

PREFACE

This is a book about the spatial and temporal dynamics of warm-water stream fish communities, based largely on our individual and combined research since the 1970s. Since 1994 we have shared our research on stream fish communities, using broad geographic sampling, continued long-term sampling in numerous systems, and experiments to help us understand mechanisms underlying the phenomena we have measured in the field. We use a substantial number of our own large data sets throughout the book to summarize community structure and dynamics, in what is, we hope, a "critical synthesis." These data sets range from spatially very broad, such as our collecting fish at more than 80 stream sites throughout the midwestern United States in one month of one year, to several that span four to five decades of sampling at fixed sites within watersheds. With publication of this book, we make all of these data sets available publicly and invite all who might be interested to use them in further analyses. Data are available from the Dryad Digital Repository: <http://dx.doi.org/10.5061/dryad.2435k>. We ask only that we be acknowledged as the source of any data that are used.

The book relies heavily on new analyses of fish communities that we have surveyed at multiple sites upstream to downstream at least four times on 9 streams (which we refer to as "global" communities) and analyses of the "local" communities at 31 individual sites that we also have sampled four or more times. The experiments we address in the book range in dimensions from "tabletop" tests (in units as small as 1 L boiling flasks), to large outdoor stream mesocosms that mimic riffles and pools in small streams, to enclosures in actual streams.

The goals of the book are to combine field observations and related experiments to provide a synthesis of "the big picture" that our own work reveals, all in the context of historical questions or previous research on stream fishes by ourselves or many other workers who have made stream fish ecology the energetic and vibrant science that it is today. In each chapter we briefly review the key concepts and previous publications that have set the tone for research in stream fish ecology in particular or for ecology in general, and, where appropriate, we test conventional wisdom or theoretical concepts with our empirical data sets.

The data sets and experiments were obtained across more than 40 years, for many different reasons and across many different individual projects. No single hypothesis drove the collection of these data, although we have always had an underlying question about why stream fish are where they are, and how they do what they do there. Looking back across these individual projects, we now combine them into a single large synthesis, or "workshop," in which we use these data sets and experiments as tools to

test ideas across systems to look for pervasive factors in the dynamics of stream fish communities.

We address topics including comparative structure of these fish communities; taxonomic and emergent properties of fish communities and variability; traits of individual species such as body form, environmental tolerances, or resource user patterns; species interactions, including competition, predation, and facilitation; effects of extreme disturbance events; temporal and spatial dynamics of fish communities with emphasis on both short-term and long-term change; effects of fish species or communities in ecosystems; and an overview with thoughts about future projects. Zoogeography of North American stream fishes as related to our study region was covered in detail in Matthews's (1998) *Patterns in Freshwater Fish Ecology* (Chapman and Hall, New York) and in a large chapter, "Evolution and Ecology of North American Freshwater Fish Assemblages," by Ross and Matthews (2014) in *Freshwater Fishes of North America*, volume 1 (Johns Hopkins University Press, Baltimore), so it is not covered in any detail in the present book. We also do not address other important topics for stream fishes, such as internal physiology, genetics, phylogenetic analyses, or modeling, as these areas of research are outside our own, and we wish to keep the topics in the book within our areas of expertise or experiences. The book is not an attempt to update previous comprehensive works on stream fishes, such as Matthews's 1998 book or Ross's (2013) *Ecology of North American Freshwater Fishes* (University of California Press, Berkeley). Accordingly, readers should refer to the books above for thorough literature surveys. Here, we focus on our own work, using selected examples of papers by other authors to introduce or to summarize particular topics.

We do not use this book to make statements about our personal views on scientific nomenclature for any of the fishes we have worked with. We recognize that, during the writing of this book or while it was in press, nomenclatural changes continued to be forthcoming in peer-reviewed literature, but for standardization of names we followed *Common and Scientific Names of Fishes from the United States, Canada, and Mexico*, 7th edition, 2013 (American Fisheries Society) for all taxonomy, rather than to attempt to incorporate every change that could apply as new papers were published.

The specific questions that we address with our data are diverse, and many have been the subject of ecological studies for a long time. The fundamental questions about factors that influence distribution and abundance patterns of species, which date to the founding of the discipline, remain as important as ever given that the effects of global climate change, human perturbations, and invasive species, among other issues, on fish community structure are just beginning to be understood. We believe that the strength of this book is that we can ask many of those questions or test hypotheses using data sets for samples that we have personally collected, across many systems, giving us the insight that comes from knowing the sampling and the environments of the systems in intimate detail.

The book is organized into 10 chapters. Chapters 1 and 2 describe our methods and the study systems in detail. In chapter 3 we characterize the stream fish communi-

ties with respect to emergent properties, and then we use those properties in comparisons of community dynamics and the factors that affect dynamics. Chapters 4 and 5 explore mechanisms related to species traits and interspecific interactions, respectively, that are important for understanding community structure and dynamics. In chapters 6, 7, and 8, we address different aspects of community change over time. In chapter 6, we examine effects of extreme events (e.g., floods and droughts), and in chapter 7, we take a more general approach and relate variation in community structure over time to the model of loose equilibrium. In chapter 8, we add a spatial component to our study of community change and explore spatiotemporal community dynamics. In chapter 9, we examine effects of fishes on ecosystem properties and relate change in community structure to potential effects in ecosystems. Chapter 10 summarizes our conclusions and thoughts about future studies.

Colleagues who kindly reviewed chapters or parts of chapters, and greatly helped us to make improvements, include Katie Bertrand, Mark Eberle, Tony Echelle, David Edds, Aaron Geheber, Melissa Gibbs, Keith Gido, Chad Hargrave, Andrew Marsh, Mary Power, Steve Ross, Jake Schaefer, Art Stewart, Larry Weider, and Jeff Wesner.

We especially thank the late Robert S. (Bob) Matthews, who helped WJM locate field sites and took part in all collecting on Piney Creek from 1972 to 1981. Without Bob Matthews, the Piney Creek project could not have been started, and there might have been no long-term studies (or this book). We also offer special thanks to Bob Cashner and Fran Gelwick, who were instrumental in long-term field studies on Brier Creek and in experimental work; to Henry Robison for sharing data and for many years of collegial support; and to Betty Crump, Keith Gido, Mary Power, Steve Ross, Jake Schaefer, and Art Stewart for their key roles in collaboration on major projects.

We thank many others for their help in the field or laboratory, for sharing data, or with analyses, on various projects that form the basis for this book, including Ginny and Reid Adams, who now collaborate with us on Piney Creek, Ken Asbury, Judith Barkstedt, Hank Bart, Robert Bastarache, Jeff Bek, Barry Bolton, Melody Brooks, Rich Broughton, Carol Brown, Linda Byrd, Irene Camargo, Curtis Campbell, Sara Cartwright, Alan Clingenpeel, Ken Collins, Danny Crump, James Cureton, Cari Deen, Mike Douglas, Alice Echelle, Tony Echelle, David Edds, Mike Eggleton, Jack Feminella, Daniel Fenner, Courtney Franssen, Nate Franssen, Bryan Frenette, Aaron Geheber, David Gillette, Steve Golliday, Joe Gryzbowski, Chad Hargrave, George Harp, Bret Harvey, Kim Hauger, Tom Heger, Loren Hill, Kiki Hiott, Jan Hoover, Dan Hough, Dennis House, Clark Hubbs, Donald A. Jackson, Pete Johnson, Bob Kinneburgh, Jim Lauchman, Ricky Lehrter, Mike Lodes, Frank McCormick, Roland McDaniel, David McNeely, Amber Mackowitz, Bill Magdych, Jody Maness, Andrew Marsh, Rebecca Marsh, Amy Matthews, Bob Matthews, Scott Matthews, Woody Matthews, Mike Meador, Maria Miller, Vernon Miner, Ray Moody, Bob Nairn, Susan Orosz, Zolton Orosz, Larry Page, Mitzi Pardew, Randy Parham, David Partridge, Brian Pounds, Kerri Pratt, Rhea Putnam, Mike Putz, Mark Pyron, John Robinson, Gary

Schnell, Mark Schorr, Mike Schwemm, Bill Shelton, Bill Shepard, Nick Shepherd, C. Lavett Smith, Dave Soballe, Rich Standage, Bruce Stewart, Jeff Stewart, Marsha Stock, Jim Stout, John Styron, Eric Surat, Katy Sutherland, Barbara Taylor, Chris Taylor, Jacob Thompson, Michi Tobler, Jona Tucker, Brent Tweedy, Caryn Vaughn, Bruce Wagner, Peter Wainwright, Mel Warren Jr., Jeff Wesner, Matt Winston, Zach Zbinden, and Earl Zimmerman. Coral McAllister and Andy Vaughn did the final figures, and the cover photograph was graciously provided by Garold Sneeegas. Special thanks go to Richard Page, Donna Cobb, Malon Ward, Wendal Porter, and George Martin for many years of logistical support at the University of Oklahoma Biological Station or on the University of Oklahoma main campus. Our experimental streams would not have worked without their efforts.

We are grateful to all the families who have allowed us access to field sites on private property, including (for Brier Creek) Ricky Coleman, Jim Martin, the Parrish family, Jim Williams, and John Woody, and (for Piney Creek) the Byler family, the Calvin, Marie, and Arthur Jones families, the Killian family, the Kever family, Mike and Sue Richardson, Mickey and Tamara Bevil, the Marge Cooper family, Morris and Mavis Jones, the Gameliel and Melissa Jones family, Frederick and Sharon Wright, Albert Smith, and Dr. Adam Gray. For providing a wealth of information on Piney Creek and floods in the watershed, we particularly thank Adam Gray, Arthur Jones, and the late Calvin Jones. We also thank Camp Egan, Tahlequah, Oklahoma, for support and access to Baron Fork.

We thank the University of Oklahoma Biological Station and Department of Biology at the University of Oklahoma for logistical support and the Sam Noble Oklahoma Museum of Natural History for archiving specimens. For collecting permits, we thank the Arkansas Game and Fish Commission and the Oklahoma Department of Wildlife Conservation for many years of continuous approval, and the fish divisions of other states throughout the Midwest and in Virginia. All collecting (since IACUCs were established) has been by approval of the IACUC of the University of Oklahoma. Over the years our work has been funded at various times by the National Science Foundation; US Environmental Protection Agency; US Department of Agriculture Forest Service; US Fish and Wildlife Service; Oklahoma Department of Wildlife Conservation; Oklahoma Department of Environmental Quality; US Department of Defense; North Texas Municipal Water District; the Warren County R-III School District of Warrenton, Missouri; and a Raney Fund Award to WJM from the American Society of Ichthyologists and Herpetologists.

Finally, we wish to acknowledge our executive editor at Johns Hopkins University Press, Vince J. Burke, for his excellent advice and assistance in all phases of this book. We also thank Meagan Szekely and Debby Bors at Johns Hopkins University Press for helping us through the process of book submission and production and Ashleigh McKown and Deborah Tourtlotte for skilled copyediting and indexing respectively.