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Riparian Willow Restoration at Arapaho National Wildlife Refuge

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Photo 1. Sparse willow along portions of the Illinois River. View is looking upstream (south) from the Arapaho National Wildlife Refuge overlook off Highway 14 near Walden, Colorado.

Riparian willow communities along the Illinois River at Arapaho National Wildlife Refuge in North Park near Walden, Colorado, provide important

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habitat for a number of wildlife species, including neotropical migratory birds. Existing stands in the northern (downstream) portion of the refuge are sparse and discontinuous (Photo 1) compared to upstream portions of the Illinois River and the parallel Michigan River.

Mountain valley willow communities are increasingly viewed as complex, non-linear systems with multiple semi-stable states and interacting causal relations. In 2003, the U.S. Fish and Wildlife Service (FWS) began employing an adaptive management approach to restoration of bottomland willow communities at the refuge. They are partnering with the U.S. Geological Survey (USGS), which is conducting measurements of the riparian ecosystem responses, and Wildlands Restoration Volunteers (WRV), a volunteer organization assisting with direct restoration actions. At the refuge scale, the core elements of an adaptive management approach are to (1) establish measurable management objectives; (2) develop hypotheses on the relations that determine system responses; (3) implement management actions; (4) measure system responses, and (5) iterate through revisions of the previous steps.

Photo 2. Fence-line contrast at one of the permanent exclosures shortly after overbank flow in 2005. The exclosure was constructed in 2003. Note the notched, browsed growth form of willow on the left (outside the exclosure) and fencing maintenance problems at the river crossing.

One of the management objectives in the refuge's Comprehensive Conservation Plan is to increase the density and extent of tall riparian willow

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in the northern portion of the refuge. Willow stands at Arapaho NWR have little natural regeneration from seed. Likely causes of the current, sparse distribution of tall willow include historical clearing; low beaver populations, and consequently fewer beaver dams to raise groundwater levels and promote overbank flooding; reduced streamflow from water diversion; channel incision; possible climatic shifts; and high levels of herbivory from wintering elk (approximately 1,500 head in the winters of 2004–5 and 2005–6), some summer-grazing cattle, and a small resident moose herd (Photo 2). The combination of elevated herbivory and physical conditions—including a stable channel location, short growing season, low (<30 cm) average annual precipitation, and a substantial drop in water levels from early June (inundated) to late August (1.0–1.5 m deep)—could allow the persistence of tall willow stands, yet not support recruitment of new stands.

We have been testing two types of management actions: (1) exclosures to minimize or eliminate ungulate herbivory on willow and (2) planting to bypass the apparent bottleneck of natural seed regeneration. Tall, welded-wire exclosures with paired control plots and groundwater-monitoring wells were constructed at five locations in 2003, with the assistance of the Colorado Division of Wildlife, to support a long-term experiment, with the first re-sampling scheduled for 2007. Incidental observations of individual plants suggest that the exclosures are beginning to produce greater overall shoot growth of willow, especially height growth of suppressed individuals initially less than 1.5 m tall. This type of fencing is expensive to construct and maintain, especially at bank or channel crossings. Thus, we have also begun to experiment with small fenced patches in off-channel depressions associated with relict channel locations. In these sites, existing small willow and planted material might be partially protected from ungulate herbivory by traditional barbed-wire fencing installed by volunteers.

Photo 3. Wildlands Restoration Volunteers constructing temporary fencing and using a generator-powered hammer drill to plant willow (Salix monticola) poles in a relict channel location, May 2006. Some herbivory-suppressed, short Salix geyeriana are visible in the foreground.

Initially, planting actions have focused on pole planting in 1 meter holes near the time of spring bud-break using recently harvested, local plant material. Design considerations included (1) planting deep enough to maintain contact with groundwater even in late summer, (2) using local material, (3) affordably establishing large numbers of plants, and (4) effectively using a "pulsed" work force of volunteers. In the first three years, we have tried a combination of species (*Salix lasiandra*, *S. geyeriana*, *S. exigua*, and *S. monticola*) and hole-digging equipment (auger on tracked skidsteer, gasoline-powered hand auger, pump-powered water jet, generator-powered hammer drill with long bit (Photo 3), and hand-inserted metal spikes). Choices about equipment are complicated by the fact that the best time to plant ecologically, i.e. spring, is also the time when access is most difficult and unpredictable for vehicles and for hand-carrying heavy, unwieldy equipment.

Our results are necessarily preliminary at this point and are complicated by delayed planting in 2005 caused by overbank flooding and an early June snowstorm. The general pattern is that virtually all planted material vigorously leafs out in the first month, and most survives to the end of the first growing season (e.g., average 94% survival of S. monticola in September 2006 from June 2006 planting). However, survival through the

second and third growing seasons has been poor (e.g., 12% after the second growing season and 4% after the third growing season for *S. lasiandra* planted in 2004). Height growth of survivors has been more encouraging, with average heights of 41 and 58 cm and maximum heights of 130 and 165 cm after the second and third growing seasons, respectively, for *S. lasiandra* planted in 2004. Possible, correctable problems include (1) lack of good soil contact by not backfilling holes well enough and (2) using some poor plant material harvested from levee locations that needed to be cleared, rather than concentrating on harvesting healthy stems from vigorously growing plants. We plan continued experimentation with pole planting because of its logistical advantages, but we may begin to test containerized, greenhouse-grown plantings as well.

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