Live Gravel Bar Staking Channel Stabilization in the Lower Elk River

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During the past 70 years, the Elk River on northern Vancouver Island has evolved from a narrow, single-thread, stable channel to a wide multi-thread, laterally unstable, aggraded channel. This change was in response to several factors including: valley-bottom logging; channel relocation due to road construction; a large landslide in the river's headwaters; and increased flows resulting from the diversion of water into the Elk River from the adjacent Heber River watershed. The net result: a 4–7 times increase in the unvegetated channel width in the lower 13 km of river and degraded fish habitat because pools infilled, banks eroded, and cover was lost.

Previous channel morphology studies (e.g., M. Miles and Associates 1999) demonstrated the need to restore channel processes in the lower Elk River to expedite the re-formation of a stable, single channel. This project addresses this recommendation and does not incorporate any upland restoration activities that likely will be part of future restoration plans. Based on successful treatments of rivers with similar conditions, such as the San Juan (Switzer 1999), we chose the soil bioengineering technique of live gravel bar staking as the preferred restoration method to achieve our objective. This article describes the application of and lessons learned from live gravel bar staking in the lower Elk River.

Live Gravel Bar Staking: Background

Live staking of gravel bars using willow (*Salix* spp.) and other plant species such as red-osier dogwood (*Cornus stolonifera*) and black cottonwood (*Populus trichocarpa*) can be used to treat river channels that have become aggraded and braided. In live staking, cuttings (stakes) from the selected pioneering species are planted at high density into the gravel bars.

During high flows, the treated areas are inundated; the friction caused by the protruding stakes traps very small woody debris and leads to local deposition of sediment. Each winter, once enough sediment is deposited to cover the protruding stakes, streamflow will top the bars without resistance. In the next growing season, the cuttings will grow and protrude above the gravel bar. This seasonal process of growth followed by sediment and debris accumulation causes the gravel bars to progressively stabilize and elevate (Figure 1). At the same time, the accumulation of fines and organics, such as small woody debris, promotes the establishment of additional riparian vegetation, further stabilizing the bars. Over time the gravel bars elevate, and become inundated less frequently. The streamflow becomes increasingly confined to the main channel, redirecting the river's energy to scouring a narrower and deeper mainstem channel. Polster (1999) discusses live gravel bar staking and other soil bioengineering techniques in detail.

Site Selection

The Elk River, a tributary to Upper Campbell Lake, is located on northern Vancouver Island near the town of Gold River, B.C. The potential treatment sites were first selected by analyzing historical air photos from 1931 to 1995. The main site selection criteria were gravel bars (1) with easy equipment access, (2) in incipiently stable depositional areas, and (3) outside of the most active channel sections that convey high flows. Criteria 2 and 3 were extremely important as live gravel bar staking of the more active channel sections could reduce flood conveyance capacity and possibly accelerate bank erosion or channel shifting (M. Miles and Associates 2004).

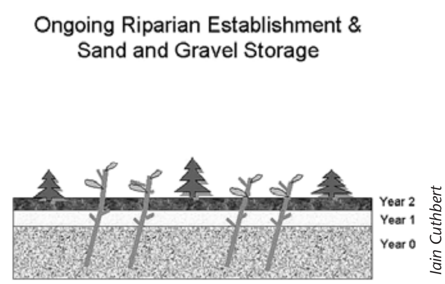

Figure 1. Function of live gravel bar staking.

A June reconnaissance trip finalized restoration site selection, determined site access, and located suitable stock donor and soaking sites. During this trip we discovered that the natural recovery of many of the potential sites identified on the air photos was significant, and included deciduous trees older than 5 years. We theorized that this recovery, the greatest in the previous 45 years, was due to several years with unusually wet summers and smaller than average flood flows. The natural recovery observed was vigorous enough to eliminate several of the potential treatment sites. Thus, three additional sites not identified in

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Figure 2. Assembling limbed poles into bundles.

the office review were investigated in the field.

While many areas would have benefitted from live gravel bar staking, site access became the largest limiting factor. Although Highway 28 parallels much of the river, steep banks from the highway prevented equipment from accessing the river. The only other road in the area that would have provided access to the river had been deactivated for much of its length. As most of the lower river lies within Strathcona Provincial Park, excavator access trail building needed to be minimized to preserve ecological values. In total, three sites were selected for treatment.

Collecting and Preparing the Stakes

The project began in September 2004 with the collection of donor stock from areas close to the restoration sites in Strathcona Park. Stock was collected by cutting down small deciduous trees close to the ground with chainsaws. The donors would coppice and regenerate in the following year. The stakes collected were comprised of 85% willow (Scouler's and Sitka), 6% black cottonwood, and 9% red-osier dogwood. Crew members then collected, topped, and limbed the cut trees. Using high quality, relatively expensive pruning and lopping shears was invaluable, as smaller shears tended to break, disrupting production. The topped and limbed "poles," which ranged from 2 to 4 m in length, were then placed on sawhorses and tied with biodegradable sisal baling twine into bundles of 7–10 stems (Figure 2). Flagging tape was attached to each bundle, with a different colour used for each day. When the weather conditions were cool and wet, bundles were loaded into trucks and taken to the soaking site at the end of each day. During warmer, sunny weather, bundles were taken to the soaking sites throughout the day to prevent desiccation (wilting) and death. The use of a Silva cool-tarp to cover the bundles during collection would have been beneficial during hot, dry weather. Production averaged 2840 stakes per day for a seven-person crew.

The target size for stake collection was 2 cm in diameter or larger. This size is often referred to as the "rule of thumb" as typically anything greater in diameter than your thumb is the desired size. After several days of harvesting it became apparent that the main cutting site would not provide enough stock to plant the treatment areas, and two additional donor sites were located. Also, a limited quantity of stock at the main donor site met the diameter criteria. Due to the shortage of large stock, cuttings that were slightly smaller than 2 cm in diameter were also collected and were referred to as "undersize stock."

The cuttings need to be soaked in fresh water for 7–10 days to remove rooting inhibitors before planting (D. Polster, pers. comm., 2004). One challenge of this project was finding adequate soaking sites, as nearby ponds were shallow and water levels dropped during the soaking period due to warm, dry weather. As a result, bundles had to be repositioned several times to avoid drying out. Beavers added another challenge: they raided the soaking area; removed some of the largest cuttings, stripping the bark and cambium layers from others; and sometimes took entire bundles.

Once most of the donor stock had been collected, the crew split up: one crew continued cutting, while the second crew began planting stakes. The planting crew collected the bundles from the soaking sites, taking the earliest cuttings first; and then transported them to the treatment sites where they were cut with lopping shears into 1 m length stakes in preparation for planting.

Stake Planting

Due to the inherent difficulty of planting in gravel, an excavator with a digging bucket was used to install the cuttings in the coarse gravel bars. The use of the excavator minimized damage to the stock during planting, and ensured that the cuttings were planted deep enough to survive the dry summer. The excavator did not dig holes, but rather inserted the bucket into the gravel and pulled back the material, creating a 1 m wide gap into which the stakes were placed by

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Figure 3. Crew member instructing student on planting stakes.

hand (Figure 3). The excavator then withdrew its bucket allowing the gravel to settle back in place. The stakes were planted with about three-quarters of their length in the gravel at a 45° or greater downstream angle (Figure 4). Four large stakes and three to five undersized stakes, if available, were placed into each opening, taking about one minute for each opening. While the undersized stakes may not flourish as well as the large stakes, they significantly increased the overall number of stakes planted, which should improve the chances of the project in overcoming mortality due to elk browse.

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Figure 4. Planted stakes.

The excavator worked by backing upstream while planting in successive rows spaced 1.5–2 m apart and staggered to prevent large open patches within the planted areas. The first pass of planting occurred nearest the river channel with the excavator positioned at the edge of the zone to be planted. This ensured that the edge of the row nearest the river was planted parallel to the flow. The excavator then reached as far as possible upland from the river. To maximize the area covered with the available stock, the stakes were planted with tighter spacing and at higher densities on the first pass nearest the mainstem channel where they would likely receive the greatest flows.

Live staking planting began on September 29, 2004, and was completed on October 12. In total, 1.86 ha was planted at three sites at an average density of 17 200 stems per hectare. Planting took an average of 4.5 days per hectare, with a crew of four people working with the excavator.

With the live staking of gravel bars completed, the success of the project will depend on a number of factors, including the growth and survival of the stakes, mortality or stunting due to elk browse, and the response of the treated areas to peak flows.

Monitoring

Long-term monitoring will allow us to assess the success of the live gravel bar staking in achieving the project goals. This information can also be used to help direct future restoration activities. The following measures were taken to assist in gauging project success.

The perimeters of the treated areas as well as longitudinal and cross-sectional profiles were surveyed at each site using a total station survey instrument. Benchmarks were established at each site for future reference during surveys and monitoring. Fifty-one monitoring plots, including seven control plots, were established at various locations within the project area. Each research plot had a 3-m radius (28.3 m²). A subset of 16 research plots was established to monitor changes in substrate composition. Within each of these 16 plots the substrate in three 0.5-m² squares was photographed and documented. Vegetation surveys at each of the 51 monitoring plots included recording the number, species, and size of stakes planted in each plot. Finally, three permanent photo points were established at each treatment site for future monitoring. In 2005, the areas treated in 2004 will be monitored and additional live staking of gravel bars in the Elk River will take place.

While securing funding to study the success of restoration treatments is difficult, monitoring of the live gravel bar staking project is needed to continually improve the selection and successful application of restoration techniques in British Columbia.

Summary of Lessons Learned

- Often spring planting offers several benefits in soil bioengineering. Due to funding timelines, we planted in the fall.
- Use the most recent air photos available for preliminary site selection and reconnaissance.
- Have several stock donor sites selected before beginning cutting. A local Ministry of Forests office or forest company may offer some advice on donor sites.
- Use high-quality lopping shears and hand pruners. The loss in productivity due to the use of poor equipment will cost more than the initial expense of purchasing quality equipment.
- Use lopping shears rather than a chainsaw to cut stakes to length. The chainsaw tended to make rougher cuts and “shred” the bark near the cut end.
- Avoid soaking sites near known beaver populations. The loss of bundled donor stock due to beavers was much higher than we had expected. Using beaver protection such as a rodent fence around the soaking bundles would have prevented some loss.
- Ensure soaking sites have stable water levels. The sudden change from wet weather to several days of dry weather caused one soaking site to dry up, and the bundles required repositioning several times during the soaking period. Covering soaking bundles with Silva cool-tarps may be beneficial in hot, sunny weather.
- Flag bundles collected each day with a different colour flagging tape. This system allows for quick and easy identification of the bundles when collecting them from the soaking site. Use bundles in the order that they were cut.
- While securing funding to study the success of restoration treatments is difficult, monitoring of the live gravel bar staking project is needed to continually improve the selection and successful application of restoration techniques in British Columbia.

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