Defining agroecological classes for assessing land use dynamics

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Land use is a dynamic property that arises from multiple socioeconomic and biophysical factors and is highly relevant to climate change science and agricultural sustainability. For agroecosystems, changes in socioeconomic factors (e.g., emerging markets, increasing fertilizer prices, or advances in precision technologies) as well as biophysical variables (e.g., weather and climate variations or land resource degradation) are powerful signals to land managers, expressed through the continuous evolution of technologies, management practices, and agroecosystem properties. Not surprisingly, land use classification has been increasingly used for structuring and implementing agroecosystem management strategies and as a basis for organizing and interpreting agroecological data for inventory, monitoring, research, education, and outreach.

IMPACT

Defining agroecological classes (AECs) enables researchers, stakeholders, students, the public, and policymakers to acquire a more holistic understanding of agriculture and climate change. AECs are intended to be part of a prescription for land management that, given climate change, will support and enhance the use of information from climate models; socio-economic models; crop models; pest, disease, and weed vulnerabilities; and many other data sources.

Agroecological zones (AEZs) attempt to delineate land use into relatively homogeneous areas where constraints and capabilities result in common production systems. These and other land use classifications have primarily relied on methods that integrate multiple geospatial layers of relatively stable biophysical drivers such as climate, physiography, geology, soil, and native vegetation. Here, "weight of evidence" and expert opinion regarding identification and integration of agriculturally relevant biophysical drivers have led to the development of agroclimatic zones, Ecoregions, and Major Land Use Areas.

Defining AEZs based on relatively stable biophysical drivers provides a consistent standard for assessing factors such as agroecosystem health and land resource suitability. Weak relationships, however, can occur between delineated zones and actual land use. This arises as agroecosystem complexity and dynamics are substantially augmented by socioeconomic drivers that promote greater transfers of materials, energy, and information

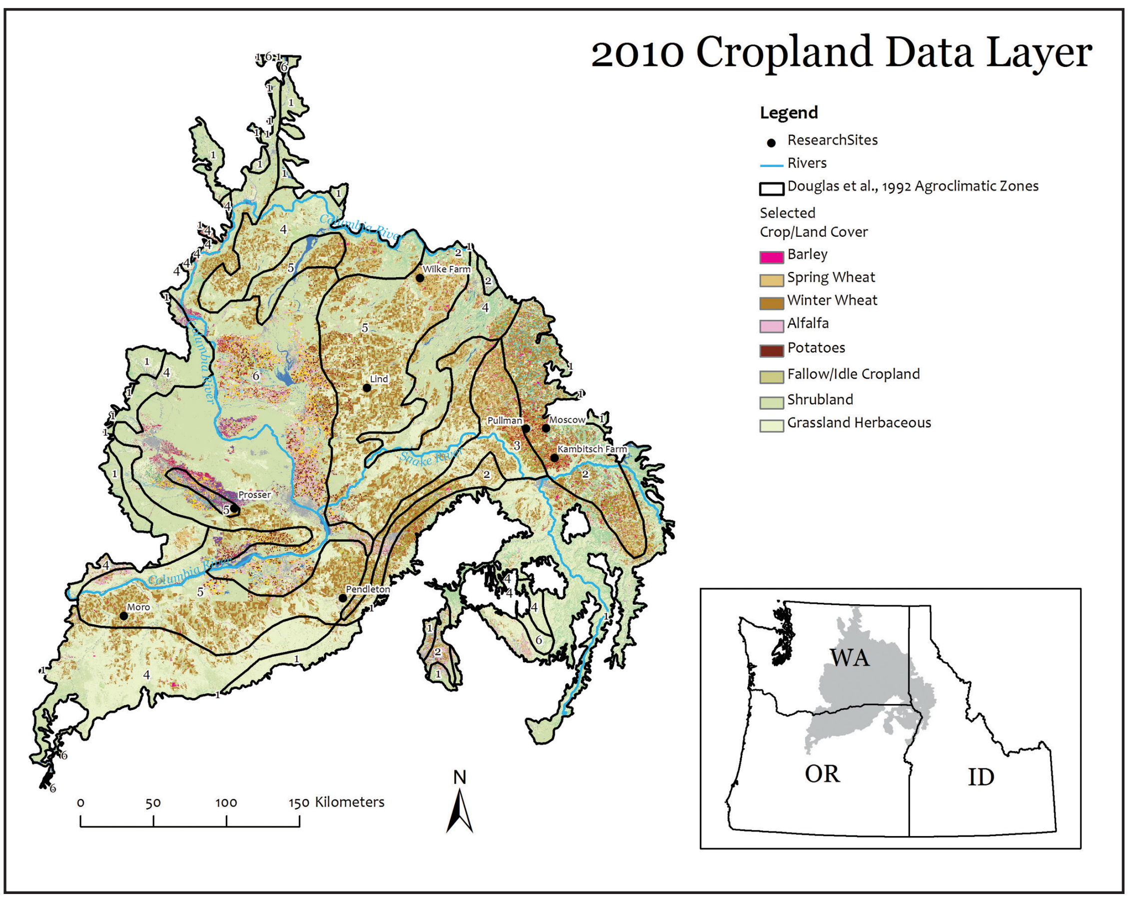

Figure 1. *Land use classification of the REACCH study area from National Agricultural Statistics Service (2010).*

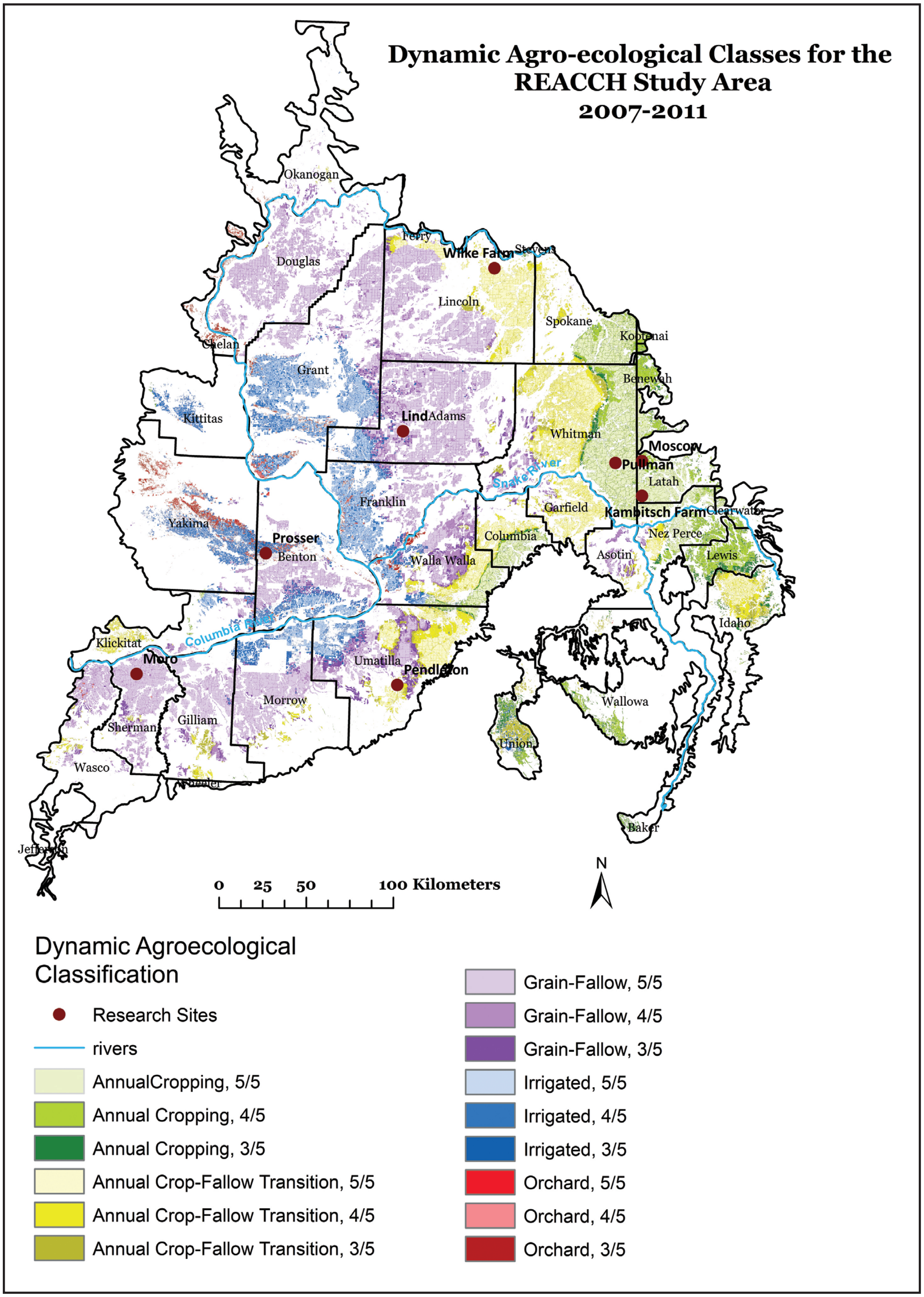

Figure 2. *Agroecological classification (AEC) for REACCH study region, where cells (56 m) had the same AEC for 3, 4 and 5 years during the 5-year period (2007–2011). Research sites on this map are locations of long-term experiments being conducted as part of REACCH.*

among interconnected systems than are found in natural ecosystems. Integration of socioeconomic drivers into AEZs, however, has been elusive, as relevant geospatial data are often lacking.

New approaches to land classification are becoming possible as geospatial capacities to identify land use and associated biophysical and socioeconomic drivers increase. In contrast to delineating areas derived from simplifications of biophysical and socio-economic drivers, classification based on land uses that have emerged as a consequence of these determinants may be advantageous. Here, no assumptions would be made regarding the magnitude and interactive effects of various agroecosystem drivers on shaping land use. Each classified area of agricultural land use would be considered a discrete system that emerged from the interactions of many diverse factors over time. Agroecological

A farmer gazes across his wheat field in Eastern Idaho. Photo courtesy Stone-Buhr Flour Company.

areas could then be derived solely from classifying the geographic distribution of defined agricultural systems (e.g., grain-fallow). Defining agroecological classes (AECs) in this way deviates from the current concept of AEZs and enables potentials to: (1) apply AEC classification at fine geographic scales; (2) provide baseline information that spatially classifies current AECs and therefore the capacity to detect spatial changes over time; (3) formulate hypotheses and analyze relationships among biophysical (e.g., climate, soils, terrain) and socioeconomic (e.g., land prices, commodities grown) factors useful for understanding AEC distribution and for predicting changes; (4) develop AEC-relevant research, education, and outreach strategies for climate mitigation and adaptation as well as other sustainable agricultural practices; and (5) integrate biophysical and socioeconomic data sources to pursue a transdisciplinary examination of AEC futures including considerations of climate change and agricultural sustainability.

Specifically, our objectives are to: (1) develop methodology to classify agricultural land representing major AECs of the inland Pacific Northwest based on single years of National Agricultural Statistical Service (NASS) cropland data and specific defining criteria; (2) characterize defined AECs with respect to climatic and edaphic drivers; (3) initiate monitoring and assessment of spatio-temporal changes in AECs; (4) compare AECs with currently used land classifications that are based on biophysical drivers; (5) provide a spatio-temporal context for assessing agricultural sustainability, including the forecasting of climate change effects on AECs as well as targeting of research, education, and outreach efforts to effectively study, plan, and implement mitigation and adaptation strategies.

The Cropland Data Layer (CDL) from NASS provides annual land classification of specific crops grown or not grown (e.g., winter wheat, barley, fallow) at a fine resolution (30- or 56-m scales) (Figure 1). For a given year, these data do not directly identify crop sequences that would occur on an agricultural field over time. Therefore, we developed a methodology that allows a single year of NASS cropland data to be used with specific criteria to define three dryland farming AECs: (1) grain-fallow, >40% fallow; (2) annual crop-fallow transition, 10 to 40% fallow; and (3) annual cropping, <10% fallow. In addition, an irrigated AEC was defined as an annual cropping region (<10% fallow) where mean annual precipitation was less than 330 mm or where crops known to require irrigation were grown. Non-agricultural land use/cover were also identified using Anderson's classification (e.g., range, forest, urban, water). Applying the methodology each year enables the capacity to detect spatial changes in AECs and other land uses over time, although it should be recognized that classification errors of the CDL also contribute to this dynamic (Table 1).

Range is the largest and most stable land use in the REACCH study region, with nearly 90% remaining unchanged during 2007 through 2011. Dryland AECs were also relatively stable, with the primary alternative a land use strategy that involved more fallow or a complete shift out of crops (e.g., range). Agricultural land use dynamics are spatially identified in Figure 2, where transitional areas among various AECs are emerging after 5 years. Changes in crops grown within each AEC can also be quantified over time (Table 2). These data will be useful for tracking temporal trends in the extent of various crops.

Table 1. *Land use for REACCH study region, area remaining unchanged and primary alternative land use (2007-2011).*

Land use/cover classification	Total area		Area unchanged (%)	Alternative land use (%)	Alternative land use (%)	Alternative land use (%)
	mean (ha)	CV[1] (%)				
Range	5,318,154	3.3	88.9	Grain-Fallow (2.4)	Urban (2.0)	Forest (1.9)
Forest	477,392	2.7	73.6	Range (22.6)	Urban (1.3)	Water, other (1.0)
Urban	365,774	14.2	45.3	Range (28.7)	Grain-Fallow (8.1)	Irrigated (5.2)
Annual Cropping	541,011	14.8	80.9	A-C-transition (12.1)	Range (8.6)	Urban (2.1)
Annual crop-fallow transition	675,608	17.1	69.1	Grain-Fallow (11.8)	Range (9.0)	Annual Cropping (2.5)
Grain-fallow	1,249,928	8.5	81.0	Range (7.8)	A-C transition (5.1)	Irrigated (3.2)
Irrigated	459,009	8.8	68.3	Range (12.8)	Grain-Fallow (10.0)	Urban (3.0)
Orchard	79,669	82.1	29.7	Range (29.2)	Urban (9.6)	Irrigated (9.3)
Water and other	211,733	11.0	72.7	Range (15.8)	Orchards (4.0)	Irrigated (2.5)

[1] *Coefficient of variation*

Table 2. *Crops and fallow by agroecological class (AEC) for the REACCH study region (2007-2011).*

Agroecological classification AEC	Year	Total area (ha)	Winter wheat (%)	Spring wheat (%)	Spring barley (%)	Spring lentil (%)	Spring pea (%)	Spring garbanzo bean (%)	Canola (%)	Fallow (%)	Alfalfa (%)	Potato (%)
Annual Cropping	2007	553,084	48.9	13.6	10.1	6.6	4.4	5.2	0.6	3.0	2.9	0.0
	2008	611,095	45.0	14.8	7.9	5.2	6.0	3.6	0.6	3.0	8.8	0.0
	2009	592,771	38.4	17.6	3.0	7.4	6.2	3.8	0.3	3.3	2.0	0.0
	2010	540,636	41.3	17.7	2.9	9.1	5.8	6.9	0.6	3.2	5.0	0.0
	2011	407,468	41.7	18.5	3.7	6.1	4.7	8.3	0.4	4.7	4.5	0.0
Annual crop-fallow transition	2007	552,686	46.0	14.0	7.4	0.2	1.7	0.3	0.3	27.5	2.3	0.0
	2008	643,819	42.7	15.2	6.2	0.1	1.7	0.2	0.3	27.5	5.1	0.0
	2009	674,744	41.6	18.4	2.3	0.3	2.1	0.2	0.2	26.9	3.4	0.0
	2010	640,817	40.4	18.6	2.4	0.5	1.9	0.5	0.2	27.6	5.5	0.0
	2011	865,972	41.9	16.0	3.3	0.8	1.3	0.8	0.5	25.8	5.3	0.0
Grain-fallow	2007	1073,443	46.4	4.5	0.8	0.0	0.7	0.4	0.1	43.8	2.3	0.0
	2008	1,290,512	44.0	7.2	0.6	0.0	0.7	0.3	0.1	42.6	2.5	0.0
	2009	1,235,417	45.8	4.9	0.3	0.0	0.8	0.4	0.1	43.8	1.9	0.0
	2010	1,345,175	44.7	4.2	0.3	0.0	0.6	0.5	0.1	44.4	3.2	0.0
	2011	1,305,093	45.6	5.8	0.5	0.0	0.6	0.5	0.2	43.0	2.5	0.0
Irrigated	2007	406,036	8.3	4.1	0.1	0.0	1.3	1.7	0.2	0.7	29.6	18.0
	2008	477,522	9.5	7.5	0.1	0.0	1.7	1.7	0.1	1.2	19.0	14.1
	2009	432,006	8.3	5.2	0.1	0.0	2.8	3.1	0.2	1.0	22.6	15.0
	2010	466,851	6.0	4.3	0.1	0.0	1.9	2.8	0.1	1.2	20.7	14.7
	2011	508,785	6.9	7.5	0.1	0.0	1.6	1.7	0.2	1.2	15.5	14.8

Photo courtesy Stone-Buhr Flour Company.