To the reviewer who once participated in preparing a similar but more local work on a like subject, the advance in accurate knowledge of waterfowl during a quarter century is impressive. Mr. Kortright has the happy ability to condense from an abundance of subject matter, items of prime importance and to phrase them concisely and pleasantly. The author and the Institute, in its initial publication, merit the thanks of all persons interested in these birds for the splendid and usable volume which they have produced.—TRACY I. STORER.

Wildlife Refuges. Ira N. Gabrielson. New York, The Macmillan Co. xiii+257 pp., 32 pls., 17 figs. 1943. $4.00.

Somehow the indefatigible Director of the United States Fish and Wildlife Service finds time aside from his manifold duties to write books and good ones Following his earlier volumes on Oregon birds, alpine plants, and wildlife conservation he now has produced one on a subject long close to his heart—wildlife refuges. Out of a full experience that included field studies in many places, laboratory work on food habits of birds, and supervision of work on useful and harmful birds and mammals in the western states, he was gathered into the administrative fold of the Biological Survey at Washington just as the big program of the last decade on wildlife restoration was beginning. He has been part and parcel of the herculean efforts that both restored old habitats and created new ones for useful and desirable vertebrates.

Much of the detail comes from the files and publications of the Service, but Dr. Gabrielson has "written against a background of personal observation," having visited all but one of the major refuges and many of the others.

The opening chapters give a history of the refuge movement and the purposes, values and limitations of refuges; their types and management are discussed briefly but understandingly. Then follow rather detailed accounts of refuges of various types—bird, fur seal, big game, waterfowl—and those on lands used for other purposes and administered by other agencies, public and private. Canadian and Mexican refuges also are included. The short bibliography will lead the reader to other publications on the subject. The plates show various scenes and important animals on different refuges and the maps give the locations of refuges and certain returns from waterfowl banded at various stations in the United States.

Some of the statements included are of current and future plans that may or may not become history, but the book provides a solid core of principles and facts that will prove useful for education in classrooms and legislative halls and serve widely for reference.—TRACY I. STORER.

The mammals of eastern United States; an account of recent land mammals occurring east of the Mississippi. William J. Hamilton, Ithaca, N. Y., Comstock Publishing Co. 7+1—432 pp., frontispiece+183 figs. 1943. $4.00.

Dr. Hamilton is well known as a productive and critical contributor to literature on the ecology, food habits, and economic importance of mammals in the eastern states and also has published a general volume on "American Mammals" (1940). His present work will be helpful to both scientific students and laymen. It provides accounts of 253 species and subspecies found from Maine and Michigan to Florida and Louisiana, with keys to families and genera. For each species, the principal taxonomic characters, measurements, and geographic range are given, followed by a short generalized account of ecologic preferences, habits, food, and breeding activities. Short paragraphs give the essential data on characters and range of subspecies. The text is clear and pleasing, in both physical form and literary style. The author, artists, and publisher have cooperated to provide an abundance of useful illustrations of good quality. Some skulls are figured in drawings and others in group photographs, by families, but the scale of reduction unfortunately is omitted in a few. Excellent distribution maps are provided for all major species and subspecies. In addition there are photographs of the living mammals and a series of 29 full-page wash drawings by Earl L. Poole. The bibliography (pp. 411–421) cites references on state and local lists, taxonomic works, and life histories.—TRACY I. STORER.

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AGE AND GROWTH OF MONTANA GRAYLING[1]

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A growth-rate study of the Montana grayling (*Thymallus signifer montanus*) was initiated in the summer of 1936 and continued through the following spring while the writer was associated with the Zoology Department of Montana State College. This was part of a general study aimed at the conservation of the species. Reports on the feeding and breeding habits have already been published (Brown 1938a, 1938b).

The data collected in Montana and in Yellowstone National Park have been supplemented substantially by studies of Montana grayling of known age planted in Michigan during the past 5 years.

MATERIALS AND METHODS

The present study was based on 460 grayling taken as follows:

MICHIGAN (315)	
Wolf Lake State Fish Hatchery, Van Buren Co.	31
Ford Lake, Otsego Co.	259
O'Brien Lake, Alcona Co.	21
East Fish Lake, Montmorency Co.	2
Suttons Pond, Montmorency Co.	2
MONTANA (114)	
Ennis Hatchery, Madison Co.	6
Rogers Lake, Flathead Co.	44
Meadow Lake, Madison Co.	39
Agnes Lake, Beaverhead Co.	10
Georgetown Lake, Deer Lodge Co.	15
WYOMING (31)	
Grebe Lake, Yellowstone National Park	31

The fish were collected by nets and angling at all seasons, but mostly during the spring and autumn. Specimens were weighed and measured while fresh; those from Montana mostly to the nearest $\frac{1}{8}$ inch of standard and total length, and the nearest ounce in weight, and the Michigan specimens to the nearest millimeter of standard and total length, and to nearest gram in weight. Scales were collected from the left side of the body between the lateral line and dorsal fin. Ordinarily five typical scales from each were cleaned, mounted in glycerine-gelatin, examined, and measured by microprojection at a magnification of 44.3. The average measurements of all in each sample were used in later computations.

Annuli were determined by the presence of incomplete circuli formed at the

[1] Contribution from the Institute for Fisheries Research, Michigan Department of Conservation. The expense of making collections was defrayed largely from a grant by the National Research Council. M. H. Spaulding of Montana State College, and Elmer G. Phillips, Superintendent of Fisheries, Montana State Fish and Game Commission, assisted in making the Montana collections; A. S. Hazzard made continuation of the study possible in Michigan; L. E. Perry and F. E. Locke assisted in aging the fish and tabulating growth data; and Ralph Hile helped in interpreting the data.

of 33 feet. Water temperatures are suitable for cold-water fish the year round, at least in the thermocline and immediately below. In unusually hot summers, however, conditions may attain to near the upper limit of toleration for cold-water species as to temperature and concentration of dissolved oxygen.

There is little shallow water and the bottom is soft, hence aquatic plants are limited in kind and quantity. Save for plankton, the amount of fish food was decidedly below the average of small Michigan lakes but possibly slightly more than in the small, cold, deep-basin lakes of the region. There are no inlets or outlets and obviously no place where grayling could spawn successfully. This condition prevents the permanent establishment of the species, but is a boon to any study of fish of known age.

If each year of life is assumed to end in May, the grayling from Ford Lake showed average lengths by years as follows:

Year	Standard length	Total length
First	86 mm.	4.1 inches
Second	199 mm.	9.2 inches
Third	267 mm.	12.3 inches
Fourth	288 mm.	13.5 inches

There is some evidence of growth throughout the winter although our collections were inadequate to prove the point.

The average lengths and weights at capture and the average calculated standard lengths are shown in Table 3. Representative scales from these collections are shown in Figures 8 to 14. The average calculated standard lengths of all grayling collections from Ford Lake were as follows: 1st year, 76 mm.; 2nd year, 185 mm.; 3rd year, 258 mm.; 4th year, 284 mm.

Table 3.—Ford Lake Grayling—Average Lengths and Weights by Intervals of Standard Length

Number of specimens	Size group (millimeters)	Standard length (millimeters)	Weight (grams)	Total length (inches)	Weight (ounces)
3	140–149	147	51	6.9	1.8
10	150–159	157	58	7.3	2.0
12	160–169	165	68	7.7	2.4
7	170–179	175	80	8.1	2.8
6	180–189	184	69	8.4	2.4
15	190–199	194	84	8.9	2.9
5	200–209	204	95	9.3	3.4
6	210–219	212	108	9.8	3.8
6	230–239	234	166	11.0	5.9
5	240–249	244	179	11.5	6.3
13	250–259	253	204	11.8	7.2
3	260–269	265	240	12.2	8.5
1	280–289	280	312	13.1	11.0

Creaser and Creaser (1935) in a study of 13 Michigan grayling, mostly from the Otter River, gave calculated standard lengths, by years of life, as follows: 1st year, 86 mm.; 2nd year, 178 mm.; 3rd year, 232 mm.; 4th year (1 specimen, Au Sable River), 242 mm. No significant comparison can be made between their figures and mine because the methods employed in making calculations were probably not comparable. The authors gave no adequate description of their methods and their collections were small. The difference at the end of the first year might be due, in part, to the fact that the Ford Lake specimens spent their first summer of life under hatchery conditions not altogether favorable for good growth.

Scales of 21 Montana grayling from O'Brien Lake in Montmorency County, Michigan, gave an average calculated standard length of only 43 millimeters when the first annulus was formed and 171 millimeters at the end of their second year; their first year was spent under hatchery conditions. A comparison between the size of 1-year Montana grayling kept in the Wolf Lake hatchery and wild stock of the same age from Montana showed that the former grew only about one-third as fast as the latter. A difference in growth under hatchery and lake conditions can be seen by comparing the scales of grayling kept at the Wolf Lake hatchery until October of their second year (Fig. 7) with those of fish planted in Ford Lake in October of their first year and recovered during October of their second year (Fig. 9). This shows that ordinary hatchery methods for trout are not entirely satisfactory for grayling but does not necessarily mean that conditions in the hatchery were below those possible with our present knowledge of grayling requirements.

The length-weight relationships of grayling from Ford Lake are shown in Table 3, omitting four collections without information on weight. The series is fairly complete except for the 220–229 and 270–279 groups. With each increase in standard length of 10 millimeters these fish showed an increase in average weight of over 4 grams.

Growth Rate of Montana and Yellowstone Grayling

The grayling of Montana and Yellowstone National Park are most abundant in certain small mountain lakes into which they have been introduced (Table 4), and not in their native waters, which are the tributary streams of the Missouri River above the Great Falls. Meadow Lake is the only water in which this species can be considered as native. This lake itself is a man-made impoundment, but the stream previously was supplied abundantly with grayling.

Table 4.—Western Lakes Where Grayling Collections Were Made

Lake	Elevation (feet)	Area (acres)	Maximum depth (feet)	Methyl orange alkalinity (p.p.m.)	Other game fish present
Rogers	4500	325	21	72	cutthroat trout
Meadow	5000	5000	12	—	brown trout rainbow trout cutthroat trout whitefish
Agnes	8500	115	40	38	—
Georgetown	7000	2990	25	—	cutthroat trout
Grebe	8000	90	30	23	cutthroat trout rainbow trout

Aquatic vegetation was common in all except Agnes Lake which has a sharp "drop off" and shoals almost exclusively of angular rock. The plant beds in Rogers, Meadow, and Georgetown lakes cover more than 50 per cent of the lake bottoms. Georgetown Lake is especially

TABLE 5.—GRAYLING FROM MONTANA AND YELLOWSTONE NATIONAL PARK

Date collected	Number of specimens	Annuli	Weight (grams)	Standard length (millimeters)	Total length (inches)	Calculated standard length in millimeters at end of each year of life					
						1	2	3	4	5	6
Rogers Lake											
5/24/36	2	2	198	251	10.8	142	242	—	—	—	—
5/24/36	3	3	369	298	13.6	138	242	286	—	—	—
5/24/36	3	4	418	314	14.0	152	249	295	312	—	—
7/19/36	10	1	126	198	9.0	123	—	—	—	—	—
7/19/36	9	2	291	282	12.9	145	260	—	—	—	—
7/19/36	3	3	342	296	13.6	122	244	303	—	—	—
7/19/36	3	4	424	311	14.1	152	245	283	303	—	—
5/30/37	4	3	408	307	13.7	135	244	291	—	—	—
5/30/37	7	4	418	306	13.7	141	239	274	296	—	—
Total	44				Averages	137	247	285	304	—	—
Meadow Lake											
4/26/36	1	2	284	264	11.6	167	252	—	—	—	—
4/26/36	1	3	342	273	12.8	108	239	268	—	—	—
6/14/36	1	4	454	330	15.0	121	254	297	323	—	—
6/27/36	3	1	132	205	9.1	138	—	—	—	—	—
6/27/36	2	2	369	277	12.6	152	248	—	—	—	—
6/27/36	4	3	517	314	14.1	137	260	301	—	—	—
7/10, 12/36	15	1	135	209	9.4	135	—	—	—	—	—
7/10, 12/36	4	2	376	289	13.1	139	254	—	—	—	—
7/10, 12/36	8	3	429	298	13.7	128	248	283	—	—	—
Total	39				Averages	135	252	298	323	—	—
Agnes Lake											
6/ 6/36	3	1	64	155	7.1	132	—	—	—	—	—
6/ 6/36	2	2	129	240	11.0	105	205	—	—	—	—
6/ 6/36	3	4	246	287	13.0	106	184	248	280	—	—
6/ 6/36	2	5	186	284	12.9	106	194	253	271	279	—
Total	10				Averages	114	193	250	276	279	—
Georgetown Lake											
6/ 7/36	1	1	459	286	12.9	201	—	—	—	—	—
6/ 7/36	3	4	756	348	15.7	118	257	323	340	—	—
6/ 7/36	1	5	766	368	16.7	109	244	311	338	359	—
Total	5				Averages	133	254	320	339	359	—
Grebe Lake											
5/31–6/2/36	6	2	130	231	10.5	104	205	—	—	—	—
5/31–6/2/36	6	3	153	251	11.3	96	203	244	—	—	—
5/31–6/2/36	2	4	370	320	14.4	107	225	299	314	—	—
5/31–6/2/36	2	5	440	319	14.6	108	216	269	295	311	—
5/31–6/2/36	1	6	459	318	14.3	82	200	245	269	279	307
7/ 1–6/36	10	1	59	151	6.6	104	—	—	—	—	—
7/ 1–6/36	2	2	200	235	10.5	112	179	—	—	—	—
7/ 1–6 36	2	3	259	254	11.6	98	202	236	—	—	—
Total	31				Averages	100	205	255	297	301	307

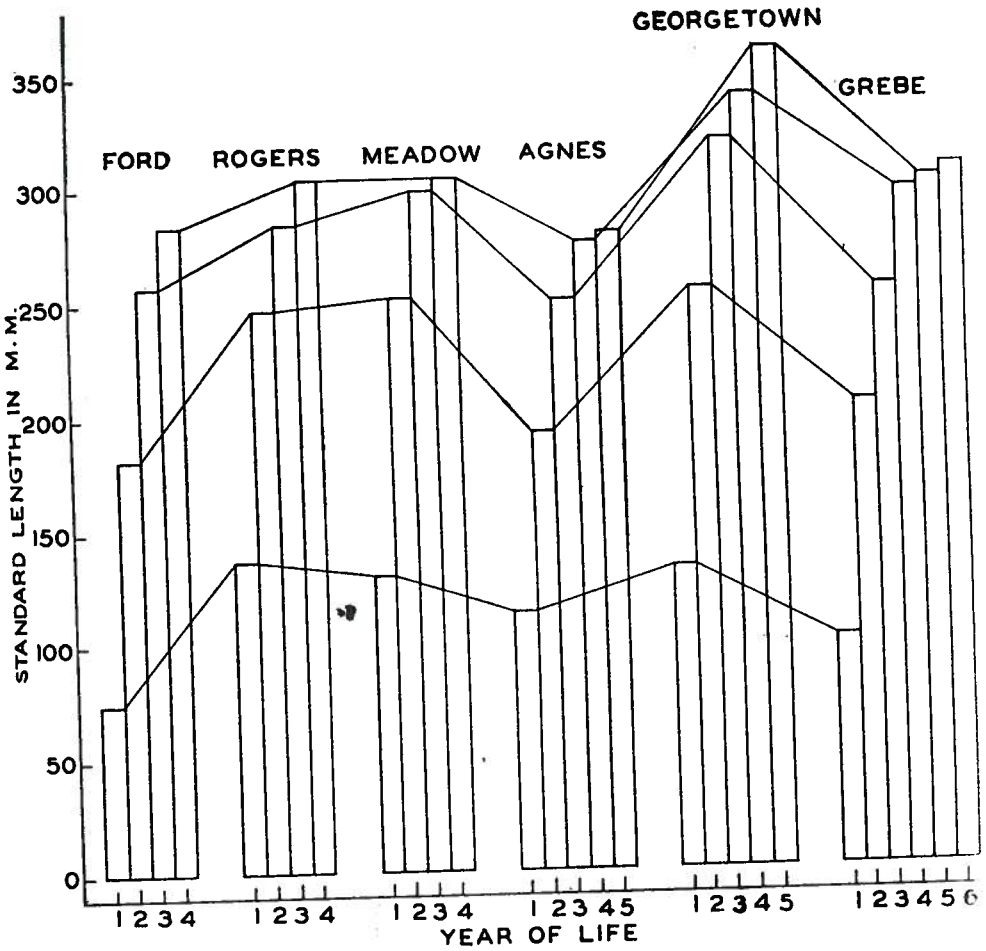

Fig. 20. Comparison of calculated standard lengths of grayling from six lakes at end of each year of life.

productive. The high organic content of the bottom has resulted in occasional severe winter kills of fish. The fluctuation of the water level in Georgetown and Meadow lakes is sufficient to have a damaging effect on the fisheries but they are extremely productive waters despite the fluctuation. Both are artificial impoundments under private control.

The length of the growing season in all of these lakes varies considerably according to elevation. Regular therm and chemical stratification exists i Grebe, Georgetown, and Agnes lak but not in Rogers or Meadow lak Maximum summer temperatures a the highest in Rogers Lake. On Ju 19, 1936, the temperature of this la was 76°F. at the surface and 71°F. the bottom (20 feet). Maximum su mer temperatures are undoubted much higher than these figures. T maximum surface temperature in M