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USDA Conservation Programs and Pesticides in Great Plains Depressional Wetlands—Texas to North Dakota

Summary of Findings

Throughout the Great Plains, sediments were collected for pesticide analysis from depressional wetlands embedded in uplands used mostly for cropland, native prairie, or the Conservation Reserve Program (CRP). The exception is the Rainwater Basin of Nebraska--used mostly for cropland, reference condition uplands, and the former Wetland Reserve Program (WRP).

Sediments were tested for herbicides, insecticides, and fungicides, with analyte lists determined based on use patterns in the Southern and Northern Western High Plains (WHP), Rainwater Basin (RWB), and Prairie Pothole Region (PPR)).

Pesticides were detected regularly, but not always, in wetlands from all land uses across the entire study area, although individual sites typically contained only one or two pesticides. Herbicides were the dominant pesticides detected, as would be expected given their widespread use for controlling weeds in cropland landscapes. Fungicides and insecticides were detected much less frequently, likely because they are used only as needed to manage region- and field-specific pest outbreaks.

Though pesticides were found regularly in sediments of all land uses, the frequency of detection and concentration of the pesticide was affected by land use. For example, in the Southern WHP trifluralin detections in wetlands located in CRP were only a third of those in wetlands located in cropland. The same trends were observed for herbicide concentrations in the Southern and Northern WHP, where levels were significantly lower for wetlands located within CRP or native grassland than for wetlands located within cropland. Similar trends were observed for wetlands in the PPR.

These results demonstrate the movement of pesticides into depressional wetlands, but also that land use surrounding wetlands has an active or passive ability to meaningfully mitigate that input. Concentrations of the predominant pesticides in both CRP and WRP wetlands compared favorably with native prairie or reference condition wetlands. These data provide evidence for another ecosystem service benefit of both CRP and WRP, and provide additional support for the implementation of buffers for protecting wetlands against pesticide input.

Background

The Great Plains of the central United States is one of the most intensely cultivated regions in the world. Over 15 million ha of grassland in the area have been converted to production agriculture (Samson and Knopf 1994). Dominant crops produced include cotton in the Southern High Plains of Texas and wheat, corn, and soybeans further north through the Dakota's. Given the history of cultivation in the region and the unsustainable land management practices often used in the past, depressional wetlands in the Great Plains have experienced significant sedimentation and concomitant loss of various ecosystem services (Luo et al. 1997, Euliss et al. 2011, Smith et al. 2011).

Conservation programs have been implemented throughout the Great Plains in an effort to control soil erosion and in some cases protect and restore ecosystem function (Smith et al. 2011). The Conservation Reserve Program (CRP) is an important USDA program in the Great Plains. CRP in the Plains occurs from Texas to North Dakota and includes the planting of perennial grasses for erosion control in uplands. The Wetland Reserve Program (WRP), now under the Agricultural Conservation Easement Program (ACEP), is applied in some areas of the Great Plains, most notably in the Rainwater Basin (RWB) of south central Nebraska. This program is focused on preserving and restoring hydrological function of wetlands, often through sediment removal and establishing perennial grass buffers around wetlands.

Figure 1. Wetland within a cultivated cornfield in North Dakota (photo by S. A. Morrison).

Dominant crops grown in the Great Plains involve intensive management practices such as regular use of fertilizers and pesticides throughout the growing season. Further, depressional wetlands in the Great Plains are often situated within cultivated fields and it is not unusual for crops to be planted on the edge or even within the wetland itself (Smith et al. 2008, Figure 1). Consequently, the potential for pesticides to move into wetlands is significant, either through drift, runoff, or direct overspray. Nonetheless, only a few studies have examined pesticide levels in Great Plains wetlands. Conservation practices applied to the uplands have the potential to protect wetlands from pesticide input, as can practices applied to the wetlands themselves.

Assessment Approach

Four hundred and fifteen wetlands were selected and sampled across 8 states in the Great Plains, including Texas, New Mexico, Oklahoma, Kansas, Colorado, Nebraska, South Dakota, and North Dakota (Belden et al. 2012, McMurry et al. 2016). Sampling occurred throughout the western High Plains (WHP; June/July 2008), the Rainwater Basin in central Nebraska (RWB; June/July 2009), and the Prairie Pothole Region in the Dakota's (PPR; June/July 2011). The western High Plains was divided into southern (Texas, New Mexico, and Oklahoma) and northern (Kansas, Nebraska, and Colorado) regions to capture the differences in major crop production and thus differences in pesticide use. Each wetland was categorized as being within one of the following three dominant upland land uses for each region: cropland, native prairie, and CRP in the WHP and PPR; and cropland, reference condition, and WRP in the RWB. Reference condition wetlands in the RWB were "best condition" wetlands that are not cropped and were characterized as retaining most of their remaining natural hydrologic function as determined through the Hydrogeomorphic Method (Cowardin et al. 1979). Few if any wetlands exist in native prairie in the RWB.

Sediments were collected from WHP and RWB wetlands as composite samples from three random locations. Sediments from PPR wetlands were collected from the center and five equidistant locations around the center, each between the center and edge of the wetland. In all cases, the top 5-6 cm of sediment was collected and composited as a total volume of about 500 ml, stored on ice during transport to the laboratory, and frozen until analysis.

Pesticides to be assessed were chosen based on estimated use within the regions, feasibility of analysis in the laboratory, and potential toxicity. Twenty four analytes were included in the analysis list for the WHP and RWB, and 18 were included for the PPR. Both lists included insecticides (n=11), herbicides (n=8), and fungicides (n=5). Sediment processing, sample extraction, and analysis of analytes were conducted using standard methods (Belden et al. 2012, Morrison et al. 2013, McMurry et al. 2016).

Findings

Pesticides were commonly detected in all wetland sediments across the Great Plains. This was expected given the intensity of row crop agricultural activities in the region and the timing of the sampling events. In general, herbicides were the most common pesticides detected, which is in accordance with their relatively high rate of use on most crops.

WHP and RWB

The dominance of herbicides in sediments was particularly evident for the southern and northern WHP and RWB regions, and the same herbicides were generally detected in playas among the regions (Table 1). Twelve

Table 1. Predominant pesticides detected in sediments from depressional wetlands in the WHP, RWB, and PPR as a function of the dominant land uses in each region. Adapted from Belden et al. 2012 and McMurry et al. 2016.

Pesticide	WHP - Southern			WHP - Northern			RWB			PPR[1]		
	Crop	Grass	CRP	Crop	Grass	CRP	Crop	Refer	WRP	Crop	Grass	CRP
	90th Percentile (ug/kg)			90th Percentile (ug/kg)			90th Percentile (ug/kg)			90th Percentile (ug/kg)		
Atrazine	3.3	2.4	<2	51	2.1	2.8	26	6.9	4.7	<QL	<QL	<QL
S-metolachlor	<2	<2	<2	1.6	1.3	<1	12	1.5	1.3	-[2]	-	-
Pendimethalin	2.6	<1	<1	-	-	-	-	-	-	-	-	-
Trifluralin	8.4	0.5	2.6	<0.5	0.9	<0.5	0.9	1	0.5	-	-	-
Acetochlor	-	-	-	<1	<1	<1	<1	<1	3.6	-	-	-
Glyphosate	-	-	-	-	-	-	-	-	-	370	72	66
Fungicides[3]	-	-	-	-	-	-	-	-	-	56	79	60

[1]PPR QL for atrazine was 10ug/kg.
[2]Missing cells denote pesticide not analyzed or insufficient data to compute 90th percentile.
[3]Includes all five fungicides.

of the 24 analytes in WHP and RWB sediment samples were at levels above the quantification limit (QL<5 ug/kg, except for acetamiprid, 50 ug/kg; and aldicarb, 75 ug/kg). Five herbicides were detected regularly: acetochlor, atrazine, metolachlor, pendimethalin, and trifluralin (Table 1).

Playa sediments associated with CRP and WRP practices generally had lower herbicide concentrations (Table 1). Indeed, 90th percentile values for herbicides in CRP and WRP playas were equivalent to those in native grassland and reference playas, whereas values for cropland playas were often elevated (Table 1). These practices may be actively or passively protecting wetlands from pesticide input, by either filtering runoff or simply removing the wetland from the area of pesticide use.

Detection frequency of herbicides also varied but typically suggested that wetlands in CRP or WRP were less likely to have detectable pesticides compared to wetlands in cropland. In the southern WHP, atrazine and pendimethalin were detected at half the frequency above quantification limits in CRP than cropland playas (Figure 2). This result was less evident for trifluralin, as detection frequency was 25% in CRP versus 32% in cropland (Figure 2).

In the northern WHP, only atrazine and metolachlor were detected often enough to compare land uses (Figure 3). In both cases, the number of CRP wetlands with detectable residues was lower than for cropland playas.

The remaining seven pesticides were detected in only one or two of the 264 samples from cropland playas and one grassland playa. These included four insecticides (bifenthrin, chlorpyrifos, cypermethrin, and malathion), one herbicide (metribuzin), and two fungicides (propiconazole and pyraclostrobin).

PPR

Herbicides and fungicides were detected regularly in PPR wetland sediments. Overall, seven of the 18 analytes found in PPR sediment samples were above the quantification limit (Table 1). These included two herbicides (atrazine and glyphosate) and five fungicides (azoxystrobin, chlorathalonil, propiconazole, pyraclostrobin, and trifloxystrobin). Pyraclostrobin was the most frequently

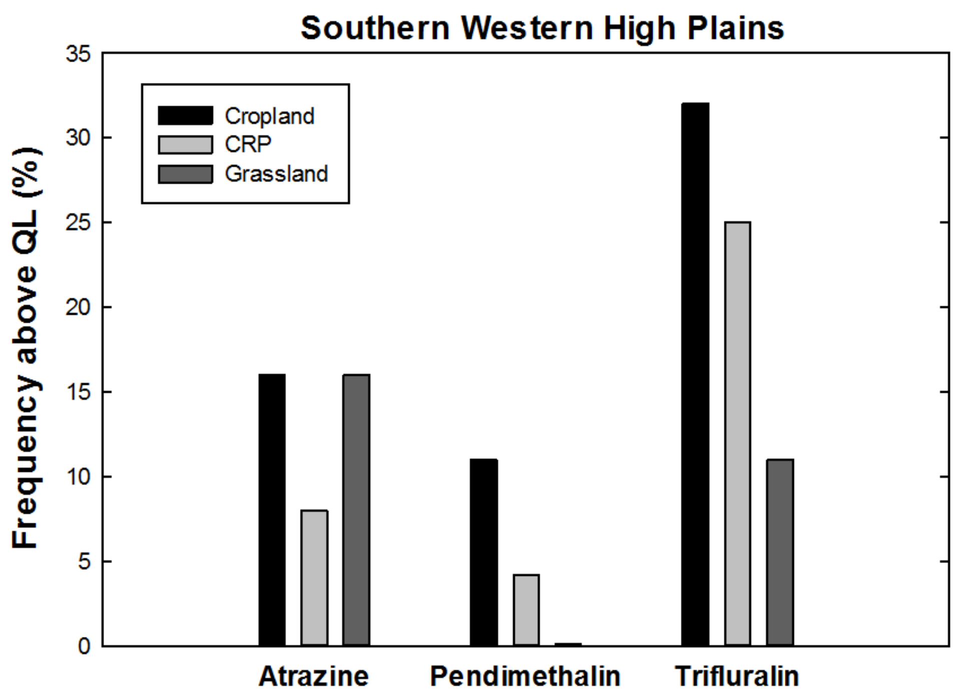

Figure 2. Percent of southern WHP playas (Texas, Oklahoma, and New Mexico) with pesticide concentrations above the quantification limits (QL) for the three predominant pesticides detected in sediment samples among the three dominant land uses in the region. Figure modified from Belden et al. 2012.

detected of all the fungicides, showing up in 28-31% of the wetlands sampled, regardless of land use. However, concentrations of fungicides and atrazine varied little among land uses (Figure 4).

Glyphosate was the most frequently detected herbicide and was found in over 75% of samples from cropland and 53% and 55% of samples from CRP and native grass, respectively. This trend paralleled glyphosate concentrations as well, with cropland glyphosate levels of about 130 ug/kg (dry weight) compared to about 40 ug/kg in CRP and native grass playas (Figure 4). These results show that CRP is either actively or passively mitigating pesticide input into associated wetlands.

No insecticides were detected in 151 playa sediment samples from the PPR. This finding is similar to the general lack of insecticides in WHP and RWB playas, and likely reflects differences in use intensity between insecticides and herbicides. Insecticides are generally used only as needed for pest outbreaks, whereas herbicides are more commonly used.

For example, USDA-NASS data show that 1-17% of corn, soybeans, wheat, and barley crops were treated with insecticides in North and South Dakota from 2010 through 2012. Conversely, glyphosate was applied to 63% to over 80% of the soybeans, wheat, and corn during the same period in the Dakota's. Nonetheless, the sampling design (single sampling event) could have missed some insecticide applications in the PPR as well as the WHP and RWB.

Conservation Implications

The presence of pesticides in cropland wetlands throughout the Great Plains demonstrates the potential for wetland contamination from agricultural activities. Pesticide runoff, drift, and direct spray are likely routes of contamination.

The wetlands sampled in these studies are often completely surrounded by some form of cultivation and may have a crop planted to the wetland

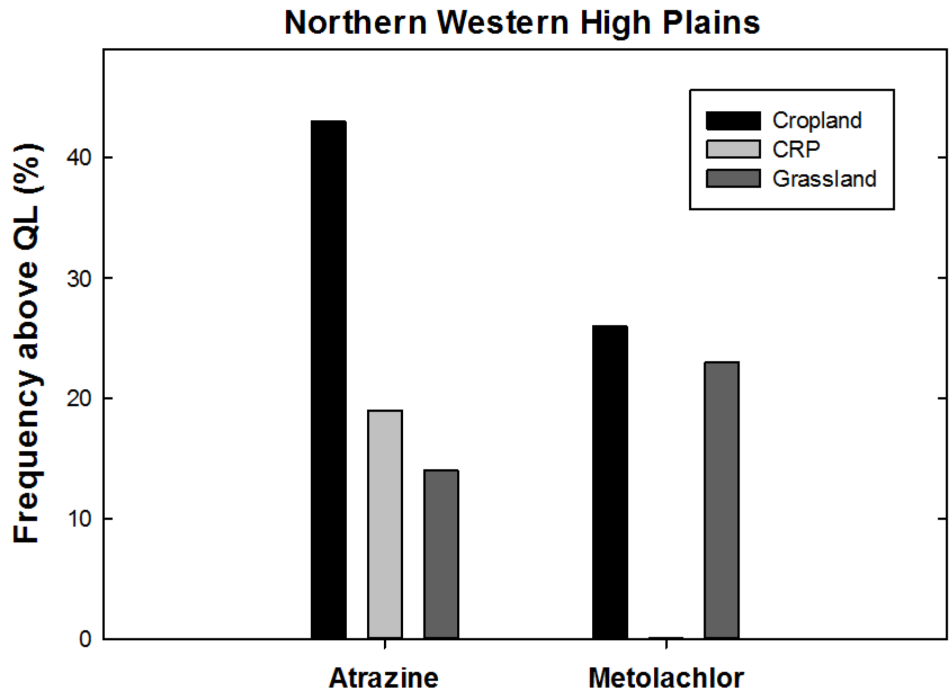

Figure 3. Percent of northern WHP playas (Kansas, Nebraska, and Colorado) with pesticide concentrations above the quantification limits (QL) for the predominant pesticides detected in sediment samples among the three dominant land uses in the region. Figure modified from Belden et al. 2012.

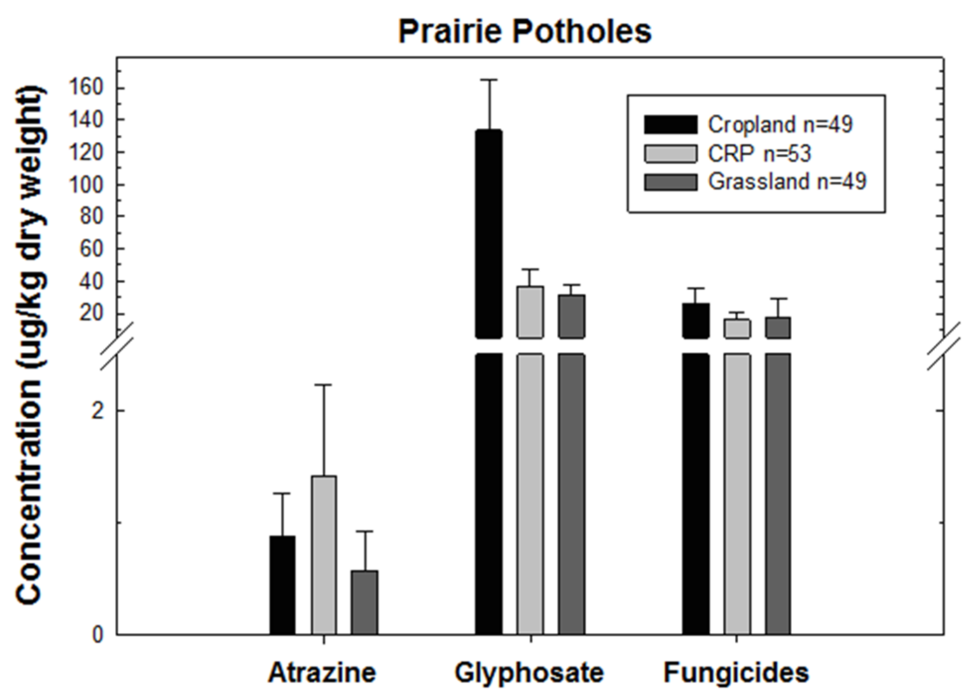

Figure 4. Mean (+SE) concentration of pesticides in sediments collected from prairie pothole wetlands in North and South Dakota in 2011. Non-detects included in calculations. Figure modified from McMurry et al. 2016.

edge or even into the wetland during dry periods.

Management practices in the upland directly influence closed-basin depressional wetlands, including sediment and water runoff, both of which can transport pesticides. Thus any conservation practice in the upland such as conservation tillage that inhibits runoff will afford some level of wetland protection. Moreover, the mere presence of a conservation practice will limit pesticide application, providing a passive benefit.

Perennial grasses planted as part of the CRP are very efficient at stopping sediment and water movement into wetlands and can act as buffers for wetlands systems. Buffer strips of perennial vegetation can effectively filter pesticides and are a useful tool within the CRP program for wetland protection while upland is still cultivated.

WRP wetlands also had reduced concentrations of pesticides, either by reducing pesticide input and/or removing pesticides with sediment removal, a wetland restoration practice under WRP. Taken together, these data (1) highlight the importance of these conservation programs at protecting wetland systems throughout the Great Plains, (2) provide insight into different management strategies (e.g., perennial grass buffers, surface runoff reducing practices such as conservation tillage, and Integrated Pest Management (IPM)) that could be effective if promoted and implemented on a large scale, and (3) can be combined with other ecosystem service data to evaluate wetland service provisioning to society. The economic value of these services alone is likely worth millions of dollars annually (Smith et al. 2011, Costanza et al. 2014).

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