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Reclamation of a Stone Quarry

in a Ponderosa Pine/Grassland Ecotone

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INTRODUCTION

Gravel and stone quarry operations result in extensive manipulation of the landscape and of the ecosystems indigenous to their sites. Disturbance to the natural contour of the topography has repercussions, not only for those communities in the immediate vicinity, but also for those adjacent. Quarrying presents prime conditions for accelerated erosion because the topsoil environment required for establishment of stabilizing vegetation is eliminated. Once quarry resources are exhausted or operations cease, the landscape has often been degraded to an extent that recolonization by pre-disturbance communities is difficult, if not impossible. The cultural perception of such degraded land is highly unfavorable for several reasons, spanning a range of safety, ecology, and aesthetics-related concerns. The intrinsic legacy of quarrying is the exposure of bare soil and underlying strata which vary in stability, do not support vegetation, and which contrast sharply with adjacent undisturbed landscape features. The reclamation of Conda Rock Quarry on the front range of the Rocky Mountains in Colorado is an example of a project motivated by public concern.

DESCRIPTION OF SITE AND MOTIVATION FOR RECLAMATION

The quarry is located at approximately 6300 feet on the northeast face of Eldorado Mountain, twenty-five miles northwest of Denver, Colorado. General opposition by the public in the nearby communities of Eldorado Springs and Boulder to the noise and landscape scarring from the mine reached a peak in 1986, when Wesley Conda & Sons proposed extending its operation further up the face of the mountain. A local organization, People for Eldorado Mountain, attempted to legally halt the expansion of the quarry, which is readily visible from Eldorado Springs, but the county court to which they brought the case had no jurisdiction over the private permit nor the state-owned land. City of Boulder Open Space, saw the opportunity to fund the purchase of both the lease permit from the operator and the land from the state of Colorado, as the site in question was contiguous to lands which were already part of the City of Boulder Open Space and Natural Areas system. The acquisition would not only extend its holdings, but also reduce the impact of the quarry on adjacent areas and prevent further scarring of the mountainside. Reclamation became the subject of public debate as the land changed hands in 1992.

In its acquisition of the mining rights, the City of Boulder also became subject to the preexisting regulations, set forth in the Colorado Mined Land Reclamation Board (CMLRB)-approved mining permit, for minimum legally required reclamation of the site. The guidelines essentially stipulated revegetation and suggested prevention of public access. However, many of the site conditions presumed by the CMLRB reclamation guidelines had changed over time due to continued mining operations. The City therefore commissioned an outline and cost estimate of alternative plans for the current conditions of the site. Through the cooperation of the community, experts from multiple disciplines, the Open Space board and private contractors, a plan for the site was adopted which ultimately exceeded the minimum requirements. The goals emphasized public safety and terrain stability foremost, with revegetation directed mainly toward support of these goals.

The City of Boulder and surrounding area, including the quarry, is situated in a transition zone where high plains and mountains interface, creating a mountainous ponderosa pine (*Pinus ponderosa*) community/ grassland ecotone. Fire suppression had allowed encroachment of the pines into ecotone areas surrounding the mined land, and overgrazing had limited the competitive advantage of native grass species.

Twenty-three years of quarry activity had left the site with a substantially undercut talus slope on its southwest side and a bare cut rock face along its west side. From an aesthetic standpoint, the bare highwalls were severely cut and pinkish tan in color, contrasting sharply with the well-oxidized, greyish-pink of the crustose-lichen covered native rock outcrop. Approximately 122,000 cubic yards of material were estimated to have been removed from the site by mining, and no topsoil had been salvaged. Thus, the preexisting CMLRB reclamation plan, which called for grading of overburden and spoils into the extraction corridor, regrading of bordering highwalls into "gently sloping hills to harmonize with the surrounding topography," and spreading stockpiled topsoil over the pit and its haul roads, was deemed not feasible, mainly because of the absence of suitable quantities of material on site.

The water table within the quarry had been substantially lowered as a result of the upper strata removal and the porosity of the coarse material below. Two small flows coming off the north and northeast slopes had been interrupted by the mined area, but were deemed to pose little threat for erosion except during isolated peak flow from major storm events, which might cause redeposition of mined materials.

INTENDED RESULTS

As stated in the alternative conceptual reclamation plans, the feasibility of complete restoration to match the visual and ecological characteristics of the surrounding terrain would be very low due to prohibitive cost and the inherent instability when attempting to reconstruct original steep slopes from loose fill. Such fill would mostly have to be obtained from a remote similar site, which would only add to the cost, without contributing a useful solution to the main concern, stabilization.

The goals for reclamation were ordered by priority: ensure public safety by eliminating the threat of falling rock from the talus slope and stabilizing its rock face of Fountain formation composition; assess the threat of erosion and minimize its impact on the site; revegetate, primarily to assist in success of the first two goals, but secondarily to achieve ecological harmony with adjacent natural areas; and finally, halt further aesthetic degradation, a result which planners hoped would be incidental if the first three goals were achieved. Land use was intended to be wildlife habitat and light public access.

INTERVENTIONS

Since stabilization of the site was the primary goal, the first stage of the reclamation was to prevent rockfall by buttressing the undercut talus slope with a reconstructed toeslope. Since on-site loose material was limited, recontouring of the toeslope required overexcavation of the existing quarry floor to achieve enough fill to match the original slope of approximately 2:1. Steep sided piles were removed, as well as interior pit dropoffs. The previous quarry floor was regraded to match the grade of the surrounding native slope. Regrading the highwalls would have caused more disturbance upslope, which was undesirable. Assessment by a consultant from the Colorado School of Mines judged the stability of the walls to be approximately equal to the stability of adjacent native steep slopes. Regrading would not have substantially changed the falling rock hazard. In addition, although the revegetation plan suggested that woody species planted on the rock faces would assist in stabilization as well as enhance aesthetics, the impracticality of accessing the individual crevices, coupled with low expectation for successful establishment in those areas due to limited available groundwater, led to eventual abandonment of that portion of the plan. Through the public review process, little interest was shown in chemical use to speed oxidation of the exposed rock face solely for aesthetic reasons, even though the scar has visibility from several points in the Boulder County area. A railroad grade further upslope, excavated in the early 1900's, had weathered over time to be indistinguishable from the adjacent native rock, thus, the prospective natural weathering of the current excavation was favored over immediate intervention.

Revegetation of the remainder of the site required the reconstruction of suitable subsoil and topsoil to support native species. Analysis of the on-site Lykins Formation material by Colorado State University Soil Testing Laboratory gave evidence that, although low in organic matter, the clay texture of the material would make it appropriate for use as a subsoil. A layer approximately six inches in depth was used to cover the rough fill on the talus slope and quarry floor areas. Since no topsoil had been stockpiled during quarry operation it was necessary to obtain it from some other source. Although the pre-existing CMLRB plan and the tentative suggestions of the adopted revised plan both called for sewage sludge mixed with other material for use as topsoil, investigation into other sources led to eventual discovery of an alternative in the form of filter fines from the City of Boulder Betasso Water Treatment Plant. Filter fines are sediments, consisting mostly of mountain topsoil that washes into the clean water pipeline en route to the treatment facility. A 3% organic matter content and excellent sandy loam texture made it a superior choice to sewer sludge. The material was used to cover the clay subsoil at a depth of three to six inches.

The revegetation strategy of the adopted plan differs substantially from the preexisting CMLRB plan, since the original plan did not take into account the extent of regrading necessary for stabilization, the lack of stockpiled topsoil, nor the subsequent poor edaphic conditions. Because the encroachment of mountain pine species into the ecotone was deemed to be more advanced than typical of its natural state before fire suppression, and because biologists consulting on the project felt the ecotone was being lost, the priorities for revegetation were changed to emphasize more grassland and transitional species, rather than trees. The main thrust of revegetation efforts centered around reestablishment of cool season native grasses, with the addition of native forbs and shrubs. Seed from local collecting was used as available, but to achieve the desired planting density, additional supplies of native species seed were obtained from a commercial source in Greeley, CO, approximately fifty miled away.

The first seeding was done in the fall of 1994 and consisted mainly of *Pascopyron smithii* (western wheatgrass) and *Elytrigia dasystachya*(thickspike wheatgrass). Seed was spread by hand and raked into the talus slope area, since the 2:1 slope precluded the option of equipment use. To protect the seeded area, Weyerhauser Soil GuardTM bonded fiber matrix was applied at a rate of 3500 lbs/acre. Those areas with less than 2:1 slope, including the quarry floor, were hydromulched after seeding. The Soil GuardTM successfully held during high winter winds, but record high spring rainfalls in 1995 caused some slumping of the material and rilling where slopes were particularly steep. However, due to the favorable precipitation levels, germination and establishment of seedlings was better than expected, both in the intact areas and the eroded spots. During dry summer conditions, areas with a more shallow topsoil layer were observed to have better seedling survival rates, presumably because it permitted better contact of newly established plant roots with the water-holding subsoil. Areas with deeper topsoil dried out more in late summer. Areas with exposed clay subsoil also did not perform as well, presumably because of the absence of suitable organic matter provided by the topsoil dressing of filter fines.

Previously unseeded areas were seeded in the fall of 1995, along with an additional seeding of the entire area, using a mixture containing native grasses and forbs. Good germination of this second seeding has been reported in the spring of 1996. Also in the spring of 1996, a group of volunteers consisting of local citizens and members of People for Eldorado Mountain participated in the planting of 160 shrubs, grown from locally collected seed at local nurseries. The shrub species were mainly *Cercocarpus montanus* (mountain mahogany), *Rhus trilobata* (three-leafed sumac), *Crateagus sp.*(red stem hawthorne), *Ribes aureum* (golden currant) and *Rubus deliciosus* (Boulder raspberry), and their positioning on site was primarily around sediment control structures. Seeding and weed maintenance will likely be ongoing throughout the first few establishment years, as local seed becomes available, and as needed to repair areas that may fail due to weather conditions.

ASSESSMENT OF SUCCESS

There is no quantitative performance standard in place for the

Conda reclamation overall. However, beginning in 1997, assessments will be made as to relative success of revegetation. By choosing the plan option that called for buttressing the unstable talus slope, Open Space board members and public reviewers seem confident that the best choice was made to meet the goal of public safety preservation. Because the Boulder community places high value on its natural areas, the success of the project will remain closely monitored by its citizens.

REVIEW OF CONDA PROJECT

The main emphasis of the Conda project centers on the stabilization of physical features as it pertains to safety and erosion control, with some attention to aesthetic benefits. Clearly, although ecological concerns are not specifically mentioned in the plan, through personal conversation with consultants to the project Tamara Naumann and David Buckner, the intent to reestablish ecotone structure and function to the area has underlain much of the decision-making process. The utilization of locally-collected seed for grasses, forbs and shrubs is an intentional measure to preserve the integrity of ecotone-typical vegetation. The decision to veer from the published plan by restricting the plant list exclusively to grassland species and eliminating tree seedlings is an effort to partially mitigate the loss of ecotone in adjacent areas. These measures, if successful, should help to protect the transitional zone as a distinct ecological community.

The plan does not address wildlife recovery specifically, but wildlife integration is expected to naturally occur over time if vegetation establishment is achieved. One shortfall of the project is its overall lack of specifications for follow-up assessment of success in any quantitative measure. Nor does it include guidelines for maintenance of the area in the future, such as sustaining the intended vegetation mix and keeping out invasives.

Only a brief reference to hydrology is made with regard to directing surface runoff so as to minimize the movement of loose material from off the site. Without more detailed hydrology information, comparison of the site to adjacent natural areas to predict species suitability in terms of water needs is difficult. Plan authors considered hydrology only as it pertained to erosion. However, the success of the first year's cool-season grass germination and establishment appears to be at least partly linked to water availability. Should weather prove uncooperative in the future, monitoring of the site may be necessary to ensure that intended species are sustained.

Aesthetics were given only minor consideration in the reclamation plan, which is surprising considering that the revegetated area makes up less than one third of the readily visible landscape from most viewponts, with the highwall scars remaining prominent. However, the plan allows for future embellishment to the basic outline as the reclamation reaches its final stages. The timeline for actual "completion" of the project appears to be somewhat open-ended, although those activities specifically set down by the documented plan have been accomplished. Recovery can only be truly measured over the long term.

In many repects, every reclamation is a unique undertaking, since site conditions cannot be expected to absolutely conform to previously attempted projects. In this particular venture, it is encouraging to find that consultants, officials, and the community were willing to go beyond the "minimum legal requirements" with thoughtful consideration of issues specific to their site. These extensions of the basic recommendations will be likely to produce more rewarding long-term results, and will give precedent to the use of materials and technique that may be applicable to similar projects in the future.

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