

Managing White-tailed Deer in Forest Habitat From an Ecosystem Perspective Pennsylvania Case Study

Report of the Deer Management Forum

Roger Earl Latham, Jan Beyea, Merlin Benner, Cindy Adams Dunn,
Mary Ann Fajvan, Ronald R. Freed, Marrett Grund, Stephen B. Horsley,
Ann Fowler Rhoads, and Bryon P. Shissler

Convened by Audubon Pennsylvania and the Pennsylvania Habitat Alliance
to compile and examine the pertinent research, enlist other expertise, weigh the issues,
and set forth a vision of what ecosystem-based deer management might entail in large
forested areas of the eastern United States, using Pennsylvania as an example.

100 Wildwood Way
Harrisburg, Pennsylvania 17110

January 2005

Citing this report

Latham, R. E., J. Beyea, M. Benner, C. A. Dunn, M. A. Fajvan, R. R. Freed, M. Grund, S. B. Horsley, A. F. Rhoads and B. P. Shissler. 2005. *Managing White-tailed Deer in Forest Habitat From an Ecosystem Perspective: Pennsylvania Case Study*. Report by the Deer Management Forum for Audubon Pennsylvania and Pennsylvania Habitat Alliance, Harrisburg. xix + 340 pp.

Availability

This report is available for downloading in portable document format (PDF) at the Audubon Pennsylvania web site (pa.audubon.org). Paper copies may be obtained on request while supplies last, with prepayment of \$5 to cover postage, from Audubon Pennsylvania, 100 Wildwood Way, Harrisburg, Pennsylvania 17110.

Contact information

For further information or to contact any of the authors, write to facilitator@woodsandwildlife.org.

Front cover

Painted trillium, redback salamander, white oak, red trillium, hobblebush, and eastern wood-pewee are among the many native species that have been overlooked by traditional approaches to white-tailed deer management. Deer are a valued part of our natural ecosystems, but many other species have declined, sometimes drastically, in areas where deer densities have exceeded the cultural carrying capacity of the forest (see back cover).

Photo credits (clockwise from upper left): Roger M. Latham (painted trillium); Stephen V. Silluzio (redback salamander); John A. Haarstad, courtesy of Cedar Creek Natural History Area (white oak); Roger M. Latham (red trillium); Roger Earl Latham (hobblebush); J. Heidecker, courtesy of VIREO, Academy of Natural Sciences of Philadelphia (eastern wood-pewee); Roger M. Latham (white-tailed deer).

Back cover

Photo credits (clockwise from bottom): Ann Fowler Rhoads (fern carpet, Wyoming County, Pennsylvania); Roger Earl Latham (fenced-undefenced comparison, Susquehanna County, Pennsylvania); Roger Earl Latham (boulder-top “rock garden,” Warren County, Pennsylvania); Tom Kornack (close-up of bluebead lilies).

To Dr. Roger M. Latham (1914-1979),
a pioneering advocate for ecosystem management before the term was created. His work on deer
research and management beginning in 1938 still informs our current understanding of
Pennsylvania's deer problem. In a lifetime of speaking and writing about his love of nature and the
sport of hunting, he educated the public about the need for a scientific basis for managing wildlife,
without sidestepping controversy. We dedicate this book to Roger and his vision.

Members of the Deer Management Forum

(See biographical sketches in Appendix A, page 303)

ROGER EARL LATHAM, Ph.D. (Editor and contributor)
Ecologist/Conservation Biologist
Continental Conservation
Rose Valley, Pennsylvania 19086-0057

JAN BEYEA, Ph.D. (Facilitator and contributor)
Senior Scientist
Consulting in the Public Interest
Lambertville, New Jersey 08530
facilitator@woodsandwildlife.org

MERLIN BENNER
Wildlife Biologist
Pennsylvania Department of Conservation
and Natural Resources
Wellsboro, Pennsylvania 16901

CINDY ADAMS DUNN*
Director
Office of Education, Communications and Partnerships
Pennsylvania Department of Conservation
and Natural Resources
Harrisburg 17105-8552

MARY ANN FAJVAN, Ph.D.
Research Silviculturist
U.S. Forest Service, Northeastern Research Station
Morgantown, West Virginia 26505

RONALD R. FREED
Former Chairman
Pennsylvania Habitat Alliance
Carlisle, Pennsylvania 17013

MARRETT GRUND, Ph.D.†
Deer Project Leader
Farmland Wildlife Populations and Research Group
Minnesota Department of Natural Resources
Madelia, Minnesota 56062

STEPHEN B. HORSLEY, Ph.D.
Plant Physiologist
U.S. Forest Service, Northeastern Research Station
Irvine, Pennsylvania 16329-0267

ANN FOWLER RHOADS, Ph.D.
Senior Botanist
Pennsylvania Flora Project
Morris Arboretum of the University of Pennsylvania
Philadelphia, Pennsylvania 19118

BRYON P. SHISSLER
Wildlife Biologist
Consultant to Audubon Pennsylvania
N.R.C., Inc.
Fort Hill, Pennsylvania 15540

* Position during the Deer Management Forum process: Executive Director, Audubon Pennsylvania, Harrisburg

† Position during the Deer Management Forum process: Wildlife Biologist, Deer Management Section, Pennsylvania Game Commission

Preface

In April 2001, the Pennsylvania office of the National Audubon Society and the Pennsylvania Habitat Alliance asked a group of professionals to look at deer management from an ecosystem perspective. The resulting Deer Management Forum, first convened in October 2001, was asked to set forth a vision of what ecosystem-based deer management might entail. In particular, the group was asked to describe how deer management might differ from current practices if deer were managed within an ecosystem framework that aims to conserve native biodiversity. Only with such a vision in hand could decision makers, should they be so inclined, take the steps that will be needed to move deer management in Pennsylvania from a single-species approach to ecosystem management.

The preparation of this report is supportive of a recommendation made by a stakeholder group convened by the Pennsylvania Game Commission (P.G.C.) in July 2002. The group's top-priority recommendation was that deer be managed on an ecosystem basis. This report presents a vision of how that might be done.

Participants in the Deer Management Forum reviewed the scientific literature, visited field sites, heard presentations from other ecosystem and wildlife management experts, and interviewed others (See Appendices B and C for a list of presentations, field sites visited, and interviews).

The report is generally based on consensus. The one exception is the inclusion of material in Chapter 13, which is critical of P.G.C. Two former Game Commission staff members¹ felt that discussion of external critiques of the agency was inappropriate and counterproductive. It was a consensus of the remaining members of the Deer Management Forum, however, that it would be impossible to manage deer from an ecosystem perspective without facing up to and correcting deficiencies identified by external reviews of P.G.C., including reviews commissioned by the agency itself. Presented with an irresolvable impasse, the minority members withdrew their names from the report, although they allowed their contributions to the scientific portions of the report to remain.

By including in Chapter 13 past critiques of P.G.C. (e.g., the so-called MAT review and legislative audits), we do not imply any disrespect for the agency, its commissioners, or staff. We recognize that managing a large resource agency is no easy task, and all agencies have problems. A strong institution will welcome outside critiques as an opportunity for self-improvement.

Two members of the Deer Management Forum are on the staff of the Pennsylvania Department of Conservation and Natural Resources (D.C.N.R.). Their participation does not imply concurrence and endorsement of the report by D.C.N.R. leadership or the administration. To fully explore the issues of policy and structure around the management of deer, D.C.N.R.

permitted staff members participating in the Forum the freedom to openly discuss issues and alternatives from a scientific viewpoint.

The draft version of this report or portions of it have been reviewed by 10 experienced scientists and managers (listed on page ix; also see Appendix D). However, the reviewers were not asked to endorse the conclusions or recommendations, nor have they seen the final report before its release. Overall, the reviewers were very complimentary.² In a few cases, as explained in several endnotes and in Appendix D, we did not accept the suggestions or advice of reviewers. In the vast majority of cases, however, we were able to incorporate the suggested improvements. The Pennsylvania Game Commission was also given an advance review copy and senior staff members responded with updates, clarification of their position, and suggestions for revision, many of which are included in the final report.

This document is organized to facilitate its use by a range of readers, including scientists, interested stakeholders, policy analysts, and policy makers. It begins with a brief executive summary. Summary findings and recommendations are placed at the end of each chapter. The most important findings and recommendations appear in a separate chapter at the end of the main report. Supporting material appears in appendices.

Audubon Pennsylvania and the Pennsylvania Habitat Alliance

The mission of the Pennsylvania state office of the National Audubon Society is to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the Earth's biological diversity. The state office supports 22 chapters in Pennsylvania with expertise on conservation projects, chapter capability building, fundraising, advocacy, education, and collaboration with other environmental organizations.

Pennsylvania has played a major role in the Audubon Society's history. When John James Audubon first moved to America in 1803, he settled at Mill Grove near Valley Forge. It was in Pennsylvania that he developed his spectacular and unique painting style. In 1896, the Pennsylvania Audubon Society was created as the second state Audubon Society in the country.

The Pennsylvania Habitat Alliance is a coalition of 30 organizations dedicated to conservation issues. It was formed in 1998 with a commitment to conservation of habitat through effective communication and cooperation among conservation organizations, sportsmen's groups, and land trusts.

This report was produced at the request of the Pennsylvania Habitat Alliance, with Audubon Pennsylvania acting as project administrator. The statements, findings and recommendations contained in this report do not necessarily reflect the positions of the member organizations of the Alliance.

Endnotes

¹ Dr. Duane R. Diefenbach and Jerry Hassinger

² Complimentary comments from reviewers included the following:

“I will start by complimenting the authors on the wealth of information contained in the report. It is a good reference source for a range of ecosystem topics.”

“First and foremost, I want to congratulate all of you on this wonderful document. I know how incredibly hard you worked to produce this, and that work is richly and sometimes eloquently reflected on each page of this document. It is quite unusual in both its breadth and depth, its degree of interdisciplinarity, its readability (no, it’s not casual reading, but interested parties from nearly any discipline or interested lay people will gain a great reward for the effort that they put into perusing this volume, and it is accessible to the willing from across that range), and its specific adaptive resource management framework.”

“The report of the Deer Management Forum is a fascinating and superb effort to capture deer management in a comprehensive context. The report is an impressive document written by a group of biologists who have rich experience with the issues of deer in eastern forest ecosystems. The adaptive management approach provides the framework for a managing both deer and forests in manner that can build consensus for multiple objectives and incorporate the best scientific knowledge. The synthesis of existing knowledge presented here makes this a valuable document to many readers beyond the intended audience.”

“First, I would like to say it was a great read. The task force is to be congratulated on pulling together an amazing amount of information. I have tried to write several chapters like the ones in this plan and I know how scattered the information is. Excellent job.”

“I have just spent the last couple hours reading your draft report and I wish to commend you all on a job very well done. I came away from my visit with the Forum feeling overwhelmed with the complexity of the task before you but somehow you seem to have got your arms around it and come up with a credible way forward. Congratulations!”

“In general, I think that this is an excellent publication. I was particularly impressed by the logical, organized presentation of information in the book. I also think that the sections at the end of each chapter on ‘Findings’ and ‘Recommendations’ will greatly improve the utility of the publication.”

Acknowledgments

We are grateful to those who have provided data, expert knowledge, or logistical support, in particular the reviewers of earlier versions of the manuscript (listed on opposite page). Dr. Duane R. Diefenbach, Pennsylvania State University, Cooperative Fish and Wildlife Research Unit, contributed introductory material on adaptive resource management and the bulk of the chapter on measuring deer population density. He and Jerry Hassinger, Pennsylvania Game Commission, Wildlife Diversity Section (retired) attended most of the Forum meetings, providing valuable guidance on deer management. In addition, we thank: Steve Balzano, formerly Pennsylvania Department of Conservation and Natural Resources; James Bailey, Dr. E. Michael Blumenthal, Mark W. Deibler, Dr. James R. Grace, and Dr. Thomas J. Hall, Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry; Dr. James K. Bissell, Cleveland Museum of Natural History; Robert C. Boyd, Calvin W. DuBrock, Dr. Chris Rosenberry, and Vernon R. Ross, Pennsylvania Game Commission; Dr. Patrick H. Brose and Dr. Susan L. Stout, U.S. Forest Service, Northeastern Research Station, Irvine, Pennsylvania; Dr. James C. Finley, Pennsylvania State University, School of Forest Resources; Dr. Kurt W. Gottschalk, U.S. Forest Service, Northeastern Research Station, Morgantown, West Virginia; Dr. William H. McWilliams, U.S. Forest Service, Forest Inventory and Analysis, Newtown Square, Pennsylvania; Brad Nelson, U.S. Forest Service, Allegheny National Forest; Michael Pechart, Pennsylvania Department of Agriculture; Beth Sanders and Sharon Sherick, Audubon Pennsylvania; Justin Vreeland, Pennsylvania Cooperative Fish and Wildlife Research Unit, University Park; and Paul g. Wiegman, formerly Western Pennsylvania Conservancy. We also thank:

Forum presenters

Dr. Roger C. Anderson, Illinois State University; Dr. Jody W. Enck, Cornell University; Dr. Malcolm Hunter, University of Maine; Dr. Bill Kendall, Patuxent Wildlife Research Center; Dr. James N. McNair, Patrick Center for Environmental Research, Academy of Natural Sciences of Philadelphia; Dr. Karl V. Miller, University of Georgia; Dr. John L. Roseberry, Southern Illinois University, Carbondale; Dr. Michael Soulé, University of California, Santa Cruz (retired); and Dr. Harry Zinn, Pennsylvania State University.

Forum interviewees

Dr. Walter P. Carson, University of Pittsburgh; Dr. David R. DeWalle, Pennsylvania State University; and Dr. William E. Sharpe, Pennsylvania State University.

Field trip hosts and presenters

Dr. Patrick H. Brose, Todd Ristau, and Dr. Susan L. Stout, U.S. Forest Service, Northeastern Research Station, Irvine, Pennsylvania; Chad Kirschbaum, Sand County Foundation; and Paul Troutman, Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry.

Reviewers of earlier versions of the manuscript

KIP P. ADAMS

Director
Northeast Regional Office, Quality Deer
Management Association
Hanover, Pennsylvania 17331

DAVID R. DEWALLE, Ph.D.

Professor of Forest Hydrology
School of Forest Resources, Pennsylvania
State University
University Park, Pennsylvania 16802

MALCOLM HUNTER, JR., Ph.D.

Professor of Conservation Biology
Department of Wildlife Ecology, University
of Maine
Orono, Maine 04469

WILLIAM J. MCSHEA, Ph.D.

Research Scientist
Conservation and Research Center,
Smithsonian Institution
Front Royal, Virginia 22630

BEN MOYER

Editor, *Pennsylvania Sportsman* magazine;
Outdoor Writer, *Pittsburgh Post-Gazette*
Farmington, Pennsylvania 15437

WILLIAM F. PORTER, Ph.D.

Professor of Wildlife Ecology; Director,
Adirondack Ecological Center; Director,
Roosevelt Wild Life Station
Department of Environmental and Forest
Biology, State University of New York
Syracuse, New York 13210

TIMOTHY D. SCHAEFFER, Ph.D.

Central Pennsylvania Regional Director
Pennsylvania Environmental Council
Harrisburg, Pennsylvania 17101

SUSAN L. STOUT, Ph.D.

Silviculturist; Research Project Leader
Forestry Sciences Laboratory, U.S. Forest
Service
Irvine, Pennsylvania 16329-0267

DANIEL TOWNSEND, Ph.D.

Associate Professor of Ecology
Department of Biology, University of
Scranton
Scranton, Pennsylvania 18510-4625

ROBERT J. WARREN, Ph.D.

President of the Wildlife Society
Professor of Wildlife Ecology and
Management
School of Forest Resources, University of
Georgia
Athens, Georgia 30602-215

Table of Contents

| | |
|--|-----------|
| Citing this report | ii |
| Availability | ii |
| Contact information | ii |
| Members of the Deer Management Forum | iv |
| Preface..... | v |
| Audubon Pennsylvania and the Pennsylvania Habitat Alliance | vi |
| Acknowledgments..... | viii |
| Forum presenters..... | viii |
| Forum interviewees | viii |
| Field trip hosts and presenters..... | ix |
| Reviewers of earlier versions of the manuscript..... | ix |
| EXECUTIVE SUMMARY | 1 |
| Major Findings Regarding Science and Management of Forests and Wildlife..... | 3 |
| Major Findings Regarding Policy and Administration | 5 |
| Major Recommendations Regarding Science and Management of Forests and Wildlife | 7 |
| Major Recommendations Regarding Policy and Administration..... | 8 |
| Looking Forward | 9 |
| PART I. INTRODUCTION TO MANAGING DEER FROM AN ECOSYSTEM | |
| PERSPECTIVE..... | 11 |
| Chapter 1. Introduction | 13 |
| History of deer management in Pennsylvania | 13 |
| Task of the Deer Management Forum..... | 14 |
| Report organizing principle | 14 |
| Report content..... | 15 |
| Limitations of the report | 17 |
| Chapter 2. The Adaptive Resource Management Approach..... | 21 |
| Findings on the adaptive resource management approach | 28 |
| Recommendations on the adaptive resource management approach | 29 |

Chapter 3. A Brief History of Penn’s Woods 31

 Influence of Native Americans..... 31

 Cutting down the trees 32

 Early lumbering 32

 The chemical wood industry and the indiscriminate removal of forests 33

 Impact of pests and diseases..... 33

 Major forest types 34

 Beech-maple forests, sugar maple-basswood forests..... 35

 Mixed mesophytic forests 35

 Oak-hickory-pine forests..... 35

 Northern hardwoods..... 36

 Appalachian oak forests 36

 Additional forest types 37

 Coastal plain forests 37

 Glacial bog forests 37

 Barrens 37

 Riparian forests..... 38

 Swamp forests..... 38

 The forest today 38

 Findings on the history of Penn’s Woods 42

Chapter 4. Some Root Causes of Our Current Ecological Problems 45

 The roots of the deer problem 45

 Findings on the root causes of our current ecological problems 47

PART II. DEER IMPACT AND FOREST RECOVERY..... 49

Chapter 5. The Role of White-tailed Deer in Altering Forest Structure in Pennsylvania 51

 Forest plants 51

 Forest animals..... 61

 Interaction of deer and silviculture 64

 Interaction of deer and unpalatable or browsing-resilient plant species..... 66

 Role of alternative forage..... 68

 Deer and diversity..... 68

 Findings on the role of white-tailed deer in altering forest structure 69

 Recommendation on the role of white-tailed deer in altering forest structure..... 70

| | |
|--|-----|
| Chapter 6. Factors of Human Origin in Addition to Deer Browsing that Affect Recovery of Pennsylvania’s Forests | 77 |
| Acidic deposition | 77 |
| Fire suppression in oak-dominated forests | 79 |
| Silviculture and unsustainable tree harvesting..... | 80 |
| Impacts of logging on forest understory plant species diversity..... | 80 |
| Impacts of non-sustainable harvesting on forest tree species diversity..... | 82 |
| Introduced pests | 83 |
| Insects | 83 |
| Diseases | 85 |
| Climate change..... | 86 |
| Impacts of deer and other factors on forest ecosystems — accommodating different views..... | 87 |
| Combining multiple stresses and responses into one equation..... | 88 |
| Findings on other factors affecting forest recovery | 89 |
| Recommendations on factors affecting forest recovery | 89 |
| Chapter 7. Recovery of Pennsylvania’s Forest Ecosystems from Deer Overbrowsing..... | 93 |
| A forest is more than trees | 93 |
| Prospects for recovery of forest ecosystems..... | 94 |
| Slow growth rates and loss of propagules limit recovery potential | 97 |
| Slow growth rates..... | 97 |
| Reduced seed production..... | 97 |
| Propagule dispersal from refugia | 98 |
| Seed production and dispersal by canopy trees | 98 |
| Losses to seed predation | 98 |
| Seed banks | 99 |
| Root and stump sprouting..... | 100 |
| Role of infrequent long-distance dispersal events | 101 |
| Site quality limitations on growth rates..... | 101 |
| Other elements of the forest ecosystem..... | 104 |
| Forest structure..... | 104 |
| Birds | 105 |
| Amphibians..... | 105 |
| Other factors that may affect recovery of forest ecosystems..... | 106 |
| Are nineteenth and twentieth century forest removal and other large-scale disturbances responsible for some or all of the changes in the forests? | 106 |

Has fern dominance created alternative persistent states? 107

Findings on forest recovery from heavy deer browsing 108

Chapter 8. Predicting Forest Recovery Rates in Pennsylvania 113

Recovery time..... 114

 Recovery start time 118

 Propagule lag time 119

 Fern penetration lag time..... 120

 Competition lag time..... 120

 Average time to recovery 121

 Geographical distribution of partial recovery times 123

Speeding up recovery..... 125

Findings on predicting forest recovery 128

Recommendations on predicting forest recovery 128

PART III. INDICATORS OF PROGRESS TOWARDS FOREST RECOVERY 133

Chapter 9. Indicators of Forest Recovery Useful for Ecosystem Management..... 135

 Certain tree species as rapid-response surrogates for all forest plants 136

 Combined sets of indicators for northern hardwood forest regeneration..... 137

 Indicators of soil acidity and other soil chemical properties..... 140

 Findings on indicators..... 141

Chapter 10. Methods of Estimating Abundance of White-tailed Deer..... 145

 Indirect Methods..... 145

 Direct methods..... 147

 Drive counts..... 148

 Spotlight counts 148

 Aerial surveys 148

 Thermal imagery..... 149

 Mark-recapture 149

 Camera surveys..... 150

 Change-in-ratio 150

 Findings on methods of estimating abundance of white-tailed deer 150

 Recommendations on methods of estimating abundance of white-tailed deer 151

PART IV. DETAILS OF HOW DEER MIGHT BE MANAGED IN PENNSYLVANIA FROM AN ECOSYSTEM PERSPECTIVE 153

| | |
|---|------------|
| Chapter 11. Management of White-tailed Deer Populations | 155 |
| Ecology of deer and their role in ecosystems | 155 |
| Population ecology of white-tailed deer..... | 157 |
| Population growth rates | 157 |
| Sustained harvest yield theory | 159 |
| Immunocontraception as an alternative to hunting | 161 |
| Findings on deer population management..... | 161 |
| Chapter 12. How Deer Might be Managed in Pennsylvania from an Ecosystem Perspective Using Adaptive Resource Management | 165 |
| An example of a second-tier A.R.M. protocol..... | 170 |
| Findings on how A.R.M. might work in Pennsylvania..... | 177 |
| Recommendations on how A.R.M. might work in Pennsylvania..... | 178 |
| PART V. DEER MANAGEMENT POLICY AND INSTITUTIONAL STRUCTURES NECESSARY FOR CARRYING OUT DEER MANAGEMENT FROM AN ECOSYSTEM PERSPECTIVE | 181 |
| Chapter 13. Deer Management Policy and Administration in Pennsylvania | 183 |
| Introduction..... | 183 |
| Background information on regulatory structure and authority | 189 |
| Regulatory structure in Pennsylvania..... | 189 |
| Regulatory authority to manage deer | 190 |
| Deer management policy established by P.G.C..... | 191 |
| How P.G.C. deer management policy affects management of other natural resources: an example | 200 |
| Lessons to be learned from external reviews of P.G.C. | 202 |
| Summary of contributing causes to the current high populations of white-tailed deer..... | 209 |
| Issues that must be addressed by any proposal that relies on recreational hunting to manage deer populations | 210 |
| Revenues and decline in hunter numbers | 210 |
| Seasons and bag limits..... | 211 |
| Non-license revenues..... | 212 |
| Findings on deer management policy and administration in Pennsylvania..... | 214 |
| Recommendations on deer management policy and administration..... | 218 |
| Recommendations to the Pennsylvania Game Commission..... | 218 |

Recommendations to the Governor, the Governor’s Advisory Council on Hunting, Fishing and Conservation, the Department of Conservation and Natural Resources, and the General Assembly 219

Chapter 14. Toward Management Solutions..... 225

 Proposal for changes to the appointment process for P.G.C. commissioners..... 225

 Proposals for structural change 225

 Proposal for better coordination between agencies through the Natural Resources Workgroup..... 227

 Proposal to focus on hunter education and dialogue 229

 Proposal to focus on stakeholders..... 230

 Proposal for augmentation of P.G.C. staff expertise 231

 Proposal for D.C.N.R. to be more publicly visible on the deer issue 232

 Proposal to increase hunter access to land 232

 Findings on making progress toward solutions 233

 Recommendations on making progress toward solutions..... 234

 Recommendations to the Pennsylvania Game Commission 234

 Recommendations to the Governor, the Governor’s Advisory Council on Hunting, Fishing and Conservation, the Department of Conservation and Natural Resources, and the General Assembly 235

Chapter 15. Hunter Satisfaction and Adaptive Resource Management 239

 Findings on hunter satisfaction..... 240

 Recommendations on hunter satisfaction..... 240

Chapter 16. Stakeholder Participation in Deer Management Policy Development 243

 Findings on deer management stakeholders..... 246

 Recommendation on deer management stakeholders 246

Chapter 17. Planning for the Long Term..... 247

 Finding on long-term planning 247

 Recommendation on long-term planning..... 247

Major Findings and Recommendations 249

 Major findings regarding science and management of forests and wildlife 249

 Major findings regarding policy and administration 250

 Major recommendations regarding science and management of forests and wildlife..... 253

 Major recommendations regarding policy and administration..... 253

| | |
|---|--------|
| REFERENCES CITED | 255 |
| APPENDICES | 301 |
| Appendix A. Biographies of members of the Deer Management Forum | 303 |
| Merlin Benner | 303 |
| Jan Beyea, Ph.D. (Facilitator and contributor) | 303 |
| Cindy Adams Dunn..... | 303 |
| Mary Ann Fajvan, Ph.D..... | 304 |
| Ronald R. Freed | 305 |
| Marrett Grund, Ph.D..... | 305 |
| Stephen B. Horsley, Ph.D..... | 305 |
| Roger Earl Latham, Ph.D. (Editor and contributor)..... | 306 |
| Ann Fowler Rhoads, Ph.D. | 307 |
| Bryon P. Shissler..... | 307 |
| Appendix B. Forum presentations and interviews..... | 309 |
| Appendix C. Forum field trips..... | 311 |
| Appendix D: Responses to review comments | 315 |
| Appendix E. Names of plants, animals, and other organisms mentioned in the report | 323 |
| Trees | 323 |
| Shrubs, vines, and herbaceous plants | 327 |
| Animals..... | 335 |
| Fungi..... | 337 |
| Bacteria..... | 337 |
| Appendix F: The Pennsylvania Game Commission’s 1976 deer management policy | 339 |
| Boxes | |
| Carrying capacity | 16, 17 |
| Definition of “model” | 22 |
| Institutional conditions favoring adaptive resource management..... | 27 |
| Vertical structure in forests..... | 34 |
| Values, forest integrity, and management goals | 94, 95 |
| Estimating deer densities | 184 |
| Linking hunters and landowners | 230 |

Figures

Figure 1. Hypothetical relationship between the frequency or severity of natural disturbance, such as browsing by deer, and the number of species an ecological community will support 68

Figure 2. Relationships among major factors affecting rates of recovery of Pennsylvania forests after release from deer overbrowsing 117

Figure 3. Average yearly buck harvest by county, 1915-1998. 122, 123

Figure 4. Indicators of factors influencing rates of forest recovery following deer population reduction..... 126, 127

Figure 5. Average ratio of *Rubus* cover to hay-scented and New York fern cover in uncut stands over 50 years old, following abrupt reduction of deer density from 40 to 20 deer per square mile..... 139

Figure 6. Average ratio of *Rubus* cover to hay-scented and New York fern cover in recently thinned stands following abrupt reduction of deer density from 40 to 20 deer per square mile 139

Figure 7. Deer population sizes derived from the exponential growth model 158

Figure 8. Deer herd sizes modeled by the logistic model. 158

Figure 9. Number of deer available to harvest (based on the number of deer recruited) at each population size calculated in Figure 7. 160

Figure 10. Number of Pennsylvania hunting licenses purchased and statewide post-hunt deer population estimates based on a sex-age-kill model, 1983-2000 211

Figure 11. Pennsylvania Game Commission deer hunting license sales, timber harvest operations, and total revenues, 1982-2002 213

Tables

Table 1. Example of updating model weights in adaptive resource management with two competing theories 24

Table 2. Example of changes in allocation of deer harvest permits following updating of model weights 25

Table 3. Regeneration of trees of value to the wood products industry in Pennsylvania forests..... 40

Table 4. The 116 native tree species of Pennsylvania (exclusive of subspecies, varieties, and hybrids) ranked by value to the wood products industry and, where known, relative browsing preference by deer..... 53-58

Table 5. Factors affecting forest recovery time following reduction of severe deer browsing 115, 116

Table 6. Steps that might be taken to develop a protocol for managing deer using adaptive resource management in multiple, 10-square-mile forest treatment and comparison areas..... 167, 168

Table 7. Examples of quantitative goals for adaptive management to improve forest conditions 170

Table 8. Forest monitoring cost estimates for second tier (experimental component) of the adaptive research management protocol 172, 173

Table 9. Deer monitoring cost estimates for second tier (experimental component) of the adaptive research management protocol 175

Table 10. Changes in Pennsylvania’s deer management program most pertinent to the ability to achieve density goals..... 186, 187

