Western Meadowlarks and Wet Prairie Habitat in the Willamette Valley: Population Enhancement through Private Land Habitat Restoration

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January 2011

Objective

The objective of this project was to determine the occurrence, area requirements, nesting success, and associated habitat characteristics of Western Meadowlarks on private land wet prairie restoration sites and a reference protected wet prairie site with a large population of meadowlarks. Information from the reference site will be used to characterize the coarse-scale habitat features of territories and the fine-scale habitat conditions at nest sites being selected for by meadowlarks, and provide a baseline to assess the progress of the restoration sites to achieve those conditions. Management recommendations will be developed to describe how restoration sites can be manipulated to resemble the structure and composition of productive meadowlark habitat in the Willamette Valley.

Background

Western Meadowlark, the state bird of Oregon, is often considered an umbrella or focal species for grassland bird conservation because their relatively large territory requirements and variable habitat conditions within those territories can encompass the habitat requirements of many other priority grassland bird species (Altman 2000). In the Willamette Valley, anecdotal information indicates that meadowlarks have experienced substantial population declines from historic conditions (B. Altman in press). More recently, data from the Breeding Bird Survey indicates that they have the highest rate of decline (10 % per year since 1968) among all grassland bird species in the Willamette Valley (Sauer et al. 2008). Further, a recent study at 544 point count stations throughout the Willamette Valley reported a 59% decline in detections of meadowlarks between 1996 and 2008 (Myers and Kreager 2010). As a consequence of these population declines, Western Meadowlarks have been identified as Species of Greatest Conservation Need in the Oregon Conservation Strategy (Oregon Department of Fish and Wildlife [ODFW] 2005), and a priority species for conservation in every natural resource assessment for the Willamette Valley.

Scope

The focus of this report is the interpretation of data and analyses supported with funding from the Oregon Watershed Enhancement Board (OWEB) to the Institute of Applied Ecology (IAE) as part of the Oregon 150 project *Western Meadowlark Habitat Enhancement: Linking and Restoring Willamette Valley Grasslands* (OWEB grant # 208-921-7179). Additional data and interpretation are presented from supporting work by ODFW on the William L. Finley National Wildlife Refuge (FNWR) with funding from the U.S. Fish and Wildlife Service (USFWS) State Wildlife Grant Program as part of the Willamette Valley Grassland Bird Conservation Program (A. Kreager and K. Halstead, pers. comm.).

Study Areas

The project occurred in the southern Willamette Valley, Oregon on 1) three private properties where the IAE is conducting extensive prairie habitat management and restoration activities (Long Tom Ranch, Tyee Wine Cellars, and Kawonu Acres), 2) one private property where the USFWS is conducting similar activities (Diamond Hill Ranch), and 3) the Willamette Floodplain Research Natural Area (WFRNA) at the FNWR where the USFWS has a remnant wet prairie reference site with an extensive meadowlark population (Figure 1).

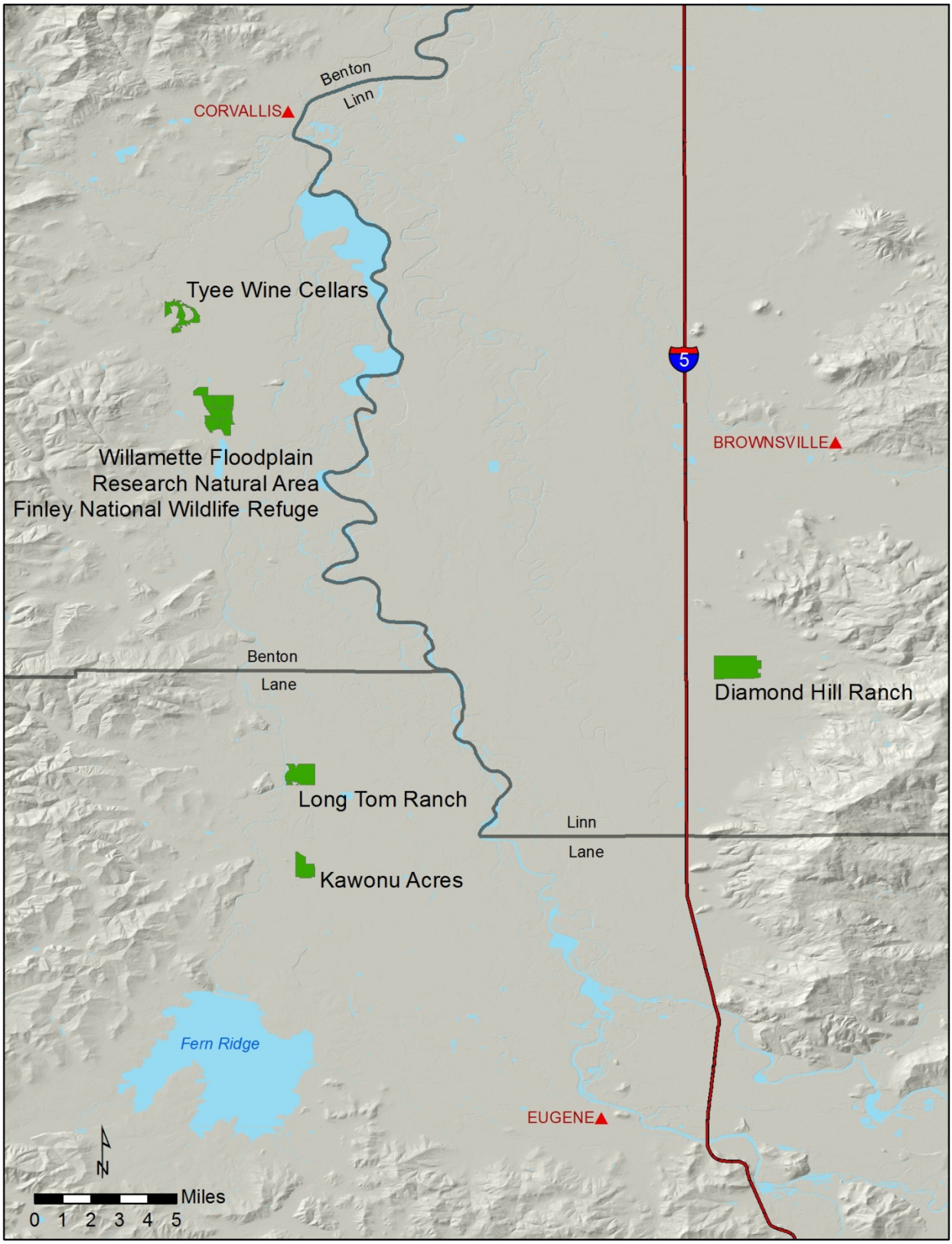

Figure 1. Location of project sites in the southern Willamette Valley, Oregon.

OWEB support of the project focused on all the private lands and the northern part of the WFRNA (i.e., Field 1, North Prairie, Field 3, and Northeast Prairie) (Figure 2). ODFW support included the southern part of the WFRNA (i.e., Middle Prairie, South Prairie, and Field 31) (Figure 2), and Field 29 elsewhere on FNWR.

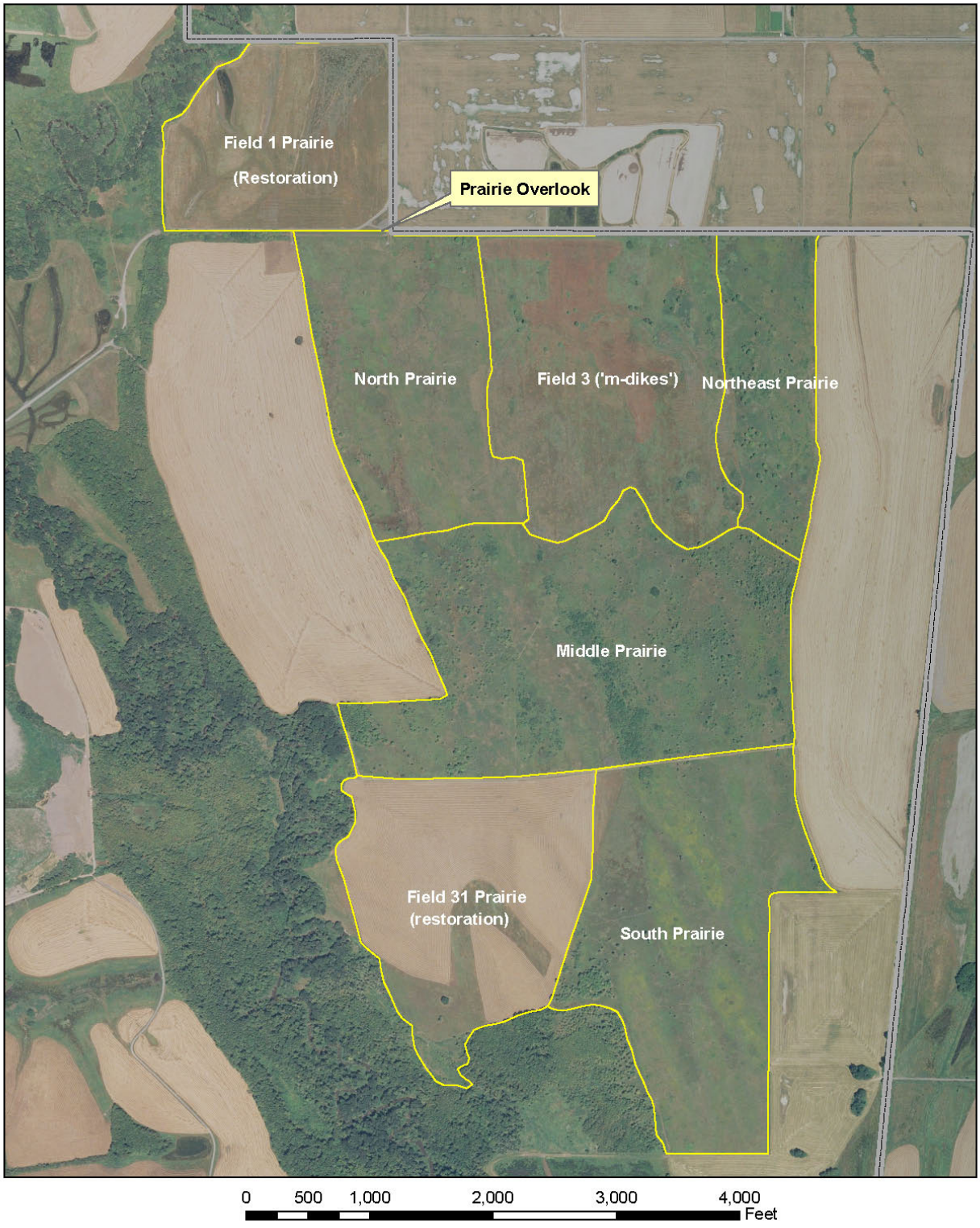

Figure 2. The Willamette Floodplain Research Natural Area, Finley National Wildlife Refuge.

The WFRNA is approximately 615 acres of seven designated fields based on FNWR management with boundaries comprised of roaded fire break lines/dikes and former plow lines. Approximate sizes of the fields include: Field 1 (60 acres); North Prairie (77 Acres); Field 3 (101 Acres); Northeast Prairie (42 Acres); Middle Prairie (143 acres); South Prairie (107 acres), and Field 31 (85 acres) (Figure 2). The site is relatively level wet prairie with scattered trees and shrubs and a couple stands of trees. Much of the ground is saturated during May and into June with heavy rain events. Restoration activities including controlled burns, mechanical removal of woody vegetation, broadcast and spot spraying to kill invasive and undesirable vegetation, and planting/seeding of grasses/forbs have occurred to varying degrees in each of the prairies.

Long Tom Ranch (Figure 1) is 316 acres of freshwater marsh, wet prairie, upland prairie, and bottomland forest owned by the Long Tom Ranch LLC that is under a permanent conservation easement with the Natural Resources Conservation Service (NRCS). The easement was established in 1997 and NRCS and USFWS began restoration activities shortly thereafter on managing the network of freshwater marsh. IAE initiated restoration activities in 2007 on about 100 acres of wet prairie and upland prairie. Restoration work focused on replacing the existing non-native vegetation with native grassland species through extensive mowing, burning, disking, herbicide applications, and seeding of native species.

Tyee Wine Cellars (Figure 1) is 241 acres of freshwater marsh, wet prairie, upland prairie, and bottomland forest owned by Dave and Margy Buchanan that is under a 30-year conservation easement with the NRCS. The easement was established in 1998 and the NRCS and USFWS began restoration activities shortly thereafter on portions of the wet prairie along the flood plain. IAE initiated restoration activities in 2007 on 42 acres of wet prairie that was not previously restored. That restoration focused on replacing the existing non-native vegetation with native grassland species through extensive mowing, burning, disking, herbicide applications, and seeding of native species. The Buchannan's enrolled an additional 60 acres into the program in 2010, thereby connecting two disjunct prairies.

Kawonu Acres (Figure 1) is 204 acres of freshwater marsh, wet prairie, and upland prairie owned by Dale Bergey that is under a permanent conservation easement with the NRCS. The easement was established in 2003 and NRCS and USFWS began restoration shortly thereafter by establishing a very dense stand of native grasses over most of the prairie habitat. IAE initiated restoration activities in 2007 on about 60 acres of wet prairie and upland prairie. That restoration focused on enhancing the existing native grass community by controlling non-native vegetation through mowing, burning, and herbicide applications. Native wildflowers were later seeded amongst the native grasses to increase the overall diversity.

Diamond Hill Ranch (Figure 1) is 580 acres of private land owned by Pat and Stephanie Hagerty that is under a permanent conservation easement with the NRCS. The easement was established in 2005, and NRCS, USFWS, and ODFW are restoring over 100 acres of seasonal wetland, over 100 acres of bottomland hardwood forest, and over 300 acres of wet prairie habitat on former agricultural lands.

Methods

Species Occurrence

At least four site visits were made to each of the four private land sites in May and June 2010 to ascertain if meadowlarks were present. Each site visit was a minimum of two hours. Once presence was determined, territory mapping was initiated with a minimum of five site visits for this activity.

Area Requirements
Territory mapping was conducted in May and June 2010 to provide data on meadowlark area requirements. Territory mapping was conducted using the "repeat-flush" technique (Wiens 1969) combined with general spot-mapping protocols (Bibby et al. 1993). A single observer walked throughout the study area and used aerial photos to map the location and flight paths of meadowlarks as they were located and/or flushed. As a general understanding of the territory developed over multiple visits, effort was made to approach a perched male and flush it in a new direction to determine the territory boundaries. At least five visits were made to each territory (six for the ODFW sites), although some territories received additional effort due to their proximity to the parking area (e.g., Field 1) and/or continual passing through them to get to other territories farther from the road (e.g., North Prairie).

Territories were delineated by reviewing the daily maps and using a clean aerial photo to draw straight lines connecting the 5-8 most perimeter point locations. Digital polygons were created in ArcGIS using 2009 NAIP digital aerial imagery as a base map and heads-up digitizing of the hand drawn territories. The area of each territory was calculated in ArcGIS using the "calculate geometry" command in ArcView with Oregon Statewide Lambert NAD 83 as the base projection.

Nesting Success
Nest monitoring was conducted in May-July 2010 to assess the role of reproductive success and productivity in populations of Western Meadowlarks. Nests were located by observation of behavioral cues that narrowed a nest search down to a small area (Martin and Conway 1994), and fortuitously when walking through an area and flushing a bird off a nest. Nests were marked and revisited in a manner to reduce predator attraction and investigator-induced predation (Martin and Conway 1994). To determine nest outcome, nests were checked every 3-4 days until either the young fledged or the nest failed. A nest fledging at least one young was considered successful. Causes of nest failure were surmised based on examinations of the nests and the surrounding area (Patterson and Best 1996). If nest contents (eggs or nestlings) were removed prior to the projected fledging date, the nest was considered depredated.

Available resources limited the effort that could be dedicated to the time-consuming activity of nest searching. Alternatively, we identified "nest areas" as places where adult birds were observed to repeatedly visit with food in their beak.

Habitat Characterization
Vegetation data were collected in July 2010 at the WFRNA to characterize the species composition and abundance at nest sites or within nest areas. Data were collected after nests were no longer active, but as soon as possible to minimize changes in the physical structure or identification ability of the vegetation due to growth or senescence. At the restoration sites we collected vegetation data at a randomly selected single location, since there were no active meadowlark nests at these sites.

Vegetation data at nests were collected within a 1-meter square plot centered on the nest in the four cardinal directions, and in a 5-meter plot located 25 meters away from the nest in a randomly generated compass direction. Data collected within the 1-meter plot included ocular estimates of the percent cover of each species rooted inside in the plot, and of five ground cover categories - bare ground, rock, thatch, coarse wood, and moss/lichen. Within the 5-meter plot, ocular estimates of percent cover were made by growth form (i.e., grasses, forbs, shrubs, trees) and the same ground cover categories.

Vegetation data at nest areas were collected within a 200 square meter plot created by measuring out 10 meters in each cardinal direction from the nest area center to create a square plot 14.1 meters on each

side. Additionally, a random control plot of the same size was created 50 meters from the nest area center by generating a random number as a compass bearing. Each plot was divided into quarters of approximately 50 square meters and ocular estimates of percent cover were made for every species rooted inside the plot within the quarter plot. Cover estimates for all four quarters were averaged to create a single cover estimate per species for the entire plot. The same vegetation data collection protocol for the nest area was used for the control plot.

Percent cover was greater than 100% in some plots if there were multiple canopy layers in the vegetation, but all plots were +/- 5 % of 100% cover since layering was not common. For visual estimation, 1% cover was approximately 0.7 meter x 0.7 meter (i.e., 2.3 feet x 2.3 feet) and 10% cover was approximately 2.2 meters x 2.2 meters (i.e., 7.2 feet x 7.2 feet). GPS points were established at both nest area and random plots.

Data on vegetation height was not collected because it is dependent on when the measurement is taken within the growing season. Since vegetation stature is important to meadowlarks (Altman 1997), each plant species was assigned a height class based on the average height for the species in Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). Five height classes were delineated: 1) ground cover (< 25 cm), 2) low growing (26-50 cm), 3) intermediate (51-75 cm), 4) tall (76-100 cm), and 5) very tall (>100 cm).

Data Analyses

Data analyses and presentation are descriptive rather than statistical due to low sample sizes in this initial year of effort. Additional data collected in the next two years will allow for statistical analyses and a broader scope of inference for Western Meadowlark habitat in the Willamette Valley.

The unit of measurement for data collection, analyses, and presentation was percent cover by plant species at the plot scale. The categories of analyses included total vegetation (i.e., live vegetation), and the five primarily non-live ground cover types (i.e., bare ground, thatch, mosses and lichens, wood, and rock); the three growth forms (i.e., shrubs, forbs, and graminoids [grasses, sedges, and rushes]); whether the plant species was annual or perennial and native or introduced, and height class.

The plots were further characterized by an analysis of species richness to describe the diversity of the plant communities in the plots independent of percent cover. We did some preliminary analyses of species composition, but no patterns of dominance were apparent, perhaps due to small sample size and the variability that occurs in species presence/abundance in different-aged restoration sites.

Data analyses from the territories at FNWR were conducted primarily at three scales: overall which includes the WFRNA and Field 29 (n=9), just the WFRNA (n=8), and the remnant prairie in the WFRNA (i.e., all fields except Fields 1 and 31) (n=6). Some additional analyses are presented for the two new restoration sites on the WFRNA (Field 1 and Field 31).

Results and Discussion

Occurrence and Site Habitat Assessments

Tyee Wine Cellars

2010 Results: No meadowlarks were detected on five visits to Tyee Wine Cellars. Additionally, no meadowlarks were detected by IAE staff during multiple visits to the site during spring and summer.

Future: Tyee Wine Cellars is in an excellent location for recruitment of meadowlarks because of its proximity to the population at FNWR, approximately 1.5 miles to the south. If the FNWR population is a source as suspected, surplus birds produced each year will be prospecting for suitable habitat near the refuge. Prairie restoration and recent efforts to "open-up" Tyee Wine Cellars by removing trees and brush separating fields should increase habitat suitability for prospecting meadowlarks. However, Tyee Wine Cellars is in a bottomland floodplain with several patches of riparian forest that fragment fields on the property and adjacent properties, especially to the north and east. Additional efforts at reducing the cover of tree lines and small patches in the landscape would be desirable to ensure habitat suitability for meadowlarks. The most likely area of establishment for meadowlarks is from the uplands to the southwest where there is a more open landscape of fields and some recent breeding season use by meadowlarks (i.e., 1990s).

It is likely that initial use of Tyee Wine Cellars will be during the non-breeding season (i.e., late summer post-breeding dispersal and winter) when birds move around and are opportunistic in search of suitable foraging habitat. Non-breeding season use does not necessarily correlate to breeding season use since philopatry brings birds back to the general area of their birth or previous years nesting. Thus, breeding season recruitment to Tyee Wine Cellars is more dependent on the likely expansion of nearby populations at FNWR to provide surplus birds, than discovery and use of the site during the non-breeding season.

Kawonu Acres

2010 Results: Kawonu Acres had inconsistent breeding season use by 1-2 male meadowlarks. During the first couple visits in May there were no meadowlarks detected on the property, although birds were detected off-property to the south and southeast. In late May, a male was singing in the southeast corner of the property and appeared to have part of its territory on the property. IAE staff detected meadowlarks on two visits in mid-June. However, during a couple other visits in June no meadowlarks were detected.

Future: The landscape context at Kawonu Acres is excellent for meadowlarks with mostly open fields of different agricultural types and a population of meadowlarks in adjacent and nearby areas. The amount of potentially suitable habitat on the property could support a couple breeding pairs in conjunction with the larger surrounding population. However, current habitat conditions in much of the eastern and southern portions of the site (i.e., the potential suitable habitat) are dominated by tall, dense tufted hairgrass (~1.5 meters tall) which may be limiting meadowlark use, especially considering the inconsistent sightings of birds during the breeding season. Thus, the partial and inconsistent use by meadowlarks suggests unsuccessful reconnaissance attempts to colonize the property for breeding. Additional restoration efforts that encourage more diversity of lower-statured grasses should increase the likelihood of colonization by breeding meadowlarks.

Long Tom Ranch

2010 Results: The eastern portion of Long Tom Ranch supported approximately one-half of a meadowlark territory which was shared with the private property dog training area on the east side of Washburn Road (Figure 3). The meadowlark pair used the Long Tom Ranch throughout the breeding season. A nest was not located although nesting was suspected on the dog training area based on repeated visits by the female to a general area on that property. Territory size was 33.4 acres, approximately 50% larger than those on the WFRNA in 2010. As discussed below, reasons for that may include lower quality habitat at this in-progress restoration site which would require more area to support a pair, and/or reduced competition from adjacent pairs for space and resources. Meadowlark territories on private property to the north, east, and southeast abutted with the Long Tom Ranch pair to

some degree. However, there was some habitat to east and southeast that appeared to be unoccupied, and there were no meadowlarks in potential habitat to the west.

Future: Use of the eastern portion of the Long Tom Ranch by at least one pair of birds is likely to continue as the quality of the habitat improves over time through restoration, and there is an adjacent population to potentially provide recruitment of new birds. The western portion of the Long Tom Ranch has sufficient area to support a second pair of meadowlarks, especially centered in the upland northwest corner with adjacent private property to the north and west. Restoration of that field has provided a good structural diversity of forbs and grasses, but the relatively small size of the field (26 acres) will require continued restoration to the south on Long Tom Ranch, and/or use of the farm fields to the north or west to provide a landscape of suitable habitat for meadowlarks. The middle of the Long Tom Ranch, which is primarily wetlands and ponds, will likely function as post-breeding and early fall dispersal habitat for meadowlarks as the wetlands dry out.

Diamond Hill Ranch

2010 Results: There were at least three singing males immediately adjacent to Diamond Hill Ranch and at least a couple other singing males within one mile. However, breeding season use of the property by meadowlarks was only observed by a pair of birds in the extreme southeast corner near the entrance road. This pair was only detected on two visits, and most of the detections were on private land to the southeast. Two other males immediately adjacent to the property sang from telephone poles on Diamond Hill Road on all visits, but were never observed to use the Diamond Hill Ranch restoration site. Further, repeated efforts to flush them towards the restoration site were unsuccessful. They were only observed to use the grass seed field to the south, and Diamond Hill Road appeared to be the northern limit of their territory.

Future: The immediate proximity of several meadowlark pairs to Diamond Hill Ranch suggests the restoration site provides great potential for meadowlarks. Although most of the site is dominated by non-suitable wetland and pond habitat, there is enough restoration prairie along the road and to the east to support a couple meadowlark territories. The near non-existent use of these areas suggests specific habitat conditions that are not suitable for meadowlarks. The prairie is dominated by spike bentgrass and meadow barley which grow tall and relatively dense. If these areas become more vegetatively and structurally diverse and lower-statured, it is likely that use by breeding meadowlarks will occur. For now, the greatest value of the site for meadowlarks is likely during late-summer post-breeding dispersal when the wetlands have dried up and before the seasonal rains have replenished them.

Area Requirements

In the OWEB supported part of the project, there were 16 territories with a mean territory size of 16.63 acres and a range of 11.71-29.72 acres (Table 1). In the ODFW part of the project, there were 11 territories with a mean territory size of 27.52 acres and a range of 6.3-74.70 acres. However, when two territories of extreme size in Field 31 were removed from the analyses (see explanation below), mean territory size was 24.63 acres with a range of 15.60-35.70 acres. Overall mean territory size for the WFRNA (n=25) was 19.58 acres with a range of 11.71-35.70 acres.

Table 1. Summary of Western Meadowlark territory size on Finley National Wildlife Refuge, 2010, and throughout the Willamette Valley, 1996.

Data Source	n	Mean	Range	Comments
2010 OWEB 150 (North WFRNA)	16	16.63	11.71-29.72	
2010 ODFW (South WFRNA)	11	27.52	6.30-74.70	
2010 WFRNA all territories	27	21.06	6.30-74.70	
2010 ODFW minus territories in Field 31	9	24.63	15.60-35.70	Two outliers (see text)
2010 WFRNA minus teritories in Field 31	25	19.58	11.71-35.70	Two outliers (see text)
2010 recently restored Field 1	3	22.28	16.15-29.72	
2010 North Prairie	5	14.05	12.05-17.08	
2010 Field 3	4	16.78	11.71-21.18	
2010 Northeast Prairie	3	14.27	13.87-14.49	
2010 Middle Prairie	5	25.62	15.60-32.30	
2010 South Prairie	4	23.40	20.30-29.00	
2010 ag field dominant	4	32.35	6.3-74.70	
2010 ag field dominant minus Field 31	2	24.01	19.01-29.00	
2010 Field 29	1	13.39	na	
2010 Long Tom Ranch WRP	1	33.40	na	
All 2010 sites	29			
1996 Pastures	10	12.3	7.1-21.6	
1996 Fallow Field	8	15.4	4.8-35.0	
1996 Grass Seed Field	1	11.1	na	
1996 Christmas Tree farm	1	19.5	na	
1996 Vineyard	1	23.9	na	
All 1996 Sites	21	14.3	4.8-35.0	Mix of upland habitats
1996 and 2010 Sites	50		4.8-74.7	

A territory was considered part of a classification if >50% of the territory occurred in that classification

The difference between the 1996 data on mean territory size (approximately 14 acres) and the 2010 data (approximately 20 acres) is noteworthy. Numerous factors as described below may be contributing to the differences, but the most obvious difference is the type of fields; upland prairie of various types in 1996 and wet prairie in 2010. Meadowlarks are generally considered to be an upland grassland bird, and the smaller territory size in upland habitats may reflect enhanced suitability of those habitats. Additional data collection in 2011 and 2012 in upland prairie sites will provide an opportunity to evaluate this hypothesis.

The size of a meadowlark territory can be highly variable and is likely dependent on multiple factors including the quality of the habitat (i.e., the ratio of non, low, medium, and high quality), the amount of non-use or limited use areas within the territory, the adjacency of other meadowlark territories and competition for space and resources, and the location of prominent singing perches such as large trees. We did not characterize the habitat quality of the territories through vegetation data collection, but there are some potential examples of the factors affecting territory size. One of the largest territories (29.72 acres) was mostly in Field 1 and included a significant amount of road and parking area (non-habitat) and received the most human disturbance (Figure 3). There also are a couple examples of territory size

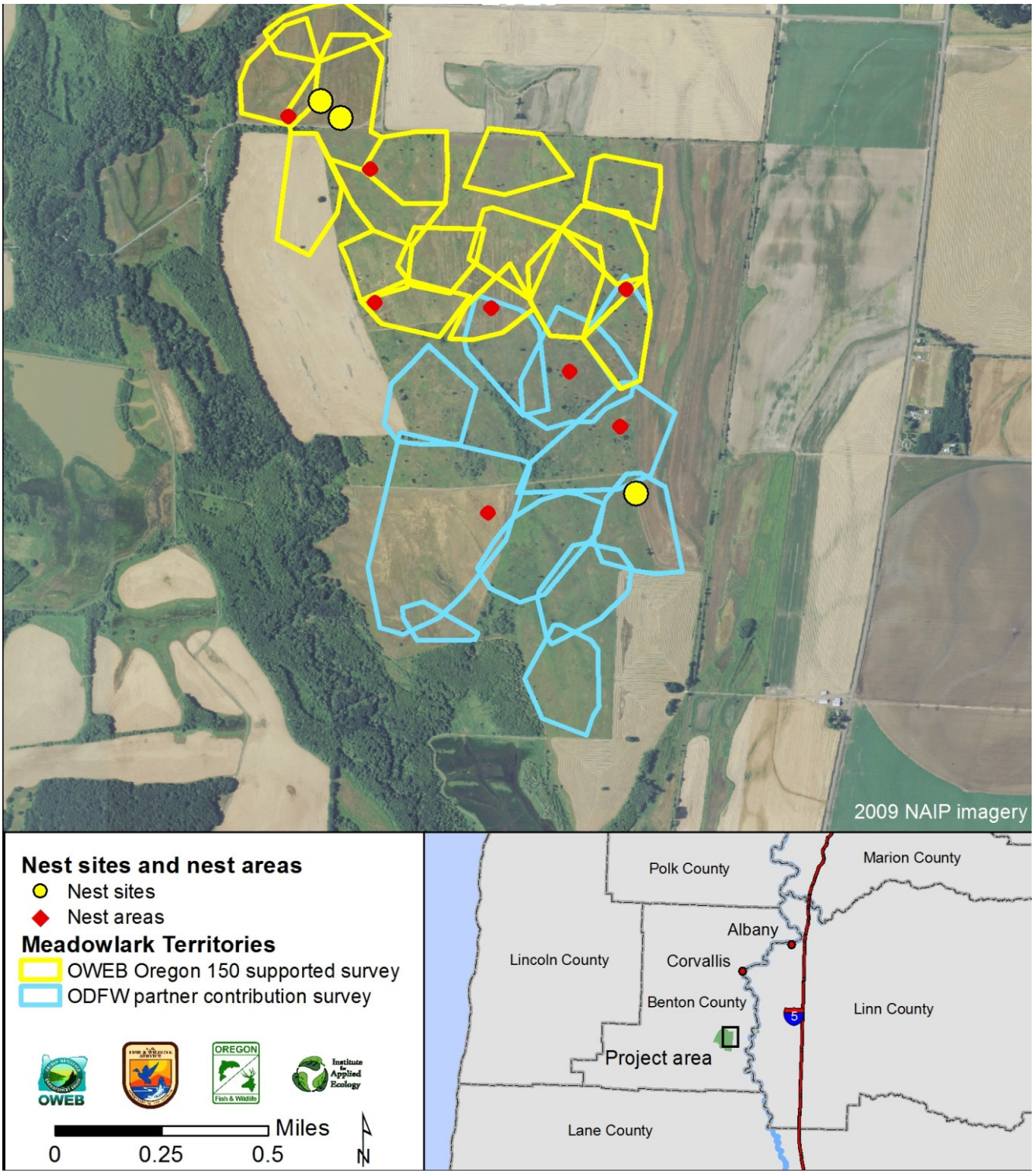

Figure 3. Location of Western Meadowlark territories on the Willamette Floodplain Research Natural Area, Finley National Wildlife Refuge, 2010.

being potentially affected by the surrounding adjacency of other territories. The abutment of adjacent territories limits to some degree the size of the territory because of the inability of birds to opportunistically extend their territorial boundaries. However, without knowledge of the comparable quality of the habitat there may be other issues affecting territory size than the "pressure" of adjacent

territories. Further, most territories were characterized by the repeated use of one or more trees (large and small) as territorial singing perches that marked territory boundaries.

In addition to the aforementioned factors, differences in our estimation of the size of meadowlark territories can be due to variable amounts and timing of mapping efforts. There can be temporal fluidity in territory size as the nesting status of the territory and/or adjacent territories changes (i.e., nests fail or nests fledge). For example, the smaller southernmost territory in Field 31 was short-lived with birds present on two visits in early May and then never encountered again. Shortly thereafter, the meadowlark pair in the territory to the north expanded their territory to the south and absorbed part of that territory, thus increasing the size of their territory to approximately three times that of the mean territory size of all other territories. However, this expanded part of the territory received limited use other than the male occasionally singing from trees near the southern boundary of the territory. Thus, indicating how territory size can be affected by areas of non-use or limited use.

Another factor potentially affecting territory size by the quality of the habitat was the maturity of the prairie. Territories within prairies with the oldest history and most amount of restoration (i.e., remnant prairies) tended to be smaller (e.g., North Prairie, Northeast Prairie), and those in more recent and ongoing restoration sites (e.g., Field 1, Long Tom Ranch) or those dominated by agricultural fields (e.g., North Prairie NW, Field 31) tended to be larger in size.

Areas of Non-use

Despite areas of overlap and adjacency among most of the territories there still were some areas on the WFRNA that did not appear to be a part of a meadowlark territory. These included primarily a linear strip of non-habitat woody vegetation (approx 660 meters X 135 meters) that bisected Middle Prairie including the non-woody adjacent habitat to the west and northwest, and much of the northern part of Field 3 which is dominated by a reed canary grass monoculture and parts of which were continuously inundated with water well into the breeding season.

Nesting Success

Three meadowlark nests were located and monitored (Table 2). All three were discovered during the nestling stage, and clutch sizes at time of discovery were two or three nestlings. One of the nests had a single nestling dead just outside the nest. All three nests were successful.

Table 2. Summary of Western Meadowlark nests monitored on the Willamette Floodplain Research Natural Area at Finley National Wildlife Refuge, 2010.

Location	Date Found	Status	Last Date	Observation Days [1]	Outcome
South Prairie	May 20	2 or 3 nestlings	May 26	4.5	Success – 2 fledged; one unknown presumed depredated
Field 1	May 28	3 nestlings, 5-6 days old	June 1	4	Success – 2 fledged; one unknown presumed depredated
Field 1	July 1	2 nestlings – 1 nestling dead near nest	July 10	8	Success – 2 fledged

[1] Observation days is the number of days from the date found to the mean of the last date with nestlings and the date visited when birds had fledged.

Observations of fledglings throughout May-July indicated that many other territories had successful nests that were not found (Table 3). Additionally, some nests likely failed based on the abrupt cessation

of breeding behaviors and the absence of fledgling observations. In particular, there were a couple nests where food-carries by adults ceased after a significant rain event in early June which inundated many areas of the WFRNA.

Table 3. Western Meadowlark territory sizes and known or suspected nesting status at the Willamette Floodplain Research Natural Area wet prairie on Finley National Wildlife Refuge, 2010.

Territory ID	Acres	Females	Comments
North Prairie NW	19.01	1	unknown; no confirmation of nest attempt observed
North Prairie N	17.08	1	Fledglings observed
North Prairie C	13.36	1	Nestlings based on food delivery
North Prairie E	14.55	1	unknown; no confirmation of nest attempt observed
North Prairie W	12.05	1	unknown; no confirmation of nest attempt observed
North Prairie S	13.21	2	Fledglings observed
Field 1 SE	29.72	1	Nestlings from two nests
Field 1 SW	20.97	2	Fledglings observed
Field 1 N	16.15	1	unknown; no confirmation of nest attempt observed
Northeast Prairie N	13.87	1	unknown; no confirmation of nest attempt observed
Northeast Prairie C	14.49	1	unknown; no confirmation of nest attempt observed
Northeast Prairie S	14.45	2	Fledglings observed
Field 3 N	16.44	1	Fledglings observed
Field 3 C	17.78	1	unknown; no confirmation of nest attempt observed
Field 3 SE	21.18	1	unknown; no confirmation of nest attempt observed
Field 3 SW	11.71	1	Fledglings observed
Middle Prairie NW	22.50	1	Nestlings based on food delivery
Middle Prairie C	32.30	1	Nestlings based on food delivery
Middle Prairie NE	15.60	2	unknown; behavioral evidence for nest attempt
Middle Prairie SE	35.70	1	Nestlings; two attempts (both produced nestlings)
Middle Prairie W	22.0	1	unknown; no confirmation of nest attempt observed
South Prairie NW	22.90	1	unknown; no confirmation of nest attempt observed
South Prairie NE	29.00	2	Nestlings from one nest
South Prairie C	21.40	0	unknown; no confirmation of nest attempt observed
South Prairie S	20.30	1	Nestlings based on food delivery
Field 31 S	6.30	1	unknown; no confirmation of nest attempt observed
Field 31 N	74.70	1	Nestlings; behavioral evidence for fledglings
Field 29	13.39	2	unknown; no confirmation of nest attempt observed

The small sample size of nests precludes analyses of Mayfield (1975) estimates of nest success. Additional nest monitoring during the 2011 and 2012 field seasons may increase the sample size to where Mayfield estimates of nest success can be calculated. Further, these data will be combined with nest success data from the 1996 field season (Altman 1997) to enhance the sample size and breadth of the analyses to habitat types other than wet prairie.

Habitat Characterization at WFRNA Nest Sites and Nest Areas

The relationship between percent cover of vegetation in control versus nest area plots were the same in the three primary scales of analyses except for forbs which were lower in nest plots in the remnant prairie and the WFRNA, but not overall which included Field 29 (Table 4). Percent cover vegetation

was greater in nest plots for native species (~6-10% difference), annual species (~1-6% difference), and graminod species (~2-8% difference), and greater in control plots for introduced species (~7-12% difference), perennial species (~2-7% difference), and shrub species (~5-7% difference) (Table 4). It is most noteworthy from a restoration perspective that the greatest differences in percent cover were in the remnant prairie of the WFRNA for native species cover at nest areas (~10%) and introduced species cover at control sites. This suggests the potential for meadowlark selection of native cover at nest areas, especially in the remnant prairie of the RNA, and supports the value of a long-term commitment for restoration to meadowlarks.

Table 4. Percent cover of vegetation at Western Meadowlark nest areas and control plots at the Willamette Floodplain Research Natural Area on Finley National Wildlife Refuge, 2010.

	Percent Cover								
Sites	**Total Veg**	**Total Sub**	**Introduced**	**Native**	**Annual**	**Perennial**	**Graminod**	**Forb**	**Shrub**
All (9) [1]									
Control	94.40	7.64	33.63	60.76	9.36	85.04	58.55	12.33	23.51
Nest Area	93.80	8.12	26.89	66.59	15.45	78.04	68.62	14.55	18.31
WFRNA (8) [2]									
Control	95.88	6.59	29.91	65.97	10.16	85.72	56.25	13.61	21.02
Nest Area	93.76	8.18	21.92	71.87	10.74	83.04	62.03	11.35	20.41
Remnant (6) [3]									
Control	97.47	5.63	31.85	65.62	11.61	85.86	46.96	15.82	34.69
Nest Area	95.23	7.12	19.38	75.86	13.73	81.50	54.32	13.70	27.21
New (2) [4]									
Control	91.10	9.50	24.09	67.01	5.82	85.28	84.13	6.97	0.00
Nest Area	89.84	11.38	29.53	59.91	1.78	87.66	85.13	4.28	0.03

[1] Includes eight plots on the WFRNA (wet prairie) and one plot in Field 29 (upland prairie).
[2] Includes only the eight plots on the WFRNA (all wet prairie)
[3] Includes only the six plots in remnant prairie on the WFRNA (excludes two plots in Fields 1 and 31)
[4] Includes only two "new" restoration fields (1 and 31)

The greatest differences between the "new" prairie plots (n=2) and the older prairie plots (n=6-9) was annuals (~4-8% less cover), graminods (~18-38% more cover), forbs (~7-11% less cover), and shrubs (~20-35% less cover) (Table 4). Despite the large discrepancy in shrub cover, meadowlarks were nesting in the newer restoration prairies, suggesting substantial flexibility in this habitat feature.

Among height classes in the three primary scales of analyses, percent cover of vegetation was lowest in class 1 and greatest in height classes 2 and 5 (Table 5). Perhaps most noteworthy was the consistently higher percent cover of vegetation in height class 1 at nest areas over control sites (generally100% or more cover). This supports prairie restoration objectives to increase forb cover (dominant in height class 1) relative to its occurrence in degraded or non-restored grassland habitats.

Table 5. Percent cover of height classes and ground cover at Western Meadowlark nest areas and control plots at the Willamette Floodplain Research Natural Area on Finley National Wildlife Refuge, 2010.

	Height Class [1]					Ground Cover				
	1	**2**	**3**	**4**	**5**	**Bare**	**Wood**	**Moss**	**Rock**	**Thatch**
All (9) [2]										
Control	2.72	36.16	7.69	24.14	23.68	5.60	0.15	0.03	0.00	1.87
Nest Area	7.72	33.45	12.73	20.46	19.12	5.74	0.31	0.06	0.02	2.00
WFRNA (8) [3]										
Control	2.78	33.64	8.26	24.99	26.20	4.42	0.16	0.00	0.00	1.98
Nest Area	4.88	31.81	14.14	22.36	20.60	5.70	0.34	0.00	0.00	2.13
Remnant (6) [4]										
Control	3.35	31.71	9.73	17.87	34.81	3.15	0.22	0.04	0.00	2.22
Nest Area	6.28	26.79	17.87	16.88	27.42	4.36	0.46	0.01	0.00	2.29
New (2) [5]										
Control	1.10	39.44	3.85	46.34	0.38	8.25	0.00	0.00	0.00	1.25
Nest Area	0.66	46.85	2.97	38.81	0.16	9.75	0.00	0.00	0.00	1.63

[1] Height classes increase in 25 cm increments.
[2] Includes eight plots on the WFRNA (wet prairie) and one plot in Field 29 (upland prairie).
[3] Includes only the eight plots on the WFRNA (all wet prairie)
[4] Includes only the six plots in remnant prairie on the WFRNA (excludes two plots in Fields 1 and 31)
[5] Includes only two "new" restoration fields (1 and 31)

There were great differences between the "new" prairie plots (n=2) and the older prairie plots (n=6-9) in percent cover in all the height classes. This is not unexpected considering the "youth" of these sites and the ongoing restoration activities to achieve more stable desired conditions in the future. The greatest difference among ground cover was for bare ground (~3-6% more cover in the new prairie sites).

Habitat Characterization Comparisons with Private Land Restoration Sites

Although data was only collected at a single vegetation plot on the three private sites managed by IAE, comparisons of those data with the WFRNA nest area and control plots are presented below to provide an initial assessment of the similarities and differences of habitat features. In particular, we emphasize the comparisons of nest area data with the restoration sites, assuming their representation of the desired conditions for meadowlark nest sites. With additional data collection over the next two years, we will be able to examine that assumption with reproductive success data correlated with habitat features, and make statistical comparisons between sites that will elucidate the direction of desired management on prairie restoration sites.

Total vegetation cover was lower at both the WFRNA nest plots (93.76%) and control plots (95.88%) than the restoration sites (range 96.50-99.53%) (Table 6). The only other noteworthy difference was the higher percent of bare ground at the WFRNA nest areas than any of the restoration sites (although Kawonu Acres was similar at 5.50% cover) despite the tendency for newer restoration sites to have a higher percent of bare ground as presented above in Table 5. These results suggest the need to provide at least 5% bare ground cover for suitable meadowlark nesting conditions.

Table 6. Percent cover of total vegetation and ground cover types at the Willamette Floodplain Research Natural Area and three private land wet prairie restoration sites managed by the Institute for Applied Ecology. [1]

Site	Total Vegetation	Bare Ground	Thatch	Moss	Wood	Rock
WFRNA Nest Area	93.76	5.70	2.13	0.00	0.34	0.00
WFRNA Control	95.88	4.42	1.98	0.00	0.16	0.00
Kawonu Acres	96.50	5.50	0.00	0.00	0.00	0.00
Long Tom Ranch	99.53	3.25	2.25	0.28	0.00	0.00
Tyee Wine Cellars	99.13	1.00	1.50	0.75	0.00	0.00

[1] WFRNA values are the means of eight plots; private land site values represent one random plot.

Among the three growth forms, the greatest difference between the WFRNA plots and the restoration sites was the amount of shrub cover, approximately 20% on the WFRNA and none or trace on the three restoration sites. Despite these differences, as mentioned above, the presence and nesting status of meadowlarks at restoration sites with little or no shrub cover, suggest flexibility in this habitat feature. The restoration sites varied greatly in the relative contribution made by the three growth forms, with Tyee Wine Cellars showing the greatest differences.

Table 7. Percent cover of plant growth forms (graminoids, forbs, and shrubs) and native status at the Willamette Floodplain Research Natural Area and three private land wet prairie restoration sites managed by the Institute for Applied Ecology. [1]

Site	Graminoids	Forbs	Shrubs	Introduced	Native
WFRNA Nest Area	62.03	13.61	20.41	21.92	71.87
WFRNA Control	56.25	11.35	21.02	29.91	65.97
Kawonu Acres	83.68	12.08	0.75	3.78	92.73
Long Tom Ranch	77.55	21.93	0.05	1.90	97.63
Tyee Wine Cellars	44.88	54.25	0.00	23.38	75.75

[1] WFRNA values are the means of eight plots; private land site values represent one random plot.

Among the restoration sites, Tyee Wine Cellars had the largest amount of introduced species, but the numbers were similar to that of the WFRNA nest area and control plots. Kawonu Acres and Long Tom Ranch were dominated by native vegetation.

Species richness was similar at all the sites (ranging from 26-31 species) except for Long Tom Ranch which had nearly half as many total species (16.0) (Table 8). The WFRNA plots had more native species (1-8 more), graminods (3-8 more), and shrubs (1 more) than the three restoration sites. These results suggest the need to promote native species and in particular graminoids in prairie restoration activities.

Table 8. Species richness from four perspectives (Total, Native, Annual, and Growth Form) at the Willamette Floodplain Research Natural Area and three private land wet prairie restoration sites managed by the Institute for Applied Ecology. [1]

Site	Total	Native	Annual	Graminoids	Forbs	Shrubs
WFRNA Nest Area	27.88(2.9)	19.88(2.3)	10.00(1.0)	12.75(1.0)	13.13(1.9)	2.0(0.53)
WFRNA Control	30.75(2.4)	20.13(1.7)	10.88(1.7)	13.3(1.0)	15.5(2.1)	2.0(0.6)
Kawonu Acres	26.00	14.00	12.00	10.00	15.00	1.00
Long Tom Ranch	16.00	12.00	6.00	5.00	10.00	1.00
Tyee Wine Cellars	31.00	19.00	12.00	10.00	21.00	0.00

[1] WFRNA values are the means of eight plots; private land site values represent one random plot.

One of the most noteworthy comparisons is that the WFRNA plots had substantially higher percent cover of height class 1 (i.e., mostly forbs) and a relatively even distribution of the other height classes (Table 9). This suggests meadowlark habitat has good overall structural diversity with a relatively high percent cover of forbs and good representativeness of all other height classes. Further, the WFRNA plots had substantially higher cover of height classes 1 and 2 and lower cover of height classes 4 and 5 than the restoration sites (except for Tyee Wine Cellars). Tyee Wine Cellars had the least structural diversity with a relatively even distribution of height classes in the middle categories (i.e., height classes 2-4), but species from the shortest and tallest categories were not well represented.

Table 9. Percent cover of five height classes at the Willamette Floodplain Research Natural Area and three private land wet prairie restoration sites managed by the Institute for Applied Ecology.[1]

	Height Class				
Site	1	2	3	4	5
WFRNA Nest Area	2.78	33.64	8.26	24.99	26.20
WFRNA Control	4.88	31.81	14.14	22.36	20.60
Kawonu Acres	1.98	28.98	2.60	62.20	0.75
Long Tom Ranch	2.80	17.40	3.18	76.10	0.05
Tyee Wine Cellars	2.00	26.00	28.88	37.00	5.25

[1] WFRNA values are the means of eight plots; private land site values represent one random plot.

Population Size

We confirmed five territories (20%) with two females on the WFRNA (Table 3). Thus, our population estimate on the WFRNA was 59 breeding adults. Additional meadowlarks elsewhere on FNWR included one pair in Field 29 with two females, and males also were heard singing in areas south of Bruce Road. Thus, approximately 70-75 breeding adult meadowlarks were present on FNWR in 2010.

It is likely that more intensive effort may have resulted in additional females being detected on some territories. In the 1996 study (Altman 1997), approximately 50% of the territories had a second female. Females are inherently less detectable than males, plus the closeness and overlap of the territories made it difficult at times to be certain if independent observations of females in a territory (especially at the edges) indicated multiple individuals.

Meadowlarks and Restoration of Wet Prairie at the WFRNA

The history of a meadowlark breeding season population at the WFRNA is relatively recent, and appears directly related to the prairie restoration that has occurred in the last 10-15 years. During Willamette Valley grassland bird surveys in 1996 (Altman 1997), and into the late 1990s, meadowlarks were only

occasionally and irregularly encountered during the breeding season on the WFRNA, and a breeding population was not known to occur.

All of the WFRNA was historically wet prairie, but Fields 1 and 31 were converted to agriculture many years ago. Restoration on the WFRNA has mostly addressed issues of succession to woody vegetation and invasion of non-native plant species. Typical management has included removal of woody vegetation, burning, and spot spraying. However, Fields 1 and 31 required major restoration conversion that has included tilling, broadcast spraying, and planting. This was initiated in Field 1 in 1999 and in Field 31 in 2006.

Several factors have likely contributed to the establishment of a breeding population of meadowlarks at the WFRNA. First and foremost is the landscape context of mostly herbaceous-dominated fields and limited woody vegetation in all directions except the west. This provides the potential coarse-scale structural conditions needed by a grassland bird like western meadowlark. Secondly is the relatively large size of the WFRNA independent of the landscape, but then also in conjunction with the adjacent open herbaceous-dominated agricultural landscape. This provides the potential for a relatively large population of meadowlarks. Thirdly is the protected status of the WFRNA which enhances the likelihood of a source population because of the absence of land management activities during the breeding season that might reduce reproductive success. Fourthly is the coarse-scale habitat management that has occurred to reduce the woody canopy and understory to create a herbaceous-dominated site. This created the suitable habitat type needed for meadowlarks. Finally, fine-scaled restoration activities provided the appropriate structural and compositional habitat conditions for meadowlark nesting. These five factors, landscape context, size of the area, protected status, coarse-scale habitat type, and fine-scale habitat conditions should be the primary considerations for meadowlark habitat suitability.

The success of prairie restoration at the WFRNA for attracting a breeding population of meadowlarks provides a strong example of the potential of prairie restoration in the Willamette Valley to support conservation of this priority species. Undoubtably, the size of the WFRNA was important in establishing a population, and the protected status also provided the potential for development of a reproductively viable source population since there are no land management activities during the breeding season that can reduce reproductive success, which typically occurs on agricultural production lands. The establishment of a population (presumably a source population based on its growth) at FNWR provides a much greater likelihood of prairie restoration successfully attracting meadowlarks at other nearby sites due to a potential source for recruitment.

Preliminary Recommendations for Meadowlark Wet Prairie Habitat and Population Enhancement
The following preliminary recommendations are suggested for conservation of Western Meadowlarks as part of restoration in established or developing wet prairie habitats based on the data and observations from this project. Continuing work on meadowlarks and prairies in the Willamette Valley funded by OWEB for 2011 and 2012 will likely provide further additions and/or specificity to these recommendations.

• Ensure high percent cover of native species composition (>65%), especially low-growing wildflowers, sedges, and rushes.

• Ensure good overall structural diversity with a relatively high percent cover of native forbs (>10%) and bare ground (>5%) and good representativeness of all height classes.

• Control and remove reed canarygrass which is an ecosystem altering plant and not suitable habitat for meadowlarks.

• Provide suitable habitat type and conditions on conservation lands immediately proximate to known populations, especially at protected sites (e.g. FNWR, private lands under conservation easements).

Acknowledgments

Funding for this project was provided by the OWEB as part of the Oregon 150 program (OWEB grant # 208-921-7179). Additional data and coordination was provided by the Oregon Department of Fish and Wildlife through A. Kreager and K. Halstead. Field assistance was provided by L. Bristol, K. Meyers, M. Monroe, and S. Dettloff. R. Schwindt and K. Halstead produced all the maps and figures. Several private landowners permitted access to their properties including Dave and Margy Buchanan, Dale Bergey, Pat and Stephanie Hagerty, and members of the Long Tom Ranch LCC. Permitting and management history at Finley National Wildlife Refuge was provided by J. Beall. Aerial photos and prairie acreages were provide by J. Jebousek. The cover photo of the WFRNA prairie was taken by M. Monroe.

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