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Reconstructing Historical Riparian Conditions of Two River Basins in Eastern Oregon, USA

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Abstract As land use continues to alter riparian areas, historical information is increasingly needed to help establish reference conditions for monitoring and assessment. I developed and applied a procedure in the John Day and Deschutes river basins of eastern Oregon for synthesizing historical documentary records available across broad spatial areas to reconstruct 19th-century riparian conditions. The study area was stratified by ecoregion and stream physical characteristics to partition regional variability. Three primary data sources—General Land Office survey notes, historical photographs, and written accounts—provided descriptive records, which were grouped by topic to develop common riparian attributes. The number of records for each attribute was tallied by stratum to compare and contrast riparian structure and composition across strata and ecoregions. Detailed descriptions of historical riparian conditions using the original documentary records further illustrated the unique riparian conditions in each stratum. Similarities and differences in historical riparian structure and composition at the stratum and ecoregion levels were evident based on the distributional pattern and numbers of records of attributes across strata. A high number of repeated observations within and among primary data sources helped to corroborate descriptive data. Although these reference data cannot provide the detail needed for rigorous quantitative assessments, they do describe a range of conditions approaching a minimally disturbed condition and provide an important perspective for conducting riparian assessments in highly disturbed regions where least-disturbed reference sites are often poor examples of a desired condition.

Keywords Historical reconstruction · Streamside vegetation · Reference condition · John Day River · Deschutes River · Stream monitoring and assessment

Stream monitoring and management activities are often challenged by the lack of adequate reference data for assessing biological integrity and setting future priorities. Least-disturbed stream sites are those subjected to the least amount of ambient human disturbance in a particular region and are often used to define the best available physical, chemical, and biological habitat conditions given the current state of the landscape. However, the least-disturbed condition is not always a desired condition (Stoddard and others 2006). Resource management agencies have a growing need for alternative reference data, particularly in highly disturbed regions where increasing human alteration of landscapes results in more impaired least-disturbed sites with time.

The use of an impaired condition as reference is ineffective for assessing the biological integrity of a resource or monitoring change through time. It also risks a reduction in expectations and compromises interpretation and management actions if, over time, the least-disturbed condition is construed as an acceptable or target condition.

In addition, least-disturbed sites are a relatively short-term representation of current conditions in few locations and might not reveal a range of natural conditions that occur as a result of long-term and multiscale processes. They therefore may provide a limited context for making

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judgments about other sites or locations to which they are compared.

Historical reconstruction offers an additional source of data for defining reference conditions. Using historical data to restore landscapes to their historical condition is usually not realistic or desired. Instead, historical data can help to assess the relative deviation of current condition from a minimally disturbed condition and promote better-informed management decisions within the context of present-day land uses and range of attainable conditions.

The natural range of riparian conditions during a predefined period of minimal human influence can serve as a fixed benchmark and will change only as new techniques and approaches to reconstruct and describe it are developed. In contrast, using the present condition at least-disturbed sites as reference establishes a moving benchmark, which is likely to deteriorate as human land uses and cumulative impacts increase over time. Historical data can be used alone or interactively with current data to set reference benchmarks.

Researchers have been reconstructing historical conditions for many years (e.g., Sears 1925; Lutz 1930; Leopold 1951; Cooper 1960; Habeck 1961) using a variety of approaches. Historical reconstruction has more recently gained new attention, as evidenced by recent overviews (Egan and Howell 2001a; Swetnam and others 1999; Steedman and others 1996) and methods papers (Black and Abrams 2001; Mladenoff and others 2002), recommendations for inclusion in ecosystem management and restoration projects (Kauffman and others 1994; Manley and others 1995; Egan and Howell 2001b), and numerous applications (e.g., Swetnam and others 1999; Thoms and others 1999; Dawdy 1989; Collins and others 2002; Steen-Adams 2002; Wallin and others 1996). Historical reconstructions can address questions at large spatial scales (Kaufmann and others 1998; Steedman and others 1996), and many authors emphasize the importance of characterizing a range of historical conditions (Swetnam and others 1999; Landres and others 1999; White and Walker 1997; Egan and Howell 2001b; Morgan and others 1994).

A number of stream reconstructions have addressed riparian conditions in portions of river basins, usually valley or floodplain segments (e.g., Sedell and Froggatt 1984; Johnson 1994; Boyle and others 1997; McDowell 2000), but no known applied studies have attempted to reconstruct riparian conditions for more varied landscapes and stream types throughout river basins. The goal of this work was to apply and evaluate an approach for reconstructing presettlement riparian conditions for broad areas and ecophysiographic categories using existing documentary records. Of particular interest were the types, structural characteristics, and extent of streamside vegetation and its spatial variation. Whereas most vegetation reconstruction studies report upland forest composition, this research focused on the streamside community—including tree, shrub, and herbaceous vegetation—as one aspect of stream function and biological integrity. The specific objectives were (1) to devise a method for synthesizing and analyzing descriptive historical information from multiple sources; (2) to develop descriptions of presettlement riparian conditions in multiple ecophysiographic strata of a region; (3) to determine whether descriptions of historical conditions can be differentiated among strata; and (4) to assess the suitability of documentary records for reconstructing historical riparian conditions by evaluating data quality.

I use the term “riparian” to refer to the corridor along streams that includes banks and the high-water zone, encompassing terraces and floodplains. In describing vegetation, I use “riparian” to describe typical riparian species that are adapted to live in or near water and “streamside” to describe vegetation occurring in the riparian corridor that includes, or is composed entirely of, upland species. Because the historical literature examined in this project almost always reported common names of plants, I also use common names, with the scientific name in parentheses when provided. Many of the adjectives used in historical summaries were preserved from original 19th-century writings to avoid altering the original meaning.

Methods

Study Area and History

Reconstruction was done for portions of the Deschutes and John Day river drainages in eastern Oregon, USA (Fig. 1). Both drainages are part of the Columbia River Basin and drain dry forest and shrub steppe regions east of the Cascade Range.

Beginning with very early European exploration of the Pacific Northwest, the area has undergone substantial and rapid change. Although Native Americans had been practicing land management such as burning for thousands of years prior to European arrival (Robbins and Wolf 1994; Meinig 1968), the changes that occurred during western expansion were more significant in their degree and extent (Todd and Elmore 1997; Barker 1996), with a greater focus on extraction of resources and hydrological modifications. The Lewis and Clark expedition and many of the subsequent explorations of the region did not enter the interior Deschutes and John Day Basins; most of the overland travel by immigrants traveling west over the Cascade Range skirted only the northern boundaries of these basins, near the river mouths. The Northwest and Hudson Bay Companies led fur trapping operations and explorations into the region beginning in 1811. Trapping nearly

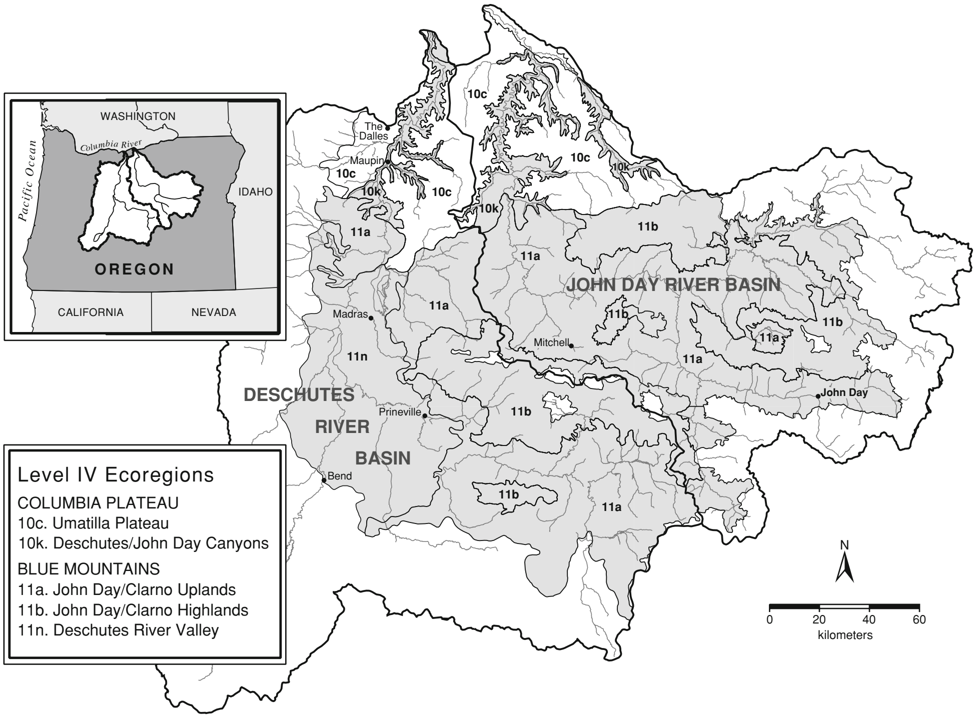

Fig. 1 Locations of the study area (shaded) and five Level IV ecoregions (Omernik 1995) in the John Day and Deschutes basins of eastern Oregon, USA

decimated the beaver by 1847 and, presumably, greatly affected the riparian habitats and processes associated with beaver activity (Robbins and Wolf 1994; Svejcar 1997).

Due to geographic isolation of the area and conflicts between settlers and Native Americans, land in the interior basins was not opened to settlement until 1855 and was not permanently homesteaded until the 1880s (Shaver and others 1905). As the area was rapidly developed, unregulated activities such as mining, livestock grazing, agriculture, logging, railroad building, and, later, road construction and water projects altered the lands in the region (Todd and Elmore 1997; Robbins and Wolf 1994; Grant 1993) and imposed long-term impacts on riparian systems (Wissmar and others 1994; Svejcar 1997).

Because of substantial land alterations throughout the study area and the paucity of suitable least-disturbed reference sites for gauging the current condition of streams, historical information can potentially provide data for establishing a more accurate picture of reference conditions for assessing current aquatic health in the region.

Stratification

Reconstruction focused on broad areas and stream types, rather than individual stream sites or segments. To partition natural variation, the landscape was divided into reporting units of approximate ecological similarity according to Omernik level IV ecoregions (Omernik 1995; Clarke and Bryce 1997; Thorson and others 2003). Reconstruction was concentrated in four level IV ecoregions, which comprise much of the Deschutes and John Day drainages and are distributed within two level III ecoregions, the Columbia Plateau (10) and the Blue Mountains (11): (1) Deschutes/John Day Canyons (10k), (2) Deschutes River Valley (11n), (3) John Day Clarno Uplands (11a), and (4) John Day/Clarno Highlands (11b) (Fig. 1).

Valley form and stream gradient were combined as a secondary stratification level (*sensu* Kovalchik 1987; Crowe and Clausnitzer 1997) to describe four basin physiographic conditions: (1) broad valleys with a low gradient; (2) narrow V-shaped valleys with a high gradient; (3) narrow to moderately wide V- or trough-shaped valleys with a moderate gradient; and (4) trough- or V-shaped valleys with a low gradient. Valley form was assigned based on valley shape as indicated by contour lines on topographic maps (TopoZone http://www.topozone.com). Gradient was calculated as [(rise/run) × 100] and then classified as low (0–1.8%), moderate (1.9–4.5%), or high (>4.5%). Gradient categories were determined by dividing a log base 10 normal distribution of gradients of 209 randomly generated streams sites in the John Day/Deschutes basins into three standard quantiles.

The classification matrix resulted in 11 reporting units, or ecoregion-physiographic types (hereafter, Types), rather than 16 (Table 1), since not all physiographic conditions exist in each ecoregion. Data for each Type were pooled to maximize data observations per stratum and to capture the range of regional riparian conditions.

Table 1 Stratification matrix used for assigning historical documentation to ecoregion-physiographic strata (i.e., Types) based on Level IV ecoregions (Omernik 1995) and stream physical conditions (stream gradient, valley form)

Physiographic conditions	Ecoregion			
	10k	11n	11a	11b
Broad valley/low gradient; flat or gently sloping flood plain	–	Type 3	–	–
Narrow, V-shaped valleys with high gradient	–	–	Type 6	Type 9
Narrow to moderately wide V- or trough-shaped valleys with moderate gradient	Type 1	Type 4	Type 7	Type 10
Trough or V-shaped valleys with low gradient	Type 2	Type 5	Type 8	Type 11

Note: (–) Conditions that are not commonly found in a particular ecoregion. Gradient categories are defined as follows: low, 0–1.8%; moderate, 1.9–4.5%; and high, >4.5%. Ecoregions: 10k, John Day and Deschutes Canyons; 11n, Deschutes River Valley; 11a, John Day/Clarno Uplands; 11b, John Day/Clarno Highlands

Time Frame and Primary Data Sources

Although the original intent was to document a minimally disturbed riparian condition, defined as the time before European settlement, little information was available for the period prior to 1860. I acquired the earliest documentary data available, although many records were from the late 1800s to about 1910. The data therefore reflect varying degrees of impacts and alterations that had already occurred due to early European influence. Native American impacts and traditional land management practices were considered part of a minimally disturbed condition. Any impact of macroclimate on vegetation over the past 200 years was considered inconsequential to this assessment (Schoonmaker and Foster 1991; Hann and others 1997).

Large-scale stream monitoring and assessment are often implemented in a multiagency/tribal framework, requiring standard methods. In the interest of employing techniques that can be applied throughout the West by diverse agency staff, often confined by resource limitations, I intentionally utilized approaches that are widely applicable and can be transferred and applied easily. Documentary records used in this analysis came from three primary data sources (PDSs): (1) General Land Office (GLO) survey notes, (2) historical photographs, and (3) written accounts from diaries, journals, scientific explorations, and expedition reports.

General Land Office Survey Notes

Records are readily available throughout most of the western and midwestern United States and have been used in various applications (e.g., Sedell and Froggatt 1984; Johnson 1994; Nelson 1997; McDowell 2000), though they are limited in their range of uses and interpretations (Schulte and Mladenoff 2001; Manies and others 2001). Surveyors collected data systematically on a square-mile grid denoted by township sections corners. Details of the survey procedures are described elsewhere (Bourdo 1956; Galatowitsch 1990; Schulte and Mladenoff 2001).

In the study area GLO surveys were conducted in the late 1870s and early 1880s. Records stored on microfiche were obtained through the Bureau of Land Management office in Portland, Oregon, and summarized for 29 stream segments of $\sim$15 km (or less, depending on the stream size). Stream segments were arbitrarily selected from a set of randomly selected sample sites used for a larger stream assessment program in the western United States and evenly distributed across the four ecoregions of the study area. Sample sites were not selected relative to stream gradient or valley form, which resulted in an uneven distribution of GLO sites across Types. Since the intent was to collect data on riparian attributes, only the GLO notes for section lines that crossed or closely paralleled a stream were utilized.

The synthesis of GLO notes relied heavily on section line descriptive summaries, which often included specific mention of streamside plant composition of the overstory, understory, and ground cover. The species and diameter of bearing trees occurring in streamside forests and soil quality ratings were also extracted. In the study area, the usefulness of GLO data was limited for several reasons: (1) because riparian habitat comprises a relatively small proportion of the western landscape, the 1-mi surveying grid was too large to evaluate streamside forest composition based on bearing-tree data; (2) black cottonwood, the primary riparian tree species in the study area, was considered a poor choice as a bearing tree because of its low durability, and its occurrence at section corners was possibly underrepresented in GLO data; (3) shrub communities are often dominant in riparian areas, but the quantitative GLO data pertain to trees; and (4) possibly because of the desert landscape, GLO notes were scant, and riparian characteristics were inconsistently reported.

Historical Photographs

Historical photographs were obtained primarily from the private collection of Steve Lent, stored at the A. R. Bowman Memorial Museum in Prineville, Oregon, and acquired in

2000. Additional photographs came from the Salem, Oregon, Public Library Historic Photograph Collection (http://photos.salemhistory.org/) and from several published sources. Photographs were available for most Types; most were taken in the western half of the study area in the late 1890s through 1911.

Trees and shrubs in photographs were identified to the extent possible based on knowledge of the native vegetation of eastern Oregon. Vegetation extent, structure, and interaction with the stream, and physical characteristics of streams were also described from photos.

Written Accounts

Written accounts were extracted from a range of sources including journals of explorers and settlers, university and government exploration reports, natural history surveys, historical summaries, Web sites, and historical society documents. One more recent source, partial results of a 1942 stream survey, provided valuable information specifically about stream and riparian areas and was therefore used, but usually in conjunction with older sources.

Information Extracted from Data Sources

A variety of unique riparian information was extracted from each of the three PDSs (Table 2). Each PDS had advantages and limitations (Table 2), which made the combination of all three more effective for gathering and corroborating information about riparian conditions, compared to using only one PDS. For example, GLO notes and written accounts typically list plant species or types, whereas photographs reveal more detail about vegetation extent, structure, and pattern. Photographs allow a modern interpretation, whereas GLO notes and written accounts are limited to 19th-century perspectives and interests. Written records, although very subjective and sometimes exaggerated, are still among the earliest and most descriptive documentation that exists.

The amount of extractable information per source was limited and often incidental to the intended purpose of the source. Presumably, the limitation was partly because of the isolation of the region and partly because of a perceived lack of interest by early inhabitants in streams, riparian habitats, and fish. During settlement of the West, immigrants, explorers, and surveyors focused on natural resources for survival and economic development and viewed rivers as a source of irrigation and transport, but with indifference in other respects. Scientific expeditions to the region concentrated on landscape features, geology, and collection and naming of biological specimens, but little attention was given to characteristics of rivers or riparian areas. Grant (1993) identified the same disinterest in many aspects of streams and rivers, based on interviews with long-term inhabitants in a portion of the John Day Basin.

Information Synthesis and Data Quality Assessment

Only historical accounts that provided a specific location were used so that each account could be assigned to a Type (Table 1). Historical accounts interpreted from all documentary sources were entered into a database, assigned a Type, and grouped by PDS. Each *account* represented historical documentation from a specific source, location, year, and observer (if pertinent). Accounts could be lengthy descriptions covering a range of topics. The GLO survey notes for each segment were considered separate sources, since surveyors often differed among regions and stream segments. Similarly, each photograph was considered a separate source of data.

A *topic* was treated as specific information about a resource component, for example, “scattered cottonwoods along stream.” When accounts reported more than one topic, they were replicated into two or more database records such that each record represented unique data from the historical account. For example, an account reporting “Willow and alder lining banks with large cottonwoods interspersed” was replicated into three separate database records, each documenting the presence, and description if pertinent, of a separate type of tree of shrub. For each Type and PDS, records were sorted and then tallied by topic. Using the lists of topics and their reporting frequency in each Type as a framework, I developed descriptive summaries of historical riparian conditions in each Type, illustrated with descriptive detail, quotations, and photographs from the original historical accounts. Characteristics that distinguished Types were identified through a systematic comparison process facilitated by developing *attributes*, i.e., descriptive phrases, based on similar or unique topics from the individual lists of topics for each Type. In this step, some of the original detail was sacrificed to compartmentalize topics for comparing and contrasting riparian conditions across Types. For example, details of the extent, height, and density of willows were sacrificed, and willow and alder—two common riparian shrubs with similar structure—were combined into one attribute; similarly, bunchgrasses, prairies, and meadows were grouped under one attribute. Although this synthesis generalized and condensed the original wording, it facilitated comparisons of descriptive data reported in multiple formats across Types. I tallied the number of records of each attribute for each Type (all PDS combined) for a semi-quantitative comparison of presence/absence and frequency of reporting of attributes, assuming that the proportion of records from a Type corresponding to each attribute provided a rough estimate of the prominence of an attribute in

Table 2 Information extractable and the advantages and limitations of each primary data source

	Primary data source		
	GLO notes	Photographs	Written accounts
Baseline information extracted	• Common names for streamside vegetation	• Vegetation types (e.g., shrub, tree)	• Common names for streamside vegetation
	• Qualitative description of size, density, distribution, patchiness, quality, associated species	• Vegetation structure, position, pattern	• Qualitative description of size, density, distribution, patchiness, quality, associated species
	• Dominant community, e.g., forest, prairie, shrub, scattered trees, or shrubs	• Local and broad-scale views	• Dominant structural types, e.g., forest, prairie, scattered trees, or shrubs
	• Soil suitability for agriculture	• Relative stream size and channel complexity	• Location of vegetation types in relation to streams, springs, seeps
		• Riparian corridor width	• Soil suitability for agriculture
		• Presence of large wood and snags	• Water quality and quantity; presence of riparian wetlands
Advantages	• GLO survey data easy to find and obtain for most locations	• Provide a visual reference	• Greater potential for containing earliest documentary records
	• Used systematic data collection and consistent reporting	• Can be interpreted with modern-day perspectives and objectives	• Potential to contain a large range of information
	• Contain both quantitative and descriptive data	• Provide a full picture from which numerous features of interest can be interpreted	• Often written by scientists with specialized knowledge, raising the potential for detailed descriptions and accuracy
Limitations	• Scale of data collection (1-mi grid) too large for some riparian-based applications	• Photo quality makes identification of vegetation difficult	• Subjective observations posing potential for inaccurate identifications and biased or exaggerated descriptions
	• Data not collected for ecological reasons; quantitative data have limited application	• Numerous photos needed for temporal or spatial extrapolation	• Assessment limited by observer's selective reporting
	• Inconsistencies among surveyors in the reporting of riparian vegetation	• Riparian area photos sometimes scarce or difficult to locate	• Riparian information often time-consuming to find

Note: GLO, General Land Office

that Type. Locations of the original documentation were recorded and carried through this process to assure a broad spatial distribution of topics within an ecoregion and avoid overrepresentation of a notable feature at a single location.

Data quality was compared across PDSs through evaluation of data availability (number of database records), and repeated observations of the same topic, by Type. The latter evaluation assumed that repeated historical observations by different observers or in different locations within a Type help to corroborate results.

Results

Data Quality

Data availability varied over the study area. The greatest number of data records available for a Type was 216 in Type 8, and the lowest was 16 in Type 6 (Fig. 2, Table 3). In general, more information was available for areas of low or moderate gradient with wide valleys (e.g., Types 2, 5, and 8) than for areas of high gradient with narrow valleys (e.g., Types 6 and 9), which is consistent with where most of the early exploration and settlement was occurring in the region, as reflected by the frequency of historical accounts of human activities and land development.

The proportion of GLO, written, and photographic records extracted from data sources varied across Types (Fig. 2); not all PDSs were represented in all Types. It is apparent from Fig. 2 that the numbers of data records extracted per Type using all three PDSs were generally greater in comparison to those extracted using any one PDS alone. No single PDS appeared to be consistently superior. The use of more than one PDS was important for filling in information gaps when data for one or more PDS were sparse or lacking.

Data showed a high degree of repetition of attributes within a Type (Table 3), which aided in corroborating data

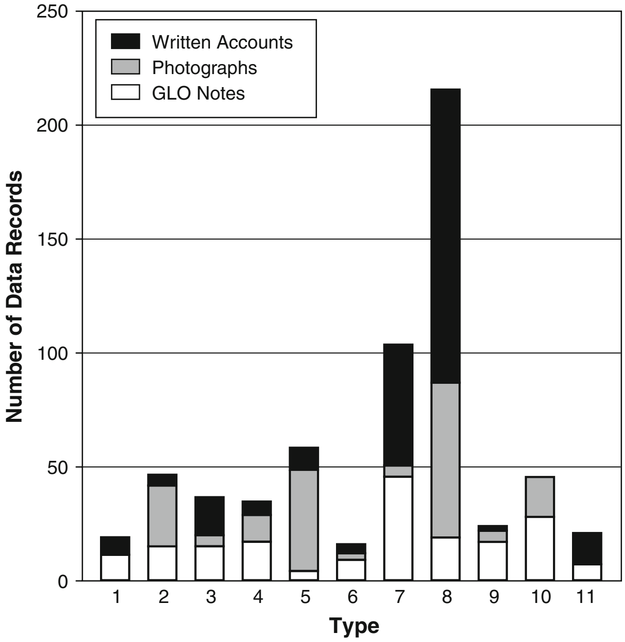

Fig. 2 Number of data records generated from historical accounts in each Type, apportioned by primary data source (PDS)

from diverse and often non-authoritative sources. Topics were commonly repeated at least once, both within PDSs (Fig. 3A) and across PDSs (Fig. 3B). The data tended to represent groupings of descriptions that were very much alike, rather than isolated records with little relevance or application.

Synthesis of Riparian Attributes

Twenty general attributes were synthesized from documentary records for the 11 Types (Table 3). The distribution of attributes among Types showed that some riparian attributes were widespread (lower half of Table 3), while others were specific to certain Types or ecoregions (upper half of Table 3). The reporting frequency of widespread attributes helped to differentiate Types according to attribute prominence.

Streamside attributes reported most frequently in the study area also tended to be the most widespread (occurring in most Types). These included (in order of their reported frequency): (1) willow and alder shrubs; (2) abundant, healthy bunchgrasses and prairie and meadow habitats; (3) scattered juniper; (4) well-watered landscape; (5) large pine; and (6) sage brush (Table 3). Two additional attributes that were fairly widespread but recorded less frequently were rich, fertile, bottomland soils and cottonwood timber (Table 3).

Several patterns were evident in the data, as shown by the general distribution and percent frequency of observations in Table 3. Oak was reported only from the Deschutes/John Day Canyons (Ecoregion 10k). Rocky soils and barren river banks were reported at a relatively high frequency in the same ecoregion and also in the Deschutes River Valley (Ecoregion 11n). In the John Day/Clarno Uplands (Ecoregion 11a) and the John Day/Clarno Highlands (Ecoregion 11b), records documented a greater variety of evergreen species along stream banks, but also a higher incidence of riparian areas without woody vegetation, than in the other two ecoregions. Also in this area, beaver, beaver dams, and large wood were characteristic, but meandering, braided channels and beavers were associated only with low-gradient Types. Type 4, the only Type in the Deschutes River Valley (Ecoregion 11n) without low gradient streams, showed a greater similarity to Types in the John Day/Clarno area (Ecoregions 11a and 11b) than to other Types in its own ecoregion with respect to the presence of aspen, birch, and extensive streamside forests and the diversity of riparian shrubs. Similarly, the frequency of occurrence was lower for willow and alder and higher for large pine in Types 4 and 9–11 compared with other Types. Juniper, willow, and sagebrush, although widespread, were less frequently reported on streams in the John Day/Clarno Highlands (Ecoregion 11b), whereas other shrubs (e.g., currant, mahogany, ceanothus, laurel, cherry) were somewhat more common in those locations. High reporting frequencies of sagebrush and juniper overlapped in Types 4–6, although juniper was also very common in Type 3. Bunchgrasses were characteristic throughout the region but best defined riparian areas in broad, low-gradient valleys of Type 3.

Detailed Historical Description—An Example

To illustrate the kinds and range of descriptive information extractable from historical documentary information in the study area, this section presents detailed historical descriptions for a selected portion—the John Day/Clarno Uplands (Ecoregion 11a). Descriptions include characteristics that distinguish each Type from other Types within the ecoregion. They incorporate pertinent results of the previous section and Table 3, as well as more detailed material from original documentary records.

In low-gradient streams of Ecoregion 11a (Type 8), streamside vegetation was usually well-developed. Willow was, by far, the most frequently reported vegetation type in historical documentation, occurring as a dominant community or an understory component. Willows were denser in broad valleys than in canyons and were referred to as "lush vegetation, well-watered" (Williams and others 1971). Historical photographs show willows lining streams, varying in size and density. For example, willows along North Fork Beaver Creek east of Paulina, Oregon, were dense, robust, about 12 ft tall, and thickly vegetated throughout their vertical profile, and they formed a

Table 3 Distribution across Types and number of records for attributes derived from historical data (all primary data sources combined)

Attribute	Type											Total records
	1	2	3	4	5	6	7	8	9	10	11	
	Ecoregion 10k		Ecoregion 11n			Ecoregion 11a			Ecoregion 11b			
Soils stony and rocky		3 (8)										3
Oak on banks and hillside seeps	1 (5)	3 (8)										4
Boulder-lined shores; barren, rocky banks with little vegetation		8 (20)		1 (3)	7 (12)							16
Riparian shrubs other than willow and alder, often dense and in various associations: currant, mahogany, rose, myrtle, hawthorn, serviceberry, laurel, cherry, bitterbrush, ceanothus, and young cottonwood and aspen	1 (5)			1 (3)		1 (6)	5 (5)	4 (2)	2 (7)	7 (14)		21
Aspen–often dense—in overstory and/or understory				1 (3)			6 (6)	4 (2)		3 (6)		14
Birch on banks, ravines, and steep gulches				1 (3)			2 (2)	4 (2)				7
Wooded stream banks or extensive streamside forests with large trees (non-species-specific)				4 (11)				15 (7)	5 (19)		2 (8)	26
Meandering, braided channel; oxbow lakes			1 (3)					6 (3)			2 (8)	9
Large wood—on ground, in stream, or standing (snags)					1 (2)			5 (2)		2 (4)		8
Fir, tamarack, sometimes spruce in forests with pine—often large							10 (9)	3 (1)	3 (11)	6 (12)	2 (8)	24
Land open; woody vegetation scarce along stream								6 (3)	1 (4)			7
Presence of many beaver, beaver dams, or "excellent" beaver habitat								5 (2)				5
Cottonwood timber—scattered and in large riparian forest groves or thickets	3 (15)	1 (3)		1 (3)	2 (3)	1 (6)	4 (4)	15 (7)			3 (12)	30
Sage brush—sometimes also rabbitbrush, greasewood—throughout landscape, including on stream banks		3 (8)	2 (5)	5 (14)	7 (12)	2 (13)	8 (8)	17 (8)		2 (4)		46
Well-watered landscape: wet meadows and terraces, springs, marshes, swampy bottom lands, seeps	2 (10)	6 (15)	5 (13)	3 (9)			7 (7)	26 (12)	2 (7)	4 (8)	2 (8)	57
Line of willow and/or alder shrubs along stream banks	6 (30)	8 (20)	6 (15)	1 (3)	12 (20)	2 (13)	17 (16)	47 (22)	2 (7)		3 (12)	104
Rich, fertile bottomland soils	2 (10)		4 (10)	2 (6)	3 (5)	1 (6)	7 (7)	5 (2)	2 (7)	5 (10)	2 (8)	33
Abundant, healthy bunchgrasses, often on stream banks; *or* prairie and meadow habitats	2 (10)	5 (13)	12 (31)	3 (9)	10 (17)	5 (3)	15 (14)	21 (10)	3 (11)	7 (14)	4 (16)	87
Scattered juniper throughout landscape, including on stream banks	2 (10)	2 (5)	8 (21)	6 (17)	11 (19)	3 (19)	13 (12)	28 (13)	2 (7)	4 (8)	2 (8)	81

Table 3 continued

Attribute	Type											Total records
	1	2	3	4	5	6	7	8	9	10	11	
	Ecoregion 10k		Ecoregion 11n			Ecoregion 11a			Ecoregion 11b			
Large pine—scattered on banks, in gulches, or in riparian woodlands	1 (5)	1 (3)	1 (3)	6 (17)	6 (10)	1 (6)	12 (10)	5 (2)	5 (19)	9 (18)	3 (12)	50
Total data records	20	40	39	35	59	16	106	216	27	49	25	

Note: The corresponding percentage of total data records for a Type is given in parentheses to represent the relative frequency of each attribute in a Type, as perceived and recorded by early settlers, surveyors, and explorers. Ecoregions: 10k, Deschutes/John Day Canyons; 11n, Deschutes River Valley; 11a, John Day Clarno Uplands; 11b, John Day/Clarno Highlands

continuous wide band along the bank. Of this creek, Peter Skene Ogden wrote, “Indians set fire to plain; willows on creek stopped fire.” In contrast, Ogden wrote of the Crooked River southeast of Prineville, “banks of river well-lined with willow, none of great size” (Rich and Johnson 1950), and photographs show small, but scattered, willows along the banks of the Ochoco River. In addition to willow, several accounts mention the presence of other understory shrubs, including alder (A. R. Bowman Memorial Museum 2000; Pacific Northwest Stream Survey 1942; Russell 1905; GLO 1873), currant (Elliott 1913; Minear 1999; GLO 1879), gooseberries, serviceberries, choke cherries (Minear 1999), mahogany, rose (GLO 1879), and “thorn bushes” (Miller 1899).

Cottonwood, documented multiple times in all PDSs, was the dominant riparian overstory species, growing in dense stands of small trees or more widely spaced (Pacific Northwest Stream Survey 1942). It typically occurred in association with aspen, willow, alder, and sometimes birch. Observations throughout the 1800s reveal that most river margins were well-wooded with aspen, cottonwood, and willow, including portions of the Crooked River and other tributaries of the Deschutes River, the main stem and South Fork John Day River, and all tributaries of the North Fork John Day River (Davies 1961; Williams and others 1971; Rich and Johnson 1950; Elliott 1913; McNary 1934). Birch was noted in only a few accounts (Miller 1899, 1904; GLO 1879); pine was documented mostly on the hills, but it also occurred near streams (GLO 1879, A. R. Bowman Memorial Museum 2000), as did scattered fir and juniper (GLO 1879, A. R. Bowman Memorial Museum 2000; McNary 1934; Miller 1904).

Sagebrush, greasewood, and juniper bordered streams in many locations (A. R. Bowman Memorial Museum 2000; McNary 1934; Sharp 1985; Pacific Northwest Stream Survey 1942; U.S. War Department 1857; Miller 1899, 1904; Rich and Johnson 1950; GLO 1873, 1879). Extensive stands of greasewood (*Sarcobatus vermiculatus*)-big sagebrush (*Artemisia tridentata*), the climax tall shrub community of flat alluvial bottomland, were cleared for cultivated agriculture after the turn of the 20th century and are now completely absent in some locations (Sharp 1985).

Other historical accounts suggest an open landscape with little or no woody vegetation along some stream reaches. Stephen Hall Meek wrote in 1845 of the Crooked River east of the North Fork confluence, “a delightful stream running to the southwest, affording an abundance of fine grass; no wood,” and of the South Fork Crooked River, “found no wood except sage which grew in abundance near its margin” (McNary 1934). Later reports (Shaver and others 1905; Pacific Northwest Stream Survey 1942) also note the lack of trees or shrubs and the presence of only grasses and sage on the South Fork Crooked River. Similarly, of the John Day basin (which comprises other Types), Knowlton (1902) stated, “The present woody flora of the John Day basin is inconsiderable, consisting of pines along the higher ridges, occasional junipers along the lower ridges, and a scant fringe of cottonwoods and willows along the streams. At best, not more than three families are represented.”

Historical documentation provides evidence of large meadowlands in river valleys and marshes with herbaceous wetland plants in wider, level stream bottoms (Miller 1899, 1904; Shaver and others 1905; Pacific Northwest Stream Survey 1942). These areas were described as “beautiful meadowlands,” “wide meadows,” and “fine grasslands.” Meandering, braided, and shifting channels were documented in wide valleys (McNary 1934; A. R. Bowman Memorial Museum 2000; Russell 1905; GLO 1873, 1879), suggesting the presence of off-channel wetlands. Undoubtedly, many beaver were associated with these habitats. During his 1825 trapping expedition Ogden writes of the main stem John Day, “River is a fine-looking stream for beaver—well-wooded with poplar and aspen” and “Beaver habitat on [Crooked] river is exceptional” (Rich and Johnson 1950). Paralleling Ogden’s observations, an 1881 account states, “The Crooked River was as clear as a mountain stream. There were lots of beaver and beaver dams...” (Redmond Spokesman August 22, 1955; Minear 1999).

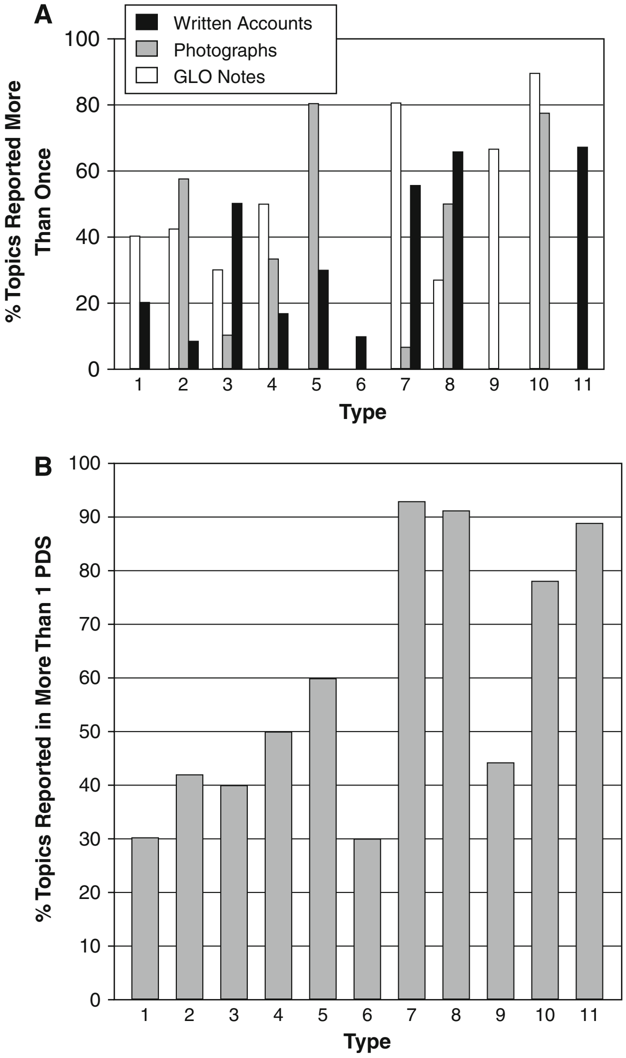

Fig. 3 Relative repetition of observations, expressed as a percentage of topics reported more than once (**A**) within each primary data source (PDS) and (**B**) among PDSs in each Type

Very little information was found for Type 6 (narrow V-shaped valleys with a high gradient), but the limited data indicate that juniper and sagebrush were more commonly associated with streams, while willow and alder were less prominent than in Types 7 and 8. Type 7 streams, higher gradient than those in Type 8, more frequently included conifers such as pine, fir, tamarack, and spruce (Miller 1899; GLO 1881, 1879, 1882) (Table 3), which were scattered or dense and often large. Some of the pine and fir trees measured by GLO surveyors were 50–90 cm in diameter. Aspen was also found in steep ravines in association with pine (Miller 1904). Riparian shrub communities of Type 7 were well-developed, as in Type 8. For example, one particular photograph taken in 1913 shows tall, dense willows, composed of multiple age classes or species, and well-vegetated throughout the vertical profile. Also notable in the photo are the gently sloped banks thickly covered with grasses and a partially shaded, narrow stream.

Riparian areas lacking woody vegetation, reported in Type 8, were not documented for Type 7 (Table 3). However, healthy bunchgrasses dominated the landscape in Type 7, often interspersed with sagebrush and sparse junipers and extending to stream banks (A. R. Bowman Memorial Museum 2000; Miller 1899; Shaver and others 1905; McNary 1934; U.S. War Department 1857; Pacific Northwest Stream Survey 1942; GLO 1881, 1882) or forming “wide meadows” or “fine grasslands” (Miller 1899). Because of higher gradients and steeper terrain in Type 7, meandering channels and oxbow lakes were less common than in Type 8, but historical accounts document springs (Shaver and others 1905; Miller 1904) and numerous marshy areas, typically in upper stream reaches (Shaver and others 1905; GLO 1874, Pacific Northwest Stream Survey 1942).

Discussion

Historical descriptive summaries (previous section) and enumeration of observations by Type (Table 3) provided a range of information representing the capability of the three PDSs to document and differentiate historical riparian conditions among strata. Assembling data at a regional scale provided a greater range of historical information than could be acquired at the stream reach or site scale and thus optimized the use of available information over broad areas.

A stratification that minimizes within-Type variability is an important part of the reconstruction process. The John Day/Deschutes region was isolated for much of European settlement, and historical data were limited. The stratification system used in this investigation balanced data availability, degree of stratification, and relationship of the stratification variables to the characteristics of riparian areas. Ecoregions, the first tier of the stratification, were the logical geographical stratification units since they were originally developed to integrate terrestrial and aquatic characteristics (Bryce and Clarke 1996), and they are being used in large-scale stream assessments (Stoddard and others 2005; USEPA 2000). Ecologically defensible boundaries define areas where site-specific results may be extrapolated so that local results can be applied to a broader scale. Within relatively homogeneous areas, streams of a particular type are expected to respond similarly, which reduces apparent variability and increases precision in analyses (Clarke and Bryce 1997). The second tier, a combination of valley form and gradient, characterizes stream types that may differ in size, hydrological regime, and elevation. Combining these two variables in the tier (Table 1) best compartmentalized conditions that commonly exist together in the study area while also distributing limited data for describing Types. The stratification design was adapted from a system previously used in a portion of the region for large-scale assessment of wetland vegetation (Crowe and Clausnitzer 1997) and is considered effective for minimizing within-Type variation for this large-scale application.

Results are best applied and interpreted at the regional scale suggested by the stratification. They should not be applied in isolated assessments of individual sites because they describe a range of conditions occurring at a regional scale. Thus, site-specific historical data from a subpopulation of sites can be extrapolated to describe a region (or Type). A regional application might then determine whether attributes of reference sites fall within the range of historical conditions and, more importantly, whether the full range of historical conditions is exhibited across a Type in the modern landscape.

The degree of repeated observations of riparian topics (Fig. 3) and attributes (Table 3) was considered fairly high, given that the availability of historical documentary records for the study area is relatively low, compared to the nearby Lewis and Clark route, for example. During data collection, locations of original documentation were recorded to assure that multiple records from the same location did not overrepresent the Type description. The Deschutes River crossing at Sherars Falls (Type 2), however, was a location where many settlers passed, and the rocky, barren landscape was so notable that it may have resulted in a reporting bias and overrepresentation in Type 2. This is the only location where multiple observations of the same location were recorded; overall, data were well-distributed spatially within Types, and repeated observations were made from unique locations, which allowed their uses in corroborating results and estimating prominence in a Type.

Historical data have certain limitations that influence their application; as a result, historical reconstruction is often avoided as an approach to describing reference conditions. Most historical information is descriptive, and not directly comparable to quantitative data being collected today. The reconstruction process is time-intensive, and historical data are limited, inconsistently reported, non–randomly distributed, and widely scattered, often in unfamiliar literature. Historical data collection is opportunistic and data contain probable omission bias resulting when existing conditions were not documented, which creates data gaps in the presence and details of attributes. Because of these inherent qualities of historical data, rigorous quantitative analyses to assess spatial variability or to compare and differentiate Types were less preferable than a semiquantitative synthesis and analysis of tabular results. The semiquantitative assessment is more suited to the intended users, although it relies more heavily on careful selection of a stratification framework. Using this simpler approach, it was possible to identify differences in Type descriptions in the study area and extract general patterns from the tabular presentation of data, for example, the absence or higher frequency of an attribute in certain Types or apparent trends in prominence of attributes that were historically ubiquitous.

Despite the limitations of historical reconstruction, results suggest that historical data can be ordered and synthesized at least to the extent that they can be used as ancillary data in riparian assessments. Although the time investment is high compared to the amount of information collected, the risks and costs of overlooking historical data in some regions may be inaccurate condition assessments, mismanagement, and degradation of resources due to reference sites that are highly altered from their baseline conditions. The use of quantitative and consistently collected reference data from least-disturbed sites is a convenient approach to develop reference benchmarks and make comparisons with nonreference samples, but it fails to identify deviations from baseline conditions when those conditions are no longer evident in the landscape. The range of historical conditions in Type 8 included riparian areas with little vegetation, but the majority of historical records described dense riparian shrub communities, healthy abundant bunchgrasses, well-wooded river margins, a continuous vertical profile of vegetation, and large meadowlands and marshes. Much of the vegetation composition and structure in Type 8 riparian areas today, however, has been altered or eliminated by widespread domestic animal grazing and other human impacts. As a result, only a portion of the former range of riparian conditions may be represented by reference data from least-disturbed sites. The data gathered in this assessment can supplement those data to better approximate the full range.

In highly altered areas, even a coarse level of information, such as that produced in this reconstruction, when combined with current reference data from least-disturbed sites, assures more insightful assessments of current conditions. At a minimum, historical data could influence the rigor with which results of assessments using least-disturbed sites are applied in policy and management decisions. Small adjustments in expectations should lead to better target setting in stream protection and restoration.

Applying historical riparian information in restoration research could help determine (1) the extent to which current riparian conditions resemble the historical picture, (2) whether restoring riparian areas to more closely resemble the historical condition can be achieved, given large-scale, human-induced changes that have occurred in hydrological regimes, for example, and (3) whether riparian sites that have already been restored approach the conditions described in historical literature.

This investigation used PDSs that might be limited in parts of the world with long histories of human presence or where significant human settlement and impacts predate photography or land surveys. However, the approach can be adapted to utilize different kinds of documentary records or different time frames. Information about human history, land uses, and impacts in a region might support the use of a time frame following settlement—for example, in countries with longer histories than the United States—but results would have more limited use and must be interpreted accordingly. Historical reconstruction is probably not cost-effective in regions with minimal human presence and impacts, for example, certain mountainous regions, parks, or protected areas, since least-disturbed sites typically represent a minimally altered condition in those circumstances and can supply ample reference data.

In conclusion, the results are representative of the kinds of historical information that can be extracted from the three PDSs used. The procedure demonstrated that (1) historical documentary records can be synthesized by stratum to develop descriptive summaries of streamside communities and other riparian characteristics; (2) riparian attributes can be extracted and evaluated to illustrate descriptive differences in riparian conditions among ecophysiographic strata (i.e., Types); (3) observations of specific attributes are encountered repeatedly in historical literature; and (4) information for all Types could not have been provided with any single PDS—the variety of primary data sources provided a broader picture and better corroboration of results.

Limited historical data in the John Day/Deschutes region resulted in descriptive attributes that are probably too coarse for use as a sole data source for developing reference conditions in most applications. Results are considered useful as supplemental information for identifying a representative group of least-disturbed sites or for supplementing regional reference-site data that do not include the historical condition. Finer detail and better differentiation of Types might be achieved in regions that are more data-rich; thus the approach will have varying degrees of utility depending on location.

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