CHAPTER 10 THE HYDROLOGIC REQUIREMENTS OF COMMON PACIFIC NORTHWEST WETLAND PLANT SPECIES

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INTRODUCTION

The vegetation and associated hydrologic regime of wetland study sites located in the Puget Sound Basin was evaluated between 1988 to 1995. Our study examined the role of hydrology in determining the vegetation composition of wetlands in the region. The observed hydrologic regime of common vegetation communities as defined by Cowardin et al. (1979) was evaluated and included forested, scrub-shrub, emergent, and aquatic bed type communities.

Additionally, the hydrologic requirements of individual species was examined in order to determine the optimal conditions and tolerances for some common wetland plants. Several hydrologic conditions present where plant species were growing, including water depth and water level fluctuation (WLF), were examined seasonally and annually. This paper presents an analysis of some of these vegetation and hydrology associations.

METHODS

The wetlands evaluated in this study are inland palustrine wetlands ranging in elevation from 50 m to 100 m above mean sea level and characterized by a mix of forested, scrub-shrub, emergent, and aquatic bed wetland vegetation classes. Twenty-six wetlands total were surveyed. In addition to the nineteen study wetlands surveyed at least three times between 1988 and 1995, the data set also includes seven other wetlands which were surveyed at least once during the years 1993, 1994 and 1995 as part of several related studies.

Sample plots were assigned a category based on the dominant structure of the vegetation community classified in the Cowardin system (Cowardin et al. 1979). The categories included aquatic bed (PAB), emergent (PEM), scrub-shrub (PSS), forested (PFO), upland, or some transition zone between them, for example, PEM/PSS. In some cases vegetation communities changed over time and were then re-categorized. Plant species presence was sampled in permanent plots established every 50 M installed along a gradient from the upland through the transition zones and, at intervals, crossing the different wetland vegetation communities.

The year was divided into four seasonal periods important to plant growth, early growing season, defined to be from March 1 through May 15, intermediate growing season which lasts from May 16 to August 31, senescence lasting from September 1 to November 15th and dormancy and decay, November 16 to February 28. The seasonal hydrologic regime was calculated for each vegetation sample station from 1988 to 1995. Species found in each sample station were associated with the seasonal hydrologic regime we observed at the station . This data was used to describe a hydrograph for many commonly found wetland plants showing typical conditions for mean and maximum water depths and water level fluctuation. This method presumes that plant species presence is associated with conditions favorable to their survival and that, with sufficient observations, ranges of hydrologic conditions successfully tolerated by species, could be determined.

Hydrologic measurements, including instantaneous water levels from staff gauges for measuring typical water level conditions and peak levels from crest gauges to measure depths from storm events occurring between gauge visits, were recorded at least eight times annually (measured every four to six weeks) while water was present in the wetlands (Reinelt and Horner 1990). Gauge measurements were averaged to obtain mean and maximum water depth for each season or for the year. Water level fluctuation (WLF) was computed as the difference between the peak level and the average of the current and previous instantaneous water levels for each four to six week monitoring period. Mean WLF was calculated by averaging all WLFs for a given season or year.

The elevation of each vegetation community was surveyed in order to tie the hydrologic conditions found at the gauge site with the vegetation communities observed at the sample stations. The elevation of all vegetation plots relative to the water depth measured at the wetland gauge was used to determine the likely water depths at the vegetation sample stations for a given sampling date (Figure 10-1).

The method assumed that the water depth measured at the staff gauge would accurately reflect the hydrologic conditions found throughout the wetland, after the data was corrected for elevation. This was not always true as hydrologic conditions in and around the plots sometimes varied from the conditions predicted through elevation change alone. Sometimes intervening topography or large woody debris would produce localized impoundments or dry hummocks unaccounted for in our methods which may affect the accuracy of our results. Whenever such plots were identified we made more accurate surveys or eliminated the plots from the analysis. In addition, our method did not determine whether soils were dry or saturated. We could only estimate saturation given the water depths found at the gauge.

$$D = G - E$$

where: D = water depth at the vegetation plot
G = gauge reading, depth above zero water level and
E = plot survey elevation above zero water level

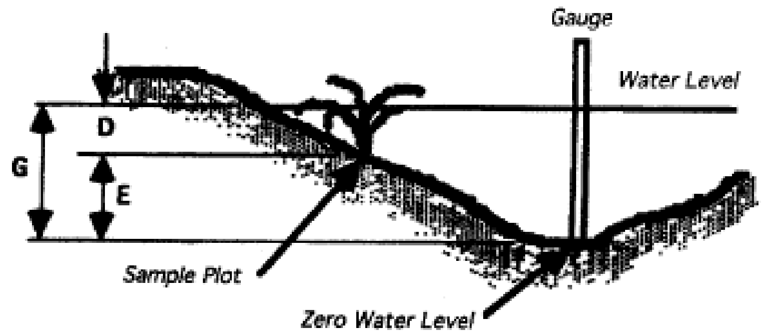


Figure 10-1 Relationship between water depth at vegetation sample plot and the depth at the water gauge (Taylor 1993).

Negative numbers in the hydrographs are interpreted as below the water surface, or inundated. Positive numbers represent the distance, in elevation, above the water surface. Negative numbers are interpreted as depth of inundation. Positive numbers indicate the plant or community being examined is dry during that period. Bar charts show the median and the central 80% of the range of observations for the condition being evaluated. The solid portion of the bar represents the central 50% of observations. We eliminated outliers from our analysis because we wanted to define the most likely range of wettest to driest conditions where particular wetland communities or species would be found.

RESULTS

Hydrologic Regimes By Community Type

The range of average conditions we calculated for instantaneous and maximum water depths found during the study period was in the PEM, PFO, PAB, and PSS communities are displayed in Figure 10-2. The solid bars in the figure show 50% of observations and, including the tails, represent 80% of observations. Forested communities were, as expected, the driest of the community types with a median of 62 cm above typical water levels, and ranged from about 12 cm inundation to about 210 cm above typical water levels. By contrast, the annual instantaneous median condition in the emergent zones was about 5 cm inundation and ranged from 96 cm of inundation to about 28 cm above typical water levels.

The biggest variation from wet to dry conditions through the year was observed in the PSS communities where the median condition for instantaneous water depths was 18 cm above water levels but decreased to 0 for maximum water depth conditions. This corresponds to field observations of different types of shrub communities. Willow dominated communities (*Salix lucida* var. *lasiandra*, *S. sitchensis*) including red stem dogwood (*Cornus sericea*) represent the wetter shrub communities, while Scouler willow (Salix scouleriana), salmonberry (*Rubus spectabilis*), and black twinberry (*Lonicera involucrata*) represent the drier shrub communities. While the central 50% of observations depict the scrub-shrub communities as saturated to dry under normal conditions, during storm events, represented by the maximum depth, conditions in the PSS zones were much wetter, ranging between about 40 cm of inundation to 25 cm above water levels.

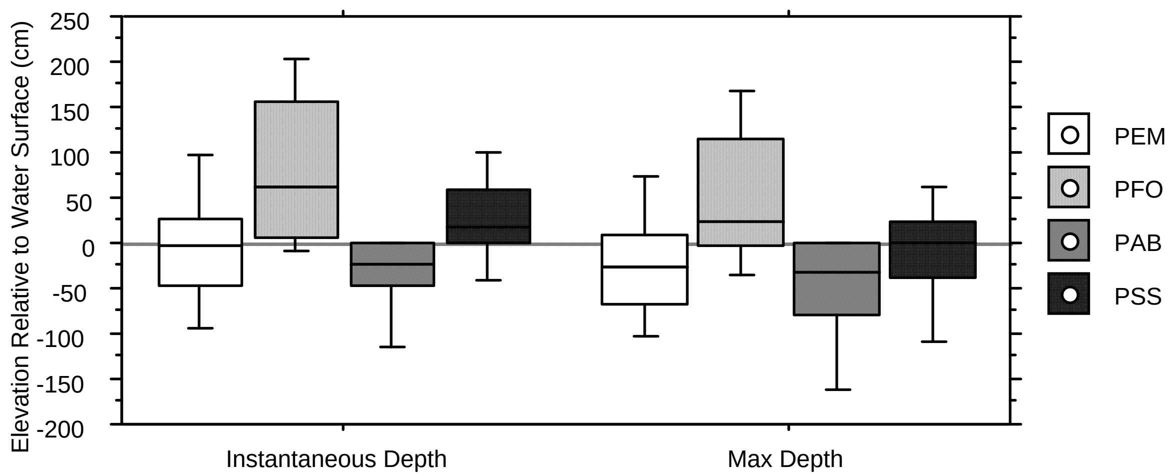


Figure 10-2. Annual mean instantaneous and maximum water depths (Max) associated with vegetation community types, 1988 through 1995.

In fact, annual water level fluctuation averaged 21 cm among all scrub-shrub zones as compared with about 12 cm in the aquatic bed communities and 14 cm in the emergent zones. Forested zones were usually at an elevation above surface inundation, so water level fluctuation was not a significant factor. Aquatic bed communities were observed to have very high water level fluctuations averaging 60 cm as compared with 11 cm and 18 cm, respectively, for emergent and scrub-shrub zones. Figure 10-3 shows the median and range of water level fluctuation calculated in each zone for all four seasons. Open water and scrub shrub zones showed the greatest variation in water level fluctuation between seasons while emergent zones were fairly stable. The median WLF for the aquatic bed zones was always less than 20 cm however the range of observations was quite a bit higher than seen in other community types, in all seasons, but particularly the early growing season of March through May.

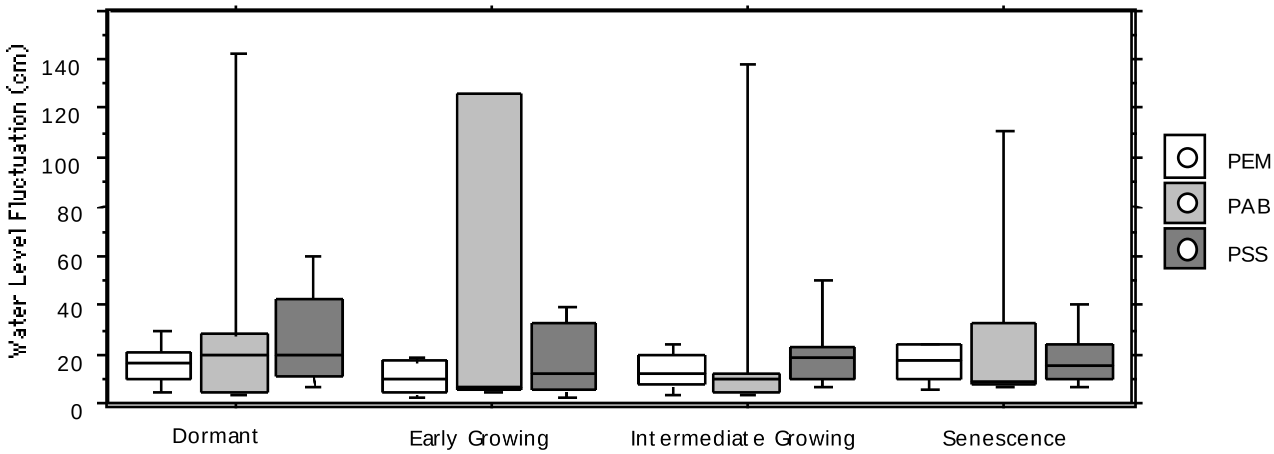


Figure 10-3. Water level fluctuation associated with vegetation community types in each season.

The range of instantaneous and maximum water levels for all seasons were plotted for each vegetation zone and are shown in Figures 10-4 through 10-7. The seasonal changes in each community are apparent in the box plots. The period of senescence, September through November is definitely drier in all zones, including the aquatic bed communities. Most aquatic bed zones had no surface water during this period except during storm events although many were observed to have saturated soils. Most emergent communities were inundated most of the year with the exception of during senescence. Forest wetland communities were relatively wetter during the early growing season than other seasons unlike the other community types which were mostly wettest during the dormant season.

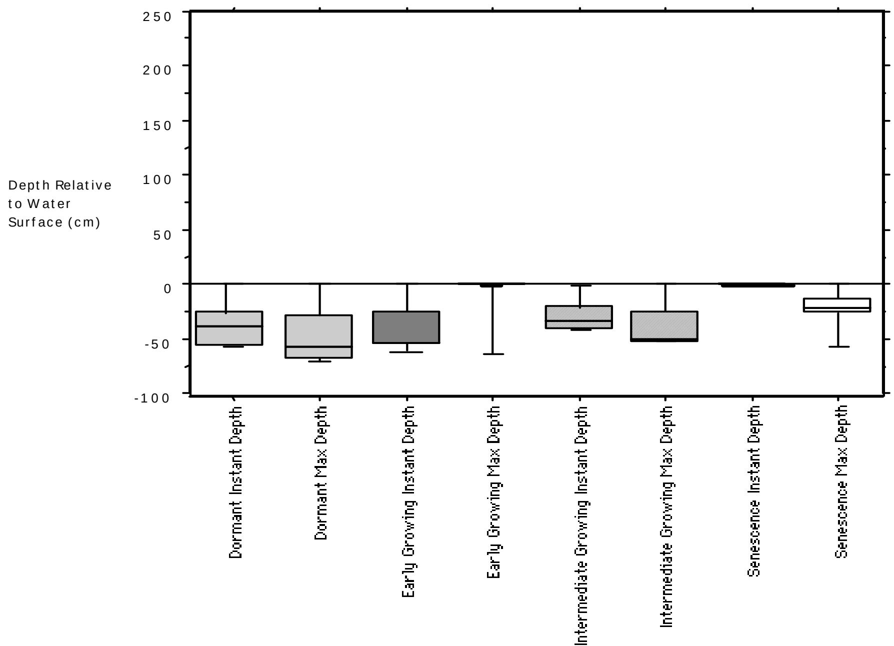


Figure 10-4. Seasonal hydrology associated with aquatic bed communities.

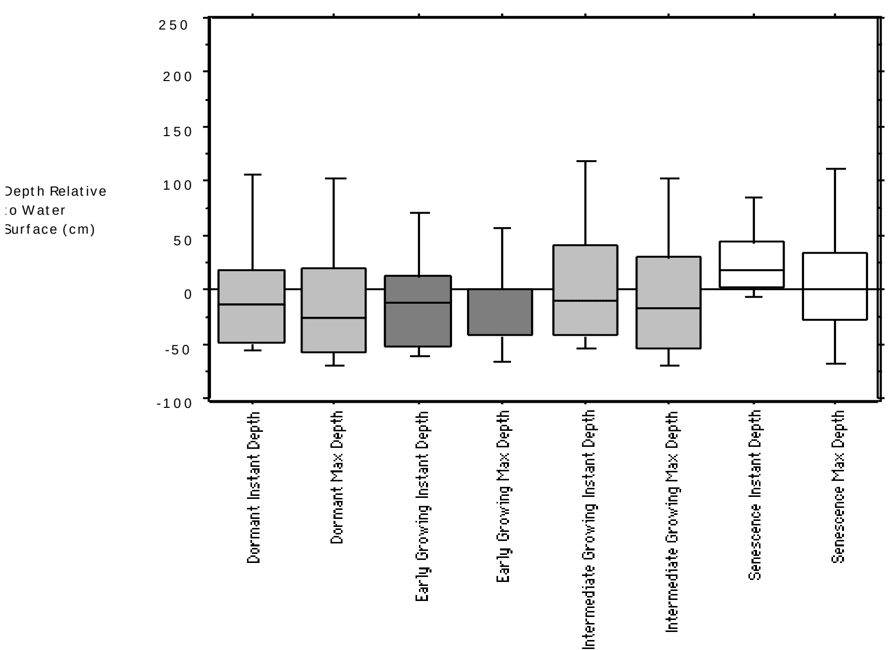


Figure 10-5. Seasonal hydrology associated with emergent communities.

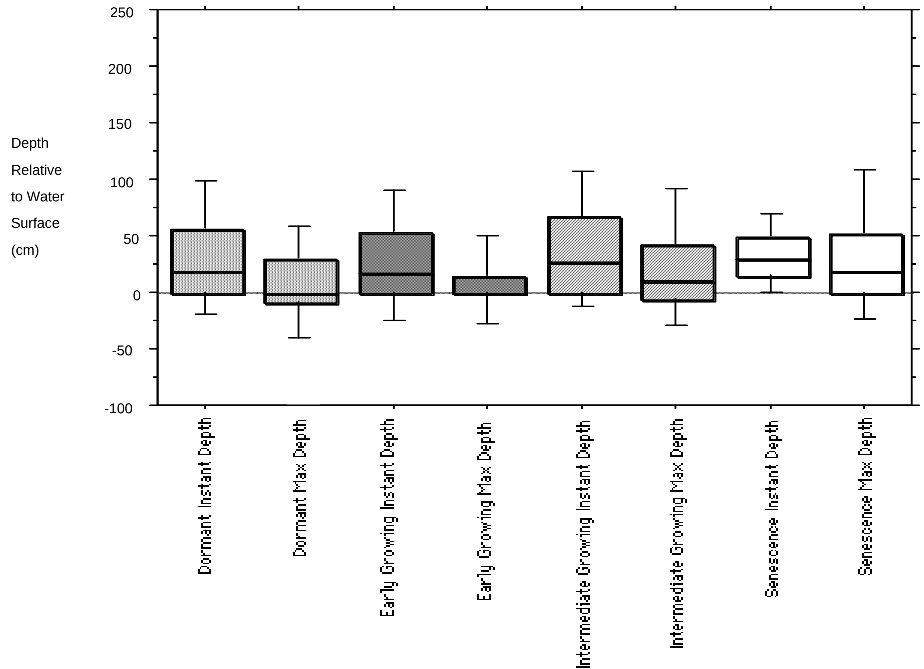


Figure 10-6. Seasonal hydrology associated with scrub-shrub wetland communities.

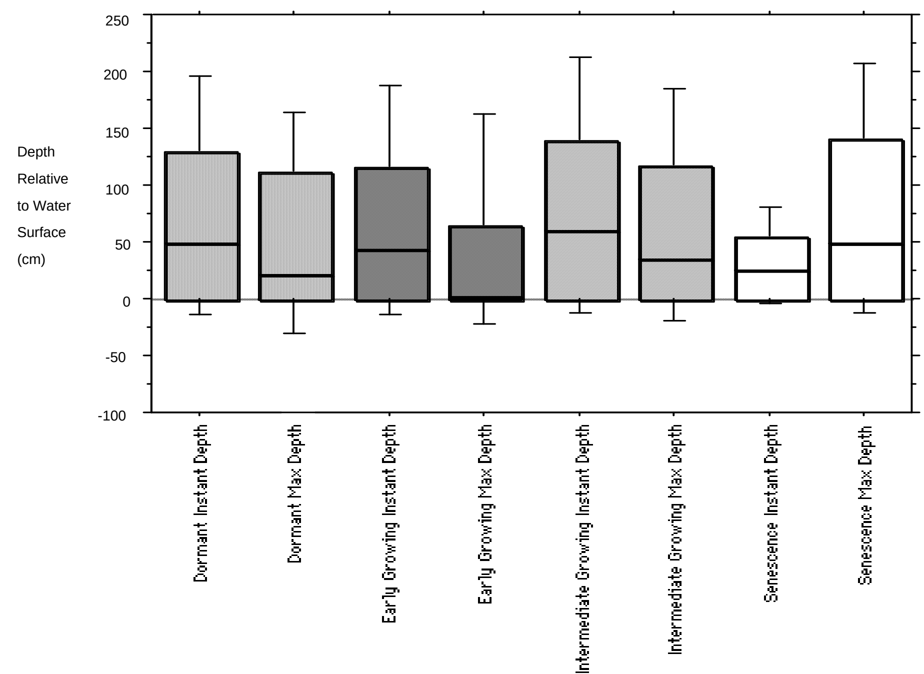


Figure 10-7. Seasonal hydrology associated with forested wetland communities.

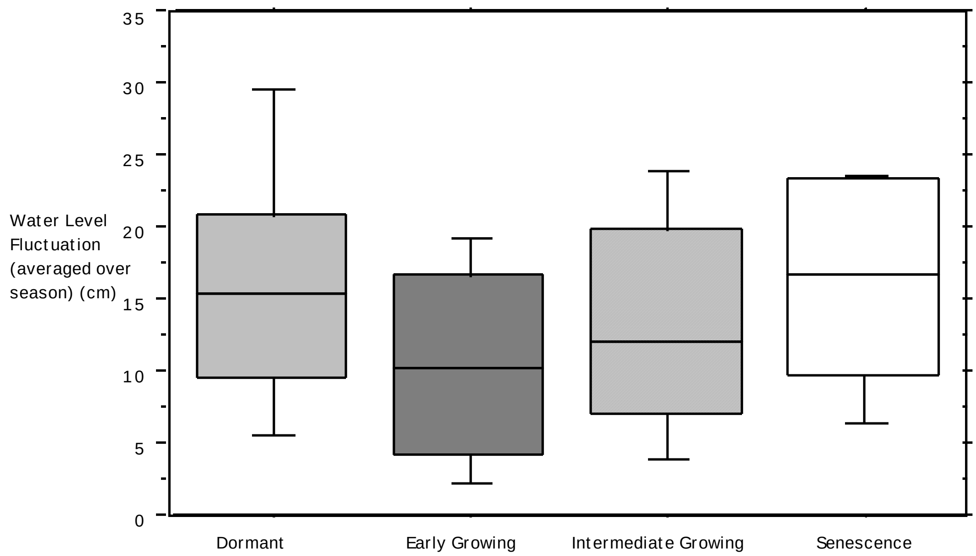


Figure 10-7. Seasonal WLF in the emergent zone.

Individual Plant Hydrologic Requirements

The hydrologic regime for some common wetland species was determined in the same manner as for the wetland zones. Black cottonwood (*Populus balsamifera* spp. *trichocarpa*) was mostly found in areas where there was little to no surface water during the active growing period but it was observed in stations which, on average, are inundated to 20 cm of water at some time during all seasons (Figure 10-8).

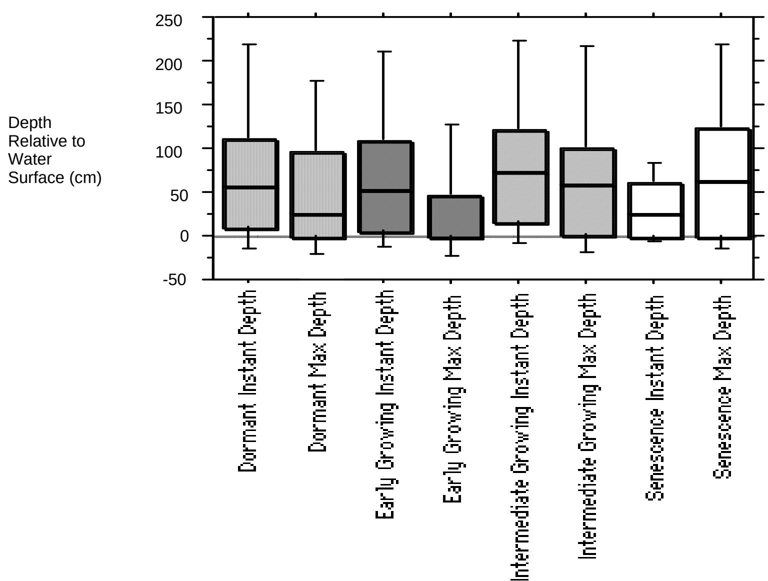


Figure 10-8. Hydrologic characteristics of instantaneous and maximum water depth (Max) of *Populus balsamifera*.

Hard hack spirea *(Spirea douglasii*) was found in a wide range of hydrologic conditions from typically dry through the year, to being frequently temporarily inundated, to complete inundation through both growing seasons (Figure 10-9). This adaptability is probably one reason why this species was among the most widely distributed in our study. In addition hard hack was found in wetlands with some of the highest water level fluctuations measured in our study, averaging as high as 57 cm in the dormant season and 35 cm in the early growing season.

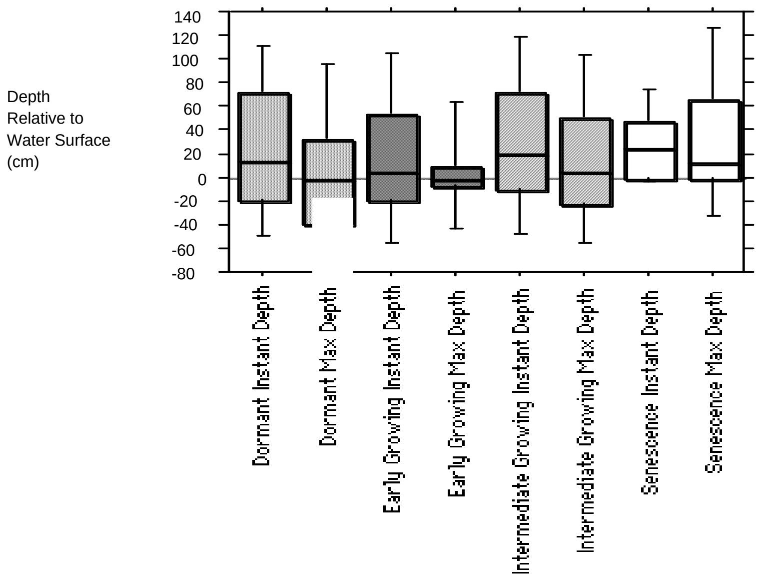


Figure 10-9 Hydrologic characteristics of instantaneous water depth, maximum water depth (Max) of *Spirea douglasii*.

Comparisons were made between plants that either fill the same niche, or are different species of the same genera but found in different habitats. Analysis of the hydrologic conditions where species were observed often showed seasonal hydrologic differences which may account for their distribution (Table 10-1). For example, two common wetland trees, red alder (*Alnus rubra)* and Oregon ash (*Fraxinus latifolia)* were both more prevalent on the drier sites we studied. Red alder differed, however, in that, it was found on many sites subjected to high average seasonal WLF (greater than 20 cm) during the early growing season, suggesting that it is frequently inundated for periods while Oregon ash was observed in areas with mostly stable water levels in the early growing season (Figure 10-10). Oregon ash was often observed in areas where the soil was organic rish and, though rarely inundated, soils were saturated for most of the growing season while red alder was mostly found growing in mineral soils that typically went dry in the summer.

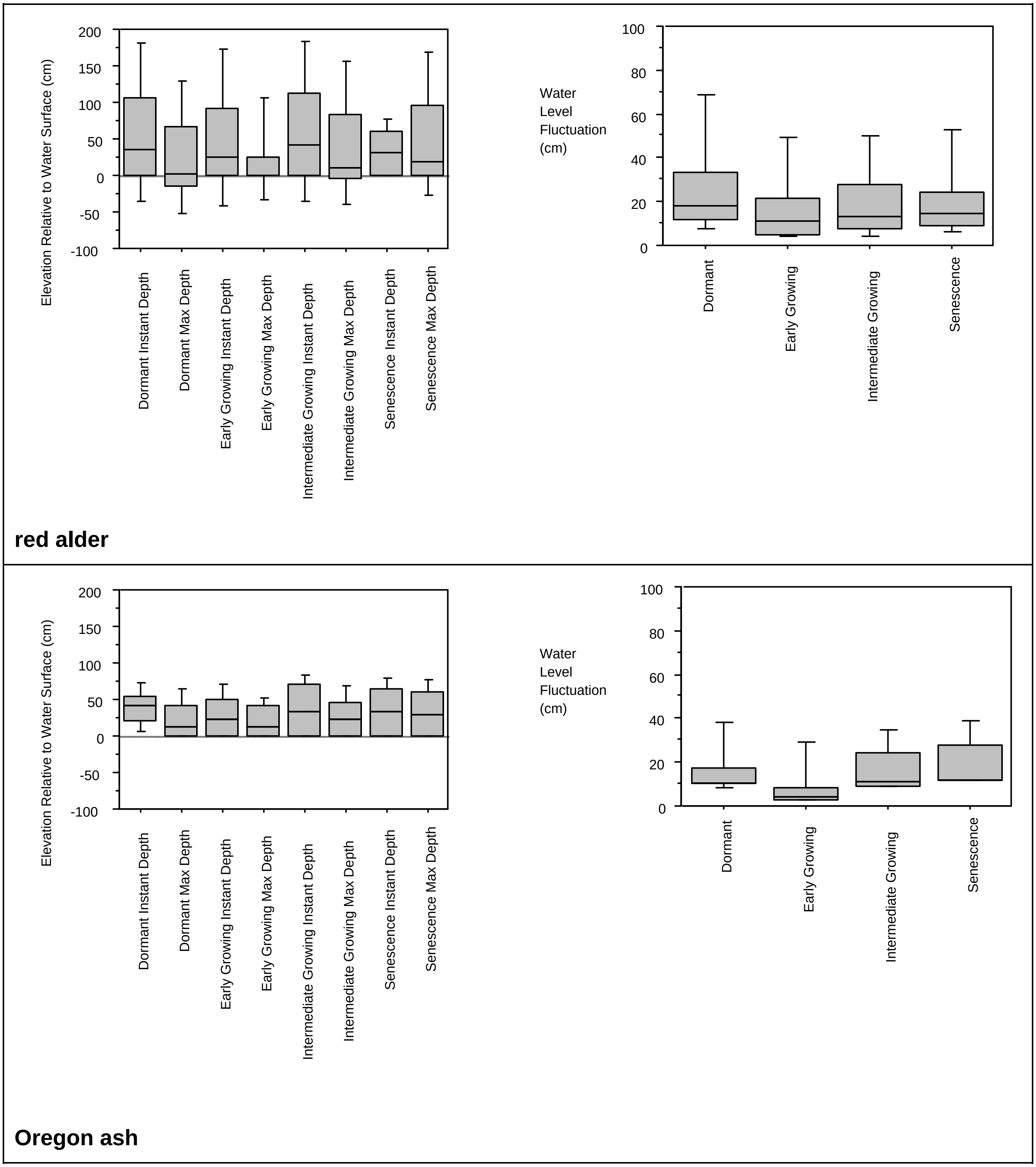


Figure 10-10. Seasonal hydrology and water level fluctuation of red alder and Oregon ash.

Scouler willow (*Salix scouleriana)* and Sitka willow *(Salix sitchensis*), two willows common in the Puget lowland, were both found in areas from inundated to dry in all seasons, but overall, the medians, means and most of the population data, indicate Sitka willow was growing closer to water than Scouler willow (Figure 10-11).

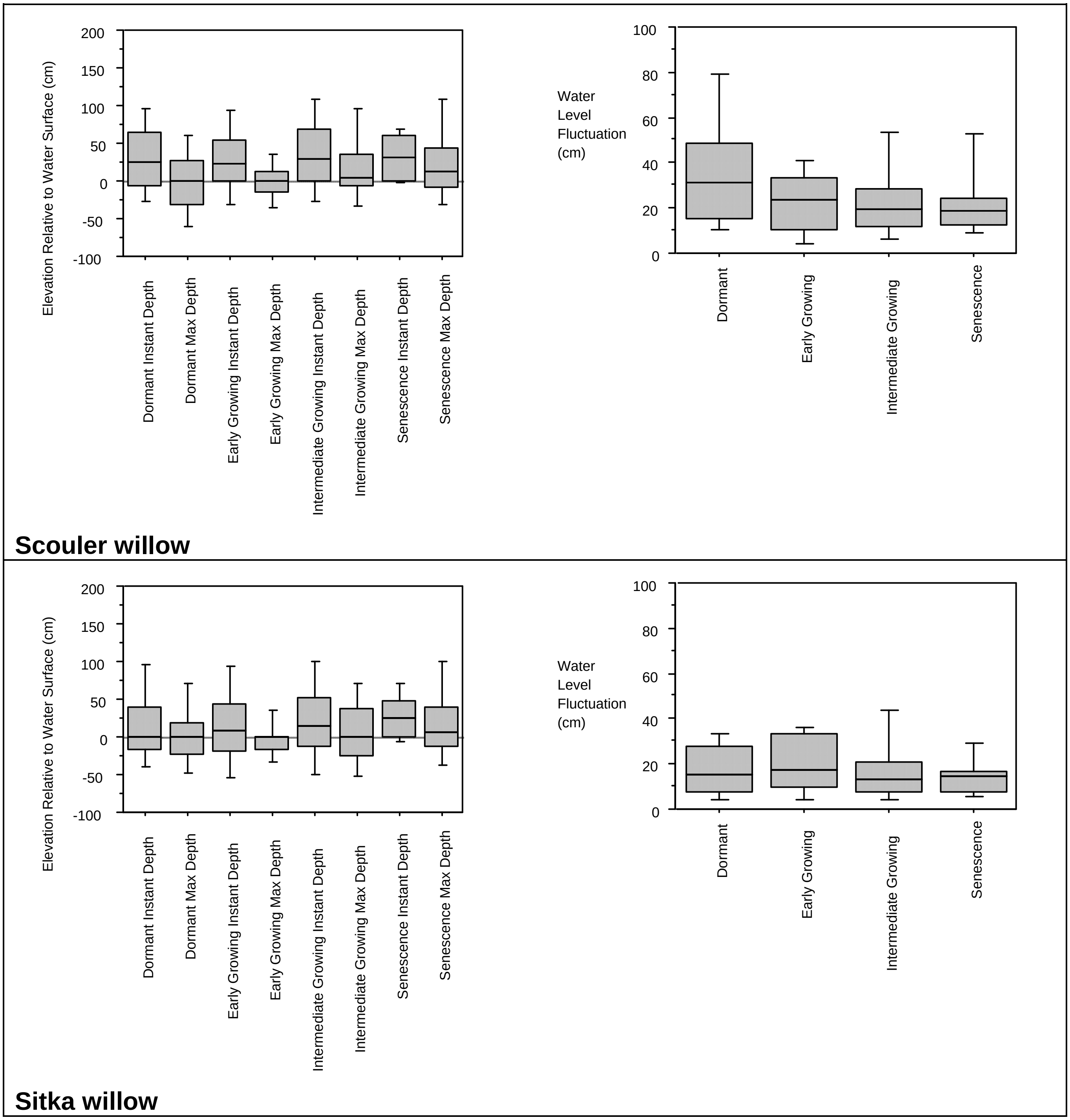


Figure 10-11. Seasonal hydrology and water level fluctuation of Scouler willow and Sitka willow.

Though both species were found growing in a similar range of conditions, tapertip rush (*Juncus acuminatus*) was found on more dry sites than soft rush (*Juncus effusus*) which was usually shallowly inundated during the early spring (Figure 10-12).

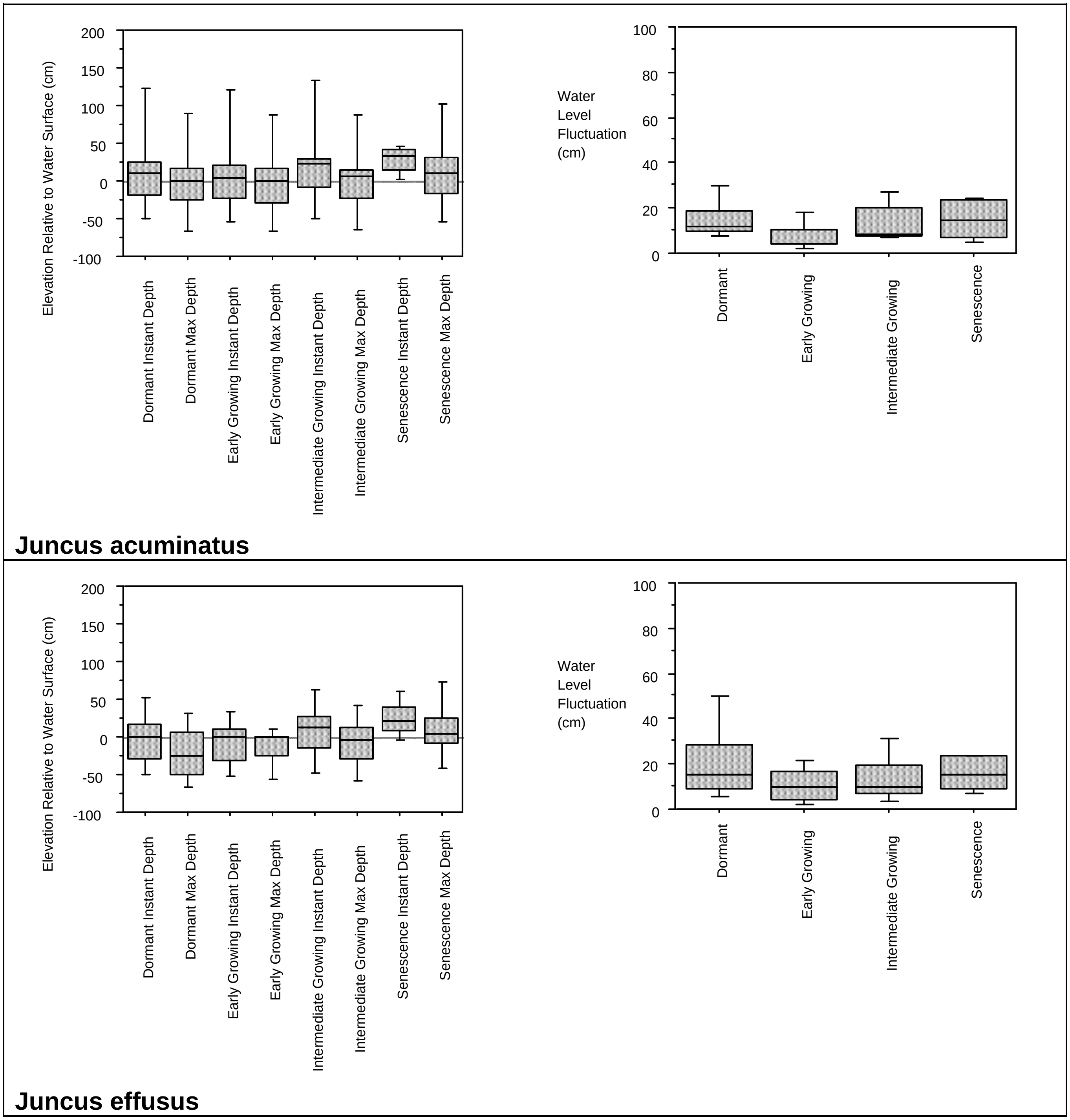


Figure 10-12. Seasonal hydrology and water level fluctuation of tapertip rush and soft rush.

Two sedges were evaluated, Slough sedge (*Carex obnupta)* which is very common in wetlands around the region, and inflated sedge (*Carex exsiccata*) (old name = *C. vesicaria*) which is found almost exclusively in relatively undisturbed wetlands (Figure 10-13). Slough sedge was found in drier areas above the water level during the early and intermediate growing seasons, while inflated sedge grew in saturated soils and areas of shallow inundation. Both species were found in areas inundated during the dormant season and both were found in conditions of high water level fluctuation.

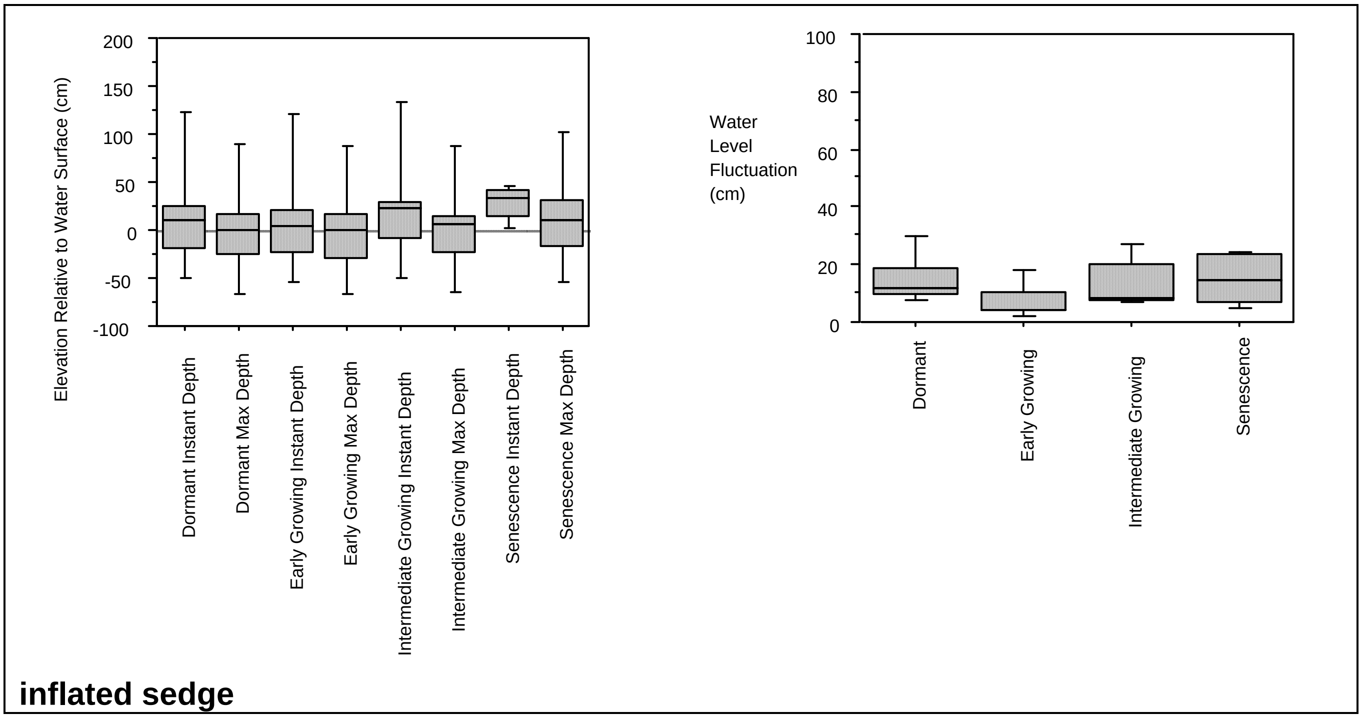
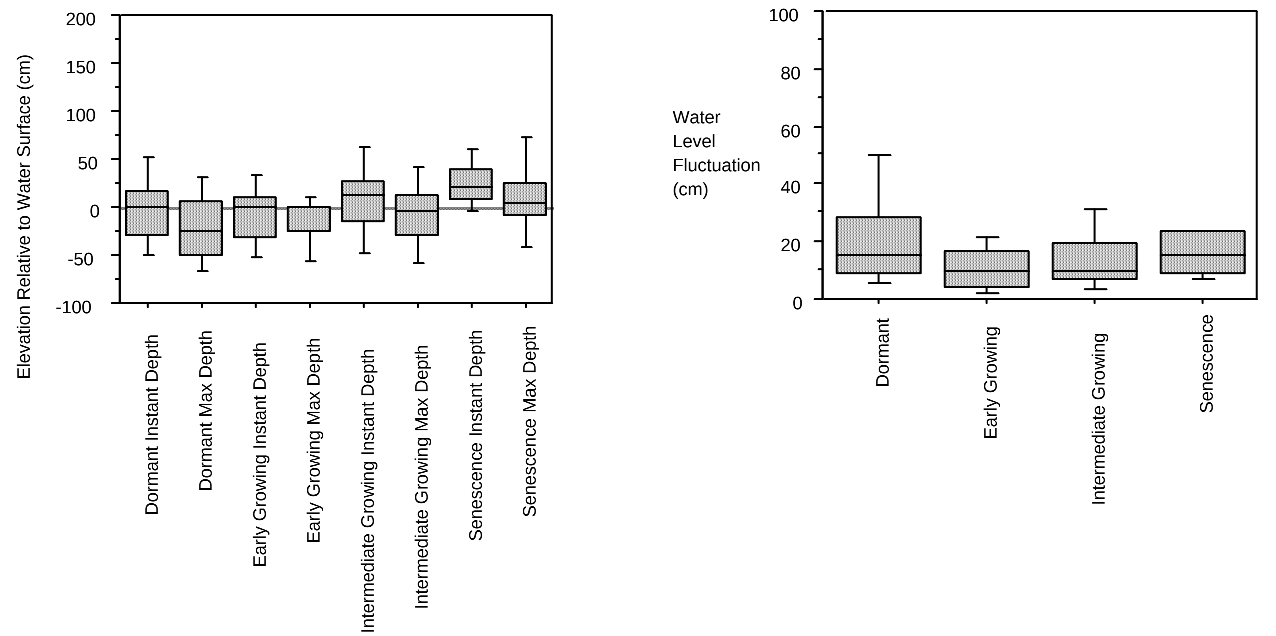


Figure 10-13. Seasonal hydrology and water level fluctuation of inflated sedge and slough sedge (figure continued next page).



slough sedge

Figure 10-13 (continued). Seasonal hydrology and water level fluctuation of inflated sedge and slough sedge.

Small fruited bulrush, *Scirpus microcarpus*, found in disturbed wetlands, and wooly sedge, *Scirpus atrocinctus* (old name = *S. cyperinus*), found in relatively undisturbed wetlands, were observed growing in similar hydrologic conditions (Figure 10-14). Wooly sedge, however, was found in slightly wetter conditions during the early growing season. In addition, small-fruited bulrush was found in wetlands with high WLF throughout the growing season where wooly sedge was not.

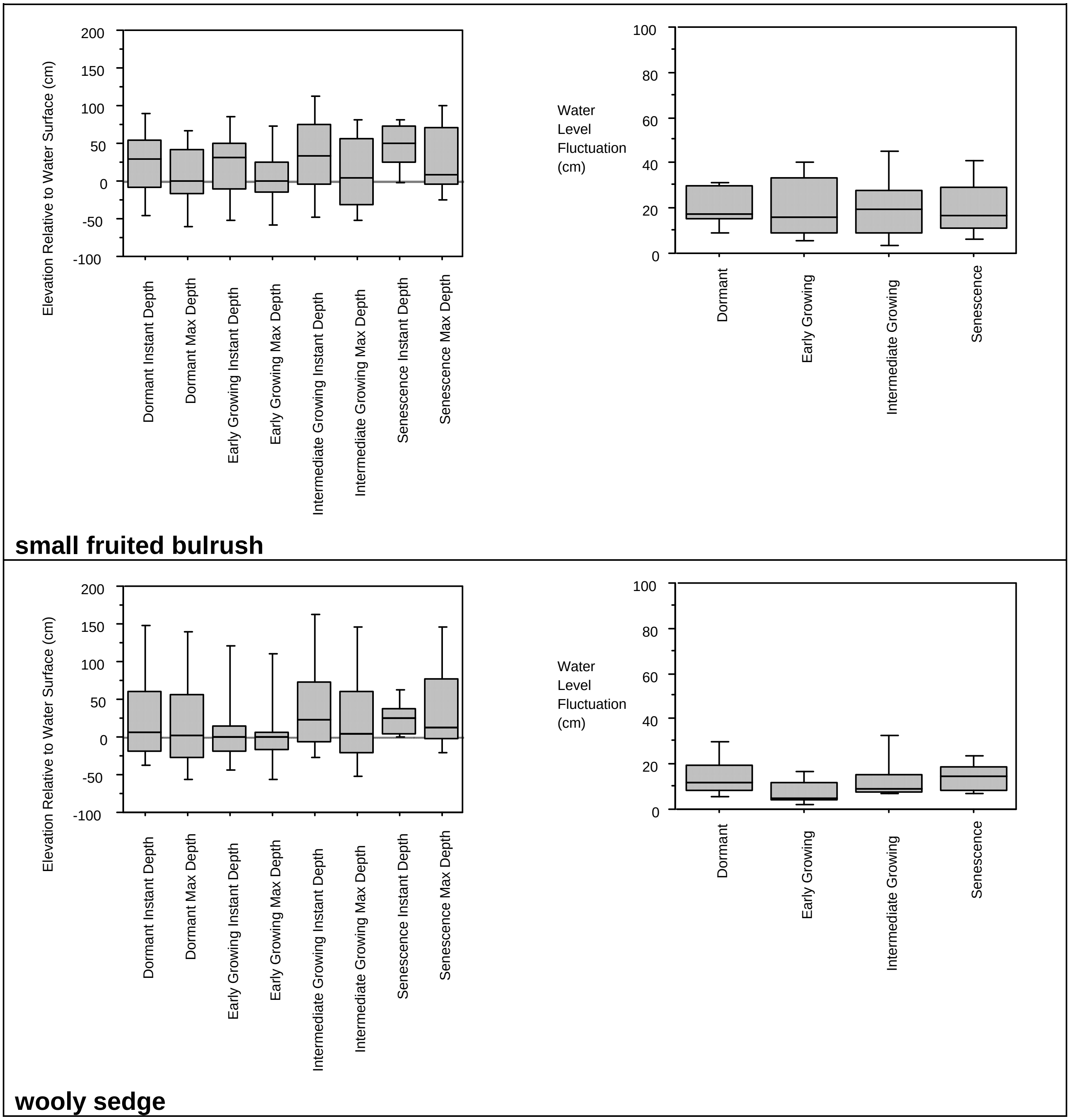


Figure 10-14. Seasonal hydrology and water level fluctuation of small fruited bulrush and wooly sedge.

Several invasive species including soft rush, reed canarygrass (*Phalaris arundinaceae)*, and cattail (*Typha latifolia)* were evaluated to see if there were hydrologic conditions common to aggressive species. Of the three, reed canarygrass grows in the driest areas, and cattail in the wettest (Figure 10-15). Reed canarygrass was found in many wetlands with very high seasonal WLF whereas cattail and soft rush were found in areas where there is low WLF except during the dormant period. The only consistent hydrologic condition shared between these species was their distribution, most commonly within the emergent zones of wetlands.

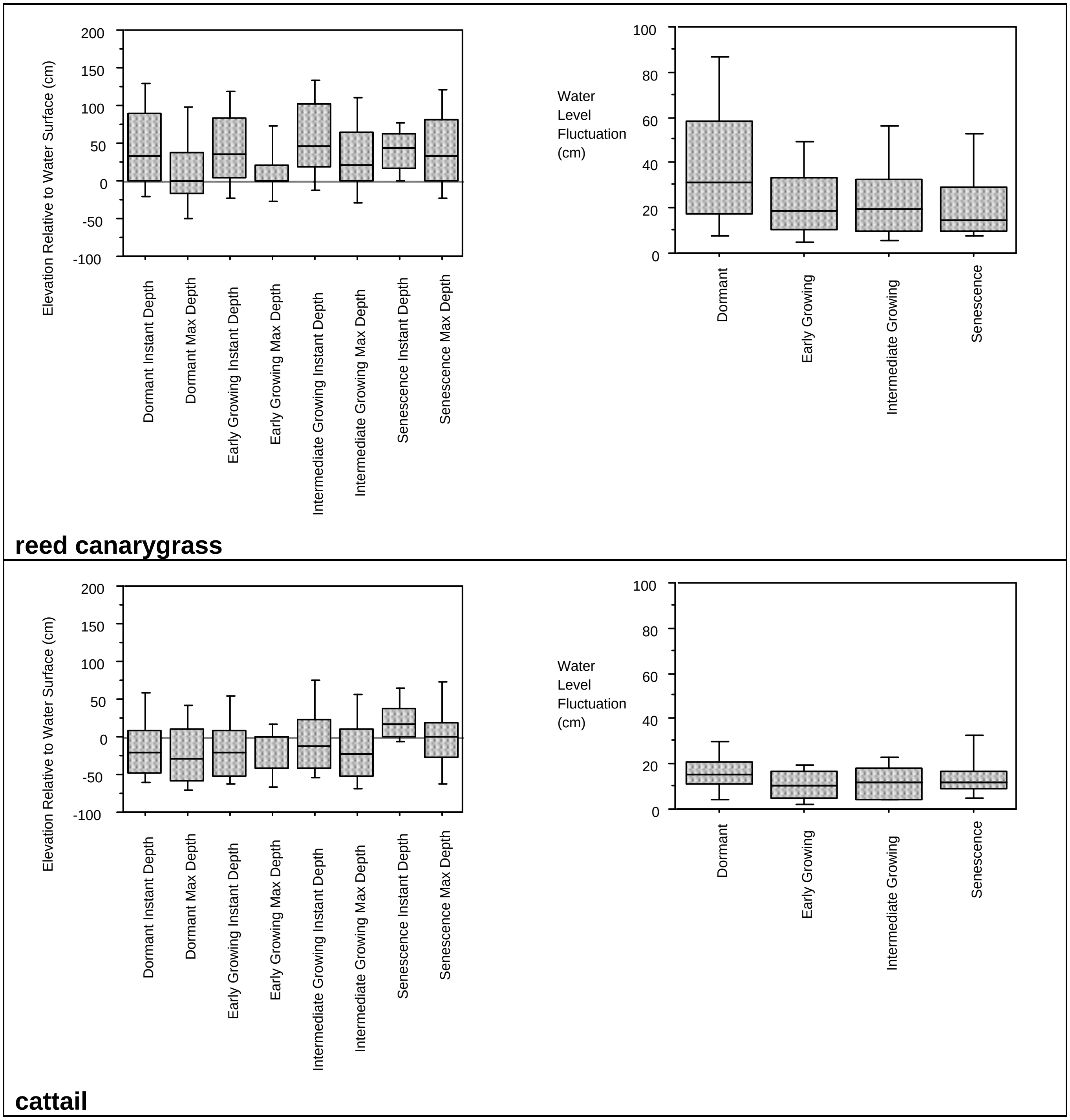


Figure 10-15. Seasonal hydrology and water level fluctuation of reed canarygrass and cattail.

Table 10-1 Comparison of different species and their hydrologic characteristics.

Measure Note: Negative numbers are depth under water. Positive numbers are distance from water surface.	Dormant Instant Depth	Dormant Max Depth	Dormant WLF	Early Growing Instant Depth	Early Growing Max Depth	Early Growing WLF	Inter-mediate Growing Instant Depth	Inter-mediate Growing Max Depth	Inter-mediate Growing WLF	Senes-cence Instant Depth	Senes-cence Max Depth	Senes-cence WLF
Species:	**Alnus rubra**											
Wettest Elevation From Water Surface (cm)	-97	-98	0	-98	-99	0	-97	-96	2	-10	-97	1
Driest Elevation From Water Surface (cm)	430	419	142	438	421	126	441	404	138	98	424	111
Median (cm)	35	2	18	25	0	11	41	11	13	30	20	15
Mean (cm)	58	32	30	48	21	21	60	41	21	33	51	21
Species:	**Fraxinus latifolia**											
Wettest Elevation From Water Surface (cm)	-55	-58	8	-62	0	2	-43	-56	9	-9	0	11
Driest Elevation From Water Surface (cm)	185	129	69	188	71	50	200	193	57	87	196	53
Median (cm)	42	13	10	23	12	4	34	23	11	33	29	12
Mean (cm)	40	22	18	31	20	9	43	31	18	36	37	20
Species	**Salix scouleriana**											
Wettest Elevation From Water Surface (cm)	-96	-98	4	-96	-100	0	-99	-99	0	-7	-94	5
Driest Elevation From Water Surface (cm)	286	261	139	237	194	116	233	185	95	82	235	84
Median (cm)	26	0	31	22	0	23	28	4	19	30	13	19
Mean (cm)	31	2	38	27	3	25	33	17	25	31	24	23
Species	**Salix sitchensis**											
Wettest Elevation From Water Surface (cm)	-97	-83	0	-98	-99	0	-97	-95	0	-9	-97	1
Driest Elevation From Water Surface (cm)	429	399	139	425	385	125	432	376	122	95	406	88
Median (cm)	0	0	15	8	0	17	15	0	13	25	6	15
Mean (cm)	18	8	22	17	3	23	24	10	19	28	20	16
Species:	**Juncus acuminatus**											
Wettest Elevation From Water Surface (cm)	-65	-82	5	-65	-79	2	-66	-79	6	-4	-82	5
Driest Elevation From Water Surface (cm)	169	156	135	166	158	125	182	153	122	88	182	88
Median (cm)	11	1	12	3	0	4	23	7	9	34	10	15
Mean (cm)	16	0	18	12	1	11	24	3	17	30	15	16
Species:	**Juncus effusus**											
Wettest Elevation From Water Surface (cm)	-68	-90	0	-64	-87	0	-60	-81	4	-9	-77	1
Driest Elevation From Water Surface (cm)	163	159	87	163	156	33	172	157	56	88	179	41
Median (cm)	0	-25	15	0	0	10	13	-3	10	21	5	15
Mean (cm)	1	-16	23	-5	-8	11	11	-4	14	26	10	15
Species:	**Carex exsiccata**											
Wettest Elevation From Water Surface (cm)	-23	-90	5	-31	-57	2	-16	-26	4	2	-21	17
Driest Elevation From Water Surface (cm)	106	102	77	75	65	27	117	103	32	87	111	27
Median (cm)	-11	-27	15	0	0	27	19	1	7	16	5	17
Mean (cm)	9	-16	31	0	-6	19	28	11	12	28	20	20

Table 10-1 (continued). Comparison of different species and their hydrologic characteristics.

Measure Note: Negative numbers are depth under water. Positive numbers are distance from water surface.	Dormant Instant Depth	Dormant Max Depth	Dormant WLF	Early Growing Instant Depth	Early Growing Max Depth	Early Growing WLF	Inter-mediate Growing Instant Depth	Inter-mediate Growing Max Depth	Inter-mediate Growing WLF	Senes-cence Instant Depth	Senes-cence Max Depth	Senes-cence WLF
Species:	**Carex obnupta**											
Wettest Elevation From Water Surface (cm)	-89	-95	4	-93	-94	0	-81	-92	2	0	-85	4
Driest Elevation From Water Surface (cm)	362	320	87	367	194	50	367	340	59	95	334	53
Median (cm)	26	0	17	20	0	11	31	10	19	25	20	19
Mean (cm)	43	19	26	40	11	16	51	31	22	35	39	22
Species	**Scirpus microcarpus**											
Wettest Elevation From Water Surface (cm)	-62	-93	8	-53	-70	5	-49	-68	4	-10	-70	4
Driest Elevation From Water Surface (cm)	175	162	69	173	162	50	188	162	57	90	173	53
Median (cm)	29	0	17	31	0	16	34	4	20	50	9	16
Mean (cm)	29	10	22	27	9	21	41	15	20	47	29	20
Species	Scirpus atrocinctus											
Wettest Elevation From Water Surface (cm)	-56	-90	5	-61	-78	2	-60	-81	6	-9	-77	5
Driest Elevation From Water Surface (cm)	187	173	77	181	176	34	202	182	37	88	199	41
Median (cm)	7	2	12	0	0	5	22	5	9	24	13	15
Mean (cm)	27	16	16	15	7	8	38	22	13	26	40	15
Species	**Phalaris arundinaceae**											
Wettest Elevation From Water Surface (cm)	-97	-93	0	-98	-99	0	-95	-88	0	-9	-97	1
Driest Elevation From Water Surface (cm)	430	419	142	438	421	126	441	395	138	99	424	111
Median (cm)	32	0	31	35	0	19	46	21	20	43	34	15
Mean (cm)	51	17	40	48	17	28	60	36	27	41	46	22
Species	**Typha latifolia**											
Wettest Elevation From Water Surface (cm)	-95	-98	0	-98	-98	0	-97	-96	4	-9	-97	1
Driest Elevation From Water Surface (cm)	308	283	50	259	185	40	157	146	57	86	175	41
Median (cm)	-20	-29	15	-21	0	10	-13	-23	12	17	0	12
Mean (cm)	-9	-17	17	-11	-13	11	-3	-14	13	22	3	15

DISCUSSION

Preliminary evaluations of the hydrologic characteristic of some common wetland species have shown that water level fluctuation and depth of inundation during the year, but especially the early growing season, can be key factors in the development of plant associations. The distribution of individual species or vegetation community are related to the hydrologic profile. If the hydrologic profile changes, such as through upstream controls, outlet controls or changing land use in the watershed, it is likely the plant community will shift towards the conditions produced by the new hydrograph. This can have both beneficial or negative consequences depending on the conditions created by management of the upstream watershed. For example, many common dominating species were found in a wider range of conditions of drought to inundation and water level fluctuation. In contrast, less common and less dominant species were almost always found in narrow ranges of hydrologic conditions.

Similarly, hydrologic profiles can help to determine the appropriate plantings for wetland design. The design and successful establishment of plant communities depends on whether individual species in those communities can flourish in the hydrologic regime. Planting designs should be developed based on the seasonal hydrologic conditions.

While our data is useful as a guideline, it is limited in its application. We did not measure plant responses or vigor with respect to hydrologic conditions. Ewing (1996), who measured and analyzed actual tree responses, observed that A. rubra was stressed by repeated cycles of inundation while Fraxinus shows no significant response to repeated inundation, provided the duration of the flooding was less than two to three days. Our methods did not measure such detailed impacts. We also did not accurately account for soil saturation and did not consider soil type which additionally effects species distribution.

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