

Restoration Ecology

THE JOURNAL OF THE
SOCIETY FOR ECOLOGICAL RESTORATION

Volume 25, Number 4, July 2017



WILEY
Blackwell

ISSN 1061-2971

Cover: View of Tomales Bay, California, USA, showing tidal reintroduction into previously leveed dairy pastures to restore historic tidelands of the Giacomini Wetlands (credit: Robert Campbell)

EDITOR-IN-CHIEF

Stephen D. Murphy
University of Waterloo, Canada

MANAGING EDITOR

Valter Amaral
MARE Universidade de Lisboa,
Portugal

BOOK REVIEW EDITOR

Jelte van Andel
University of Groningen,
The Netherlands

EDITORIAL BOARD

Purushothaman C Abhilash
Banaras Hindu University, India

Stuart Allison
Knox College, USA

James Anderson
West Virginia University, USA

Roger Anderson
Illinois State University, USA

James Aronson
Missouri Botanical Garden, USA

Sara Ashpole
St. Lawrence University, USA

Sara Baer
Southern Illinois University, USA

Heather Bateman
Arizona State University, USA

Loretta Battaglia
Southern Illinois University, USA

Susan Bell
University of South Florida, USA

Brandon Bestelmeyer
New Mexico State University, USA

Jacob Bowman
University of Delaware, USA

Pedro Brancalion
Universidade de São Paulo, Brazil

Martin Breed
University of Adelaide, Australia

Mark Briggs
World Wildlife Fund, USA

Rebecca Brown
Eastern Washington University, USA

Peter Cale
Australasian Landscape Trust, Australia

Steven Cooke
Carleton University, Canada

Giselda Durigan
Instituto Florestal, Floresta Estadual de
Assis, Brazil

Alasdair Edwards
Newcastle University, UK

Louise Egerton-Warburton
Chicago Botanic Garden, USA

David Eldridge
University of New South Wales, Australia

Valerie Eviner
University of California, Davis, USA

Kern Ewing
University of Washington, USA

Aida Farag
USGS – CERC, USA

Siobhan Fennessy
Kenyon College, USA

Andrew Grigg
Alcoa World Alumina, Australia

Matthias Gross
Helmholtz Centre of Environmental
Research, Germany

Jefferson Hall
Smithsonian Institution, USA

James Harris
Cranfield University, UK

Christine Hawkes
University of Texas, USA

Liam Heneghan
DePaul University, USA

Eric Higgs
University of Victoria, Canada

John Isanhart
U.S. Department of the Interior, USA

Jeremy James
UC ANR, USA

Gary Kendrick
University of Western Australia, Australia

Kathrin Kiehl
University of Applied Sciences, Germany

Siegy Krauss
Kings Park and Botanic Garden, Australia

Lori Lach
James Cook University, Australia

Sam Lake
Monash University, Australia

J. Leighton Reid
Missouri Botanical Garden, USA

John Ludwig
CSIRO, Australia

Virginia Matzek
Santa Clara University, USA

Cara Nelson
University of Montana, USA

Beth Newingham
ARS USDA, USA

David Norton
University of Canterbury, New Zealand

Gerhard Overbeck
Universidade Federal do Rio Grande do
Sul, Brazil

Margaret Palmer
University of Maryland, USA

John Parrotta
USDA Forest Service, Washington, D.C.,
USA

Mark Paschke
Colorado State University, USA

Lora Perkins
South Dakota State University, USA

Michael Perring
University of Western Australia,
Australia

Maksym Polyakov
University of Western Australia,
Australia

Karel Prach
Czech Academy of Sciences,
Czech Republic

David Pyke
US Geological Survey, Oregon, USA

Darren Ryder
University of New England,
Australia

John Scullion
University of Wales, UK

Jacques Swart
University of Groningen,
The Netherlands

Vicky Temperton
Leuphana University, Lüneburg,
Germany

Rachel Thiet
Antioch University New England,
USA

William Throop
Green Mountain College, USA

Mark Tibbett
University of Reading, UK

José Marcelo Torezan
Universidade Estadual de Londrina,
Brazil

Fernando Valladares
CCMA-CSIC, Spain

Kari Veblen
Utah State University, USA

Hong-Sheng Wu
Nanjing University of Information
Science & Technology, China

Joy Zedler
University of Wisconsin, USA

SOCIETY FOR ECOLOGICAL RESTORATION <http://www.ser.org>, <http://www.GlobalRestorationNetwork.org>

2015–2017 SER BOARD OF DIRECTORS

Alan Unwin** Chair
Niagara College
Niagara-on-the-Lake, Ontario, Canada
aunwin@niagaracollege.ca

Cara R. Nelson** Vice Chair
University of Montana, USA
cara.nelson@cfc.umt.edu

Jim Hallett** Treasurer
Eastern Washington University, USA
jhallett@ewu.edu

Stuart Allison** Secretary
Knox College,
Illinois, USA
sallison@knox.edu

Nancy Shaw
Representative-At-Large
USDA FS Rocky Mountain Research Station, USA

James Aronson
Representative-At-Large
Missouri Botanical Garden, USA

Carol Maxwell
Representative-At-Large
Temple University, School of Environmental
Design, USA

Kris Decler
Representative-At-Large
Research Institute for Nature and Forest,
Belgium

Joe Berg
Representative-At-Large
Biohabitats Inc., USA

Karen Keenleyside
Representative-At-Large
Parcs Canada/Parks Canada

Patricia McIlvenna
Student Representative
University of Wyoming, USA

Swidiq Mugerwa
Regional Representative, Africa
National Livestock Resources Research Institute,
Uganda

Samira Omar Asem
Regional Representative, Asia
Kuwait Institute for Scientific Research (KISR), Kuwait

Anne Tolvanen
Regional Representative, Europe
Natural Resources Institute Finland (Luke)
University of Oulu, Finland

Vera Lex Engel
Regional Representative, Latin America/Caribbean
Sao Paulo State University, Brazil

Mary Beth McCormack
Regional Representative, Midwest North America
Cleveland Montessori School, USA

Jim Furnish
Regional Representative, Northeast North
America
Retired Deputy Chief, USDA Forest Service, USA

Dave Polster
Regional Representative, Pacific Northwest North
America
Polster Environmental Services Ltd., USA

Daniel Spencer
Regional Representative, Rocky Mountains/
Great Plains
University of Montana, USA

Kingsley Dixon
Regional Representative, Pacific
Curtin University, Australia
Kings Park and Botanic Garden, Australia
University of Western Australia, Australia
Missouri Botanic Garden, USA

Connie Bersok
Regional Representative, Southeastern US
Florida Department of Environmental Regulation,
USA

VACANT
Regional Representative, Western US

**Serves on the Executive Committee

SER HEADQUARTERS

Bethanie Walder Executive Director

Levi Wickwire Program Manager

Marguerite Nutter Membership &
Communications Manager

Hannah Boone Program Assistant

RESEARCH ARTICLE

Tidal marsh restoration stimulates the growth of winter shorebird populations in a temperate estuary

John P. Kelly^{1,2}, T. Emiko Condeso¹

The regional responses of winter shorebird populations in the nearly 3,000 ha estuary of Tomales Bay, California, to the restoration of 223 ha of historic tidal wetlands were evaluated for 27 years: 19 years prior to tidal reintroduction and 8 years after tidal reintroduction. We used interrupted time series analyses to measure the spatial extent of the restoration effect and to model the magnitude and length of time associated with the gradual, restoration-induced growth of winter shorebird populations in the bay. Expanded, regional benefits of the restoration were revealed by consistent patterns of winter shorebird population growth. Eight years after tidal reintroduction, overall shorebird abundances in southern Tomales Bay nearly tripled in response to the restoration. Substantial winter population growth by most species in southern Tomales Bay was evident within 3 years after tidal reintroduction, and maximum responses to the restoration were estimated to be predominantly achieved within 8 years. In contrast to strong effects of tidal marsh restoration on winter shorebird populations in southern Tomales Bay, no significant overall responses were exhibited by shorebirds in the northern portion of the bay, although marginal evidence of expanded effects on a few species in northern Tomales Bay were suggested. The results illustrate the importance of accounting for restoration effects beyond the spatial and temporal boundaries of the restored habitat, to consider both the potentially expanded benefits and the spatial limits of those benefits to regional wildlife populations.

Key words: estuarine restoration, population dynamics, spatial scale, tidal reintroduction, waders

Implications for Practice

- The sizes of wintering shorebird populations may not be affected by tidal marsh restoration beyond their daily foraging range.
- Wintering shorebird populations within foraging range of a tidal marsh restoration may increase in size within 3 years of tidal reintroduction, with most of the expected increases achieved within the first 8 years.
- The removal of constraints imposed by constructed levees, on tidal flow, freshwater run-off, and estuarine circulation, is likely to enhance winter shorebird numbers in temperate tidal marshes, but the impacts of winter storms may continue to result in midwinter declines in abundance.

Introduction

The success of tidal marsh restoration projects, measured by the numerical and behavioral responses of shorebirds (Scolopacidae, Charadriidae, Recurvirostridae, Haematopodidae), is usually evaluated in the immediate vicinity of the project area (Armitage et al. 2007; Patten & O'Casey 2007; Mander et al. 2013). However, the dynamics of winter shorebird abundances may operate at spatial scales that exceed the boundaries of restoration areas or the supported scope of restoration monitoring (Neckles et al. 2002; Atkinson 2003). Consequently, little is known about the extent to which local tidal marsh restoration efforts lead to the growth of surrounding winter shorebird populations versus opportunistic shifts in local foraging distributions or habitat use.

Shorebird populations at regional and larger scales may be strongly influenced by habitat conditions encountered in wintering and migration-stopover areas (Thomas et al. 2006; Bart et al. 2007; Aharon-Rotman et al. 2015; Xu et al. 2015). The restoration of previously lost or degraded tidal or nontidal wetlands, or the protection of key habitat features in tidal wetlands, have been associated with numerous benefits to wintering shorebirds. These benefits include increases in the extent of suitable foraging areas (Atkinson 2003; Armitage et al. 2007; Patten & O'Casey 2007), including seasonally available habitat (Colwell & Dodd 1995; Warnock & Takekawa 1995); landscape position and proximity to natural wetlands (Brusati et al. 2001; Reiter et al. 2015); increased food supply or availability (Atkinson 2003; Miller & de Rivera 2014); reestablishment of the natural hydroperiod and water levels suitable for foraging (Bellio & Kingsford 2013; Brand et al. 2014); development of roosting opportunities or other conditions that facilitate improved predator avoidance (Rogers et al. 2006; Huang et al.

Author contributions: JPK designed the research; JPK, TEC supervised field observers and performed field investigations; TEC managed the database and conducted data quality assurance and control; JPK analyzed the data and wrote the manuscript; JPK, TEC edited the manuscript.

¹Cypress Grove Research Center, Audubon Canyon Ranch (ACR), PO Box 808, Marshall, CA 94940, U.S.A.

²Address correspondence to J. P. Kelly, email john.kelly@egret.org

© 2017 Society for Ecological Restoration

doi: 10.1111/rec.12487

Supporting information at:

<http://onlinelibrary.wiley.com/doi/10.1111/rec.12487/supinfo>