Report to Metro

EXISTING VEGETATION AND SITE OBSERVATIONS AT KILLIN WETLAND, WASHINGTON COUNTY, OREGON

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Background

The history, current condition, and options for restoration at Metro's Killin Wetland were outlined recently by Christy (2015). As part the site evaluation, Metro requested an inventory of current vegetation at Killin Wetland, which is presented here with information on other miscellaneous features observed that may be of interest for future management decisions.

Killin Wetland, occurring on organic Labish soil, was drained in the 1890s, and farmed and grazed until about 1940, after which native vegetation slowly reestablished itself. John Christy examined some of the vegetation at Killin between 1990 and 1993. By 2002, when Metro purchased the site from Kistner Farms, renewed beaver activity had flooded much of the wetland, and many willows were already dying. Today, the site is a lake 5 to 6 feet deep, and most trees and shrubs have been killed except on steeper banks around the perimeter. Based on NRCS mapping of hydric soils, the wetland has expanded to approximate its historical footprint that includes Metro's adjoining Moore property and the Spiering property. As part of this process, wetland plant communitiess are re-establishing themselves in former farm fields.

Historically, beavers were a keystone species in wetlands on Labish, Semiahmoo, and Wapato soils. Their activities regulated hydrology, vegetation, and soil formation. Reestablishment of beavers at Killin Wetland have caused dramatic changes since 1990, but these changes are part of a long-term wetland cycle. Responding to fluctuations in beaver populations, these sites were subjected to ongoing episodes of flooding and regeneration, rotating through phases from lakes, to marshes, to swamps and back again to lakes (Pollock et al. 2015). Because virtually all sites on these soils were drained and farmed, examples useful as reference sites no longer exist. Killin Wetland and adjoining properties have the potential to accommodate all phases of beaver-driven wetland ecosystems on these soils, but restoration of historical conditions will be a long-term undertaking.

Methods

The project area was limited to the flooded portion of Killin Wetland between the Kistner barn and the eastern property boundary adjoining Metro's Moore property. We examined the site by kayak on 30 April and 17 June 2015, launching from the Kistner barn. A written request for

access through Frank Hartmann's property along Highway 6 was denied. Christy made supplemental roadside visits on 14 January, 6 April, and 23 July 2015.

We compiled lists of plant species in aquatic, emergent, and shoreline habitats within the lake. We sampled bathymetry with an 8-foot fiberglass graduated rod to measure relative depths of live and dead vegetation, depths of old drainage ditches, depth of water ponded behind the beaver dam, and the height of the beaver dam. Photos were taken where needed, including repeat photography from vantage points used in 1990 and 1991. We mapped patches of vegetation on laminated air photos, and used GPS to mark locations of beaver dams, beaver lodges, hunting blinds, silt marks on trees, old Metro transects, and our tracks around the lake. Voucher specimens were collected as needed, and will be deposited in the Portland State University Herbarium.

Information about the historical vascular flora at Killin Wetland was compiled from Trutch and Trutch (1855) and Christy (1990, 1991, 1993, 2002). Information on the historical flora of other Labish sites was compiled from GLO survey notes and publications cited in Table 1, and online herbarium databases [Consortium of Pacific Northwest Herbaria (2015), National Museum of Natural History (2015)], which contained only records from Lake Labish.

Precision of historical locality data. Although early botanists generally were not precise about where they collected specimens, records from "Lake Labish" presumably were more or less accurate, at least as far as wetland species are concerned. Because the historical record for vascular plants is fairly large, we chose to be conservative by excluding records that were collected "near" Lake Labish, or that were obvious weedy upland species (e.g., *Avena fatua, Digitaria sanguinalis*). A few records were collected as late as 1947, decades after drainage, but the species in question could easily have occurred along the drainage ditches.

Nomenclature follows the Oregon Flora Project (2014).

Existing vegetation at Killin Wetland

Table 1 lists 130 species of vascular plants, 32 of which we saw at Killin Wetland in 2015, 39 seen at Killin by Christy (1990-2002), and the remainder comprising all known historical records of species that occurred in similar Labish soil wetlands prior to drainage. A search of herbarium databases yielded 113 specimens from Lake Labish, representing 67 species, a few of which are present at Killin Wetland.

In 2015 we observed 32 species of plants at Killin, in contrast to 39 species recorded by Christy (1990-2002). Because of the major shift in habitat from shrub swamp to open water since 1990, the species composition has changed almost completely (Figures 1 and 2). Eleven species (28%) remain from 1990-2002, and most woody vegetation has died (Figure 3). The only significant species remaining is *Salix geyeriana*, which is struggling to survive in 3-5 feet of water, producing weak shoots among the many dead branches of the formerly large shrubs (Figure 4). In water of this depth, *Spiraea douglasii* also struggles to survive, but it is abundant on the banks of the lake. A few floating tussocks of *Carex obnupta* were seen in the deep part of the lake,

presumably dislodged from the lakeshore, or perhaps pulled from former rooted positions by rising water or beaver activity.

Most of the species seen at Killin in 2015 are typical components of aquatic bed vegetation in our region. Emergent species persisting from 1990 and now expanding include *Eleocharis palustris*, *Ludwigia palustris*, and *Sparganium emersum*. Most of these species occur in 1 to 4 feet of water, in extreme cases to 5 feet. Aquatic bed species, scant to nonexistent in 1990-2002, are proliferating rapidly on the surface of the lake, with *Nuphar polysepala*, *Potamogeton natans* and *Brasenia schreberi* being the most conspicuous in the area formerly occupied by willows and ash (Figure 5). *Persicaria hydropiperoides* is abundant closer to shore. Extensive submerged beds of *Ceratophyllum demersum*, *Elodea canadensis*, *Myriophyllum spicatum*, *Potamogeton berchtoldii*, and *Utricularia gibba* fill much of the water column up to 6 feet deep.

Utricularia gibba and *Wolffia borealis* are List 2 species, ranked G5S1 (Oregon Biodiversity Information Center 2013). Presumably dispersed by waterfowl, these species are probably undercollected and not as rare as they appear to be. Voucher specimens will be submitted to Oregon State University for verification.

Flooding on the neighboring Spiering property is transforming a former agricultural field into a *Sagittaria latifolia* (wapato) marsh (Figure 6), and wapato plants are becoming established in former ash forest on adjacent Metro property.

A generalized map of vegetation in 2015 is shown in Figure 7. Accurate mapping of aquatic bed vegetation was problematic because patches of *Brasenia schreberi*, *Persicaria hydropiperoides*, and *Potamogeton natans* intermingle, and coloration in all three species can range from green to coppery-brown, depending on maturation of the plants. The extent and configuration of patches also changes from year to year, so imagery from 2014 did not match what we saw in 2015.

Exotic plant species. The primary exotic species seen at Killin were *Impatiens capensis*, *Myriophyllum spicatum*, *Nymphaea odorata*, *Phalaris arundinacea*, and *Solanum dulcamara*. *Impatiens capensis* is most notable in the lower lake area near the beaver dam, but it does not appear plentiful because it probably cannot compete with *Phalaris arundinacea*. *Myriophyllum spicatum* is one of the dominant aquatic bed species, and will continue to increase its biomass over time, as will the other aquatic macrophytes. Although it is exotic and a well-known pest for boaters, it does create habitat for fish, invertebrates, and epiphytic algae. It is also an effective sediment trapper, contributing organic and inorganic sediment to the lakebed, enhancing the slow reversal of the subsided lakebed caused by historical drainage and oxidation. We saw two individual plants of *Nymphaea odorata*, each consisting of a single or a few leaves. This plant is invasive, and we pulled up what we saw but did not get the roots out, so Metro should be vigilant to prevent this species from establishing. In 1990-2002, *Phalaris arundinacea* was abundant and the primary understory species under both willows and ash, so its persistence in 2015 is no surprise. It dominates all elevated sites around the margins of the lake, and becomes a persistent emergent species as the lake becomes shallower west of the Kistner barn. *Solanum dulcamara* was scant along the north bank of the lake and near the beaver dam, where it was emergent in shallow water. This can spread and become problematic, so should be monitored.

Historical vegetation of Killin Wetland

Aside from more recent observations made by Christy in 1990-2002, reference to only three historical species specific to Killin Wetland have been located (Trutch and Trutch 1855). These, along with herbarium records and literature reports from similar sites on Labish, Semiahmoo and Wapato soils, provide a list of 117 native species that could be used to enhance restoration work at Killin Wetland (Table 1).

Historical wetland vegetation at Labish sites was composed of an unusual combination of species typical of low-elevation interior valleys, as well as elements from both montane and coastal peatlands. Species from coastal or Cascade peatlands, now extremely rare in the Willamette Valley and to a lesser extent in the Puget Trough, include *Alnus incana* ssp. *tenuifolia, Alnus viridis* ssp. *sinuata, Betula glandulosa, Betula pumila, Caltha palustris, Canadanthus modestus, Carex aperta, Carex aquatilis* var. *dives, Carex echinata* ssp. *echinata, Comarum palustre, Eriophorum gracile, Menyanthes trifoliata, Micranthes oregana, Rhododendron columbianum, Salix geyeriana, Salix pedicellaris,* and *Senecio hydrophiloides.* Additional species that are now rare in the local metro area include *Heterocodon rariflorus, Heuchera chlorantha, Potentilla norvegica* (Christy et al. 2009). All of these species are worthy targets for restoration. The historical loss of peat soils caused by drainage and oxidation may preclude reintroduction of some species that require organic soils, such as *Carex echinata, Eriophorum gracile, Rhododendron columbianum,* and *Salix pedicellaris.*

Miscellaneous site observations and recommendations for future data collection

Beaver dams and lodges. The primary beaver dam at the outlet of the lake was described by Christy (2015). In 1990, several small beaver dams existed in the main east-west drainage channel running through Killin Wetland. Near the outlet of the lake, one or two of these dams still exist, no doubt built higher than they had been in 1990, but submerged by the present lake level. These subordinate dams may work as backup structures to retain water if the main dam fails. We saw two beaver lodges in 2015, one near the outlet and a much larger one in the middle of the lower lake (Figures 6 and 8). Although scent piles and half-eaten aquatic vegetation were present on the lodge, the wood was all old. The only sign of recent beaver browse was on *Nuphar polysepala* and *Spiraea douglasii*, which is not unusual for summer diet (Pollock et al. 2015). It is possible that the beavers are importing woody browse from elsewhere at Killin, or from the irrigation ponds on the Spiering property, but we did not investigate this and saw no sign of new woody material. Paths for dragging in such material may be present, but we did not notice any from our location on the lake.

Hunting blinds and boat launches. We saw 6 duck blinds in the study area, 3 of which were on Metro property (Figure 8). Two boat launches on the Hartmann and Schlottman properties (Figure 8) presumably are used to access the blinds.

Bathymetry. Our method for measuring bathymetry was crude, and not tied to any benchmark elevation. However, it provided relative depths for various parts of the lake, and a measure of flood tolerance for wetland plants at Killin. In general, water reached a depth of 5 feet when

about 50-75 feet from shore, and depth was fairly even to a maximum of 6 feet, except in the old drainage channels that were over 7 feet deep. The bottom was hummocky, causing variation in depth, presumably because of previous sediment-trapping surface features prior to flooding, such as hummocks of *Phalaris arundinacea*. The staff gage installed by Metro just below the bridge on Cedar Canyon Road is still there, but we did not use it because it was outside of our study area. Because of the possibility of an unseen obstruction between the study area and the bridge, we could not be sure that the lake level was the same in both places.

Invertebrates. Globular colonies of the bryozoan *Pectinatella magnifica* were frequent to abundant around the margins of the lake, attached to sticks of *Spiraea* in 1-2 feet of water. Freshwater sponge (*Spongilla* sp.) also occurred on sticks in this zone, but was much less common. Dragonflies (*Aeshna* and *Plathemis*) and damselflies were the most conspicuous insects that we saw at Killin. A survey of invertebrates at Killin by the Xerces Society might shed light on water quality issues, as well as identify any species of conservation concern.

Fish. Carp are plentiful at Killin Wetland, as are minnows or chub up to about 4 inches long, the latter using aquatic bed vegetation as cover. We do not know species of fish, and recommend that a fish survey be conducted to identify any species of conservation concern.

Amphibians. We saw several egg masses in the lake that most likely were those of the Northwestern salamander. These were hard to identify because it was late in the season and egg masses were deteriorating. Bullfrogs are plentiful at Killin, and were especially vocal in the area below the Kistner barn. Other species of amphibians may be present at Killin, but due to the timing of our visits, these would have been difficult to detect. As with invertebrates, a survey of amphibians at Killin might shed light on water quality issues, as well as identify any species of conservation concern.

Birds. We observed Canada geese, mallards, wood ducks, great blue herons, and kingfishers at Killin. In April, the bald eagle nest on Metro's adjoining Moore property (Christy 2012) was active.

Mammals. Aside from beavers, the only other obvious mammal sign that we saw were the floating scat pellets of nutria. Nutria feed on herbaceous vegetation, and while this is the preferred summer food of beavers also, there seems plenty of food for all at Killin. A variety of small mammals such as mink, voles, shrews and possibly muskrats are probably present at Killin.

Water quality. We did not measure water quality, but this could be done with simple measurements of conductivity, pH, temperature, and clarity. The water in Killin Wetland is eutrophic, indicated by the predominance of *Ceratophyllum demersum, Elodea canadensis, Lemna minor, Myriophyllum spicatum*, and *Potamogeton berchtoldii* (Seddon 1972). Beavers and carp both cause turbidity in the water, which was most pronounced behind the beaver dam in April and June, and in weedy shallows during a visit in July. In April and June, away from the areas with obvious turbidity, visibility in the lake was about 2 feet. Clarity to at least this depth is required by both *Spongilla* and the bryozoan *Pectinatella*, both of which also prefer circumneutral pH (Klots 1966). Growth of algae on the surface and on submerged macrophytes,

particularly on *Myriophyllum spicatum*, was more noticeable in June than in April, presumably corresponding to rising water temperatures near the peak of the growing season.

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Table 1. Historical and existing vascular and bryophyte flora of Killin Wetland and related Labish soil sites, 1884-2015. Herbarium acronyms: HPSU = Portland State University; ID = University of Idaho; NY = New York Botanical Garden; OSC = Oregon State University; US = Smithsonian Institution; WS = Washington State University; WTU = University of Washington.

Taxon	Family	Native/ Exotic	Historical (all Labish sites)	Current (Killin)	Source
Acer circinatum	Sapindaceae	N	Labish 1852	–	Hyde 1852a; Powers 1919; Strozut 1959; Steusloff 1980
Agrostis exarata	Poaceae	N	Labish 1916	–	Nelson 1918, 1919
Agrostis oregonensis	Poaceae	N	Labish 1916	–	OSC (Nelson)
Alisma triviale	Alismataceae	N	Killin 1991	–	Christy 1991
Alnus incana ssp. *tenuifolia*	Betulaceae	N	Labish 1916	–	OSC (Peck)
Alnus rubra	Betulaceae	N	Beaver Swamp [Beaverton] 1852; Coffee Lake 1852; Onion Flat 1852; Killin 1855	2015	Ives 1852a, b, c; Trutch & Trutch 1855; Powers 1919; Strozut 1959; Steusloff 1980; Peterson 1986)
Alnus viridis ssp. *sinuata*	Betulaceae	N	Killin n.d.	–	Kral 2014
Azolla sp. (sterile)	Salviniaceae	N	Killin	2015	
Beckmannia syzigachne	Poaceae	N	Labish 1916, Killin 1993	–	OSC (Peck); Christy 1993
Betula glandulosa	Betulaceae	N	Labish 1917	–	OSC (Gorman)
Betula pumila	Betulaceae	N	Labish 1871-1922	–	OSC, WS (Gorman, Howell, Nelson, Peck); Howell 1897-1903; Nelson 1918 (as *B. hallii*)
Bidens cernua	Asteraceae	N	Killin 1990, 1991	–	Christy 1990, 1991
Brasenia schreberi	Cabombaceae	N	Killin	2015	
Callitriche heterophylla var. *bolanderi*	Plantaginaceae	N	Labish 1917	–	OSC (Peck)
Callitriche stagnalis	Plantaginaceae	E	Labish 1947	–	OSC (Peck)
Callitriche verna	Plantaginaceae	N	Labish 1947, 1955	–	ID, OSC (Furtick, Peck)

Caltha palustris	Ranunculaceae	N	Labish 1893-1917	–	OSC, WTU (Gorman, Howell, Nelson, Peck); Howell 1897-1903; Nelson 1918
Canadanthus modestus	Asteraceae	N	Labish 1922	–	OSC (Nelson)
Carex sp.					Powers 1930, 1932a, 1932b
Carex aperta	Cyperaceae	N	Labish 1917	–	OSC (Peck); Nelson 1918
Carex aquatilis var. *dives*	Cyperaceae	N	Labish 1916; Killin 1993	–	OSC (Nelson); Nelson 1918; Christy 1993
Carex cusickii	Cyperaceae	N	Labish 1917, 1918; Killin 1991	–	NY, OSC (Nelson, Peck); Nelson 1918; Christy 1991
Carex densa	Cyperaceae	N	Labish 1916	–	OSC (Nelson)
Carex echinata ssp. *echinata*	Cyperaceae	N	Labish 1916	–	OSC (Nelson); Nelson 1918 (as *C. interior*)
Carex exsiccata	Cyperaceae	N	Killin 1991	–	Christy 1991
Carex obnupta	Cyperaceae	N	Killin 1990	2015	Christy 1990
Carex pachystachya	Cyperaceae	N	Labish 1916	–	OSC (Peck)
Carex scoparia	Cyperaceae	N	Labish 1916	–	OSC (Peck)
Centaurium erythraea	Gentianaceae	E	Labish 1947	–	OSC (Peck)
Ceratophyllum demersum	Ceratophyllaceae	N	Killin	2015	
Cicuta douglasii	Apiaceae	N	Killin 1993	–	Christy 1993
Collinsia grandiflora	Plantaginaceae	N	Labish 1916	–	OSC (Peck)
Collinsia multiflora	Plantaginaceae	N	Labish 1916	–	OSC (Nelson)
Comarum palustre	Rosaceae	N	Labish 1917	–	OSC (Peck); Nelson 1918
Cornus sericea	Cornaceae	N	Killin 1990	2015	Christy 1990
Crataegus douglasii	Rosaceae	N	Killin 1991	–	Christy 1991
Crataegus gaylussacia	Rosaceae	N	Labish 1917	–	OSC (Gorman)
Cyperus erythrorhizos	Cyperaceae	N	Killin 1990	–	Christy 1990
Eleocharis acicularis	Cyperaceae	N	Killin 2002	–	Christy 2002
Eleocharis obtusa	Cyperaceae	N	Killin 1991	–	Christy 1991
Eleocharis ovatus	Cyperaceae	N	Killin 2002	–	Christy 2002
Eleocharis palustris	Cyperaceae	N	Killin 1991	2015	Christy 1991
Elodea canadensis	Hydrocharitaceae	N	Labish 1955; Killin 2012	2015	OSC (Furtick); Christy 2012
Epilobium brachycarpum	Onagraceae	N	Labish 1922	–	OSC (Nelson)
Epilobium ciliatum ssp. *watsonii*	Onagraceae	N	Labish 1916	–	Nelson 1918

Equisetum arvense	Equisetaceae	N	Labish 1916	–	Nelson 1918; Dachnowski-Stokes 1936
Equisetum x *litorale*	Equisetaceae	N	Labish 1916	–	WS (Nelson)
Equisetum palustre	Equisetaceae	N	Labish 1921	–	OSC, WTU (Peck)
Eriophorum gracile	Cyperaceae	N	Labish 1895	–	OSC (Howell)
Fraxinus latifolia	Oleaceae	N	Coffee Lake 1852; Labish 1852; Onion Flat 1852; Killin 1855, 1990	2015	Hyde 1852a, b; Ives 1852a, c; Trutch & Trutch 1855; Anonymous 1913; Strozut 1959; Steusloff 1980; Peterson 1986; Christy 1990
Glyceria borealis	Poaceae	N	Killin 1993	–	Christy 1993
Glyceria occidentalis	Poaceae	N	Labish 1917	–	OSC (Peck)
Gnaphalium palustre	Asteraceae	N	Killin 1991	–	Christy 1991
Helenium autumnale	Asteraceae	N	Labish 1947	–	OSC (Peck)
Heterocodon rariflorus	Campanulaceae	N	Labish 1916	–	WS (Nelson)
Heuchera chlorantha	Saxifragaceae	N	Labish 1916	–	OSC (Peck); Nelson 1918
Impatiens capensis	Balsaminaceae	E	Killin	2015	
Juncus spp.	Juncaceae	N	Beaver Swamp [Beaverton] 1852	–	Ives 1852b
Juncus acuminatus	Juncaceae	N	Labish 1917	–	OSC (Peck)
Juncus effusus ssp. *effusus*	Juncaceae	E	Killin 2002	–	Christy 2002
Juncus hemiendytus var. hemiendytus	Juncaceae	N	Labish 1916	–	OSC, WS, WTU (Nelson, Peck); Nelson 1918 (as *Juncus uncialis*)
Leersia oryzoides	Poaceae	N	Killin 1990	–	Christy 1990
Lemna minor	Araceae	N	Killin 1991	–	Christy 1991
Lonicera involucrata var. *involucrata*	Caprifoliaceae	N	Killin 2002	–	Christy 2002
Ludwigia palustris	Onagraceae	N	Killin 1991	2015	Christy 1991
Lysichiton americanus			Labish		Strozut 1959
Lysimachia thyrsiflora	Primulaceae	N	Labish 1892	–	OSC, WTU (Howell)
Malus fusca	Rosaceae	N	Coffee Lake 1852; Killin 1991	–	Ives 1852c; Christy 1991
Mentha longifolia	Lamiaceae	E	Labish 1930	–	OSC (Ellis)
Menyanthes trifoliata	Menyanthaceae	N	Labish 1916, 1917	–	OSC, WS (Gorman, Nelson); Nelson 1918

Micranthes oregana	Saxifragaceae	N	Labish 1893-1916	–	NY, OSC, US, WS, WTU (Howell, Peck)
Mitella caulescens	Saxifragaceae	N	Labish 1916	–	OSC (Peck)
Myosurus minimus	Ranunculaceae	N	Labish 1917	–	WTU (Peck); Nelson 1918
Myriophyllum spicatum	Haloragaceae	E	Killin	2015	
Nuphar polysepala	Nymphaeaceae	N	Beaver Swamp [Beaverton] 1852; Labish 1910; Killin 2012	2015	Ives 1852b; Drake 1910; Dachnowski-Stokes 1936; Christy 2012
Nymphaea odorata ssp. *odorata*	Nymphaeaceae	E	Killin	2015	
Persicaria amphibia	Polygonaceae	N	Killin 2002	–	Christy 2002
Persicaria hydropiper	Polygonaceae	E	Killin 1991	–	Christy 1991
Persicaria hydropiperoides	Polygonaceae	N	Killin 1990	2015	Christy 1990
Phalaris arundinacea	Poaceae	E	Killin 1991	2015	Christy 1991
Phragmites australis	Poaceae	?	Labish 1916	–	OSC, WS (Nelson); Nelson 1918, 1919
Physocarpus capitatus	Rosaceae	N	Onion Flat 1852; Killin 2002	2015	Ives 1852a; Christy 2002
Plagiobothrys figuratus var. *figuratus*	Boraginaceae	N	Labish 1917	–	OSC (Gorman)
Platanthera dilatata var. *leucostachys*	Orchidaceae	N	Labish 1916	–	WS (Nelson)
Polygonum polygaloides ssp. *confertiflorum*	Polygonaceae	N	Labish 1916	–	OSC (Peck)
Populus trichocarpa	Salicaceae	N	Labish	–	Strozut 1959
Potamogeton spp.	Potamogetonaceae	N	?	2015	Dachnowski-Stokes 1936
Potamogeton berchtoldii	Potamogetonaceae	N	Killin 2012	2015	Christy 2012
Potamogeton epihydrus	Potamogetonaceae	N	Killin	2015	
Potamogeton natans	Potamogetonaceae	N	Killin 2012	2015	Christy 2012
Potentilla norvegica	Rosaceae	N	Labish 1922	–	OSC (Nelson)
Quercus garryana	Fagaceae	N	Killin 1855	2015	Trutch & Trutch 1855
Ranunculus aquatilis var. *aquatilis*	Ranunculaceae	N	Labish 1916	–	OSC (Peck)

Ranunculus aquatilis var. *diffusus*	Ranunculaceae	N	Labish 1917	–	WS (Gorman)
Ranunculus arvensis	Ranunculaceae	E	Labish 1916	–	OSC, WS (Nelson, Peck); Nelson 1918
Ranunculus flammula var. *flammula*	Ranunculaceae	N	Labish 1917	–	WS (Gorman)
Ranunculus repens	Ranunculaceae	E	Labish 1916	–	OSC (Peck)
Rhamnus purshiana	Rhamnaceae	N	Onion Flat 1852; Labish 1917, Killin	2015	WS (Gorman); Ives 1852a
Rhododendron columbianum	Ericaceae	N	Labish 1916	–	OSC, WS (Nelson, Peck); Nelson 1918
Rorippa curvisiliqua	Brasssicaceae	N	Killin 1991	–	Christy 1991
Rosa pisocarpa	Rosaceae	N	Killin 1990, 1991, 2012	2015	Christy 1990, 1991, 2012
Sagittaria latifolia	Alismataceae	N	Wapato Lake 1852; Killin	2015	Elder 1852
Salix spp.	Salicaceae	N	Beaver Swamp [Beaverton] 1852; Coffee Lake 1852; Labish 1852; Onion Flat 1852; Wapato Lake 1852	2015	Hyde 1852a, b; Ives 1852a, b, c; Elder 1852; Anonymous 1913; Powers 1919, 1930, 1932a, 1932b; Hall 1936; Strozut 1959; Steusloff 1980; Peterson 1986
Salix geyeriana	Salicaceae	N	Labish 1916, 1917; Killin 1991	2015	OSC (Peck); Nelson 1918; Christy 1991
Salix hookeriana	Salicaceae	N	Killin 1990, Labish 1991	–	WTU (Zika); Christy 1990
Salix lasiandra var. *lasiandra*	Salicaceae	N	Killin 1990, Labish 1991	–	WTU (Zika); Christy 1990
Salix pedicellaris	Salicaceae	N	Labish 1916, 1917	–	OSC (Gorman, Peck)
Salix scouleriana	Salicaceae	N	Labish 1991	–	WTU (Zika)
Salix sitchensis var. *sitchensis*	Salicaceae	N	Killin 2012	–	Christy 2012
Sambucus nigra ssp. *caerulea*	Adoxaceae	N	Killin	2015	
Schoenoplectus cf. *tabernaemontani*	Cyperaceae	N	Labish 1916	–	WS (Nelson); Powers 1919; Dachnowski-Stokes 1936

Scirpus microcarpus	Cyperaceae	N	Killin 2002	–	Christy 2002
Scutellaria galericulata	Lamiaceae	N	Labish 1917	–	WS (Nelson); Nelson 1918
Senecio hydrophiloides	Asteraceae	N	Labish 1895-1917	–	OSC, NY, WS (Gorman, Howell, Peck
Senecio integerrimus var. *exaltatus*	Asteraceae	N	Labish 1916	–	OSC (Peck); Howell 1897-1903; Nelson 1918
Sisyrinchium bellum	Iridaceae	N	Labish 1916	–	OSC (Peck)
Solanum dulcamara	Solanaceae	E	Killin	2015	
Sparganium emersum	Typhaceae	N	Killin 1990	2015	Christy 1990
Spiraea douglasii var. *douglasii*	Rosaceae	N	Beaver Swamp [Beaverton] 1852; Coffee Lake 1852; Onion Flat 1852; Killin 1990	2015	Ives 1852a, b, c; Powers 1919; Christy 1991
Spirodela polyrrhiza	Araceae	N	Killin	2015	
Symphyotrichum hallii	Asteraceae	N	Labish 1947	–	OSC (Peck)
Tiarella trifoliata var. *trifoliata*	Saxifragaceae	N	Labish 1916	–	OSC (Peck)
Torreyochloa pallida var. *pauciflora*	Poaceae	N	Killin 1991	–	Christy 1991
Typha spp.	Typhaceae	N	Beaver Swamp [Beaverton] 1852	–	Ives 1852b; Strozut 1959
Typha latifolia	Typhaceae	N	Labish 1916, Killin 1990	–	WS (Nelson); Powers 1919; Christy 1990
Utricularia gibba	Lentibulariaceae	N	Killin	2015	
Viola blanda	Violaceae	N	Labish 1884	–	HPSU (Howell)
Viola palustris	Violaceae	N	Labish 1917	–	OSC (Peck)
Vulpia microstachys	Poaceae	N	Labish 1916	–	OSC (Peck)
Wolffia borealis	Araceae	N	Killin	2015	

Figure 1. Top: self-designed revegetation at Killin Wetland, 1990. Bottom: same view after deep flooding by beaver, 2015.

Figure 2. Top: self-designed revegetation at Killin Wetland, 1991. Bottom: same view after deep flooding by beavers, 2015.

Figure 3. Willows (top) and ash (bottom), killed by beaver flooding between 2001 and 2015.

Figure 4. Feeble sprouting by *Salix geyeriana* in water 3-5 feet deep, 2015.

Figure 5. Expanding aquatic beds of *Nuphar polysepala* (top) and *Potamogeton natans* and *Brasenia schreberi* (bottom), 2015.

Figure 6. Beaver lodge near center of east end of lake (top) and wapato marsh developing on flooded Spiering property (bottom), 2015.

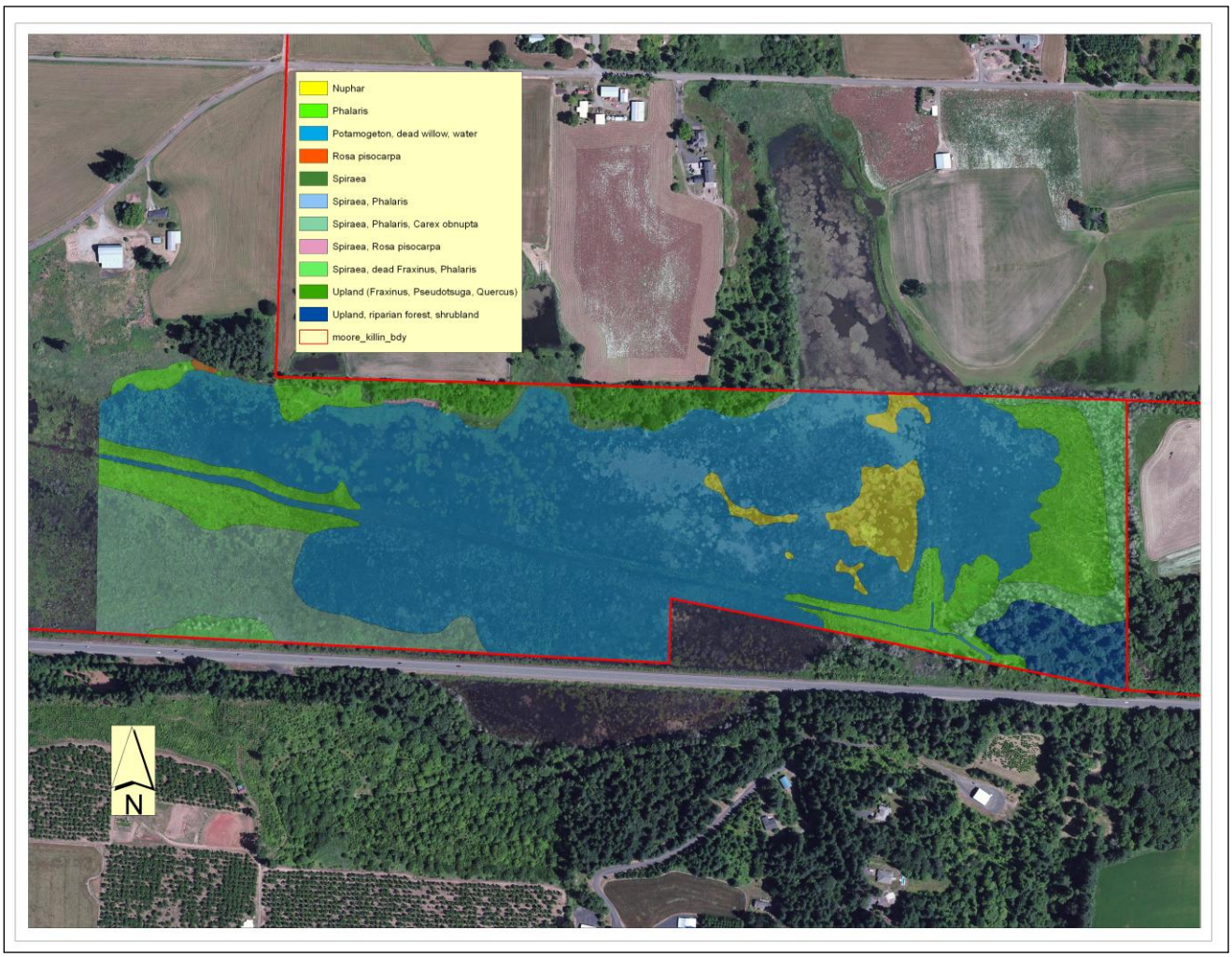

Figure 7. Generalized vegetation map, Killin Wetland, 2015.

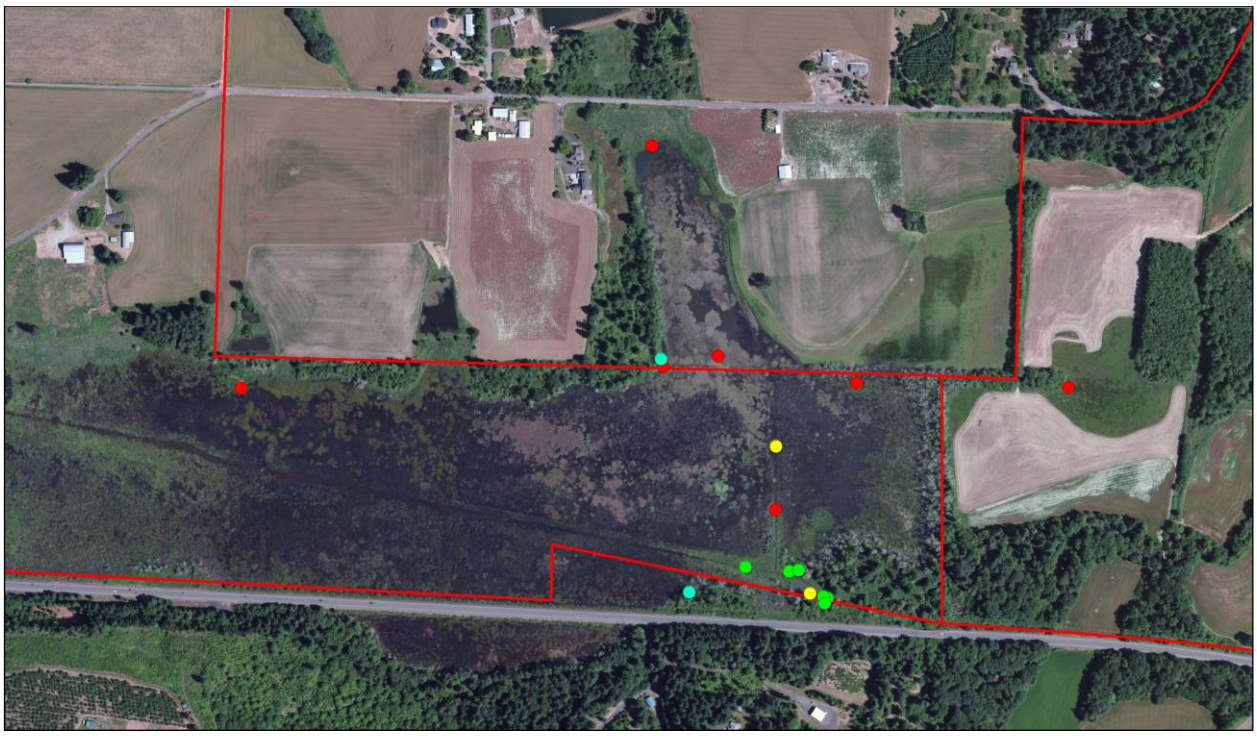

Figure 8. Miscellaneous features at Killin Wetland, 2015. Green = beaver dams; Yellow = beaver lodges; Red = hunting blinds; Light blue = boat launches.