WETLAND SCIENCE AND PRACTICE

Dragonfly at Colyer Lake, Pennsylvania - Photo by C. P. Ferreri

Contents

Aim and Scope of Wetland Science and Practice

The *WSP* is the formal voice of the Society of Wetland Scientists. It is a quarterly publication focusing on news of the *SWS*, at international, national and chapter levels, as well as important and relevant announcements for members. In addition, manuscripts are published on topics that are descriptive in nature, that focus on particular case studies, or analyze policies. All manuscripts should follow guidelines for authors as listed for Wetlands as closely as possible. All papers published in *WSP* will be reviewed by the editor for suitability. Letters to the editor are also encouraged but must be relevant to broad wetland-related topics. All material should be sent electronically to the current editor of *WSP*. Complaints about *SWS* policy or personnel should be sent directly to the elected officers of *SWS* and will not be considered for publication in *WSP*.

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WSP

Society of Wetland Scientists   www.sws.org

SWS — an international organization dedicated to the conservation, management and scientific understanding of the world's wetland resources

2013 SWS ELECTION OF OFFICERS PRESIDENT-ELECT CANDIDATE PROFILES

Dear SWS Member,

Our organization continues to grow and remains vibrant thanks to you, our members, and the dedicated leadership of our Board of Directors, committee members, volunteers and staff. It is important to continue this leadership through the election of one individual to serve as President-Elect of SWS. The President-Elect serves a one-year term, followed by a one-year term as President, and then a final year as Past-President. The elected official will be introduced and take office during the 2013 Annual Meeting in Duluth, Minnesota, USA.

Please take a moment to read the profiles and vote for one of the following two candidates:

- Scott W. Jecker, CWB, PWS, Whitenton Group Environmental Consultants, San Marcos, TX
- James E. Perry, PhD, PWS, College of William and Mary, Gloucester Point, VA

All individual members are entitled to one vote, which may be submitted with this paper ballot or using the electronic ballot circulated via email. All ballots must be received by 8pm EDT on Friday, April 19, 2013.

Thank you for your participation in choosing the leaders of your professional society – SWS.

Sincerely,

Ben LePage
SWS Past-President & Nominations Committee Chair
*The statements on the following pages were provided by the candidates for this office and are listed solely in alphabetical order.
Andy Cole Editor WSP

Society of Wetland Scientists www.sws.org

an international organization dedicated to the conservation, management and scientific understanding of the world's wetland resources

Scott W. Jecker, CWB, PWS
Whitenton Group Environmental Consultants
San Marcos, TX

SWS VOLUNTEER EXPERIENCE:
My volunteer work with the SWS includes involvement at the Chapter and International level, working in numerous Board and Committee roles since 2001. For the South Central Chapter, I have served as President, Board Member, and multiple committee positions. In 2005, I co-hosted the South Central Chapter meeting in San Marcos, Texas and helped organize the joint meeting between the South Central Chapter, South Atlantic Chapter, and the Gulf Estuarine Research Society in Pensacola Beach, Florida (2004). I have helped organize and host multiple wetland plant identification and wetland soils courses for the South Central Chapter in Texas and Louisiana. I have served on multiple committees for the SWS (International) and currently serve on the Education and Outreach Committee. In 2002/2003, I was fortunate enough to be one of many volunteers that helped to organize and host the New Orleans meeting. I presented a paper on wetland restoration and monitoring at the meeting in Madison, Wisconsin (2011).

I served as President of the SWS Professional Certification Program and multiple committees. I have worked with the SWS and the SWS PCP efforts to maintain a strong relationship between the two organizations. Although the organizations have different goals, both benefit from mutual association.

WHY YOU WISH TO SERVE ON THE BOARD:
I would like to continue serving and working for the SWS to further strengthen the organization's purpose and mission to be the leader in wetland science and the education of wetland science professionals and students. I would also like to continue to help grow the relationship between the SWS and the SWS Professional Certification Program to make sure both organizations benefit as much as possible from each other. International Chapters are very important to the Society and I hope to do as much as possible to further develop those Chapters and the SWS involvement in other countries.

WHAT YOU WILL CONTRIBUTE TO THE BOARD:
I will do my best to help maintain and improve the efficiency and effectiveness of the Board, provide strong leadership when needed, help facilitate communication with the chapters and general membership, and help contribute new ideas and solutions. In other words, I will do my best to fit in with and support all the other Board members who dedicate their time to make the SWS the best it can be.

My professional experience includes owning and operating a natural resources consulting firm that provides wetland-oriented services that includes training, surveying, monitoring, reporting, and permitting; as well as water quality compliance assistance. Our firm works

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with agencies, universities, municipalities, and the private sector to properly plan for and execute various projects while adhering to budgets set forth. I plan to utilize my professional skills and my working knowledge of the SWS to assist with ongoing and proposed initiatives of the Society, and to help research and develop new initiatives that will ensure the continued success of the SWS.

WHAT YOU ENVISION FOR THE SOCIETY'S FUTURE:

The SWS is an ever-changing organization with much to offer wetland researchers, educators, and professionals. I envision the SWS experiencing growth in membership and recognition, and leading the wetland "world" through education and outreach. I hope to be a part of that effort in the future.

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an international organization dedicated to the conservation, management and scientific understanding of the world's wetland resources

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March 2013

PRESIDENT'S MESSAGE

James E. Perry, PhD, PWS
College of William and Mary
Gloucester Point, VA

SWS VOLUNTEER EXPERIENCE:

I have been a SWS member since the mid-1980s and I'm currently a life member. I served as one of the original members of the SWS Certification Panel, Chair of the SWS Professional Certification Program (PCP) Ethics Committee, Chair of the SWS South Atlantic Chapter, Technical Committee Chair for the 1999 SWS annual meeting, a member of the SWS Education and Outreach Committee and I'm currently a member of the SWS Sections Subcommittee and the adhoc joint SWS and PCP Course Accreditation committee. I am also in my last year as the Secretary General for the SWS – PCP, a position that I have held for over 10 years.

WHY YOU WISH TO SERVE ON THE BOARD:

For more than past 30 years I have lived a breathed wetlands; with SWS playing a major role. Therefore, I feel it is only correct to give back to an organization that has given so much to me.

WHAT YOU WILL CONTRIBUTE TO THE BOARD:

I bring with me a broad interest in national and international wetland science and policy. My research interests include determining the development of ecological function in restored and created wetlands, monitoring stress and documenting long-term changes in vascular plant communities of tidal and non-tidal wetlands, and the relationship of those changes to changes in environmental parameters within watersheds. My teaching experience includes undergraduate and graduate level classes in Asian Environmental Issues, Wetlands Ecology, and Coastal Ecosystem Restoration, as well as ecotourism certification and wetlands delineation classes that are open to the public. I have conducted workshops on wetland science, restoration and/or creation in China, Venezuela, Paraguay and the US. I believe my work experience will provide a broad base to help me better understand the needs of our diverse membership comprised of applied practitioners, regulators, and academicians.

WHAT YOU ENVISION FOR THE SOCIETY'S FUTURE:

My vision for SWS is to move forward with the recognition that SWS is comprised not only of hydrologists, soil scientists, and botanists, but also of a tripartite group of members including applied practitioners, regulators, and academicians. I strongly believe that the integrity of our profession depends on a strong link in communications and the development of trust between these three groups. Consultants and regulators often provide on the ground experiences that can be used to help identify areas of needed research while academicians can hopefully provide answers that can be used by consultants and regulators on the ground to better understand the functions and social values of wetlands and how to more quickly achieve the replacement of any functions and values lost to permitting processes. I would also like to move forward with the production of position and rapid response public papers from all three groups that could 1) be used to help relate the current knowledge of potential impacts of global climate changes on wetlands to a broader audience, 2) examine how can we improve wetland laws and regulations to better protect our national and international

wetland resources, and 3) identify the most effective forms of restoration and creation. SWS papers have been a valuable resource in the past for our members as well as acting as a potential conduit to policy makers. Finally, I would like to see SWS continue to work with PCP to develop continuing education classes to help keep our members up to date on the most recent wetland regulations, scientific findings and applied methods for wetlands protection and mitigation.

2013 SWS BOARD OF DIRECTORS ELECTION BALLOT

All individual members are entitled to one vote, which may be submitted with this paper ballot or using the electronic ballot circulated via email. If you prefer to submit a paper ballot, please complete and return the following form to the address below. You may print mail, fax or email the ballot as an attachment by Friday, April 19, 2013. Post mail must also be postmarked by Friday, April 19, 2013.

Society of Wetland Scientists   608.521.5941 Fax

22 North Carroll Street   bolson@sws.org

Suite 300

Madison, Wisconsin 53703

DUTIES OF THE PRESIDENT-ELECT:

The person elected to the position of President-Elect serves three consecutive one-year terms on the Board of Directors and Executive Board. The first term is served as the President-Elect, whose duties are to assist the President and to perform the duties of the President when that officer is absent or unable to act. The President-Elect also serves as liaison between the Board, the Meetings Committee, and the Conference Committee for the Annual Meeting to be held during their year as President. The President-Elect is responsible for updating and maintaining the SWS Policies and Procedures Manual. The second term is served as the President, whose duties are to assume responsibility for the business of the Society, make appointments authorized in the Standing Rules, establish special committees as needed, and exercise such other responsibilities determined from time to time by action of the Society or its Board of Directors. The third term is served as the immediate Past-President, who chairs the Nominating Committee and Bylaws Committee, serves as Parliamentarian at meetings, and performs the duties of President if both the President and President-Elect are unable to act.

Please provide the following information:

NAME: _____

SWS MEMBER ID: _____

Please vote for one of the following President-Elect candidates:

      ☐ - Scott W. Jecker, CWB, PWS

      ☐ - James E. Perry, PhD, PWS

Research

Vegetation of natural and artificial shorelines in Upper Klamath Basin's fringe wetlands

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Abstract

The Upper Klamath Basin (UKB) in northern California and southern Oregon supports large hypereutrophic lakes surrounded by natural and artificial shorelines. Lake shorelines contain fringe wetlands that provide key ecological services to the people of this region. These wetlands also provide a context for drawing inferences about how differing wetland types and wave exposure contribute to the vegetative assemblages in lake-fringe wetlands. Here, we summarize how elevation profiles and vegetation richness vary as a function of wave exposure and wetland type. Our results show that levee wetland shorelines are 4X steeper and support fewer species than other wetland types. We also summarize the occurrence probability of the five common wetland plant species that represent the overwhelming majority of the diversity of these wetlands. In brief, the occurrence probability of the culturally significant *Nuphar lutea* spp. *polysepala* and the invasive *Phalaris arundinacea* in wave exposed and sheltered sites varies based on wetland type. The occurrence probability for *P. arundinacea* was greatest in exposed portions of deltaic shorelines, but these trends were reversed on levees where the occurrence probability was greater in sheltered sites. The widespread *Schoenoplectus acutus* var. *acutus* occurred throughout all wetland and exposure type combinations but had a higher probability of occurrence in wave exposed sites. Results from this work will add to our current understanding of how wetland shoreline profiles

interact with wave exposure to influence the occurrence probability of the dominant vegetative species in UKB's shoreline wetlands.

Key Words: shoreline wetlands, lake-fringe wetlands, Upper Klamath Lake

Introduction

Shoreline or lake-fringe wetlands are essential to the functioning and diversity of large lakes (Levine and Willard 1989; Keddy and Fraser 2000). These wetlands are subjected to large fluctuations in water levels, precipitous physical and nutritional gradients, and frequent disturbance from wave exposure and ice scour (Weisner 1987; Mortsch 1998; Keddy and Fraser 2000). Shoreline wetlands provide critical services to large lakes including nutrient sequestration (Sollie et al. 2008), wave attenuation (Pennings et al. 2009), and the provisioning of habitat for invertebrates and fish (Jude and Pappas 1992; Burton et al. 2002).

The characterization of vegetation in shoreline wetlands has been the focus of research efforts for decades (see Keddy 1983; Wilson and Keddy 1985; Nilsson and Keddy 1988), yet, in some regions, including the Upper Klamath Basin (UKB) of northern California and southern Oregon, little is known about the factors that influence vegetative assemblages. This lack of information is surprising given that UKB is recognized for its abundance of large shallow lake and associated fringe-wetland complexes (Bradbury et al. 2004; NRC 2004). In fact, lake-fringe wetlands historically represented about half the total lake area of Upper Klamath Lake (UKL)—the largest lake in the UKB. While still abundant, diking, draining, and cultivation reduced wetlands around UKL to < 20% of their original size (Akins 1970). Systematic draining and diking also contributed to land subsidence (upwards of 2 to 3 m behind dikes) from historic elevations (Wong et al. 2011), severely altered lake productivity (Eilers et al. 2004), and led to the decline of two federally-listed fish (Cooperman and Markle 2004).

Despite the dramatic loss of wetlands in this region, the UKL system still contains fringe wetlands and provides opportunities to document the occurrence of emergent vegetation along natural and artificial shorelines (Bradbury et al. 2004). Vegetative assemblages along shorelines are believed to be determined by hierarchies of competitive ability and physiological tolerances to stress and disturbance with species occupying unique, albeit overlapping, positions on lake shorelines (Keddy and Fraser 2000). Shoreline positions of vegetation can be described relative to lake surface elevation or expressed in absolute terms, but elevational positions are dynamic (Mortsch 1998).

Although the flora of degraded or farmed wetlands whose hydrology has been restored has been described (Elseroad et al. 2011), information on the vegetation in wave exposed and sheltered regions of UKB shoreline wetlands is still needed. This information will help predict how vegetation may respond to future lake level scenarios or to the reconnection/restoration of former wetland habitats. As managers in the UKB work to restore culturally significant fish and plant communities, consideration of the factors contributing to the contemporary distribution of wetland vegetation is needed. For example, *Nuphar lutea* spp. *polysepala*, a species whose dietary importance to the Klamath people was second only to fish was once widespread along UKL shorelines (Deur 2009). The distribution of *N. lutea* in UKL has been reduced and restoration of this species to wetlands has been largely unsuccessful (Elseroad et al. 2009).

Here we describe the emergent and floating-leaved vegetation assemblages in shoreline wetlands of Upper Klamath and Agency lakes, Oregon (Fig. 1). We first summarize elevation profiles and vegetation richness of wave exposed and sheltered regions for three wetland types (deltaic, levee, and remnant). Because subsidence throughout human-modified wetlands of the UKL system has significantly deepened water depths (Wong et al. 2011), we document the minimum surface elevation with rooted vegetation along each wetland-exposure type combination to test the hypothesis that plants occupying wave exposed sites will grow at shallower depths than conspecifics occupying sheltered sites (Hypothesis 1; H1). Finally, we summarize the probability of occurrence for the dominant emergent species documented and explicitly test the hypotheses: N. lutea will be absent from wave exposed sites (H2), and the invasive Phalaris arundinacea will be most prevalent in wetlands that have been subject to significant alteration (e.g., received artificial fill to create levees; H3).

Methods

Study Site

The Upper Klamath Basin of California and Oregon, USA, is typified by broad valleys with large lake and wetland complexes (NRC 2004). At the heart of the basin is UKL, the largest lake in Oregon covering approximately 270 km^2 at full pool (Fig. 1). The UKL system includes two large, shallow hypereutrophic lakes – Upper Klamath and Agency lakes (Fig. 1). Combined, these lakes maintain minimum flows in the Klamath River, produce electricity, support irrigated agriculture, and provide critical habitat for waterfowl and federally-listed fish. Both lakes are supported by groundwater and riverine inputs (Sprague, Williamson, and Wood rivers). Storage and release operations create substantial water elevation fluctuations that are approximately 1 m below natural lake levels (Bradbury et al. 2004; Kann and Welch 2005).

Sampling Methods

We used 38 randomly selected locations to characterize vegetation along natural (deltaic [located along river mouths] and remnant lake fringe wetlands) and artificial (located on levees) shorelines of Agency Lake (Fig. 1). Within each wetland type we stratified sampling by wave exposed and sheltered shorelines (Table 1). At each location, transects were created perpendicular to the existing shoreline. The transect center was established at the lakeward extent of existing vegetation. We recorded species occurrence and rooting surface elevations in 1 m increments for 25 m in both lakeward and landward directions from the center. Total transect length was shorter at some locations due to the limited expanse of emergent vegetation (e.g., remnant exposed and levee exposed shorelines; Fig. 2). Often, emergent vegetation extended beyond the 25 m landward extension of some transects.
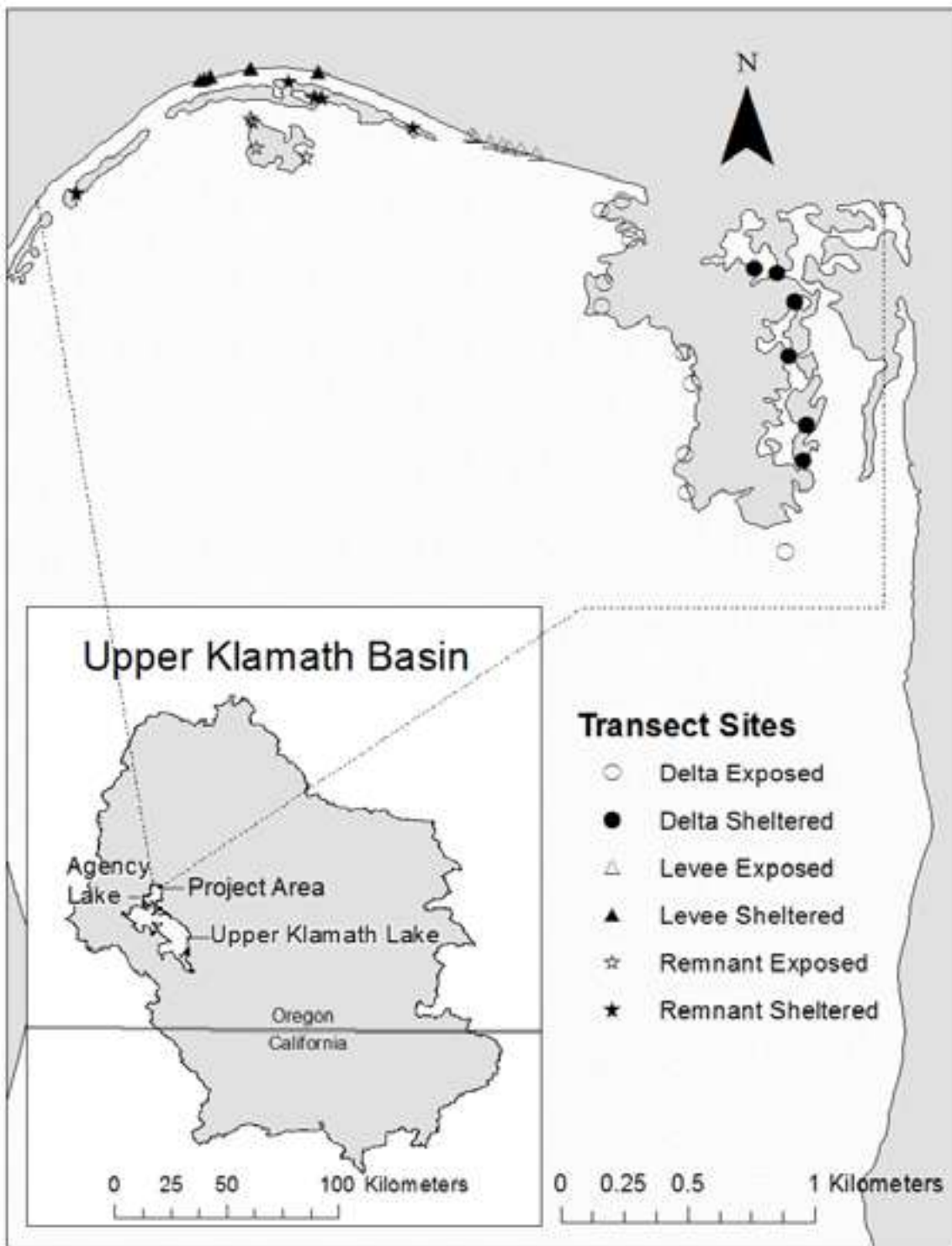
Figure 1: Location of Upper Klamath Basin and Upper Klamath and Agency lakes (inset). Shoreline sampling locations are shown for each wetland and exposure type.

Water depths, the difference between the water surface and firm rooting substrates, were collected at 1 m increments and calculated using the average of three measurements. Rooting surface elevations for transect locations present above the water surface were estimated using a level transit and surveyor's rod. Relative elevations were converted to elevations in meters above sea level (m.a.s.l.) in the laboratory based on the average daily water level elevations published on the U. S. Geological Survey's UKL surface elevation readings (USGS 11507000 Gage) using the U.S. Bureau of Reclamation's Upper Klamath Lake Vertical Datum. Ground surface elevations for transect locations in standing water were calculated by subtracting the depth of standing water from the daily water level elevation from the USGS gage. This approach provides an estimate of water depths that are < 0.02 m from true depths

(Dunsmoor et al. 2000).

To document the presence and absence of common rooted emergent vegetation (e.g., *Schoenoplectus acutus* var. *acutus* and *Typha latifolia*) we used 0.1 m2 quadrats (dimensions 0.2 m x 0.5 m). For floating-leaved macrophytes (e.g., *N. lutea*) we used larger, 1 m x 1 m, quadrats to detect their presence (Ray et al. 2001).

Statistical Analyses

We calculated slope by dividing the elevation change by total transect length for each transect. We used a two-way ANOVA to explore variations in shoreline slope, vegetative richness, and rooting surface elevation at the vegetative edge. Our factors were wetland type (deltaic, levee, and remnant) and wave exposure type (exposed or sheltered). If no interaction was detected, we used a main effects only model. To address H1 we subset the data for each species to transects that had at least one observation for that species. For these transects, we then calculated the minimum elevation (m) that each species was recorded. Based on this restricted dataset, we were able to make comparisons of exposed and sheltered transects for the most abundant species and for different wetland types. For those species only recorded in both exposure types within a single wetland type, we used a two-sample t-test with unequal variances. For multi-group comparisons we used a one-way ANOVA with six groups and a Tukey HSD test to control for all pairwise comparisons. For evaluation of species occurrence by wetland and exposure type and to explicitly test H2 and H3, we used binomial logistic regression with over-dispersion.

Results

Wetland Type	Exposure Type	Number of Transects	Average Slope	Average Elevation (m) at Margin of Vegetation	Average Vegetative Richness
D	E	11	0.01	1261.30	2.0
D	S	6	0.01	1261.52	3.2
L	E	7	0.07	1261.67	0.6
L	S	5	0.07	1261.52	2.6
R	E	4	0.01	1261.23	1.5
R	S	5	0.02	1261.29	3.0

Table 1: Total number of transects sampled from deltaic (D), levee (L), and remnant (R) wetlands summarized by sheltered (S) and exposed (E) locations within each wetland type. The average slope, elevation at vegetative margin, and vegetative richness are summarized by each wetland X exposure combination. Elevations are based on the Upper Klamath Lake Vertical Datum used by U.S. Bureau of Reclamation in reporting elevation in Upper Klamath Lake.
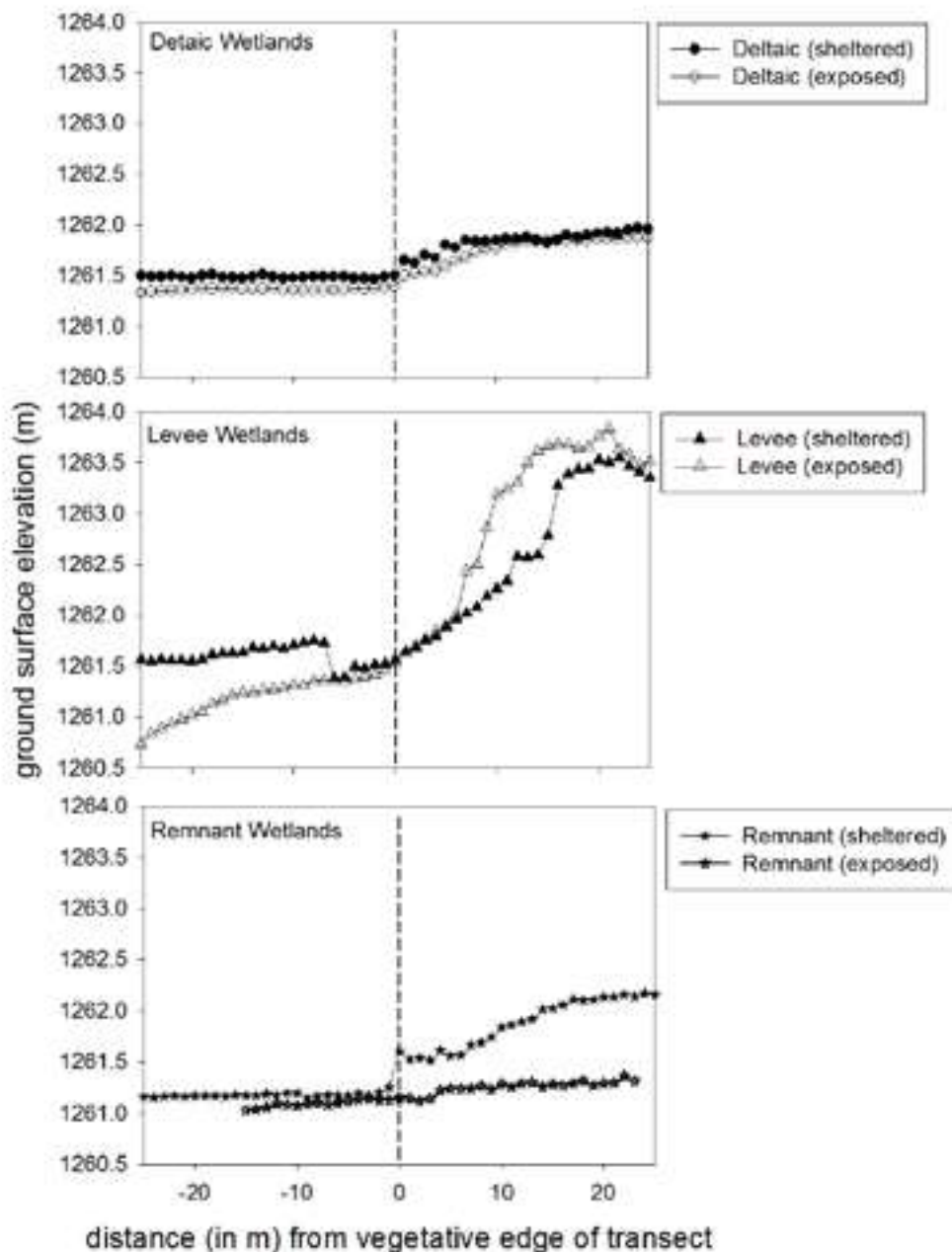
Figure 2: Representative shoreline elevation profiles for each wetland and exposure type. Elevations are based on the Upper Klamath Lake Vertical Datum used by U.S. Bureau of Reclamation in reporting elevation in Upper Klamath Lake. The total number of transects in each wetland x exposure combination is summarized in Table 1

Fringe wetlands of Agency Lake were comprised largely of five species: *N. lutea* (NULU), *P. arundinacea* (PHAR), *S. acutus* (SCAC), *Sparganium eurycarpum* (SPEU), and *Typha latifolia* (TYLA). Main effects models summarized differences in shoreline slope, the elevation of the vegetative margin, and vegetative richness by wetland type and exposure type. The slope of shorelines differed among wetland types; levee shorelines were nearly 4X steeper than the other wetland types (Table 1). Wave exposure did not influence shoreline slopes ($P = 0.255$). Wetland ($P = 0.003$) and wave exposure type ($P < 0.001$) affected vegetative richness (e.g., exposed remnant wetlands had fewer species than sheltered remnant wetlands) and levee wetlands had significantly fewer species than the other wetland types (Table 1). Importantly, culturally significant NULU was not present in levee wetlands and the invasive PHAR was absent from remnant wetlands. Finally, the rooting surface elevation of the vegetative margin differed by wetland type ($P = 0.020$) and was lower (by 0.35 m) for remnant wetland

shorelines than for levee shorelines.

Contrary to our predictions, there was no evidence that the average minimum depth of NULU occurrences differed between wave exposed and sheltered portions of remnant wetlands (Fig. 3, $P = 0.314$). Also, there was no evidence that SPEU or TYLA grew at shallower depths based on exposure to waves within the deltaic wetlands (Fig. 3, one-sided $P > 0.500$). Finally, there was no evidence that SCAC grew at lower depths in wave exposed compared to sheltered portions of any wetland type (Fig. 3, all $P > 0.200$).

There was strong evidence that NULU occurrence probability in exposed versus sheltered sites varied based on wetland type (Fig. 4, interaction between wetland and exposure type, $P < 0.001$). Contrary to our predictions, there was a higher probability of NULU occurrence in exposed compared to sheltered regions of remnant wetlands (Table 2). In deltaic wetlands, the probability of NULU occurrence was higher in sheltered sites (Table 2). There was strong evidence that the probability of PHAR occurrence differed in exposed versus sheltered sites; however, it varied based on wetland type (Table 2 and Fig. 4, $P < 0.008$). The probability of SPEU occurrence was typically higher in sheltered portions of all wetland types (Table 2). SCAC consistently had higher probability of occurrence in exposed sites across all wetland types (Table 2, interaction between wetland and exposure type, $P > 0.100$). TYLA displayed higher probabilities of occurrence in sheltered sites for all wetland types (Table 2, interaction between wetland and exposure type, $P > 0.100$).

Discussion

Shoreline wetlands in the UKL system are compositionally simple and comprised largely of just five plant species. Wetland type and wave exposure influence the vegetative characteristics of shoreline wetlands of Agency Lake. Generally, deltaic and remnant wetlands contained more species than levee wetlands. SCAC occurred throughout all wetland and exposure type combinations and had relatively high occurrence probabilities. NULU, a species of both biological and cultural significance in the region (Deur 2009), was completely absent from wetlands established on levee shorelines.

In our sampling, PHAR did not occur in remnant wetlands; it was most common in levee wetlands. PHAR may have been intentionally introduced to levees as an attempt to stabilize these artificial shorelines (Lavergne and Molofsky 2004). This species has commonly moved beyond introduction sites and invaded natural habitats. Given that levees sampled were established during the 1950s, it is noteworthy that this species was not detected in remnant wetlands. Since native vegetative diversity of wetlands typically declines following PHAR invasion (Schooler et al. 2006), identifying factors that have limited PHAR invasion in remnant wetlands should be considered in any long-term conservation strategy for fringe wetlands in the UKL system.

In the UKL system exposure to waves appears to be an important factor for describing which species occur in fringe wetlands. Overall, exposed sites had fewer species than sheltered sites within a given wetland type. However, contrary to our expectations, not all species were negatively affected by wave exposure. For example, SCAC had consistently higher probabilities of occurrence in exposed sites regardless of wetland type. Also, we predicted that NULU would be absent from exposed sites, however, this species was relatively common in remnant wetlands that were exposed to waves. Both SPEU and TYLA tended to have higher probabilities of occurrence in portions of wetlands sheltered from wave exposure. Given this understanding of the local species pool and probability of species occurrence, these results offer an understanding of the physical constraints that may limit colonization of emergent and floating species to future restoration projects in UKL (Galatowitsch 2009).

Many efforts underway in the UKB are being implemented to protect or restore lake-fringe habitats that are vital to the conservation of endemic species, improvement of water quality, and restoration of culturally significant wetland plant species (Aldous et al. 2005; Crandall et al. 2008; Elseroad et al. 2009; Wong et al. 2011). Restoration of wetlands in this region has followed the rewetting of former wetland habitat, breaching of existing levees, and small-scale restoration of shoreline habitats. The information described herein reveals how wetland shoreline profiles interact with wave exposure to influence the occurrence probability of common wetland plant species. We believe that this information is a necessary first step to improving the success of future restoration efforts and restoring key ecosystem services to the lakes of the UKB.
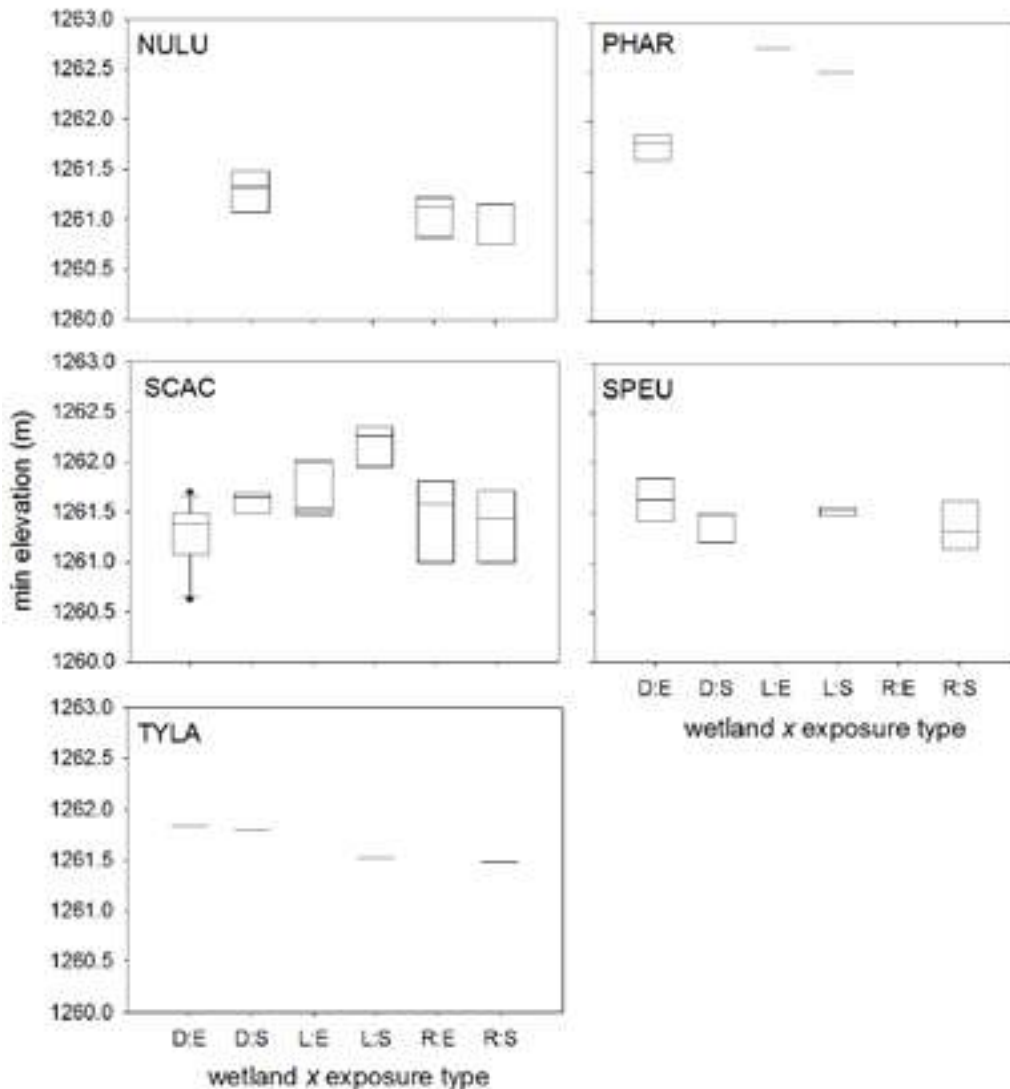

Figure 3: Minimum elevation (m) that each vegetative species was detected. Species codes are as follows: *Nuphar lutea* (NULU), *Phalaris arundinacea* (PHAR), *Schoenoplectus acutus* (SCAC), *Sparganium eurycarpum* (SPEU), and *Typha latifolia* (TYLA). Detections are summarized by transect for each wetland and exposure type. The total number of transects in each wetland X exposure combination is summarized in Table 1. Boxes represent the upper and lower quartiles of the dataset; internal lines indicate the medians. Boxed summaries represent a minimum of three observations. Whiskers are produced when there was a minimum of seven observations and represent the 10th and 90th percentiles. The absence of a box plot indicates that the vegetative species was not detected on transects within the wetland X exposure combination. Elevations are based on the Upper Klamath Lake Vertical Datum used by U.S. Bureau of Reclamation in reporting elevation in Upper Klamath Lake.

Species	Wetland Type	Exposure Type	Probability	SE
PHAR	D	S	0.00	0.000
	D	E	0.054	0.019
	L	S	0.089	0.038
	L	E	0.013	0.013
	R	S	0.000	0.000
	R	E	0.000	0.000
NULU	D	S	0.209	0.056
	D	E	0.000	0.000
	L	S	0.000	0.000
	L	E	0.000	0.000
	R	S	0.145	0.053
	R	E	0.538	0.082
SPEU	D	S	0.157	0.053
	D	E	0.142	0.037
	L	S	0.254	0.075
	L	E	0.000	0.000
	R	S	0.333	0.075
	R	E	0.000	0.000
SCAC	D	S	0.412	0.068
	D	E	0.460	0.054
	L	S	0.079	0.034
	L	E	0.094	0.038
	R	S	0.201	0.056
	R	E	0.234	0.063
TYLA	D	S	0.081	0.040
	D	E	0.020	0.014
	L	S	0.018	0.021
	L	E	0.004	0.006
	R	S	0.030	0.026
	R	E	0.007	0.008

Table 2: Estimated probability of occurrence for each species within deltaic (D), levee (L), and remnant (R) wetland types and sheltered (S) versus exposed (E) sites using quasi-binomial likelihood estimation. *Phalaris arundinacea* (PHAR), *Nuphar lutea* (NULU), *Sparganium eurycarpum* (SPEU) models include interaction between wetland type and exposure type and *Schoenoplectus acutus* (SCAC) and *Typha latifolia* (TYLA) models are additive (no interaction of wetland type and exposure type). The SE estimates of zero are because of rounding to only 3 significant digits.
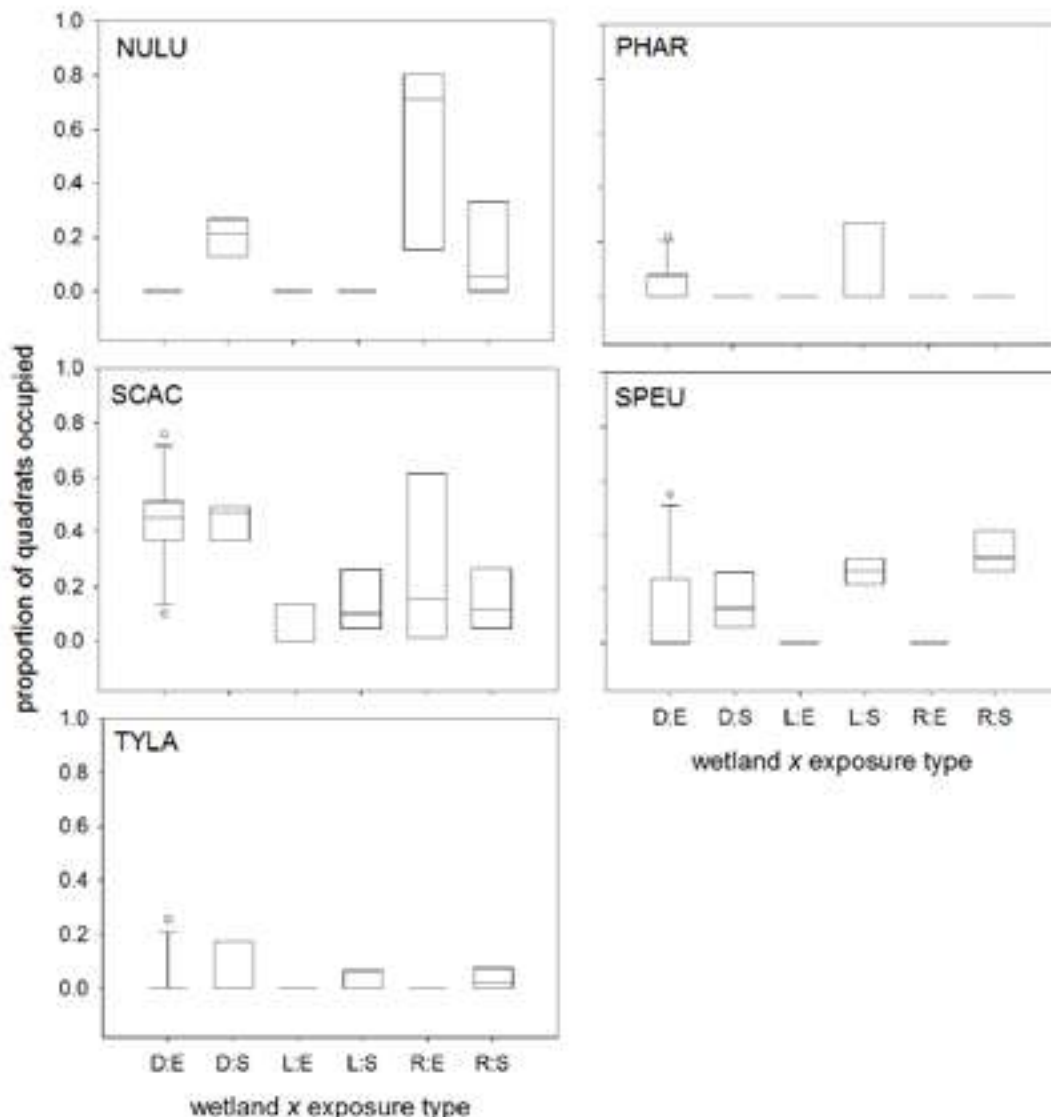
Acknowledgements

Figure 4: Comparison of the proportion of plots occupied by each species and summarized by transect for each wetland and exposure type. Species codes are as follows: *Nuphar lutea* (NULU), *Phalaris arundinacea* (PHAR), *Schoenoplectus acutus* (SCAC), *Sparganium eurycarpum* (SPEU), and *Typha latifolia* (TYLA). Boxes represent the upper and lower quartiles of the dataset; internal lines indicate the medians. Boxed summaries represent a minimum of three observations. Whiskers are produced when there was a minimum of seven observations and represent the 10th and 90th percentiles.

References

Akins, G. J. 1970. The effects of land use and land management on the wetlands of the Upper Klamath Basin. MSc Thesis. Western Washington State College

Aldous, A.R., P. McCormick, C. Ferguson, S. Graham, and C. Craft. 2005. Hydrologic regime controls soil phosphorus fluxes in restoration and undisturbed wetlands. Restoration Ecology 13:341-347

Bradbury, J. P., S. M. Colman, and R. L. Reynolds. 2004. The history of recent limnological changes and human impact on Upper Klamath Lake, Oregon. Journal of Paleolimnology 31:151-165

Burton, T. M., C. A. Stricker, and D. G. Uzarski. 2002. Effects of plant community composition and exposure to wave action on invertebrate habitat use of Lake Huron

coastal wetlands. Lakes & Reservoirs: Research and Management 7:255-269

Cooperman, M. S., and D. F. Markle. 2004. Abundance, size, and feeding success of larval shortnose suckers and Lost River suckers from different habitats of the littoral zone of Upper Klamath Lake. Environmental Biology of Fishes 71:365-377

Crandall, J. D., L. B. Bach, N. Rudd, M. Stern, and M. Barry. 2008. Response of larval Lost River and shortnose suckers to wetland restoration at the Williamson River Delta, Oregon. Transactions of the American Fisheries Society 137:402-416

Deur, D. 2009. "A caretaker responsibility": revisiting Klamath and Modoc traditions of plant community management. Journal of Ethnobiology 29:296-322

Dunsmoor, L., L. Basdekas, B. Wood, and B. Peck. 2000. Quantity, composition, and distribution of emergent vegetation along the lower river and Upper Klamath Lake shorelines of the Williamson River Delta, Oregon. 27 pp. (Unpublished report)

Eilers, J. M., J. Kann, J. Cornett, K. Moser, and A. St Amand. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon, USA. Hydrobiologia 520:7-18

Elseroad, A. C. , C. Erdman, and H. Hendrixson. 2009. *Nuphar lutea* ssp. *polysepala* transplanting at the Williamson River Delta Preserve in 2008. The Nature Conservancy, Portland (Unpublished report)

Elseroad, A., N. Rudd, and H. Hendrixson. 2011. Williamson River Delta Preserve vegetation monitoring: Tulana third-year post-breaching results. The Nature Conservancy, Portland.

Galatowitsch, S. M. 2009. Restoring prairie pothole wetlands: does the species pool concept offer decision-making guidance for re-vegetation? Applied Vegetation Science 9:261-270

Jude, D. J., and J. Pappas. 1992. Fish utilization of Great Lakes coastal wetlands. Journal of Great Lakes Research 18:651-672

Kann, J., and E. B. Welch. 2005. Wind control of water quality in shallow hypereutrophic Upper Klamath Lake, Oregon. Lake and Reservoir Management 21:149-158

Keddy, P. A. 1983. Shoreline vegetation in Axe Lake, Ontario: effects of exposure on zonation patterns. Ecology 64:331-344

Keddy, P. A., and T. H. Ellis. 1985. Seedling recruitment of 11 wetland plant species along a water level gradient: shared or distinct response? Canadian Journal of Botany 63:1876-1879

Keddy, P. A., and L. H. Fraser. 2000. Four general principles for the management and conservation of wetlands in large lakes: the role of water levels, nutrients, competitive hierarchies and centrifugal organization. Lakes & Reservoirs: Research and Management 5:177-185

Lavergne, S., and J. Molofsky. 2004. Reed canary grass (*Phalaris arundinacea*) as a biological model in the study of plant invasions. Critical Reviews in Plant Sciences 23:415-429

Levine, D. A., and D. E. Willard. 1989. Regional analysis of fringe wetlands in the Midwest: creation and restoration. pp 305-332 In: J. A. Kusler and M. E. Kentula (eds.) Wetland Creation and Restoration: The Status of the Science Volume 1. U.S. Environmental Protection Agency, Corvallis,

Mortsch, L. D. 1998. Assessing the impact of climate change on the Great Lakes shoreline wetlands. Climatic Change 40:391-416

Natural Research Council. 2004. Endangered and threatened fishes in the Klamath River Basin: causes of decline and strategies for recovery. The National Academies Press, Washington DC.

Nilsson, C., and P.A. Keddy. 1988. Predictability of change in shoreline vegetation in a hydroelectric reservoir, northern Sweden. Canadian Journal of Fisheries and Aquatic Sciences 45:1896-1904

Pennings, W.E., R. Raghuraj, and A. E. Mynett. 2009. The effects of macrophyte

morphology and patch density on wave attenuation. Proceedings from the 7th International Symposium on Ecohydraulics, Concepción.

Ray, A.M., A. J. Rebertus, and H. L. Ray. 2001. Aquatic macrophyte succession in Minnesota beaver ponds. Canadian Journal of Botany 79:487-499

Schooler, S. S., P. B. McEvoy, and E. M. Coombs. 2006. Negative per capita effects of purple loosestrife and reed canary grass on plant diversity of wetland communities. Diversity and Distributions 12:351-363

Sollie, S., H. Coops, and J. T. A. Verhoeven. 2008. Natural and constructed littoral zones as nutrient traps in eutrophicated shallow lakes. Hydrobiologia 605:219-233

Weisner, S. E. B. 1987. The relation between wave exposure and distribution of emergent vegetation in a eutrophic lake. Freshwater Biology 18:537-544

Wilson, S.D. , and P. A. Keddy. 1985. Species competitive ability and position along a natural stress/disturbance gradient. Ecology 67:1236-1242

Wong, S. W., M. J. Barry, A. R. Aldous, N. T. Rudd, H. A. Hendrixson, and Cm. M. Doehring. 2011. Nutrient release from a recently flooded delta wetland: comparison of field measurements to laboratory results. Wetlands 31:433-443

Wetlands One-Stop Mapping: Providing Easy Online Access to Geospatial Data on Wetlands and Soils and Related Information

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The Association of State Wetland Managers (ASWM) in collaboration with Virginia Tech's Conservation Management Institute (CMI) and the U.S. Fish and Wildlife Service's Northeast Region have created "*Wetlands One-Stop Mapping*" (http://www.aswm. org/wetland-science/wetlands-one-stop-mapping) – a new website designed mainly to provide easy online access to geospatial data on wetlands and soils produced by federal and state agencies. Because different agencies post data on their own sites, there is not a single place to go for this information. *Wetlands One-Stop Mapping* provides links to these and other websites of interest to people interested in learning about the presence and diversity of wetlands in a given locale as well as learning more about the nature and societal and environmental values of wetlands (Table 1). It provides online access to classification tools for adding hydrogeomorphic (hgm) properties to wetland inventory data along with the results of National Wetlands Inventory special projects, especially maps showing wetlands grouped by hgm features and predicted significance for performing numerous wetland functions via the NWI+ Web Mapper. Access to the NWI+ Web Mapper is a focal point of the website as this provides additional classification of wetlands along with preliminary landscape-level assessments of wetland functions for rather large geographic areas including some states. The new website also provides links to other federal and state websites that contain vital information on wetlands (e.g., regulatory programs, wetland delineation manuals, and other publications) and geospatial wetland data. Links to NatureServe Explorer and the U.S. National Vegetation Classification Hierarchy Explorer allow users to extract descriptions of wetland plant communities from those sites for specific areas of interest. Among the national datasets accessible via *Wetlands One-Stop Mapping* are the NWI's wetlands mapper and U.S. Department of Agriculture's web soil survey while U.S. Geological Survey's national hydrography data and watershed boundaries (hydrologic units; HUCs) can easily be added to the NWI+ Web Mapper. The site also provides information about the activities of the Wetland Mapping Consortium (including recorded webinars), Coastal Mapping Resources, and a summary of the status of state wetland mapping. This website greatly expands the amount of information ASWM serves up to the public and thereby further aids its mission to provide useful information for improving wetland management, conservation, and resource decision-making.

Table 1: List of topics included in "*Wetlands One-Stop Mapping.*"

Wetland Maps

Pre-published hardcopy maps are largely a thing of the past as color printing and maintaining an inventory of these maps and a distribution system are too expensive for current agency budgets. Furthermore, mapping technology has advanced to the point where geospatial databases are created, thereby allowing people to print custom maps of specific areas of interest from their personal computers. In the mid-1990s, the U.S. Fish and Wildlife Service (FWS) discontinued hardcopy map production and since then posts its National Wetlands Inventory (NWI) data for public use on its "Wetlands Mapper." The data posted are standard NWI "map" data and not data from special projects which generate more detailed information. Virginia Tech's CMI has worked closely with the FWS Northeast Region to enhance NWI data by adding hydrogeomorphic-type attributes (landscape position, landform, and water flow path = LLWW descriptors) to mapped wetlands (Tiner 2011a). The expanded database now called "NWI+ data" is used to better characterize wetlands and to predict wetland functions at the landscape-level. NWI+ data may be further expanded to include other geospatial layers showing: 1) wetlands that are likely to perform various functions at significant levels, 2) land that was not detected as wetland by NWI but may support wetland due to soil mapping ("P-wet areas") and 3) potential wetland restoration sites. These special projects have produced geospatial data, maps and technical reports on study findings for specific watersheds or, in a few cases, entire states.

Using Enhanced NWI Data for Improved Characterization and Landscape-Level Functional Assessment of Wetlands

When standard NWI data are combined with LLWW descriptors to produce a NWI+ database, wetland functions can be predicted for large geographic areas in addition to producing a more detailed characterization of wetlands across the landscape. A summary of the NWI+ database and applications as of July 2010 were provided in the *National Wetlands Newsletter* article "NWIPlus – Geospatial Database for Watershed-level Functional Assessment" (Tiner 2010).

To use the NWI+ database for predicting wetland functions, relationships between wetland properties in the database and wetland functions had to be developed. The Northeast Regional Wetland Coordinator worked with several groups of scientists and wetland practitioners from the East Coast, Midwest, and Southwest on various NWI+ applications to develop these relationships for what now are eleven functions of interest: surface water detention (for nontidal wetlands only), coastal storm surge detention, streamflow maintenance, nutrient transformation, retention of sediment and other particulates, carbon sequestration, bank and shoreline stabilization, provision of fish and aquatic invertebrate habitat, provision of waterfowl and waterbird habitat, provision of habitat for other wildlife, and provision of unique, uncommon, or highly diverse plant communities (see Tiner 2011b for the latest correlation report).

Since building NWI+ databases is not a standard NWI product, it has been applied to pilot study areas and to areas of interest in some regions. Applications are particularly widespread in the Northeast where the technique evolved. In the Northeast, we've attempted to add NWI+ data to updates of NWI data for large geographic areas and have produced statewide NWI+ databases for Delaware, Connecticut, Massachusetts, Rhode Island, and New Jersey. Similar data should be available for several areas in other regions by the end of 2013. Completed NWI+ datasets may be viewed online through the NWI+ Web Mapper. Several states have produced similar data for select watersheds or regions, including Georgia, Michigan and Montana (see the State Data links for their results), while other states are conducting pilot studies or statewide applications (e.g., Minnesota, New Mexico, Oregon, and Wisconsin).

NWI+ Web Mapper

The NWI+ Web Mapper is an online mapping tool that allows users to view special project data prepared by the NWI that are not available through the FWS's "Wetlands Mapper." In addition to viewing NWI and LLWW types for these areas, a number of other data layers may be available. These layers may show wetlands that have been predicted to be important for providing numerous functions, potential wetland restoration sites, and lands that may support wetlands based on soil mapping (hydric soils lacking a recognizable wetland photo-signature).

Once you have opened the mapper, you'll see a map of the United States plus icons on the tool bar above the map and a list of five topics: "Intro to the Mapper" (a must-read description of mapper contents and operation), "Wetlands One-Stop" (takes you to the page where other sources of wetland information can be accessed), "NWI" (takes you to the NWI website), "Northeast NWI" (takes you to the home page of the Northeast Region's NWI Program), and "CMI" (takes you to the home page of Virginia Tech's Conservation Management Institute). The icons allow you to: 1) view the data on a variety of maps or imagery ("Choose Basemap"), 2) show available data layers ("Map Contents"; click to view

available NWI+ data), and 3) add data layers (either from ESRI sources via "Browse" or from the web via "Search")

NWI+ Data Layers

Several data layers may be available for each project area: NWI Types, LLWW Types (NWI+ Landscape, NWI+ Landform, and NWI+ WaterFlowPath), eleven Functions, Restoration Types (NWI+ Restoration Type1, NWI+ Restoration Type2), NWI+ P-WetAreas, and layers for accessing more information (e.g., Wetland Codes). These layers are described below. The date of the inventory is listed in the project name, e.g., Connecticut Wetlands 2010.

NWI Types – this layer displays wetlands and deepwater habitats mapped by the U.S. Fish and Wildlife Service National Wetlands Inventory Program and classified by the Service's official wetland classification system (Cowardin et al. 1979).

LLWW Types – these layers ("NWI+ Landscape", "NWI+ Landform", and "NWI+ WaterFlowPath") display NWI wetlands and deepwater habitats by hydrogeomorphic-types according to Tiner (2003a, 2011a): landscape position (Figure 1), landform, and water flow path. For this classification, ponds have been separated from other wetlands for more detailed classification.

Function – these layers display wetlands identified as potentially significant for each of eleven functions: surface water detention (SWD), streamflow maintenance (SM), coastal storm surge detention (CSS), nutrient transformation (NT), sediment and other particulate retention (SR), carbon sequestration (CAR), bank and shoreline stabilization (BSS), provision of fish and aquatic invertebrate habitat (FAIH), provision of waterfowl and waterbird habitat (WBIRD; Figure 2), provision of other wildlife habitat (OWH), and provision of habitat for unique, uncommon, or highly diverse plant communities (UWPC). Descriptions of these functions and the wetlands that provide those functions are found in correlation reports and tables that update the relationships (Tiner 2011b, 2003b).

NWI+ Restoration Type1 – this layer identifies former wetlands (now nonwetlands) that are in a land use where wetland restoration may be possible. Type 1 restoration sites should be former wetlands that were converted to either potentially "developable land" by drainage and/or filling or deepwater habitats by impoundment (diking) or excavation (dredging). Most of the former sites should be agricultural land that involved wetland drainage or barren land that may represent drained wetlands or filled wetlands. The latter sites are deepwater habitats created from wetlands by impoundment (e.g., L1UBHh in NWI code) or by dredging (e.g., E1UBLx in NWI code). All of the designated sites were mostly likely wetlands based on soil mapping; these sites should not include deepwater habitats created by flooding dryland in river valleys. The referenced sites should have potential for restoration. Whether or not they are viable sites depends on site-specific characteristics, landowner interest, agency funding/priorities, and other factors. For the name of the soil type mapped at a particular site, click the "NWI+ Rest Type 1 Soil Codes" (Figure 3). If the site is agricultural land or barren land, restoration will typically require action to bring back the hydrology and may involve removal of fill. For an inundated sites (now deepwater habitats), full or partial removal of the dike or dam would be needed to restore more natural hydrologic regimes, while excavated sites would require restoration of wetland elevations by bringing in suitable fill material.

NWI+ Restoration Type2 – this layer shows existing wetlands that have been impaired to a degree that affects their ability to function like an undisturbed natural wetland (Figure 4).
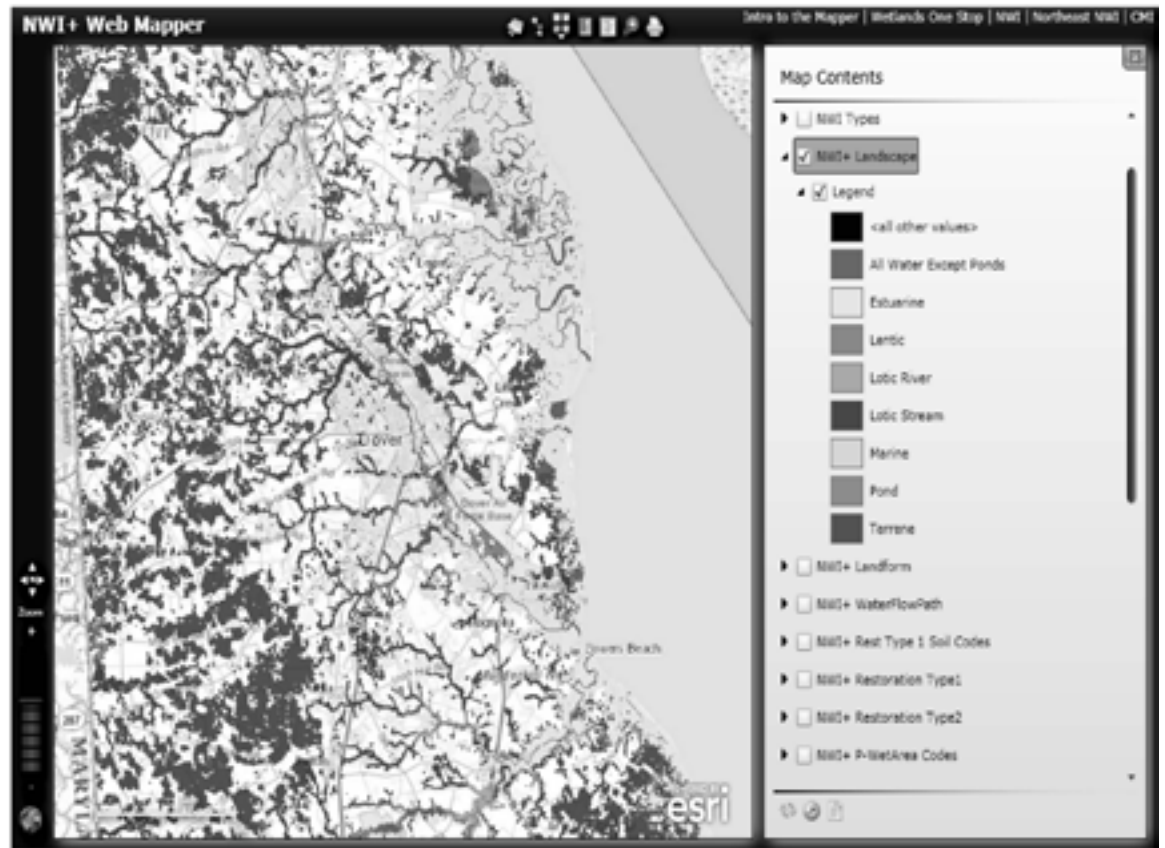
Figure 1: Wetlands around Dover, Delaware classified by landscape position as displayed on the NWI+ Web Mapper. (Note: Color-coded types are shown in black and white for this article.)
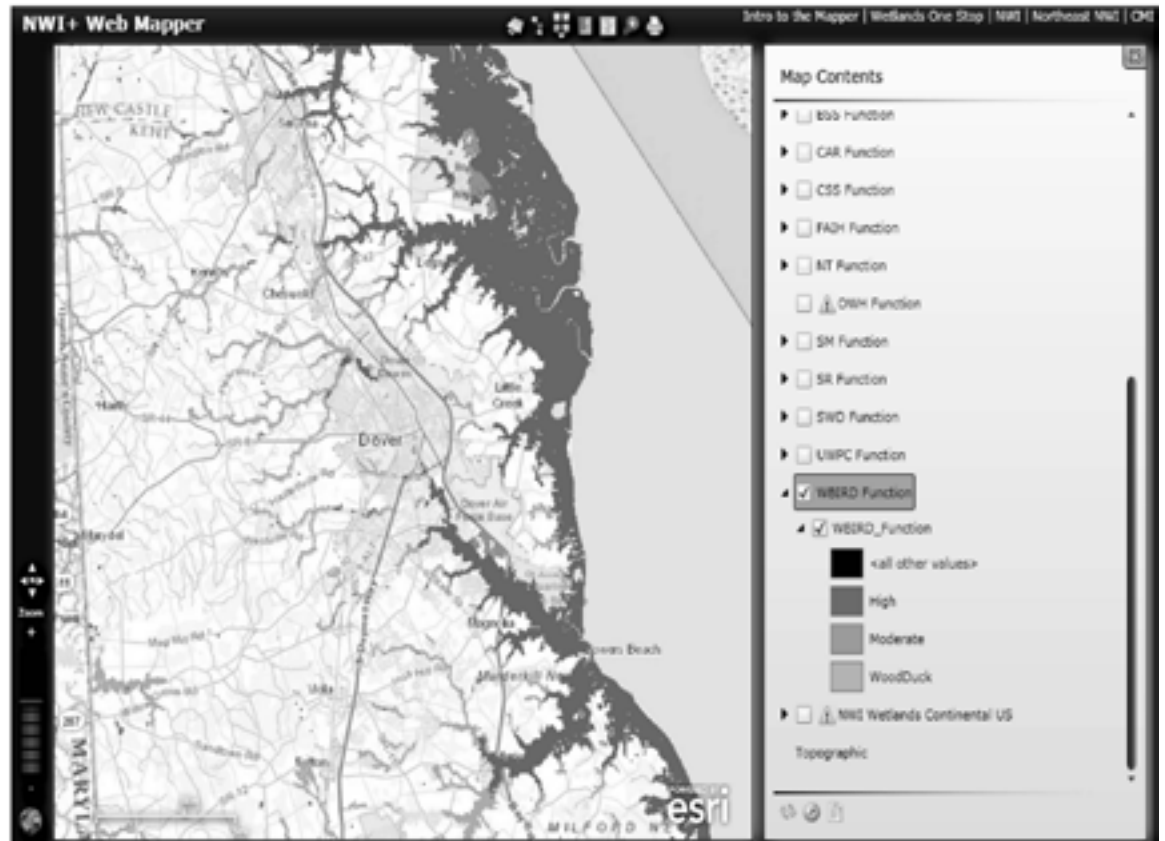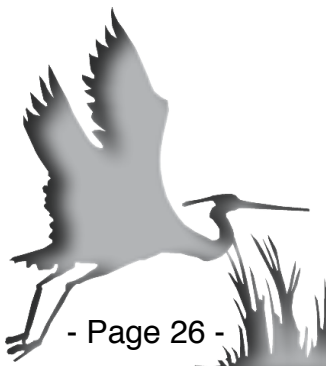

Figure 2: Wetlands around Dover, Delaware predicted to be important for waterfowl and waterbirds as displayed on the NWI+ Web Mapper. (Note: Color converted to black and white for this article.)

Click on the "Wetland Codes" box for access to NWI and LLWW codes as described above. In the coastal zone, most of these type 2 restoration sites are either partly drained wetlands (with "d" modifier in the NWI code) or tidally restricted wetland. The former are extensively ditched (e.g., E2EM1Pd in NWI code) while the latter are separated by other tidal wetlands by roads and/or railroads (look for "td" – tidally restricted/road or "tr" – tidally restricted/ railroad in the LLWW code). For inland wetlands, type 2 restoration sites also include partly drained wetlands ("d" modifier), impounded wetlands ("h" modifier; often ponds – PUBHh – built on hydric soils), excavated wetlands ("x" modifier, typically ponds – PUBHx – dug out from a wetland), and farmed wetlands (NWI code = Pf or PSSf). Sites designated have impairments that may be restorable through various means including plugging drainage ditches, removing tide gates, installing self-regulating tide gates, increasing culvert sizes, or breaching impoundments, for example.

NWI+ P-WetAreas – this layer identifies "areas that may support wetlands based on soil mapping;" they did not exhibit a recognizable wetland photo-signature on the aerial imagery used for NWI mapping, but were mapped as hydric soils by USDA soil surveys. They are portions of hydric soil map units from the USDA Natural Resources Conservation Service (NRCS) soil survey geographic database (SSURGO database) that were not farmland, roads, residential houses and lawns, or commercial, industrial or "other" development on the imagery used for NWI mapping (see applicable report). Since they were designated as hydric soil map units, they have a high probability of containing at least some wetland despite not possessing a readily identifiable wetland signature on the aerial imagery used by the NWI. It is a well-known fact that NWI methods cannot detect all wetlands (especially drier-end wetlands – seasonally saturated types) due to limitations of remote sensing techniques and the difficulty of identifying some types even in the field. Many of these hydric soil areas are adjacent to mapped wetlands and may therefore represent the drier portion or upper limit of the wetland while other areas may be upland inclusions within a hydric soil mapping unit. Inclusion of these data make the NWI+ database more complete in terms of locating areas of photointerpretable wetlands and other areas with a high probability for wetland occurrence based on soil mapping.

Printing a Map

The "print" function on the Web Mapper will give you the map without the legend. If you want the legend, go to "file" on your browser, then to "print." You can send the map to your printer or print as pdf. In either case, be sure to have "print set-up" in landscape mode, otherwise image will be distorted on portrait mode.

Other Geospatial Datasets of Interest for Wetland Identification

Other datasets including national datasets can be added to the NWI+ Web Mapper via ArcGIS Online where you can simultaneously view them and build composite maps. These sources can be added using the "Search" command; also click on "The Web" to search the web. The U.S. Fish and Wildlife Service's wetland data can be linked to the "NWI+ Web Mapper" by typing in "fws wetlands mapper" in the "Search" box, then locate the file on a list of layers that appears. Opening this layer will add all NWI data to your viewer. Another national dataset of particular interest is the National Hydrography Data (NHD) which shows streams and rivers (with flow lines) and watershed boundaries (hydrologic units to the 12 digit level). It can be added by typing in "NHD" in the "Search" box, then locate the file on a list of layers that appears: "nhd (Map Server)." You will then have NHD data for the entire country. Added layers will appear at the top of the list of layers in the Table of Contents.

Figure 3: Example of potential type 1 restoration sites with table showing soil type for area of interest. Sites are mostly cropland (drained hydric soil). Numbers in circles represent multiple polygons, zoom in to locate "dots" for accessing soil code.

Figure 4: Examples of potential type 2 restoration sites.

Another valuable dataset is soil survey data produced by the U.S. Department of Agriculture. Unfortunately at the present time, their data can't be uploaded onto the NWI+ Web Mapper. Instead you'll have to use their online Web Soil Survey (WSS) mapping tool. After accessing the WSS site, read the directions, then just click on the green button and begin to locate your area of interest and the soils that have been mapped there. With this tool you can produce a map showing soils in your area of interest and also print out the acreage of the soil units in this area. You can also get official soil series descriptions and access copies of archived soil surveys. Information on hydric soils including lists, technical criteria, and the latest guide to field indicators of hydric soils can be accessed at the USDA Hydric Soils site.

Wetland Plant Community Descriptions

The Wetlands One-Stop Mapping website also links to reports and websites that can provide information on wetland plant communities in your area of interest. NWI state wetland reports typically include descriptions of wetland types. State reports however have only been produced for a few states in the Northeast. Descriptions of wetland plant communities for the entire nation can be accessed from two sources: NatureServe and the U.S. National Vegetation Classification. Guidance on how to use these sites is provided at Wetlands One-Stop Mapping.

References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31. http://library.fws.gov/FWS-OBS/79_31.pdf

Tiner, R.W. 2003a. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. http://www.fws.gov/northeast/EcologicalServices/pdf/wetlands/dichotomouskeys0903.pdf

Tiner, R.W. 2003b. Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. http://www.aswm.org/wetlandsonestop/CORRELATION_REPORT_October_2003R.pdf

Tiner, R.W. 2011a. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. Version 2.0. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA. http://www.aswm.org/wetlandsonestop/Dichotomous_Keys_March-2012-w-cover.pdf

Tiner, R.W. 2010. NWIPlus: geospatial database for watershed-level functional assessment. National Wetlands Newsletter 32(3): 4-7, 23. http://www.fws.gov/northeast/wetlands/Publications%20PDFs%20as%20of%20March_2008/Mapping/NWIPlus_NWN.pdf

Tiner, R.W. 2011b. Predicting Wetland Functions at the Landscape Level for Coastal Georgia using NWIPlus Data. U.S. Fish and Wildlife Service, Region 5, Hadley, MA. In cooperation with the Georgia Department of Natural Resources, Coastal Resources Division, Brunswick, GA and Atkins North America, Raleigh, NC. http://www.fws.gov/northeast/EcologicalServices/pdf/CORRELATIONREPORT_GeorgiaFINAL092011.pdf

From the Bog

PHRAG MILLS AND BAKERY
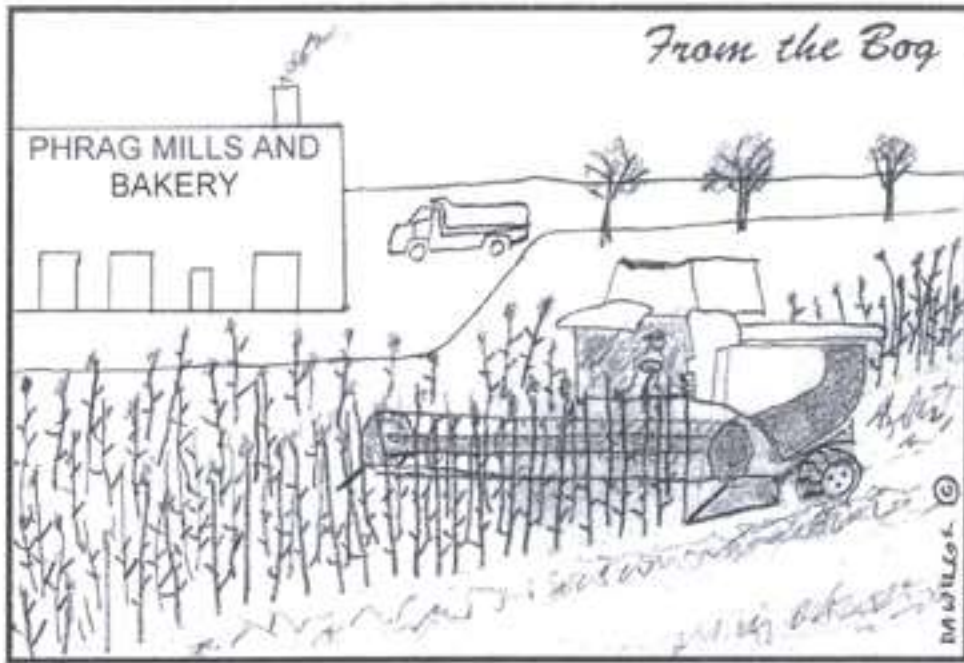
Gluten-free bread from *Phragmites* flour

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