News and Comment

Can we Create Alvars or Fully Restore those Damaged?

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A brief survey of the literature indicates that there is no scientific basis for the assumption that a self-sustaining and fully diverse alvar ecosystem can be created or fully repaired following serious damage. Consequently it is much better to protect an existing alvar than to accept promised creation elsewhere, or full repair, as a justification for allowing damage due to human activities. Although conservation may be well served by establishing some alvar species *ex situ* in partially restored areas, at present the best way of protecting alvar diversity is by protecting alvars, through a well-planned system of protected natural sites of high quality.

Key Words: alvar, protection, restoration, quarry, rehabilitation, ecological integrity, Great Lakes region, Ontario.

Alvars are naturally more or less open areas of shallow soil over essentially flat limestone or marble rock with a cover of herbs and shrubs with trees absent or not forming a continuous canopy. They are a very restricted habitat and include rare and restricted flora and fauna. Ontario includes more than three quarters of the imperilled alvar ecosystems in the Great Lakes region (Brownell & Riley 2000, Catling and Brownell 1995). Many of the Ontario sites have been partly destroyed and damaged by permanent development or temporary use for construction on adjacent lands (Table 1, Catling et al. (2012) for examples of damage). Some developers have suggested that disturbance may be condoned because damaged sites can be fixed and/or disruption compensated for by creation of a new alvar elsewhere. The "fix" proposed may involve a mitigation plan. One proposal to develop an alvar and fix damage presently under consideration includes the following statements: "New alvar will be created … For all alvar habitat disturbed during construction, re-vegetation to pre-construction conditions will occur as soon as possible after construction. … if natural regeneration is unlikely to occur, … re-vegetation through transplanting from established alvar communities …. or seeding …." The likelihood of any of this restoration or mitigation occurring with a satisfactory result is low in light of recent literature and policy of the Canadian Botanical Association.

The question of whether or not creating or fixing is possible is an important one for alvar conservation because there is still much conservation work to be done on this very unusual and biodiversity-rich ecosystem and this work should have a strong scientific base to continue. Currently there is interest in updating the conservation targets for alvars in a new international protective effort that would extend the international alvar initiative of 1999 (Reschke et al. 1999). Also the very significant contributions to protection of alvars in the Great Lakes Region have been made on the basis of "ecological integrity", meaning that the least damaged and most complete sites were priorized for protection. It is anticipated that a similar process will follow in the future.

A Summary of Alvar Restoration and Mitigation

(1) Bakker et al. (2007)

The title of this article suggests that alvar plants appear to be spontaneously colonizing old fields, but the abstract clearly indicates the limitations: "A group of alvar species had re-established after 20 years, but others did not re-establish even after 50 years of abandonment, although they are present in the local species pool. We found no evidence of dispersal as a constraint for re-establishment." If in this study dispersal did not limit colonization of abandoned arable land there must have been other constraints, – possibly the changed condition of the soil, seed predation, or competition. Failure of a fully functional alvar community to establish over 50 years in an area surrounded by alvar indicates that these ecosystems do not automatically redevelop naturally. Further, it seems improbable that seeding would aid restoration.

(2) Lundholm and Richardson (1999)

The authors argue that limestone quarries must be used to conserve alvar biodiversity because there are not enough protected alvar sites. However, they provide no evidence that quarries can really do the job.

(3) Richardson et al. (2010)

Alvars are regarded by these authors as a "degraded state analogue" for quarry bottoms. This suggests

TABLE 1. Alvars usually benefit from natural events such as fire, drought and flooding. They do not benefit from unnatural disturbances such as development which may include the activities listed below (from Catling et al. 2012, personal observation and other sources). Most of these activities can be influential on-site and when occurring near to a site.

Type of activity/stress	Impact
(1) **Building** roads and structures on top of vegetation communities.	Complete and immediate destruction of flora and fauna.
(2) **Driving over** vegetation with heavy equipment in temporary storage and laydown areas.	Flora and fauna is crushed and the damage may range from complete destruction to limited and incomplete recovery.
(3) **Building of crane pads** and other temporary construction facilities	Complete destruction to serious damage and loss of native species diversity due to crushing and alteration of substrate conditions.
(4) **Excessive foot traffic**	Complete destruction to serious loss of native species diversity due to trampling.
(5) **Introduction of nutrients** from blowing soil, runoff, misinformed direct soil improvement practices, etc., to communities that require nutrient-poor conditions.	Competition with species that are promoted by higher nutrients and/or non-adapted abnormal growth leading to a modified community composition or elimination of particular community types .
(6) **Contamination of substrate** with fill, wash off of lubricants, and spillage.	Complete destruction due to serious spills to localized damage and diversity loss in a changed ecosystem.
(7) **Changes in hydrology** due to roads, ditching, compaction, ruts, and cable trenches, all leading to excess flooding in some areas and excess drainage in others.	Complete destruction of flora and fauna to seriously altered communities. A very delicate balance of extent and timing of water flow is essential to maintenance of natural alvar communities and it may include ground water, rain dispersion, sheet flow and temporary ponding over flat rock.
(8) **Transport of contaminants** over extensive areas by ground water and/or surface water flow during flooding.	Loss of native species diversity and alteration of communities.
(9) **Introduction of invasive alien species** with mud caked on the underside of construction equipment, in tire treads, with fill, or by natural processes.	Any disturbance is likely to increase the presence of invasive species and once present, elimination may not be possible and control may require extensive management making the loss of native diversity a certainty.

that some degree of restoration to alvar-like vegetation may be possible. Establishment of 18 alvar species seeded on a quarry floor was analyzed after three growing seasons and suggested strong dispersal limitation and weak microsite limitation for alvar species. Relatively rich species assemblages including some alvar components were developed, but experimentally seeded plots had only half the richness of alvar species as natural alvars and half the cover of vascular plants (Figure 4).

Richardson et al. (2010) provide evidence suggesting that targeting alvar assemblages in developing vegetation cover can promote efficient site colonization and *ex situ* biodiversity conservation. However, it is a skip, a hop and a jump (and a long hike) from here to saying that their data signifies that an alvar can be repaired or created. This is because: (1) Some of the alvar plants seeded in the experiment did not establish, others established to a very limited degree, and still others did not produce flowers and fruit enabling survival into the future; (2) Alvars may depend upon longer-term overall conditions as well as short-term annual conditions. For example, the severe drought that occurs on average once every 40–60 years that sets succession back may be necessary for the perpetuation of alvar communities. If so, observations made after a few average years may not be very informative; (3) Relationships between plants and other biota, (pollinators, consumers, predators of consumers, microbes, etc.) may be crucial to success of alvar plant communities, and these interactions are so complex that they probably cannot be recognized, let alone duplicated, in attempts to reconstruct.

The Richardson et al. (2010) experiment thus, while it produced valuable plant cover by seeding, did not include enough alvar species or biomass, continue for long enough, nor consider interactions and processes sufficiently to evaluate the possibility of repair or creation of a self-sustaining alvar plant community or an alvar ecosystem.

(4) Savanta Inc. (2008)

There are a number of articles such as this one available on the web concerning “aggregate rehabilitation” or treating land from which aggregate has been extracted to increase the utility of the land or to improve its condition. Some of these reports feature alvars, and sometimes important alvar species are conserved. However, these efforts have not produced the equivalent of a naturally-occurring alvar plant community or alvar ecosystem.

(5) Tomlinson et al. (2008)

This article projects that conditions on the floors of abandoned limestone quarries are similar to those on alvars and some of the species that are found on alvars also occur on abandoned quarry floors. Although observations were not new (see text box), it was of interest because it suggested that alvars could be used as a model, or analogue, for efficiently greening quarries and simultaneously protecting some rare and at-risk alvar species (extended by Richardson et al. 2010). Using artificial (built) landscapes for species conservation is a great improvement over filling a quarry with fertilized soil and planting it with alien Crested Wheatgrass! However, it is a mistake to conclude that fully-functioning and self-perpetuating alvar plant communities have been developed on a quarry floor.

The work of Tomlinson et al. (2008) was not designed to compare alvar and quarry floor vegetation; otherwise it would have used information such as cover, fruiting condition, number of individuals and biodiversity measures instead of just presence or absence. Nevertheless, the paper does indicate that alvars are biologically quite different from quarry floors: (1) Figure 1a shows all the alvar samples on the left side with almost no overlap between these and quarry samples; (2) In Figure 2c there are two major groups of species, the one with few exotics evidently represents the alvars. On quarry floors, 40% of the plant species recorded are exotics compared to only 7% of those on natural alvars; (3) "Characteristic alvar species" constitute 12% of the species found on quarry floors but usually 25-50% of species on alvars. However, rare and restricted species may also be important alvar indicators; (4) The authors note that the factors preventing quarry communities from resembling alvar communities even more closely than they do are at present uncertain – a noteworthy point!

(6) Solandz (2011)

This paper is one of a number reflecting on results from some of the peer-reviewed papers above. It also reports on studies aimed at establishment of alvar mosses on quarry floors. Like other studies, this review does not claim that alvar plant communities or alvar ecosystems equivalent to those of natural alvars have been produced.

To summarize, based on all recent papers mentioned above, the fact that some alvar plants may re-establish on abandoned arable land, and that with monitoring and gardening some can be grown on a quarry floor, at least for a short period, is good news. However, there is no case of a self-sustaining alvar ecosystem complete with all of its biodiversity and all of its ecological functions being destroyed or seriously damaged and then completely repaired or created.

Policy of a national organization

Restoration, repair and the various methodologies involved, including transplanting and seeding, are useful and helpful to conservation in general, but the concept of restoration can be destructive if its conservation value is overstated. It is misleading to promise that mitigation will prevent irreversible damage, or resolve preservation versus development conflicts.

It was in 1985 that the Conservation Committee of the Canadian Botanical Association (CBA) advised against the development of a quarry on the Oriskany Sandstone Outcrop, an area of unusual geology, flora and fauna in southwestern Ontario. Aggregate extractors suggested that after they had removed all the rock, they would replace the flora exactly as it was by transplanting it to the limestone quarry floor. This assertion demonstrated poor biological understanding. The committee considered it impossible to restore what would be destroyed, either nearby or in the hole left behind, in part because growing conditions would not be the same. The CBA Conservation Committee then developed a "Position paper on transplantation as a means of preservation" (CBA 1986, 1991). This document reads in part: "Attempts have been made to recreate natural ecosystems through transplantation and seeding. …. Despite considerable expense, development of sophisticated techniques, and passage of time which might have allowed for establishment, such attempts can only be judged as partially successful."

The Canadian Botanical Association had a number of reasons for its position, which are elaborated on its website (Canadian Botanical Association 2013, Fahselt 2004, 2007). Many concerns related to the ecosystem as a whole, but it was also felt that, unlike *in situ* reproduction in the natural habitat, transplanting and seeding offered little protection in the long term. Morton (1982) supported this view, and Keddy (1983) wrote: "It is extremely difficult to demonstrate scientifically that transplanting will succeed." Many similar concerns have been expressed recently; for example, Lusby (1996) stated: **"**It is stressed that translocation experiments must be regarded as horticultural operations with a full and flexible aftercare programme to provide a reasonable chance of successful plant establishment".

Restoration – what does it mean?

"Restoration" does not necessarily mean putting an ecosystem or a community back just the way it was, and the assertion that "we can restore it" can have a variety of meanings. The Society for Ecological Restoration (http://www.ser.org/resources) defines ecological restoration as an "intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability." Importantly it "accelerates" but does not necessarily "complete." Wikipedia (https://en.wikipedia.org/wiki/Restoration_ecology) notes that: "restoration ecology assumes that environmental degradation and population decline are to some extent, reversible processes. Therefore, targeted human intervention is used to promote habitat, biodiversity recovery and associated gains. This does not provide, however, an excuse for converting extremely valuable "pristine" habitat into other uses." The wording: "to some extent reversible" is important. The alert to providing an excuse is also noteworthy. Operationally, restoration often means putting some of the species back, or allowing an ecosystem to partially recover on its own (Catling & King 2007) or with one time manipulation (Catling & Kostiuk 2010), or with continuing management. See also Bradshaw (1997), Hilderbrand et al. (2005) and Young (2000) for more information. Although it might be expedient for developers to regard it as an acceptable substitute or a complete "fix", it is not, nor is it thought of that way by its proponents and performers.

The Lakeside Daisy Preserve: the Case of a great conservation effort but not a reconstruction

A quarry floor on the Marblehead Peninsula of Ohio became the last chance for the Great Lakes endemic Lakeside Daisy (*Tetraneuris herbacea*, Catling and Brownell 1995) in the state in the late 1980s. It was protected and became the Lakeside Daisy Preserve. This very worthwhile project protected a handful of extremely rare alvar plants that were nowhere else in Ohio and nowhere else in the United States. The two women responsible for the protection of this site received the Ohio Conservation Achievement Award in 1989, and it was well deserved. More recently the Lakeside Daisy has been established at other sites in northern Ohio, which may help to ensure the survival of the self-incompatible Ohio population.

This early use of a quarry to conserve alvar vegetation was a major achievement. However, it did not reconstruct the alvar ecosystem that was destroyed on the adjacent plateau, a few small remnants of which still existed when I visited the site in 1989. Seeding, transplanting and especially the continuing control of woody vegetation (Red Cedar, Dogwood, Cottonwood) is necessary to this day. The restoration of alvar, although an intense effort, has been partial. No subsequent establishment of alvar plants in quarry bottoms in the Great Lakes region has created an alvar ecosystem.

Integrity and excuses

If damaged alvars cannot be "fixed", we should not accept the promise of a "fix" or a "creation" as an explanation (or excuse) for destruction. The primary conservation goal should be ecological integrity, meaning that "the structure, composition and function of the ecosystem are minimally impaired by stresses from human activity; natural ecological processes are intact and self-sustaining, the ecosystem evolves naturally and its capacity for self-renewal is maintained; and the ecosystem's biodiversity is ensured" (British Columbia Parks Legacy Panel 1999). Putting it most simply, the conservation objective should be "wholeness" of the natural environment. All we have to date as indications of our capability to create or fix damaged alvars is short-term establishment of a dozen vascular plant species, – one dozen out of hundreds of species in many taxonomic and functional groups. Given a choice, it is much more realistic to protect an existing alvar than to expect creation elsewhere or full repair. Since full restoration is not possible, environmental assessments and development permitting processes should indicate this clearly in the documentation.

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