EVALUATING THE EFFECTS OF TALL FESCUE (*FESCTUCA ARUNDINACAE)* IN RECLAIMED WILDLIFE HABITAT USING LAND TYPE ASSESSMENTS AND MOBILE COMPUTING TECHNOLOGY[1]

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Abstract. Kentucky -31 (KY-31) tall fescue (*Festuca arundinacae*) produces an effective ground cover and can be a valuable forage crop; however, it has been shown to be a detriment to wildlife populations through habitat colonization (elimination of bare ground, suppression of other valuable plants, and the toxic nature of seeds and vegetative matter to wildlife species). Because of its ability to effectively control erosion and produce high forage yields, KY-31 has been a commonly used grass species for surface mine reclamation. The objective of this study is to assess the suitability of approximately 54.1 hectares of reclaimed wildlife habitat inadvertently seeded with KY-31 fescue at Associated Electric Cooperative, Inc. (AECI), Prairie Hill Mine in northern Missouri. Land type assessment models were used to score wildlife habitat suitability. Models were structured to rate quality factors based on vegetative communities, spatial distribution, and favorable environmental conditions to wildlife species. Data collection was accomplished with real time mobile mapping GPS devices using ArcPad software and analyzed with ArcGIS desktop. Through the use of spatial technologies, wildlife models produced a score under optimal conditions as well as applied a rating to both KY-31 seeded wildlife habitat and wildlife areas proposed by AECI for mitigation. Rating points for wildlife habitat seeded with KY-31 and areas proposed for mitigation were totaled and compared to the derived target value. Initially, wildlife sites seeded with KY-31 fescue scored below the target values. However, when the fescue areas were totaled with the wildlife mitigation tracts the habitat suitability exceeded the target values generated by the assessment models. This study demonstrates the site specific effects of KY-31 in differing wildlife habitat land types and provides field assessment techniques to measure suitability. Through the use of adapted wildlife habitat rating models and new technologies such as mobile computing and GIS, the effects of KY-31 can be quantified, allowing appropriate mitigation to offset resource losses.

Additional Key Words: habitat evaluation, reclamation, ArcPad, ArcGIS

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Introduction

Determining the adverse effects of tall fescue (*Festuca arundinacea*) in wildlife habitat on reclaimed surfaced mined lands has become an increasingly complex revegetation issue. Due to its ability to control erosion, tolerance of poor soils with wide pH ranges, and capacity to grow in both wet and dry microclimates, fescue has been a widely used species during mining reclamation. While fescue effectively controls erosion and under proper management can produce high hay crop yields, it is a persistent perennial that has been shown to strongly out-compete many native species reducing habitat diversity. Past research has found much of the resilience associated with tall fescue is a result of a mutualistic relationship with an endophytic fungus (*Neotyphodium coenophialum*). This cultivar of fescue was discovered in Kentucky in 1931, released in 1943 as "Kentucky-31" (KY-31), and to date covers approximately 17 million acres of land in Missouri (Roberts 2000). Similar to many exotic species, the KY-31 cultivar diminishes the biodiversity of soil organisms, plant life, insect, bird, and mammal species (Henson 2001) through increased fitness and produces toxic alkaloids that can cause illness to wildlife species and livestock (Roberts 2000). This competitive and allelopathic advantage can result in the conversion of a once-diverse wildlife area to a KY-31 monoculture.

Until recently, little research has been focused on the adverse relationship KY-31 has in reclaimed post-mining wildlife habitat through its ability to alter environmental conditions. Many Federal and State wildlife conservation and natural resource agencies in the Midwestern United States have begun to restrict the introduction of KY-31 on public lands and have developed incentive programs to limit seeding on private lands. Because of KY-31's ability to produce an effective ground cover under a wide array of conditions, it has been widely used in surface mining reclamation to achieve regulatory compliance and bond release.

Purpose and Objective

The overall objective of this study was to evaluate the effects of KY-31 in wildlife habitat at the Associated Electric Cooperative, Inc. (AECI) Prairie Hill Mine in north central Missouri. In July 1996, the Missouri Land Reclamation Program (LRP) approved a permit revision excluding the future seeding of KY-31 in wildlife habitat on all AECI mine sites due to the potential adverse effects to wildlife. Subsequent to the permit revision, AECI inadvertently seeded 15 parcels of forested wildlife habitat, totaling 54.1 hectares with a tall fescue, orchard grass (*Dactylis glomerata*), and smooth brome (*Bromus inermis*) ground cover mix within the Prairie Hill Mine.

Several tools, including an adapted wildlife habitat evaluation system, mobile computing, and Geographical Information Systems (GIS) were utilized to assess the suitability of the reclaimed wildlife habitat seeded with KY-31. Additionally, potential mitigation areas were assessed using the same procedures. Given the recommendations and findings of this study, AECI was able to implement the appropriate measures to mitigate reclaimed wildlife habitat seeded with KY-31. Moreover, the methods and results of this research can be implemented and adapted by other regulatory agencies and private industry to evaluate and enhance wildlife habitat on reclaimed mine sites; thereby, reducing the chance of failure on permits with wildlife habitat as the post-mining land use. Table 1 shows the mining permits and corresponding acreages seeded with KY-31 post July 1996 and Fig. 1 illustrates the map locations of the affected wildlife habitat.

Table 1. Permit Acreages Seeded with Tall Fescue Post July 1996

Permit(s)	Map Identification	Hectares
1986-01, 1990-04, 1991-03	01	8.0
1986-01	02	0.6
1981-02	03	1.1
1981-02	04	0.5
1981-02	05	0.6
1981-02, 1982-09	06	32.0
1985-10	07	0.4
1985-10	08	1.2
1985-10	09	0.8
1985-06, 1990-02	10	8.9
	Total Hectares	**54.1**

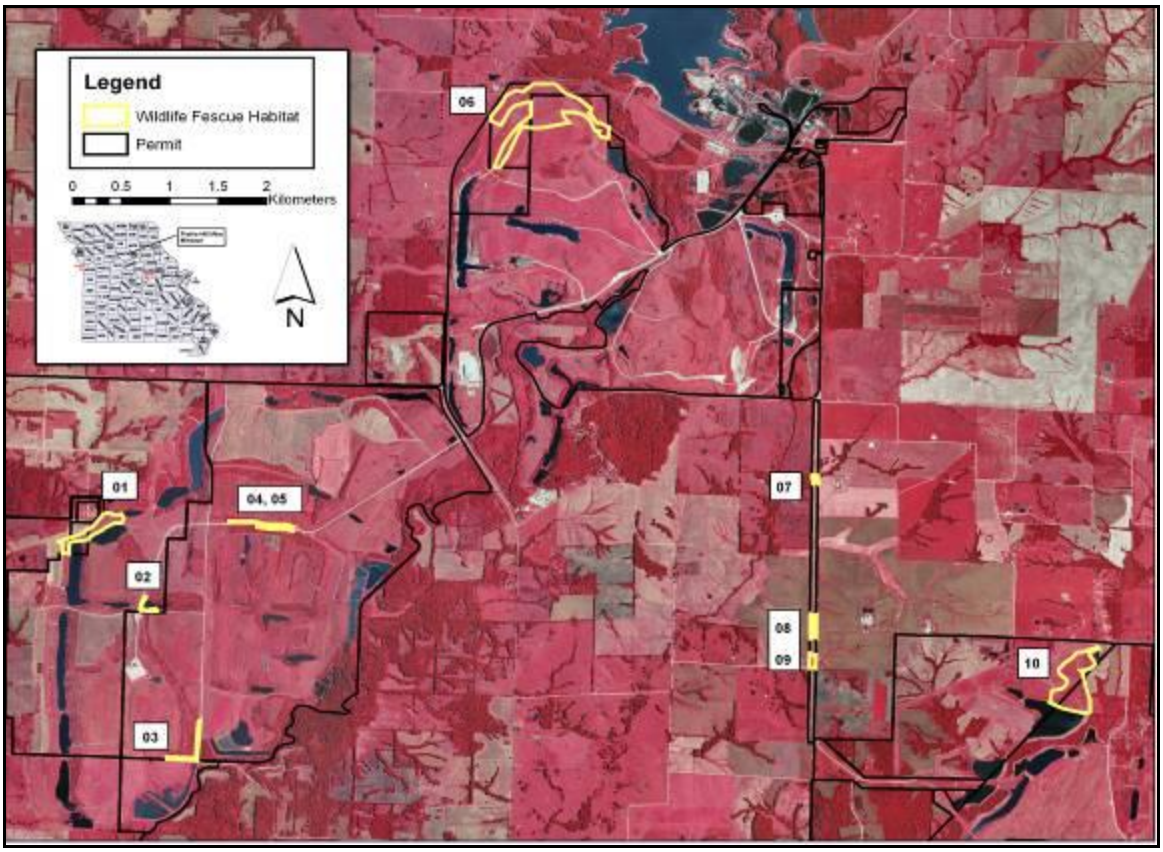

Figure 1. Map Locations of Wildlife Habitat Seeded with Tall Fescue.

Study Site

AECI Prairie Hill Mine lies within the Chariton River Basin in Randolph and Chariton counties in the Glaciated Plains region of Missouri. The mine is located approximately 20 miles northwest of Moberly, Missouri, south of the Thomas Hill Reservoir and is comprised of approximately 5,405 hectares. Mining operations began in 1980 with various permits being

issued in later years extending until 1993. Currently, all permit areas in the mine are in reclamation and there is no active mining at the site.

Over 80% of the land in the Chariton River Basin is used for commodity production (Cashatt & Neuswanger 2001). In 2000, 43% of the basin was in hay or pasture, 38% was in cropland, 15% was forested, including grazed woodlands, and 4% was used for other purposes (Cashatt & Neuswanger 2001). In general, row crops are grown on the level ridgetops and floodplains while pasture occurs on the hillsides and ridgetops. Forested land can be found along drainages and streams, on hillsides and ridges, but is not a predictable part of any landform.

Vegetative characteristics of reclaimed areas within the mine site differ little from the surrounding undisturbed land uses. AECI's most dominant land use at the Prairie Hill Mine is pastureland with interspersed cropland and wildlife habitat land uses. Dominant cool season forages in the pasture and cropland include KY-31 fescue, orchard grass, and smooth brome. These land uses are well managed and revegetation productivity data has shown the areas to produce above average yields.

Much of the designated wildlife habitat in the mine has undergone an aggressive reforestation initiative and stem counts typically range from 450-800 trees per acre. As indicated by past revegetation data, woody species diversity ranges from an excellent composition in later successional areas to a moderate rating in more recently planted wildlife habitat. Common tree species within the mine include red oak (Quercus rubra), pin oak (Quercus palustris), autumn olive (Eleaganus umbellate), green ash (Fraxinus pennsylvanica), black locust (Robinia pseudoacacia), river birch (Betula nigra), bald cypress (Taxodium distichum), shortleaf pine (Pinus echinata), and eastern red cedar (Juniperus virginiana).

Tall Fescue Competition on Mine Sites

Several studies conducted in the eastern United States and past revegetation data from the Prairie Hill Mine indicate the effectiveness of KY-31 to control erosion and produce high agricultural yields under proper management techniques. These data sets also reveal the adverse effects of the KY-31 cultivar on plant biodiversity and demonstrate its increased competition and fitness over other species. In west-central Illinois, Rodgers & Anderson (1989) studied the effects of KY-31 planted on mine soils amended with dry sewage sludge and on similar unamended sites. By the end of the second growing season, fescue produced significantly (in excess of two times) more biomass on amended sites than on unamended sites. Similarly, data from Prairie Hill Mine demonstrated the ability of fescue to produce high yields on reclaimed mine soils that receive fertilization. Three pasture areas, totaling 81 hectares, were seeded with orchard grass, fescue, and alfalfa (*Medicago sativa*) at a rate of 25 to 30 kilograms of seed per species per hectare. These areas were also amended with approximately 66.7 kilograms of nitrogen, 56.8 kilograms of phosphorus, and 79.0 kilograms of potassium on a per hectare basis. Productivity data indicated a mean yield of 100.6 grams of forage per sample frame which exceeded the mean 89.9 grams of forage per sample frame produced in the undisturbed reference area.

While the previous data sets showed the positive response KY-31 has to fertilization and its ability to produce high yields on mine soils, no attempt was made to show effects on plant biodiversity. Several past research studies (Hughs 1987; Andersen 1989; Skousen et. al 1998) found that KY-31 hindered woody plant growth and survival on surface mined sites. Areas

seeded with KY-31 showed less tree cover and fewer stems, whereas areas not seeded with grasses demonstrated tree cover similar to that of undisturbed sites. The tree seedlings suffered severe stem dieback on plots with no groundcover control. When KY-31 was chemically controlled, survival and height growth of tree species were greater. Similar diversity results were identified when a comparative evaluation on the composition of cool season grass species was completed on 150.5 hectares of pasture at the Prairie Hill Mine. Pasture land uses in the mine were seeded with orchard grass, tall fescue, red clover (*Trifolium pretense*), and alfalfa at a rate of 25 to 30 kilograms of seed per species per hectare in the fall of 1997. Transect data demonstrated a mean acceptable ground cover of 98.7 percent, which far exceeds the ground cover requirement of the Missouri State Regulatory Program. Of the 98.7 percent, cool season grass species comprised 81.8 percent of the total plant cover while the other 16.9 percent was primarily red clover and alfalfa legume species. A closer review of the cool season grass composition was accomplished and revealed KY-31 made up 56.7 percent of the stand. Under high levels of management and proportionate seeding rates between cool season grasses and legume species, KY-31 exhibited a twofold dominancy over all other species in the stand. These studies indicate that KY-31 fescue increases in vegetative vigor, competition, and fitness compared to other woody and herbaceous species under identical environmental conditions.

Methods

Wildlife Habitat Evaluation Models

Land type assessment models were tailored to rate the quality of wildlife habitat seeded with KY-31 and the wildlife habitat areas proposed by AECI for mitigation. This classification and modeling method was adapted for reclaimed wildlife habitat from the USDA Natural Resources Conservation Service assessment procedures for the Missouri Wildlife Habitat Incentives Program (WHIP). Relationships between quality factors that increase positive niches for wildlife and plants support a more diverse range of acceptable species, thereby increasing wildlife habitat suitability. More specifically, these models assign a numerical score based on vegetative composition, biodiversity, wetland characteristics, tree survival, invasive plant populations, continuous land areas, and management techniques. Each quality factor has independent variables which in turn generate a specific score that indicates the wildlife habitat value. After field analysis, quality factors are totaled and each tract of habitat is assigned a community index rating. Community index ratings provide a qualitative analysis of the suitability of the habitat for wildlife populations. Models were designed to characterize the individual wildlife land use types under evaluation at the Prairie Hill Mine. Land use models in the rating system include evaluation criteria for the three specific land types, early successional forested community, grassland community, and seasonal wetland community (Table 2).

Two criteria were utilized to determine how the wildlife land uses would be assessed, wildlife land type and contiguous land areas. Habitat with the same land type (i.e. forested, wetland, grassland) and comprised of a single tract of contiguous land, regardless of permit association, was evaluated as a single unit. Many of the wildlife areas seeded with KY-31 fell within different permit boundaries, but are part of contiguous land areas that are the same post-mining land use. Utilizing a landscape approach allowed for a more accurate assessment of the total mine area removing the bias that would otherwise be created by administrative permit boundaries. Rating points for wildlife habitat seeded with KY-31 and areas proposed for mitigation were totaled and compared to a target value. The target value was developed from the

land use models factoring optimal conditions for the early successional forest land type. Mitigation measures are considered to be at an acceptable level when the total index score of the existing KY-31 fescue-seeded habitat and the proposed wildlife habitat mitigation areas are equal to or greater than the target value.

Table 2. Wildlife Habitat Modeling Quality Factors

Wildlife Land Use Type	Quality Factor	Scoring Range
Forested	Tree Survival	0 - 8
Forested	Tree Composition and Diversity	0 - 10
Forested	Ground Cover and Composition	0 - 10
Forested	Invasive Species Population	0 - 5
Forested	Wildlife Habitat Hectares	2 - 10
Grassland	Grass Composition and Ground Cover	0 - 10
Grassland	Desirable Forb Diversity	0 - 8
Grassland	Grassland Management	0 - 8
Grassland	Invasive Species and Woody Invasion	0 - 5
Grassland	Wildlife Habitat Hectares	2 - 10
Wetland	Water Regime	0 - 10
Wetland	Wetland Plant Diversity	0 - 10
Wetland	Native Emergent Vegetation	0 - 8
Wetland	Invasive Species and Woody Invasion	0 - 5
Wetland	Wildlife Habitat Hectares	2 - 10

Mobile Computing and Geographic Information Systems

Real time mobile mapping technology was used to capture the field data of the wildlife habitat seeded with KY-31 and the wildlife areas proposed for mitigation. Wildlife habitat suitability models were digitally created in the office using the Layer Form Creation Wizard in the ESRI ArcPad software package version 6.0.3 (Fig. 2). ArcPad software along with the digital layer forms were downloaded to a Hewlett Packard Handheld iPAQ Pocket Personal Computer to collect field data. The iPAQ supports WAAS enabled Bluetooth Global Positioning System technology so real-time information could be collected on the mine site. Using the ArcPad software and the Layer Form Creation Wizard allowed for a specific customization of the wildlife habitat evaluation models. Additional layers for spatial reference such as the mine permit boundaries, land uses, and ortho-quarterquadrangle (DOQQ) aerial photography were downloaded to the iPAQ to assist with field analysis.

In order to create specific layer forms for use with the ArcPad software, ESRI shapefiles were created and projected using the ArcGIS desktop. Shapefiles are vector data files used for storing the location, shape, and attributes of geographic features (Booth et al. 2002). Once the basic shapefile information was established, it was then imported into ArcPad for Layer Form creation and eventually to the iPAQ for field analysis of the wildlife areas.

After field collection of the data using the iPAQ and ArcPad software, the shapefile feature class information was analyzed using ArcGIS version 9.0. Wildlife habitat suitability information collected in the field was automatically transposed to tabular format in ArcGIS. In addition to quantification of the wildlife rating scores, map-based applications in ArcGIS were

used to assess other spatial factors such as wildlife habitat acreages, distance calculations, spatial distribution of affected environments, and analysis of adjacent land uses.

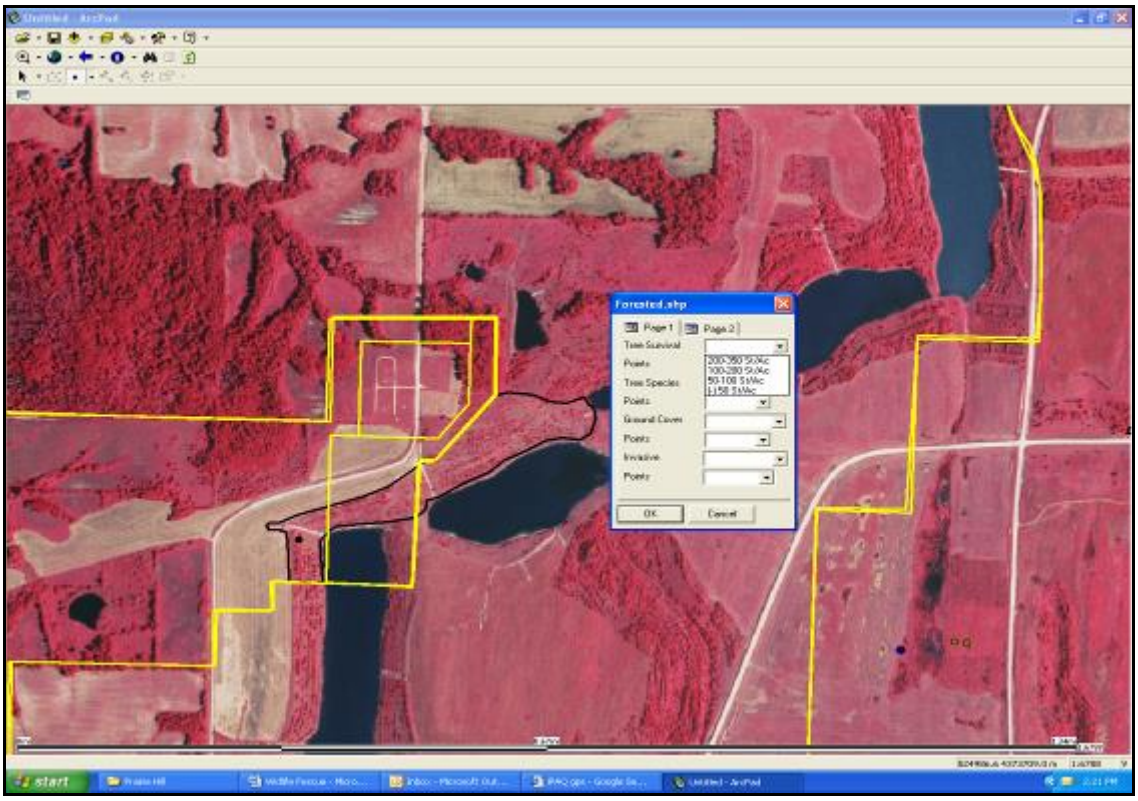

Figure 2. Screen Shot of the ArcPad Layer Form Used for Field Data Collection.

Results/Discussion

Wildlife Habitat Target Rating

Wildlife habitat suitability target values were calculated using the techniques presented in the methods discussion of this study. A total target score of 340 was generated demonstrating the value of the affected wildlife habitat if KY-31 would have been excluded from the seeding mixture. Likewise, the target value addresses other wildlife habitat considerations such as biodiversity, tree survival, ground cover composition, and presence of invasive plant species. Since all 54.1 hectares of habitat is considered early successional forest, tree survival, ground cover density, and woody and herbaceous species composition received equal rating scores under optimal conditions for each assessment. Acreage was the only variable factor in determining the target rating, which predictably resulted in the variance of point values. Target scoring ranged from 40 points in the largest wildlife habitat to 32 points in the smaller areas. Table 3 shows the target values for the wildlife areas seeded with KY-31 at the Prairie Hill Mine.

Evaluation of Fescue-Seeded and Mitigation Wildlife Habitat

Areas seeded with KY-31 demonstrated scores ranging from 12 points in the smallest tract to 28 points in the third largest tract evaluated. While acreage was a factor in scoring, other aspects such as ground cover diversity and tree species composition weighed heavily on point ranges. The largest tract reviewed was 32 hectares and received a wildlife suitability score of 20

points. In contrast, several smaller tracts less than two hectares received scores ranging from 20 points to 23 points. This variation resulted from quality rating factors within the assessment model. Poor tree species diversity, plant cover composition, along with a substantial invasive plant population resulted in a reduced wildlife suitability rating for the 32 hectare tract. A total of 204 points were assessed in the wildlife habitat land uses seeded with KY-31.

Table 3. Target Scoring for Wildlife Habitat

Parameter	Permit(s)	Hectares	Score
Forested Wildlife Habitat	1986-01, 1990-04, 1991-03	8.0	38
Forested Wildlife Habitat	1986-01	0.6	32
Forested Wildlife Habitat	1981-02	1.1	32
Forested Wildlife Habitat	1981-02	0.5	32
Forested Wildlife Habitat	1981-02	0.6	32
Forested Wildlife Habitat	1981-02, 1982-09	32.0	40
Forested Wildlife Habitat	1985-10	0.4	32
Forested Wildlife Habitat	1985-10	1.2	32
Forested Wildlife Habitat	1985-10	0.8	32
Forested Wildlife Habitat	1985-06, 1990-02	8.9	38
		Total Target Score	**340**

Mitigation areas scored in the upper range of total available wildlife points. Wetland wildlife habitat received the highest score (33 points) and one grassland scored 31 points while the other three grassland areas scored 29 points each. Minor variance of wildlife mitigation scores can be attributed to the significant wildlife value of the areas and the high level of management each area receives. Proposed wildlife mitigation areas scored 151 total points. Mitigation areas and the existing wildlife habitat seeded with KY-31 scored a combined 355 points indicating the total index score. This index score exceeded the target score (340 points) demonstrating an acceptable level of mitigation was achieved. Table 4 demonstrates the index score of the wildlife areas proposed for mitigation and those seeded with KY-31.

Table 4. Fescue-Seeded and Mitigation Scoring for Wildlife Habitat

Parameter	Permit(s)	Hectares	Score
Forested Wildlife Habitat	1986-01, 1990-04, 1991-03	8.0	28
Forested Wildlife Habitat	1986-01	0.6	23
Forested Wildlife Habitat	1981-02	1.1	23
Forested Wildlife Habitat	1981-02	0.5	23
Forested Wildlife Habitat	1981-02	0.6	20
Forested Wildlife Habitat	1981-02, 1982-09	32.0	20
Forested Wildlife Habitat	1985-10	0.4	12
Forested Wildlife Habitat	1985-10	1.2	14
Forested Wildlife Habitat	1985-10	0.8	15
Forested Wildlife Habitat	1985-06, 1990-02	8.9	26
		Fescue-Seeded	**204**
Wetland Wildlife Mitigation	1981-02	3.0	33
Grassland Wildlife Mitigation	1981-02	4.6	31
Grassland Wildlife Mitigation	1981-02	4.9	29
Grassland Wildlife Mitigation	1981-02	4.9	29
Grassland Wildlife Mitigation	1981-02	3.0	29
		Mitigation	**151**
		Total Index Score	**355**

Wetland Wildlife Mitigation

Vegetation within the three hectare wetland cell was quite diverse as evidenced by the distinct woody and herbaceous species documented during the site assessment. Dominant woody and herbaceous taxa represented a significant hydric affiliation. Common emergent and submergent species noted during the wildlife habitat evaluation included smartweed (*Polygonum*), pondweed (*Potamogeton*), beggar's tick (*Bidens L.*), golden rod (*Oligoneuron rigidum*), woolgrass (*Scirpus cyperinus*), spike rush (*Eleocharis*), soft rush (*Juncus effuses*), cattail (*Typha latifolia*), lotus (*Nelumbo lutea*), black willow (*Salix nigra*), bald cypress, sycamore (*Plantus occidentalis*), and eastern red cedar. Likewise, plant cover was estimated to be in excess of 50 percent within the inundated wetland basin and in excess of 95 percent in the semipermanently saturated outlying areas. All plant species noted were classified as facultative or obligate and are commonly located in wetland environments within the regional area. Wetland plant species recorded on the site produce a valuable food source for a number of mammals, waterfowl, song and game birds as well as creating escape and brood cover. In addition, the zone of saturation and inundation creates a water source for wildlife use and provides habitat for amphibian, reptile, and insect species. Due to the wetland plant composition, diversity, and water regime, the mitigation wetland scored high using the wildlife habitat models. Figure 3 demonstrates ground cover density and species diversity within the wetland cell.

Figure 3. Ground Cover Composition and Diversity of the Wetland Mitigation Area.

Grassland Wildlife Mitigation

A total of four native warm season grassland areas (17.6 hectares) have been approved as tall fescue mitigation areas. Established warm season grasses include a switchgrass (*Panicum virgatum*), indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii*) species mix. Other native prairie plant species such as golden rod, milkweed (*Asclepias syriaca*),

butterfly weed (*Asclepias tuberose)*, sunflower (*Helianthus annus*), Queen Anne's Lace (*Dacus carota*), and Illinois bundleflower (*Desmanthus illinoensis*) were commonly noted on the sites (Figure 4). Natural recruitment of these forbs can be attributed to seed dispersal by song and game birds and through the use of prescribed fire by AECI. These native warm season grass sites within the Prairie Hill Mine have a high early seral cover value for neotropical birds, gamebirds, and raptors.

Native warm season grasslands and prairie are becoming endangered in northern Missouri and have been replaced by more hardy agricultural grasses such as tall fescue, smooth brome, and orchard grass. Much of the mine reflects this land use pattern and is planted in perennial cool season species which provides less suitable wildlife ground cover than the warm season grass areas proposed for mitigation. These warm season grass habitats will provide areas with an open cover structure, winter cover, nesting, brooding, and escape habitat for numerous wildlife species within the Prairie Hill Mine. Because of desirable plant diversity, ideal wildlife ground cover, and high management, these native grasslands scored within the upper range when tested with the wildlife habitat models.

Figure 4. Warm Season Grassland Composition and Diversity on AECI Prairie Hill Mine.

Conclusions

While KY-31 produces an effective ground cover that stabilizes the soil and can be a valuable livestock forage crop, it has been shown to be a detriment to wildlife populations through habitat colonization. The following conclusions can be drawn from this study of examining the effects of KY-31 in wildlife habitat at the Prairie Hill Mine site.

(1) Wildlife habitat seeded with KY-31 adversely affected woody and herbaceous plant diversity and composition. This was evidenced by the far lower index scores of the existing habitat

when compared to the target areas and areas proposed for mitigation. Primarily, poor woody and herbaceous species diversity, increased invasive plant populations, and similar plant cover composition was a common factor found throughout most of the sites seeded with KY-31.

(2) When proportionately seeded with other cool season grass and legume species, tall fescue will show ground cover dominancy within the stand. Past studies combined with an analysis of wildlife habitat and pastureland seeded with KY-31 fescue demonstrated increased fitness and competition over other herbaceous and woody plant species.

(3) Mobile computing technologies were well suited for collection and analysis of information. Downloading land type assessment models using ArcPad software aided in proficient field data collection. Also, using spatial technologies allowed for an interface with ArcGIS for analysis of the affected wildlife habitat and mitigation areas to quantify and offset resource losses.

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