**Annotated Bibliography of Literature Related to Connectivity Conservation**

 **in Northeast Puerto Rico and Northwest Vermont**

*by Audrey Clark*

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Connectivity Conservation in General

Anderson, A. B. and C. N. Jenkins. 2006. Applying nature's design: corridors as a strategy for biodiversity conservation. Columbia University Press, New York, NY. 231 p.

*This book discusses the theory behind landscape connectivity and corridor conservation, then the design and implementation of corridors. It also describes case studies from Atlantic coastal rainforest, Costa Rica, Florida, the Northern Rocky Mountains, the Pacific Northwest, Malaysia, India and Nepal, and the Netherlands.*

Beier, P. 2006. Effects of artificial night lighting on terrestrial mammals. pp. 19–42 in: Rich, C. and T. Longcore, editors. Island Press, Washington, D.C.

*This book chapter reviews the physiology of vision and biological clocks in mammals and suggests possible effects of artificial night-lighting on mammals. This is relevant to connectivity conservation because night-lighting likely reduces the effectiveness of corridors and crossing structures.*

Beier, P. 2007. Cougars, connectivity, and missing linkages: two decades of expanding vision and partnerships. Transactions of the Western Section of the Wildlife Society 43:1-7.

*In this keynote address, Beier, a leader in connectivity conservation thinking and application, describes lessons he has learned during 20 years of research on and implementation of wildlife corridors. This is a must-read for anyone developing a wildlife linkage.*

Beier, P. and R. F. Noss. 1998. Do habitat corridors provide connectivity? Conservation Biology 12:1241-1252.

*An early review of the evidence in support of and against habitat corridors. The authors found that of the few well-designed studies, most concluded that corridors were beneficial to focal species. This is the most recent thorough review and little progress has been made since in determining if corridors reduce genetic distance.*

Donald, P. F. and A. D. Evans. 2006. Habitat connectivity and matrix restoration: the wider implications of agri-environment schemes. Journal of Applied Ecology 43:209-218.

*Donald and Evans note that the US and European governments support agri-environment schemes, which provide funding for farmers to enact environmental improvements on their land. The authors suggest that restoring agricultural areas is likely to improve landscape connectivity. This idea is relevant in Puerto Rico, where agricultural land is reverting to pasture, and in Vermont, where farmers are more likely to be interested in sustainable farming.*

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics 34:487-515.

*Fahrig reviewed the literature on the effects of habitat fragmentation on biodiversity and found that not much can be concluded because of differing scales and measures of fragmentation and biodiversity and because habitat loss and habitat fragmentation are often confounded. Evidence thus far suggests that habitat fragmentation alone has variously positive and negative effects on biodiversity, while habitat loss typically has negative effects only.*

Fischer, J. and D. B. Lindenmayer. 2007. Landscape modification and habitat fragmentation: a synthesis. Global Ecology and Biogeography 16:265-280.

*This review is a must-read for those interested in understanding connectivity conservation. Its main benefit is in clarifying terms that have been used ambiguously in the literature and in illuminating the relationships between key concepts. These clarifications will help land managers more effectively delineate objectives.*

Hilty, J. A., W. Z. Lidicker and A. M. Merenlender. 2006. Corridor ecology: the science and practice of linking landscapes for biodiversity conservation. Island Press, Washington, D.C. 323 p.

*Discusses concepts in landscape ecology and biogeography related to connectivity conservation, the ecology of habitat fragmentation, the pros and cons of linkages, and corridor planning and implementation. More theory-heavy and technical than Anderson and Jenkins (2006).*

MacDonald, M. 2003. The role of corridors in biodiversity conservation in production forest landscapes: a literature review. Tasforests 14:41-52.

*This review examined the biodiversity value of retained strips of vegetation in harvested forests. MacDonald concludes that the importance of corridors varies depending on focal species, corridor shape and size, habitat type, matrix composition, and location. Thus far, few studies have investigated the value of corridors in production forest landscapes.*

Road Ecology and Connectivity Conservation

Beckmann, J. P., A. P. Clevenger, M. P. Huijser and J. A. Hilty, editors. 2010. Safe Passages: Highways, Wildlife, and Habitat Connectivity. Island Press, Washington, D.C. 396 pp.

*An edited volume that reviews the most up-to-date science and management practices related to mitigating the effects of highways on wildlife. Discusses current practices in highway design, reducing wildlife-vehicle collisions, and hydrologic connectivity. Reviews case studies in the Northern Rocky Mountains, New Mexico, Florida, North Carolina, Vermont, and Arizona. Describes techniques for improving participation and current and developing technologies for reducing collisions.*

Coffin, A. W. 2007. From roadkill to road ecology: a review of the ecological effects of roads. Journal of Transport Geography 15:396-406.

*Coffin reviews the literature on the development of road ecology as a science and its findings. It focuses on both abiotic and biotic effects of roads (both negative and positive), discusses the ecology of road networks, and recommends the application of the field of transportation geography to road ecology.*

Servheen, C., R. Shoemaker and P. Basting. 2007. Measuring the success of wildlife linkage efforts. Proceedings of the 2007 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC. pp. 409-421.

*This article reviews biological, economic, public safety, social, and political measures of success in efforts to make highways more permeable to wildlife and reduce wildlife-vehicle collisions.*

Connectivity Conservation in Vermont

Austin, J. M. and L. Garland. 2001. Evaluation of a wildlife underpass on Vermont State Highway 289 in Essex, Vermont. Proceedings of the 2001 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC. pp. 616-624.

*This study used infra-red cameras to document wildlife use of underpasses on a state highway in a suburban area of Vermont. Austin and Garland found that raccoons and mink were the main species that used these underpasses, and that use by other species was minimal. They suggest that substrate, vegetation, and underpass design could be limiting use.*

Bateson, E. M. 2005. Two Countries, One Forest—Deux Pays, Une Forêt: launching a landscape-scale conservation collaborative in the Northern Appalachian Region of the United States and Canada. Conservation Practice at the Landscape Scale 22:35-45.

*This article describes the formation, development, and accomplishments of the international wildlife network that aims to connect core habitat from New York to Nova Scotia.*

Brown, J. 2001/2002. Keeping Track. Wild Earth Fall/Winter:1-3.

*This article describes the Keeping Track Monitoring Program, which trains citizen volunteers to conduct track transects throughout the year to determine wildlife movement patterns. This program has been used by conservationists across the country to provide evidence of how wildlife use areas being considered for development or conservation, including identifying wildlife use corridors and where animals are crossing highways.*

Calandrelli, J. D. 1999. Prediction of suburban encroachment on the Ethan Allen Firing Range and Camp Johnson, Chittenden County, Vermont. M.S. thesis. Department of Geography and Earth Resources. Utah State University, Logan, UT.

*Calandrelli investigated suburban and urban growth patterns and rates in Chittenden County in order to make recommendations for how the National Guard uses Ethan Allen Firing Range (EAFR) and Camp Johnson. His discussions of growth in the area and background on EAFR are useful for those interested in connectivity conservation in the town of Jericho. EAFR is the only National Guard training facility within 150 miles large enough for firing practice, but this occurs on only a small portion of the land. However, as the land around EAFR is developed, pressure increases for the facility to change the way it uses the land.*

Goetz, S. J., P. Jantz and C. A. Jantz. 2009. Connectivity of core habitat in the northeastern United States: parks and protected areas in a landscape context. Remote Sensing of Environment 113:1421-1429.

*The authors mapped significant roadless areas in the northeastern U.S. to identify where connectivity and conservation are needed. They defined core habitat as parcels >500 m to the nearest maintained road and >2000 ha in size. They found that a third of all core habitat (no focal species mentioned) in the Northeast is not protected. According to this study, the Champlain Valley has no core habitat.*

Jaquez, C. and C. Negra. 2005. Conservation at the landscape scale: leadership and action in conservation in Vermont [report]. Snelling Center for Government, University of Vermont. Conservation Study Institute, Burlington, VT. 36 pp.

*The authors of this study interviewed conservation leaders across the state of Vermont to determine their motivations, conceptual backgrounds, outreach and networking methods, funding and resources, organization, obstacles, and successful leadership models. This document is useful for learning what approaches to conservation have been successful in Vermont and where gaps need to be filled.*

Slesar, C., S. C. Morse, J. Andrews and J. M. Austin. 2003. Vermont Agency of Transportation Wildlife Crossing Team: building an inter-agency planning tool to address ecological connectivity in Vermont. Proceedings of the 2003 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

*This document discusses the development of the VTrans Wildlife Crossing Team. It is a useful document for land managers to identify potential networking opportunities and resources.*

Connectivity Conservation in Puerto Rico

Blanco, J. F. and F. N. Scatena. 2006. Hierarchical contribution of river–ocean connectivity, water chemistry, hydraulics, and substrate to the distribution of diadromous snails in Puerto Rican streams. Journal of the North American Benthological Society 25:82-98.

*Blanco and Scatena found that diadromous snails were not present in Puerto Rican streams that were not connected to the ocean for most of the year (due to water draw-down for human uses). This study was conducted in the Rio Mamayes, which is on the north coast of Puerto Rico. It seems likely that similar hydrologic connectivity problems occur in nearby rivers, including those in the Northeast Ecological Corridor.*

Fabricius, K. E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Marine Pollution Bulletin 50:125-146.

*This article reviews the literature on the effects of terrestrial runoff on coral reefs. It is useful for Puerto Rican land managers because it reinforces the argument that river-ocean and land-ocean connectivity is important to consider in coral reef conservation.*

Garcia, M. A., J. A. Cruz-Burgos, E. Ventosa and R. Lopez-Ortiz. 2005. Puerto Rico Comprehensive Wildlife Conservation Strategy. Department of Natural and Environmental Resources, San Juan, Puerto Rico.

*This document provides an overview of wildlife status and conservation in Puerto Rico. Of note, “the population status of most non-game, non-listed species is unknown.” This makes conservation of these species more challenging. Perhaps conservation can incorporate data collection more regularly, and thereby contribute to general knowledge of the status of these species.*

Gould, W. A., C. Alarcon, B. Fevold, M. E. Jimenez, S. Martinuzzi, G. Potts, M. Quinones, M. Solorzano and E. Ventosa. 2008. The Puerto Rico Gap Analysis Project, Volume 1: Land Cover, Vertebrate Species Distributions, and Land Stewardship. USDA Forest Service, International Institute of Tropical Forestry, and USGS, Rio Piedras, Puerto Rico.

*Gould et al. examined the status of wildlife and conservation in Puerto Rico and developed recommendations for improvement. In particular, they recommend that protected land area be increased from 7.6% to 15% of the island, especially in the coastal plain, where there is proportionately less protected land. Development around protected areas should be better regulated, especially in relation to hydrologic integrity. And, corridors and buffers should be implemented to connect the mountains to the coasts.*

Grau, H. R., T. M. Aide, J. K. Zimmerman, J. R. Thomlinson, E. Helmer and X. Zou. 2003. The ecological consequences of socioeconomic and land-use changes in postagriculture Puerto Rico. BioScience 53:1159-1168.

*Grau et al. outline the history of land-cover and land-use changes in Puerto Rico and discuss how this history may give conservationists insight into these kinds of changes in other tropical forests. After 40 years, secondary forests had returned to structural conditions similar to pre-harvest forests, but with some major differences, including abundance of invasive species and homogenization of vegetation.*

Greathouse, E. A., C. M. Pringle, W. H. McDowell and J. G. Holmquist. 2006. Indirect upstream effects of dams: consequences of migratory consumer extirpation in Puerto Rico. Ecological Applications 16:339-352.

*This study investigated the trophic effects of dams on food webs in Puerto Rican streams. Greathouse et al. found that dams eliminated upstream consumers such as migratory freshwater shrimp and fish, which dismantled trophic cascades from the top down. Because migratory shrimp are indicators of the hydrologic connectivity between mountains and the sea, mitigation of the effects of dams should be taken into account in connectivity conservation efforts in Puerto Rico.*

Helmer, E. H. 2004. Forest conservation and land development in Puerto Rico. Landscape Ecology 19:29-40.

*Helmer quantified land-cover changes in Puerto Rico from 1977 to 1992 and related them to ecological zone. This study found that lowland areas are the least protected and most likely to be developed.*

Martinuzzi, S., W. A. Gould and O. M. Ramos Gonzalez. 2007. Land development, land use, and urban sprawl in Puerto Rico integrating remote sensing and population census data. Landscape and Urban Planning 79:288-297.

*Martinuzzi et al. classified land cover in Puerto Rico based on population density and land use. They found that 11% of the island is covered by urban surfaces, 40% of which is sprawl. Moderately developed areas, often called wildland-urban interface, and most at risk for land-use changes, constitute 36% of the island.*

Mumby, P. J. 2006. Connectivity of reef fish between mangroves and coral reefs: algorithms for the design of marine reserves at seascape scales. Biological Conservation 128:215-222.

*Mumby developed four algorithms to help conservation planners design linkages between mangrove nurseries and coral reefs. This article is also useful because it reviews the literature on mangrove-reef connectivity.*

Mumby, P. J. and A. Hastings. 2008. The impact of ecosystem connectivity on coral reef resilience. Journal of Applied Ecology 45:854-862.

*This study found that mangroves are critical to coral reef recovery following hurricanes in the Caribbean. This is especially relevant given the predicted increase of hurricanes in the future. Protecting linkages between mangroves and coral reefs is also critical to coral reef health.*

Pizzini, M. V. 2006. Historical contentions and future trends in the coastal zones: the environmental movement in Puerto Rico. pp. 44-64 in: Baver, S. L. and B. D. Lynch, editors. Rutgers University Press, Piscataway, NJ.

*This book chapter presents an overview of the history of the environmental movement in Puerto Rico and the social and political forces behind it.*

Ramos Gonzalez, O. M. 2001. Assessing vegetation and land cover changes in northeastern Puerto Rico: 1978-1995. Caribbean Journal of Science 37:95-106.

*Ramos Gonzalez investigated land cover changes in northeastern Puerto Rico from 1978 to 1995 using remote sensing and GIS. She found that half of all pasture and agricultural land in the area was lost, while forest area increased. Most afforestation occurred at higher elevations and slopes, while the lower areas in the coastal plains experienced urbanization. The land around three protected areas became more developed, which makes connecting the habitat among these protected areas more difficult.*