A Conceptual Model of European Wet Meadow Restoration

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RESEARCH REPORT

A Conceptual Model of European Wet Meadow Restoration

by A.P. Grootjans and S.K. Verbeek

Restoring species-rich European grasslands requires traditional management techniques coupled with an understanding of current ecological conditions.

Species-rich meadows, once widespread in northwestern and central Europe, are today found only in nature reserves. Managed in traditional ways, these meadows, which are remnants of our cultural inheritance, often preserve high levels of biodiversity but only when several management techniques are used. In this paper, we develop a conceptual model based on case studies that demonstrate which management techniques to use in the various situations where former wet meadows are found.

Historic Land Use of European Mires

The transformation of European fens and bogs to agricultural fields began on a very limited scale about 7,000 years ago. This situation, which resulted in treeless mires with forests on higher grounds, remained unchanged throughout large parts of northwestern Europe until approximately 1,500 years ago (Figure 1). At that time, degradation and destruction of primeval forests and mires began on a large scale. Cistercian monks, in particular, were very active in transforming wetlands into meadows that could be used for agriculture. The majority of species that invaded these newly created grasslands and heaths were already present in open parts of forests, along the fringes of streams, or in fens and bogs. In addition, new species that were adapted to the open landscape—typically hybrids between closely related species—emerged. These included: cuckooflower (*Cardamine pratensis*), cock's foot (*Dactylis glomerata*), and jointed rush (*Juncus articulatus*). The final results of this process were widespread, species-rich grasslands—ecosystems whose species richness was much higher than the original mires.

The species-rich grasslands remained intact until the 1920s when agriculture in Europe became increasingly more mechanized and artificial fertilizer use more widespread. In addition, extensive drainage systems were constructed that also affected the meadows and other remaining wetlands (Pfadenhauer and Grootjans 1999). These changes resulted in the development of an ecologically impoverished landscape. A study by Garcia (1992) found that 95 to 98 percent of the species-rich hay may meadows in the United Kingdom that were present before 1940 had been lost as a result of these new agricultural technologies. In the Netherlands, many wet meadow species have been Red Listed because they are endangered and restricted to marginal environments in a fragmented landscape.

Techniques for Restoring Species-Rich Grasslands

When national governments or private nature conservation organizations first began purchasing species-rich meadows in the 1950s, they decided to continue or to reinstate traditional mowing regimes,

Ecological Restoration, Vol. 20, No. 1, 2002 ISSN 1522-4740

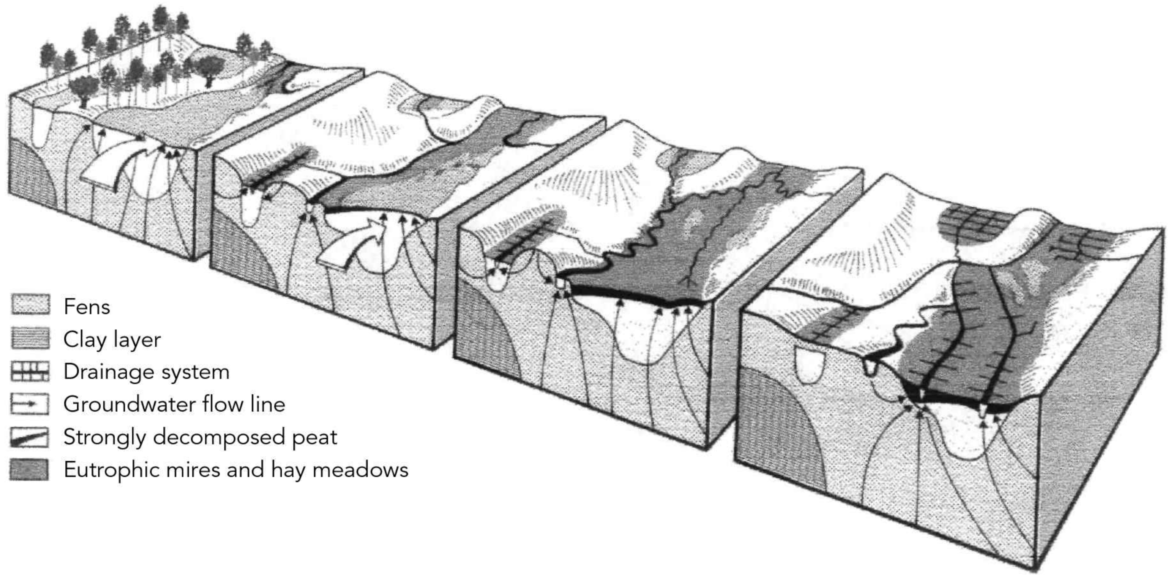

Figure 1. The transformation of brook valley vegetation due to changes in agricultural practices. Starting from the far left, natural peat-forming ecosystems, such as bogs and fens, were changed into semi-natural grasslands with high biodiversity. This was followed by ecological degradation due to intensive drainage and fertilization. *Adapted from Grootjans and van Diggelen 1995*

either by hand or with machines. Most hay meadows were mown in June. Some nutrient-poor meadow types (litter fens) were mown in late summer, while highly productive flood meadows were mown twice (May and July). Studies of this type of management (Bakker and Olff 1995, Muller and others 1998) indicate that mowed, unfertilized meadows have low yields—so low that farmers will not harvest them unless they receive some kind of financial subsidy. Moreover, the new machinery needed for such work is expensive, being specially designed for this purpose.

By the 1970s it became clear that many of the rare and endangered species were disappearing from established meadows in nature reserves, despite the continuation or reinstatement of mowing. Drainage in surrounding agricultural areas, extraction of groundwater for public drinking water, and atmospheric deposition of nitrogen were determined to be the cause of this decline (Roelofs and others 1996, Grootjans and others 1996, Runhaar and others 1997). Figure 2 shows the decrease in the number of target species due to adverse effects from lands surrounding a reserve, despite management practices. Since that time, many restoration projects have been undertaken to remedy the situation. These projects have, in addition to mowing, used rewetting and sod cutting in order to meet their restoration goals.

Rewetting is simply returning the water levels to their historic elevations. If, however, water levels in the surrounding land have been lowered, rewetting will only acidify the top soil layer because the added water will flow into the lower outlying areas and the meadow will receive only acidic precipitation water (Beltman 1995). For this reason, it is often necessary to purchase the surrounding agricultural land and eliminate all drainage systems. In other cases, groundwater-pumping facilities might have to be closed down in order to maintain the proper levels of water. Rewetting by flooding the area with surface water is also used with some success, not only to increase productivity but also to

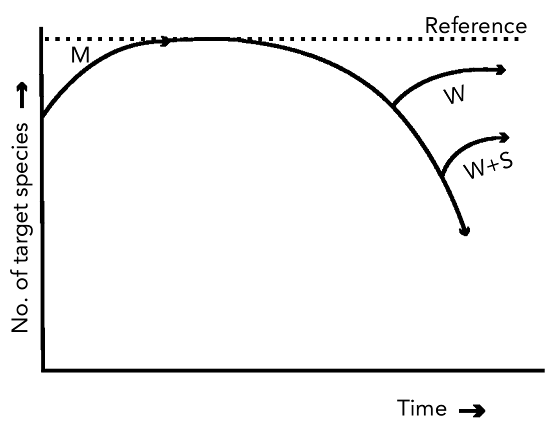

Figure 2. Traditional management of wet meadows consisted of mowing without fertilization (m), which kept species-richness at a high level. Drainage and atmospheric deposition of nitrogen from nearby farm fields made it impossible for traditional management techniques to maintain high levels of diversity. Restoration measures, such as rewetting (w) and sod cutting (s) were somewhat effective over the short-term.

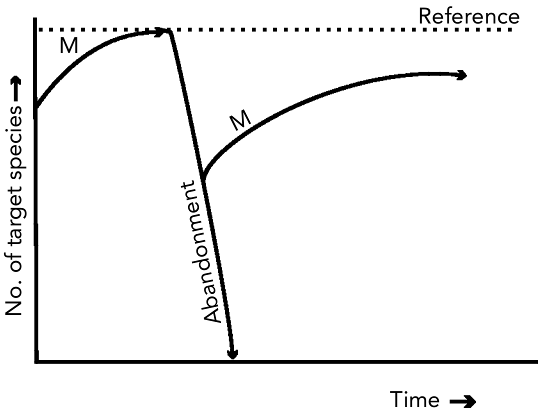

Figure 3. Resuming mowing without fertilization (m) is often very successful in establishing target species on sites that have been abandoned for only a short time.

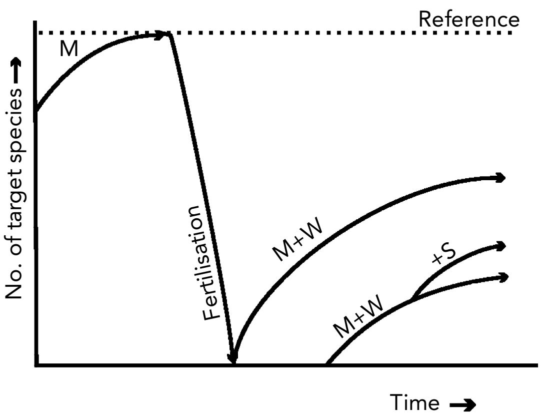

Figure 4. The number of target species in wet meadows declines rapidly after intensive fertilization. If restoration techniques, such as mowing (m), rewetting (w), or sod cutting (s), are resumed shortly after the cessation of agricultural use, the success rate is usually high compared to situations where fertilization has taken place for a long time.

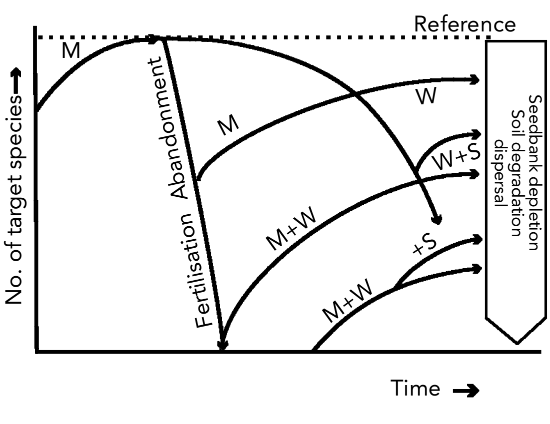

Figure 5. A conceptual model of the occurrence of target species in wet meadows under restoration management. *Adapted from Grootjans and others 2002.*

prevent desiccation and acidification of meadows. Floodwater usually contains much silt and organic material, which contributes to soil fertility and the silt fraction buffers the soil exchange complex. Rewetting has been especially effective in cases where the process of desiccation had taken place for only a few decades.

Prior to the 20th century, farmers regularly cut sod from heathlands, mixed it with animal dung, and worked it into their fields to increase soil fertility. Sod cutting for restoration purposes involves complete removal of the nutrient-rich topsoil, up to a depth of 4-16 inches (10-40 cm). This technique is often used in areas that were former agricultural fields, and is particularly successful on mineral soils. It is applied in existing fen meadow reserves to counteract the effects of acidification and atmospheric nitrogen and sulfur deposition (Jansen and Roelofs 1996).

Developing a Conceptual Model

There have been several researchers who have studied the effectiveness of different techniques for restoring wet meadows in Europe (Baker and Olff 1995, Grootjans and others 2002, Jansen and others 2000, Oomes and others 1996). In this paper we will not discuss the successes or failures of individual cases, but rather use the results of these empirical studies to develop a conceptual model of wet meadow restoration. In considering a restoration model, we established the condition of wet meadows at the beginning of the 20th century as the reference state.

Former species-rich meadows are in various stages of decline throughout Europe. Most species-rich meadows have disappeared because they have been abandoned. This is especially true in Eastern Europe where traditional management simply ceased to exist following the breakup of the Soviet Bloc, and even more so after the introduction of the free-market economy. Tall sedges, tussock species, and willow shrubs now cover large areas of former meadow in Eastern Europe. These species produce shade during the summer and large amounts of litter in the autumn. This results in the loss of conservative meadow species within five to ten years after abandonment. Some meadow species are able to survive in the seed bank or as relic populations in ditches or in sites kept open by grazing animals. Resuming traditional management (mowing) in early stage of abandonment (5-10 years) is essential for nearly complete restoration (Figure 3). Large meadow reserves have been restored by using this technique in river valleys in the Netherlands (Drentse Aa), Belgium (Zwarte beek), England (Sedgemoor), Germany (Wümme, Peene), and Poland (Biebrza).

Sometimes, however, an early success is followed by a loss of target species after 10-15 years. This is most often caused by drainage in areas around the reserve or by pumping of groundwater near the reserve.

In situations where the meadows were intensively farmed the species richness drops dramatically and restoration is more difficult (Figure 4). The most successful of these restorations are on sites with mineral soils, situated adjacent to existing meadow reserves. When restoration management practices (mowing and rewetting) are applied in these former agricultural settings, the increase in target species depends on the amount of nutrients accumulated from the previous fertilization (Bakker and Olff 1995). It may take 5 to 15 years before the nutrient stocks reach a level in which productivity no longer prevents the establishment of target species. For example, Oomes and his colleagues (1996) reported on a restoration experiment where mowing alone was very unsuccessful, even after ten years and regardless of the fact that several target species were present in the seedbank. In that case, mowing in combination with rewetting was much more successful and, when combined with sod cutting, led to the reappearance of many, but not all, target species within a period of 5 to15 years. Jansen and his colleagues (2000) reported on a very successful restoration of a site where corn was grown for at least ten years. In this case, the hydrological conditions were restored, the topsoil removed, and flooding resumed in both the source and target areas, thus activating the seedbank and dispersal mechanisms.

Combining Figures 2, 3, and 4 leads to a conceptual model of wet meadow restoration. The model summarizes successes and failures of restoration measures in a wide range of conditions. Figure 5 shows that restoration measures usually do not succeed in restoring wet meadows to their original, early 20th-century state. This is particularly true when the meadows have been drained and farmed for a long time. The implication for managers of nature reserves in Europe is that the most successful wet meadow restoration projects will be those on sites that have been least affected by intensive agriculture and drainage. This further suggests that restoration projects should be undertaken in areas not affected by drainage problems and where some relic populations of meadow species still exist.

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