their relationships to taxa from the early and middle Miocene, South Dakota: University of California Publications in Geological Sciences, v. 102, 95 p.

Rose, K.D., 1981a, The Clarkforkian land-mammal age and mammalian faunal composition across the Paleocene-Eocene boundary: University of Michigan Museum, Papers on Paleontology 26, 197 p.

_____1981b, Composition and species diversity in Paleocene and Eocene mammal assemblages—an empirical study: Journal of Vertebrate Paleontology, v. 1, p. 367–388.

_____1982, Skeleton of *Diacodexis*, oldest known artiodactyl: Science, v. 216, p. 621–623.

_____1985, Comparative osteology of North American dichobunid artiodactyls: Journal of Paleontology, v. 59, p. 1203–1226.

_____1987, Climbing adaptations in the early Eocene mammal *Chriacus* and the origin of Artiodactlya: Science, v. 236, p. 314–316.

_____1990, Postcranial skeletal remains and adaptations in early Eocene mammals from the Willwood Formation, Bighorn Basin, Wyoming, *in* Bown, T.M., and Rose, K.D., eds., Dawn of the age of mammals in the northern part of the Rocky Mountain interior: Geological Society of America Special Paper 243, p. 107–133.

Rose, K.D., and Bown, T.M., 1984, Gradual phyletic evolution at the generic level in early Eocene omomyid primates: Nature, v. 309, p. 250–252.

_____1986, Gradual evolution and species discrimination in the fossil record, *in* Flanagan, K.M., and Lillegraven, J.A., eds., Vertebrates, phylogeny, and philosophy: Contributions to Geology Special Paper 3, p. 119–130.

_____1991, New fossil evidence on differentiation of the earliest Euprimates: National Academy of Sciences Proceedings, v. 88, p. 98-101.

Rose, K.D., Bown, T.M., and Simons, E.L., 1977, An unusual new mammal from the early Eocene of Wyoming: Postilla, no. 172, p. 1–10.

Rose, K.D., and Walker, Alan, 1985, The skeleton of early Eocene *Cantius*, oldest lemuriform primate: American Journal of Physical Anthropology, v. 66, p. 73–89.

Savage, D.E., Waters, B.T., and Hutchison, J.H., 1972, Wasatchian succession at Bitter Creek Station, northwestern border of the Washakie Basin, Wyoming, *in* West, R.M., ed., Society of Vertebrate Paleontology field conference on Tertiary biostratigraphy of southern and western Wyoming: Unpublished report available from Society of Vertebrate Paleontology archives, p. 32–39.

Schankler, David, 1980, Faunal zonation of the Willwood Formation in the central Bighorn Basin, Wyoming, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming: University of Michigan Museum, Papers on Paleontology 24, p. 99–114.

_____1981, Local extinction and ecological re-entry of early Eocene mammals: Nature, v. 293, p. 135–138.

Sinclair, W.J., and Granger, Walter, 1911, Eocene and Oligocene of the Wind River and Bighorn Basins: American Museum of Natural History Bulletin, v. 30, p. 83–117.

_____1912, Notes on the Tertiary deposits of the Bighorn Basin: American Museum of Natural History Bulletin, v. 31, p. 57–67.

Skinner, M.F., and Johnson, F.W., 1984, Tertiary stratigraphy and the Frick Collection of fossil vertebrates from north-central Nebraska: American Museum of Natural History Bulletin, v. 178, p. 215–368.

Skinner, M.F., Skinner, S.M., and Gooris, R.J., 1977, Stratigraphy and biostratigraphy of Late Cenozoic deposits in central Sioux

County, western Nebraska: American Museum of Natural History Bulletin, v. 158, p. 263–370.

Stevens, J.B., Stevens, M.S., and Wilson, J.A., 1984, Devil's Graveyard Formation (new), Eocene and Oligocene age, Trans-Pecos Texas: Texas Memorial Museum Bulletin 32, 21 p.

Stucky, R.K., 1984a, Revision of the Wind River faunas, early Eocene of central Wyoming. Part 5. Geology and biostratigraphy of the upper part of the Wind River Formation, northeastern Wind River basin: Carnegie Museum Annals, v. 53, p. 231–294.

_____1984b, Revision of the Wind River faunas, early Eocene of central Wyoming. Part 6. Stratigraphic sections and locality descriptions, upper part of the Wind River Formation: Carnegie Museum Annals, v. 53, p. 295–325.

Tedford, R.H., 1970, Principles and practices of mammalian geochronology in North America: North American Paleontological Convention, Proceedings, v. F, p. 666–703.

Van Houten, F.B., 1944, Stratigraphy of the Willwood and Tatman Formations in northwestern Wyoming: Geological Society of America Bulletin, v. 55, p. 165–210.

_____1945, Review of latest Paleocene and early Eocene mammalian faunas: Journal of Paleontology, v. 19, p. 421–461.

_____1948, Origin of red-banded Early Cenozoic deposits in the Rocky Mountain region: American Association of Petroleum Geologists Bulletin, v. 32, p. 2083–2126.

Walker, Alan, and Teaford, M.F., 1989, The hunt for *Proconsul*: Scientific American, v. 260, p. 76–82.

Walker, Alan, Teaford, M.F., and Leakey, R.F., 1986, New information concerning the R114 *Proconsul* site, Rusinga Island, Kenya, *in* Else, J.G., and Lee, P.C., eds., 10th Congress of the International Primatological Society Proceedings, v. 1: Cambridge, England, Cambridge University Press, p. 143–149.

West, R.M., 1973, Geology and mammalian paleontology of the New Fork-Big Sandy area, Sublette County, Wyoming: Fieldiana (Geology), v. 29, 193 p.

_____1979, Apparent prolonged evolutionary stasis in the middle Eocene hoofed mammal *Hyopsodus*: Paleobiology, v. 5, no. 3, p. 252–260.

Wheeler, H.E., 1958, Time-stratigraphy: American Association of Petroleum Geologists Bulletin, v. 42, p. 1047–1063.

Whittaker, R.H., 1972, Evolution and measurement of species diversity: Taxon, v. 21, p. 213–251.

_____1977, Evolution of species diversity in land communities: Evolutionary Biology, v. 10, p. 1–67.

Wilson, J.A., 1977, Stratigraphic occurrence and correlation of early Tertiary vertebrate faunas, Trans-Pecos Texas. Part 1. Vieja area: Texas Memorial Museum Bulletin 25, 42 p.

_____1986, Stratigraphic occurrence and correlation of early Tertiary vertebrate faunas, Trans-Pecos Texas—Agua Fria-Green Valley areas: Journal of Vertebrate Paleontology, v. 6, p. 350–373.

Wing, S.L., 1980, Fossil floras and plant-bearing beds of the central Bighorn Basin, *in* Gingerich, P.D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming: University of Michigan Museum, Papers on Paleontology 24, p. 119–126.

_____1981, A study of paleoecology and paleobotany in the Willwood Formation (early Eocene, Wyoming): New Haven, Conn., Yale University Ph.D. dissertation, 391 p.

_____1984a, Relation of paleovegetation to geometry and cyclicity of some fluvial carbonaceous deposits: Journal of Sedimentary Petrology, v. 54, p. 52–66.

_____1984b, A new basis for recognizing the Paleocene-Eocene boundary in Western Interior North America: Science, v. 226, p. 439–441.

Wing, S.L., and Bown, T.M., 1985, Fine scale reconstruction of late Paleocene-early Eocene paleogeography in the Bighorn Basin of northern Wyoming, *in* Flores, R.M., and Kaplan, S.S., eds., Cenozoic paleogeography of west-central United States: Denver, Silers, p. 93–105.

Wing, S.L., Bown, T.M., and Obradovich, J.D., 1991, Early Eocene biotic and climatic change in interior western North America: Geology, v. 19, p. 1189-1192.

Winkler, D.A., 1983, Paleoecology of an early Eocene mammalian fauna from paleosols in the Clarks Fork Basin, northwestern Wyoming (U.S.A.): Palaeogeography, Palaeoclimatology, Palaeoecology, v. 43, p. 261–298.

Wolfe, J.A., and Poore, R.Z., 1982, Tertiary marine and nonmarine climatic trends, *in* Climate and earth history, studies in geophysics: Washington, D.C., National Academy Press, p. 154–158.

Wood, H.E., II, Chaney, R.W., Clark, John, Colbert, E.H., Jepsen, G.L., Reeside, J.B., Jr., and Stock, Chester, 1941, Nomenclature and correlation of the North American continental Tertiary: Geological Society of America Bulletin, v. 52, p. 1–48.

Woodburne, M.O., ed., 1987, Cenozoic mammals of North America; geochronology and biostratigraphy: Berkeley, University of California Press, 336 p.

Wyoming Geological Association, 1968, Tertiary well-logs in all Wyoming basins; Log #4, Washakie County, Gulf Oil Corporation, #1, Teeters: Wyoming Geological Association, well log, 1 sheet.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming.

[All localities are in the Willwood Formation except D1578 and D1580. m, meter level (minus values denote position beneath top of Fort Union Formation); B, Bown sections; S, Schankler-Wing sections; K, Kraus sections; E, stratigraphic position estimated during Bown's sectioning; EB, into Bown sections; EK, into Kraus sections; ES, into Schankler-Wing sections; ?, unknown. Localities are given to the nearest quarter section and are shown on plates 1 and 2. Names of topographic quadrangles in which the localities occur follow locality information. All are U.S. Geological Survey 7 ½-minute topographic maps at scale 1:24,000, unless otherwise indicated. Names in parentheses following the quadrangle names are other names by which the localities are known or equivalent localities established by other institutions. Localities represent collecting efforts of the U.S. Geological Survey in 1977–79 and of the joint U.S. Geological Survey-Johns Hopkins University School of Medicine expeditions from 1980 to 1992]

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1128	470 m B	NW¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam.
D1136	?m	NW¼ sec. 28, T. 54 N., R. 100 W.	Vocation.
D1137	?m	SW¼ sec. 22, T. 54 N., R. 100 W.	Vocation.
D1138	?m	SW¼ sec. 22, T. 54 N., R. 100 W.	Vocation.
D1139	?m	SW¼ sec. 22, T. 54 N., R. 100 W.	Vocation.
D1140	?m	SE¼ sec. 29, T. 54 N., R. 100 W.	Vocation.
D1141	290 m ES	SW¼ sec. 32, T. 51 N., R. 94 W.	Jones Reservoir.
D1142	275 m EB	SW¼ sec. 32, T. 51 N., R. 94 W.	Jones Reservoir.
D1143	280 m ES	NE¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
D1144	285 m ES	SW¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
D1145	300 m EB	SE¼ sec. 36, T. 51 N., R. 95 W.	Jones Reservoir.
D1146	300 m EB	SW¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
D1147	?m	NE¼ sec. 24, T. 54 N., R. 100 W.	Ralston Reservoir.
D1148	?m	NW¼ sec. 33, T. 53 N., R. 99 W.	Stone Barn Camp.
D1149	?m	SE¼ sec. 33, T. 53 N., R. 99 W.	Stone Barn Camp.
D1150	?m	SE¼ sec. 1, T. 54 N., R. 99 W.	Gilmore Hill NW.
D1151	?m	SW¼ sec. 1, T. 54 N., R. 99 W.	Gilmore Hill NW.
D1152	?m	NE¼ sec. 11, T. 54 N., R. 99 W.	Gilmore Hill NW.
D1153	?m	NW¼ sec. 15, T. 53 N., R. 100 W.	Corbet Dam.
D1154	?m	NE¼ sec. 11, T. 47 N., R. 95 W.	Schuster Flats.
D1155	?m	NW¼ sec. 4, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1156	482 m B	SW¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1157	478 m B	NW¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1158	482 m B	SW¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1159	482 m B	SW¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1160	470 m B	NW¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam.
D1160N	470 m B	SW¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
D1161	472 m EB	SW¼ sec. 18, T. 48 N., R. 95 W.	Sucker Dam.
D1162	481 m S	SW¼ sec. 34, T. 49 N., R. 96 W.	Dutch Nick Flat NW (*Chriacus* locality).
D1163	491 m EB	SW¼ sec. 5, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1164	476 m B	SE¼ sec. 34, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1165	486 m EB	NW¼ sec. 5, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1166	481 m ES	SW¼ sec. 33, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1167	511 m B	NW¼ sec. 31, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1168	?m	SE¼ sec. 8, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1169	491 m EB	SW¼ sec. 5, T. 48 N., R. 96 W.	Dutch Nick Flat NW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1170	531 m ES	NE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1171	526 m EB	NE¼ sec. 36, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1172	556 m EB	SE¼ sec. 36, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1173	536 m EB	NE¼ sec. 36, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1174	501 m ES	NE¼ sec. 13, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1175	501 m ES	SE¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1176	511 m EB	SW¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1177	481 m B	NE¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam (Purple Hills).
D1178	160 m S	SE¼ sec. 30, T. 50 N., R. 93 W.	Orchard Bench.
D1179	?m	SW¼ sec. 35, T. 54 N., R. 97 W.	Gilmore Hill SE.
D1180	?m	NW¼ sec. 5, T. 53 N., R. 96 W.	Emblem.
D1181	?m	NW¼ sec. 35, T. 54 N., R. 96 W.	Emblem.
D1182	?m	SW¼ sec. 3, T. 50 N., R. 94 W.	Jones Reservoir.
D1183	290 m ES	SW¼ sec. 25, T. 51 N., R. 95 W.	Jones Reservoir.
D1184	?m	SW¼ sec. 15, T. 51 N., R. 94 W.	Gould Butte (Deerfly locality).
D1185	?m	NW¼ sec. 14, T. 51 N., R. 94 W.	Gould Butte.
D1186	?m	SW¼ sec. 18, T. 46 N., R. 94 W.	Chimney Gulch.
D1187	?m	NW¼ sec. 30, T. 46 N., R. 94 W.	Chimney Gulch.
D1188	140 m EB	SE¼ sec. 29, T. 50 N., R. 93 W.	Orchard Bench.
D1189	175 m EB	NE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.
D1190	130 m S	SE¼ sec. 29, T. 50 N., R. 93 W.	Orchard Bench.
D1191	130 m EB	NE¼ sec. 29, T. 50 N., R. 93 W.	Orchard Bench.
D1192	170 m S	NE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.
D1193	170 m S	SE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.
D1194	140 m EB	SW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
D1195	140 m EB	NE¼ sec. 30, T. 50 N., R. 93 W.	Orchard Bench.
D1196	?m	NW¼ sec. 34, T. 47 N., R. 94 W.	Schuster Flats SE.
D1197	481 m S	NE¼ sec. 10, T. 48 N., R. 96 W.	Sucker Dam.
D1198A	470 m B	NW¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam.
D1198B	470 m B	NW¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam (equal to Y45).
D1198C	470 m B	SW¼ sec. 5, T. 48 N., R. 95 W.	Sucker Dam (equal to Y45).
D1198D	470 m B	SW¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam.
D1198E	470 m B	NE¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam.
D1198F	470 m B	NW¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam.
D1198G	470 m B	NE¼ sec. 5, T. 48 N., R. 95 W.	Sucker Dam.
D1198H	470 m B	NW¼ sec. 5, T. 48 N., R. 95 W.	Sucker Dam.
D1199	10 m EB	NE¼ sec. 27, T. 47 N., R. 91 W.	Worland SE.
D1200	370 m B	NW¼ sec. 3, T. 47 N., R. 94 W.	Schuster Flats.
D1201	344 m B	NE¼ sec. 6, T. 48 N., R. 93 W.	Schuster Flats NE.
D1201N	344 m B	NE¼ sec. 6, T. 48 N., R. 93 W.	Schuster Flats NE.
D1202	324 m EB	NW¼ sec. 30, T. 49 N., R. 93 W.	Schuster Flats NE (equal to Y133).
D1203	438 m B	SE¼ sec. 7, T. 48 N., R. 94 W.	Schuster Flats NW (Rose Flats).

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1204	444 m B, upper; 442 m B, middle; 438 m B, lower.	NW¼ sec. 8, T. 48 N., R. 94 W.	Schuster Flats NW (Kraus Flats Bonanza).
D1205	356 m B	SE¼ sec. 34, T. 48 N., R. 94 W.	Schuster Flats SE.
D1206	438 m EB	NW¼ sec. 15, T. 48 N., R. 94 W.	Schuster Flats NE.
D1207	448 m B	SE¼ sec. 6, T. 48 N., R. 94 W.	Schuster Flats NW.
D1208	438 m B	SW¼ sec. 5, T. 48 N., R. 94 W.	Schuster Flats NW.
D1209	452 m B	NE¼ sec. 6, T. 48 N., R. 94 W.	Schuster Flats NW.
D1210	458 m EB	SW¼ sec. 29, T. 49 N., R. 94 W.	Schuster Flats NW.
D1211	?m	SW¼ sec. 27, T. 54 N., R. 96 W.	Jack Horner Reservoir.
D1212	546 m EB	NE¼ sec. 27, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1213	?m	SW¼ sec. 6, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1214	?m	NW¼ sec. 6, T. 49 N., R. 96 W.	Sheep Mountain.
D1215	?m	NW¼ sec. 5, T. 49 N., R. 96 W.	Sheep Mountain.
D1216	380 m B	NW¼ sec. 33, T. 48 N., R. 94 W.	Schuster Flats.
D1217	412 m B	NE¼ sec. 20, T. 48 N., R. 94 W.	Schuster Flats.
D1218	392 m B	SW¼ sec. 28, T. 48 N., R. 94 W.	Schuster Flats.
D1219	392 m B	SW¼ sec. 21, T. 48 N., R. 94 W.	Schuster Flats.
D1220	370 m B	SE¼ sec. 33, T. 48 N., R. 94 W.	Schuster Flats.
D1221	384 m B	NW¼ sec. 33, T. 48 N., R. 94 W.	Schuster Flats.
D1222	400 m B	NE¼ sec. 21, T. 48 N., R. 94 W.	Schuster Flats.
D1223	180 m B	SE¼ sec. 27, T. 47 N., R. 93 W.	Schuster Flats SE.
D1224	180 m B	NW¼ sec. 27, T. 47 N., R. 93 W.	Schuster Flats SE (equal to Big "W", W125).
D1225	180 m B	NE¼ sec. 28, T. 47 N., R. 93 W.	Schuster Flats SE.
D1226	180 m B	SE¼ sec. 27, T. 47 N., R. 93 W.	Schuster Flats SE.
D1227	?m	NW¼ sec. 10, T. 47 N., R. 92 W.	Worland.
D1228	81 m B	NW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
D1229	481 m S	SW¼ sec. 3, T. 48 N., R. 96 W.	Sucker Dam (Moocow Hollow locality, equal to Y42).
D1230	490 m B	SW¼ sec. 14, T. 48 N., R. 96 W.	Sucker Dam (Fossil Hollow Bonanza, includes UMRB-10).
D1231	?m	SW¼ sec. 26, T. 53 N., R. 96 W.	Emblem.
D1232	?m	NE¼ sec. 21, T. 52 N., R. 99 W.	Oregon Basin (scale 1:62,500).
D1233	?m	NE¼ sec. 16, T. 52 N., R. 99 W.	Oregon Basin (scale 1:62,500).
D1234	425 m K	NW¼ sec. 14, T. 50 N., R. 96 W.	Wardel Reservoir (includes Y247).
D1235	414 EK	SE¼ sec. 15, T. 50 N., R. 96 W.	Wardel Reservoir (includes Y69).
D1236	?m	NE¼ sec. 16, T. 51 N., R. 94 W.	Gould Butte.
D1237	?m	NW¼ sec. 36, T. 52 N., R. 95 W.	Gould Butte.
D1238	?m	SW¼ sec. 36, T. 52 N., R. 95 W.	Gould Butte.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1239	?m	SE¼ sec. 22, T. 51 N., R. 95 W.	Wardel Reservoir.
D1240	408 m EK	SE¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain.
D1241	270 m B	SW¼ sec. 9, T. 47 N., R. 93 W.	Schuster Flats SE.
D1242	379 m B	SW¼ sec. 31, T. 49 N., R. 93 W.	Schuster Flats NE.
D1243	348 m EB	SW¼ sec. 5, T. 48 N., R. 93 W.	Schuster Flats NE.
D1244	470 m B	NW¼ sec. 8, T. 48 N., R. 95 W.	Sucker Dam.
D1245	477 m B	SE¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam (*Oxyaena* locality).
D1246	482 m B	SE¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam (*Esthonyx* locality).
D1247	?m	NW¼ sec. 16, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1248	?m	Center sec. 28, T. 53 N., R. 96 W.	Emblem.
D1249	?m	SW¼ sec. 27, T. 48 N., R. 93 W.	Schuster Flats SE.
D1250	461 m B	SW¼ sec. 35, T. 50 N., R. 96 W.	Wardel Reservoir.
D1251	378 m B	NW¼ sec. 33, T. 48 N., R. 94 W.	Schuster Flats.
D1252	?m	SW¼ sec. 20, T. 52 N., R. 96 W.	Burlington.
D1253	?m	SW¼ sec. 24, T. 47 N., R. 95 W.	Schuster Flats.
D1254	?m	SW¼ sec. 25, T. 47 N., R. 95 W.	Schuster Flats.
D1255	490 m EB	NE¼ sec. 10, T. 47 N., R. 95 W.	Schuster Flats.
D1256	546 m S	NE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW (Bobcat Draw Bonanza).
D1257	486 m B	NW¼ sec. 35, T. 49 N., R. 95 W.	Schuster Flats (Brinkerhoff Well locality).
D1258	288 m ES	SW¼ sec. 35, T. 50 N., R. 94 W.	Jones Reservoir.
D1259	380 m EB	SW¼ sec. 3, T. 50 N., R. 95 W.	Wardel Reservoir.
D1260	?m	NW¼ sec. 34, T. 51 N., R. 96 W.	Sheep Mountain.
D1261	410 m EK	SE¼ sec. 22, T. 50 N., R. 96 W.	Wardel Reservoir.
D1262	140 m B	NW¼ sec. 19, T. 50 N., R. 93 W.	Orchard Bench.
D1264	?m	NW¼ sec. 33, T. 51 N., R. 96 W.	Sheep Mountain.
D1265	?m	NE¼ sec. 2, T. 55 N., R. 101 W.	Elk Basin SW.
D1266	285 m ES	NE¼ sec. 34, T. 50 N., R. 94 W.	Jones Reservoir.
D1267	?m	SE¼ sec. 13, T. 50 N., R. 94 W.	Orchard Bench.
D1280	?m	NW¼ sec. 9, T. 51 N., R. 97 W.	Y-U Bench NE.
D1281	?m	SE¼ sec. 10, T. 51 N., R. 97 W.	Burlington.
D1282	352 m B	NW¼ sec. 31, T. 48 N., R. 93 W.	Schuster Flats SE.
D1283	374 m B	SW¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
D1284	338 m B	NE¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1285	509 m B	SW¼ sec. 15, T. 49 N., R. 95 W.	Sucker Dam.
D1286	489 m B	NW¼ sec. 22, T. 49 N., R. 95 W.	Sucker Dam.
D1287	346 m B	SE¼ sec. 3, T. 47 N., R. 94 W.	Schuster Flats SE.
D1288	336 m B, upper; 332 m B, lower.	NW¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1289	342 m B	SE¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1290	282 m B	SE¼ sec. 6, T. 47 N., R. 93 W.	Schuster Flats SE.
D1291	260 m B	NW¼ sec. 8, T. 47 N., R. 93 W.	Schuster Flats SE.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1292	368 m EB	SW¼ sec. 34, T. 48 N., R. 94 W.	Schuster Flats SE.
D1293	376 m EB	NW¼ sec. 27, T. 48 N., R. 94 W.	Schuster Flats SE.
D1294	342 m B	SW¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1295	424 m B	SW¼ sec. 13, T. 48 N., R. 95 W.	Schuster Flats NW.
D1296	30 m EB	NE¼ sec. 12, T. 46 N., R. 92 W.	Banjo Flats East.
D1297	262 m B, upper; 260 m B, middle; and lower.	NW¼ sec. 7, T. 47 N., R. 93 W.	Schuster Flats SE.
D1298	278 m B	SW¼ sec. 6, T. 47 N., R. 93 W.	Schuster Flats SE.
D1299	352 m B	NE¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1300	378 m B	NW¼ sec. 13, T. 48 N., R. 94 W.	Schuster Flats NE.
D1301	378 m B	NW¼ sec. 13, T. 48 N., R. 94 W.	Schuster Flats NE.
D1302	334 m EB	NE¼ sec. 25, T. 49 N., R. 94 W.	Schuster Flats NE.
D1303	360 m B	SE¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
D1304	516 m B	SE¼ sec. 15, T. 49 N., R. 95 W.	Sucker Dam.
D1305	486 m B	SE¼ sec. 27, T. 49 N., R. 95 W.	Sucker Dam.
D1306	410 m B	NE¼ sec. 24, T. 48 N., R. 95 W.	Schuster Flats.
D1307	483 m B	NW¼ sec. 29, T. 49 N., R. 95 W.	Sucker Dam.
D1308	448 m B	NE¼ sec. 6, T. 48 N., R. 94 W.	Schuster Flats NW.
D1309	426 m B	NE¼ sec. 19, T. 48 N., R. 94 W.	Schuster Flats.
D1310	442 m B	SE¼ sec. 36, T. 49 N., R. 95 W.	Schuster Flats NW (Bell Bonanza).
D1311	442 m B	NW¼ sec. 2, T. 48 N., R. 95 W.	Schuster Flats NW (Brinkerhoff Bonanza).
D1312	483 m B	SW¼ sec. 20, T. 49 N., R. 95 W.	Sucker Dam.
D1313	342 m B	NE¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1314	470 m B	NW¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam.
D1315	470 m B	SE¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
D1316	481 m B	SE¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
D1317	483 m B	SW¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
D1318	?m	SE¼ sec. 13, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1319	438 m B	SE¼ sec. 2, T. 48 N., R. 95 W.	Schuster Flats NW.
D1320	438 m B	SW¼ sec. 1, T. 48 N., R. 95 W.	Schuster Flats NW.
D1321	438 m B	NE¼ sec. 1, T. 48 N., R. 95 W.	Schuster Flats NW.
D1322	438 m B	NE¼ sec. 2, T. 48 N., R. 95 W.	Schuster Flats NW.
D1323	438 m B	NW¼ sec. 2, T. 48 N., R. 95 W.	Schuster Flats NW.
D1324	424 m B	SE¼ sec. 12, T. 48 N., R. 95 W.	Schuster Flats NW.
D1325	438 m B	NE¼ sec. 11, T. 48 N., R. 95 W.	Schuster Flats NW.
D1326	425 m B	SW¼ sec. 13, T. 49 N., R. 96 W.	Sucker Dam (Dry Cottonwood Bonanza).
D1327	?m	SW¼ sec. 24, T. 48 N., R. 99 W.	Hillberry Rim.
D1328	292 m B	NW¼ sec. 9, T. 47 N., R. 93 W.	Schuster Flats SE.
D1329	?m	SW¼ sec. 33, T. 48 N., R. 93 W.	Schuster Flats SE.
D1330	428 m B	SW¼ sec. 19, T. 49 N., R. 95 W.	Sucker Dam.
D1331	483 m B	SE¼ sec. 29, T. 49 N., R. 95 W.	Sucker Dam.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1332	360 m B	SE¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
D1333	360 m B	SE¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
D1334	360 m B	NW¼ sec. 31, T. 48 N., R. 93 W.	Schuster Flats SE.
D1335	346 m B, upper; 336 m B, lower.	SE¼ sec. 31, T. 48 N., R. 93 W.	Schuster Flats SE.
D1336	481 m B	NW¼ sec. 3, T. 48 N., R. 96 W.	Sucker Dam.
D1337	499 m EB	NW¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1338	491 m EB	NE¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1338N	491 m EB	NE¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1339	452 m B	NW¼ sec. 6, T. 48 N., R. 94 W.	Schuster Flats NW.
D1340Q	364 m B	NW¼ sec. 32, T. 48 N., R. 93 W.	Schuster Flats SE (Howard's Quarry).
D1341	384 m B	NW¼ sec. 33, T. 48 N., R. 94 W.	Schuster Flats.
D1342	390 m B	SW¼ sec. 28, T. 48 N., R. 94 W.	Schuster Flats.
D1343	?m	SW¼ sec. 21, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1344	491 m EB	NW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1345	491 m B	NW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1346	491 m B	SW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW (*Anacodon* locality).
D1347	431 m B	NE¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1348	430 m B	NW¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1349	430 m B	SW¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1350	410 m B, upper; 408 m B, lower.	Center sec. 19, T. 48 N., R. 94 W.	Schuster Flats.
D1350Q	410 m B	SW¼ sec. 19, T. 48 N., R. 94 W.	Schuster Flats.
D1369	292 m B	NE¼ sec. 11, T. 47 N., R. 94 W.	Schuster Flats SE.
D1370	384 m B	NW¼ sec. 33, T. 48 N., R. 94 W.	Schuster Flats.
D1371	370 m B	NW¼ sec. 3, T. 47 N., R. 94 W.	Schuster Flats.
D1372	356 m B	SE¼ sec. 34, T. 48 N., R. 94 W.	Schuster Flats SE.
D1373	338 m B, upper; 336 m B, lower.	SW¼ sec. 8, T. 48 N., R. 93 W.	Schuster Flats NE.
D1374	336 m B	SW¼ sec. 5, T. 48 N., R. 93 W.	Schuster Flats NE.
D1375	511 m ES	SW¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1376	430 m B	NE¼ sec. 18, T. 48 N., R. 94 W.	Schuster Flats NW.
D1377	436 m B	SW¼ sec. 7, T. 48 N., R. 94 W.	Schuster Flats NW.
D1378	430 m B	SE¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1379	430 m B	SE¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1380	430 m B	SW¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1381	430 m B	SE¼ sec. 24, T. 49 N., R. 96 W.	Sucker Dam.
D1382	430 m B	SW¼ sec. 30, T. 49 N., R. 95 W.	Sucker Dam.
D1383	270 m B	SW¼ sec. 8, T. 47 N., R. 93 W.	Schuster Flats SE.
D1384	342 m B	NE¼ sec. 1, T. 47 N., R. 94 W.	Schuster Flats SE.
D1385	392 m B	NE¼ sec. 29, T. 48 N., R. 94 W.	Schuster Flats.
D1386	344 m B	NE¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
D1387	360 m B	NE¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1388	360 m B	NW¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
D1389	264 m B	SW¼ sec. 7, T. 47 N., R. 93 W.	Schuster Flats SE.
D1390	278 m B	NW¼ sec. 7, T. 47 N., R. 93 W.	Schuster Flats SE.
D1391	356 m B	SW¼ sec. 35, T. 48 N., R. 94 W.	Schuster Flats SE.
D1392	292 m B	NE¼ sec. 11, T. 47 N., R. 94 W.	Schuster Flats SE.
D1393	296 m B	SE¼ sec. 2, T. 47 N., R. 94 W.	Schuster Flats SE.
D1394	?m	NE¼ sec. 6, T. 51 N., R. 94 W.	Gould Butte.
D1395	324 m EB	NE¼ sec. 14, T. 47 N., R. 94 W.	Schuster Flats SE.
D1396	420 m B	SE¼ sec. 13, T. 48 N., R. 95 W.	Schuster Flats NW.
D1397	483 m B	NE¼ sec. 29, T. 49 N., R. 95 W.	Sucker Dam.
D1398	438 m B	NE¼ sec. 14, T. 48 N., R. 95 W.	Schuster Flats NW.
D1399	434 m B	NE¼ sec. 14, T. 48 N., R. 95 W.	Schuster Flats NW.
D1400	438 m B	SE¼ sec. 11, T. 48 N., R. 95 W.	Schuster Flats NW.
D1401	438 m B	NW¼ sec. 11, T. 48 N., R. 95 W.	Schuster Flats NW.
D1402	420 m B	NW¼ sec. 24, T. 48 N., R. 95 W.	Schuster Flats.
D1403	420 m B	SW¼ sec. 13, T. 48 N., R. 95 W.	Schuster Flats NW.
D1404	438 m B	SW¼ sec. 6, T. 48 N., R. 94 W.	Schuster Flats NW.
D1405	438 m B	SW¼ sec. 7, T. 48 N., R. 94 W.	Schuster Flats NW.
D1406	436 m B	SW¼ sec. 9, T. 48 N., R. 94 W.	Schuster Flats NW.
D1407	442 m B	NW¼ sec. 31, T. 49 N., R. 95 W.	Schuster Flats NW.
D1408	494 m B	SW¼ sec. 23, T. 49 N., R. 95 W.	Schuster Flats NW.
D1409	455 m B	SE¼ sec. 8, T. 48 N., R. 95 W.	Sucker Dam.
D1410	418 m B, upper; 416 m B, middle; 410 m B, lower.	SE¼ sec. 17, T. 48 N., R. 94 W.	Schuster Flats NW.
D1411	412 m B	NE¼ sec. 20, T. 48 N., R. 94 W.	Schuster Flats.
D1412	364 m B	NE¼ sec. 24, T. 48 N., R. 94 W.	Schuster Flats SE.
D1413	392 m B	SE¼ sec. 14, T. 48 N., R. 94 W.	Schuster Flats SE.
D1414	378 m B	SE¼ sec. 12, T. 48 N., R. 94 W.	Schuster Flats NE.
D1415	354 m EB	NW¼ sec. 7, T. 48 N., R. 93 W.	Schuster Flats NE.
D1416	354 m EB	SE¼ sec. 7, T. 48 N., R. 93 W.	Schuster Flats NE.
D1417	360 m B	SW¼ sec. 7, T. 48 N., R. 93 W.	Schuster Flats NE.
D1418	282 m B	NE¼ sec. 7, T. 47 N., R. 93 W.	Schuster Flats SE.
D1419	260 m B	NW¼ sec. 8, T. 47 N., R. 93 W.	Schuster Flats SE.
D1420	360 m B	SW¼ sec. 12, T. 48 N., R. 94 W.	Schuster Flats NE.
D1421	384 m B, upper; 379 m B, lower.	NE¼ sec. 2, T. 48 N., R. 94 W.	Schuster Flats NE.
D1422	370 m B	NE¼ sec. 1, T. 48 N., R. 94 W.	Schuster Flats NE.
D1423	?m	NE¼ sec. 27, T. 49 N., R. 94 W.	Schuster Flats NW.
D1424	?m	SW¼ sec. 27, T. 49 W., R. 94 W.	Schuster Flats NW.
D1425	465 m EB	SE¼ sec. 30, T. 49 N., R. 94 W.	Schuster Flats NW.
D1426	490 m EB	NW¼ sec. 30, T. 49 N., R. 94 W.	Schuster Flats NW.
D1427	?m	NE¼ sec. 14, T. 49 N., R. 94 W.	Schuster Flats NE.
D1428	440 m B	NW¼ sec. 14, T. 49 N., R. 96 W.	Sucker Dam.
D1429	446 m B	SW¼ sec. 11, T. 49 N., R. 96 W.	Sucker Dam.
D1430	455 m B	SE¼ sec. 15, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1431	501 m S	NE¼ sec. 24, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1432	501 m S	NE¼ sec. 24, T. 49 N., R. 97 W.	Dutch Nick Flat NW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1433	501 m S	NE¼ sec. 24, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1434	496 m EB	NE¼ sec. 19, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1435	501 m S	NW¼ sec. 18, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1436	492 m S	SE¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1437	511 m EB	NE¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1438	516 m B	NE¼ sec. 15, T. 49 N., R. 95 W.	Sucker Dam.
D1439	446 m B	SE¼ sec. 10, T. 49 N., R. 96 W.	Sucker Dam.
D1440	?m	NE¼ sec. 14, T. 49 N., R. 96 W.	Sucker Dam.
D1441	296 m B	SW¼ sec. 1, T. 47 N., R. 94 W.	Schuster Flats SE.
D1442	No data	No data.	No data.
D1443	420 m B	NE¼ sec. 23, T. 48 N., R. 95 W.	Schuster Flats.
D1444	No data	No data.	No data.
D1445	?m	SW¼ sec. 35, T. 51 N., R. 97 W.	Sheep Mountain.
D1446	?m	SW¼ sec. 22, T. 52 N., R. 96 W.	Burlington.
D1447	113 m EB	NW¼ sec. 6, T. 46 N., R. 91 W.	Banjo Flats East.
D1448	?m	NW¼ sec. 9, T. 47 N., R. 94 W.	Schuster Flats.
D1449	344 m EB	NW¼ sec. 23, T. 47 N., R. 94 W.	Schuster Flats SE.
D1450	?m	NW¼ sec. 20, T. 47 N., R. 94 W.	Schuster Flats.
D1451	448 m EB	NW¼ sec. 18, T. 47 N., R. 94 W.	Schuster Flats.
D1452	440+ m EB . . .	NE¼ sec. 18, T. 47 N., R. 94 W.	Schuster Flats.
D1453	378 m B	SW¼ sec. 13, T. 48 N., R. 94 W.	Schuster Flats NE.
D1454	409 m B	NE¼ sec. 7, T. 47 N., R. 94 W.	Schuster Flats (Potala Bonanza).
D1455	?m	NW¼ sec. 4, T. 52 N., R. 95 W.	Emblem SE.
D1456	?m	NE¼ sec. 19, T. 47 N., R. 93 W.	Schuster Flats SE.
D1457	?m	NE¼ sec. 19, T. 47 N., R. 93 W.	Schuster Flats SE.
D1458	400 m B	NW¼ sec. 8, T. 47 N., R. 94 W.	Schuster Flats.
D1459	438+ m EB . . .	NE¼ sec. 18, T. 47 N., R. 94 W.	Schuster Flats.
D1460	409 m B	SW¼ sec. 8, T. 47 N., R. 94 W.	Schuster Flats.
D1460Q	411 m B	SW¼ sec. 8, T. 47 N., R. 94 W.	Schuster Flats (Rose Quarry).
D1461	180 m EB	SE¼ sec. 20, T. 47 N., R. 93 W.	Schuster Flats SE.
D1462	463 m EB	NE¼ sec. 13, T. 47 N., R. 95 W.	Schuster Flats.
D1463	546 m S	NW¼ sec. 7, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1464	546 m S	NE¼ sec. 7, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1465	546 m ES	SW¼ sec. 8, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1466	516 m ES	NE¼ sec. 18, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1467	546 m S	SE¼ sec. 7, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1468	501 m S	NE¼ sec. 18, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1469	491 m B	SW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1470	491 m B	NW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1471	491 m ES	NE¼ sec. 8, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1472	?m	SW¼ sec. 9, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1473	556 m B	NW¼ sec. 20, T. 48 N., R. 96 W.	Dutch Nick Flat SW (Hoover Renner Reservoir Bonanza).
D1474	496 m EB	NE¼ sec. 19, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1475	496 m EB	SE¼ sec. 18, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1476	?m	NE¼ sec. 24, T. 48 N., R. 97 W.	Dutch Nick Flat SW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1477	?m	NW¼ sec. 19, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1478	?m	SE¼ sec. 31, T. 50 N., R. 96 W.	Sheep Mountain.
D1479	?m	NW¼ sec. 31, T. 50 N., R. 96 W.	Sheep Mountain.
D1480	?m	SE¼ sec. 32, T. 48 N., R. 95 W.	Dutch Nick Flat.
D1481	546 m EB	NE¼ sec. 2, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1482	541 m EB	NW¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1483	415 m EK	NE¼ sec. 14, T. 50 N., R. 96 W.	Wardel Reservoir.
D1484	416 m EK	NW¼ sec. 23, T. 50 N., R. 96 W.	Wardel Reservoir.
D1485	18 m EB	NW¼ sec. 2, T. 48 N., R. 92 W.	Worland SE.
D1486	430 m B	NW¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
D1487	432 m B	NW¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
D1488	?m	NW¼ sec. 12, T. 50 N., R. 95 W.	Jones Reservoir.
D1489	?m	NW¼ sec. 34, T. 48 N., R. 92 W.	Worland.
D1490	474 m B	SW¼ sec. 26, T. 49 N., R. 95 W.	Schuster Flats NW.
D1491	486 m B	NW¼ sec. 25, T. 49 N., R. 95 W.	Schuster Flats NW.
D1492	?m	SW¼ sec. 17, T. 47 N., R. 94 W.	Schuster Flats.
D1493	344 m B	SE¼ sec. 6, T. 48 N., R. 93 W.	Schuster Flats NE.
D1494	370 m B	NE¼ sec. 2, T. 48 N., R. 94 W.	Schuster Flats NE.
D1495	464 m B	SW¼ sec. 35, T. 50 N., R. 96 W.	Wardel Reservoir.
D1496	?m	SE¼ sec. 34, T. 50 N., R. 96 W.	Sheep Mountain.
D1497	452 m B	SW¼ sec. 3, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1498	344 m EB	SW¼ sec. 32, T. 49 N., R. 93 W.	Schuster Flats NE.
D1499	334 m EB	NE¼ sec. 32, T. 49 N., R. 93 W.	Schuster Flats NE.
D1500	322 m EB	NW¼ sec. 32, T. 49 N., R. 93 W.	Schuster Flats NE.
D1501	290 m EB	SE¼ sec. 29, T. 49 N., R. 93 W.	Schuster Flats NE.
D1502	?m	SE¼ sec. 20, T. 47 N., R. 93 W.	Schuster Flats SE.
D1503	550 m B	NW¼ sec. 22, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1504	556 m B	SW¼ sec. 21, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1505	550 m B	SW¼ sec. 21, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1506	550 m B	SW¼ sec. 21, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1507	494 m B	NE¼ sec. 22, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1508	494 m B	NE¼ sec. 22, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1509	?m	NW¼ sec. 28, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1510	482 m B	SW¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat (Crooked Creek Bonanza).
D1511	478 m B	SE¼ sec. 22, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1512	?m	NE¼ sec. 2, T. 49 N., R. 95 W.	Jones Reservoir.
D1513	509 m B	NW¼ sec. 4, T. 49 N., R. 95 W.	Wardel Reservoir.
D1514	380 m EK	SE¼ sec. 12, T. 50 N., R. 96 W.	Wardel Reservoir.
D1515	?m	NE¼ sec. 6, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1516	?m	SE¼ sec. 11, T. 47 N., R. 95 W.	Schuster Flats.
D1517	?m	SE¼ sec. 11, T. 47 N., R. 95 W.	Schuster Flats.
D1518	436 m B	NW¼ sec. 16, T. 48 N., R. 94 W.	Schuster Flats NW.
D1519	?m	NE¼ sec. 16, T. 48 N., R. 94 W.	Schuster Flats NW.
D1520	?m	SE¼ sec. 16, T. 48 N., R. 94 W.	Schuster Flats NW.
D1521	?m	SW¼ sec. 9, T. 47 N., R. 96 W.	Dutch Nick Flat SW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1522	?m	SE¼ sec. 4, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1523	?m	SW¼ sec. 3, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1524	409 m EB	NE¼ sec. 36, T. 49 N., R. 94 W.	Schuster Flats NE.
D1525	?m	SW¼ sec. 34, T. 49 N., R. 94 W.	Schuster Flats NW.
D1526	418 m EB	NW¼ sec. 3, T. 48 N., R. 94 W.	Schuster Flats NW.
D1527	410 m EB	SW¼ sec. 3, T. 48 N., R. 94 W.	Schuster Flats NW.
D1528	414 m EB	SW¼ sec. 3, T. 48 N., R. 94 W.	Schuster Flats NW.
D1529	420 m EB	SE¼ sec. 4, T. 48 N., R. 94 W.	Schuster Flats NW.
D1530	420 m EB	SE¼ sec. 4, T. 48 N., R. 94 W.	Schuster Flats NW.
D1531	485 m EB	NE¼ sec. 30, T. 49 N., R. 94 W.	Schuster Flats NW.
D1532	485 m EB	NW¼ sec. 25, T. 49 N., R. 95 W.	Schuster Flats NW.
D1533	438 m B	SW¼ sec. 14, T. 48 N., R. 95 W.	Schuster Flats NW.
D1534	536 m ES	Center sec. 17, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1535	?m	SW¼ sec. 24, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1536	450 m EB	Center sec. 28, T. 48 N., R. 95 W.	Dutch Nick Flat.
D1537	449 m B	SE¼ sec. 16, T. 48 N., R. 95 W.	Sucker Dam.
D1538	405 m B	NE¼ sec. 30, T. 48 N., R. 94 W.	Schuster Flats.
D1539	410 m B	SW¼ sec. 25, T. 48 N., R. 95 W.	Schuster Flats.
D1540	399 m B	NW¼ sec. 36, T. 48 N., R. 95 W.	Schuster Flats.
D1541	414 m K	NW¼ sec. 30, T. 50 N., R. 96 W.	Wardel Reservoir.
D1542	?m	NW¼ sec. 3, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1543	?m	NE¼ sec. 3, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1544	?m	SE¼ sec. 3, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1545	430 m EK	NW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
D1546	?m	SW¼ sec. 2, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1547	405 m EK	NE¼ sec. 23, T. 50 N., R. 96 W.	Wardel Reservoir.
D1548	390 m EK	SE¼ sec. 3, T. 50 N., R. 96 W.	Sheep Mountain.
D1549	410 m EK	SW¼ sec. 3, T. 50 N., R. 96 W.	Sheep Mountain.
D1550	425 m EK	NW¼ sec. 10, T. 50 N., R. 96 W.	Sheep Mountain.
D1551	400 m EK	NW¼ sec. 10, T. 50 N., R. 96 W.	Sheep Mountain.
D1552	485 m B	NE¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
D1553	377 m EK	SE¼ sec. 10, T. 50 N., R. 96 W.	Wardel Reservoir.
D1554	416 m K	SE¼ sec. 10, T. 50 N., R. 96 W.	Sheep Mountain.
D1555	394 m K	SW¼ sec. 30, T. 50 N., R. 96 W.	Wardel Reservoir.
D1556	397 m K	NE¼ sec. 30, T. 50 N., R. 96 W.	Wardel Reservoir.
D1557	356 m B	SE¼ sec. 35, T. 48 N., R. 94 W.	Schuster Flats SE.
D1558	556 m ES	NE¼ sec. 13, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1559	405 m ES	SW¼ sec. 20, T. 50 N., R. 95 W.	Wardel Reservoir.
D1560	392 m B	SE¼ sec. 29, T. 48 N., R. 94 W.	Schuster Flats.
D1561	362 m B	NW¼ sec. 19, T. 48 N., R. 94 W.	Schuster Flats SE.
D1562	490 m B	SE¼ sec. 9, T. 49 N., R. 95 W.	Sucker Dam.
D1563	493 m B	NW¼ sec. 9, T. 49 N., R. 95 W.	Sucker Dam.
D1564	485 m EB	SW¼ sec. 16, T. 49 N., R. 95 W.	Sucker Dam.
D1565	485 m EB	NE¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
D1566	528 m B	NE¼ sec. 11, T. 49 N., R. 97 W.	Dutch Nick Flat NW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1567	531 m ES	NE¼ sec. 11, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1568	?m	NE¼ sec. 32, T. 51 N., R. 96 W.	Sheep Mountain.
D1569	?m	SE¼ sec. 32, T. 51 N., R. 96 W.	Sheep Mountain.
D1570	435 m EK	SE¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
D1571	435 m EK	SE¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
D1572	?m	NE¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1573	511 m ES	NE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1574	546 m S	NE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1575	546 m S	NE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1576	546 m S	NW¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1577	311 m EB	NW¼ sec. 5, T. 47 N., R. 93 W.	Schuster Flats SE.
D1578	-25 m B	NW¼ sec. 26, T. 46 N., R. 91 W.	Cabin Fork.
D1579	5 m B	SW¼ sec. 24, T. 46 N., R. 91 W.	Cabin Fork.
D1580	-?m	NW¼ sec. 4, T. 45 N., R. 90 W.	Cabin Fork.
D1581	546 m ES	NW¼ sec. 17, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1582	546 m ES	NE¼ sec. 18, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1583	551 m S	SE¼ sec. 17, T. 48 N., R. 96 W.	Dutch Nick Flat NW (Bownanza).
D1584	?m	NE¼ sec. 13, T. 51 N., R. 94 W.	Greybull South (equal to Y405).
D1585	?m	SE¼ sec. 26, T. 48 N., R. 99 W.	Hillberry Rim.
D1586	483 m B	SE¼ sec. 17, T. 49 N., R. 95 W.	Sucker Dam.
D1587	444 m B	SW¼ sec. 1, T. 49 N., R. 96 W.	Sucker Dam.
D1588	442 m B	NE¼ sec. 2, T. 49 N., R. 96 W.	Sucker Dam (Peterson School Bus locality).
D1589	?m	SE¼ sec. 26, T. 51 N., R. 97 W.	Sheep Mountain.
D1590	?m	SE¼ sec. 25, T. 51 N., R. 97 W.	Sheep Mountain.
D1591	?m	SE¼ sec. 25, T. 51 N., R. 97 W.	Sheep Mountain.
D1592	466 m ES	NW¼ sec. 24, T. 50 N., R. 96 W.	Wardel Reservoir.
D1593	?m	SW¼ sec. 33, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1594	?m	NE¼ sec. 5, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1595	?m	NW¼ sec. 4, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1596	591 m EB	SE¼ sec. 32, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1597	420 m B	NW¼ sec. 26, T. 48 N., R. 95 W.	Schuster Flats.
D1598	428 m B	SW¼ sec. 15, T. 48 N., R. 95 W.	Schuster Flats.
D1599	449 m B	NE¼ sec. 17, T. 48 N., R. 95 W.	Sucker Dam.
D1600	?m	SW¼ sec. 34, T. 51 N., R. 98 W.	Sheets Flat.
D1601	?m	SE¼ sec. 34, T. 51 N., R. 98 W.	Tatman Mountain.
D1602	463 m B	SW¼ sec. 10, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1603	463 m B	SW¼ sec. 10, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1604	463 m B	SE¼ sec. 16, T. 49 N., R. 96 W.	Dutch Nick Flat NW (possibly equal to Y44).
D1605	478 m B	SW¼ sec. 10, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1606	?m	SW¼ sec. 28, T. 50 N., R. 96 W.	Sheep Mountain.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1607	?m	SE¼ sec. 29, T. 50 N., R. 96 W.	Sheep Mountain.
D1608	516 m EB	NE¼ sec. 36, T. 50 N., R. 97 W.	Sheep Mountain.
D1609	505 m EB	SE¼ sec. 36, T. 50 N., R. 97 W.	Sheep Mountain.
D1610	?m	NE¼ sec. 3, T. 50 N., R. 98 W.	Tatman Mountain.
D1611	?m	SW¼ sec. 34, T. 51 N., R. 98 W.	Tatman Mountain.
D1612	505 m EB	NW¼ sec. 31, T. 50 N., R. 96 W.	Sheep Mountain.
D1613	541 m S	NE¼ sec. 21, T. 49 N., R. 97 W.	Dead Indian Hill.
D1614	?m	SW¼ sec. 16, T. 49 N., R. 97 W.	Dead Indian Hill.
D1615	?m	SE¼ sec. 16, T. 49 N., R. 97 W.	Dead Indian Hill.
D1616	?m	SE¼ sec. 16, T. 49 N., R. 97 W.	Dead Indian Hill.
D1617	475 m B	SE¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam.
D1618	?m	NW¼ sec. 10, T. 51 N., R. 97 W.	Y-U Bench NE.
D1619	?m	NW¼ sec. 20, T. 51 N., R. 97 W.	Y-U Bench NE.
D1620	?m	SE¼ sec. 17, T. 51 N., R. 97 W.	Y-U Bench NE.
D1621	?m	SW¼ sec. 28, T. 51 N., R. 97 W.	Tatman Mountain.
D1622	559 m ES	NW¼ sec. 21, T. 49 N., R. 97 W.	Dead Indian Hill.
D1623	513 m ES	SW¼ sec. 13, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1624	507 m ES	NW¼ sec. 13, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1625	516 m S	SW¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1626	?m	SE¼ sec. 2, T. 46 N., R. 95 W.	Chimney Gulch.
D1627	?m	NW¼ sec. 12, T. 46 N., R. 95 W.	Chimney Gulch.
D1628	435 m EK	NW¼ sec. 27, T. 50 N., R. 96 W.	Sheep Mountain.
D1629	445 m EK	NW¼ sec. 27, T. 50 N., R. 96 W.	Sheep Mountain.
D1630	190 m ES	NE¼ sec. 14, T. 50 N., R. 94 W.	Orchard Bench.
D1631	200 m ES	SE¼ sec. 15, T. 50 N., R. 94 W.	Jones Reservoir.
D1632	130 m ES	SE¼ sec. 18, T. 50 N., R. 93 W.	Orchard Bench.
D1633	149 m S	NW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
D1634	?m	SE¼ sec. 22, T. 51 N., R. 94 W.	Gould Butte.
D1635	370 m S	SE¼ sec. 10, T. 50 N., R. 95 W.	Wardel Reservoir.
D1636	361 m ES	SE¼ sec. 15, T. 50 N., R. 95 W.	Wardel Reservoir.
D1637	?m	SE¼ sec. 22, T. 51 N., R. 95 W.	Otto.
D1638	?m	SW¼ sec. 23, T. 51 N., R. 95 W.	Gould Butte.
D1639	?m	NW¼ sec. 24, T. 51 N., R. 95 W.	Gould Butte.
D1640	140 m S	NW¼ sec. 18, T. 50 N., R. 93 W.	Orchard Bench.
D1641	?m	SE¼ sec. 9, T. 48 N., R. 96 W.	Sucker Dam.
D1642	?m	NW¼ sec. 15, T. 48 N., R. 96 W.	Sucker Dam.
D1643	?m	NE¼ sec. 16, T. 48 N., R. 96 W.	Sucker Dam.
D1644	255 m ES	SW¼ sec. 36, T. 50 N., R. 94 W.	Orchard Bench.
D1645	240 m S	NW¼ sec. 36, T. 50 N., R. 94 W.	Orchard Bench.
D1646	591 m EB	SW¼ sec. 32, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1647	591 m EB	SW¼ sec. 32, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1648	130 m S	SW¼ sec. 28, T. 50 N., R. 93 W.	Orchard Bench.
D1649	?m	SW¼ sec. 27, T. 51 N., R. 96 W.	Sheep Mountain.
D1650	?m	SW¼ sec. 27, T. 51 N., R. 96 W.	Sheep Mountain.
D1651	636 m EB	NE¼ sec. 26, T. 47 N., R. 97 W.	Dutch Nick Flat SW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1651Q	636 m EB	NE¼ sec. 26, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1652	382 m B	SE¼ sec. 24, T. 48 N., R. 94 W.	Schuster Flats SE.
D1653	357 m B	NE¼ sec. 19, T. 48 N., R. 93 W.	Schuster Flats SE.
D1654	?m	NE¼ sec. 25, T. 48 N., R. 97 W.	Dutch Nick Flat SW.
D1655	?m	NE¼ sec. 30, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1656	?m	NW¼ sec. 30, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1657	443 m B	SW¼ sec. 1, T. 49 N., R. 96 W.	Sucker Dam.
D1658	410 m B	SE¼ sec. 24, T. 48 N., R. 95 W.	Schuster Flats.
D1659	442 m B	SW¼ sec. 1, T. 49 N., R. 96 W.	Sucker Dam.
D1660	442 m B	NE¼ sec. 2, T. 49 N., R. 96 W.	Wardel Reservoir.
D1661	?m	SE¼ sec. 1, T. 47 N., R. 95 W.	Schuster Flats.
D1662	470 m B	NW¼ sec. 33, T. 50 N., R. 96 W.	Sheep Mountain.
D1663	470 m B	NW¼ sec. 33, T. 50 N., R. 96 W.	Sheep Mountain.
D1664	?m	NE¼ sec. 33, T. 50 N., R. 96 W.	Sheep Mountain.
D1665	?m	NW¼ sec. 12, T. 47 N., R. 95 W.	Schuster Flats.
D1666	?m	NW¼ sec. 15, T. 50 N., R. 95 W.	Wardel Reservoir.
D1667	476 m B	SW¼ sec. 26, T. 50 N., R. 96 W.	Wardel Reservoir.
D1668	460 m B	NW¼ sec. 35, T. 50 N., R. 96 W.	Wardel Reservoir.
D1669	464 m B	NW¼ sec. 35, T. 50 N., R. 96 W.	Wardel Reservoir.
D1670	471 m B	NW¼ sec. 35, T. 50 N., R. 96 W.	Wardel Reservoir.
D1671	474 m B	SW¼ sec. 26, T. 50 N., R. 96 W.	Wardel Reservoir.
D1672	495 m B	SE¼ sec. 5, T. 49 N., R. 95 W.	Sucker Dam.
D1673	531 m B	NW¼ sec. 3, T. 49 N., R. 95 W.	Sucker Dam.
D1674	553 m B	SW¼ sec. 3, T. 49 N., R. 95 W.	Sucker Dam.
D1675Q	493 m B	SW¼ sec. 4, T. 49 N., R. 95 W.	Sucker Dam (Elk Creek Rim Quarry).
D1676	464 m B	NW¼ sec. 35, T. 50 N., R. 96 W.	Wardel Reservoir.
D1677	470 m EB	SW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
D1678	278 m EB	SW¼ sec. 12, T. 47 N., R. 94 W.	Schuster Flats SE.
D1679	?m	SE¼ sec. 9, T. 50 N., R. 95 W.	Wardel Reservoir.
D1680	414 m EK	SE¼ sec. 13, T. 50 N., R. 96 W.	Wardel Reservoir.
D1681	?m	SE¼ sec. 5, T. 48 N., R. 93 W.	Schuster Flats NE.
D1682	442 m B	NE¼ sec. 2, T. 49 N., R. 96 W.	Wardel Reservoir (Elise's Pocket).
D1683	?m	SE¼ sec. 13, T. 47 N., R. 95 W.	Schuster Flats.
D1684	440 m B	SW¼ sec. 7, T. 47 N., R. 94 W.	Schuster Flats.
D1685	?m	SW¼ sec. 14, T. 47 N., R. 95 W.	Schuster Flats.
D1686	591 m EB	SE¼ sec. 32, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1687	438 m EB	SE¼ sec. 15, T. 48 N., R. 95 W.	Schuster Flats NW.
D1688	442 m EB	SE¼ sec. 15, T. 48 N., R. 95 W.	Schuster Flats NW.
D1689	430 m S	NE¼ sec. 9, T. 50 N., R. 95 W.	Wardel Reservoir (equal to Y83).
D1690	?m	NE¼ sec. 16, T. 50 N., R. 95 W.	Wardel Reservoir (equal to Y429).
D1691	?m	NE¼ sec. 4, T. 50 N., R. 95 W.	Wardel Reservoir.
D1692	?m	NE¼ sec. 5, T. 48 N., R. 94 W.	Schuster Flats NW.
D1693	438 m B	NW¼ sec. 8, T. 48 N., R. 94 W.	Schuster Flats NW.
D1694	435 m B	NW¼ sec. 8, T. 48 N., R. 94 W.	Schuster Flats NW.
D1695	418 m B	NE¼ sec. 8, T. 48 N., R. 94 W.	Schuster Flats NW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1696	?m	SW¼ sec. 9, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1697	?m	SW¼ sec. 8, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1698	455 m B	SW¼ sec. 33, T. 50 N., R. 96 W.	Sheep Mountain.
D1699	463 m B	SW¼ sec. 33, T. 50 N., R. 96 W.	Sheep Mountain.
D1700	351 m B	SE¼ sec. 3, T. 47 N., R. 94 W.	Schuster Flats SE.
D1701	?m	NW¼ sec. 18, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1702	?m	SW¼ sec. 9, T. 47 N., R. 95 W.	Dutch Nick Flat.
D1703	?m	SW¼ sec. 4, T. 49 N., R. 98 W.	Wilson Spring.
D1704	?m	NW¼ sec. 3, T. 49 N., R. 98 W.	Sheets Flat (equal to Y182).
D1705	?m	SW¼ sec. 19, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1706	?m	SE¼ sec. 25, T. 48 N., R. 97 W.	Dutch Nick Flat SW.
D1707	?m	SE¼ sec. 25, T. 48 N., R. 97 W.	Dutch Nick Flat SW.
D1708	?m	NE¼ sec. 24, T. 48 N., R. 97 W.	Dutch Nick Flat SW.
D1709	250 m ES	SW¼ sec. 29, T. 51 N., R. 94 W.	Jones Reservoir.
D1710	245 m ES	SE¼ sec. 30, T. 51 N., R. 94 W.	Jones Reservoir.
D1711	260 m ES	NW¼ sec. 32, T. 51 N., R. 94 W.	Jones Reservoir.
D1712	390 m ES	SE¼ sec. 33, T. 50 N., R. 94 W.	Jones Reservoir.
D1713	?m	NW¼ sec. 5, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1714	?m	SE¼ sec. 6, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1715	?m	NW¼ sec. 19, T. 49 N., R. 93 W.	Schuster Flats NE.
D1716	397 m ES	SW¼ sec. 33, T. 50 N., R. 94 W.	Jones Reservoir.
D1717	?m	NE¼ sec. 22, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1718	?m	NW¼ sec. 22, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1719	?m	NW¼ sec. 22, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1720	?m	SE¼ sec. 22, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1721	?m	NE¼ sec. 27, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1722	?m	NE¼ sec. 22, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1723	?m	SW¼ sec. 14, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1724	?m	SW¼ sec. 14, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1725	?m	SW¼ sec. 14, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1726	463 m B	NE¼ sec. 4, T. 49 N., R. 96 W.	Sheep Mountain.
D1727	478 m B	NE¼ sec. 9, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1728	?m	SE¼ sec. 14, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1729	?m	NW¼ sec. 24, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1730	?m	SW¼ sec. 13, T. 47 N., R. 97 W.	Dutch Nick Flat SW.
D1731	No data	No data.	No data.
D1732	No data	No data.	No data.
D1733	?m	NE¼ sec. 9, T. 49 N., R. 95 W.	Sucker Dam.
D1734	489 m EB	NW¼ sec. 9, T. 49 N., R. 95 W.	Sucker Dam.
D1735	561 m ES	NE¼ sec. 11, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1736	?m	SE¼ sec. 10, T. 44 N., R. 96 W.	Dutch Nick Flat.
D1737	463 m, lower; . . 469 m, upper.	SW¼ sec. 4, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1738	?m	SW¼ sec. 5, T. 49 N., R. 94 W.	Schuster Flats NW.
D1739	?m	NW¼ sec. 35, T. 51 N., R. 96 W.	Wardel Reservoir.
D1740	?m	NE¼ sec. 35, T. 51 N., R. 96 W.	Wardel Reservoir.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1741	383 m K	NE¼ sec. 28, T. 50 N., R. 95 W.	Wardel Reservoir.
D1742	435 m K	SE¼ sec. 20, T. 50 N., R. 95 W.	Wardel Reservoir.
D1743	385 m K	SE¼ sec. 29, T. 50 N., R. 95 W.	Wardel Reservoir.
D1744	404 m K	NW¼ sec. 32, T. 50 N., R. 95 W.	Wardel Reservoir.
D1745	390 m EK	SW¼ sec. 29, T. 50 N., R. 95 W.	Wardel Reservoir.
D1746	?m	SW¼ sec. 18, T. 50 N., R. 95 W.	Wardel Reservoir.
D1747	415 m EK	NW¼ sec. 24, T. 50 N., R. 96 W.	Wardel Reservoir.
D1748	438 m K	NW¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
D1749	433 m K	NW¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
D1750	519 m B	NW¼ sec. 14, T. 49 N., R. 95 W.	Schuster Flats NW.
D1751	535 m B	NW¼ sec. 14, T. 49 N., R. 95 W.	Schuster Flats NW.
D1752	526 m B	NE¼ sec. 15, T. 49 N., R. 95 W.	Sucker Dam.
D1753	516 m B	NE¼ sec. 15, T. 49 N., R. 95 W.	Sucker Dam.
D1754	511 m B	NE¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1755	497 m S	NE¼ sec. 13, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1756	?m	SW¼ sec. 31, T. 49 N., R. 96 W.	Sucker Dam.
D1757	468 m	SW¼ sec. 32, T. 49 N., R. 96 W.	Sucker Dam.
D1758	397 m EB	NW¼ sec. 29, T. 48 N., R. 94 W.	Schuster Flats.
D1759	393 m EB	NW¼ sec. 29, T. 48 N., R. 94 W.	Schuster Flats.
D1760	?m	NE¼ sec. 26, T. 48 N., R. 94 W.	Schuster Flats SE.
D1761	?m	SW¼ sec. 22, T. 48 N., R. 92 W.	Worland.
D1762	414 m EB	NW¼ sec. 10, T. 48 N., R. 94 W.	Schuster Flats NW.
D1762Q	414 m EB	NW¼ sec. 10, T. 48 N., R. 94 W.	Schuster Flats NW (McKinney Quarry).
D1763	?m	SE¼ sec. 16, T. 48 N., R. 94 W.	Schuster Flats NW.
D1764	542 m EB	SE¼ sec. 14, T. 49 N., R. 95 W.	Schuster Flats NW.
D1765	537 m EB	NW¼ sec. 13, T. 49 N., R. 95 W.	Schuster Flats NW.
D1766	?m	SW¼ sec. 13, T. 49 N., R. 95 W.	Schuster Flats NW.
D1767	475 m EB	NE¼ sec. 26, T. 49 N., R. 95 W.	Schuster Flats NW.
D1768	?m	SW¼ sec. 24, T. 49 N., R. 95 W.	Schuster Flats NW.
D1769	510 m EB	SW¼ sec. 24, T. 49 N., R. 95 W.	Schuster Flats NW.
D1770	?m	SW¼ sec. 10, T. 49 N., R. 95 W.	Sucker Dam.
D1771	586 m EB	NW¼ sec. 13, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1772	566 m S	NE¼ sec. 13, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1773	491 m B	SE¼ sec. 8, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1774	413 m EB	NE¼ sec. 9, T. 48 N., R. 94 W.	Schuster Flats NW.
D1775	329 m B	NE¼ sec. 29, T. 48 N., R. 93 W.	Schuster Flats SE.
D1776	463 m B	NW¼ sec. 4, T. 49 N., R. 96 W.	Sheep Mountain.
D1776N	463 m B	NW¼ sec. 32, T. 50 N., R. 96 W.	Sheep Mountain.
D1777	474 m B	NW¼ sec. 5, T. 49 N., R. 96 W.	Sheep Mountain.
D1778	474 m B	SW¼ sec. 33, T. 50 N., R. 96 W.	Sheep Mountain.
D1779	412 m EK	SW¼ sec. 13, T. 50 N., R. 96 W.	Wardel Reservoir.
D1780	?m	NE¼ sec. 1, T. 50 N., R. 96 W.	Wardel Reservoir.
D1781	556 m B	SE sec. 20, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
D1782	496 m B	SW¼ sec. 22, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1783	474 m B	SE¼ sec. 8, T. 49 N., R. 96 W.	Dutch Nick Flat NW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1784	455 m B	SE¼ sec. 8, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1785	?m	SE¼ sec. 5, T. 48 N., R. 94 W.	Schuster Flats NW.
D1786	?m	SW¼ sec. 4, T. 48 N., R. 94 W.	Schuster Flats NW.
D1787	?m	NE¼ sec. 36, T. 49 N., R. 98 W.	Dead Indian Hill.
D1788	566 m S	NE¼ sec. 29, T. 49 N., R. 97 W.	Dead Indian Hill.
D1789	?m	SW¼ sec. 1, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1790	?m	SW¼ sec. 1, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1791	?m	NW¼ sec. 1, T. 49 N., R. 97 W.	Sheep Mountain.
D1792	385 m EK	NE¼ sec. 10, T. 50 N., R. 96 W.	Sheep Mountain.
D1793	?m	NW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1794	?m	NW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1795	?m	NE¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1796	?m	NE¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1797	?m	NE¼ sec. 29, T. 49 N., R. 94 W.	Schuster Flats NW.
D1798	?m	NE¼ sec. 29, T. 49 N., R. 94 W.	Schuster Flats NW.
D1799	?m	NW¼ sec. 24, T. 49 N., R. 95 W.	Schuster Flats NW.
D1800	?m	NE¼ sec. 20, T. 49 N., R. 94 W.	Schuster Flats NW.
D1801	?m	NW¼ sec. 19, T. 49 N., R. 94 W.	Schuster Flats NW.
D1802	?m	NE¼ sec. 24, T. 49 N., R. 95 W.	Schuster Flats NW.
D1803	385 m EK	SE¼ sec. 10, T. 50 N., R. 96 W.	Sheep Mountain.
D1804	411 m EK	NE¼ sec. 19, T. 50 N., R. 95 W.	Wardel Reservoir.
D1805	405 m EK	NW¼ sec. 29, T. 50 N., R. 95 W.	Wardel Reservoir.
D1806	?m	NE¼ sec. 12, T. 50 N., R. 95 W.	Jones Reservoir.
D1807	?m	NW¼ sec. 9, T. 50 N., R. 94 W.	Jones Reservoir.
D1808	?m	SW¼ sec. 27, T. 48 N., R. 92 W.	Worland.
D1809	360 m B	NE¼ sec. 31, T. 48 N., R. 93 W.	Schuster Flats SE.
D1810	452 m B	NE¼ sec. 31, T. 48 N., R. 93 W.	Schuster Flats SE.
D1811	344 m B	NW¼ sec. 29, T. 48 N., R. 93 W.	Schuster Flats SE.
D1812	?m	SE¼ sec. 7, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1813	?m	SW¼ sec. 5, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1814	?m	NW¼ sec. 29, T. 49 N., R. 97 W.	Dead Indian Hill.
D1815	?m	NW¼ sec. 33, T. 51 N., R. 94 W.	Jones Reservoir.
D1816	180 m EB	SW¼ sec. 12, T. 50 N., R. 94 W.	Orchard Bench.
D1817	?m	SW¼ sec. 15, T. 51 N., R. 94 W.	Gould Butte.
D1818	?m	SE¼ sec. 15, T. 50 N., R. 94 W.	Jones Reservoir.
D1819	?m	SW¼ sec. 15, T. 50 N., R. 94 W.	Jones Reservoir.
D1820	?m	SW¼ sec. 23, T. 50 N., R. 94 W.	Orchard Bench.
D1821	416 m B	NE¼ sec. 17, T. 48 N., R. 94 W.	Schuster Flats NW.
D1822	426 m B	SW¼ sec. 17, T. 48 N., R. 94 W.	Schuster Flats NW.
D1823	409 m B	SE¼ sec. 25, T. 48 N., R. 95 W.	Schuster Flats.
D1824	406 m B	SE¼ sec. 25, T. 48 N., R. 95 W.	Schuster Flats.
D1825	489 m B	SW¼ sec. 22, T. 49 N., R. 95 W.	Sucker Dam.
D1826	479 m B	SW¼ sec. 23, T. 49 N., R. 95 W.	Schuster Flats NW.
D1827	?m	SW¼ sec. 20, T. 50 N., R. 94 W.	Jones Reservoir.
D1828	546 m B	SW¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1829	501 m B	NE¼ sec. 6, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1830	501 m B	SW¼ sec. 32, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1831	529 m B	NE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1832	?m	Center sec. 29, T. 50 N., R. 96 W.	Sheep Mountain.
D1833	463 m B	SW¼ sec. 29, T. 50 N., R. 96 W.	Sheep Mountain.
D1834	511 m B	NW¼ sec. 25, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1835	?m	SE¼ sec. 16, T. 46 N., R. 92 W.	Banjo Flats West.
D1836	?m	NE¼ sec. 35, T. 50 N., R. 94 W.	Orchard Bench.
D1837	?m	NW¼ sec. 21, T. 50 N., R. 96 W.	Sheep Mountain.
D1838	?m	NW¼ sec. 21, T. 50 N., R. 96 W.	Sheep Mountain.
D1839	?m	NE¼ sec. 32, T. 50 N., R. 96 W.	Sheep Mountain.
D1840	?m	NE¼ sec. 32, T. 50 N., R. 96 W.	Sheep Mountain.
D1841	?m	NE¼ sec. 32, T. 50 N., R. 96 W.	Sheep Mountain.
D1842	?m	SW¼ sec. 16, T. 50 N., R. 96 W.	Sheep Mountain.
D1843	528 m S	NW¼ sec. 31, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1844	?m	NW¼ sec. 21, T. 50 N., R. 96 W.	Sheep Mountain.
D1845	?m	SE¼ sec. 31, T. 49 N., R. 95 W.	Sucker Dam.
D1846	?m	NE¼ sec. 1, T. 48 N., R. 96 W.	Sucker Dam.
D1847	190 m EB	SW¼ sec. 9, T. 49 N., R. 93 W.	Schuster Flats NE.
D1848	423 m EK	NW¼ sec. 35, T. 51 N., R. 96 W.	Wardel Reservoir.
D1849	?m	Unsurveyed area in T. 51 N., R. 92 W.	Gould Butte.
D1850	346 m B	NW¼ sec. 1, T. 47 N., R. 94 W.	Schuster Flats SE.
D1851	?m	Center SE¼ sec. 33, T. 49 N., R. 94 W.	Schuster Flats NW.
D1852	?m	NE¼ sec. 5, T. 48 N., R. 94 W.	Schuster Flats NW.
D1853	?m	SE¼ sec. 29, T. 49 N., R. 93 W.	Schuster Flats NE.
D1854	?m	NW¼ sec. 33, T. 49 N., R. 93 W.	Schuster Flats NE.
D1855	?m	SW¼ sec. 24, T. 49 N., R. 94 W.	Schuster Flats NE.
D1856	?m	SW¼ sec. 24, T. 49 N., R. 94 W.	Schuster Flats NE.
D1857	?m	NE¼ sec. 30, T. 51 N., R. 94 W.	Jones Reservoir.
D1858	?m	Center NW¼ sec. 21, T. 49 N., R. 94 W.	Schuster Flats NW.
D1859	410 m EB	Center NW¼ sec. 10, T. 48 N., R. 94 W.	Schuster Flats NE.
D1860	556 m B	Center SE¼ sec. 2, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
D1861	?m	NE¼ sec. 36, T. 51 N., R. 98 W.	Tatman Mountain.
D1862	?m	NW¼ sec. 1, T. 50 N., R. 98 W.	Tatman Mountain.
D1863	414 m K	SE¼ sec. 24, T. 50 N., R. 96 W.	Wardel Reservoir.
D1864	394 m K	NE¼ sec. 24, T. 50 N., R. 96 W.	Wardel Reservoir.
D1865	?m	NW¼ sec. 35, T. 51 N., R. 97 W.	Sheep Mountain.
D1866	423 m EK	SW¼ sec. 34, T. 51 N., R. 96 W.	Sheep Mountain.
D1867	?m	NE¼ sec. 36, T. 51 N., R. 97 W.	Sheep Mountain.
D1868	?m	NE¼ sec. 36, T. 51 N., R. 97 W.	Sheep Mountain.
D1869	?m	NW¼ sec. 35, T. 51 N., R. 96 W.	Wardel Reservoir.
D1870	?m	NE¼ sec. 35, T. 51 N., R. 96 W.	Wardel Reservoir.
D1871	?m	NE¼ sec. 16, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
D1872	213 m ES	SW¼ sec. 28, T. 51 N., R. 94 W.	Jones Reservoir.
D1873	?m	Center N½S½ sec. 21, T. 51 N., R. 94 W.	Jones Reservoir.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1874	?m	SW¼ sec. 22, T. 51 N., R. 94 W.	Jones Reservoir.
D1875	?m	SW¼ sec. 33, T. 51 N., R. 96 W.	Sheep Mountain.
D1876	435 m EK	SE¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
D1877	?m	SW¼ sec. 20, T. 50 N., R. 96 W.	Sheep Mountain.
D1878	?m	NW¼ sec. 29, T. 50 N., R. 96 W.	Sheep Mountain.
D1879	?m	NW¼ sec. 33, T. 51 N., R. 94 W.	Jones Reservoir.
D1880	310 m ES	Center sec. 36, T. 51 N., R. 95 W.	Jones Reservoir.
D1881	463 m B	NW¼ sec. 32, T. 50 N., R. 96 W.	Sheep Mountain.
D1882	345 m ES	SE¼ sec. 35, T. 51 N., R. 95 W.	Jones Reservoir.
D1883	435 m EK	NE¼ sec. 21, T. 50 N., R. 96 W.	Sheep Mountain.
D1884	?m	SW¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain.
D1885	474 m EK	SE¼ sec. 27, T. 50 N., R. 96 W.	Wardel Reservoir.
D1886	?m	SE¼ sec. 20, T. 50 N., R. 96 W.	Sheep Mountain.
D1887	5 m B	SE¼ sec. 19, T. 46 N., R. 89 W.	Castle Gardens.
D1888	3 m B	SE¼ sec. 16, T. 47 N., R. 91 W.	Worland SE.
D1889	472 m EB	SE¼ sec. 5, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1890	463 m B	SE¼ sec. 4, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1891	?m	Center SE¼ sec. 36, T. 49 N., R. 98 W.	Dead Indian Hill.
D1892	?m	SW¼NE¼SE¼ sec. 36, T. 49 N., R. 98 W.	Dead Indian Hill.
D1893	?m	SW¼SW¼ sec. 7, T. 47 N., R. 94 W.	Schuster Flats.
D1894	407 m EB	NW¼SE¼ sec. 10, T. 48 N., R. 94 W.	Schuster Flats NE.
D1895	409 m EB	Center S½N½NW¼ sec. 11, T. 48 N., R. 94 W.	Schuster Flats NE.
D1896	407 m EB	SE¼SW¼ sec. 3, T. 48 N., R. 94 W.	Schuster Flats NE.
D1897	428 m EK	SE¼SE¼ sec. 15, T. 50 N., R. 96 W.	Sheep Mountain and Wardel Reservoir.
D1898	?m	Center NE¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain and Wardel Reservoir.
D1899	438 m EK	NE¼NE¼NE¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain.
D1900	?m	NW¼NE¼ sec. 6, T. 50 N., R. 95 W.	Wardel Reservoir.
D1901	?m	NW¼NE¼NW¼ sec. 6, T. 50 N., R. 95 W.	Wardel Reservoir.
D1902	?m	Center E½SE¼SW¼ sec. 4, T. 50 N., R. 95 W.	Wardel Reservoir.
D1903	?m	NW¼NW¼ sec. 8, T. 50 N., R. 95 W.	Wardel Reservoir.
D1904	?m	Center W½W½SW¼NE¼ sec. 27, T. 51 N., R. 97 W.	Tatman Mountain.
D1905	?m	Center W¼W½NW¼ sec. 27, T. 51 N., R. 97 W.	Tatman Mountain.
D1906	?m	Center NW¼SW¼SE¼ sec. 3, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1907	?m	Center SW¼SW¼ sec. 2, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1908	?m	Center W1/8NW¼SW¼ sec. 11, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1909	?m	NW¼NW¼SW¼SE¼ and SE¼SE¼NW¼SE¼ sec. 10, T. 47 N., R. 96 W.	Dutch Nick Flat.
D1910	494 m B	Center S½NE¼SE¼ and center N½SE¼SE¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1911	?m	NE¼NE¼SW¼SW¼ sec. 1, T. 50 N., R. 98 W.	Tatman Mountain.
D1912	?m	SE¼SW¼SE¼ sec. 2, T. 50 N., R. 98 W.	Tatman Mountain.
D1913	?m	SW¼SW¼NW¼SE¼ sec. 2, T. 50 N., R. 98 W.	Tatman Mountain.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1914	529 m B	Center SW¼SW¼ sec. 25, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1915	?m	Center NE¼NE¼SW¼ sec. 8, T. 49 N., R. 97 W.	Dead Indian Hill.
D1916	?m	Center E¼SE¼SE¼ sec. 5, T. 49 N., R. 97 W.	Dead Indian Hill.
D1917	?m	Center W½NW¼ NE¼ sec. 8, T. 49 N., R. 97 W.	Dead Indian Hill.
D1918	544 m B	SE¼SE¼ sec. 26, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1919	539 m B	Center S½SW¼SW¼ sec. 25, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1920	530 m B	Center SW¼SW¼ sec. 25, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1921	?m	SE¼NE¼SE¼ sec. 8, T. 50 N., R. 95 W.	Wardel Reservoir.
D1922	?m	Center SE¼SE¼NW¼ sec. 17, T. 49 N., R. 97 W.	Dead Indian Hill.
D1923	362 m EB	SW¼SE¼NE¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir.
D1924	357 m B	SW¼SE¼SE¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir.
D1925	?m	Center N¼NE¼SW¼ sec. 17, T. 49 N., R. 97 W.	Dead Indian Hill.
D1926	?m	SE¼SE¼SW¼NW¼ sec. 7, T. 50 N., R. 94 W.	Jones Reservoir.
D1927	?m	NW¼NE¼NE¼NE¼ sec. 13, T. 50 N., R. 95 W.	Jones Reservoir.
D1928	?m	Center SW¼SW¼SE¼ sec. 12, T. 50 N., R. 95 W.	Jones Reservoir.
D1929	?m	NE¼NE¼SW¼ sec. 12, T. 50 N., R. 95 W.	Jones Reservoir.
D1930	?m	N½SW¼SW¼ sec. 7, T. 50 N., R. 94 W.	Jones Reservoir.
D1931	315 m ES	NE¼SW¼ and W½NW¼SW¼ sec. 7, T. 50 N., R. 94 W.	Jones Reservoir.
D1932	?m	NE¼SW¼SW¼ sec. 4, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1933	?m	NW¼NW¼NW¼NW¼ sec. 27, T. 48 N., R. 96 W.	Dutch Nick Flat.
D1934	?m	SW¼NW¼SW¼SW¼ sec. 35, T. 49 N., R. 96 W.	Sucker Dam.
D1935	250 m EB	Center NE¼SW¼ sec. 5, T. 50 N., R. 96 W.	Jones Reservoir.
D1936	463 m B	Center E¼SE¼SW¼ sec. 20, T. 50 N., R. 96 W.	Sheep Mountain.
D1937	442 m EB	NW¼SW¼SW¼NW¼ sec. 31, T. 49 N., R. 94 W.	Schuster Flats NW.
D1938	310 m ES	NE¼NE¼NE¼ sec. 1, T. 50 N., R. 95 W.	Jones Reservoir.
D1939	?m	SW¼SW¼NW¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
D1940	?m	SE¼SW¼SW¼ sec. 17, T. 49 N., R. 94 W.	Schuster Flats NW.
D1941	?m	Center NE¼ sec. 17, T. 49 N., R. 94 W.	Schuster Flats NW.
D1942	?m	SW¼NW¼NW¼ sec. 16, T. 49 N., R. 94 W.	Schuster Flats NW.
D1943	?m	NW¼NW¼NW¼NE¼ sec. 20, T. 49 N., R. 94 W.	Schuster Flats NW.
D1944	?m	NE¼NE¼SW¼ sec. 1, T. 48 N., R. 98 W.	Dead Indian Hill.
D1945	?m	NW¼NW¼NW¼ sec. 36, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1946	422 m B	E½NE¼NE¼ sec. 9, T. 48 N., R. 94 W.	Schuster Flats NW.
D1947	407 m B	Center NE¼ sec. 9, T. 48 N., R. 94 W.	Schuster Flats NW.
D1948	?m	SE¼SE¼SE¼ sec. 28, T. 48 N., R. 93 W.	Schuster Flats SE.
D1949	?m	SW¼NW¼SE¼SE¼ sec. 28, T. 48 N., R. 93 W.	Schuster Flats SE.
D1950	353 m B	NW¼NW¼NW¼SE¼NE¼ sec. 3, T. 47 N., R. 94 W.	Schuster Flats SE.
D1951	402 m B	E1/3NW¼SE¼ sec. 21, T. 48 N., R. 94 W.	Schuster Flats.
D1952	400 m B	E1/3NW¼SE¼ sec. 21, T. 48 N., R. 94 W.	Schuster Flats.
D1953	?m	Center S½SW¼SE¼ sec. 33, T. 49 N., R. 94 W.	Schuster Flats NW.
D1954	?m	SW¼SW¼NE¼NE¼ sec. 20, T. 49 N., R. 94 W.	Schuster Flats NW.
D1955	?m	Center W½ sec. 9, T. 49 N., R. 94 W.	Schuster Flats NE.
D1956	?m	SW¼SW¼NW¼NE¼ sec. 3, T. 49 N., R. 95 W.	Wardel Reservoir.
D1957	?m	Center NE¼ sec. 3, T. 49 N., R. 95 W.	Wardel Reservoir.
D1958	?m	NE¼ sec. 2, T. 49 N., R. 95 W.	Jones Reservoir.

Table 2. U.S. Geological Survey (Denver) fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
D1959	?m	N½NW¼SE¼ and NW¼NW¼SE¼SE¼ sec. 3, T. 50 N., R. 94 W.	Jones Reservoir.
D1960	?m	Center SW¼ sec. 20, T. 48 N., R. 94 W.	Schuster Flats.
D1961	?m	NW¼NE¼ sec. 22, T. 48 N., R. 94 W.	Schuster Flats SE.
D1962	?m	NW¼ sec. 13, T. 49 N., R. 94 W.	Dutch Nick Flat.
D1963	?m	SW¼ sec. 12, T. 49 N., R. 94 W.	Dutch Nick Flat.
D1964	?m	Center N½S½ sec. 11, T. 50 N., R. 95 W.	Jones Reservoir.
D1965	?m	Center SE¼ sec. 17, T. 49 N., R. 97 W.	Dead Indian Hill.
D1966	491 m B	NE¼ sec. 30, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1967	357 m B	Center NW¼SE¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir.
D1968	?m	SE¼SE¼SE¼ sec. 9, T. 47 N., R. 94 W.	Dutch Nick Flat.
D1969	?m	NW¼NW¼ sec. 16, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1970	?m	SW¼SE¼ and SE¼SW¼ sec. 35, T. 52 N., R. 95 W.	Gould Butte.
D1971	?m	SW¼ sec. 25, T. 52 N., R. 95 W.	Gould Butte.
D1972	?m	SE¼SE¼ sec. 26, T. 52 N., R. 95 W.	Gould Butte.
D1973	?m	SE¼NW¼SW¼SW¼ sec. 4, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1974	?m	NW¼NW¼SW¼SW¼ sec. 4, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1975	?m	Center NE¼SE¼SE¼ sec. 5, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1976	?m	E½NE¼ sec. 8, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
D1977	?m	SE¼SE¼ sec. 13, T. 46 N., R. 91 W.	Cabin Fork.
D1978	?m	SE¼NE¼NE¼ sec. 35, T. 51 N., R. 98 W.	Tatman Mountain.
D1979	?m	NE¼NW¼NE¼SW¼ sec. 28, T. 50 N., R. 98 W.	Sheets Flat.
D1980	?m	Center NE¼NW¼ and NW¼NW¼NW¼NW¼ sec. 32, T. 51 N., R. 97 W.	Tatman Mountain.
D1981	?m	NE¼NE¼SW¼SW¼ sec. 6, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1982	492 m B	SE¼SE¼ sec. 1, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1983	488 m B	SW¼NW¼ sec. 7, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
D1984	504 m B	SW¼SW¼SE¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1985	516 m B	SE¼SE¼SE¼SE¼ sec. 11, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
D1986	509 m B	SE¼SE¼NW¼ sec. 12, T. 49 N., R. 97 W.	Dutch Nick Flat NW.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming.

[Only locality Y307 is in the Fort Union Formation. m, meter level (minus values denote meter levels beneath top of Fort Union Formation); B, Bown sections; S, Schankler-Wing sections; K, Kraus sections; E, stratigraphic position estimated during Bown's sectioning; EB, into Bown's sections; EK, into Kraus's sections; ES, into Schankler-Wing sections; ? unknown. Localities are given to the nearest quarter section and are shown on plates 1 and 2. Names of topographic quadrangles in which the localities occur follow locality information. All are U.S. Geological Survey 7 ½-minute topographic maps at scale 1:24,000. Names in parentheses following the quadrangle names are other names by which the localities are known. Localities represent collecting efforts of the Yale Peabody Museum in 1961-65, 1968-72, 1974, and 1975]

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y1	571 m S	NE¼ sec. 29, T. 49 N., R. 97 W.	Dead Indian Hill.
Y2	571 m S	SW¼ sec. 20, T. 49 N., R. 97 W.	Dead Indian Hill.
Y3	601 m S	NE¼ sec. 26, T. 49 N., R. 98 W.	Dead Indian Hill.
Y4	?m	SW¼ sec. 12, T. 49 N., R. 99 W.	Wilson Spring.
Y5	?m	NE¼ sec. 23, T. 50 N., R. 99 W.	Sheets Flat (Rain).
Y6	?m	NW¼ sec. 20, T. 50 N., R. 98 W.	Sheets Flat (Magpie).
Y7	641 m S	SE¼ sec. 32, T. 49 N., R. 97 W.	Dead Indian Hill.
Y8	591 m S	NW¼ sec. 32, T. 49 N., R. 97 W.	Dead Indian Hill.
Y9	551 m S	NW¼ sec. 21, T. 49 N., R. 97 W.	Dead Indian Hill.
Y10	551 m S	NW¼ sec. 21, T. 49 N., R. 97 W.	Dead Indian Hill.
Y11	No data	No data.	No data.
Y12	?m	SW¼ sec. 6, T, 48 N., R. 98 W.	Wilson Spring.
Y13	541 m S	SE¼ sec. 16, T. 49 N., R. 97 W.	Dead Indian Hill.
Y14A	483 m B	NE¼ sec. 32, T. 49 N., R. 95 W.	Sucker Dam.
Y14B	No data	No data.	No data.
Y15	541 m S	SE¼ sec. 16, T. 49 N., R. 97 W.	Dead Indian Hill.
Y16	541 m S	NE¼ sec. 27, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y17	561 m ES	NW¼ sec. 35, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y18A	491 m S	NE¼ sec. 30, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y18B	521 m S	SE¼ sec. 26, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y19	521 m S	NW¼ sec. 25, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y20	511 m S	NE¼ sec. 23, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y21	501 m S	NW¼ sec. 24, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y22	551 m S	NE¼ sec. 27, T. 49 N., R. 97 W.	Dead Indian Hill.
Y23	511 m S	NW¼ sec. 13, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y24	611 m S	SW¼ sec. 22, T. 49 N., R. 98 W.	Wilson Spring.
Y25	501 m S	SW¼ sec. 18, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y26A	491 m S	SW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y26B	491 m S	SW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y26C	491 m S	NW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y27	491 m S	NW¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y28	491 m S	SW¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW (Windy Gap).
Y29	No data	No data.	No data.
Y30	?m	NW¼ sec. 5, T. 48 N., R. 98 W.	Wilson Spring.
Y31	?m	NE¼ sec. 1, T. 49 N., R. 99 W.	Wilson Spring.
Y32	611 m S	NW¼ sec. 22, T. 49 N., R. 98 W.	Wilson Spring.
Y33	601 m S	SE¼ sec. 22, T. 49 N., R. 98 W.	Dead Indian Hill.
Y34	469 m S	SW¼ sec. 10, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y35	No data	No data.	No data.
Y36	521 m S	NE¼ sec. 22, T. 49 N., R. 97 W.	Dutch Nick Flat.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y37	?m	SW¼ sec. 4, T. 49 N., R. 97 W.	Dead Indian Hill.
Y38	?m	NE¼ sec. 8, T. 49 N., R. 97 W.	Dead Indian Hill.
Y39	501 m S	NW¼ sec. 19, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y40	481 m S	SW¼ sec. 34, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y41	481 m S	SW¼ sec. 11, T. 48 N., R. 96 W.	Sucker Dam.
Y42	481 m S	SW¼ sec. 3, T. 48 N., R. 96 W.	Sucker Dam (Moocow Hollow).
Y43	481 m ES	NW¼ sec. 13, T. 48 N., R. 96 W.	Sucker Dam.
Y44	463 m B	SW¼ sec. 15, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y45	470 m B	NW¼ sec. 33, T. 49 N., R. 95 W.	Sucker Dam (called main stop on road to Worland on many museum labels).
Y45S	470 m B	SW¼ sec. 5, T. 48 N., R. 95 W.	Sucker Dam.
Y46	No data	No data.	No data.
Y47	489 m B	SW¼ sec. 15, T. 49 N., R. 95 W.	Sucker Dam.
Y47A	489 m B	NW¼ sec. 22, T. 49 N., R. 95 W.	Sucker Dam.
Y48	57 m EB	NW¼ sec. 17, T. 46 N., R. 91 W.	Banjo Flats East.
Y49	490 m EB	SW¼ sec. 2, T. 47 N., R. 95 W.	Schuster Flats.
Y50	394 m K	SW¼ sec. 11, T. 50 N., R. 96 W.	Wardel Reservoir.
Y51	416 m K	NE¼ sec. 14, T. 50 N., R. 96 W.	Wardel Reservoir.
Y52	470 m EB	SW¼ sec. 32, T. 50 N., R. 95 W.	Wardel Reservoir.
Y53	No data	No data.	No data.
Y54	No data	No data.	No data.
Y55	501 m ES	SE¼ sec. 6, T. 48 N., R. 96 W.	Dutch Nick Flat NW. (Howard's Hill and *Diacodexis* locality).
Y56	501 m ES	SE¼ sec. 32, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y57	?m	SW¼ sec. 9, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
Y58	No data	No data.	No data.
Y59	491 m S	NW¼ sec. 29, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y60	No data	No data.	No data.
Y61	474 m B	SE¼ sec. 9, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y62	No data	No data.	No data.
Y63	?m	NE¼ sec. 3, T. 49 N., R. 95 W.	Wardel Reservoir.
Y64	No data	No data.	No data.
Y65	No data	No data.	No data.
Y66	491 m S	SW¼ sec. 33, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y67	380 m K	SW¼ sec. 12, T. 50 N., R. 96 W.	Wardel Reservoir.
Y68	420 m S	No data.	No data.
Y69	414 m EK	SE¼ sec. 15, T. 50 N., R. 96 W.	Wardel Reservoir (*Didelphodus* locality).
Y70	491 m S	SW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y71A	501 m S	SW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y71B	491 m S	NW¼ sec. 20, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y72*	481 m B	SE¼ sec. 4, T. 48 N., R. 96 W.	Sucker Dam.
Y73	491 m S	SE¼ sec. 18, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y74	491 m S	NW¼ sec. 17, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y75	501 m S	SW¼ sec. 19, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y76	501 m S	NE¼ sec. 24, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y77	501 m S	NE¼ sec. 24, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y78	405 m K	NE¼ sec. 23, T. 50 N., R. 96 W.	Wardel Reservoir.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y79	?m	SE¼ sec. 27, T. 51 N., R. 96 W.	Wardel Reservoir.
Y80	390 m S	NE¼ sec. 10, T. 50 N., R. 95 W.	Wardel Reservoir.
Y81	360 m S	NW¼ sec. 12, T. 50 N., R. 95 W.	Jones Reservoir.
Y82	No data	No data.	No data.
Y82A	370 m S	NW¼ sec. 13, T. 50 N., R. 95 W.	Jones Reservoir.
Y83	430 m S	NE¼ sec. 9, T. 50 N., R. 95 W.	Wardel Reservoir.
Y84	380 m K	NE¼ sec. 13, T. 50 N., R. 96 W.	Wardel Reservoir.
Y85	414 m EK	SW¼ sec. 18, T. 50 N., R. 95 W.	Wardel Reservoir.
Y86	430 m S	SW¼ sec. 9, T. 50 N., R. 95 W.	Wardel Reservoir.
Y87	180 m S	NE¼ sec. 31, T. 50 N., R. 93 W.	Orchard Bench.
Y88	180 m S	SW¼ sec. 32, T. 50 N., R. 94 W.	Orchard Bench.
Y89	170 m S	SE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.
Y90A	90 m S	SE¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench.
Y90B	100 m S	NE¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench
Y91	160 m S	SE¼ sec. 19, T. 50 N., R. 93 W.	Orchard Bench.
Y92	140 m S	NW¼ sec. 19, T. 50 N., R. 93 W.	Orchard Bench.
Y93	140 m S	NE¼ sec. 18, T. 50 N., R. 93 W.	Orchard Bench.
Y94	140 m S	NW¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench.
Y95	50 m S	NE¼ sec. 31, T. 51 N., R. 93 W.	Orchard Bench.
Y96	140 m S	SE¼ sec. 6, T. 50 N., R. 93 W.	Orchard Bench.
Y97	140 m S	NW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
Y98	180 m S	NE¼ sec. 24, T. 50 N., R. 94 W.	Orchard Bench.
Y99	478 m B	NE¼ sec. 9, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y100	455 m B	NE¼ sec. 9, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y101	180 m S	SW¼ sec. 19, T. 50 N., R. 93 W.	Orchard Bench.
Y102	No data	No data.	No data.
Y103	?m	NW¼ sec. 36, T. 51 N., R. 97 W.	Sheep Mountain.
Y104	140 m S	NW¼ sec. 18, T. 50 N., R. 93 W.	Orchard Bench.
Y105	?m	NW¼ sec. 23, T. 51 N., R. 94 W.	Greybull South.
Y106	140 m ES	No data.	No data.
Y107	?m	SW¼ sec. 18, T. 49 N., R. 93 W.	Schuster Flats NE.
Y108	220 m S	NE¼ sec. 23, T. 50 N., R. 94 W.	Orchard Bench.
Y109	150 m S	NW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
Y110	155 m ES	NW¼ sec. 13, T. 50 N., R. 94 W.	Orchard Bench.
Y111	190 m S	SW¼ sec. 14, T. 50 N., R. 94 W.	Orchard Bench.
Y112	210 m ES	NE¼ sec. 16, T. 50 N., R. 94 W.	Jones Reservoir.
Y113	220 m S	NE¼ sec. 18, T. 50 N., R. 94 W.	Jones Reservoir.
Y114	No data	No data.	No data.
Y115	30 m EB	NW¼ sec. 24, T. 46 N., R. 92 W.	Banjo Flats East.
Y116	No data	No data.	No data.
Y117	No data	No data.	No data.
Y118	No data	No data.	No data.
Y119	100 m S	NE¼ sec. 36, T. 51 N., R. 94 W.	Orchard Bench (*Neoliotomus* locality).
Y120	100 m S	NE¼ sec. 36, T. 51 N., R. 94 W.	Orchard Bench.
Y121	150 m ES	NE¼ sec. 26, T. 51 N., R. 94 W.	Orchard Bench.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y122	?m	NE¼ sec. 27, T. 51 N., R. 94 W.	Jones Reservoir.
Y123	No data	No data.	No data.
Y124	No data	No data.	No data.
Y125	340 m ES	SW¼ sec. 13, T. 50 N., R. 95 W.	Jones Reservoir.
Y126*	370 m EK	SW¼ sec. 28, T. 50 N., R. 95 W.	Wardel Reservoir.
Y127	390 m K	SW¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y128	?m	SW¼ sec. 12, T. 49 N., R. 94 W.	Schuster Flats NE.
Y129	?m	SE¼ sec. 11, T. 49 N., R. 94 W.	Schuster Flats NE.
Y130	?m	NE¼ sec. 13, T. 49 N., R. 94 W.	Schuster Flats NE.
Y131	348 m B, upper; 344 m B, lower.	SW¼ sec. 29, T. 48 N., R. 93 W.	Schuster Flats SE.
Y132	360 m B	SW¼ sec. 30, T. 48 N., R. 93 W.	Schuster Flats SE.
Y133	324 m EB	NW¼ sec. 30, T. 49 N., R. 93 W.	Schuster Flats NE.
Y134	?m	NW¼ sec. 8, T. 49 N., R. 94 W.	Schuster Flats NW.
Y135	343 m B	SW¼ sec. 5, T. 48 N., R. 93 W.	Schuster Flats NE.
Y136	359 m B	NW¼ sec. 6, T. 48 N., R. 93 W.	Schuster Flats NE.
Y137	97 m EB	NE¼ sec. 9, T. 46 N., R. 91 W.	Banjo Flats East.
Y138	41 m EB	NE¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
Y139	77 m EB	NE¼ sec. 32, T. 47 N., R. 91 W.	Worland SE.
Y140*	?m	SW¼ sec. 11, T. 49 N., R. 94 W.	Schuster Flats NW.
Y141	?m	SE¼ sec. 8, T. 49 N., R. 94 W.	Schuster Flats NW.
Y142	370 m S	NW¼ sec. 33, T. 50 N., R. 94 W.	Jones Reservoir.
Y143	240 m S	SE¼ sec. 26, T. 50 N., R. 94 W.	Orchard Bench.
Y144	180 m S	NW¼ sec. 31, T. 50 N., R. 93 W.	Orchard Bench.
Y145	160 m S	NE¼ sec. 12, T. 50 N., R. 94 W.	Orchard Bench.
Y146	160 m S	NW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
Y147	?m	NE¼ sec. 35, T. 51 N., R. 94 W.	Orchard Bench.
Y148	150 m ES	NW¼ sec. 35, T. 51 N., R. 94 W.	Orchard Bench.
Y149	360 m S	SE¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir (*Pachyaena* locality).
Y150	360 m ES	No data.	No data.
Y151	360 m ES	No data.	No data.
Y152	380 m S	SW¼ sec. 3, T. 50 N., R. 95 W.	Wardel Reservoir.
Y152N	380 m ES	SE¼ sec. 3, T. 50 N., R. 95 W.	Wardel Reservoir.
Y153	?m	SW¼ sec. 13, T. 49 N., R. 94 W.	Schuster Flats NE.
Y154	?m	Center sec. 14, T. 49 N., R. 94 W.	Schuster Flats NE.
Y155	?m	NW¼ sec. 3, T. 48 N., R. 93 W.	Schuster Flats NE.
Y156	310 m ES	NW¼ sec. 6, T. 50 N., R. 94 W.	Jones Reservoir.
Y157	343 m B, upper; 336 m B, middle; 322 m EB, lower.	NE¼ sec. 8, T. 48 N., R. 93 W.	Schuster Flats NE.
Y158	354 m EB	No data.	No data.
Y159	?m	NW¼ sec. 13, T. 49 N., R. 94 W.	Schuster Flats NE.
Y160	591 m S	SE¼ sec. 19, T. 49 N., R. 97 W.	Dead Indian Hill.
Y161	571 m S	NE¼ sec. 29, T. 49 N., R. 97 W.	Dead Indian Hill.
Y162A	591 m S	NW¼ sec. 19, T. 49 N., R. 97 W.	Dead Indian Hill.
Y162B	591 m	NW¼ sec. 19, T. 49 N., R. 97 W.	Dead Indian Hill.
Y162C	591 m	NE¼ sec. 19, T. 49 N., R. 97 W.	Dead Indian Hill.
Y163	601 m S	NW¼ sec. 18, T. 49 N., R. 97 W.	Dead Indian Hill.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y164	?m	SW¼ sec. 33, T. 49 N., R. 98 W.	Wilson Spring.
Y165	561 m S	NW¼ sec. 28, T. 49 N., R. 97 W.	Dead Indian Hill.
Y166	601 m S	NW¼ sec. 32, T. 49 N., R. 97 W.	Dead Indian Hill.
Y167	541 m S	NE¼ sec. 21, T. 49 N., R. 97 W.	Dead Indian Hill.
Y168	501 m S	SW¼ sec. 19, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y169	?m	NE¼ sec. 12, T. 49 N., R. 99 W.	Wilson Spring.
Y170	?m	SE¼ sec. 5, T. 49 N., R. 98 W.	Wilson Spring.
Y171	511 m ES	No data.	No data.
Y172	626 m ES	NE¼ sec. 15, T. 49 N., R. 98 W.	Dead Indian Hill.
Y173	511 m S	SE¼ sec. 31, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y174	531 m S	NE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y175	531 m S	SE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW (Gray Flats locality).
Y176	531 m S	SW¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y177	511 m S	NE¼ sec. 31, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y178	531 m S	SE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y179	541 m S	SE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y180	541 m S	SW¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y181	541 m S	NW¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y182*	?m	NW¼ sec. 3, T. 50 N., R. 98 W.	Sheets Flat.
Y183	561 m S	NW¼ sec. 27, T. 49 N., R. 97 W.	Dead Indian Hill.
Y184	541 m S	SW¼ sec. 26, T. 49 N., R. 97 W.	Dutch Nick Flat NW.
Y185	531 m S	SE¼ sec. 26, T. 49 N., R. 97 W.	Dutch Nick Flat NW (*Absarokius* locality).
Y186	511 m S	SW¼ sec. 30, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y187	556 m S	SE¼ sec. 2, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y188	551 m S	NE¼ sec. 11, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y189	541 m S	SW¼ sec. 6, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y190	541 m S	NW¼ sec. 7, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
Y191	531 m S	SW¼ sec. 31, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y192	546 m S	SE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y192S	546 m S	SW¼ sec. 7, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
Y193	546 m S	NE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y193E	546 m S	NE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y194	No data	No data.	No data.
Y195	601 m S	SE¼ sec. 30, T. 49 N., R. 97 W.	Dead Indian Hill.
Y196	591 m S	NE¼ sec. 23, T. 49 N., R. 98 W.	Dead Indian Hill.
Y197	591 m S	SE¼ sec. 14, T. 49 N., R. 98 W.	Dead Indian Hill.
Y198	601 m S	SE¼ sec. 13, T. 49 N., R. 98 W.	Dead Indian Hill.
Y199	591 m S	NE¼ sec. 24, T. 49 N., R. 98 W.	Dead Indian Hill.
Y200	80 m S	NE¼ sec. 31, T. 51 N., R. 93 W.	Orchard Bench.
Y201	100 m S	NE¼ sec. 6, T. 50 N., R. 93 W.	Orchard Bench.
Y202	100 m S	NE¼ sec. 6, T. 50 N., R. 93 W.	Orchard Bench.
Y203	100 m S	NE¼ sec. 6, T. 50 N., R. 93 W.	Orchard Bench.
Y204	100 m S	SE¼ sec. 31, T. 51 N., R. 93 W.	Orchard Bench.
Y205	100 m S	SE¼ sec. 31, T. 51 N., R. 93 W.	Orchard Bench.
Y206	140 m S	SE¼ sec. 6, T. 50 N., R. 93 W.	Orchard Bench.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y207	140 m S	NW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
Y208	?m	SW¼ sec. 21, T. 50 N., R. 93 W.	Orchard Bench.
Y209	No data	No data.	No data.
Y210	No data	No data.	No data.
Y211	No data	No data.	No data.
Y212	230 m S	NE¼ sec. 23, T. 50 N., R. 94 W.	Orchard Bench.
Y212E	?m	NW¼ sec. 24, T. 50 N., R. 94 W.	Orchard Bench.
Y213	220 m S	NE¼ sec. 23, T. 50 N., R. 94 W.	Orchard Bench.
Y214*	190 m S	SW¼ sec. 14, T. 50 N., R. 94 W.	Orchard Bench.
Y215	210 m S	NE¼ sec. 15, T. 50 N., R. 94 W.	Jones Reservoir.
Y215W	190 m ES	NW¼ sec. 15, T. 50 N., R. 94 W.	Jones Reservoir.
Y216	340 m ES	SE¼ sec. 13, T. 50 N., R. 95 W.	Jones Reservoir (*Haplomylus* locality).
Y217	?m	NE¼ sec. 23, T. 50 N., R. 95 W.	Jones Reservoir.
Y218	?m	SE¼ sec. 15, T. 50 N., R. 95 W.	Wardel Reservoir.
Y219	397 m K	NW¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y220	405 m K	NE¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
Y221	412 m K	SW¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y222	430 m EK	NW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
Y223	430 m K	NE¼ sec. 36, T. 50 N., R. 96 W.	Wardel Reservoir.
Y224*	435 m EK	NE¼ sec. 36, T. 50 N., R. 96 W.	Wardel Reservoir.
Y225	435 m EK	NW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
Y226	385 m K	SE¼ sec. 29, T. 50 N., R. 95 W.	Wardel Reservoir.
Y227	457 m B	NW¼ sec. 36, T. 50 N., R. 96 W.	Wardel Reservoir.
Y227N	457 m B	SW¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
Y228	No data	No data.	No data.
Y229	No data	No data.	No data.
Y230A	407 m K	SW¼ sec. 24, T. 50 N., R. 96 W.	Wardel Reservoir.
Y230B	407 m K	NE¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir (*Hyracotherium* locality).
Y231	?m	NE¼ sec. 17, T. 50 N., R. 96 W.	Sheep Mountain.
Y232	?m	NW¼ sec. 17, T. 50 N., R. 96 W.	Sheep Mountain.
Y233	?m	NE¼ sec. 17, T. 50 N., R. 96 W.	Sheep Mountain.
Y234	410 m K	NW¼ sec. 25, T. 50 N., R. 96 W.	Wardel Reservoir.
Y235	404 m K	SW¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y236	430 m EK	NW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
Y237	412 m K	NW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
Y238	No data	No data.	No data.
Y239	No data	No data.	No data.
Y240	?m	SE¼ sec. 7, T. 50 N., R. 96 W.	Sheep Mountain.
Y241	?m	SW¼ sec. 7, T. 50 N., R. 96 W.	Sheep Mountain.
Y242	?m	SW¼ sec. 7, T. 50 N., R. 96 W.	Sheep Mountain.
Y243	?m	SE¼ sec. 13, T. 50 N., R. 97 W.	Sheep Mountain.
Y244	?m	SE¼ sec. 18, T. 50 N., R. 96 W.	Sheep Mountain.
Y245	?m	SW¼ sec. 23, T. 50 N., R. 97 W.	Sheep Mountain.
Y246	No data	No data.	No data.
Y247	425 m K	NW¼ sec. 14, T. 50 N., R. 96 W.	Wardel Reservoir.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y248	430 m EK	NW¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain.
Y249	480 m EK	NE¼ sec. 35, T. 51 N., R. 97 W.	Sheep Mountain.
Y250	440 m EK	NE¼ sec. 36, T. 50 N., R. 95 W.	Wardel Reservoir.
Y251	430 m EK	NW¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain.
Y252	440 m EK	SW¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
Y253	481 m B	SW¼ sec. 27, T. 49 N., R. 95 W.	Sucker Dam.
Y254	?m	NE¼ sec. 6, T. 49 N., R. 96 W.	Sheep Mountain.
Y255	?m	NW¼ sec. 6, T. 49 N., R. 96 W.	Sheep Mountain.
Y256	513 m ES	NW¼ sec. 7, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y257	507 m ES	NE¼ sec. 7, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y258	?m	SW¼ sec. 22, T. 51 N., R. 97 W.	Tatman Mountain.
Y259	?m	SE¼ sec. 21, T. 51 N., R. 97 W.	Tatman Mountain.
Y260	?m	SW¼ sec. 22, T. 51 N., R. 97 W.	Tatman Mountain.
Y261	430 m EK	NE¼ sec. 31, T. 50 N., R. 95 W.	Wardel Reservoir.
Y262	397 m K	NE¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y263	397 m K	NE¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y264	385 m K	SW¼ sec. 29, T. 50 N., R. 95 W.	Wardel Reservoir.
Y265	394 m K	SE¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y266	408 m K	SE¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y267	409 m K	SE¼ sec. 29, T. 50 N., R. 95 W.	Wardel Reservoir.
Y268	425 m EK	SE¼ sec. 22, T. 50 N., R. 96 W.	Sheep Mountain.
Y269	394 m K	SE¼ sec. 30, T. 50 N., R. 95 W.	Wardel Reservoir.
Y270	445 m EK	NE¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
Y271	400 m K	SE¼ sec. 24, T. 50 N., R. 96 W.	Wardel Reservoir.
Y272	?m	NE¼ sec. 8, T. 47 N., R. 96 W.	Dutch Nick Flat SW.
Y273	?m	SW¼ sec. 4, T. 47 N., R. 94 W.	Schuster Flats.
Y274	352 m B	SE¼ sec. 35, T. 48 N., R. 94 W.	Schuster Flats SE.
Y275	10 m EB	SW¼ sec. 22, T. 47 N., R. 91 W.	Worland SE.
Y276	82 m EB	NW¼ sec. 24, T. 47 N., R. 92 W.	Worland SE.
Y277	370 m S	NW¼ sec. 11, T. 50 N., R. 95 W.	Jones Reservoir.
Y278	360 m S	SE¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir.
Y279	360 m S	NE¼ sec. 11, T. 50 N., R. 95 W.	Jones Reservoir.
Y280	370 m S	NW¼ sec. 14, T. 50 N., R. 95 W.	Jones Reservoir.
Y281	360 m S	NE¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir.
Y282	370 m S	SW¼ sec. 2, T. 50 N., R. 95 W.	Jones Reservoir.
Y283	370 m S	Center sec. 11, T. 50 N., R. 95 W.	Jones Reservoir.
Y284	360 m S	NE¼ sec. 11, T. 50 N., R. 95 W.	Jones Reservoir.
Y285	280 m S	NW¼ sec. 5, T. 50 N., R. 94 W.	Jones Reservoir.
Y286	270 m S	SW¼ sec. 25, T. 51 N., R. 95 W.	Jones Reservoir.
Y287	290 m S	SE¼ sec. 26, T. 51 N., R. 95 W.	Jones Reservoir.
Y288	290 m S	SW¼ sec. 25, T. 51 N., R. 95 W.	Jones Reservoir.
Y289	280 m S	NW¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
Y290	210 m ES	NE¼ sec. 33, T. 51 N., R. 94 W.	Jones Reservoir.
Y291	?m	NW¼ sec. 34, T. 51 N., R. 94 W.	Jones Reservoir.
Y292	?m	NE¼ sec. 32, T. 51 N., R. 94 W.	Jones Reservoir.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y293	?m	NE¼ sec. 27, T. 51 N., R. 94 W.	Jones Reservoir.
Y294	270 m S	NW¼ sec. 32, T. 51 N., R. 94 W.	Jones Reservoir.
Y295	280 m S	NE¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
Y296	290 m S	NE¼ sec. 6, T. 50 N., R. 94 W.	Jones Reservoir.
Y297	290 m S	NE¼ sec. 6, T. 50 N., R. 94 W.	Jones Reservoir.
Y298	370 m S	NW¼ sec. 13, T. 50 N., R. 95 W.	Jones Reservoir.
Y299	370 m S	SW¼ sec. 12, T. 50 N., R. 95 W.	Jones Reservoir.
Y300	227 m B	SE¼ sec. 5, T. 50 N., R. 94 W.	Jones Reservoir.
Y301	280 m S	SW¼ sec. 31, T. 51 N., R. 94 W.	Jones Reservoir.
Y302	230 m ES	SW¼ sec. 4, T. 50 N., R. 94 W.	Jones Reservoir.
Y303	?m	NW¼ sec. 22, T. 51 N., R. 94 W.	Gould Butte.
Y304	?m	NW¼ sec. 11, T. 50 N., R. 94 W.	Jones Reservoir.
Y305	130 m S	SE¼ sec. 29, T. 50 N., R. 93 W.	Orchard Bench.
Y306	30 m EB	NW¼ sec. 2, T. 46 N., R. 92 W.	Banjo Flats East.
Y307	-24 m EB	NW¼ sec. 26, T. 46 N., R. 91 W.	Cabin Fork.
Y308	?m	SW¼ sec. 12, T. 47 N., R. 92 W.	Worland SE.
Y309	No data	No data.	No data.
Y310	No data	No data.	No data.
Y311	No data	No data.	No data.
Y312	No data	No data.	No data.
Y313	?m	SE¼ sec. 8, T. 49 N., R. 97 W.	Dead Indian Hill.
Y314	511 m S	NE¼ sec. 1, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y315	546 m S	NE¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y316	546 m ES	NW¼ sec. 12, T. 48 N., R. 97 W.	Dutch Nick Flat NW.
Y317*	491 m S	SW¼ sec. 8, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y318*	478 m B	SW¼ sec. 9, T. 49 N., R. 96 W.	Dutch Nick Flat NW.
Y319	412 m EK	NW¼ sec. 34, T. 51 N., R. 96 W.	Sheep Mountain.
Y320	423 m EK	NW¼ sec. 3, T. 50 N., R. 96 W.	Sheep Mountain.
Y321	430 m K	NW¼ sec. 14, T. 50 N., R. 96 W.	Wardel Reservoir.
Y322	?m	NE¼ sec. 33, T. 51 N., R. 94 W.	Jones Reservoir.
Y323	195 m ES	NW¼ sec. 28, T. 51 N., R. 94 W.	Jones Reservoir.
Y324	400 m EK	NE¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
Y325	435 m EK	SE¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
Y326	?m	NE¼ sec. 25, T. 52 N., R. 95 W.	Gould Butte.
Y327	160 m S	SE¼ sec. 33, T. 50 N., R. 93 W.	Orchard Bench.
Y328	?m	SW¼ sec. 17, T. 49 N., R. 94 W.	Schuster Flats NW.
Y329	?m	SE¼ sec. 18, T. 49 N., R. 94 W.	Schuster Flats NW.
Y330	430 m ES	NW¼ sec. 30, T. 50 N., R. 94 W.	Jones Reservoir.
Y331	?m	SE¼ sec. 18, T. 49 N., R. 94 W.	Schuster Flats NW.
Y332	?m	SE¼ sec. 18, T. 49 N., R. 94 W.	Schuster Flats NW.
Y333	?m	NW¼ sec. 21, T. 49 N., R. 94 W.	Schuster Flats NW.
Y334	370 m S	SW¼ sec. 29, T. 50 N., R. 94 W.	Jones Reservoir.
Y335	335 m ES	NE¼ sec. 19, T. 50 N., R. 94 W.	Jones Reservoir.
Y336	?m	SE¼ sec. 12, T. 49 N., R. 94 W.	Schuster Flats NE.
Y337	140 m S	SW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y338	438 m B	NE¼ sec. 7, T. 48 N., R. 94 W.	Schuster Flats NW.
Y339	452 m B	SW¼ sec. 33, T. 49 N., R. 94 W.	Schuster Flats NW.
Y340	446 m EB	NW¼ sec. 29, T. 49 N., R. 94 W.	Schuster Flats NW.
Y341	140 m S	SW¼ sec. 34, T. 50 N., R. 93 W.	Orchard Bench.
Y342	113 m EB	E¼ sec. 6, T. 46 N., R. 91 W.	Banjo Flats East.
Y343	113 m EB	NE¼ sec. 5, T. 46 N., R. 91 W.	Banjo Flats East.
Y344	210 m ES	NE¼ sec. 8, T. 50 N., R. 94 W.	Jones Reservoir.
Y345	180 m S	NE¼ sec. 14, T. 50 N., R. 94 W.	Orchard Bench.
Y346	140 m S	NE¼ sec. 13, T. 50 N., R. 94 W.	Orchard Bench.
Y347	182 m ES	NE¼ sec. 11, T. 50 N., R. 94 W.	Orchard Bench.
Y348	400 m ES	SW¼ sec. 33, T. 50 N., R. 94 W.	Jones Reservoir.
Y349	305 m ES	SE¼ sec. 7, T. 50 N., R. 94 W.	Jones Reservoir.
Y350	290 m S	SE¼ sec. 7, T. 50 N., R. 94 W.	Jones Reservoir.
Y351	240 m S	SE¼ sec. 5, T. 50 N., R. 94 W.	Jones Reservoir.
Y352	?m	SW¼ sec. 19, T. 49 N., R. 94 W.	Schuster Flats NW.
Y353	454 m B	SE¼ sec. 26, T. 49 N., R. 95 W.	Schuster Flats NW.
Y354	240 m S	NE¼ sec. 35, T. 50 N., R. 94 W.	Orchard Bench.
Y355	240 m S	NE¼ sec. 35, T. 50 N., R. 94 W.	Orchard Bench.
Y356	360 m ES	NE¼ sec. 29, T. 50 N., R. 94 W.	Jones Reservoir (*Hyopsodus* Hill).
Y357	?m	SE¼ sec. 15, T. 49 N., R. 93 W.	Schuster Flats NE.
Y358	140 m S	NE¼ sec. 1, T. 50 N., R. 94 W.	Orchard Bench.
Y359	150 m B	SW¼ sec. 6, T. 50 N., R. 93 W.	Orchard Bench.
Y360	370 m ES	NE¼ sec. 28, T. 50 N., R. 94 W.	Jones Reservoir.
Y361	430 m ES	SW¼ sec. 30, T. 50 N., R. 94 W.	Jones Reservoir.
Y362	160 m S	SE¼ sec. 30, T. 50 N., R. 93 W.	Orchard Bench.
Y363	190 m S	SE¼ sec. 25, T. 50 N., R. 94 W.	Orchard Bench (Teakettle Hill).
Y364	140 m B	NE¼ sec. 12, T. 50 N., R. 94 W.	Orchard Bench.
Y365	310 m S	SW¼ sec. 35, T. 50 N., R. 94 W.	Jones Reservoir.
Y366	?m	NW¼ sec. 9, T. 53 N., R. 96 W.	Emblem.
Y367	210 m ES	SW¼ sec. 31, T. 50 N., R. 93 W.	Orchard Bench.
Y368	215 m ES	NE¼ sec. 6, T. 49 N., R. 93 W.	Orchard Bench.
Y369	180 m ES	SE¼ sec. 10, T. 50 N., R. 94 W.	Jones Reservoir.
Y370	70 m B	SW¼ sec. 33, T. 47 N., R. 91 W.	Banjo Flats East (Banjo quarry, equal to W16A).
Y371	?m	SE¼ sec. 24, T. 50 N., R. 95 W.	Jones Reservoir.
Y372	220 m S	SE¼ sec. 23, T. 50 N., R. 94 W.	Orchard Bench.
Y373	250 m S	SE¼ sec. 22, T. 50 N., R. 94 W.	Jones Reservoir.
Y374	160 m S	NE¼ sec. 12, T. 50 N., R. 94 W.	Orchard Bench.
Y375	?m	NE¼ sec. 21, T. 50 N., R. 94 W.	Jones Reservoir.
Y376	?m	NE¼ sec. 1, T. 52 N., R. 98 W.	Gilmore Hill SE.
Y377	180 m S	NW¼ sec. 30, T. 50 N., R. 93 W.	Orchard Bench.
Y378	No data	No data.	No data.
Y379	No data	No data.	No data.
Y380	No data	No data.	No data.
Y381	115 m ES	NW¼ sec. 36, T. 51 N., R. 94 W.	Orchard Bench.
Y382	140 m S	SE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y383	140 m S	SE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.
Y384	?m	SW¼ sec. 5, T. 49 N., R. 93 W.	Schuster Flats NE.
Y385	?m	SW¼ sec. 5, T. 49 N., R. 93 W.	Schuster Flats NE.
Y386	230 m ES	NE¼ sec. 36, T. 50 N., R. 94 W.	Orchard Bench.
Y387	230 m ES	SE¼ sec. 36, T. 50 N., R. 94 W.	Orchard Bench.
Y388	180 m S	NW¼ sec. 19, T. 50 N., R. 93 W.	Orchard Bench.
Y389	170 m S	SE¼ sec. 32, T. 50 N., R. 93 W.	Orchard Bench.
Y390*	?m	SW¼ sec. 2, T. 49 N., R. 93 W.	Schuster Flats NE.
Y391	?m	SW¼ sec. 2, T. 49 N., R. 93 W.	Schuster Flats NE.
Y392	?m	SE¼ sec. 3, T. 49 N., R. 93 W.	Schuster Flats NE.
Y393	150 m ES	NE¼ sec. 3, T. 50 N., R. 94 W.	Jones Reservoir.
Y394	150 m S	SW¼ sec. 2, T. 50 N., R. 94 W.	Jones Reservoir.
Y395	150 m B	NW¼ sec. 2, T. 50 N., R. 94 W.	Orchard Bench.
Y396	160 m ES	NW¼ sec. 12, T. 50 N., R. 94 W.	Orchard Bench.
Y397	150 m ES	NE¼ sec. 1, T. 50 N., R. 94 W.	Orchard Bench.
Y398	No data	No data.	No data.
Y399	95 m ES	SW¼ sec. 30, T. 51 N., R. 93 W.	Orchard Bench.
Y400	?m	SW¼ sec. 3, T. 50 N., R. 94 W.	Jones Reservoir.
Y401	?m	SW¼ sec. 3, T. 50 N., R. 94 W.	Jones Reservoir.
Y402	?m	SW¼ sec. 3, T. 50 N., R. 94 W.	Jones Reservoir.
Y403	?m	NW¼ sec. 27, T. 51 N., R. 94 W.	Jones Reservoir.
Y404	165 m ES	NE¼ sec. 2, T. 50 N., R. 94 W.	Orchard Bench.
Y405	?m	SE¼ sec. 13, T. 51 N., R. 94 W.	Greybull South.
Y406	160 m ES	NE¼ sec. 12, T. 50 N., R. 94 W.	Orchard Bench.
Y407	145 m ES	NW¼ sec. 7, T. 50 N., R. 93 W.	Orchard Bench.
Y408	180 m S	SW¼ sec. 13, T. 50 N., R. 94 W.	Orchard Bench.
Y409	?m	SE¼ sec. 8, T. 49 N., R. 93 W.	Schuster Flats NE.
Y410	165 m ES	NE¼ sec. 2, T. 50 N., R. 94 W.	Orchard Bench.
Y411	160 m ES	NW¼ sec. 1, T. 50 N., R. 94 W.	Orchard Bench.
Y412	213 m ES	SW¼ sec. 28, T. 51 N., R. 94 W.	Jones Reservoir.
Y413	?m	SW¼ sec. 10, T. 53 N., R. 96 W.	Emblem.
Y414	?m	NE¼ sec. 17, T. 53 N., R. 96 W.	Emblem.
Y415	?m	SE¼ sec. 34, T. 54 N., R. 97 W.	Gilmore Hill SE.
Y416	205 m ES	SW¼ sec. 28, T. 51 N., R. 94 W.	Jones Reservoir.
Y417	?m	SE¼ sec. 13, T. 53 N., R. 97 W.	Emblem.
Y418*	?m	SW¼ sec. 35, T. 54 N., R. 97 W.	Gilmore Hill SE.
Y419	370 m ES	NW¼ sec. 5, T. 50 N., R. 95 W.	Wardel Reservoir.
Y420	?m	NE¼ sec. 6, T. 50 N., R. 95 W.	Wardel Reservoir.
Y421	390 m ES	SE¼ sec. 6, T. 50 N., R. 95 W.	Wardel Reservoir.
Y422	?m	NW¼ sec. 29, T. 51 N., R. 96 W.	Sheep Mountain.
Y423	?m	SE¼ sec. 29, T. 51 N., R. 96 W.	Sheep Mountain.
Y424	?m	NE¼ sec. 33, T. 51 N., R. 96 W.	Sheep Mountain.
Y425	?m	SE¼ sec. 2, T. 50 N., R. 96 W.	Wardel Reservoir.
Y426	?m	SW¼ sec. 4, T. 50 N., R. 95 W.	Wardel Reservoir.
Y427	450 m ES	SW¼ sec. 9, T. 50 N., R. 95 W.	Wardel Reservoir.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y428	?m	NW¼ sec. 16, T. 50 N., R. 95 W.	Wardel Reservoir.
Y429	?m	NE¼ sec. 16, T. 50 N., R. 95 W.	Wardel Reservoir.
Y430	?m	NE¼ sec. 15, T. 50 N., R. 95 W.	Wardel Reservoir.
Y431	?m	SW¼ sec. 16, T. 50 N., R. 95 W.	Wardel Reservoir.
Y432	?m	NW¼ sec. 22, T. 50 N., R. 95 W.	Wardel Reservoir.
Y433	?m	NW¼ sec. 15, T. 50 N., R. 95 W.	Wardel Reservoir.
Y434	?m	SE¼ sec. 14, T. 50 N., R. 95 W.	Jones Reservoir.
Y435	No data	No data.	No data.
Y436	No data	No data.	No data.
Y437	No data	No data.	No data.
Y438	No data	No data.	No data.
Y439	No data	No data.	No data.
Y440	?m	Unsurveyed area, SW¼	Ralston.
Y441	No data	No data.	No data.
Y442	No data	No data.	No data.
Y443	No data	No data.	No data.
Y444	?m	NE¼ sec. 26, T. 54 N., R. 99 W.	Gilmore Hill NW (Birthday locality).
Y445A	?m	NW¼ sec. 8, T. 54 N., R. 99 W.	Ralston.
Y445B	?m	SW¼ sec. 9, T. 54 N., R. 99 W.	Ralston.
Y446	No data	No data.	No data.
Y447	356 m B	SE¼ sec. 34, T. 48 N., R. 94 W.	Schuster Flats SE.
Y448	438 m EB	NW¼ sec. 15, T. 48 N., R. 94 W.	Schuster Flats NE.
Y449	356 m B	NE¼ sec. 3, T. 47 N., R. 94 W.	Schuster Flats SE.
Y450	?m	SW¼ sec. 24, T. 54 N., R. 99 W.	Gilmore Hill NW.
Y451	?m	Unsurveyed area, SE¼.	Emblem.
Y452	?m	Center sec. 28, T. 53 N., R. 96 W.	Emblem.
Y453	No data	No data.	No data.
Y454	?m	SW¼ sec. 4, T. 52 N., R. 99 W.	Stone Barn Camp.
Y455	?m	SW¼ sec. 28, T. 52 N., R. 98 W.	Y-U Bench.
Y456	?m	NE¼ sec. 27, T. 54 N., R. 99 W.	Ralston.
Y457	?m	SE¼ sec. 12, T. 54 N., R. 100 W.	Ralston.
Y458	324 m B	NE¼ sec. 12, T. 47 N., R. 94 W.	Schuster Flats SE.
Y459	332 m B	NW¼ sec. 6, T. 47 N., R. 93 W.	Schuster Flats SE.
Y460	392 m B	SE¼ sec. 21, T. 48 N., R. 94 W.	Schuster Flats.
Y461	405 m B	NE¼ sec. 17, T. 47 N., R. 94 W.	Schuster Flats.
Y462	400 m B	SE¼ sec. 25, T. 48 N., R. 95 W.	Schuster Flats.
Y463	410 m B	NE¼ sec. 25, T. 48 N., R. 95 W.	Schuster Flats.
Y464	?m	NE¼ sec. 9, T. 53 N., R. 96 W.	Emblem.
Y465	?m	SE¼ sec. 34, T. 53 N., R. 97 W.	Gilmore Hill SE.
Y466	?m	SW¼ sec. 35, T. 53 N., R. 97 W.	Gilmore Hill SE.
Y467	?m	NE¼ sec. 24, T. 54 N., R. 100 W.	Ralston.
Y468	?m	NW¼ sec. 10, T. 53 N., R. 96 W.	Emblem.
Y469	No data	No data.	No data.
Y470	No data	No data.	No data.
Y471	?m	SE¼ sec. 26, T. 53 N., R. 100 W.	Stone Barn Camp.

Table 3. Yale University Peabody Museum fossil vertebrate localities in the Fort Union and Willwood Formations of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
Y472	?m	SW¼ sec. 13, T. 51 N., R. 99 W.	Y-U Bench NW.
Y473	?m	NE¼ sec. 3, T. 51 N., R. 99 W.	Y-U Bench NW.
Y474	?m	Unsurveyed area, SE¼.	Gilmore Hill NW.
Y475	?m	Unsurveyed area, SE¼.	Gilmore Hill NE.
Y476*	?m	SW¼ sec. 16, T. 54 N., R. 99 W.	Ralston.
Y477	?m	Unsurveyed area, SE¼	Emblem.

*The Yale Peabody Museum maps give two different locations for these localities. The additional locations, which may represent vastly different meter levels, are shown below. We lack data for localities Y478-Y495, established by David Schankler.

Locality No.	Location	Topographic quadrangle
Y72	NE¼ sec. 4, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
Y126	SE¼ sec. 36, T. 50 N., R. 96 W.	Wardel Reservoir.
Y140	NE¼ sec. 31, T. 50 N., R. 93 W.	Orchard Bench.
Y182	NW¼ sec. 17, T. 49 N., R. 97 W.	Dead Indian Hill.
Y214	SW¼ sec. 14, T. 50 N., R. 94 W.	Jones Reservoir.
Y224	SE¼ sec. 20, T. 50 N., R. 96 W.	Sheep Mountain.
Y317	NW¼ sec. 28, T. 49 N., R. 97 W.	Dead Indian Hill.
Y318	NW¼ sec. 28, T. 49 N., R. 97 W.	Dead Indian Hill.
Y390	SW¼ sec. 20, T. 50 N., R. 93 W.	Orchard Bench.
Y418	NE¼ sec. 2, T. 53 N., R. 97 W.	Emblem.
Y476	Unsurveyed area, SE¼.	Gilmore Hill.

Table 4. Duke University Primate Center fossil vertebrate localities in the Willwood Formation of the central and southern Bighorn Basin, Wyoming.

[m, meter level; B, Bown sections; S, Schankler-Wing sections; EB, stratigraphic position estimated into Bown sections; ?, unknown. Localities are given to the nearest quarter section and are shown on plates 1 and 2. Names of topographic quadrangles in which the localities occur follow locality information. All are U.S. Geological Survey 7½-minute topographic maps at scale 1:24,000. Localities represent collecting efforts of the Duke University Primate Center during 1979–81]

Locality No.	Stratigraphic position	Location	Topographic quadrangle
DPC1	438 m B . .	SE¼ sec. 14, T. 48 N., R. 95 W.	Schuster Flats NW.
DPC2	No data . . .	No data.	No data.
DPC3	No data . . .	No data.	No data.
DPC4	No data . . .	No data.	No data.
DPC5	No data . . .	No data.	No data.
DPC6	?m	SW¼ sec. 6, T. 53 N., R. 97 W.	Gilmore Hill SE.
DPC7	No data . . .	No data.	No data.
DPC8	?m	SE¼ sec. 30, T. 53 N., R. 97 W.	Gilmore Hill SE.
DPC9	No data . . .	No data.	No data.
DPC10	?m	SE¼ sec. 25, T. 48 N., R. 97 W.	Dutch Nick Flat SW.
DPC11	536 m EB .	SW¼ sec. 16, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
DPC12	551 m EB .	SE¼ sec. 17, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
DPC13	501 m B . .	NE¼ sec. 22, T. 48 N., R. 96 W.	Dutch Nick Flat.
DPC14	556 m B . .	SE¼ sec. 20, T. 48 N., R. 96 W.	Dutch Nick Flat SW.
DPC15	546 m S . . .	SE¼ sec. 7, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
DPC16	546 m B . .	NW¼ sec. 18, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
DPC17	528 m EB .	NW¼ sec. 17, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
DPC18E	?m	SW¼ sec. 9, T. 48 N., R. 96 W.	Dutch Nick Flat NW.
DPC18W	?m	NE¼ sec. 17, T. 48 N., R. 96 W.	Dutch Nick Flat NW.

Table 5. University of Michigan fossil vertebrate localities in the Willwood Formation of the central and southern Bighorn Basin, Wyoming.

[m, meter level; B, Bown sections; EB, stratigraphic position estimated into Bown sections; ?, unknown. Localities are given to the nearest quarter section and are shown on plates 1 and 2. Names of topographic quadrangles in which the localities occur follow locality information. All are U.S. Geological Survey 7 ½-minute topographic maps at scale 1:24,000. Localities represent collecting efforts of the University of Michigan in 1976 and 1981]

Locality No.	Stratigraphic position	Location	Topographic quadrangle
		Red Butte series of localities	
UMRB1	481 m B	SE¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
UMRB1A	481 m B	NW¼ sec. 27, T. 49 N., R. 95 W.	Sucker Dam.
UMRB2	481 m B	SE¼ sec. 21, T. 49 N., R. 95 W.	Sucker Dam.
UMRB3	470 m B	NW¼ sec. 28, T. 49 N., R. 95 W.	Sucker Dam.
UMRB4	485 m B	NE¼ sec. 17, T. 49 N., R. 95 W.	Sucker Dam.
UMRB5	505 m B	SE¼ sec. 4, T. 49 N., R. 95 W.	Sucker Dam.
UMRB6	489 m B	NE¼ sec. 16, T. 49 N., R. 95 W.	Sucker Dam.
UMRB7	436 m B	SW¼ sec. 12, T. 49 N., R. 96 W.	Sucker Dam.
UMRB8	425 m B	SE¼ sec. 13, T. 49 N., R. 96 W.	Sucker Dam.
UMRB9	460 m EB	Center sec. 8, T. 48 N., R. 95 W.	Sucker Dam.
UMRB10	490 m B	SW¼ sec. 14, T. 48 N., R. 96 W.	Sucker Dam.
UMRB11	?m.	SE¼ sec. 25, T. 48 N., R. 97 W.	Dutch Nick Flat SW.
UMRB12	482 m B	SW¼ sec. 23, T. 48 N., R. 96 W.	Dutch Nick Flat.
		Greybull River series of localities	
GR1	?m.	NW¼ sec. 5, T. 50 N., R. 95 W.	Wardel Reservoir (equal to Y419).
GR2	?m.	NE¼ sec. 6, T. 50 N., R. 95 W.	Wardel Reservoir (equal to Y420).
GR3	?m.	SW¼ sec. 6, T. 50 N., R. 95 W.	Wardel Reservoir (equal to Y421).
GR4	?m.	NW¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
GR5	?m.	NW¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
GR6	?m.	NE¼ sec. 5, T. 50 N., R. 96 W.	Sheep Mountain.
GR7	?m.	NE¼ sec. 5, T. 50 N., R. 96 W.	Sheep Mountain.
GR8	?m.	NE¼ sec. 5, T. 50 N., R. 96 W.	Sheep Mountain.
GR9	?m.	SW¼ sec. 34, T. 51 N., R. 96 W.	Sheep Mountain.
GR10	?m.	SE¼ sec. 34, T. 51 N., R. 96 W.	Sheep Mountain.
GR11	?m.	SE¼ sec. 5, T. 50 N., R. 96 W.	Sheep Mountain.
GR12	No data .	No data.	No data.
GR13	?m.	NW¼ sec. 9, T. 50 N., R. 96 W.	Sheep Mountain.
GR14	?m.	NE¼ sec. 8, T. 50 N., R. 96 W.	Sheep Mountain.
GR15	?m.	SW¼ sec. 4, T. 50 N., R. 96 W.	Sheep Mountain.
GR16	?m.	NE¼ sec. 9, T. 50 N., R. 96 W.	Sheep Mountain.

Table 6. University of Wyoming fossil vertebrate localities in the Willwood Formation of the central and southern Bighorn Basin, Wyoming.

[m, meter level; B, Bown sections; E, estimated; ?, unknown. Localities are given to the nearest quarter section and are shown on plates 1 and 2. Names of topographic quadrangles in which the localities occur follow locality information. All are U.S. Geological Survey 7 ½-minute topographic maps at scale 1:24,000. Names in parentheses following the quadrangle names are other names by which the localities are known. Localities represent collecting efforts of the University of Wyoming Geological Museum in 1973–76. In the Wyoming Geological Museum catalogue, these localities have the prefix "V–73"; for example, V–73017 is W17, and V–73125 is W125, as used here]

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
W16A	70 m B	SW¼ sec. 33, T. 47 N., R. 91 W.	Banjo Flats East (Banjo quarry).
W16B	64 m B	SW¼ sec. 33, T. 47 N., R. 91 W.	Banjo Flats East (Banjo anthills).
W16C	61 m B	SW¼ sec. 33, T. 47 N., R. 91 W.	Banjo Flats East.
W17	64 m B	NW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W19	9 m B	SW¼ sec. 34, T. 48 N., R. 92 W.	Worland (Canal).
W20	97 m B	SW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East (Purple Valley).
W20A	97 m B	NE¼ sec. 9, T. 46 N., R. 91 W.	Banjo Flats East.
W20B	97 m B	NE¼ sec. 9, T. 46 N., R. 91 W.	Banjo Flats East.
W21	?m	SE¼ sec. 19, T. 46 N., R. 92 W.	Banjo Flats West.
W22	46 m B	SE¼ sec. 36, T. 47 N., R. 92 W.	Banjo Flats East (Slick Creek quarry beds; includes Slick Creek quarry).
W23	31 m B	NW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W24	48 m B	NE¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East (Campbell quarry).
W24A	48 m B	NE¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East (Jeffrey's extension of Campbell quarry).
W25	24 m B	SW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W26	24 m B	SW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W27	30 m B	NE¼ sec. 12, T. 46 N., R. 92 W.	Banjo Flats East (Stonehenge quarry beds, including Stonehenge quarry).
W28	18 m EB	SW¼ sec. 29, T. 45 N., R. 92 W.	Banjo Flats West.
W29	113 m B	NE¼ sec. 6, T. 46 N., R. 91 W.	Banjo Flats East.
W30	130 m B	SE¼ sec. 30, T. 47 N., R. 91 W.	Worland SE.
W31	?m	SW¼ sec. 6, T. 46 N., R. 91 W.	Banjo Flats East.
W32	46 m B	SW¼ sec. 6, T. 46 N., R. 91 W.	Banjo Flats East.
W33	34 m B	SE¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W34	34 m B	NW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East (Two Head Hill quarry beds).
W34N1	34 m B	SW¼ sec. 36, T. 47 N., R. 92 W.	Banjo Flats East.
W34N2	34 m B	NE¼ sec. 35, T. 47 N., R. 92 W.	Worland SE.
W35	40 m B	NW¼ sec. 3, T. 46 N., R. 91 W.	Banjo Flats East.
W36	36 m B	SE¼ sec. 26, T. 47 N., R. 92 W.	Worland SE.
W37	34 m B	NW¼ sec. 35, T. 47 N., R. 92 W.	Worland SE (Supersite quarry beds, including Supersite quarry).
W38	41 m B	NE¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W39	23 m B	SE¼ sec. 21, T. 47 N., R. 91 N.	Worland SE.
W40	?m	NE¼ sec. 9, T. 46 N., R. 91 W.	Banjo Flats East.
W41	30 m EB	NE¼ sec. 24, T. 46 N., R. 92 W.	Banjo Flats East.
W42	24 m EB	SE¼ sec. 24, T. 46 N., R. 91 W.	Cabin Fork.
W43	20 m EB	SW¼ sec. 11, T. 46 N., R. 91 W.	Cabin Fork.
W44	57 m B	NE¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East (Wadi Kraus quarry).

Table 6. University of Wyoming fossil vertebrate localities in the Willwood Formation of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
W45	46 m B	NE¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W46	75 m B	NW¼ sec. 33, T. 47 N., R. 91 W.	Worland SE.
W47	?m	NW¼ sec. 7, T. 46 N., R. 91 W.	Banjo Flats East.
W48	63 m B	SE¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W49	88 m B	NW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W50	66 m B	SE¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W51	88 m B	SW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W52	97 m B	SE¼ sec. 5, T. 46 N., R. 91 W.	Banjo Flats East.
W53	39 m B	NW¼ sec. 3, T. 46 N., R. 91 W.	Banjo Flats East.
W53A	?m	SE¼ sec. 3, T. 46 N., R. 91 W.	Cabin Fork.
W54	113 m B	NE¼ sec. 5, T. 46 N., R. 91 W.	Banjo Flats East.
W55	119 m B	NW¼ sec. 5, T. 46 N., R. 91 W.	Banjo Flats East.
W56	?m	NW¼ sec. 8, T. 46 N., R. 91 W.	Banjo Flats East.
W57	?m	NE¼ sec. 10, T. 47 N., R. 92 W.	Worland SE.
W58	?m	NW¼ sec. 11, T. 47 N., R. 92 W.	Worland SE.
W59	4 m B	NE¼ sec. 21, T. 47 N., R. 91 W.	Worland SE.
W60	39 m B	SW¼ sec. 34, T. 47 N., R. 91 W.	Banjo Flats East.
W61	113 m B	SE¼ sec. 6, T. 46 N., R. 91 W.	Banjo Flats East.
W62	27 m B	SE¼ sec. 35, T. 47 N., R. 92 W.	Banjo Flats East.
W63	46 m B	SW¼ sec. 25, T. 47 N., R. 92 W.	Worland SE.
W66	31 m B	NW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W67	26 m EB	SW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W76	30 m B	NW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East (*Tinimomys* Hills).
W77	34 m B	NW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W78	46 m EB	SW¼ sec. 25, T. 47 N., R. 92 W.	Worland SE.
W80	46 m B	SE¼ sec. 26, T. 47 N., R. 92 W.	Worland SE.
W81	77 m B	NW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East.
W82	88 m B	SW¼ sec. 33, T. 47 N., R. 91 W.	Banjo Flats East.
W83	81 m B	SW¼ sec. 33, T. 47 N., R. 91 W.	Banjo Flats East.
W84	119 m B	SW¼ sec. 31, T. 47 N., R. 91 W.	Banjo Flats East.
W85	23 m B	SW¼ sec. 1, T. 46 N., R. 92 W.	Banjo Flats East.
W86	61 m B	NW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East (Lantern Hill).
W87	94 m B	NW¼ sec. 10, T. 46 N., R. 91 W.	Banjo Flats East.
W88	?m	SW¼ sec. 3, T. 45 N., R. 92 W.	Banjo Flats West.
W89	?m	SW¼ sec. 15, T. 46 N., R. 92 W.	Banjo Flats West.
W90	57 m EB	NW¼ sec. 17, T. 46 N., R. 91 W.	Banjo Flats East.
W91	57 m EB	NW¼ sec. 17, T. 46 N., R. 91 W.	Banjo Flats East.
W92	46 m EB	SE¼ sec. 18, T. 46 N., R. 91 W.	Banjo Flats East.
W95	10 m B	NW¼ sec. 27, T. 47 N., R. 91 W.	Worland SE.
W96	20 m B	SW¼ sec. 13, T. 46 N., R. 92 W.	Banjo Flats East.
W98	?m	SW¼ sec. 8, T. 46 N., R. 91 W.	Banjo Flats East.
W105	26 m B	NE¼ sec. 24, T. 46 N., R. 92 W.	Banjo Flats East.
W110	40 m B	SW¼ sec. 3, T. 46 N., R. 91 W.	Banjo Flats East.
W111	113 m B	SE¼ sec. 32, T. 47 N., R. 91 W.	Banjo Flats East.
W124	180 m B	SE¼ sec. 27, T. 47 N., R. 93 W.	Schuster Flats SE.

Table 6. University of Wyoming fossil vertebrate localities in the Willwood Formation of the central and southern Bighorn Basin, Wyoming—Continued.

Locality No.	Stratigraphic position	Location	Topographic quadrangle (other names)
W125	180 m B	NW¼ sec. 27, T. 47 N., R. 93 W.	Schuster Flats SE (Rose Bonanza, Big W).
W126	180 m B	NE¼ sec. 28, T. 47 N., R. 93 W.	Schuster Flats SE.
W127	180 m B	SE¼ sec. 27, T. 47 N., R. 93 W.	Schuster Flats SE.
W128	?m	NW¼ sec. 10, T. 47 N., R. 92 W.	Worland.
W129	81 m B	NW¼ sec. 4, T. 46 N., R. 91 W.	Banjo Flats East (Mary's Hill).
W130	31 m B	NE¼ sec. 1, T. 47 N., R. 92 W.	Worland SE.

Published in the Central Region, Denver, Colorado
Manuscript approved for publication May 6, 1993
Edited by Barbara Hillier
Graphics by Wayne Hawkins
Color design by Virginia D. Scott
Photocomposition by Shelly A. Fields