Historical (pre-settlement) Ecosystems of the Okanagan Valley and Lower Similkameen Valley of British Columbia – pre-European contact to the present

Abstract

A series of maps compare the 1800, 1938 and 2005 ecosystems in the Okanagan and Lower Similkameen Valleys. Much of the gentle slope valley bottom ecosystems have been replaced by urban and agricultural development. Analysis of the areal extent of historical and remaining areas has been done for specific ecosystem types that are important for many species at risk and are themselves ecosystems at risk. These include: Douglas-fir – pinegrass gentle slope; Ponderosa pine – bluebunch wheatgrass gentle slope; water birch – red-osier dogwood wetland riparian shrub; black cottonwood – red-osier dogwood floodplain; the Okanagan River ecosystem; cattail marsh; Idaho fescue – bluebunch wheatgrass grassland; big sagebrush shrub-steppe and antelope-brush – needle-and-thread grass shrub-steppe. For two of these ecosystems, over 90 percent of the original ecosystem has been lost.

Uses of this mapping for conservation of species at risk are presented, including applications to status assessment, quantification of threats, informing restoration projects, and providing data on the importance of the remaining areas of ecosystems that have been severely depleted. The paper concludes that it is important to focus on conservation of ecosystems in order to maintain species at risk.

Introduction

"Until recently, most measures to save declining species have been upside down. Typically, what happens is that ecosystems are degraded without public

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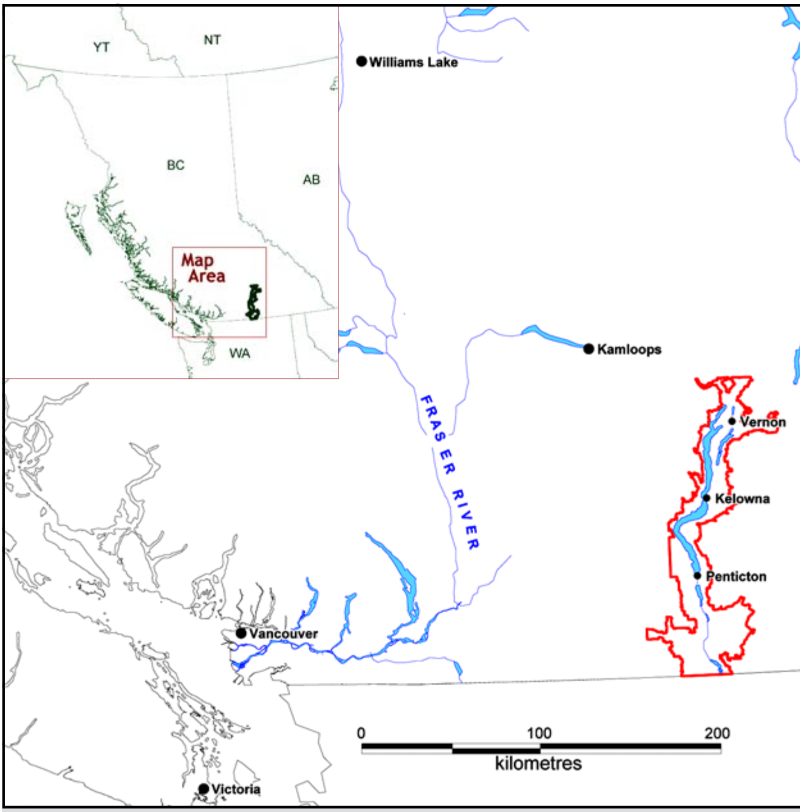

Figure 1. Location of the Okanagan and Similkameen valleys.

concern until some of their component species approach extinction. It is grossly inefficient to wait until species are endangered and then work backwards to try to protect their habitat. Instead, conservation efforts should pre-emptively identify all ecosystems in present or potential danger and act decisively to save them before further decline. By conserving adequate expanses of all types of ecosystems, we would ensure that many vulnerable species are stabilized before listing is needed."

America's Endangered Ecosystems by Robert Peters and Reed Noss (1995)

The Okanagan and Similkameen valleys occur in the south central area of British Columbia (BC), Canada (Figure 1, [1]). They

1. Due to format limits, all maps in this article have been adjusted by the publisher. The original maps are available at http://www.davidsonia.org/

originally formed a corridor from the Columbia Basin in the south, into the shrub/steppe and interior forested areas of BC including the Thompson River valleys near Kamloops, the Nicola valley, and the Fraser River valley, from Lillooet and Cache Creek, north to near Williams Lake.

The Okanagan and Similkameen grasslands are an extension of the Pacific Northwest Bunchgrass grasslands defined by Tisdale (1982).

These valleys are comprised of a mosaic of intermixed ecosystems that are geographically close to each other (MOELP 1998) and provide a variety of habitats for many species that are considered at risk in BC and Canada (BC Ministry of Environment, Lands and Parks, 1998). Settlement began in these valleys in the mid 1800s and has expanded quite rapidly since that time to include significant areas of cultivation. Much of the shrub/steppe and riparian areas in the Columbia Basin to the south have also been converted to agriculture in the past 150 years (ICBEMP, 2007) and much of the remaining shrub/steppe areas have been intensively grazed.

The study area is approximately 322,000 ha (Figure 2) within three biogeoclimatic units, the Okanagan Very Dry Hot Bunchgrass variant (BGxh1), the Okanagan Very Dry Hot Ponderosa Pine variant (PPxh1) and the Okanagan Very Dry Hot Interior Douglas-fir variant (IDFxh1) (Lloyd et al, 1990) that included the lower Similkameen valley, from near Keremeos to the United States border, and the Okanagan valley from Enderby south to the United States border.

Ecosystem distribution prior to European settlement in the mid 1800s is compared with present day distribution, and the loss of ecosystems over this time is assessed. Effects of First Nations activities and use of grassland prior to European settlement were studied by Blackstock and McAllister (2004). Noss et al. (1995) assessed ecosystem losses over time in many parts of North America at over 90%, including other Pacific Northwest shrub/steppe and grassland types, similar to the Okanagan and Similka-

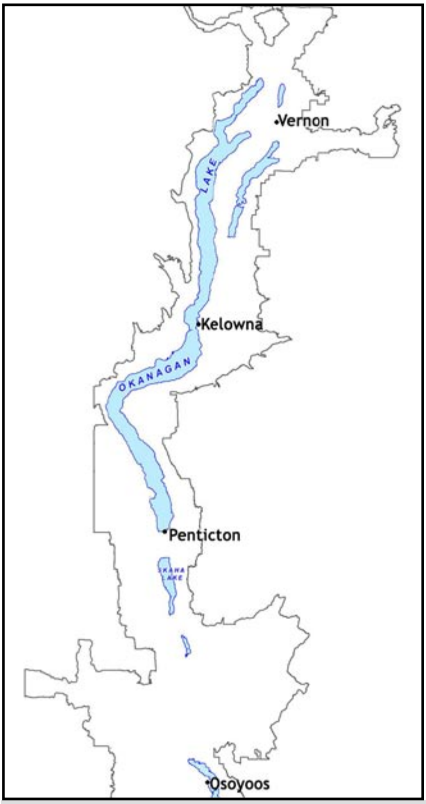

Figure 2. The study area.

meen valleys. In one example, the Palouse Prairie ecosystem in southeastern Washington and adjacent Idaho, that is dominated by *Festuca idahoensis* (Idaho fescue) and *Pseudoroegneria spicata* (bluebunch wheatgrass), more than 99% of its area has been lost due to agricultural development.

Historical perspective

Extensive alteration of BC ecosystems has occurred as a result of a variety of activities. Livestock farming began in the province in the 1840s and Okanagan ranching began in the 1860s. The Okanagan valley was a major route for livestock drives. Commercial apple orchards were first tried in 1892, although commercial fruit crops did not become common until the 1920s. The first vineyards in the Okanagan Valley began in the late 1800s. By 2006 the province had about 2,600 hectares of wine grapes, mostly in the Okanagan valley. This increased by 20% between 2004 and 2006, and the overall provincial area is expected to peak at over 4,000 ha. Production of many other field crops also began in the late 1800s.

The earliest recorded invasive species were *Bromus tectorum* (cheatgrass) and *Cirsium arvense* (Canada thistle). Cheatgrass, reported in Summerland in 1912, is currently the most widespread and common weed in the south Okanagan. The South Okanagan Similkameen Invasive Plant Committee now tracks over

45 invasive alien species. Cheatgrass invades disturbed areas, and dominates the grass-forb community of more than half of the sagebrush region in the western United States, replacing native bunchgrasses (Rich 1996). Cheatgrass can create a more continuous grass understorey that is denser than native bunchgrasses and can readily spread fire.

First Nations have been present in the valley for thousands of years. The first recorded non-native arrival is from 1811. European settlement began in 1859 and has slowly increased. Since the 1980s the population has expanded significantly. The population of the study area in 2005 was approximately 325,000 and is projected to increase to about 460,000 by 2020.

There are important ecological similarities with the Columbia Basin in the United States. Much of the shrub-steppe and grassland ecosystems have either been replaced and developed for plant agriculture, or have been heavily grazed and are presently dominated by invasive species. Most of these ecosystems in the U.S. occur on gentle slopes, while a significant amount of grassland in BC is on steeper slopes, has had less development and is less heavily grazed. The BC topography has prevented extensive development of the steeper grassland and shrub/steppe areas, and these have become very important for conservation of shrub/steppe and grassland ecosystems in North America.

Methods

The historical ecosystem mapping was done on 1:12,000 scale 1938 air photographs, that were extrapolated back to 1800 ecosystems using ecological attributes, following the Terrestrial Ecosystem Mapping (TEM) methodology (Ecosystems Working Group, 1998). The south Okanagan and Similkameen Valleys were mapped in 2001 and 2002. Mapping for 2005 was extracted from recent (TEM) and 2001 – 2004 orthophotos at a scale of 1:20,000. The Central and North Okanagan areas were begun in 2005 and completed in 2007. Egan and Howell (2001) described the variety of methods available to reconstruct historical ecological conditions. In this study the following sources of information were used:

- Maps and photographs, particularly aerial photographs.
- Forest stand history – Observational field evidence, including present day sampling and TEM of present day ecosystems.
- Geomorphology, hydrology and soils information from a variety of sources.
- Land surveys, where available.
- Written records, including historical accounts and books on the history of the area.

Aerial photographs provided the most comprehensive and consistent coverage for the study area. Other sources were mainly used to spot check or confirm areas that were assessed on the aerial photographs.

The mapping conformed to the TEM Standard for BC (Ecosystems Working Group 1998). At the plant community level, the site classification of the BC Ministry of Forests (Lloyd et al 1990) was used. The 1938 maps were based on aerial photographs taken during that year, which are available from the BC Integrated Land Management Bureau. Map unit histories were extrapolated back to before the start of European settlement in the 1800s, using ecological attributes for each polygon, such as surficial material, slope position, moisture regime and vegetation remaining on nearby areas with similar attributes. A polygon is an area of land delineated on an air photo or map. For these ecosystems, no structural stage or seral community information was considered in mapping or delineation of polygons. Present day TEM mapping was used to see what remained. Maps for three years (1800, 1938, and 2005) allowed comparison of changes over time.

To create the three years of maps, the procedure started by using the present day TEM projects, which were undertaken between 2003 and 2005. Any gaps were first filled from present day human land use maps using 2001 orthophotos to map urban areas, cultivated area, golf courses, roads and other human uses.

Where natural areas still existed in gaps, these areas were incorporated based on mapping done for the 1800s and extrapolated from the 1938 air photos. A final 2005 map was created at this step. As a final step, the polygons that had human land uses mapped (agricultural, urban, roads, mines, etc.) in the 2005 map, were replaced with historical mapping for either 1938 or for 1800 for the whole study area, to create final maps for these two years (1938 and 1800).

Maps for the 1938 study followed the aerial photographs from that time, and the 1800 maps were developed by extrapolating ecological characteristics of the landscape to determine what ecosystems may have occurred before the agricultural and urban development that already existed when the aerial photographs were taken in 1938. Presence of ecosystems on comparable sites on adjacent natural areas at the time that the 1938 air photographs were taken, was used to help determine what agricultural and urban areas may have supported before settlement occurred. Field checks were done in many areas throughout the Okanagan to determine potential ecosystems that might have developed today if land had not been converted to other uses by humans. The author undertook the present day ecosystem mapping of the southern portion of the study area from Naramata south to the United States border, and in the Similkameen drainage area between 1990 and 1995 (Lea et al, 1998).

Extensive field sampling was also undertaken for recent TEM in six different study areas, mapped by various individuals (Bruhjell, et al 2000; Iverson et al 2004; Iverson and Shypitka, 2002; Iverson and Uunila, 2005, 2006; and, Iverson and Haney, 2006). These areas were also extensively sampled in the field to confirm map units. Recent terrain mapping was available for the Kelowna, Vernon and Summerland areas (Collett and Uunila 2005).

Historical photographs (BC Archives, Kelowna Archives, Vernon Archives) were accessed to confirm vegetation types that occurred in the late 1800s and early 1900s.

Results

Over 40 ecosystem types were mapped in the study area. Ten ecosystem types were analyzed to assess the original extent of the ecosystem in 1800 and changes observed in 1938 and in 2005. Each of these types occupied areas of valley bottom that have been affected by human activities, such as agriculture and urban development. Seven of these types have maps presented in this paper, including

Douglas-fir – pinegrass gentle slope forest DP (Figure 3)

Ponderosa pine – bluebunch wheatgrass gentle slope forest PW (Figure 4)

Black cottonwood – red-osier dogwood riparian forest CD (Figure 5)

Water Birch – red-osier dogwood riparian shrub swamp wetland BD (Figure 6)

Idaho fescue – bluebunch wheatgrass grassland FW (Figure 7)

Big sagebrush shrub-steppe BS (Figure 8)

Antelope-brush – needle-and-thread grass shrub-steppe AN (Figure 9)

Characteristic properties of each ecosystem were: dominant vegetation, physical characteristics, federally listed species at risk associated with the ecosystem, aerial extent over time (for 1800, 1938 and 2005 – see Table 1) and percentage of the ecosystem that has been lost.

Ecosystem DP:

Pseudotsuga menziesii - Calamagrostis rubescens (Douglas-fir – pinegrass) (Figure 3)

Description: A gentle slope forest dominated by forests of Douglas-fir and *Pinus ponderosa* (ponderosa pine) and understoreys with a sparse shrub layer of *Amelanchier alnifolia* (saskatoon), *Spiraea betulifolia* (birch-leaved spirea) and a moderate to dense cover of pinegrass. Mostly found on gentle slopes of glaciofluvial and morainal material.

Federally listed Species-at-Risk: white-headed woodpecker, Great Basin gopher snake, western rattlesnake, spotted bat, Lewis's woodpecker, rubber boa.

Percentage of the ecosystem that has been lost: 27%

Ecosystem PW:

Pinus ponderosa - Agropyron spicatum (ponderosa pine – bluebunch wheatgrass) (Figure 4)

Description: A gentle slope forest dominated by open forests of ponderosa pine, with a sparse shrub understorey of saskatoon, and herb layer of bluebunch wheat grass, *Balsamorhiza sagittata* (arrow-leaved balsamroot). It is mostly found on gentle slopes of glaciofluvial and morainal material.

Federally listed Species-at-Risk: white-headed woodpecker, Great Basin gopher snake, western rattlesnake, Spotted bat, Lewis's woodpecker, and rubber boa.

Percentage of the ecosystem that has been lost: 53 %

Ecosystem CD:

Populus balsamifera - Cornus stolonifera (black cottonwood – red-osier dogwood) (Figure 5)

Description: A riparian forest dominated by *P. balsamifera* ssp. *trichocarpa* with a dense shrubby understorey of red-osier dogwood, *Betula occidentalis* (water birch), *Rosa* spp. (roses), *Salix* spp. (willows) and *Maianthemum stellatum* (starflower). Floodplain areas of medium to coarse-textured materials.

Federally listed Species-at-Risk: western screech owl, Lewis's woodpecker, yellow-breasted chat, rubber boa.

Percentage of the ecosystem that has been lost: 63%

Ecosystem BD:

Betula occidentalis - Cornus stolonifera (Water birch – red-osier dogwood) (Figure 6)

Description: A riparian shrub swamp wetland dominated by dense, tall shrub layer of water birch, red-osier dogwood, willows, roses, and herbs such as starflower, and *Equisetum* spp. (horsetails). Floodplain, fan, or riparian areas – medium to coarse-textured materials.

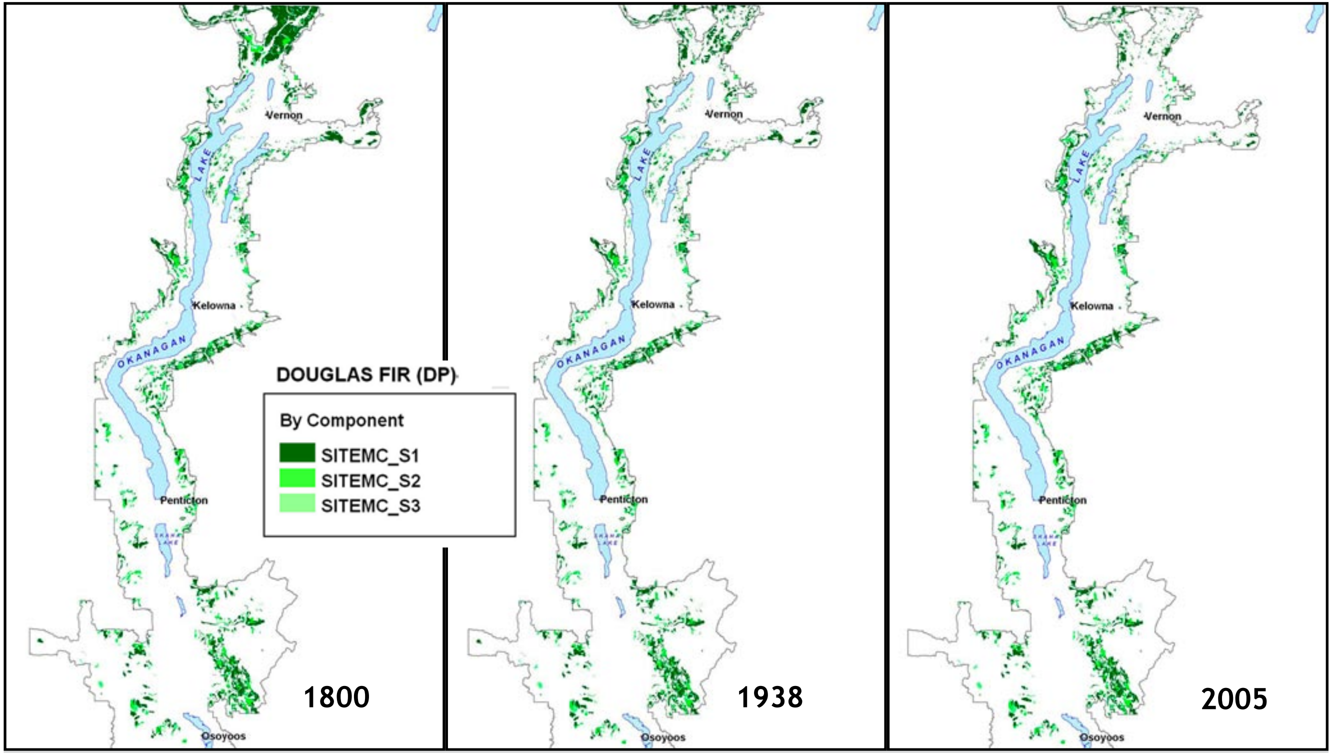

Figure 3. Maps showing changes in the Douglas-fir – pinegrass gentle slope forest (DP) ecosystem between 1800 and 2005.

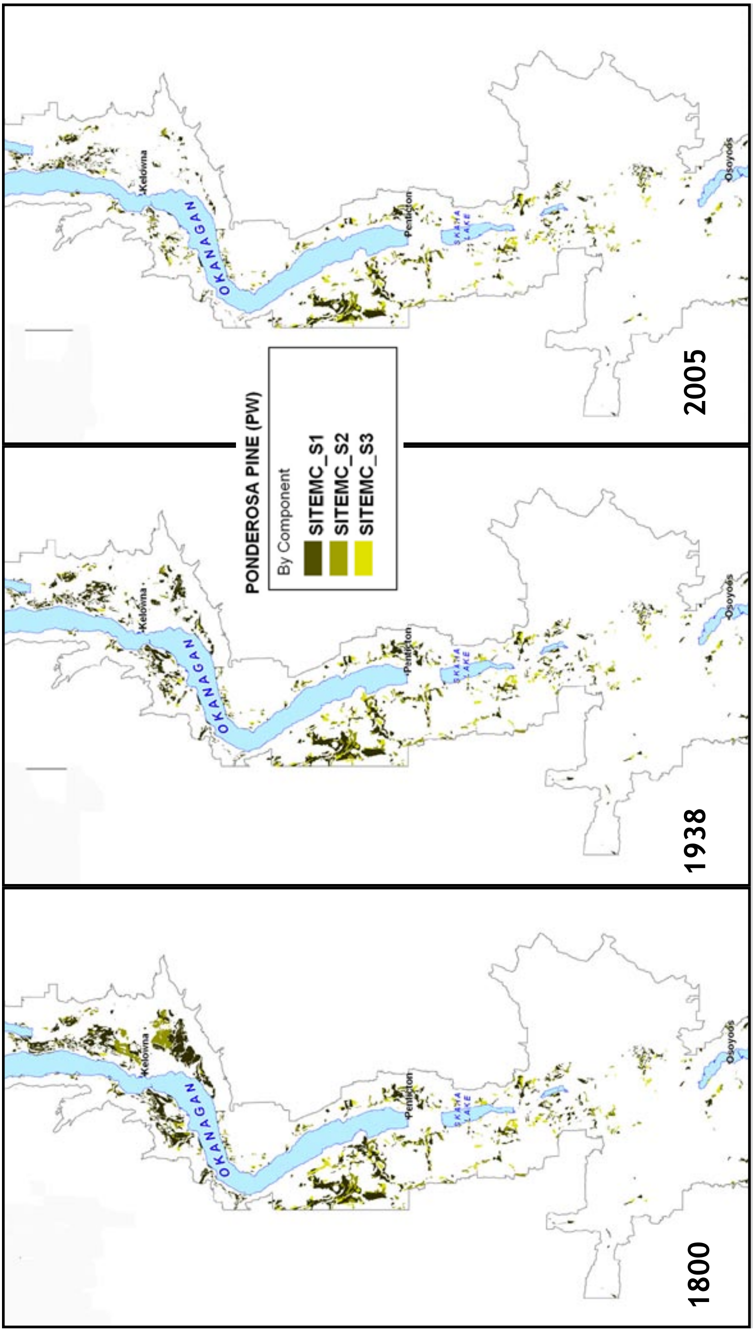

Figure 4. Maps showing changes in the Ponderosa pine – bluebunch wheatgrass gentle slope forest (PW) ecosystem between 1800 and 2005.

Federally listed Species-at-Risk: *Epipactis gigantea* (Giant Helleborine), yellow-breasted chat, Great Basin gopher snake, Western rattlesnake.

Percentage of the ecosystem that has been lost: 92 %

Ecosystem OR:

Okanagan River (not mapped)

Area: 1800 = 212 ha; 1938 = 212 ha; 2005 = 15 ha

Description: The Okanagan River originally occurred in three segments, from Okanagan Lake to Skaha Lake, from Skaha Lake to Vaseux Lake and from Vaseux Lake to Osoyoos Lake. Most of the river was channelized and dyked in 1948 for flood control and for irrigation for agricultural crops.

Federally listed Species-at-Risk: Rocky Mountain (western) ridged mussel, Chinook salmon - Okanagan population.

Percentage of the ecosystem that has been lost: 93%

Ecosystem CT:

Typha latifolia (cattail) Marsh (not mapped).

Area: 1800 = 432 ha; 1938 = 378 ha; 2005 = 264 ha

Description: Dominated by *Typha latifolia* (cattail). Wetland along lakes, shallow open water and other wetlands – mucky soil.

Federally listed species at Risk: *Azolla mexicana* (Mexican mosquito-fern), tiger salamander, Great Basin spadefoot.

Percentage of the ecosystem that has been lost: 41 %

Ecosystem FW:

Festuca idahoensis - Agropyron spicatum (Idaho fescue – bluebunch wheatgrass) (Figure 7)

Description: Grasslands dominated by Idaho fescue, bluebunch wheatgrass, many forbs and other graminoids. Occurs on glaciofluvial, fluvial and morainal materials

Federally listed species at Risk: badger, burrowing owl, pallid bat, Great Basin gopher snake, western rattlesnake, long-billed curlew.

Percentage of the ecosystem that has been lost: 77 %. Much of the remaining areas of this ecosystem type are in an early seral stage with significant invasive alien species occurring due to intensive livestock grazing over many years.

Ecosystem BS:

Artemesia tridentata-steppe (Big sagebrush shrub-steppe) (Figure 8)

Description: A gently sloping ecosystem dominated by big sagebrush, bluebunch wheatgrass, needle-and-thread grass, other graminoids and herbs, cryptogamic crusts. Found on fluvial, glaciofluvial, morainal and colluvial materials.

Federally listed species at Risk: *Bryoerythrophyllum columbianum* (Columbia carpet moss), *Microbryum vlassovii* (nugget moss), *Orthocarpus barbatus* (Grand Coulee owl-clover), badger, sage thrasher, pallid bat, Great Basin gopher snake, western rattlesnake, night snake, Nuttall's cottontail.

Percentage of the ecosystem that has been lost: 33%. Much of the remaining areas of this ecosystem type are in an early seral stage with significant invasive alien species occurring due to intensive livestock grazing over many years.

Ecosystem AN:

Purshia tridentate-Hesperostipa comata (Antelope-brush – needle-and-thread grass) (Figure (9)

Description: A shrub-steppe system dominated by antelope-brush, big sagebrush, *Chrysothamnus nauseosus* (rabbitbrush), needle-and-thread grass, bluebunch wheatgrass, other graminoids, herbs and well-defined cryptogamic crust. Mainly found on aeolian over fluvial and glaciofluvial material, with rarer ecosystems on morainal and colluvial materials.

Federally listed Species at Risk: Columbia carpet moss, Grand Coulee owl-clover .Behr's hairstreak, badger, pallid bat, Great Basin gopher snake, western rattlesnake, night snake, Nuttall's cottontail.

Percentage of the ecosystem that has been lost: 68 %. Much of the remaining areas of this ecosystem type are in an early seral stage with significant invasive alien species occurring due to intensive livestock grazing over many years.

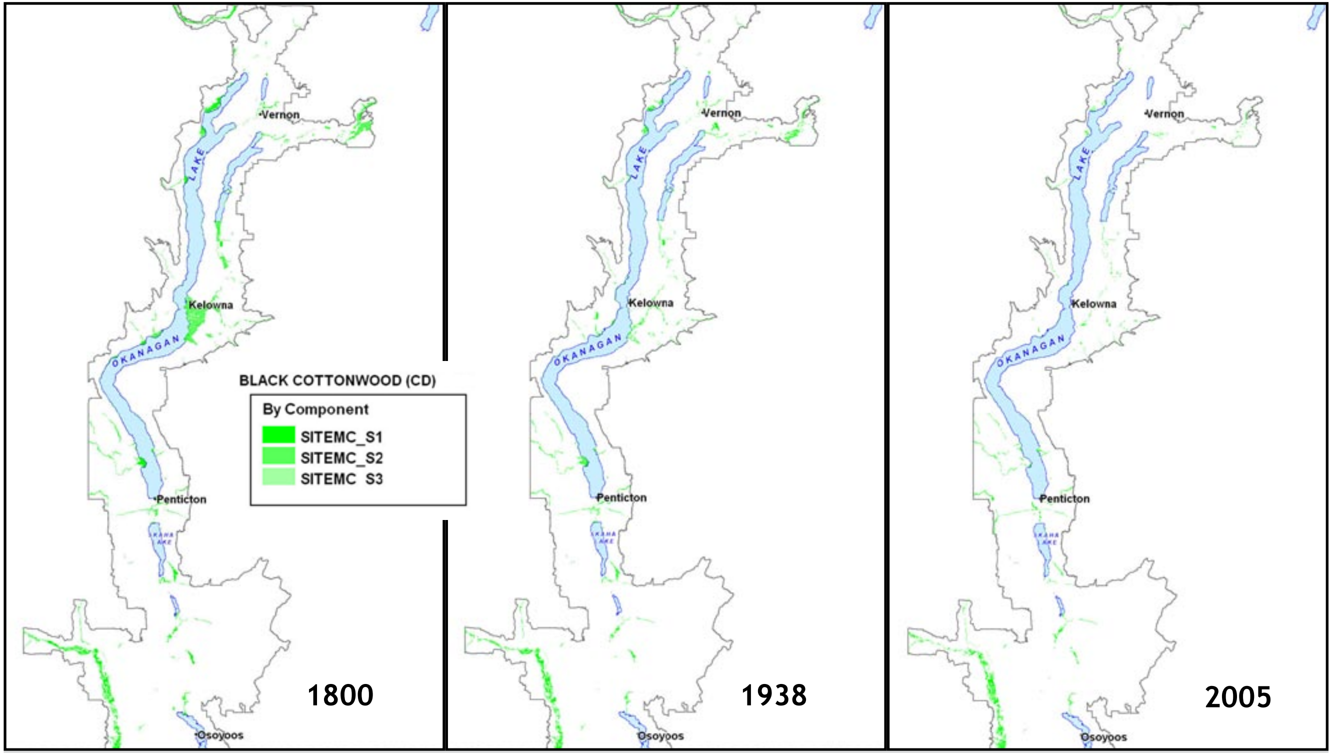

Figure 5. Maps showing changes in the Black cottonwood – red-osier dogwood riparian forest (CD) ecosystem between 1800 and 2005.

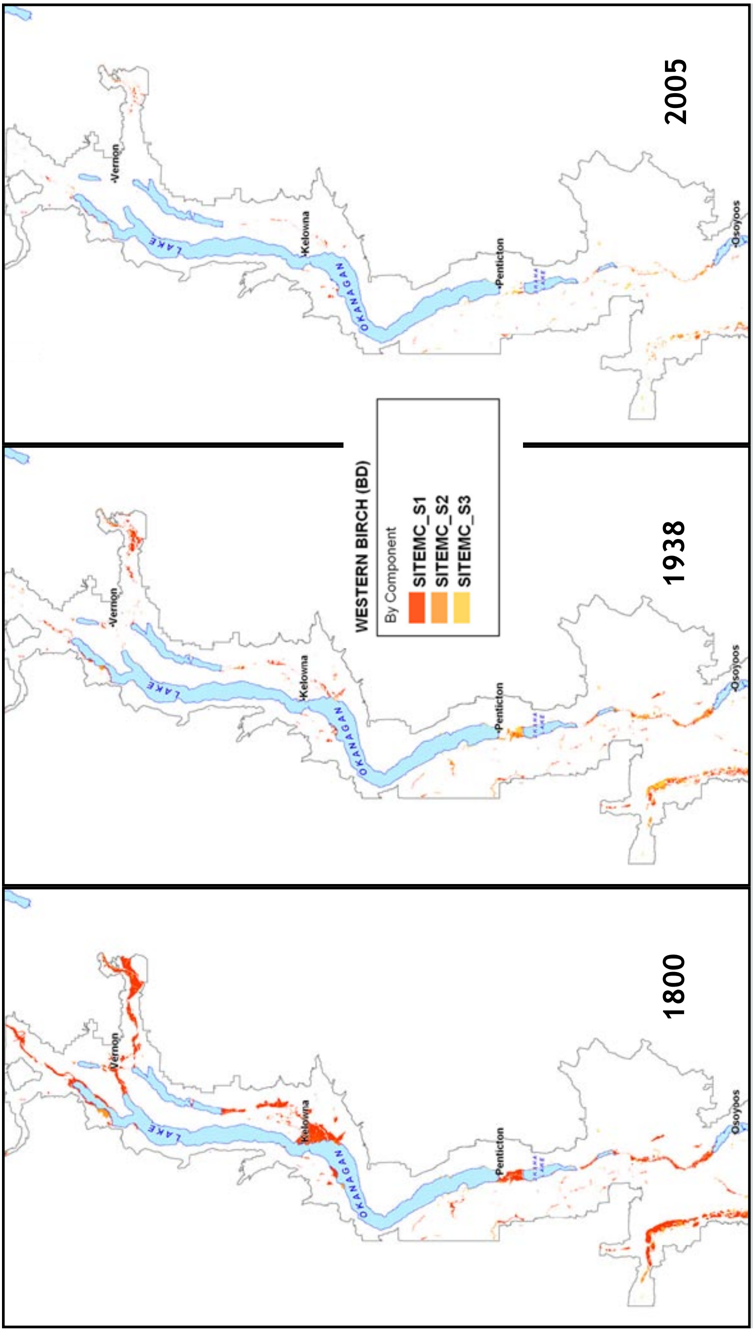

Figure 6. Maps showing changes in the Water Birch – red-osier dogwood riparian shrub swamp wetland (BD) ecosystem between 1800 and 2005.

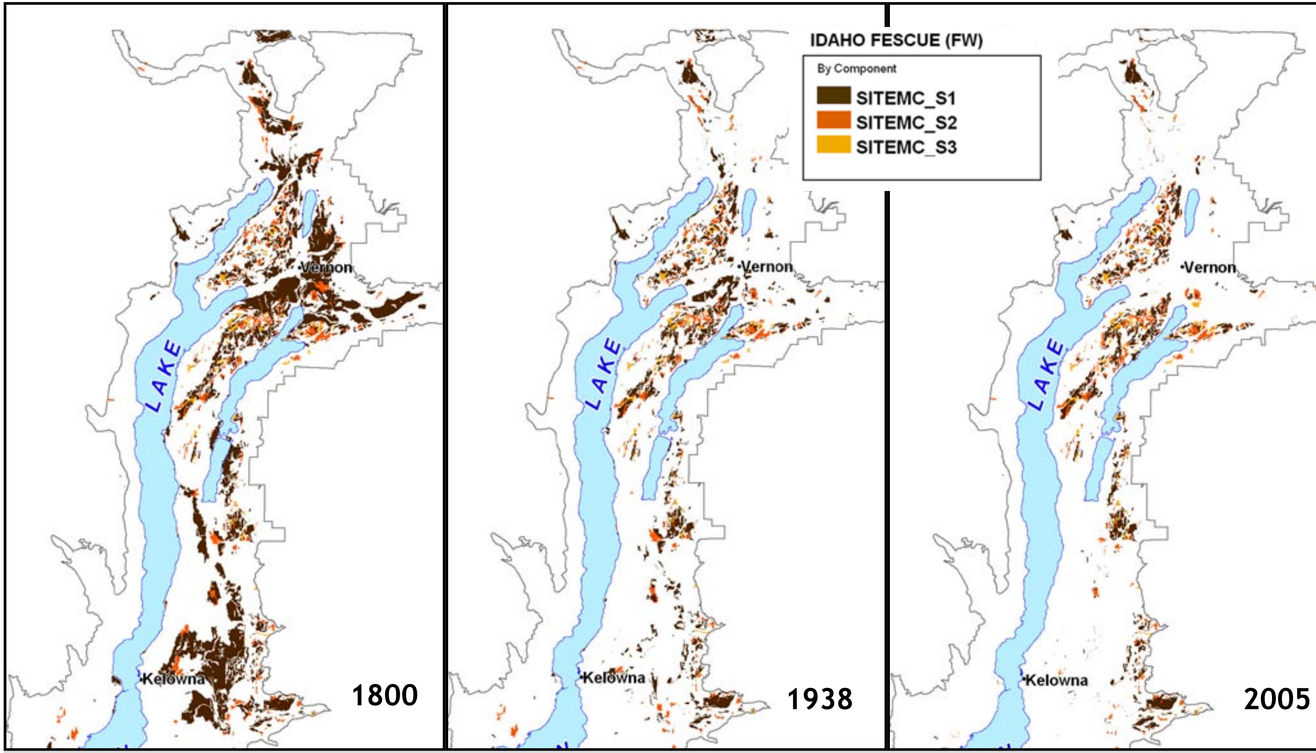

Figure 7. Maps showing changes in the Idaho fescue – bluebunch wheatgrass grassland (FW) ecosystem between 1800 and 2005.

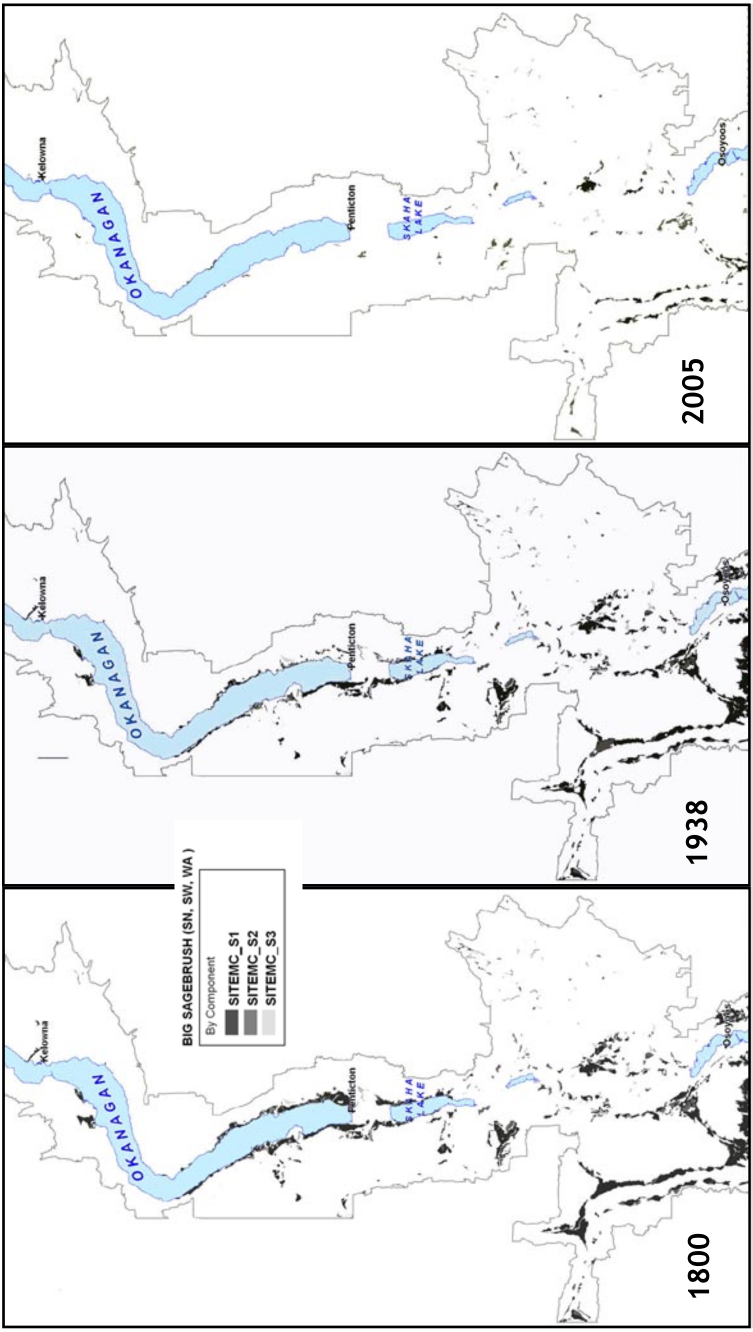

Figure 8. Maps showing changes in the Big sagebrush shrub-steppe (BS) ecosystem between 1800 and 2005.

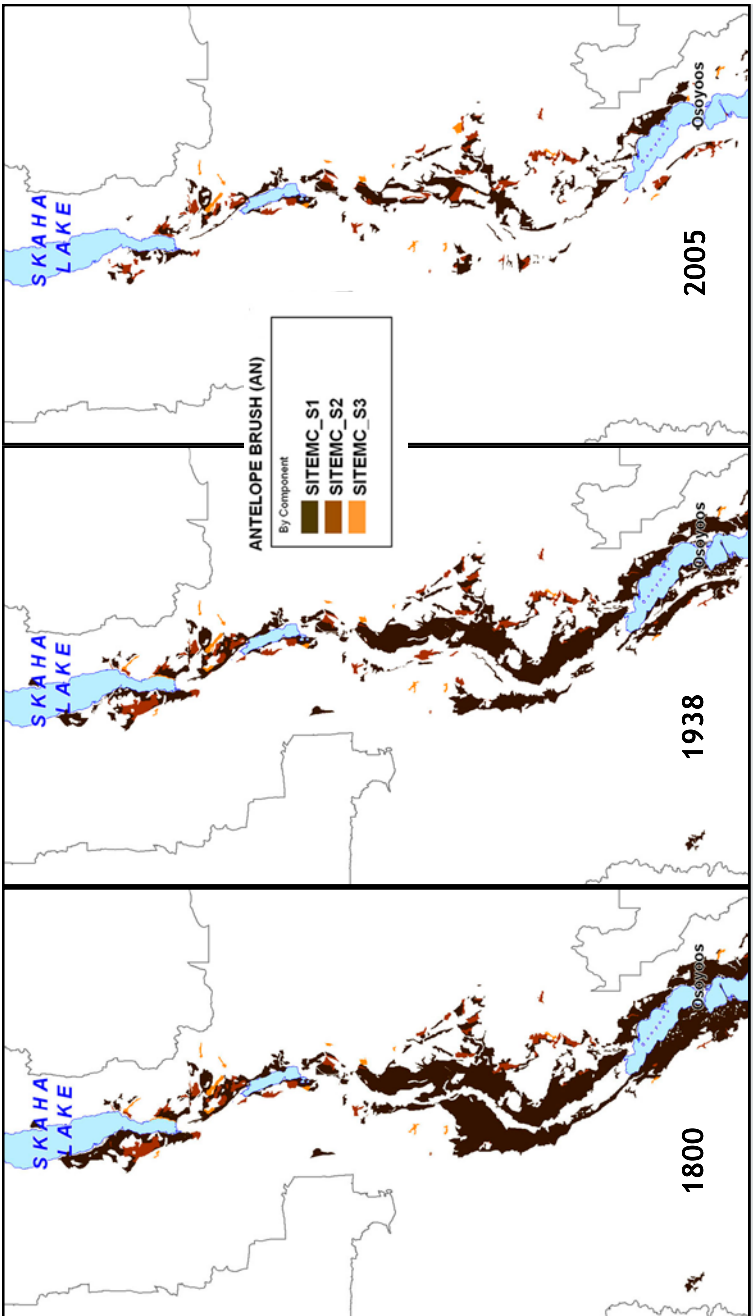

Figure 9. Maps showing changes in the Antelope-brush – needle-and-thread grass shrub-steppe (AN) ecosystem between 1800 and 2005.

Table 1 Areal analysis for major ecosystem types for the Okanagan and Similkameen Valley study area.

Ecosystem	1800 ha	1938 ha	2003 ha	Percent Lost
Douglas-fir – pinegrass (gentle slope) (DP)	23,177	17,882	15,428	33
Ponderosa pine – bluebunch wheatgrass (gentle slope) (PW)	15,307	12,091	7767	50
Black cottonwood – Red-osier dog-wood floodplain, or lakeshore (CD)	7646	5167	3216	58
Water birch – Red-osier dogwood riparian wetland swamp (BD)	15,209	4497	1208	92
Okanagan River	212	212	15	93
Cattail marsh (CT)	432	378	264	40
Idaho fescue – Bluebunch wheatgrass grass steppe (FW)	19,528	8924	5017	75
Big sagebrush – needle-and-thread shrub-steppe (SN)	4366	3229	1335	70
Overall Big sagebrush shrub steppe (BS)	12,458	10,402	8266	33
Antelope-brush – needle-and-thread grass shrub-steppe (AN)	9895	7325	3178	68
Overall Gentle slope Grassland and Shrub-steppe	41881	26651	16461	61
Overall low elevation Wetlands (including marsh, shrub swamp, meadow, shallow open water)	17,786	6890	2965	84

City of Kelowna example

Additional but smaller areas within this larger study area were analyzed for ecosystem loss, including the City of Kelowna, the City of Vernon, City of Penticton and the City of Summerland.

Results for the Kelowna area are provided in Table 2 for 5 ecosystem types. Maps of the changes within the City of Kelowna are in Figure 10 (1800), Figure 11 (1938) and Figure 12 (2001).

Table 2 Areal analysis for major ecosystem types for the City of Kelowna

	Shallow Open Water (OW)	Ponderosa pine – bluebunch wheatgrass gentle slope (PW)	Idaho fescue – bluebunch wheatgrass (FW)	Water Birch – red-osier dogwood wetland shrub swamp (BD)	Black Cottonwood – red-osier dogwood (CD)
2001 hectares	32	1,211	246	117	188
1938 hectares	155	3,061	858	498	558
1800 hectares	171	4,510	3,653	3,084	1,287
Percentage Lost	81	74	93	96	86

Percentage losses of certain ecosystem types were higher in the Kelowna area than for the whole of the Okanagan Valley. A similar analysis of the City of Vernon revealed that 100 percent of the Water birch – Red-osier dogwood shrub riparian unit was gone from this area.

Seral Community Analysis

Seral community analyses were done for the Idaho fescue – bluebunch wheatgrass ecosystem, the Rough fescue – bluebunch wheatgrass ecosystem, and for the Bluebunch wheatgrass – arrow-leaved balsamroot ecosystem from all of the present day Terrestrial Ecosystem Mapping (Bruhjell, et al 2000; Iverson et al 2004; Iverson and Shypitka, 2002; Iverson and Uunila, 2005, 2006; and, Iverson and Haney, 2006). The results in Tables 3, 4 and 5 show how livestock grazing has significantly affected the seral condition of grasslands in the Okanagan.

Table 3 Seral analysis for the Idaho fescue - bluebunch wheatgrass ecosystem

Seral Stage	Seral Association Name 1	Areal extent	% of
Climax	Idaho fescue – Bluebunch wheatgrass (climax)	410	
Total Climax		410 ha	9
Mid to Late	$Bluebunch wheatgrass – Idaho fescue (wf)	104	
	$Idaho fescue - Cheatgrass (fc)	316	
	$Columbian needlegrass – Balsamroot (nb)	22	
	$Big sagebrush – Bluebunch wheatgrass (sw)	156	
	$Bluebunch wheatgrass – knapweed (wk)	801	
Total Mid to Late		1399 ha	30
Mid	$Big sagebrush – Columbia needlegrass (sn)	397	
Total Early to Mid		397 ha	8
Early	$Cheatgrass – Columbia needlegrass (cn)	478	
	$Columbia needlegrass - Cheatgrass (nc)	360	
	$Big sagebrush – Kentucky bluegrass (sb)	73	
	$Kentucky bluegrass (kb)	52	
Total Early		963 ha	20
Early to Very Early	$Knapweed – cheatgrass (kc)	1459	
	$Big sagebrush – Knapweed (sk)	67	
Total Early to Very Early		1526 ha	32
Total All Seral Stages		4695 ha	

1. The $ defines a seral plant community

Table 4 Seral analysis for the Rough fescue - bluebunch wheatgrass ecosystem

Seral Stage	Seral Association Name1	Areal extent	% of
Climax	Rough fescue – bluebunch wheatgrass (climax)	2	
Total Climax		2 ha	0.5
Mid to Late	$Bluebunch wheatgrass – knapweed (wk)	29	

Total Mid to Late		29 ha	6
Early	$Cheatgrass – Columbia needlegrass (cn)	8	
	$Columbia needlegrass - Cheatgrass (nc)	7	
Total Early		15 ha	3
Early to Very Early	$Knapweed – cheatgrass (kc)	457	
Total Early to Very Early		457 ha	91
Total All Seral Stages		503 ha	

1. The $ defines a seral plant community

Table 5 Seral analysis for the Bluebunch wheatgrass - arrow-leaved balsamroot ecosystem

Seral Stage	Seral Association Name1	Areal extent	% of
Climax	Bluebunch wheatgrass – Arrow-leaved balsamroot	2128	
Total Climax		2128 ha	34
Late	$Big sagebrush – Bluebunch wheatgrass (sw)	330	
Total Late		330 ha	5
Mid to Late	$Bluebunch wheatgrass – knapweed (wk)	2354	
Total Mid to Late		2354 ha	38
Mid	$Big sagebrush – Columbia needlegrass (sn)	321	
Total Mid		321 ha	5
Early to Mid	$Knapweed – Cheatgrass – Bluebunch wheat grass (kw)	124	
Total Early to Mid		124 ha	2
Early	$Big sagebrush – Kentucky bluegrass (sb)	12	
	$Kentucky bluegrass (kb)	5	
	$Columbia needlegrass - Cheatgrass (nc)	34	
Total Early		51 ha	1
Early to Very Early	$Knapweed – Cheatgrass (kc)	941	
Total Early to Very Early		941 ha	15
Total All Seral Stages		6249 ha	

1.The $ defines a seral plant community

Range Condition Analysis

Range condition categories were mapped in the early 1990s for the South Okanagan project area (Lea et al, 1998). These included Excellent, Good, Fair and Poor range condition classes following McLean (1978). This was done for four different ecosystems, the gentle sloped Antelope-brush – needle-and-thread gentle slope plant ecosystem, Big sagebrush – needle-and-thread plant ecosystem and Big sagebrush – bluebunch wheatgrass ecosystem; and for the steeper slope Bluebunch wheatgrass – arrow-leaved balsamroot ecosystem on steeper slopes with warm aspects. The results are shown in Table 6. Good Range Condition was combined with Excellent Range Condition in these results, as often it was difficult to separate these categories in the field. The other categories were easier to separate. The results show that the gentle slope ecosystems have much lower occurrence of Good to Excellent Range Condition, and that the steeper slope ecosystem has a very high occurrence of Good to Excellent Range Condition, demonstrating clearly the significant impact of concentrated livestock use on the gentle slope ecosystems in the study area.

Table 6 Range Condition for selected ecosystem types

	Percentage Good to Excellent Range Condition	**Percentage Fair Range Condition**	**Percentage Poor Range Condition**
Antelope-brush – needle-and-thread grass gentle slope	5	26	69
Big sagebrush - needle-and-thread grass gentle slope	2	39	59
Big sagebrush- bluebunch wheatgrass gentle slope	20	61	19
Bluebunch wheatgrass – arrow-leaved balsamroot steep slope, warm aspect	68	27	25

Discussion

This study has shown that loss of ecosystems in the developed portion of the Okanagan has been substantial, with many lower elevation ecosystem types having lost over 60 percent of their original area, and a few reduced by more than 90 percent of their area. As well, seral community and range condition analysis of the remaining natural areas shows that there has been significant alteration of these communities, mainly by livestock grazing. The combination of ecosystem loss, fragmentation and degradation has had substantial impacts on local biodiversity and ability for species to exist, evolve, or to migrate to other areas. In many cases these options will not exist in the future with climate change, particularly for species that can only move on the ground or short distances at a time.

It is important to know the original conditions of ecosystems before restoration is attempted (MacDougall et al. 2004). Historical mapping generally only gives one point in time and usually does not describe the detailed plant composition of communities that existed 150 to 200 years ago. To determine plant composition one must look at the remnants that still exist on the landscape. Successional changes over time can confound what one might have expected in historical situations.

There is some uncertainty about the earlier existence of smaller wetlands or vernal pools in the landscape, as much of the gentle sloping grassland had already been converted to agricultural uses when the 1938 air photographs were taken.

LEGEND TO OKANAGAN MAP
Figure 10

- AB: Nuttall's alkaligrass - Foxtail barley
- AK: Alkaline pond
- AN: Antelope-brush - needle-and-thread
- AS: Trembling aspen - snowberry
- BD: Western birch - red-osier dogwood
- BE: Beach
- BM: Bulrush Marsh
- CB: Cutbank
- CD: Black cottonwood - red-osier dogwood
- CL: Cliff
- CT: Cattail Marsh
- DM: Douglas-fir - Water birch - Douglas maple
- DP: Douglas-fir - pinegrass
- DS: Douglas-fir - Ponderosa pine - Snowberry - Spirea
- DW: Douglas-fir - Ponderosa pine - Bluebunch wheatgrass - Pinegrass
- FB: Rough fescue - Bluebunch wheatgrass
- FC: Rough fescue - Cladina
- FO: Douglas-fir - Ponderosa pine -Saskatoon - Mock orange
- FW: Idaho fescue - Bluebunch wheatgrass
- LA: Lake
- OW: Shallow open water
- PB: Douglas-fir - Ponderosa pine - Bluebunch wheatgrass - Balsamroot
- PC: Ponderosa pine - Bluebunch wheatgrass - Cheatgrass
- PD: Pond
- PF: Ponderosa pine - Bluebunch wheatgrass - Rough fescue
- PT: Ponderosa pine - Red three-awn
- PW: Ponderosa pine - Bluebunch wheatgrass - Idaho fescue
- RI: River
- RO: Rock outcrop
- RS: Western redcedar - Douglas-fir - False Solomon's Seal
- SB: Selaginella - Bluebunch wheatgrass rock outcrop
- SD: Hybrid white spruce - Douglas-fir - Douglas maple - Dogwood
- SO: Saskatoon - Mock orange Talus
- SP: Douglas-fir - Ponderosa pine - Snowbrush - Pinegrass (IDFxh1)
- SW: Big sagebrush - Bluebunch wheatgrass
- TA: Talus
- WB: Bluebunch wheatgrass - Balsamroot

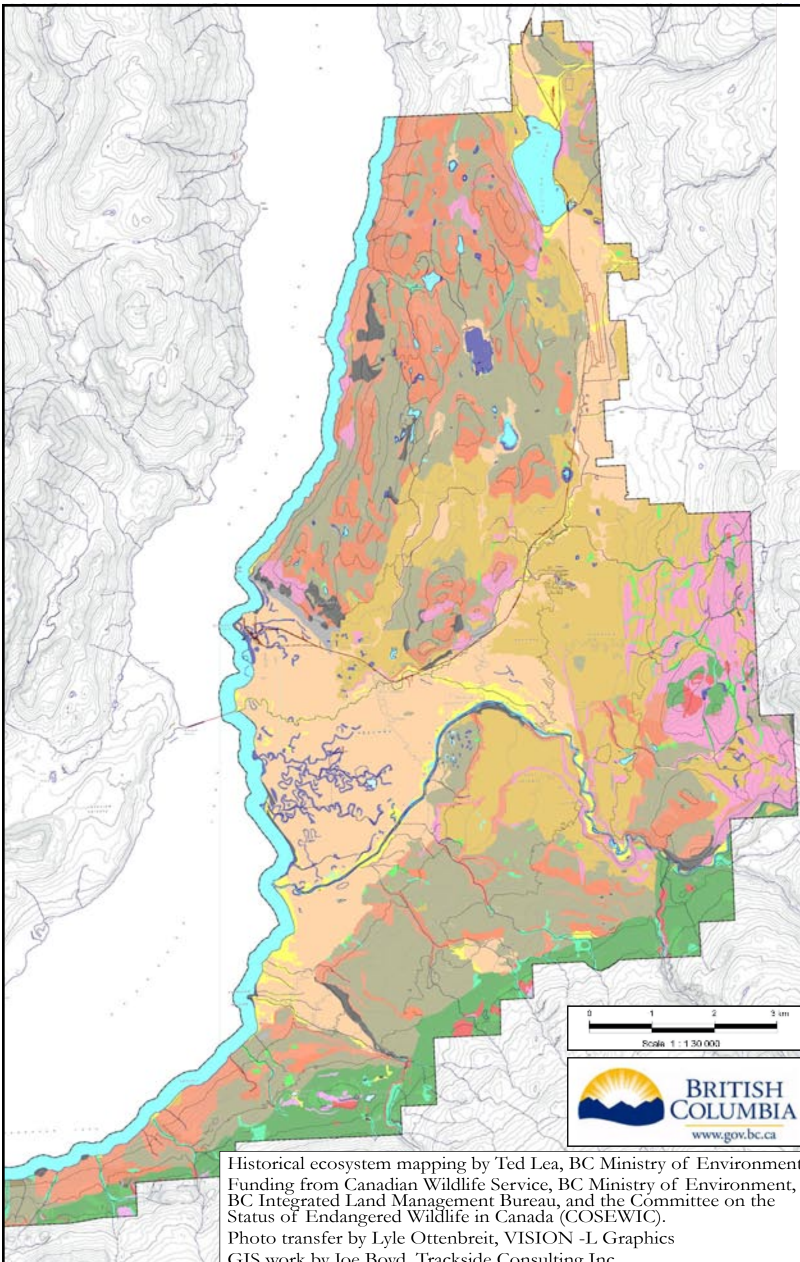

Figure 10. Terrestrial Ecosystem Mapping - City of Kelowna 1800.

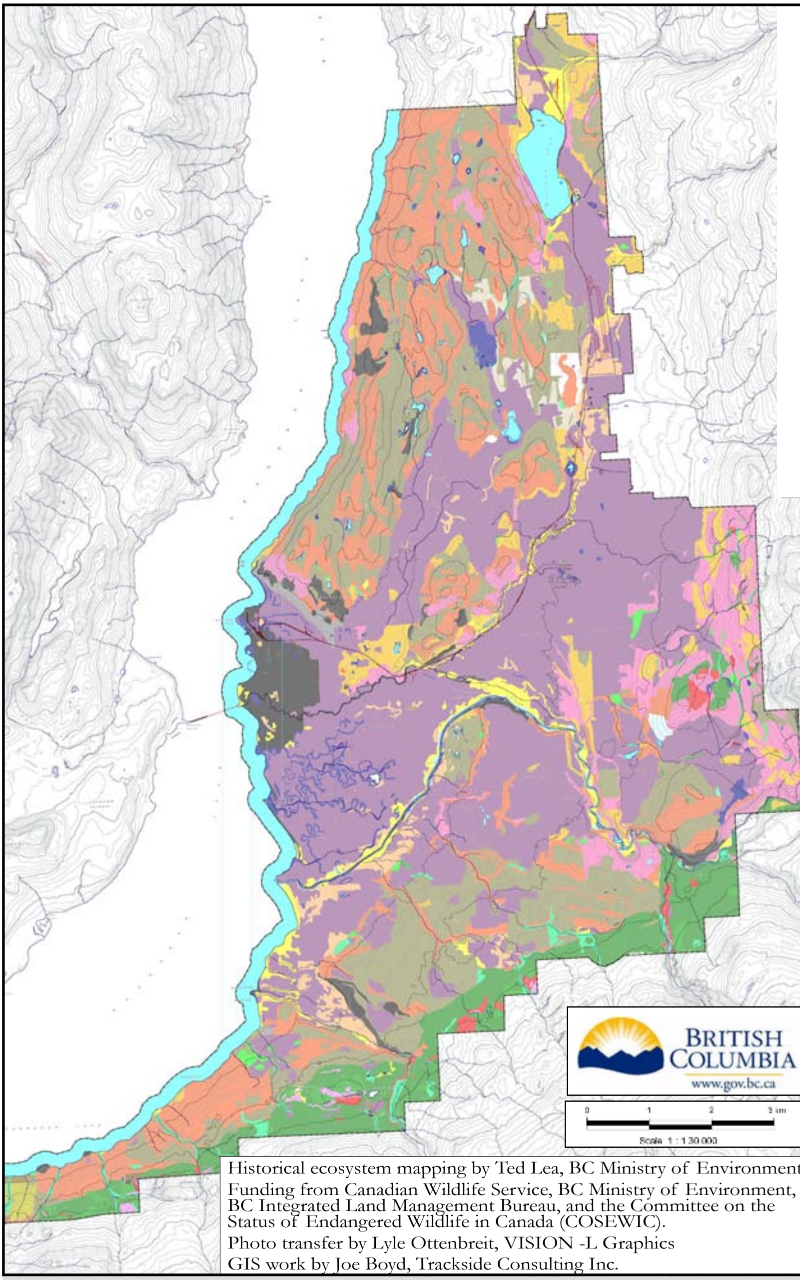

Figure 11. Terrestrial Ecosystem Mapping - City of Kelowna 1938.

This could have led to under or over estimation of grasslands areas. However, there were clues in surrounding natural areas and often reference ecosystems were still present and provided some grounds to validate extrapolation and to map these ecosystems. Similarly, shrub riparian areas of water birch and red-osier dogwood communities may have contained small areas of wetlands, shallow open water, and cattail marshes, and possibly other wetland types that no longer exist. Many such areas had been developed by human activity before the 1938 air photographs were taken. Structural and successional stages were not included in the historical maps, as it was not possible to verify the plant communities that exist at the time.

Information about forested conditions and structural stages for forests and grasslands was not essential for determining ecosystem loss. Comparisons of air photographs from 1938 and orthophotos of the same areas taken in 2001 made it obvious that substantial forest encroachment occurred during this period. Analysis of seral communities and range condition using present day terrestrial ecosystem maps provided an understanding of which grassland and shrub/steppe ecosystems have been significantly affected by livestock grazing.

Value of Mapping Historical Ecosystems

There are several potential uses of ecosystem mapping and analysis including comparisons of historical ecosystems with present day ecosystem information including (from Egan and

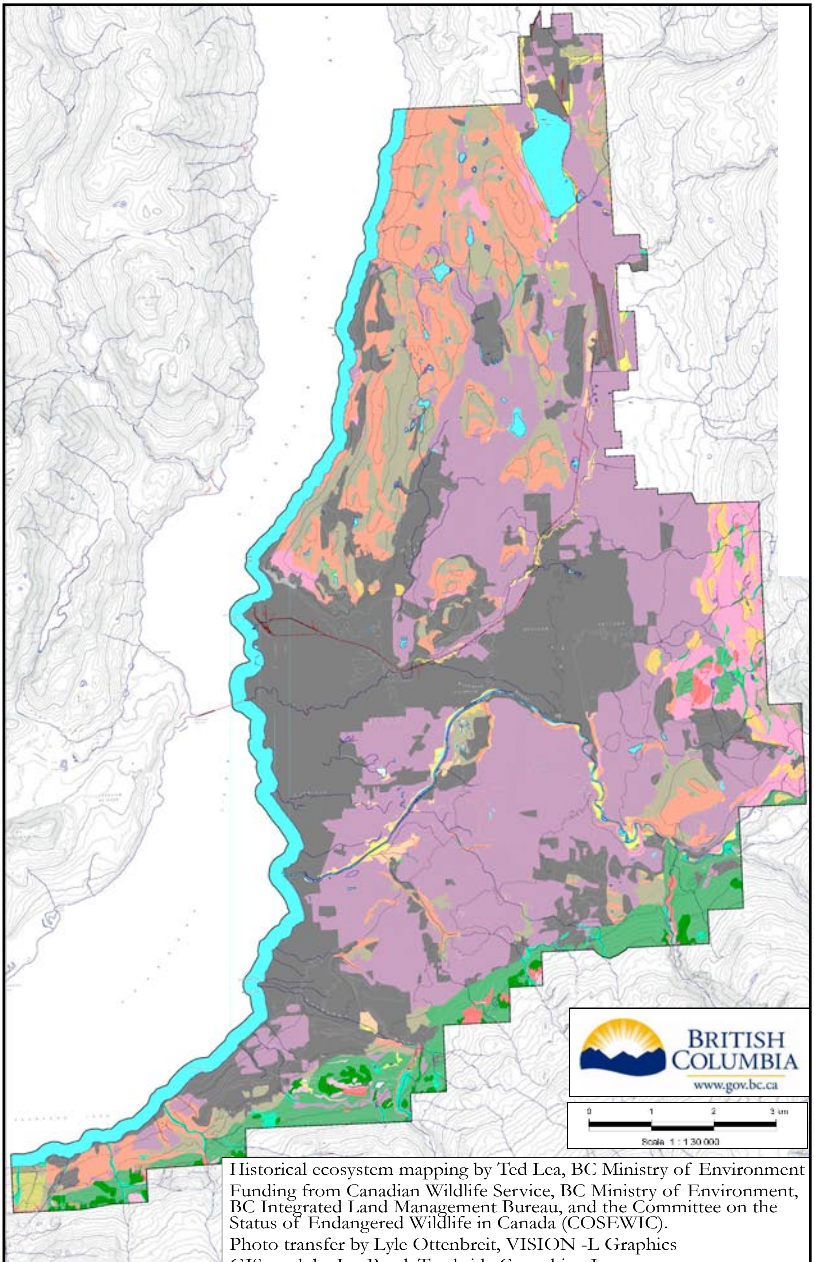

Figure 12. Terrestrial Ecosystem Mapping - City of Kelowna 2001.

LEGEND TO OKANAGAN MAP
Figure 12

- AB: Nuttall's alkaligrass - Foxtail barley
- AK: Alkaline pond
- AN: Antelope-brush - needle-and-thread
- AS: Trembling aspen - snowberry
- BD: Western birch - red-osier dogwood
- BE: Beach
- BM: Bulrush Marsh
- CB: Cutbank
- CD: Black cottonwood - red-osier dogwood
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- SW: Big sagebrush - Bluebunch wheatgrass
- TA: Talus
- WB: Bluebunch wheatgrass - Balsamroot

Howell 2001 and Dyer, O.N., Pers. Comm. 2007):

- a dramatic visual display to demonstrate extent of ecosystem loss which can be shown to local and regional government and developers, as well as to the public;
- to demonstrate the importance of the remaining areas of a particular ecosystem, especially in ecosystems which contain large numbers of species at risk. Preservation and stewardship of the remaining pieces will be required to maintain these species at risk.
- to support requests for sustainable habitat protection/ sustainable development by clearly demonstrating unsustainable practices;
- to quantify reasons for habitat loss when combined with current mapping (ie x% due to agriculture (or even types of agriculture); x% to urban, etc.);
- to quantify threats to habitat and aids in target threat reduction efforts;
- to determine loss of habitat for species at risk.
- to determine habitat value for species at risk – present potential, capability, and potential critical habitat.
- to stratify inventory for species at risk (the author was requested to provide information on locations of alkaline ponds from the ecosystem mapping to aid with inventory for the dark saltflat tiger beetle *Cicindela parowana* subsp. *wallisi*).

- to prioritize habitats for conservation based on importance for species and how much has been lost.
- to map loss of ecosystems aids in the development of species Status Reports for assigning trends in habitat – (This mapping has been used for Status Reports for sooty hairstreak, Rocky Mountain ridged mussel, Nuttall's cottontail, yellow-breasted chat, Behr's hairstreak, Mormon metalmark, sage thrasher, and sage grouse).
- for restoration of habitats – e.g. riparian areas that were channelized, identifying what is capable of being restored, where restoration is most cost effective or probable (in combination with current maps and ownership).
- to point out the importance of remaining pieces – what is lost compared with targets for functional ecosystem conservation on a landscape scale. In a detailed study of the minimal area needed to retain current estimated population levels of 29 target vertebrates in the SOSCP area, using TEM data, Warman (2001) showed that 44% of the area is needed to be maintained as high class conservation habitat. This is a minimal area estimate and did not provide for buffer zones, connectivity, corridors, natural disturbance regimes (such as fire) and climate change.
- to improve understanding of regional heritage and how humans have affected ecosystems.
- to show that ecosystems can be completely or mostly lost, caused by humans.

Several very important issues require immediate attention:

- The lands that we need to conserve to maintain species and species-at-risk are those that include the ecosystems that support them. Many such ecosystems are themselves at risk
- It is time to focus more effort on the ecosystems or we won't be able to maintain many of the species presently at risk and many more species will be added to the at risk lists

There is a strong need for ecosystems at risk legislation that parallels the legislation for species at risk that is already in place federally and provincially.

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