THREE-YEAR GIS OF WESTERN OREGON GRASS SEED CROPPING PRACTICES

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High quality georeferenced data on crop production practices and other land uses is critical but often lacking in undertakings, such as the USDA Conservation Effects Assessment Program (CEAP), that seek to measure the effectiveness of conservation practices in achieving their goals and the general impact of human activities on ecosystem services. Ecosystem services include factors ranging from food production to water purification, from capture of carbon dioxide to release of oxygen, and from reproduction of salmon to provision of habitat for birds, amphibians and other wildlife. Research on the effects of humankind on the environment must ultimately provide problem-solving answers to be effective. If studies such as CEAP are to succeed, they must provide policy makers and the general public with detailed pictures of the trade-offs between economic and environmental objectives, including the functioning of multiple ecosystem services. A multi-year CEAP project involving collaboration between USDA-ARS-NFSPRC and OSU's Dept. of Fisheries and Wildlife was designed to identify and characterize the tradeoffs among ecosystem services inherently present in current agricultural production systems in the Willamette Valley. The broad objective of this research is to identify sets of production practices that optimize the achievement of economic and environmental sustainability for producers while meeting societal expectations for food and fiber supplies and natural resource quality.

The relationships between diverse sets of land use across the landscape and ecosystem services are not well understood. While urban and rural land use in the Willamette Valley is quite varied, and each has input into ecosystem services, this study focused on agricultural production practices. In order to determine whether relationships exist between crop management practices (e.g., tillage, nitrogen fertilization, or reestablishment of forested riparian zones) and ecosystem services (e.g., grass seed production, reproduction of native birds, fish, or amphibians) the following activities are required: (1) identifying the scale over which most interaction might occur, (2) identifying pre-existing variation in management practices, and (3) quantifying the functioning of ecosystem services and management practices at similar scales. Given the documented differences in soil erosion rates between stands of established perennial grasses and conventionally tilled fields, the strongest signal we are likely to detect is one between turbidity of water in streams and prevalence of tillage across the watershed upstream from sampling points. A computer model designed by USDA-ARS scientists in Temple, Texas, the Soil-Water-Assessment Tool (SWAT), models the impact of soil disturbance and rainfall on soil erosion and water quality, but requires Geographic Information System (GIS) input of field locations and management practices across the watershed. Where high quality data are available, SWAT has proven to be an excellent approach to determine whether relationships between management practices and water quality exist and to model these relationships across the range of scales that will almost certainly include variation in occurrence, abundance, and diversity of wildlife.

To enable the application of SWAT to our research problem, we established a three-year GIS of western Oregon grass seed cropping practices for use by the CEAP project using information from two sources. First, fall and spring drive-by censuses were conducted from 2004 through the present of most grass seed fields in the Calapooia River watershed. Spring drive-by surveys of randomly selected fields from stratified samples of agricultural fields also were conducted in neighboring counties. Second, fields from the Calapooia census and the multi-county survey were used to train the classification of series of commercially available Landsat satellite images taken during each growing season. Remote sensing classification allows the GIS to expand from the fields actually visited in the drive-by census and survey to nearly the entire Willamette Valley. In order to conduct remote sensing classification, it is necessary to convert the relatively detailed information collected about each field into a simpler set of 16 to 20 categories describing combinations of crop type, stand establishment status, and other selected aspects of crop production management. The 20 categories listed in Table 2 represent approximately 97% of all agricultural fields visited each year in the Calapooia census, and in most of the remaining cases we were unable to determine enough about particular grass seed fields to assign them to a particular category.

The most striking trend present in the GIS was a reduction in the number of perennial ryegrass fields with a corresponding increase in tall fescue. The total number of tall fescue fields in the Calapooia River watershed increased from 551 in the the 2004-2005 growing season to 709 in the 2006-2007 growing season, while perennial ryegrass dropped from 464 to 356 fields over the same period (Table 1). Similar, although slightly less dramatic, trends were present in the 20-category classification data when restricted to fields categorized in all three years (Table 2). A related trend was the increase in number of spring plantings of grass seed crops from 46 fields in the first year to 122 fields in the third year, mostly tall fescue (Table 2). Use of full straw chop volunteer stand reseeding in annual ryegrass also increased over the three year period in absolute numbers of all fields (Table 1) and in the proportion of fields with unchanged boundaries classified in all three years (Table 2). Even with the increase in full straw chop volunteer stand reseeding of annual ryegrass, this production approach appears to be only used on approximately 20% of all annual ryegrass fields. Quantifying the adoption of volunteer stand reseeding of annual ryegrass is complicated by the difficulty in differentiating between it and conventional tillage methods, especially in fields visited several months after germination has occurred. We failed to distinguish between the two methods in 20% of all annual ryegrass fields in the 2004-2005 growing season (Table 2). Increasing familiarity with the appearance of fields managed using volunteer stand reseeding reduced the number of instances in which we were unable to distinguish between the two methods to 5% by the third year. Both clover and meadowfoam increased over time, with the biggest increase in meadowfoam occurring between the first and second year. The biggest increase in clover occurred between the second and third year. Wheat decreased between the first and second year, and then increased between the second and third year. Further increases in wheat have been noted in the current 2007-2008 growing season census.

Remote sensing classification was conducted using six Landsat images in the 2004-2005 growing season, five images in the next growing season, and six images in the most recent growing season for all 20 categories in Table 2 and for the 16 most consistently useful ones (omitting categories 11, 12, 13, and 14). Category number 11 (Other annual ryegrass) included a mix of fields that were really category 2 or 15. Category number 12 (Perennial ryegrass – other fall plant) only occurred in significant numbers the first year, and was poorly identified in Landsat images even then. Category number 13 (Noncrop) represented a mix of landuses ranging from temporarily abandoned fields to early stages of urban development, and was poorly identified in Landsat images. Category number 14 (Hybrid poplar trees) was well indentified in Landsat images, but nearly all the fields were harvested in 2005, eliminating the point of retaining this class. Overall classification accuracy for the 16 categories was 76.7 and 72.7% in 2004-2005 and 2005-2006. Categories classified at better than these average accuracies included established perennial ryegrass, established orchardgrass, established tall fescue, established mint (2004-2005 only), bare/disturbed ground – annual ryegrass, and meadowfoam (2005-2006 only). Remote sensing classification for the 2006-2007 growing season is underway but not yet complete. Accuracy appears likely to be similar to that in the previous two years. Comparison of remote sensing classification and OSU Extension Service grass seed acreage estimates by county revealed close agreement for total grass seed acreage, with remote sensing overestimating total multi-county grass seed acreage by 13 and 11% in 2004-2005 and 2005-2006. For multi-county totals by crop type, agreement between the two methods was closest for orchardgrass and tall fescue in 2004-2005 and for perennial ryegrass in 2005-2006.

The Calapooia River watershed GIS was used to measure the proportion of bare soil within sub-basins in order to identify drainages with contrasting amounts of soil disturbance to insure that water quality and wildlife biology data were collected over the widest possible range of conditions. Analysis of relationships between soil disturbance (or other crop management or conservation practices) and ecosystem service indicators will be simplest for drainages that are independent (i.e., sub-basins within which seasonal stream networks originate and out of which they flow at single ‘pour-points’). More complex, nested drainages can also be analyzed using SWAT to model water flow into and out of drainages. Pooling established perennial grasses, full straw volunteer annual ryegrass, and no-till planting as conservation techniques, sub-basins in which water quality and wildlife biology data are being collected ranged from lows of 18, 19, and 22% conservation practice on agricultural land in 2006-2007 to highs of 86, 88, and 99% conservation practice. The biggest single factor in these conservation practice calculations was whether established perennial grass seed stands were taken out of production and replanted to new crops in any particular year. Because of this, sub-basins with high or low percentage of conservation practices in 2006-2007 were not necessarily those with highest or lowest percentage in previous years. Indeed, the three sub-basins with lowest conservation practice percentage in 2006-2007 had 66, 24, and 35% conservation practice averaged over the two previous years, while the three sub-basins with highest conservation practice percentage in 2006-2007 had 63, 97, and 40% conservation practice averaged over the two previous years. Year-to-year changes in tillage practices within sub-basins may represent another factor influencing diversity, abundance, and reproductive success of wildlife, and will require multiple years of data to understand. It is too soon in the collection and analysis of data to draw any conclusions on relationships between crop management and conservation practices and wildlife biology, except to note that variation exists across the landscape in abundance and diversity of fish, amphibians, and birds, and large fractions of that variation are associated with previously know drivers, including distance to perennial water for fish and percentage tree cover for birds. The establishment of this GIS will enable the further use of SWAT to determine whether other relationships exist and to provide sets of options to help producers manage these relationships economically.

Table 1. Number of fields by crop type, residue management practice, and stand establishment status in the Calapooia River watershed GIS for 2004-2005, 2005-2006, and 2006-2007 growing seasons.

GIS database domains	Growing season 2004-2005†	2005-2006	2006-2007
	---------- (number of fields) ----------		
Crop type			
Annual ryegrass	1348	1483	1437
Perennial ryegrass	463	428	356
Orchardgrass	126	119	125
Tall fescue	551	604	709
Mixed grass pasture	205	404	434
All others	450	521	642
Residue management‡			
Full straw load chop	458	392	505
Residue removed	575	878	695
Bare (worked or herbicide kill)	1072	1359	1365
All others‡	984	930	1138
Establishment status§			
Previously established	1190	1481	1478
Volunteer stand reseeding	171	457	476
Conventional drill (fall)	251	1071	967
Fallow	164	160	136
All others§	1350	393	646

† Census in 2004-2005 growing season did not include many pastures on lower slopes of hills bordering the valley floor and many small fields adjacent to housing developments that were included in the following years.

‡ Other post-harvest residue management practices included haycrop harvest, pasture grazing, undisturbed residue, and unknown or unidentifiable practices.

§ Other establishment status conditions included carbon band planting in fall, no-till planting method in fall, fall plant method not known, spring planting, urban development, and questionable.

Table 2. Number of fields in each of 20 classification categories in the Calapooia River watershed GIS for 2004-2005, 2005-2006, and 2006-2007 growing seasons.

No.	Category description	Growing season 2004-2005	2005-2006	2006-2007
		-------- (number of fields in GIS in all years†) ----------		
1	Bare/disturbed ground – other crops (not 15-18)	144	135	161
2	Full straw load chop annual ryegrass	162	189	233
3	Spring plant of new grass seed crop	46	50	122
4	Established perennial ryegrass	272	303	203
5	Established orchardgrass	117	106	98
6	Established tall fescue	456	468	497
7	Mixed-grass pasture	176	208	222
8	Established clover	32	43	71
9	Established mint	15	7	6
10	Hay crop	19	29	18
11	Other annual ryegrass (not 2 or 15)	261	86	64
12	Perennial ryegrass – other fall plant (not 16)	33	1	8
13	Noncrop	18	27	34
14	Poplar trees	8	1	2
15	Bare/disturbed ground – annual ryegrass	899	1049	944
16	Bare/disturbed ground – new perennial ryegrass	122	75	83
17	Bare/disturbed ground – new tall fescue	34	38	19
18	Bare/disturbed ground – new clover	26	53	41
19	All wheat	80	21	47
20	All meadowfoam	9	40	56
	Total of 20 classes	2929	2929	2929

† Fields not classified into one of these 20 categories in each of the three years have been removed from the table in order to facilitate consistent year-to-year comparisons.