

# ECOLOGICAL ASSESSMENT OF SURFACE RECLAMATION OF A HARDROCK MINE IN WISCONSIN WHEN COMPARED TO OTHER STANDARDS OF SUCCESS<sup>1</sup>

by

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**Abstract:** Similar to the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA), Wisconsin's mining reclamation act is a broad statute that controls the reclamation of mining sites. Whereas SMCRA addresses coal mining, Wisconsin's Metallic Mining Reclamation Act of 1977 (MMRA) addresses issues attendant to *metallic* mining. Like SMCRA, MMRA places the burden on the operator to notify the regulatory agency that reclamation obligations have been fulfilled. If MMRA's ultimate goal is the reestablishment of indigenous vegetation, what standard does an operator use to determine whether that obligation is met and how does that standard compare to other standards of success such as SMCRA? Kennecott Minerals' Flambeau Mine in northern Wisconsin is a hardrock mine poised to file its Notice of Completion (NOC) of reclamation with the Wisconsin Department of Natural Resources. Wisconsin's standards of success are comparable to SMCRA. Using progressive ecological restoration methods to restore indigenous plant communities ranging from aquatic emergent wetlands to northern dry woodlands and open mesic grasslands, Flambeau has demonstrated that Wisconsin's system is workable. The plant communities have been monitored for three growing seasons. Vegetation sampling for the first three years indicate preliminary revegetation success, based on the requirements of MMRA and conventional standard measures for vegetation assessment such as diversity, cover, and survivorship.

Additional Key Words: mine reclamation, indigenous plant communities, performance standards.

## Introduction

The Committee on Surface Mining and Reclamation (COSMAR) (NRC, 1979, conducted a study of the applicability of the Surface Mining Control and Reclamation Act (SMCRA), the national coal mining reclamation law, to non-coal minerals. In it, they observed a great many differences between coal and non-coal mines. SMCRA, developed primarily for surface coal mining, could not possibly apply in totality to the myriad array of non-coal mining operations. For example, the approximate original contour requirement has little or no relevance

to large quarries or open-pits where the product is entirely removed. However, it is universally recognized that environmental protection is no less important at non-coal mining sites and many reclamation requirements contained in SMCRA are applicable to these sites. More specifically, COSMAR observed that the revegetation requirements in SMCRA are applicable to non-coal mining (NRC, 1979).

Is SMCRA a model from which procedures and standards for determining revegetation success could be utilized as part of Wisconsin's metallic mining code? SMCRA Section 102(j) provides for a means to establish effective and reasonable regulation for minerals other than coal. Interestingly enough, the Committee on Hardrock Mining on Federal Lands (NRC, 1999) did not recommend the application of SMCRA standards and procedures to hardrock mines on Federal Lands. However, they did emphasize the avoidance of technically prescriptive standards since a *one-size-fits-all* approach is too impractical in an industry where diverse conditions are the norm. Never-the-less, results from revegetation experiments on mining related wastes in Wisconsin support the idea that SMCRA-like procedures and standards for determining revegetation success could be applicable to hardrock mining reclamation (Hunt, 1989). Our thesis is that procedures and standards for revegetation performance comparable to those in SMCRA

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can be reasonably negotiated guidelines for measuring revegetation success in non-coal related projects.

### SMCRA/MMRA Comparisons

The purpose of Wisconsin's metallic mining code (Chapter NR 132, Wis. Adm. Code. 1985) is to establish procedures and standards for the comprehensive regulation of metallic mineral mining, including revegetation, as authorized under Wisconsin's mining law (Metallic Mining Reclamation Act. 1978) (MMRA). However, the code does not prescriptively define a level of revegetation performance necessary to determine whether vegetation is adequately established. Wisconsin's approach is performance-based.

Revegetation success under SMCRA is broadly judged on the effectiveness of the vegetation for the approved post-mining land use in the Code of Federal Regulations (CFR) at 30 CFR 816.116. The post-mining land use is the pre-mining land use provided that parcel of land was not in a state of degradation. Otherwise, the post-mining land use can be converted to an approved higher and better alternative. The revegetation parameters that are measured after reclamation are all indicators of capability. The return of the reclaimed area to what it was capable of before mining is a concept that tends to get lost in the regulations and guidelines but is clearly discussed in the Act. The potential of the reclaimed area to meet the needs of future users (generations) must be the pinnacle of the land use plan. Approval is based on compatibility with adjacent land use including aesthetic considerations. A comprehensive plan spells out feasibility, as well as financial and maintenance commitments in addition to numerous social and environmental considerations. There are cases where the revegetation plan is a soft and perhaps short-term standard that is passed off as successful, but the true success of the reclamation plan will be decided by future generations that need to use these lands.

Wisconsin's code provides no specific direction, standards or provisions for alternate post-mining land use. These are established in either the reclamation plan or as conditions in the mining permit and may be modified. The code does require, at section NR 123.08(3), that the reclamation plan include:

- discussion as to why the mine site will not be returned to its original state,
- description of the final land use and its relationship to the surrounding land use, and

- discussion of alternate conditions and uses suited to the affected area.

The Office of Surface Mining Reclamation and Enforcement (OSMRE), the enforcement agency of SMCRA, interprets the period of extended responsibility under SMCRA to start when ground cover meets the approved standard after the last year of augmented seeding, fertilizer, irrigation, or other work.

Wisconsin's code is silent regarding augmentation work. Augmentation consists of supplemental revegetation where vegetative establishment has failed. It includes filling rills and gullies, reseeding or restocking, and other activities necessary to repair or improve an installation of vegetation. Thus far, the Wisconsin Department of Natural Resources (WDNR), the enforcement agency of MMRA, has allowed vegetation augmentation activities to prevent erosion. It is improbable that unlimited augmentation would be allowed during the period of extended responsibility.

There is a difference between the *installation* of vegetation and the *establishment* of vegetation. For example, installation of vegetation is the process of planting seeds, cuttings, root stock, or plants. It also includes the associated cultural practices such as the planting methodology, fertilizer applications, and the use of mulches or geofabrics. Establishment, however, is the point at which the stand of vegetation is considered functionally viable.

Once vegetation is *established*, final reclamation is completed under MMRA and an operator can initiate the Notice of Completion (NOC) of reclamation. Although it is not clear whether the WDNR may deny the NOC for reasons of incompleteness, once the NOC comes to fruition, the period of extended responsibility begins. Since there are no discrete standards to indicate when reclamation is completed, the WDNR establishes procedures and standards on-the-fly, or incorporates them into either the reclamation plan or the permit during the initial permitting process.

Both MMRA and SMCRA provide ecological goals for revegetation success including vegetative cover that is:

- diverse, effective, and permanent
- comprised of native species or introduced species, if they are necessary to achieve the approved post-mining land use
- equal in the extent of cover of the natural vegetation of the area
- capable of stabilizing the soil
- compatible with the approved post-mining land use

- similar seasonal growth characteristics as the original vegetation
- capable of self-regeneration and plant succession, and
- compatible with plant and animal species in the area.

The Wisconsin code offers no specific direction on which vegetative parameters to measure, sampling techniques, or standards to measure revegetation success. Some vegetation parameters measured in SMCRA are cover, productivity, and diversity. Ground cover and productivity of the revegetated area must be at least 90 percent of that of the reference area (or approved technical standard), with 90 percent statistical confidence (30 CFR 816.116 1988). For woodlands and wildlife areas, stocking standards and survivorship are used instead of productivity standards because of the time required for trees to reach an age or size that would allow direct measurement of yield, compared to a reference area (44 FR 15237 1979).

In Wisconsin, once the NOC is filed, the metallic mining code requires a period of extended responsibility at a mining site to run at least four years. At the close of the period of extended responsibility, an operator can petition for a Certificate of Completion (COC) and the associated bond reduction. A public hearing is mandatory, after which the WDNR may issue a COC, provided the operator has fulfilled its obligations under the reclamation plan. But again, the code does not establish procedures or standards for what constitutes success.

Establishing agreement on suitable success standards can be difficult. For example, the NRCS' NASIS database, or local Field Office Technical Guides are recommended for ascertaining the productivity of crops and trees. But, these data are based on the type pedon that can be hundreds of miles away from the specific site in question. In spite of these problems, minimum stocking rates and ground cover values can be established based on average values determined from the literature.

### The Flambeau Site

To better *evaluate success*, as applied to the approximately 200-acre Flambeau Mine site in Wisconsin, Hunt et al. (1998) found it helpful to differentiate between active reclamation, management, maintenance, and long-term care (Figure 1). *Active reclamation* includes activities such as backfilling, surface contouring, topsoil

placement, initial seeding and live plant installation, and general site stabilization. At Flambeau active reclamation was substantially complete by the end of 1998.

*Short-term management* is considered the time period between the beginning of revegetation and the submittal of the NOC. The short-term management period requires an intensive level of site management. Management activities include vegetation enrichment, control of invasive species, and erosion control among others. Though this period can be variable in length, Flambeau originally estimated the short-term management period would end during the fourth quarter of 2000, but is now planning for 2001.

*Long-term management* is considered the period between the NOC and the issuance of the COC. The long-term management period requires a moderate level of site management. Flambeau estimates the long-term management period will end during the fourth quarter of 2004. The approved Reclamation Plan contained in Flambeau's Mine Permit addresses the following long-term management requirements:

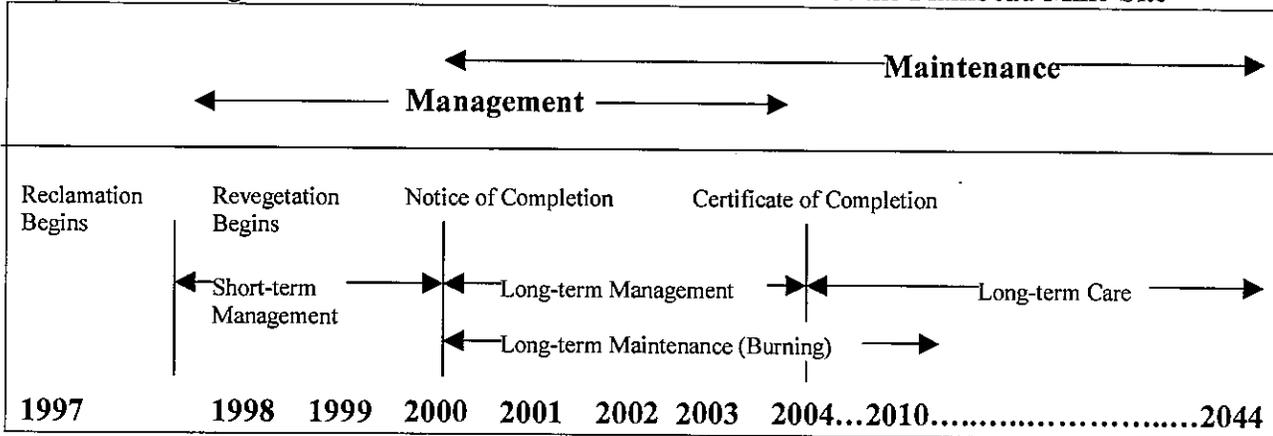
- Develop the restored native plant community consistent with naturally occurring plant communities
- Encourage native volunteer species wherever possible
- Manage grassland vegetation using controlled burning management methods
- Conduct annual maintenance of the site as necessary

Apart from controlled burning, Flambeau plans to utilize on-site and contracted resources to provide a full range of site maintenance services from integrated pest management to people control.

*Long-term maintenance* is considered the period after the NOC, extending for some time after the COC, during which vegetation will be maintained using appropriate methods. The principle method for long-term maintenance will be prescribed burning. This period can be variable in length, but at the Flambeau site, it consists of a 10-year duration beginning with the first prescribed burn of the management period, which occurred in 2000. The controlled burn regime rotates through a series of subunits that will be burned quasi-randomly in order to maintain a wildlife refugia.

*Long-term care* is the period after the COC when the former open pit and waste rock stockpiles are managed as one facility under the solid waste regulatory codes. Long-term care requires maintaining surface stabilization for a period up to 40 years (Foth and Van Dyke, 1989).

Figure 1. Management/Maintenance Definition and Timeline for the Flambeau Mine Site



### Vegetation Success Parameters at Flambeau

*Percent vegetative cover*, a metric used at the Flambeau site, is one example of a parameter that is not specifically incorporated into Wisconsin's metallic mining code but is incorporated into the reclamation plan as an indirect measure of vigor, stability, aesthetics, and habitat. It is assumed that once habitat is reestablished through land shaping and revegetation, animal populations will recolonize a mine site, although this assumption is tenuous at best (Ashby, 1987 and Kline and Howell, 1987).

The following is a partial list of monitoring requirements and performance standards that are implemented on the reclaimed mine site in accordance with Flambeau's approved Reclamation Plan:

- Minimum of annual vegetative monitoring beginning prior to submittal of the Notice of Completion (NOC) and ending at Certificate of Completion (COC)
- **Percent cover**
  - 70 percent vegetative cover averaged over the site at 90 percent statistical confidence
  - Annual measurement over entire site at no less than 160 randomly placed one square meter quadrats
  - Measurements occur during mid-August to early September
  - Measurements correlated with aerial color infrared photography
- Sample design shall accommodate all community types and moisture gradients evaluated
- Number of sample units per community type based on mean/variance tests (may be fewer than 160 quadrats)
- **Biomass**
  - Total above-ground herbaceous biomass determined twice, once for the NOC and once for the COC
  - Harvest data shall come from no less than 25 randomly placed one square meter quadrats
  - At COC no less than 80 percent of total above-ground biomass at NOC at 90 percent statistical confidence – changes in composition notwithstanding
  - Frequency and timing of controlled burns shall not interfere with measurements in the Grassland community type only
- **Survivorship of woody plant stock**
  - Determination by representative population sample
  - At the NOC, and again at the COC, no less than 80 percent of the initially planted species must survive in a similar proportion to the initial planting
  - Evidence of vigor and health
- **Wetland and biofilter vegetation**
  - Frequency of occurrence by species for aquatic vegetation
  - Species similarity of standing crop to initial planting will be no less than 80 percent, at 90 percent statistical confidence
  - **Density** stem counts, or estimated stem counts depending on the species of standing crop will be no less than 80 percent, at 90 percent statistical confidence to the initial planting
  - Minimum of 12 planted species
  - Density and percent cover determined using quadrats along transects and timed meander searches (defined in the monitoring section below)

### Vegetation Monitoring Methods at Flambeau

The two techniques used for herbaceous vegetation sampling were, 1) quadrat sampling, and 2) timed meander search (TMS). Woody species sampling consisted of canopy intercept, sapling and tree counts (including seedlings housed in tubular tree shelters referred to as tubed seedlings) along four meter wide belt transects (two meters each side of the transect lines), as well as an entire planted tree and shrub population count in all woodland planting zones.

Quadrat sampling was conducted at five-meter intervals along thirty 50-meter transects. A circular hoop, one meter square in area, was used to sample vegetation at the five meter increments along the transects. Percent cover was recorded for each species in each quadrat.

Twenty-five of these transects were installed in 1998 and an additional five transects were installed in the woodland zones (one is considered a mixed transect because it extended into the upland grassland area) in 1999. Transect locations were determined using partitioned, but randomly chosen numbers to generate end points and compass bearing for each transect. Transects were partitioned to ensure adequate representation of key planting zones. Transects were located in the field and each end point was staked with steel rebar (driven flush to ground level) and metal posts (about five feet high). Each end point was surveyed using GPS.

TMS were conducted in the vicinity of each transect. Each species was recorded as it was encountered for the first time. Also during the survey each passing minute was recorded; thus, the number of new species discovered per minute was documented and with it the order in which the species were found. When no new species were found the search ended.

Woody vegetation was sampled along the identical 50-meter study transects laid out for quadrat sampling. Two parallel 2 meters wide belts were laid out along each study transect, one on each side of the transect (creating a 4m x 50m belt transect). Woody plants equal to or greater than 0.5-meter in height and all tubed seedlings, regardless of their height, within each 4-meter wide x 50-meter long belt transect were measured for:

- Percent canopy intercept (line-intercept, the vertical projection of photosynthetic leaf area over measured lineal distance of transect tape)
- Survivorship (measured as alive or dead)

- Diameter and, if appropriate, Diameter at Breast Height [DBH- 4.5 feet above ground]
  - Number of stems for each woody plant species
- A complete count of all planted trees and shrubs (recorded as alive or dead) was also conducted in each woodland area in order to obtain more accurate woody species survivorship data.

### Vegetation Monitoring Results at Flambeau

#### Overall Mine Site

In monitoring year three, the reclaimed mine site averaged 97% vegetative cover. A total of 334 plant species were found on the revegetated mine site in 2000. Seventy-five percent of these species were native while 25% are non-native.

Spring Sampling. A total of 242 species were found on the mine site during the spring sampling, 74% of which were native and 26% were non-native. In the grasslands 115 species were found with 64% native and 36% non-native. Seventy-eight percent of the 151 species found in the wetlands were native and 22% were non-native. Sixty-four percent of the 141 species found in the woodlands were native and 36% were non-native.

Summer Sampling. During the summer sampling 269 species were found on the site, 75% of which were native and 25% were non-native. In the grasslands 74 species were found with 62% native and 38% non-native. Eighty-six percent of the 120 found in the wetlands were native and 14% were non-native. Sixty-nine percent of 110 species found in the woodland were native and 31% were non-native.

#### Grassland Plant Community

The mean percent cover for the upland plant community is about 96%. This includes an average of 23% cover by native grasses, 19% by native forbs, and 42% by all native species. Clovers, Bird's foot trefoil and Timothy (*Phleum pratense*), dominate this community with each having approximately 15% of the importance value. Native species are also abundant in this community. Black-eyed susan (*Rudbeckia hirta*), Indian grass (*Sorghastrum nutans*) and Big bluestem (*Andropogon gerardii*) each have 5-10% of the importance value in this community. On average, approximately, 30 plant species were encountered along transects in the upland grassland community. The number of plant species observed during a TMS range from 36 to 74. Of these, 19 to 56 were native, and the balance (16-19 species) were non-natives, cover crops, and invasive species (Stoll et. al, 2000).

### Woodland Plant Community

The mean percent cover for the woodland plant community is about 98%, and is comprised of 5% native grasses, 21% native forbs, and 28% total native cover. Bird's foot trefoil (*Lotus corniculatus*) is by far the most important plant species in this community at the ground story with 29% of the importance value. Importance value is the summation of relative vegetative cover and frequency of occurrence for a given species. Woodland transects generally encountered approximately 25 plant species. The total number of species observed in TMS of the woodland communities range from 62 to 95 plant species. The number of native species range from 38 to 66 while non-natives range from 17 and 28 (Stoll et. al, 2000).

The overall survivorship of woody species planted in the woodland community was 81%, and species proportions were very similar to the initial planting with the exception of Gray dogwood (*Cornus racemosa*) and the oaks. Gray dogwood had poor survivorship and now represents less than 1% of the woody species instead of 7.6%. Oaks, on the other hand, represent almost 49% of the planted woody species instead of the intended 40% (Stoll et. al, 2000).

Stem counts along the nine permanent belted transects that pass through woodland zones encountered twelve of twenty planted species. Eleven of the twelve species had greater than 80% survivorship, and most had 100%. Although this data is low in number (most of these species were encountered less than five times) it seems to suggest the same conclusion as the entire population count: Most individual planted species and the entire woody species population have greater than 80% survivorship. Gray dogwood had very poor survivorship in the total population count and was undetected along the belted transect. Staghorn sumac (*Rhus typhina*) had the highest stem density (stem and tree) and canopy intercept. Of the species planted, white oak (*Quercus alba*) and red oak (*Quercus rubra*) had the highest stem (stem and tree) density, and white ash (*Fraxinus americana*), white pine (*Pinus strobus*), white oak and hemlock (*Tsuga canadensis*) had the greatest area of canopy intercept (Stoll et. al, 2000).

### Wetland Plant Community

The mean percent plant cover for the wetland plant communities, including the biofilters and swales was 100%, with 40% cover by native forbs

and 41% cover by native grasses. The most important plant species in this community is Giant manna grass (*Glyceria grandis*), a native grass, with 10% of the important value in this community. Other native emergent and aquatic species are also abundant in this community, including Common arrowhead (*Sagittaria latifolia*), Nitella (*Nitella* sp.), Fineleaf and Floating leaf pondweeds (*Potamogeton pectinatus* and *P. natans*) and Marsh purslane (*Ludwigia palustris*), each with near or greater than 5% of the importance value in the wetland community. The native aquatic species combined with the native forb and grass species account for the very high total native cover in these communities. The number of plant species along transects in these communities varied from approximately 15 - 40. The number of plant species observed during the TMS in wetlands ranged from 46 to 76. Thirty-five to 62% of these species were natives, and 5 to 13% were non-native (Stoll et. al, 2000).

Stem counts required in the 8.5-acre wetland restoration zone(s) to fulfill the original intent of the monitoring requirement, were no longer practical. Each planted and seeded individual had multiplied and, for many species, were now represented by many stems. For all species, the original planted stems were no longer identifiable. Substantially more stems of the planted species were present in the wetlands than were originally seeded and plugged (Stoll et. al, 2000).

### Plant Community Development and Trajectory

The fall 2000 vegetation data suggests that the plant communities anticipated in the restoration plan are *becoming established*. Planted native species were more abundant in the 2000 sampling, and are becoming well established and widespread in distribution on the site. Further, each plant community is assuming the structural characteristics intended. The diversity of plant communities met or exceeded expectations. Diversity was calculated using frequency of occurrence, richness, and importance value. In fact all planting zones at Flambeau continue to perform better than anticipated, and better than most restoration projects in the region using similar planting specifications. The data illustrate that this site is tracking toward the desired trajectory for plant community development, diversity, cover, plant frequency, and productivity.

### Conclusions

Wisconsin's code does not prescriptively apply performance standards, as does SMCRA. Non-the-less it does provide flexibility sufficient to accomplish ecologically successful revegetation performance. The WDNR incorporates ecological revegetation performance standards, similar to those contained in SMCRA, into the

reclamation plan and permit, and provides iterative performance negotiations. But, Wisconsin's flexible approach works only if the regulatory authority has:

- Adequate staff with sufficient ecological competency and resources
- Authority to issue penalties for violations subject to due process
- Clear procedures for negotiating performance standards, and
- Established criteria for clear ecological goals.

The operator must also demonstrate commitment, capability, and good faith.

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