
Road Ecology

Science and Solutions

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ISLAND PRESS

Washington • Covelo • London

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Library of Congress Cataloging-in-Publication Data

Road ecology : science and solutions / Richard T.T. Forman ... [et al].
p. cm.

Includes bibliographical references and index.

ISBN 1-55963-932-6 (hardcover) — ISBN 1-55963-933-4 (pbk.)

1. Roads—Environmental aspects. 2. Automobiles—Environmental aspects. 3. Roadside ecology. I. Forman, Richard T. T.


TD195.R63 R62 2002

577.5'5—dc21

2002010027

British Cataloguing-in-Publication Data available.

Book design by Brighid Willson

Printed on recycled, acid-free paper 

Manufactured in the United States of America

09 08 07 06 05 04 03 02 8 7 6 5 4 3 2 1

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Foreword

For a generation, North Americans have been in simultaneous pursuit of twin goals that are inherently in conflict. On the one hand, they seek to harvest the manifold benefits of an expanding road system, including a strong economy, more jobs, and better access to schools, friends, family, recreation, and cheaper land on which to build ever larger homes. On the other, they have growing concerns about threats to the natural environment, including air and water quality, wildlife habitat, loss of species, and expanding urban encroachment on rural landscapes. They pursue the former goal by increasing their use of larger and larger vehicles and their demand for more roads to accommodate them. They pursue the latter by demanding more regulation of vehicles, policies to discourage auto use and increase use of mass transit, and stricter controls on local land development. Not surprisingly, these conflicting demands clash wherever transportation decisions are made, whether at the federal, state, or local levels. Thus analysis paralysis and stalemate often result.

Enmeshed in this gloomy scene, some choose to curse the darkness. But others seek to light a candle. Richard Forman, Daniel Sperling, and their colleagues have chosen the latter course. Assembling a team of experts from all sides of this tangle, they have neatly sidestepped most intractable parts of the struggle by accepting that there are already many cars, trucks, and roads and that, given continuing growth in population, there are likely to be more. Then they consider what can be done to mitigate some of the weightier problems, whether caused by the existing network or by future additions. The authors describe the tentacles of the road system as wrapping themselves around the land in an “uneasy embrace,” in which nature affects the roads while the roads influence the land in countless ways.

For more than a century, the transportation community has been increasing its knowledge of how to guard the road system against nature’s assaults, through better planning, design, materials, and construction. But we are just beginning to recognize the many ways that roads assault nature, and conse-

quently realize our need to understand these phenomena so as to mitigate negative outcomes.

This book proclaims this need and elaborates a clear call for a new field of study, which is identified by the authors as “road ecology.” For some time, existing requirements to assess environmental impacts before new road projects are undertaken have resulted in the development of a group of environmental experts, skilled in the conduct of independent ad hoc studies of proposed projects. Their work has produced a process and a body of literature and has doubtless improved the design of many poorly conceived schemes. But this book makes clear that ad hoc environmental analysis has left many gaps in our understanding of effective mitigation for individual road projects and is unlikely to ever lead to effective mitigation of the macro effects of a growing system of roads.

By looking at problems associated with vegetation, wildlife, aquatic ecosystems, wind and atmospheric effects, and flows of water, sediment, and chemicals, the authors have described the issues and provided a target for researchers in many fields to focus their efforts. Until now, the fields of opportunity in road ecology have been ripe but the workers few. Let us hope that this book will provide the incentive and direction that will lead to a new generation of leaders and specialists dedicated to finding answers to these pressing problems.

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Preface

Humans have spread an enormous net over the land. As the largest human artifact on earth, this vast, nearly five million mile (8 million km) road network used by a quarter billion vehicles permeates virtually every corner of North America. The network is both an engineering marvel and an economic success story. Indeed, it provides unprecedented human mobility, greatly facilitates the movement of goods, and stretches the boundary of social interactions. In effect, roads and vehicles are at the core of today's economy and society.

These roads are superimposed on mountains, valleys, plains, and rivers teeming with natural flows. Streams and groundwater flow through the land. Wind carries and deposits seeds, spores, and sediment. Wildlife forage and disperse and may migrate. Fish do too. In effect, nature's never-ending horizontal flows and movements mold the land mosaic and create its patterns of biodiversity.

These two giants, the land and the net, lie intertwined in an uneasy embrace. The road system ties the land together for us yet slices nature into pieces. Natural processes degrade and disrupt roads and vehicles, requiring continuous maintenance and repair of the rigid network. Conversely, the road system degrades and disrupts natural patterns and processes, requiring management and mitigation for nature. Both effects—nature degrading roads and roads degrading nature—are costly to society. They also increasingly gain public attention.

The road network was largely in place well before Earth Day 1970 and the emergence of modern ecology. It was built in an era when transportation planners focused on providing safe and efficient transport, with relatively little regard for ecology. That is changing. Today, the transportation community and ecological scientists increasingly seek to undo major mistakes of the past and prevent new ones in the future. With travel on the rise everywhere and roads expanding at urban edges, often intruding into ecologically important areas, the call for new knowledge and skills is stronger than ever.

Perhaps just in time, a solution appears to lie before us. Its underlying foundations include knowledge in transportation, hydrology, wildlife biology, plant ecology, population ecology, soil science, water chemistry, aquatic biology, and fisheries. Fitting these fields together should lead to a science of road ecology, bulging with useful applications. However, landscape ecology has emerged as a key ingredient, or glue, elucidating spatial patterns, ecological flows, and landscape changes over large areas. Although its principles have been mainly incorporated into such fields as forestry, conservation biology, and landscape architecture, they are ideal for transportation planning. Road networks, vehicle flows, biodiversity patterns, and ecological flows are distributed and operate at the same scale. Indeed, integrating landscape ecology principles with road and automotive engineering, travel behavior, and transportation planning should provide a treasure chest of new solutions for both the transportation community and society.

Thus the core objective of this book is to begin integrating the dispersed theories, principles, models, and concepts important to road ecology in order to build a coherent state-of-the-science framework and body of principles useful to transportation planning, practice, and policy. In the process, we identify a range of examples, applications, and case studies—in effect, an illustrative array of possible solutions for the reader to consider. A North American focus (the USA and Canada) is complemented by worldwide examples. Although the atmosphere is briefly included, we focus on land, water, plants, and animals. Bringing the field of road ecology together as a compelling subject should open up obvious research frontiers, in both science and engineering. Rather than becoming an exhaustive treatise, the book uses principles, illustrative applications, and plentiful references to open a door to further thought and discovery by the reader.

The transportation community of engineers, planners, environmental specialists, economists, and social scientists represents the primary audience. Ecological scientists are the second audience. We also write for policy makers, public interest groups, and informed citizens. Professionals, practitioners, and planners in state and province departments of transportation, federal agencies, nonprofit organizations, and equivalent entities in other nations should find the text indispensable. Most important, the book should stimulate students to explore its ideas and change the world.

In essence, road ecology uses the science of ecology and landscape ecology to explore, understand, and address the interactions of roads and vehicles with their surrounding environment. The book has four areas of focus: (1) roads, vehicles, and transportation planning; (2) roadsides, vegetation, wildlife, and mitigation; (3) water, sediment, chemicals, aquatic ecosystems, and the atmosphere; and (4) road systems, major landscape types, and further perspectives.

Two giants in uneasy embrace—road system and land—represent an especially useful metaphor for road ecology. But other perspectives are also valuable. For example, the journey along a road, like life, encounters a series of openings, surprises, forks, joys, and sorrows. The traveler follows a drumbeat of dashed lines, punctuated by solid-line stretches of predictability or uncertainty. The less-traveled road taken at a fork. Route 66, or Route 1, as a strip of culture. Reading the landscape en route. The turtle-eye's view at the precipice of a busy road to cross. The rectilinear network grid enclosing and controlling. Road as a catalyst for development. Road as cold concrete. Road as mirage. Road corridor as noisy dangerous strip to avoid. Road as creator, and destroyer, of communities. Road as environmental injustice. Road as mobility and freedom. Each perspective highlights an area where engineering, science, and society come together. Indeed, such perspectives also suggest many of the scientific topics in road ecology.

With fourteen coauthors collaborating (four transportation specialists, one hydrologist, and nine ecologists), writing this book was a complex, yet synergistic 27-month process. Initially some of us considered the road system as overwhelmingly “bad,” providing access with negative environmental effects, while others considered it to be “good,” essential to society despite some environmental problems. Twice, we met as a group (in 2000 at the annual meetings of the Transportation Research Board in Washington, D.C., and the Ecological Society of America in Utah), each time including presentations and discussions with leading transportation specialists. Small groups of authors met for planning sessions at Lake Tahoe in 2001, the International Association for Landscape Ecology 2001 meeting in Phoenix, and the Ecological Society of America 2001 meeting in Madison, Wisconsin. The authors also presented symposia on road ecology at the 2001 International Conference on Ecology and Transportation in Colorado and the 2002 annual meeting of the Transportation Research Board in Washington, D.C.

Individual authors generally wrote brief first drafts of sections, which were reviewed by other authors, revised, and thereafter melded into the book manuscript. All authors reviewed and interwove the material into the final tapestry. Almost all chapters were reviewed by outside specialists. Richard Forman shepherded the process of writing, reviewing, revising, and incorporating artwork, and Daniel Sperling facilitated the book development process and helped engage the transportation community at every step. We plan to deposit key materials elucidating the book development process in the archives of the Ecological Society of America.

As collaborating transportation specialists and ecological scientists, we are awed by both the present and the imminent environmental challenge. With an additional 60 million North Americans anticipated in 30 years, how will society accommodate their desire for space and travel? Can society halt, or even

reverse, the environmental deterioration caused by more roads and vehicles? Yet, as collaborators on this book, we sense a promising solution. The emergence of a science of road ecology, with its applications by transportation specialists and ecological scientists, now provides society, faced with a burgeoning population, a unique opportunity to enormously improve the road- and traffic-related environment.

We envision a transportation system that provides effectively for both (1) natural processes and biodiversity and (2) safe and efficient human mobility. Without road ecology, a successful meshing of nature and people will never occur. Wise solutions lie within grasp. The window of time remains just wide enough. Society can see the benefits, a gentle roadprint on the land.

Acknowledgments

We warmly thank many friends and colleagues in the transportation and ecological communities who helped us accomplish this book, especially the following. Robert E. Skinner Jr. and Jon Williams (both of the Transportation Research Board, National Academy of Sciences) encouraged us at the outset, and four Transportation Research Board committees and groups aided us as the book evolved. Fred G. Bank (U.S. Federal Highway Administration), David G. Burwell (Surface Transportation Policy Project), Michael Cameron (Davis, California), Mark A. Delucchi (University of California, Davis), Judith M. Espinosa (University of New Mexico), Gary L. Evink (formerly Florida Department of Transportation), Martin Lee-Gosselin (Université Laval), and Leslie M. Reid (USDA Forest Service) shared their transportation expertise at our authors' meetings. The following colleagues kindly provided critical reviews of chapters: Fred G. Bank, G.J. Hans Bekker (Dutch Ministry of Transport), James R. Brandle (University of Nebraska), David G. Burwell, Steven S. Cliff (University of California, Davis), Thomas R. Crow (USDA Forest Service), Gary L. Evink, Kerry R. Foresman (University of Montana), David R. Foster (Harvard University), Anna M. Hersperger (ETH-Zurich), Louis R. Iverson (USDA Forest Service), Scott Jackson (University of Massachusetts), James R. Karr (University of Washington), Wayne W. Kober (AASHTO, formerly Pennsylvania Department of Transportation), Kenneth Kurani (University of California, Davis), P. Spencer (Sam) Lake (Monash University), Martin Lee-Gosselin, Thomas Linkous (Ohio Department of Transportation), David Montgomery (University of Washington), John F. Morrall (University of Calgary), Barbara Petrarca (Rhode Island Department of Transportation), John Poorman (Capital District Transportation Committee, Albany), Leslie Reid, Hein van Bohemen (Dutch Ministry of Transport), and William E. Winner (Oregon State University). Cynthia Burbank and Fred G. Bank, of the U.S. Federal Highway Administration, and Bruce Runnels and W. William Weeks, of The Nature Conservancy, enthusiastically arranged sponsorship for the

book. Richard Forman gratefully acknowledges the special aid of Lauren E. Alexander, Lawrence Buell, Wayne Franklin, John H. Mitchell, Kent Ryden, and Barbara L. Forman.

Taco Iwashima Matthews kindly and efficiently prepared the illustrations, which add lucidity, consistency, and pleasure to the presentation. Finally, we deeply appreciate Fred G. Bank, G. J. Hans Bekker, Michael W. Binford, David G. Burwell, Gary L. Evink, Martin Lee-Gosselin, Wayne W. Kober, C. Ian MacGillivray, and Hein van Bohemen, who made special contributions to the book as a whole.