ANL/ESD/TM--39

ANL/ESD/TM-39

DE93 006959

Freihölser Forst Local Training Area Rehabilitation Project: Final Report

by R.R. Hinchman, S.D. Zellmer, D.O. Johnson, W.D. Severinghaus*, and J.J. Brent*

Energy Systems Division,
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

December 1991

Work sponsored by United States Army Corps of Engineers,
Construction Engineering Research Laboratories, Environmental Division,
Champaign, Illinois

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*Severinghaus is affiliated with U.S. Army Corps of Engineers, Construction Engineering Research Laboratories, Environmental Division, and Brent with Environmental Management Office, Directorate of Engineering and Housing, Headquarters, 282nd Base Support Battalion, Hohenfels, U.S. Army.

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Phase II of the Freihölser Forst Local Training Area (LTA) Rehabilitation Project and the monitoring effort for both Phase I and Phase II at the LTA in Germany were only possible because of the contributions and cooperation of a number of individuals and organizations. John J. Brent, Albert Böhm, and other members of the Environmental Management Office of the Directorate of Engineering and Housing at Hohenfels Training Area supported the LTA rehabilitation effort and rendered valuable assistance throughout the entire monitoring effort and the development and implementation of Phase II.

Special thanks are extended to Lt. Prusecki, Lt. Vertrees, and other personnel at Pond Barracks in Amberg for necessary assistance with clearance to work at the site, access to the site, and restriction of military training traffic during both phases of the Freihölser Forst LTA Rehabilitation Project.

The authors gratefully acknowledge the U.S. Army Corps of Engineers Construction Engineering Research Laboratories (USACERL) for providing the funding for the project.

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Abstract

Intensive and continued use of the Freihölser Forst Local Training Area (LTA) for military training activities had resulted in serious environmental problems, exemplified by a lack of vegetative cover and severe erosion by water and wind. The project's goal was to develop and demonstrate rapid, cost-effective methods to stabilize the LTA's barren, eroding maneuver areas and make training conditions more realistic. The major factors limiting rehabilitation efforts were the sandy, infertile, and acidic soils. The project was conducted in two phases. Phase I demonstrated and evaluated three separate rehabilitation treatments ranging in cost from moderate to expensive. Each treatment used a different type of soil amendment (fertilizer and straw, compost, or chicken manure), but all used identical seedbed preparation methods and seed mixtures. Phase I was conducted on relatively small replicated plots and was monitored three times during each growing season. All three treatments satisfactorily reestablished vegetation and controlled erosion. Because of their small size, the Phase I demonstration plots had only a minor stabilizing effect on the erosion problems of the LTA as a whole. The Phase II treatment was based on lessons learned from Phase I and from other revegetation projects in Germany. Phase II revegetated a large area of the LTA, which included nearly all of the most severely disturbed land. Phase II, which was monitored in the same way as Phase I but for a shorter period of time, was highly successful in stabilizing most areas treated. The revegetation plant community was dominated by native grasses and legumes that stabilized the loose, sandy soils and improved the training realism of a major portion of the LTA.

1 Introduction

Although approximately one-third of the U.S. Army is deployed in Europe, the amount of land available for housing and training U.S. military personnel there is very small — less than 2% of the total land area available to the entire U.S. Army. In addition, most of the combat units assigned to the U.S. Army in Europe (USAREUR) are stationed in the Federal Republic of

Germany (FRG). Because of Germany's strategic location, these units must maintain combat readiness, which requires nearly constant tactical training. However, the country is densely populated and heavily industrialized. Most maneuvers in the countryside have been suspended because the land is already intensively used for forestry, farming, and recreation and because the cost of compensation for maneuver damage is high. This intensive land use has also limited the number and size of military training areas.

Several large training areas in Bavaria (e.g., Hohenfels, Grafenwöhr, and Waldflicken) and numerous smaller Local Training Areas (LTAs), such as Freihölser Forst, receive heavy and almost constant use because so many U.S. and other North Atlantic Treaty Organization (NATO) combat units use them. Moreover, new and improved weapon systems have changed training doctrines, requiring combat units to operate over larger sectors and engage targets at greater ranges than in the past. All these factors result in very high training pressure (intensity of military use of a training area during a given time period) at all the U.S. training areas in the FRG. This intensive and continued use of training areas has damaged or destroyed their vegetative ground cover, which, in turn, has accelerated soil erosion. Loss of plant cover and the resultant soil erosion damage the environment, create safety hazards, and result in unrealistic training conditions. They can also adversely influence the environment of adjacent lands. The potential for damage to surrounding land, coupled with the degraded appearance of many training areas, may concern nearby residents and, in some cases, may generate opposition that threatens the existence of the installation.

Vegetative ground cover that protects and stabilizes the soil is a key factor in maintaining an environmentally healthy, safe, and realistic military training area. This type of cover intercepts raindrops, reducing their energy of impact and potential for erosion. Fibrous-rooted plants, such as grasses, bind soil particles, and their multiple stems inhibit sheet and wind erosion. Vegetative ground cover also reduces runoff velocity, which prevents the concentration of overland flow and development of rills. Rills become gullies that grow larger with each storm. Gullies in training areas are safety hazards to vehicles and personnel. Sheet, rill, and gully erosion also produces sediments that are carried into receiving streams and onto adjacent land, degrading it. In addition, a barren, eroded landscape is not a realistic training environment. The most cost-effective method for preventing soil erosion is the establishment and maintenance of a dense, self-sustaining plant cover composed primarily of grasses and legumes.

The Freihölser Forst Local Training Area Rehabilitation Project is part of the Integrated Training Area Management program developed by the Construction Engineering Research Laboratories of the U.S. Army Corps of Engineers for the Seventh Army Training Command of the U.S. Army in Europe.

2 Background

2.1 Training Area Rehabilitation Projects in Germany

Several ongoing rehabilitation demonstration projects in Germany are sponsored by the U.S. Army Corps of Engineers Construction Engineering Research Laboratories (USACERL). All these projects are part of the Integrated Training Area Management (ITAM) program being developed for the Seventh Army Training Command (7ATC) of USAREUR. The Environmental Division of USACERL, located in Champaign, Illinois, is responsible for developing the ITAM program for the U.S. Army. The goal of the ITAM program is to provide the processes and tools needed to support land-management programs that enhance resource conservation and training at Army installations.

The ITAM program has six components. Degrees of complexity and cost vary for each. Briefly, the components are as follows:

1. Integration of training mission requirements. This component of ITAM assesses environmental conditions and classifies training-area use and capacity.

2. Land condition-trend analysis (LCTA). This analysis procedure gives managers a standard method for collecting and analyzing natural resource data to make good land-management decisions that promote sustained ecosystems and multiple use of military lands.

3. Rehabilitation and maintenance. This effort includes the development and implementation of innovative strategies for the establishment and management of vegetation communities to stabilize the soil before erosion becomes a problem, to increase training realism, and to increase habitat diversity for wildlife.

4. Structural rehabilitation and runoff-control technologies. This portion of ITAM provides guidance for establishing durable structures and landforms (e.g., check dams, waterbars, terraces) that can withstand training activities.

5. Computerized decision-support systems. Several automated systems for resource data analysis and land-management decisions are currently available to help manage the large amount of information generated with ITAM.

6. Comprehensive, multimedia environmental awareness program. This educational program informs soldiers of the need to protect the Army's limited natural resources and presents steps for minimizing damage.

The initial ITAM effort in Europe began in early 1986 with the Range 8C Rehabilitation Demonstration Project at the Hohenfels Training Area in Germany (Zellmer et al. 1987), the U.S. Combat Maneuver Training Center in Europe. The Construction Engineering Research Laboratories requested the assistance of the Reclamation Engineering and Geosciences Section (RE&G) of the Energy Systems Division at Argonne National Laboratory (ANL) in the development of cost-effective rehabilitation and maintenance methods for training areas in Germany. This selection was made because RE&G at ANL had more than 15 years of experience in applied and basic research in land reclamation and was working on a similar USACERL/ANL training-range rehabilitation demonstration project under way at Fort Carson, Colorado. The revegetation research projects in Germany, conducted by RE&G as part of USACERL's ITAM program, are specifically designed to develop the reclamation and maintenance technologies necessary to preserve and extend the use of tactical training areas.

The Freihölser Forst LTA project is one of three rehabilitation and demonstration projects in Germany conducted by ANL. This project was conducted in two phases. Phase I demonstrated and evaluated three separate rehabilitation treatments that ranged in cost from moderate to expensive. Each treatment used a different type of soil amendment (either fertilizer and straw, compost, or chicken manure), but all used identical seedbed-preparation methods and seed mixtures consisting of adapted, native species. All three treatments satisfactorily reestablished vegetation and controlled erosion. The Phase II revegetation procedure used was based, in part, on monitoring data, information, and field observations drawn from Phase I. Phase II of the project revegetated a large area that comprised almost one-third of the LTA's total area and included nearly all of the most severely disturbed land. Phase II was highly successful in stabilizing most of the areas treated. The development and installation of Phase I is described in another report (Hinchman et al. 1989). This report describes the development and installation of Phase II and the monitoring program used for both phases; the monitoring data from both phases are presented and interpreted.

The two other USACERL/ANL training-area rehabilitation projects in Germany are both at the Hohenfels Training Area (HTA). One is the Range 8C Rehabilitation Demonstration Project (Zellmer et al. 1987, Zellmer et al. 1991a); the other is the Minimal Technologies Application Project (Zellmer et al. 1989, Zellmer et al. 1991b). Field work relating to all of these projects was completed in 1990. The ANL reports cited above describe these projects.

2.2 Freihölser Forst Local Training Area

Freihölser Forst LTA is relatively small (about 138 ha, or 341 acres). It is located in an area of intensively managed forests in the Oberpfaltz region of northern Bavaria, about 8 km (5 mi) east of the city of Amberg and close to the Czechoslovakian border. This region contains isolated areas of extremely sandy soils that form an almost dune-like topography. Because of the poor water-holding capacity of these soils, they often become droughty, particularly in exposed areas, even during short dry periods. Freihölser Forst LTA is one such area; before rehabilitation, it consisted of a series of sandy ridges and swales. It is characterized by a number of scattered, large coniferous trees (suggesting the area was probably once forested) and several small forestry

plots of younger, planted coniferous trees, which were surrounded by large expanses of barren, rutted sand.

The region in which the LTA is located has a humid mesothermal climate, with an average annual precipitation of about 960 mm (37.8 in.). This precipitation occurs mainly as rainfall, which is fairly evenly distributed throughout the year. Snow can fall from late October through early April, but the snow cover usually lasts only a few days because of the above-freezing daytime temperatures. Winters are moderately cold, with daytime temperatures averaging about 0°C (32°F) in January. Summers are cool, with warm days and cool nights; the temperature averages 13°C (55°F) during July, the warmest month.

The LTA is heavily used by a unit of the U.S. Army's 3rd Squadron Armored Cavalry stationed at Pond Barracks in Amberg, by various FRG Bundeswehr forces stationed in the Amberg area, and by units of the German border police. Training facilities include a mortar minirange, a miniature target tank range, structures representing buildings in a village setting for mock attacks against defense positions, tank firing stands, and training courses with pop-up targets. The limited remaining areas are used to practice maneuvers with tanks, armored personnel carriers, and other military vehicles (Figure 1).

Intensive and continued use of the Freihölser Forst LTA had resulted in serious environmental problems, exemplified by severe erosion of the loose, sandy soil by water and wind. One consequence of this degraded environment was the complete lack of training realism. Vehicle traffic had almost completely destroyed the natural vegetative cover. Remnants of this cover, consisting of grasses, forbs, and a low-growing heather, can be seen around the bases of some of the large trees and at the edges of the forestry plots. The severe and accelerated erosion created by the lack of vegetation increased the runoff rate and volume, and sediments were carried onto roadways and into adjacent areas, causing further environmental problems. If these conditions had remained unabated, the LTA would have continued to degrade until it became a major environmental problem and was unusable for effective training.

2.3 Phase I – Development and Installation of Demonstration Plots

Development of the ITAM program for the Freihölser Forst LTA was initiated by USACERL in 1987. Personnel from the Directorate of Engineering and Housing (DEH) at 7ATC had expressed concern about the severely degraded conditions that had developed on the maneuver areas of the LTA. Argonne National Laboratory was asked to prepare a rehabilitation demonstration plan for the maneuver areas of the LTA because ANL's RE&G Section personnel were already working with 7ATC, USACERL, and HTA's DEH on the Range 8C project and had experience in negotiating international contracts, translating detailed specifications, and working with and supervising German contractors; they also had a knowledge of the materials and services available in Germany.

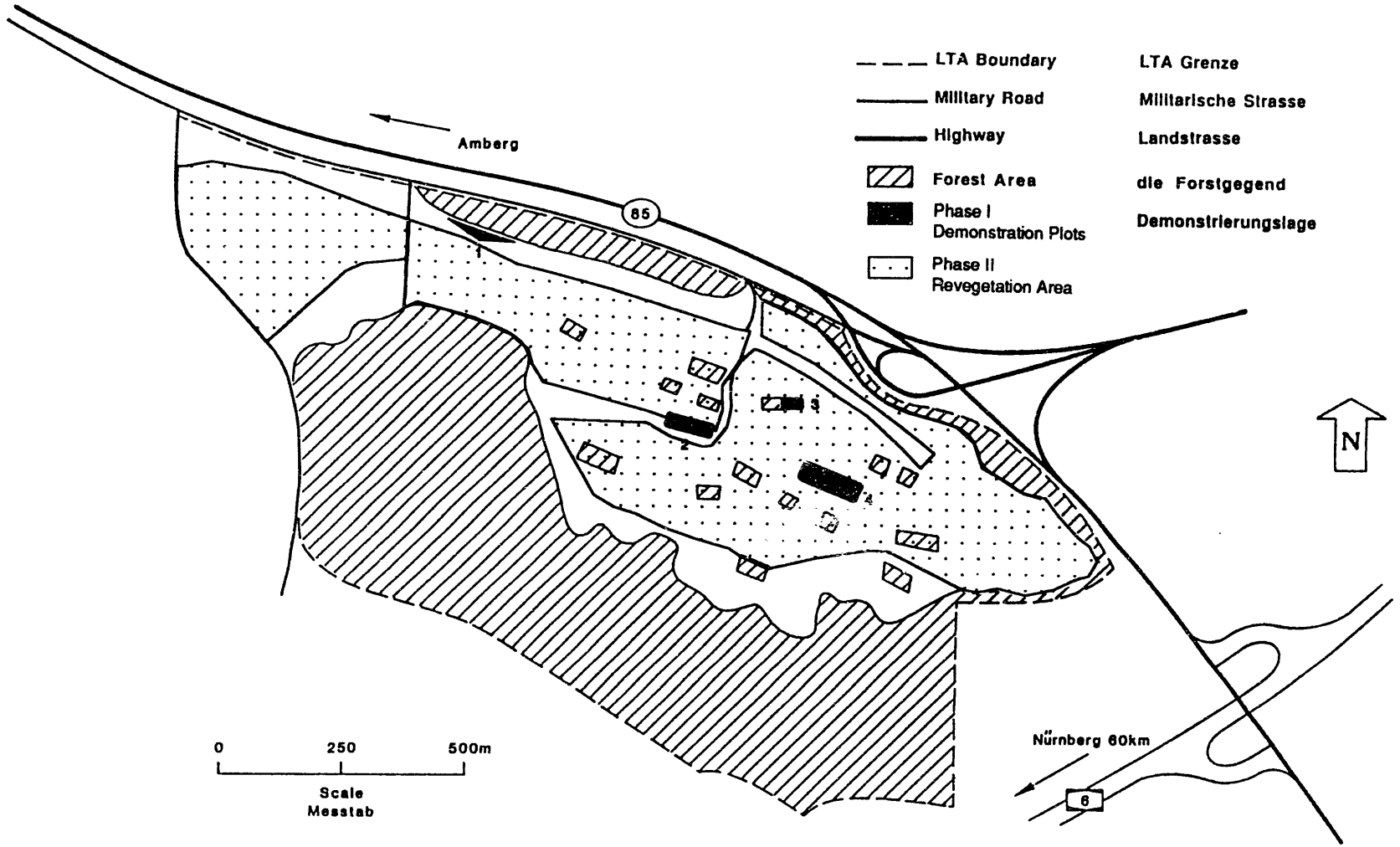

FIGURE 1 Locations of Phase I Rehabilitation Demonstration Plots and Phase II Revegetation Area

Phase I of the Freihölser Forst LTA Rehabilitation Demonstration Project was designed to demonstrate rapid, cost-effective methods for stabilizing barren maneuver areas. The sandy, infertile, and acidic soils at the LTA were considered a major limiting factor in the rehabilitation effort. Phase I of the project included the evaluation of three procedures to revegetate these soils, each incorporating a different soil amendment (fertilizer and straw, compost, or chicken manure) combined with identical seedbed-preparation methods and a single seed mixture consisting of adapted, native species. The three treatments differed widely in cost, ranging from moderate to expensive. The project was designed to have a minimal effect on the primary training mission of the LTA.

2.3.1 Goal, Objectives, and Approach

The goal of Phase I of the Freihölser Forst LTA project was to develop, demonstrate, and evaluate rapid revegetation techniques for sandy soils that would establish adequate ground cover to control erosion by water and wind, reduce sediment loads, improve the quality of water leaving the site, and increase the training realism of the site. To attain this goal, the following specific project objectives were developed and achieved:

- Assess the prerehabilitation conditions at the LTA site.
- Select several plot locations representative of soil conditions and slopes at the LTA.
- Collect information on materials for and methods and costs of rehabilitating sandy soils in Bavaria.
- Develop detailed plans and specifications (prescriptions) for revegetating the demonstration plots.
- Implement the rehabilitation prescriptions by using a local contractor.
- Evaluate the development of the revegetation plant communities under field conditions by using a site-specific vegetation-monitoring program.
- Use monitoring results to assess the need for any modifications to the prescriptions. Develop recommendations and disseminate them to personnel responsible for future rehabilitation efforts in Germany.

Tasks in Phase I (planning and installation) included (1) development of a project work plan; (2) collection and analysis of baseline data; (3) selection of study plots; (4) development of contractor specifications for seedbed-preparation operations, soil amendment types and application methods, seeding, and rolling; and (5) supervision of contractor implementation of the Phase I specifications. Phase I began in January 1986, when a work plan was developed and a preliminary site evaluation was conducted, and it was completed in June 1987, when the

revegetation treatments were installed. Phase I of the project is described in detail in an earlier report (Hinchman et al. 1989). Some of the information presented below, such as site location and baseline data-gathering, applies to both phases of the project.

2.3.2 Treatment Plots, Baseline Data-Gathering, and Rehabilitation Plan

The Freihölser Forst LTA is located on the south side of Highway 85, approximately 8 km east of Amberg, Bavaria. The LTA is northwest of the intersection of Highway 85 and Autobahn 6 (Figure 1). The soils at the LTA are essentially structureless sands, which require different rehabilitation approaches than those proposed for the loamy soils at HTA. The treatment plots would be surrounded by posts (similar to those used for tree plots), excluding military traffic. The plots would be located where they would have the least impact on the training mission of the LTA.

Four treatment plots, consisting of nine treatment locations (see Figure 2), and two control plots were proposed for installation at the LTA. The nine treatment locations contained three replicates of three types of treatment (A, B, and C). Two large treatment plots (2 and 4) containing multiple treatments were placed on relatively flat areas on the crest of a hill that was exposed and thus seldom used for maneuvers. Two smaller treatment plots (1 and 3) containing single treatments were located next to existing forestry plots and did not create new obstacles in the open maneuver areas. One control plot was located in an initially barren area at the base of a tank firing ramp; the other was located in an area of moderately disturbed natural herbaceous vegetation next to an existing tree plot.

After locations for the treatment plots had been selected, analysis of soil samples from each plot confirmed earlier assumptions that the sandy soils of the LTA were strongly acidic, extremely low in plant nutrients, and very low in organic matter. An indurated (and possibly impervious) pan, usually about 15 cm below the surface and characterized by reddish-brown iron deposits, had been observed in eroded areas during the site visits.

On the basis of these data and observations, a detailed rehabilitation demonstration plan for the LTA was prepared. This plan emphasized the establishment of adapted, native vegetation to (1) bind and stabilize the sandy soil, (2) control wind and water erosion and gully formation on slopes, (3) reduce the off-site movement of sand and other sediments, and (4) improve training realism at the site. The plan included the preparation of contractor specifications and bid documents for the revegetation operations and the development of a monitoring program to evaluate the progress of the rehabilitation process.

2.3.3 Contractor Specifications and Installation of Treatments

Argonne personnel prepared detailed contractor specifications (see Appendix of Hinchman et al. 1989) for the Phase I revegetation operations that required three revegetation procedures,

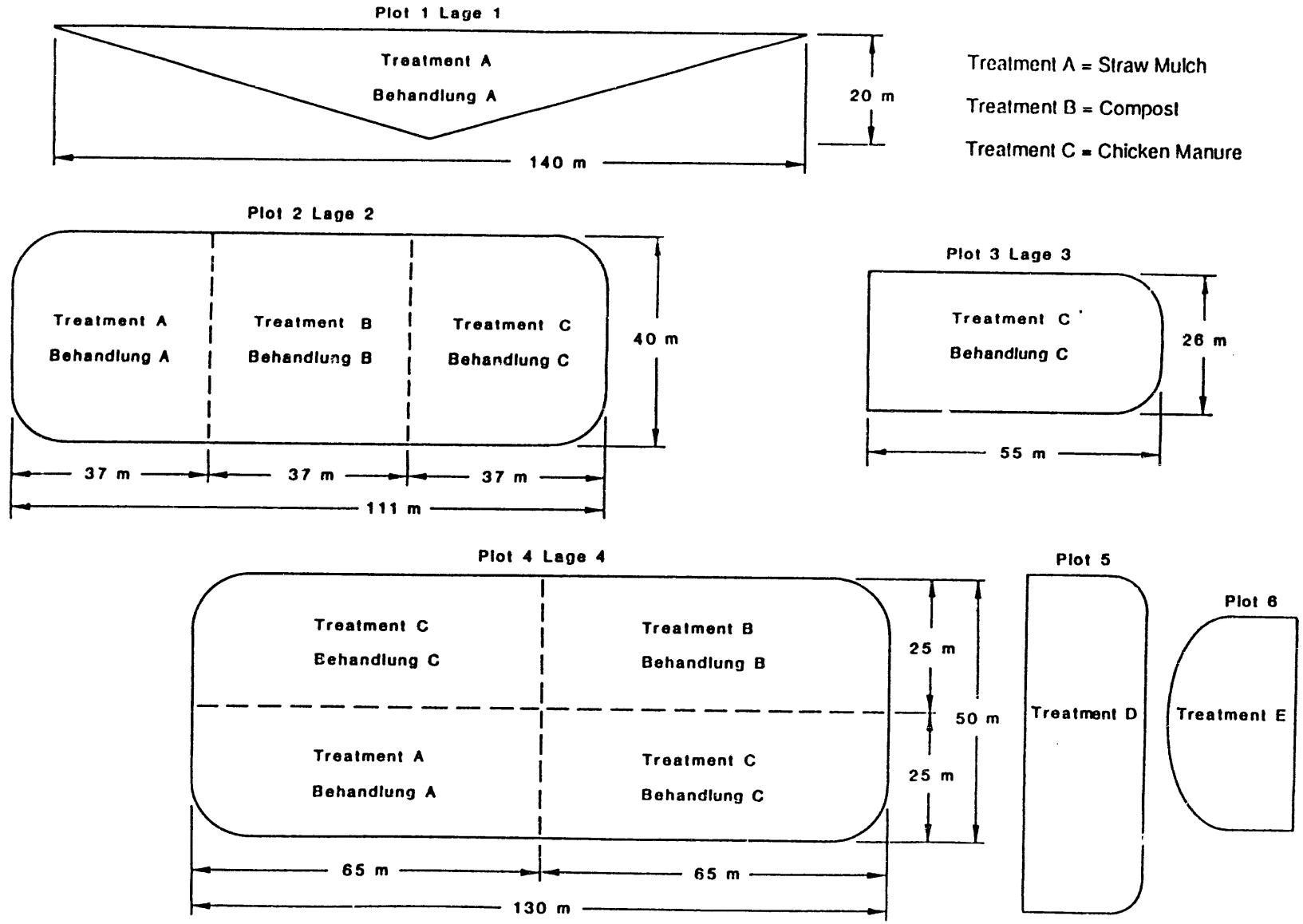

FIGURE 2 Relative Size and Shape of Phase I Plot and Treatment Locations

each incorporating identical seedbed-preparation methods and seed mixtures but different soil amendments. The three treatments were all designed to produce acceptable vegetative cover, but their costs varied from moderate for Treatment A to expensive for Treatment C. The five operations, covered in detail in the contractor specifications for Phase I (see Appendix in Hinchman et al. 1989), are summarized below:

1. Smoothing or leveling and deep tillage of all areas to receive treatments;
2. Installation of Treatment A, consisting of
   - Fertilization,
   - Seedbed preparation,
   - Seeding,
   - Harrowing to cover the seed,
   - Mulching with straw, and
   - Crimping to anchor the straw;
3. Installation of Treatment B, consisting of
   - Application of compost,
   - Seedbed preparation,
   - Seeding, and
   - Harrowing to cover the seed;
4. Installation of Treatment C, consisting of
   - Application of chicken manure,
   - Seedbed preparation,
   - Seeding, and
   - Harrowing to cover the seed; and
5. Installation of plot boundary markers.

Each treatment was installed at three locations (replicates) at the LTA (Figure 2). The treatments were installed in late June 1987 by the German landscape contractor, Lafostra of Dorfen.

2.3.4 Leveling and Deep-Tillage Operations

All treatment areas were leveled by using a bulldozer with a front-mounted blade. Deep tillage to a depth of 30-40 cm was accomplished with a chisel plow mounted on a four-wheel-drive agricultural tractor. The chisel plow had a rototiller and roller attachment that smoothed the soil surface as part of the deep-tillage operation.

2.3.5 Species Selection and Seed Mixture

Criteria for plant species selection (Hinchman et al. 1989) included the degree of adaptation to regional climatic and site-specific conditions. Despite the normally adequate and uniform precipitation, conditions at the LTA can become droughty because of the low water-holding capacity of the sandy soil, and this situation was taken into account. Other factors considered were the type of revegetation plant community desired and the use the land would be put to after revegetation. The seed had to be available locally at a reasonable cost. At the LTA, where resumption of vehicle traffic on the treated areas was anticipated in about one year, a grass-legume mixture was used because of its rapid growth and stand development and good soil-binding qualities. Cereal rye was included in the mixture to provide rapid cover and stabilization.

The seeding rates and mixtures (Table 1) were modified slightly from the original specifications in response to local availability, cost, and the recommendations of the contractor. Because of the site's degraded condition, the seeding rates exceeded somewhat the rates for normal plantings.

2.3.6 Treatment A (fertilizer and straw mulch)

Following leveling and deep tillage, dry chemical fertilizer of the slow-release type was applied by hand at a rate that delivered 50 kg/ha (45 lb/acre) each of nitrogen (reported as N), phosphorus (reported as P_2O_5), and potassium (reported as K_2O) plant nutrients. The fertilizer was incorporated into the upper 10 to 15 cm of the soil surface, and the seedbed was prepared using a rototiller mounted on a Unimog vehicle. The grass-legume seed mixture was applied using a broadcast seeder; the rye was seeded by hand. Straw mulch was applied by hand at a rate of 3,400 kg/ha (1.5 tons/acre). The plots were then rolled with a Cambridge disk to anchor the straw mulch in the soil surface layer.

2.3.7 Treatment B (compost)

The original specifications for Treatment B called for the application and incorporation of fertilizer and peat moss into the surface soil. Because of environmental concerns in Germany

TABLE 1 Seeding Mixture and Rate: Phase I

Scientific Name	German and American Names	Broadcast Seeding Rate (kg/ha)	Weight (% of total mixture)
Achillea millefolium	Wiesen-Scharfgarbe (Common yarrow)	0.9	3.0
Agropyron repens	Kriechende Quecke (Quackgrass)	6.2	20.0
Bromus inermis	Wehrlose Trespe (Smooth brome)	4.7	15.0
Calluna vulgaris	Besenheide (Scotch heather)	0.31	0.1
Dactylis glomerata	Knäuelgras (Orchardgrass)	1.4	4.5
Festuca ovina	Schafschwingel (Sheep fescue)	6.9	22.4
Festuca rubra, rubra	Ausläufertr. Rotschwingel (Creeping red fescue)	1.5	5.0
Lotus corniculatus	Hornschotenklee (Birdsfoot trefoil)	4.7	15.0
Phalaris arundinacea	Rohrglanzgras (Reed canarygrass)	1.9	6.0
Trifolium repens	Weissklee (White clover)	2.8	9.0
Total		31.31	100.0
Scale cereale[a]	Roggen (Rye)	50.0	—

[a]Cereal rye is included as a nurse and quick-cover crop.

about the use of peat moss, a composted material was used instead. This material (Edelkompost Humka) is composted food-processing waste, with a plant nutrient analysis of about 3% N, 2.9% P_2O_5, and 3.4% K_2O. It was applied at a rate of 10,000 kg/ha (about 4.5 tons/acre). Because of the nutrient content of the compost, no fertilizer was needed. After leveling and deep tillage, the compost was applied to the soil surface by using a broadcast spreader mounted on a Unimog vehicle. Because of its moisture content, the compost formed clumps, which resulted in uneven application in some areas. The composted plots were then rototilled and seeded in the same manner as that used for Treatment A, but straw mulch was not applied. The Treatment B plots were also rolled with the Cambridge disk to press the seed into the the soil surface.

2.3.8 Treatment C (chicken manure)

Treatment C specified the application of chicken manure as the major soil amendment. A processed, pelletized chicken manure (AGRICON) with a guaranteed plant nutrient analysis of 3–5% N, 4–4.5% P_2O_5, and 3.5–4.0% K_2O was used. The processed chicken manure was also applied at a rate of 10,000 kg/ha (4.5 tons/acre). All operations for Treatment C were the same as those for Treatment B, except that pelletized chicken manure was used instead of compost.

2.3.9 Installation of Plot Boundary Markers

Following the installation of the treatments, the boundaries of all treatment plots were marked with wooden posts on 3-m centers. The posts were provided by the Forstmeister and installed by the contractor.

2.3.10 Rehabilitation Costs

Costs, broken down by materials and installation, for the three rehabilitation treatments as actually installed by the contractor are presented in Table 2. They include costs for all work and materials necessary for the contractor to complete the work, transporting equipment to and from the site, transporting materials to the site, supplies, handling seed and fertilizer, labor and supervision, and profit. Costs for installation of the plot boundary posts by the contractor were DM3.80 ($2.11) per post.

Some additional costs were incurred because of unanticipated factors associated with the experimental nature of the work. Argonne experience indicates that the cost of applying treatments to small test plots is 25–50% higher per unit area than the normal cost for similar operations under large-scale, field conditions. The higher cost for experimental efforts is usually related to the need to distribute the costs for equipment mobilization and demobilization over smaller total areas and to the inconveniences that result from treating small, randomly located plots. Therefore, the

TABLE 2 Materials and Installation Costs by Treatments for Phase I

Treatment	DM/ha[a]	$/acre
Treatment A - Fertilizer/Straw Mulch		
Materials		
Fertilizer	203	47
Straw for mulch	680	157
Seed	255	59
Installation	15,800	3,654
Total	16,938	3,917
Treatment B - Compost		
Materials		
Compost	20,625	4,770
Seed	255	59
Installation	13,800	3,191
Total	34,680	8,020
Treatment C - Chicken Manure		
Materials		
Chicken manure	38,500	8,903
Seed	255	59
Installation	16,330	3,776
Total	55,085	12,738

[a]DM1.80 = $1.00 in 1987.

installation costs for the three treatment methods shown in Table 2 are probably somewhat higher than would be expected for the treatment of larger areas. Costs for materials are the prices charged by the contractor, which would not normally vary for larger operations.

2.4 Site Monitoring, Early Phase I Results, and Initial Phase II Planning

An environmental monitoring program was begun at the Freihölser Forst LTA in the fall of 1987 to determine the effectiveness of the rehabilitation demonstration treatments. This procedure is discussed in more detail in Section 3. The plots at the LTA were inspected, and vegetative-cover and other monitoring data were collected on each treatment by ANL personnel three times (spring, summer, and fall) during each growing season, through April 1990. Detailed data from and interpretation of the entire Phase I monitoring program are presented in Section 4. A visual record for each site was established, including slides, photographs, and videotape of conditions and activities there. This record was started before the onset of any rehabilitation activities to document the prerehabilitation conditions of the plot areas and the LTA in general and to demonstrate the progress of the treated areas.

By the fall of 1988 (when planning began for the Phase II large-area revegetation effort), all of the Phase I treatments and replicates in the demonstration plots had been very successful in stabilizing the loose, sandy soil of the LTA and creating vigorous stands of green vegetation that resembled patches of meadow in large expanses of barren sand. However, because these plots were relatively small (average size = 0.15 ha), they had only a minor effect on the problems of severe erosion and lack of training realism that existed throughout the site. It was also apparent that the use of manure and compost amendments could not be justified for the large area remaining to be revegetated at the LTA, because of their high cost. This was particularly true in light of the potential for continuing damage, which would require repeated rehabilitation efforts. In addition, hand spreading of the straw mulch might not be practical for large areas. These high costs and labor-intensive activities resulted in a recommendation that rehabilitation specifications for any additional areas at the LTA should be modified to reduce costs.

Original plans called for the rehabilitation demonstration plots at the LTA to be reopened to training traffic in 1988 (after about one year of traffic exclusion). However, the training procedures at the LTA had changed in the meantime, and most of the tactical traffic had been restricted to several training courses consisting of constructed roads and firing positions. Some off-road maneuvering still took place, but this change in major traffic patterns prompted 7ATC to consider revegetation of the large remaining part of the LTA that was still highly disturbed and barren. Partly on the basis of the successful progress of the Phase I demonstration, 7ATC and USACERL requested ANL to initiate a project to revegetate a large portion of the LTA that included the most severely damaged areas. That large-area revegetation effort constituted Phase II of the Freihölser Forst Rehabilitation Project. The remainder of this report describes the monitoring and data-analysis methods used for both phases, the development and installation of the Phase II rehabilitation prescription, and the results of the monitoring program for both Phases I and II.

3 Methods and Approach

3.1 Site Monitoring

3.1.1 Vegetative Cover

Achieving stabilization of the sandy soil and reducing runoff, erosion, and sedimentation is a major objective of both phases of the Freihölser Forst Rehabilitation Project. Low erosion rates are highly correlated with high levels of herbaceous vegetative cover, and this parameter was used as a major evaluation criterion in the monitoring program. The monitoring program was initiated prior to the installation of the Phase I prescription, with the collection of baseline soil samples and site surveys of existing vegetation, soil conditions, topography, and levels of disturbance from training use. These prerehabilitation surveys were supported by documentation in the form of photographs and videotape.

Following installation of the Phase I prescriptions at the LTA in June 1987, 33 ground-cover monitoring transects were established in the treatment subplots and the two control areas. The first control area was used to measure natural revegetation on a highly disturbed area, initially bare of vegetation, at the base of a tank firing ramp; the other control area was used to measure changes in an area of moderately disturbed, natural herbaceous vegetation adjacent to an existing tree plot. Three 10-m transects, to be used as replicates for statistical analysis, were located in each treatment and control area. The locations of the 33 transects were permanently marked, and the compass headings of the transects and headings to several prominent landmarks were recorded for each transect so it could be reestablished if necessary.

The Phase II prescription was installed at the LTA in early April 1989. Fifteen additional ground-cover monitoring transects were installed in July 1989, either in typical training areas (nine transects, which were all in relatively flat locations) or in steeply sloped areas (six transects). The methods used to install the Phase II transects were identical to those used for installing the Phase I transects. The same vegetated control plot established for Phase I was used as a control for the Phase II monitoring effort.

Plant cover data were collected from all of the Phase I and Phase II transects three times a year (spring, summer, and fall) and organized by cover category (grass, legume, forb, bare soil, litter, etc.). These data were used to determine changes in the revegetation community and in the relative establishment rates of the planted species and to identify the species that seemed to adapt best to the conditions at the site. Documented field observations were used to supplement the transect data and to record trends and less obvious occurrences and conditions. All of this information will be used to refine seeding mixtures for future rehabilitation efforts.

The point-intercept method (Chambers and Brown 1983) was used to measure the percentage of each cover category on each transect. A point frame with 10 pins was used to determine ground cover at 1-m intervals on the 10-m-long transect. As each pin was dropped, the first plant or other cover category contacted was recorded. Contacted plants were identified by species when possible. Because 100 observations were made on each transect, the number of pin contacts in each category equaled the percent cover in that category. The percent total vegetative cover for a transect was calculated by summing the grass, forb, legume, and rye values. The percent total ground cover could be calculated by subtracting the percent exposed soil from 100 or by adding percent litter to total percent vegetative cover. Percent total ground-cover values were not calculated, summarized, or analyzed, because the values for percent exposed soil are the inverse of those for the percent total ground cover. The percent damage on a transect was calculated by multiplying the number of damaged point-frame settings by 10, because 10 frame settings were made on each transect. The mean of the percent damage on the three transects in a treatment area was considered the average damage for the treatment area.

3.1.2 Data Analysis

A general linear model (GLM) procedure included with the Statistical Analysis System (SAS) programs (Ray 1982) was used to compare statistically the seven categories of the cover data from both the Phase I and Phase II monitoring programs. For Phase I, this included 33 transects in which the three amendment options were installed and controls for each of the eight monitoring dates for which there were cover data (June 1987 to April 1990). For Phase II, the monitoring data included cover measurements from the 15 additional transects that were established in the Phase II revegetation areas following installation of the Phase II prescription for the three monitoring dates for which there were data (July 1989 to April 1990). Data from the first monitoring sessions of Phase I and Phase II were all in the category of exposed soil, except for the vegetated control, and are not included in any of the tables.

The cover data included in this report are the actual percentages; however, analysis of variance of values expressed as percentages was not possible, because percentages violate the assumption of variance homogeneity required for regression analysis. One often-used solution to the variance homogeneity problem is a data transformation; a normal transformation for percentage values is the arc sine of the square root of the percentage value expressed as a decimal fraction.* This transformation stabilizes the variance and normalizes the percent values. Another statistical analysis problem was that of maintaining the 0.05 level of significance while making multiple t test comparisons (the mean from each treatment vs. all the other treatment means). This problem was resolved by using Sidak's pairwise t tests (Miller 1966). Sidak's method performs pairwise t tests on differences between means, with levels adjusted according to Sidak's inequality for all means. This procedure maintains a 0.05 level of significance for comparisons among multiple means. Data from Phase I transects were analyzed separately from the Phase II data.

*Carnes, B.A., 1984, Biological and Medical Research Division, Argonne National Laboratory, Argonne, Ill., personal communication.

3.2 Development of the Phase II Work Plan

In 1988, 7ATC and USACERL requested that ANL initiate planning for a second phase of revegetation and monitoring at the LTA that would encompass a much larger area than the total area of the Phase I demonstration plots. This request was based on the successful stabilization of the loose, sandy soil at the LTA by all of the Phase I prescriptions. It was also prompted by the change in training traffic patterns that restricted most military vehicle movement to several training courses consisting of constructed roads and firing positions for targets.

On the basis of a review and evaluation of the Phase I monitoring data and field observations made after the fall monitoring session of 1988, it was determined that a new revegetation prescription, incorporating some features of all of the Phase I prescriptions but lower in cost than any of them, was needed. All three of the Phase I treatments were considered to be too expensive to use without modification on the large-area Phase II revegetation effort. This was particularly true for such an active training area as the Freihölser Forst LTA, areas of which had a high likelihood of being redisturbed and which could require additional rehabilitation work on a regular basis.

Several species of *Agrostis*, a natural volunteer (invading) grass that has promising characteristics as a revegetation species (e.g., extensive vegetative reproduction by wiry stolons that results in an aggressive, invasive growth pattern, rapid growth rate, and high biomass production), had been observed at the LTA, both on and off the treatment plots. These species' rate of natural spread at the LTA is slow because of limited seed or propagule sources and destruction of colonies by vehicle traffic. Volunteer species that have desirable rehabilitation attributes are always good candidates for revegetation seed mixtures, because it is certain they are well-adapted to site conditions. In managed or agricultural plantings, these species may be considered weeds; however, tough, aggressive plants are needed on tank maneuver ranges. The identity of these grasses was confirmed, seed was available commercially at a reasonable cost, and they were included in the revegetation seed mixture for Phase II.

3.3 Development of the Phase II Rehabilitation Prescription and Contractor Specifications

In the Phase II rehabilitation effort, a new, single prescription combining some features of all of the Phase I treatments, plus several new features, was used to develop contractor specifications for the revegetation of a majority of the most severely disturbed areas of barren, sandy soil at the LTA. All of the changes in specifications were made to reduce costs while maintaining or improving high levels of vegetative cover and soil stability. The revegetation treatment used in the new specifications was less expensive than any of the previous treatments, yet it resulted in the establishment of excellent vegetative cover. The principal operations in the Phase II specifications were fertilization, harrowing, seeding, and rolling. The fertilization rate, seed mixture, and seeding rate were different than those for any of the Phase I prescriptions. The Appendix includes a copy (in English) of the complete Phase II specifications and bid package

mailed to six German contractors (the specifications and packages sent were translated into German).

The rationale for the changes in specifications was as follows:

1. The deep tillage operation was eliminated, because the indurated layer that it was designed to break up quickly reformed. This pan did not appear to have a detrimental effect on growth of planted vegetation in any of the Phase I treatments.

2. The application of straw mulch was also eliminated, because there was no observable erosion (originating within the plot) on any of the Phase I treatment areas, not even on those without mulch on sloped plots.

3. A balanced (1 N:1 P_2O_5:1 K_2O), slow-release chemical fertilizer (similar to that used in the straw mulch treatment) was applied at a rate that provided approximately twice the plant nutrients applied to the straw mulch treatment. This change brought the level of the plant nutrients in Phase II more in line with that of the nutrients applied to the compost and chicken manure treatments of Phase I.

4. The specifications called for a spiketooth harrow to be used to break up the surface crust, incorporate the fertilizer into the surface soil, and produce a roughened soil surface suitable for broadcast seeding. Harrowing will not completely destroy all volunteer vegetation and may facilitate distribution of plant propagules.

5. The Phase II seed mixture (see Table 3) was developed by eliminating species that did not grow or perform well in the Phase I seed mixture and by adding several species observed to be vigorous volunteers at the site or that have demonstrated desirable qualities elsewhere in the vicinity. Seeding rate was increased to about 90 kg/ha to ensure a dense, diverse revegetation community.

Broadcast seeding and use of a roller after seeding — both used in Phase I — were specified to be used in Phase II as well. Broadcast seeding is effective for seeding areas where complete seedbed preparation is not used. Seed can be applied to areas around trees, on road shoulders, and in wet areas that could not be planted with a seed drill.

Good seed/soil contact (observed in Phase I) was achieved by using a Cambridge disk on the roughened, uneven seedbed. Some wind and water erosion control is provided by the ridges produced by the Cambridge disk. Rolling the seedbed with a Cambridge disk after seeding ensures maximum contact between seed and soil.

TABLE 3 Seeding Mixture and Rate: Phase II

Cover Type	Scientific Name	German Name (American Name)	Mixture	
			Broadcast Seeding Rate (kg/ha)	Percent by Weight (wt%)
Forbs	*Achillea millifolium*	Weisen-Scharfgarbe (common yarrow)	2.0	2.2
Grasses	*Agrostis alba/gigantea*	Weisse Straussgras (redtop)	2.0	2.2
	Agrostis stolonifera	Flechtstraussgras (bentgrass)	2.0	2.2
	Dactylis glomerata	Knaulgras (orchardgrass)	5.0	5.6
	Deschampsia caespitosa	Rasenschmiele (hairgrass)	5.0	5.6
	Eragrostis abessinica	Liebesgras (lovegrass)	1.0	1.1
	Festuca arundinacea	Rohrschwingel (tall fescue)	10.0	11.1
	Festuca ovina	Schafschwingel (sheep fescue)	2.0	2.2
	Festuca rubra var. rubra	Anslaufertr. Rotschwingel (creeping red fescue)	5.0	5.6
	Lolium perenne	Deutsches Weidelgras (perennial ryegrass)	20.0	22.2
	Phalaris arundinacea	Rohrglanzgras (reed canarygrass)	6.0	6.7
Legumes	*Lotus corniculatus*	Hornschotenklee (birdsfoot trefoil)	15.0	16.7
	Spartium scoparium	Besenginster (scotch broom)	5.0	5.6
	Trifolium repens	Weissklee (white clover)	10.0	11.1
Total			90.0	100.1

3.4 Phase II Contractor Selection and Prescription Installation

The bidding process for the Phase II revegetation work was set up differently than for the prior revegetation contract for Phase I. For Phase II, there was a fixed contract amount ($77,000, or DM134,750 at DM1.75 per $1.00), and the bidders were requested to bid the largest area they would rehabilitate for the fixed contract amount. The smallest rehabilitation area allowed to be bid was set at 15.6 ha. Bidders could increase the required minimum area by including any number of 15 designated optional parcels in their bid. These parcels ranged in size from 0.4 to 4.9 ha and were required to be added in a designated order to maintain contiguous revegetation areas. This bid process resulted in obtaining a maximum revegetated area at the LTA for a predetermined amount of available funds.

Eligible bids were received from four contractors. The bids were evaluated using the point system described in the bid package. The Kellermeier Ludwig Company received the highest point total, mainly because of the large area (43.2 ha) bid. This area included the minimum bid area plus all of the optional areas. This company was able to bid a large area at a relatively low cost per hectare by acting as a general contractor and subcontracting operations (harrowing, seeding, etc.) to local farmers who own the large equipment appropriate for the work. The subcontractors were assembled and coordinated by a *Maschinenring* (the German equivalent of an equipment cooperative). Use of the services of a *Maschinenring* resulted in low labor costs, no investment by the general contractor for equipment, and very low costs for such overhead items as transportation, mobilization, and demobilization.

Awarding the contract to a firm using an equipment cooperative had several advantages for Argonne: (1) the area bid was almost twice as large as the next ranking bidder's; (2) equipment operators were local farmers, who are familiar with local conditions and well-qualified to perform the required operations; and (3) the site work was completed in less time than estimated because farmers in Germany are used to working more than the normal (German) 35-h week. Similarly, an Argonne rehabilitation contract for the work at Range 8C, Hohenfels Training Area, was satisfactorily implemented by using an equipment cooperative.

Several changes to the original specifications were proposed by the successful bidder, Kellermeier Ludwig Company, and approved by the Argonne technical representative prior to the start of installation work. These changes introduced improvements or provided additional operations with no additional cost or reduction in the total area to be revegetated, so it was to Argonne's advantage to accept them.

The contractor tested both a *tiefengrubber* and a spiketooth harrow to determine the best method of seedbed preparation for varying conditions of existing vegetation (e.g., no plant cover, varying amounts of natural plant cover, areas with and without roots, around trees, etc.). The *tiefengrubber* is a cultipacker-type implement that loosens the soil to a depth of about six inches and smooths the seedbed in rutted areas; it was used in areas with little or no vegetation. Under the conditions at the LTA, the *tiefengrubber* produced a better seedbed in open areas than did the

spiketooth harrow. The harrow (the specified implement) was used on areas that had some vegetation present, on areas that were not rutted, and around trees.

The contractor proposed drill seeding a majority of the open treated areas rather than broadcast seeding (specified). Drill seeding provides better placement of the seed within the seedbed, which usually results in higher percentages of actual germination. Drill seeding is usually more expensive than broadcast seeding, but since the drill seeding was included as part of the successful bid, it was approved. The specifications called for broadcast seeding at 90 kg/ha, but because the seed mixture was drilled, the rate was reduced to 80 kg/ha. Broadcast seeding was used inside the wooded area at the east end of the LTA and around the forestry plots to prevent damage to tree root systems. These changes to the specifications were based on the contractor's knowledge of local agricultural practices and available equipment, as well as on a desire to ensure success at the harsh, sandy LTA site. Areas revegetated in Phase II were not closed to military traffic, because at the time of this work most military traffic was using the improved roads that had been recently constructed at the LTA.

3.5 Rehabilitation Costs

Table 4 shows the costs for the Phase II rehabilitation effort, broken down by materials and installation and presented in terms of cost per unit area.

By comparing the data in Table 2 with those in Table 4 (and ignoring the small difference in exchange rates for marks and dollars), it can be seen that the Phase II revegetation prescription cost considerably less than any of the Phase I treatments. In fact, the Phase II prescription cost was only 18% of the least expensive Phase I treatment (the straw mulch and fertilizer).

TABLE 4 Materials and Installation Costs for Phase II

	Costs	
Component	DM/ha[a]	$/acre
Materials		
Fertilizer	31	7
Seed	919	212
Installation	2168	500
Total	3118	719

[a]DM1.75 = $1.00 in 1989.

4 Results and Discussion

4.1 Rehabilitation Patterns

A plant community's vegetative growth, production, and plant succession represent the integration by that community of all the environmental factors that influence it. The end point of natural revegetation and plant succession on disturbed areas is the reestablishment of a stable plant community that is similar to the natural, undisturbed communities in the vicinity. The aim of rehabilitation is to emulate natural succession, to the extent possible, while accelerating the rate of change. Thus, rehabilitation is really a manipulation of natural succession, which is usually unacceptably slow with respect to the condition and training uses of such severely degraded areas as the Freihölser Forst LTA and other tactical training areas in Germany. The goal of the rehabilitation work at the LTA is the rapid establishment of a plant community that will stabilize the disturbed areas against erosion and provide enhanced training realism. The major objective of Phase I was to demonstrate and evaluate several revegetation options representing a range of costs and to provide data and recommendations that could be used to develop Phase II, a cost-effective rehabilitation plan for the remainder of the disturbed areas at the LTA.

The major objective of the monitoring program at the LTA was to determine the amount and type of vegetative ground cover produced by various revegetation options (Phases I and II) and to monitor the survival and durability of various species and communities with renewed military use of the site. The proportion of total ground cover (live vegetation cover plus litter) or its reciprocal (exposed soil) has been shown to be highly correlated with erosion rates and soil stability (Hoffman et al. 1983; Meeuwig 1970). However, not all types of vegetative cover provide equal erosion protection and soil stabilization. Grasses are usually considered better for erosion control than most forbs (Wischmeier and Smith 1978) because grasses, even in their dormant condition, have multiple leaves and stems, branching rhizomes, and a fibrous root system to bind and hold soil particulate matter, preventing soil erosion by both water and wind. Forbs usually have a single stem and often have a shallow root or taproot system that does not bind the soil as well as grass roots do. Even dead grasses (a type of litter) tend to remain intact and rooted in the soil for several years, whereas the aboveground parts of dead forbs tend to break up into loose litter at the end of the growing season. The establishment and maintenance of a dense, vigorous vegetative community composed predominantly of native grasses is the most effective and practical means of controlling erosion, stabilizing the soil, and providing a safer and more realistic training environment at the LTA and other training areas.

4.2 Phase I — Demonstration Plots

Throughout the three-year monitoring period, differences were observed between treatments and, in a few cases, between replicates of the same treatment in different locations. Some differences were conspicuous; others were more subtle and were only revealed by closely examining the plots or by analyzing the data. In both cases, the differences may or may not have

been statistically significant. Some differences were visual, while others involved measurements of cover composition. The most prominent visual differences included differences in size, vigor, and density of plants; species composition; color; texture of plant stands; and intensity of flowering. Many of the visual differences are documented in the photographic and videotape record that was maintained throughout the study.

The measured differences in cover composition are represented by the data in Table 5. This table lists the mean percent cover in eight cover categories and the percent damage for the three Phase I treatment prescriptions and two control areas on eight monitoring dates. (The total cover category is the sum of the total live vegetation cover and litter cover categories, and the sum of the values for the exposed soil and total cover categories is always 100%.) For a given cover category and monitoring date, significant differences between treatments are indicated. Other significant differences occurred between monitoring dates and within treatments for specific cover categories, but these differences are of less interest and are not indicated here because they resulted from normal and expected changes associated with growth, development, and succession.

At the time the prescriptions were installed at the LTA in late June 1987, all of the treatment areas were devoid of vegetation, as a result of previous military use and the planting operations. Posts surrounding the treatment areas (similar to those around the forestry plots) effectively prevented trespass by vehicles on most of the plots for the duration of the monitoring period. The control area (with natural vegetation) was the only area that had vegetative cover at the start of monitoring. The live vegetation cover on this plot was 29.3% at the time the other plots were installed. Live vegetation cover on the control area increased to a maximum of 64.3% in 1988, probably due to the exclusion of traffic, and never exceeded this value. The second control plot, which was bare at the time of prescription installation, attained a maximum live vegetation cover of only 17.3% in 1988, before it was eliminated in April 1989 by the installation of Phase II. These data suggest that natural revegetation at the LTA was a very slow process.

Evaluation of the Phase I cover data (Table 5) and extensive field observations through 1990 at the LTA show that, in general, all three treatments met the project goal of stabilizing the loose, sandy soil against erosion and providing enhanced training realism. In fact, by the September 1987 monitoring session (three months after installation), all of the treatment plots had developed adequate vegetative cover to be stabilized against normal erosion, despite the record rainstorm that occurred in early July, only a few days after the installation work was completed. None of the treatment plots (some of which were on slopes) developed erosion gullies that originated within the plots. In a few cases, the plots had gullies that had originated in the barren sand outside the plot boundaries and continued through the plot.

Considerable differences were observed between treatments, in terms of both visual appearance and measured cover composition. During the first two monitoring sessions, the revegetation community growing on the chicken manure plots was vegetationally more diverse, greener, and denser; had more flowers; and comprised taller plants than the vegetation on the other treatments. A comparison of cover percentages measured on the same date clearly indicates the consistent superiority of the chicken manure treatment over the other two treatments in producing

TABLE 5 Means of Cover Categories for Three Phase I Revegetation Treatments and Controls, by Monitoring Date

Monitoring Date	Cover Category	Percent Cover				
		Treatment A, Straw Mulch	Treatment B, Compost	Treatment C, Chicken Manure	Control, Initially Bare	Control, Natural Vegetation
September 1987	Total cover	89.6^{ab}	75.9^{a}	77.3^{b}	12.3^{ab}	45.3^{ab}
	Total live vegetation	54.6^{abc}	74.1^{bd}	75.2^{ce}	11.7^{abcd}	43.3^{de}
	Grass	14.8^{a}	16.1^{b}	17.4^{c}	2.0^{abc}	37.7^{abc}
	Legume	17.8^{ab}	32.6^{cd}	23.9^{ef}	0.0^{ace}	0.0^{bdf}
	Forb	5.8	2.3^{a}	5.0	9.7^{a}	5.7
	Rye	16.2^{ab}	23.1^{cd}	28.9^{ae}	0.0^{ac}	0.0^{bde}
	Litter	35.0^{abcd}	1.8^{a}	2.1^{b}	0.7^{c}	2.0^{d}
	Exposed soil	10.4^{abc}	24.1^{b}	22.7^{c}	87.7^{abc}	54.7^{abc}
	Damage	0.0	0.0	0.0	0.0	0.0
April 1988	Total cover	90.1^{a}	85.2^{b}	89.8^{c}	9.0^{abc}	52.7^{abc}
	Total live vegetation	54.1^{abc}	72.9^{b}	81.9^{c}	4.3^{abc}	31.7^{abc}
	Grass	33.1^{a}	38.0^{b}	45.3^{c}	3.3^{abcd}	30.3^{d}
	Legume	16.9^{ab}	30.2^{cd}	32.2^{ae}	0.0^{ac}	0.0^{bde}
	Forb	4.1	3.7	4.0	1.0	1.3
	Rye	0.0	1.0	0.3	0.0	0.0
	Litter	36.0^{abc}	12.3^{a}	7.9^{b}	4.7^{c}	21.0
	Exposed soil	9.9^{a}	14.8^{b}	10.2^{c}	91.0^{abc}	47.3^{abc}
	Damage	0.0	0.0	0.0	30.0	0.0

TABLE 5 (Cont'd)

Monitoring Date	Cover Category	Percent Cover				
		Treatment A, Straw Mulch	Treatment B, Compost	Treatment C, Chicken Manure	Control, Initially Bare	Control, Natural Vegetation
July 1988	Total cover	94.1[a]	91.1[b]	96.4[b]	15.3[ab]	76.0[ab]
	Total live vegetation	64.4[a]	77.8[b]	93.0[ab]	13.0[ab]	50.0[ab]
	Grass	37.4[a]	55.2[a]	78.3[ab]	7.7[ab]	44.0[b]
	Legume	22.7[ab]	17.3	11.7	0.0[a]	0.0[b]
	Forb	4.2	4.6	2.3	5.3	6.0
	Rye	0.1	0.7	0.7	0.0	0.0
	Litter	29.7[ab]	13.3[a]	3.4[bc]	2.3[ad]	26.0[cd]
	Exposed soil	5.9[a]	8.9[bc]	3.6[c]	84.7[abc]	24.0[abc]
	Damage	0.0	0.0	0.0	30.0	0.0
September 1988	Total cover	92.2[a]	80.7[abc]	94.1[bc]	18.0[abc]	67.0[ac]
	Total live vegetation	68.4[a]	78.6[b]	93.0[abc]	17.3[abc]	64.3[c]
	Grass	39.7[ab]	65.9[b]	77.9[ac]	6.7[abc]	52.0[c]
	Legume	23.6[ab]	8.1	11.2	0.0[a]	0.0[b]
	Forb	5.2	4.6[a]	3.9[bc]	10.7[b]	12.3[ac]
	Rye	0.0	0.0	0.0	0.0	0.0
	Litter	23.8[abcd]	2.1[a]	1.1[b]	0.7[c]	2.7[d]
	Exposed soil	7.8[abc]	19.3[b]	5.9[d]	82.0[abcd]	33.0[bcd]
	Damage	0.0	0.0	0.0	0.0	0.0

TABLE 5 (Cont'd)

Monitoring Date	Cover Category	Percent Cover				
		Treatment A, Straw Mulch	Treatment B, Compost	Treatment C, Chicken Manure	Control, Initially Bare	Control, Natural Vegetation
April 1989	Total cover	91.7[a]	86.4	93.4[b]	n.a.	74.3[ab]
	Total live vegetation	64.9[a]	79.3[ab]	91.1[ab]	n.a.	50.7[b]
	Grass	51.4[a]	72.0[ab]	85.0[ab]	n.a.	45.7[b]
	Legume	7.0[ab]	2.8	1.2[a]	n.a.	0.0[b]
	Forb	6.3	4.6	4.9	n.a.	5.0
	Rye	0.0	0.0	0.0	n.a.	0.0
	Litter	26.8[ab]	7.1[ac]	2.3[bd]	n.a.	23.7[cd]
	Exposed soil	8.3[a]	13.6	6.6[b]	n.a.	25.7[ab]
	Damage	0.0	1.1	0.0	n.a.	0.0
July 1989	Total cover	96.1	98.0	99.9	n.a.	89.3
	Total live vegetation	81.1	88.9	93.9[a]	n.a.	62.3[a]
	Grass	69.6[a]	79.2[b]	90.0[ac]	n.a.	44.7[bc]
	Legume	10.4	8.3	2.7	n.a.	0.0
	Forb	1.1[a]	1.3[b]	1.2[c]	n.a.	17.7[abc]
	Rye	0.0	0.0	0.0	n.a.	0.0
	Litter	15.0	9.1	6.0	n.a.	27.0
	Exposed soil	3.9	2.0	0.1	n.a.	10.7
	Damage	0.0	0.0	0.0	n.a.	0.0

TABLE 5 (Cont'd)

Monitoring Date	Cover Category	Percent Cover				
		Treatment A, Straw Mulch	Treatment B, Compost	Treatment C, Chicken Manure	Control, Initially Bare	Control, Natural Vegetation
September 1989	Total cover	84.3	81.0	87.8	n.a.	68.0
	Total live vegetation	70.4	78.8	84.3	n.a.	62.0
	Grass	53.0[a]	70.6[b]	78.4[ac]	n.a.	35.3[bc]
	Legume	10.0	4.8	2.7	n.a.	0.0
	Forb	7.4[a]	3.4[b]	3.2[c]	n.a.	26.7[abc]
	Rye	0.0	0.0	0.0	n.a.	0.0
	Litter	13.9[ab]	2.2[a]	3.4[b]	n.a.	6.0
	Exposed soil	15.7	19.0	12.2	n.a.	32.0
	Damage	0.0	0.0	0.0	n.a.	0.0
April 1990	Total cover	92.0	95.0	97.0	n.a.	77.7
	Total live vegetation	72.8[a]	86.2[b]	93.8[ac]	n.a.	40.7[bc]
	Grass	56.6[a]	66.4	84.8[ab]	n.a.	29.0[b]
	Legume	2.7	0.9	0.9	n.a.	0.0
	Forb	13.6	18.9[a]	8.1[a]	n.a.	11.7
	Rye	0.0	0.0	0.0	n.a.	0.0
	Litter	19.2[a]	8.8[a]	3.2[a]	n.a.	37.0[a]
	Exposed soil	8.0	8.0	3.0	n.a.	22.3
	Damage	0.0	0.0	0.0	n.a.	0.0

Within each category and monitoring date, means followed by the same letter are significantly different ($P \leq 0.05$), as determined by Sidak's pairwise t test.

total live vegetation cover and grass cover. (These two cover categories are considered to be the most important indicators of soil stability and erosion protection.) Furthermore, throughout the monitoring period, the compost treatment invariably had higher total percentages of live vegetation and grass cover than did the treatment using straw mulch and fertilizer.

Generally, the statistically significant differences between treatments peaked in 1988 and then tended to become less divergent with time, both visually and in terms of the measured cover percentages for total live vegetation and grass cover. By July and September 1989, the only significant differences between any of the treatment cover categories were that the chicken manure treatment developed greater grass cover than the straw mulch treatment, and the straw mulch treatment developed greater litter cover than either of the other treatments in September 1989. In fact, as Table 5 shows, the litter cover for the straw mulch and fertilizer treatment was consistently highest throughout the entire monitoring period. This high percentage of litter cover occurs because straw (a type of litter) was part of the straw mulch treatment, and the added straw was not distinguished from natural litter in the monitoring measurements. The presence of the added straw may also have been a factor in the relatively modest values recorded for the categories of total live vegetation cover and grass cover for this treatment early in the monitoring program. In some cases, the added straw on the soil surface may have been a physical barrier to young seedlings (from the planted seed) as they tried to push to the surface. Also, early in the development of the straw mulch revegetation stands, the added straw may have shaded the soil surface and prevented the seedbed from warming as quickly as the seedbeds of the other treated areas on sunny days in early spring.

Cereal rye was added to the seed mixture as a quick-cover component. It germinates and grows quickly, provides initial soil stabilization, and contributes to early habitat moderation (shading, soil moisture retention, etc.) while the more slow-growing perennials become established. Although botanically a grass, rye cover was measured separately from grass cover, which included the native perennial grasses in the revegetation seed mixture and any volunteer grasses that happened to grow in the treatment areas. Rye cover was measured separately because it was useful and informative to track its quick-cover characteristics.

Table 5 shows that the cereal rye component of the seed mixture functioned as intended. Rye cover constituted a substantial part of the total cover in September 1987; the rye then essentially dropped out of the cover measurements, except for a very small percentage in 1988 caused by a small amount of natural reseeding.

The legumes in the revegetation seed mixture germinated and grew well initially and were a substantial component of the total cover for all three treatments during the first year following installation. It can be assumed that essentially all of the legumes encountered in the monitoring program originated from planted seed, since no legume cover was measured on either of the control plots. Throughout the monitoring period, legume cover was consistently higher in areas treated with straw mulch and fertilizer, perhaps due to higher soil moisture and lower plant nutrient levels in this treatment. Legume cover decreased substantially in the compost treatment areas after July 1988 and in the chicken manure treatment areas after September 1988, perhaps because of increasing competition from the perennial grasses. Legumes, which fix nitrogen in the soil, are an

important component of any plant community growing in sandy soil with low nutrient-holding capability, like the soil at the LTA.

Revegetation is not a uniform process. Even within replicates at different locations, it progresses at different rates and with different successional patterns, which depend on a complex interaction among numerous microsite factors. For example, one of the replicates of the chicken manure treatment area (in the southeast corner of plot 4) appeared particularly luxuriant compared with all the other treatment replicates, including an adjacent chicken manure treatment area. In another example, much higher percentages of legume cover (predominantly birdsfoot trefoil) were measured in the low, moist Plot 1 replicate of the straw mulch and fertilizer treatment area than in the replicates on a hilltop (Plots 2 and 4). These differences between replicates of the same treatment appeared to be related primarily to differences in soil moisture conditions in the root zone, which were caused by differences in topography.

4.3 Phase II — Large-Area Rehabilitation

Phase II of the Freihölser Forst rehabilitation project revegetated a large area of the LTA (43.2 ha), comprising almost one-third of its total area and including nearly all of the most severely disturbed land. Phase II was highly successful in stabilizing most of the areas treated. A single revegetation prescription was used, based in part on lessons learned from Phase I. The Phase II prescription was installed by a German contractor in early April 1989 and was monitored using the same procedures of data collection and analysis as in Phase I. Fifteen new ground-cover monitoring transects were installed in July 1989. Nine of these transects were installed in typical, relatively flat areas of the LTA, and six were installed on steeply sloped areas. All of the transect locations had been highly disturbed prior to rehabilitation. The development of the Phase II revegetation plant community was only monitored for three sessions, July and September 1989 and April 1990.

Table 6 lists the mean percent cover in eight cover categories and the percent damage for the Phase II treatment prescription and the control area for three monitoring dates. The natural vegetation control area is the same one used in Phase I. For a given cover category and monitoring date, significant differences between treatments are indicated.

The cover data listed in Table 6 indicate that the revegetation community developed very rapidly on the relatively flat, typical areas of the site to produce a dense, turf-like stand dominated by native grasses and legumes, which stabilized the loose, sandy soils and improved the training realism of a major portion of the LTA. In these areas, the Phase II prescription produced a grass-dominated (72.7%) stand in three months that was very similar to the stand attained by the best-performing Phase I treatment (chicken manure) only after one year. The rapid development of the grass component may have been due to the inclusion of a larger number of grass species (10) in the Phase II seed mixture (Table 3) than in the Phase I mixture (6). In addition, several of the grasses in the Phase II mixture were of the fast-growing, aggressive type (tall fescue, lovegrass,

TABLE 6 Means of Cover Categories for Phase II Revegetated Areas and Control for Typical and Steeply Sloped Areas, by Monitoring Date

	Percent Cover, by Monitoring Date*								
	Typical Areas			Steeply Sloped Areas			Control Area (typical) Natural Vegetation		
Cover Category	July 1989	Sept. 1989	April 1990	July 1989	Sept. 1989	April 1990	July 1989	Sept. 1989	April 1990
Total cover	81.6^{a}	75.1^{r}	69.6	44.0^{ab}	45.7^{r}	53.7	89.3^{b}	68.0	77.7
Total live vegetation	80.0^{a}	73.7^{r}	65.4	42.0^{a}	45.5^{r}	46.7	62.3	62.0	40.7
Grass	72.7^{a}	63.2	54.8	38.8^{a}	41.7	45.3	44.7	35.3	29.0
Legume	4.6	8.2	10.1^{xy}	1.5	3.2	0.5^{x}	0.0	0.0	0.0^{y}
Forb	2.8	2.2	0.6	1.7	0.7	0.8	17.7	26.7	11.7
Litter	1.6	1.4^{r}	4.1^{x}	2.0	0.2^{s}	7.0^{y}	27.0	6.0^{rs}	37.0^{xy}
Exposed soil	18.4^{a}	24.9^{r}	30.4	56.0^{ab}	54.3^{r}	46.3	10.7^{b}	32.0	22.3
Damage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Within each cover category and monitoring date, means followed by the same letter are significantly different ($P \leq 0.05$), as determined by Sidak's pairwise t test.

and perennial ryegrass), which were not in the Phase I mixture. Including a larger number of grass species in the mixture also gives the prescription as a whole a wider range of adaptation, which permits accommodation to a greater variety of microsite conditions.

Initially, the percent legume cover was relatively low (4.6%) for the typical area transects. This was not unexpected, considering the rapidity of the development of the grass cover and the normally slower growth and establishment of legumes. By April 1990, about one year after planting, the legume cover had increased to 10.1%, or about 15% of total live vegetation cover.

For both the July and September 1989 monitoring sessions, the steeply sloped areas had significantly less cover than the typical areas, both in total live vegetation and in grass cover, because harsher, more droughty conditions prevailed in these sites. By April 1990, however, the only cover category that was significantly lower on the steeply sloped transects than in the typical areas was legume cover. Legumes are known to be less tolerant of droughty conditions than are grasses.

A comparison of revegetation costs (see Tables 2 and 4) showed that the Phase II prescription was considerably less expensive than even the least expensive Phase I treatment (straw mulch and fertilizer).

5 Summary and Conclusions

The Freihölser Forst Rehabilitation Project was begun in 1987 with the goal of developing and demonstrating rapid, cost-effective methods to stabilize the LTA's barren, eroding maneuver areas and make training conditions more realistic. The sandy, infertile, and acidic soils at the LTA were considered the major factor limiting rehabilitation efforts.

The project was conducted in two phases. Phase I demonstrated and evaluated three separate rehabilitation treatments that had a wide range of costs. Each treatment used a different type of soil amendment (fertilizer and straw, compost, or chicken manure), but they all had identical seedbed-preparation methods and seed mixtures, which consisted of adapted, native species. Cereal rye, included in the seed mixture as a quick-cover component, functioned as intended. This initial demonstration phase was conducted on relatively small (average size = 0.15 ha) replicated plots and was monitored three times during each growing season. Generally, from best to worst cover, the plots ranked as follows: chicken manure, compost, and straw mulch. The statistically significant differences in cover categories corresponding to this treatment ranking peaked in 1988 and then tended to become less divergent with time, both visually and in the measured cover percentages, through the end of the monitoring program. All three treatments reestablished vegetation satisfactorily and controlled erosion at the LTA.

The better initial appearance of areas treated with chicken manure or with compost treatments did not justify the high cost of these prescriptions; at best, these areas remained greener and vegetationally more diverse for only about a year. The straw mulch and fertilizer treatment was considered only marginally cost-effective. In fact, all three Phase I prescriptions were considered to be too expensive to use on large areas without substantial modification. Because of their small size, the Phase I demonstration plots had only a minor stabilizing effect on the extensive erosion problems at the LTA as a whole. Natural revegetation at the LTA, as demonstrated by control plots, was a very slow process.

Phase II of the project revegetated a large area of the LTA (43.2 ha), comprising almost one-third of its total area and including nearly all of the most severely disturbed land. The Phase II revegetation work took place in early April 1989 and used a prescription that was based, in part, on information gathered from Phase I, as well as experience from other revegetation projects in Germany at the nearby Hohenfels Training Area. The Phase II seed mixture contained a larger number of grasses than did the Phase I mixture, including several fast-growing, aggressive species. Phase II was monitored by means of the same procedures as Phase I, but for a shorter period of time. The Phase II prescription was considerably less expensive than any of the Phase I treatments.

The Phase II revegetation plant community developed more rapidly than any of the Phase I treatments and produced a dense, turf-like stand dominated by native grasses and legumes. The revegetation community initially developed more rapidly on relatively flat areas than it did in the harsher environment of steeply sloped areas. However, the vegetative cover on these

areas did not differ significantly after one year. Phase II was highly successful in establishing a revegetation community that stabilized the loose, sandy soils and improved the training realism of a major portion of the LTA.

Military and other personnel at 7ATC and Amberg have become aware of the potential for and the benefits of improving the quality and realism of the training environment at the LTA. Regional and site-specific data needed to plan and implement the rehabilitation project were located, assembled, and documented. Information on adapted, native plant species was assembled. Sources of information about materials (such as the availability and cost of fertilizer and seed) and equipment were identified. All the above information, as well as data on the methods used to design the Phase I and Phase II plans for the LTA, is available for future rehabilitation efforts at the LTA and at other installations in Germany.

6 Recommendations

Because the sandy soils at the LTA are capable of holding only very low levels of nutrients, all Phase I and Phase II rehabilitated areas should be fertilized annually to maintain the existing stand. A slow-release fertilizer supplying 45 kg/ha of N and 30 kg/ha each of P_2O_5 and K_2O should be applied with a broadcast spreader, as was done when the Phase II prescription was installed.

Future rehabilitation efforts on degraded military training lands should take advantage of the proven superiority of grass cover as a principal component of the revegetation community. The morphology and growth characteristics of grasses make them more suitable for stabilization and erosion prevention, as well as more resistant to damage from tracked and wheeled vehicles, than are legumes, other forbs, or even small woody plants.

The training use of an area and the level of intensity should be controlled so that the most heavily used portions of a site never become completely barren. This control policy will help to maintain some stabilizing vegetation and associated soil microorganisms on the most damaged areas. Vegetation also provides a source of seeds and vegetative propagules within the damaged areas. This approach will require more coordinated planning of training activities than currently occurs at most training areas.

The real value of the LTA rehabilitation project and its benefit to the ITAM program should be determined through a long-term assessment of the effectiveness of the Phase II rehabilitation prescription after a period of renewed military use. Questions related to the location of training activities, training intensity, the rate of renewed site degradation, the required frequency of additional rehabilitation, and the influence of these activities on the adjacent environment can only be answered after tactical vehicles resume their use of the LTA.

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Appendix:

Specifications for Freihölser Forst, Rehabilitation of a Local Training Area — Phase II Project

SPECIFICATIONS

FOR

FREIHÖLSER FORST
- REHABILITATION OF A LOCAL TRAINING AREA -
PHASE II PROJECT

AMBERG, BAVARIA, FEDERAL REPUBLIC OF GERMANY

ENGLISH

prepared by

Argonne National Laboratory
Energy and Environmental Systems Division
Renewable Resources Section
Argonne, Illinois, USA

prepared for

United States Army Corps of Engineers
Construction Engineering Research Laboratory
Champaign, Illinois, USA

January 1989

NOTICE TO BIDDERS

The following specifications are for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project located near Amberg, Bavaria, in the Federal Republic of Germany (FRG). These specifications, including tables and drawings, describe (1) rehabilitation work (fertilizing, harrowing, seeding, and rolling) to be accomplished, (2) equipment and implements to be used, (3) materials (types and amounts of fertilizer and seed) required per hectare, (4) location of the Freihölser Forst Local Training Area (LTA), and (5) location and ranking of optional plots at the LTA to be considered in bidding this contract. Bidders shall take no advantage of any apparent errors or omissions in the specifications, tables, or drawings. The rehabilitation supervisor (a representative of Argonne National Laboratory) shall be permitted to make such corrections and interpretations as deemed necessary for fulfilling the intent of the specifications, tables, and drawings to accomplish the rehabilitation work.

The requirements described in, and established by, these specification are binding. The surface area of all plots (required and optional) is fixed, ranking of optional plots for rehabilitating is established, all operations described are necessary, and the types and amounts of fertilizer and seed per hectare are required. For these reasons, bidders are advised to carefully review the instructions to bidders, general conditions, description of work, tables, drawings, and bid package before submitting a bid. Bidders are also advised to examine the location and condition of the individual plots at the LTA before submitting a bid.

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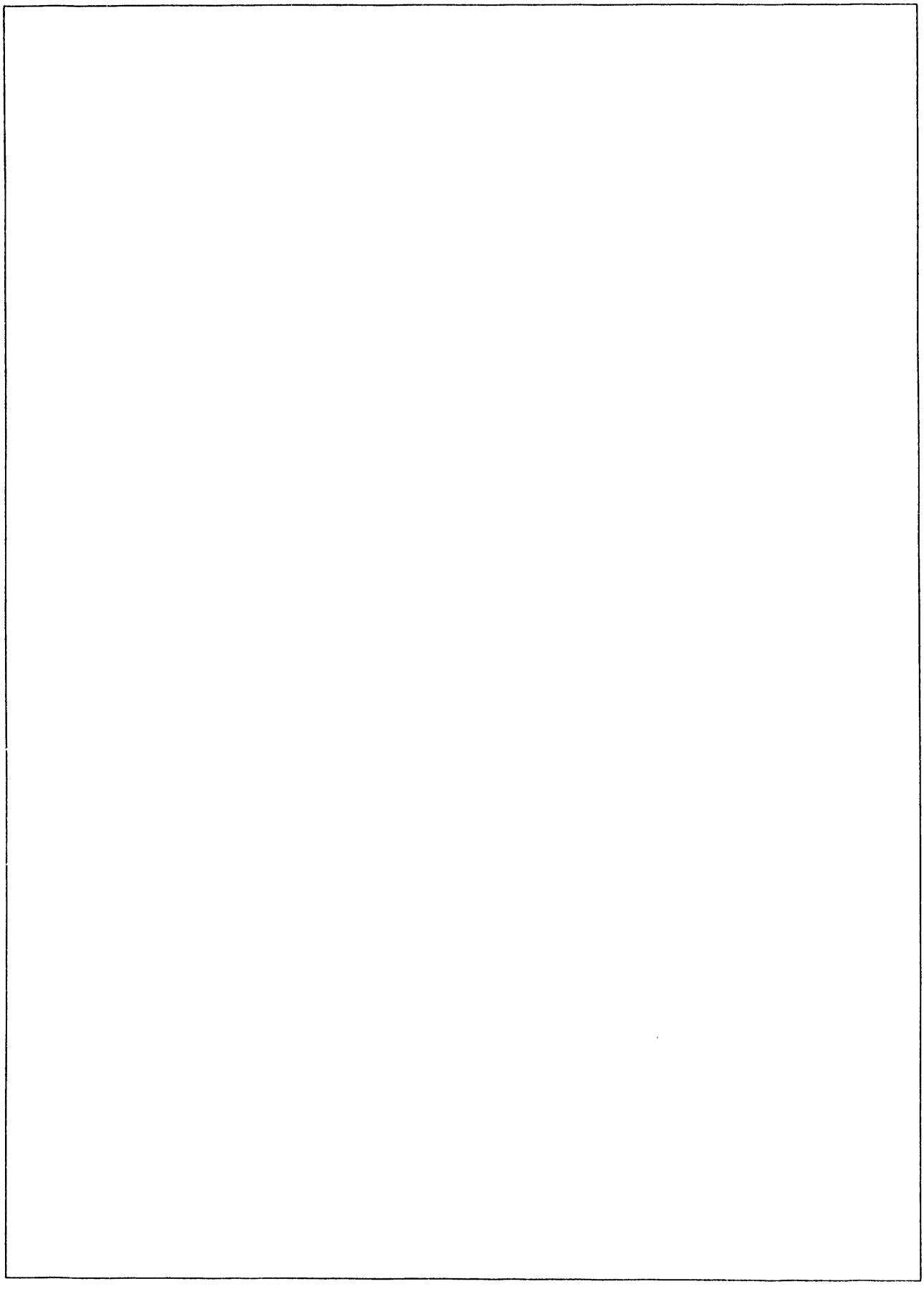
TABLES

DRAWINGS



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1 INSTRUCTIONS TO BIDDERS

1.1 Method of Bidding

A major factor in awarding the contract for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project will be the cumulative area, in hectares (ha), rehabilitated (fertilized, harrowed, seeded, and rolled) for the fixed contract price of $77,000 (DM 134,750 at DM 1.75 per $1.00). *A minimum cumulative area bid of 15.55 ha is required to award the contract.* The required minimum cumulative area to be rehabilitated is shown on Drawing 8C439-FF-5 of these specifications. Optional plots can be added to increase the cumulative area bid. However, optional plots must be added in the order or rank established in these specifications. The location, order or rank, and relative size of the optional plots are shown on Drawing 8C439-FF-5 and Table 1 lists the order or rank, optional plot area, and cumulative area for bidding more than the minimum cumulative area of 15.55 ha. An example of a cumulative area bid of 18.40 ha would include the rehabilitation of optional plots 1, 2, and 3 in addition to the required minimum cumulative area of 15.55 ha for the fixed contract price of $77,000 (DM 134,750). If a cumulative area bid of 26.08 ha were made optional plots 1, 2, 3, 4, and 5, in addition to the required minimum cumulative area, would rehabilitated for the same fixed price of $77,000 (DM 134,750).

Bidders must submit a cumulative area bid (ha) and, if more than the minimum required cumulative area of 15.55 ha is bid, a listing of the optional plots to be rehabilitated for the fixed contract price of $77,000 (DM 134,750). This fixed contract price will include (1) cost for use of all equipment, implements, and tools; (2) cost for all labor and equipment operators; (3) cost of all material (types and amounts of fertilizer and seed mixture) required; (4) other costs necessary to complete the work as specified; and (5) payment of all value-added (Mehrwertsteuer) taxes required by the FRG government. Because this contract is *not* with the U.S. Army, payment of the 14% FRG value-added tax will be required and *must* be included in the fixed contract price of $77,000 (DM 134,750).

1.2 Required Bid Information

All bids *must* be submitted on the forms provided in the bid package. The required bid information includes:

- The cumulative area (ha) and a listing of optional plots, if any, to be rehabilitated for the fixed contract price (Form 1). A project schedule (starting date, completion date, and number of working days required to complete the rehabilitation project) is also required (Form 2).

- A list of all equipment and implements, together with an estimated cost per hour for each operation required by the contract (Form 3).

- A list of the job categories (laborers, equipment operators, etc.) and the number of workers in each category, together with an estimate of the cost per hour for each operation required for the contract (Form 4).

- Type of fertilizer to be used, analysis of the fertilizer, estimated cost per kilogram (kg), description of the method used for calculating the required application rate (kg/ha), and description of the method used to adjust the equipment to ensure application of the fertilizer at the required rate (Form 5).

- Estimated cost per kg and cost per ha of individual species in the seed mixture, estimated cost per ha of the seed mixture, and description of the method used to adjust the equipment to ensure application of the seed mixture at the required rate (Form 6).

- Estimates of other costs necessary to complete the rehabilitation project (mobilization and demobilization of equipment, storage and transport of materials, etc.) and an estimate of the value-added taxes payable to the FRG government (Form 7).

- Each bidder *must* provide a work history of rehabilitation projects completed by the bidding company. This history should include (1) a list of rehabilitation or similar contract work completed, (2) project location, (3) type of operation, (4) total area (ha), and (5) contact (name and telephone number) for completed projects (Form 8).

Other information provided by the bidder in the bid package will be used to judge contractor qualifications and will be considered in awarding the contract.

1.3 Bid Submission

Sealed bids for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project *MUST BE RECEIVED AT ARGONNE NATIONAL LABORATORY NO LATER THAN 17:00 HOURS, WEDNESDAY, 1 MARCH 1989.*

All bids must be returned by mail to:

Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439-4815, USA
Attention: Dianne Hutchinson
Reference: RFP 89-47DH-07

Argonne National Laboratory reserves the right to reject any and all bids.

- Estimates of other costs necessary to complete the rehabilitation project. Examples of these costs include, but are not limited to, equipment mobilization and demobilization, storage cost for fertilizer and seed, transport of fertilizer and seed to the project site, and site cleanup costs. *An estimate of value-added (Mehrwertsfeuer) taxes payable to the FRG government is required* (Form 7).

Work History (Form 8)

Information on bidder history is required and may be verified by telephone interviews with persons representing organizations that have had rehabilitation work done by the bidder in the past. Bidders with an average work history will *NOT* be awarded points, bidders with a good work history can be awarded a maximum of two (2) points, and bidders with an excellent work history can be awarded a maximum of four (4) points. Because of the nature and combination of information in this section, fractional parts of a point may be awarded. However, no more than four (4) total points will be awarded for work history.

Work history is defined as follows:

- **Average Work History** (0 points)
  - Bidder has most of the equipment and personnel necessary to complete the rehabilitation project.
  - Bidder usually completes contracts on schedule.
  - Bidder does acceptable-quality work.
  - Bidder has completed one (1) or more rehabilitation contracts.
- **Good Work History** (Maximum 2 points)
  - Bidder has all equipment and personnel necessary to complete the rehabilitation project.
  - Bidder completes contracts on schedule.
  - Bidder does above-average-quality work.
  - Bidder has completed several (3-5) rehabilitation contracts.
- **Excellent Work History** (Maximum 4 points)
  - Bidder has all equipment and personnel necessary to complete the rehabilitation project on schedule.

2 GENERAL CONDITIONS

2.1 Scope of Work

The bidder will determine the cumulative area (ha) that will be rehabilitated (fertilized, harrowed, seeded, and rolled) at the LTA by this contract, which has a fixed price of $77,000 (DM 134,750). As stated in the Method of Bidding (Section 1.1), a major factor in awarding this contract will be the cumulative area rehabilitated. *A minimum bid of 15.55 ha is required.* The order, or rank, for including optional plots in a bid is established, and Table 1 and Drawing 8C439-FF-5 list the plot order or rank, optional plot areas, and the cumulative bid area. Examples of bids with more than the required 15.55 ha minimum bid are also given in Section 1.1 of these specifications.

Rehabilitation work for this contract will consist of broadcast fertilizing, spiketooth harrowing, broadcast seeding, and rolling with a Cambridge disk on 15.55 ha or more at the U.S. Army Freihölser Forst Local Training Area located near Amberg, FRG. The initial task will require the broadcast application of slow- or time-release dry chemical fertilizer at an established rate on all plots included in the bid. Plots will then be harrowed with a spiketooth harrow to roughen the soil surface and incorporate some of the fertilizer into the soil. After harrowing, plots will be seeded with a cyclone-type broadcast seeder, using the prescribed seed mixture at the specified rate. The final rehabilitation operation will consist of rolling the seeded plots with a Cambridge disk to ensure contact between the soil and seed.

The amount (kg/ha) of plant nutrients (N, P_2O_5, K_2O) to be applied as slow- or time-release dry chemical fertilizer is established and listed in Section 3.1 of these specifications. Plant species seed to be included in the seed mixture, and the seed mixture application rate (kg/ha), are established and listed in Table 2 of these specifications. Changes in the type or amounts of plant nutrients applied, plant species in the seed mixture, and seeding rate can be made only with the written approval of the rehabilitation supervisor.

A fixed price of $77,000 (DM 134,750) has been established for this contract and will include (1) cost for the use of all equipment, implements, and tools; (2) cost for all labor and trained operators; (3) cost of all required materials and supplies (types and amounts of fertilizer and seed); (4) other associated costs (mobilization and demobilization of equipment, etc.); and (5) payment of all FRG value-added taxes necessary to complete the rehabilitation work. Because this is *not* a contract with the U.S. Army, payment of the 14% FRG value-added tax will be required and *must* be included in the fixed $77,000 (DM 134,750) contract price.

2.2 Project Location and Access

The Freihölser Forst Local Training Area is located on the south side of Highway 85 approximately 8 km east of Amberg, Bavaria. This is also northwest of the intersection of Highway 85 and Autobahn 6. The location of the LTA is shown in Drawing 8C439-FF-4 of these specifications. Access to, and travel on, the LTA is restricted and

controlled. Clearance for inspection, access, or any work on the LTA must be obtained daily, in advance from 2nd Lieutenant William M. Vertrees, LTA Project Officer, or his representative (telephone number 09621 700 82[illegible] or Mr. Jake Turner, LTA Facility Engineer (telephone number 09621 700 819).

2.3 Security and Storage

Security of all equipment, materials, supplies, and tools is the sole responsibility of the contractor. Loss by theft, vandalism, pilferage, fire, flood, or waste in no way reduces the obligation of the contractor to complete all rehabilitation work. No payment shall be made for lost or damaged equipment, materials, supplies, or tools.

All arrangements for storage of equipment, materials, supplies, and tools are the sole responsibility of the contractor. Equipment, materials, supplies, and tools can be stored outside the LTA if desired. Any arrangements for storage of equipment, materials, supplies, and tools on the LTA *must* be made with 2nd Lieutenant William M. Vertrees or Mr. Turner.

2.4 Vegetation and Water

The contractor shall not cause damage to the existing vegetation outside the work areas on the LTA. The contractor shall also avoid unnecessary destruction of vegetation in the work areas (individual plots) unless authorized by the rehabilitation supervisor and required for accomplishment of the rehabilitation work. Provision for construction water and potable water for contractor laborers, equipment operators, and other personnel is the sole responsibility of the contractor.

2.5 Material Handling and Site Cleanup

All rehabilitation materials (fertilizer and seed) shall be handled and stored so as to preserve their quality and fitness for the work. At all times, the contractor shall maintain the project work areas in an orderly manner and keep the site free from accumulations of debris, waste materials, or rubbish. On completion of work, the contractor shall remove all equipment, excess materials, supplies, tools, and rubbish from the LTA. Final inspection of the LTA will be made by the rehabilitation supervisor following completion of the rehabilitation project.

2.6 Contractor Responsibility

The contractor shall defend, protect, indemnify, and save Argonne National Laboratory and the United States Government, its successors and assignees, harmless against any and all claims, demands, and liability of every kind and character for any loss, damage, injury, or other casualty to property whether it belongs to either of the parties hereto or to a third person, and to persons, including the parties hereto, their employees and third persons, caused by, growing out of, incident to, or resulting directly

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or indirectly from the activity undertaken by the contractor associated with the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project located near Amberg, Bavaria, Federal Republic of Germany.

3 DESCRIPTION OF WORK

The Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project will consist of four operations to be carried out by the contractor on all plots included in the bid. The four operations are:

- Broadcast fertilizing.
- Spiketooth harrowing.
- Broadcast seeding.
- Rolling with a Cambridge disk.

The sequence of the four operations on an individual plot is to be conducted in the order listed in these specifications. An individual operation (e.g., broadcast fertilizing) can be completed on all plots of the cumulative area before the following operation (spiketooth harrowing) is begun. Any modification of the operations described, sequence of operations, or use of equipment not described in these specifications can be made only with the approval of the rehabilitation supervisor.

Detailed descriptions and requirements for each of the four operations are give in Sections 3.1 through 3.4 of these specifications.

3.1 Broadcast Fertilizing

Description. Broadcast fertilizing shall consist of the uniform application of a dry chemical fertilizer at the required rate using a mechanical cyclone-type broadcast fertilizer spreader.

Requirements. Broadcast fertilizing shall be the first rehabilitation operation done on all plots (cumulative area) included in the contact. The dry chemical fertilizer material applied shall be of the slow- or time-release type and shall be applied at a rate to supply the following plant nutrients: 100 kg/ha of N; 100 kg/ha of P_2O_5; and 100 kg/ha of K_2O. The fertilizer material shall be dry and free-flowing, free of lumps or consolidated fertilizer materials, and of uniform composition. An analysis of the fertilizer material (%N:%P_2O_5:%K_2O), the method used for calculating the required application rate, and a description of the method used to adjust the equipment to ensure application of fertilizer at the required rate shall be provided to the rehabilitation supervisor.

3.2 Spiketooth Harrowing

Description. Spiketooth harrowing shall consist of breaking the crust on the soil surface, incorporating some of the fertilizer into the surface soil, and roughening the soil surface using a spiketooth harrow or similar implement.

Requirements. Spiketooth harrowing shall be done following the broadcast fertilizing on all plots included in the contract. A spiketooth harrow or similar implement shall be used to break the soil surface crust, incorporate some of the fertilizer into the surface soil, and roughen the soil surface before broadcast seeding. Use of any implement other than a spiketooth harrow for this operation must be approved by the rehabilitation supervisor.

3.3 Broadcast Seeding

Description. Broadcast seeding shall consist of the uniform application of the specified seed mixture (Table 2) at the rate of 90 kg pure live seed/ha, using a mechanical cyclone-type broadcast seeder.

Requirements. Broadcast seeding shall be done following spiketooth harrowing on all plots (cumulative area) included in the contact. The seed mixture to be used is given in Table 2 of these specifications, which lists the plant species and percent by weight of pure live seed (PLS) for each species in the seed mixture. PLS is defined as the product of percent purity times percent germination divided by 100. Appropriate legume inoculants shall be mixed with the legume seed before broadcast seeding. The scientific name, variety, percent germination, percent purity, and the percent by weight of each species in the seed mixture and a description of the method used to adjust the equipment to ensure application of the seed mixture at the required rate must be provided to the rehabilitation supervisor. Any changes in percentages or species in the seed mix must be approved by the rehabilitation supervisor.

3.4 Rolling with a Cambridge Disk

Description. Rolling with a Cambridge disk shall consist of rolling the soil surface following broadcast seeding to ensure good contact between the soil and the planted seed, using a Cambridge disk or similar implement.

Requirements. Rolling with a Cambridge disk shall be done following broadcast seeding on all plots (cumulative area) included in the contract. A Cambridge disk or similar implement shall be used to firm the planted seed and ensure good contact between soil and seed. Rolling with a Cambridge disk shall be done at a right angle to the slope of each plot to prevent water erosion. Use of any implement other than a Cambridge disk for this operation must be approved by the rehabilitation supervisor.

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TABLE 1 Required Minimum Cumulative Area and Optional Plot Order or Rank, Optional Area, and Cumulative Area Bid for the Freihölser Forst- Rehabilitation of a Local Training Area - Phase II Project

Required Minimum Cumulative Area: 15.55 ha

Optional Plot Order or Rank	Optional Plot Area (ha)	Cumulative Area Bid (ha)
1	1.09	16.64
2	1.33	17.97
3	0.43	18.40
4	4.86	23.26
5	2.82	26.08
6	1.16	27.24
7	1.15	28.39
8	2.60	30.99
9	2.06	33.05
10	3.13	36.18
11	2.08	38.26
12	1.26	39.52
13	1.28	40.80
14	0.91	41.71
15	1.50	43.21

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TABLE 2 Seeding Mixture for Freibölser Forst Rehabilitation Project - Phase II

Scientific Name	Deutscher Name / American Name	Mixture: Broadcast kg/ha	Mixture: Percent Weight
Forbs			
Achillea millifolium	Wiesen-Scharfgarbe common yarrow	2.0	2.2
Grasses			
Agrostis alba/gigantea	Weisse Straussgras redtop	2.0	2.2
Agrostis stolonifera	Flechtstraussgras bentgrass	2.0	2.2
Dactylis glomerata	Knaulgras orchardgrass	5.0	5.6
Deschampsia caespitosa	Rasenschmiele hairgrass	5.0	5.6
Eragrostis abessinica	Liebesgras lovegrass	1.0	1.1
Festuca arundinacea	Rohrschwingel tall fescue	10.0	11.1
Festuca ovina	Schafschwingel sheep fescue	2.0	2.2
Festuca rubra var. rubra	Anslaufertr. Rotschwingel creeping red fescue	5.0	5.6
Lolium perenne	Deutsches Weidelgras perennial ryegrass	20.0	22.2
Phalaris arundinacea	Rohrglanzgras reed canarygrass	6.0	6.7
Legumes			
Lotus corniculatus	Hornschotenklee birdsfoot trefoil	15.0	16.7

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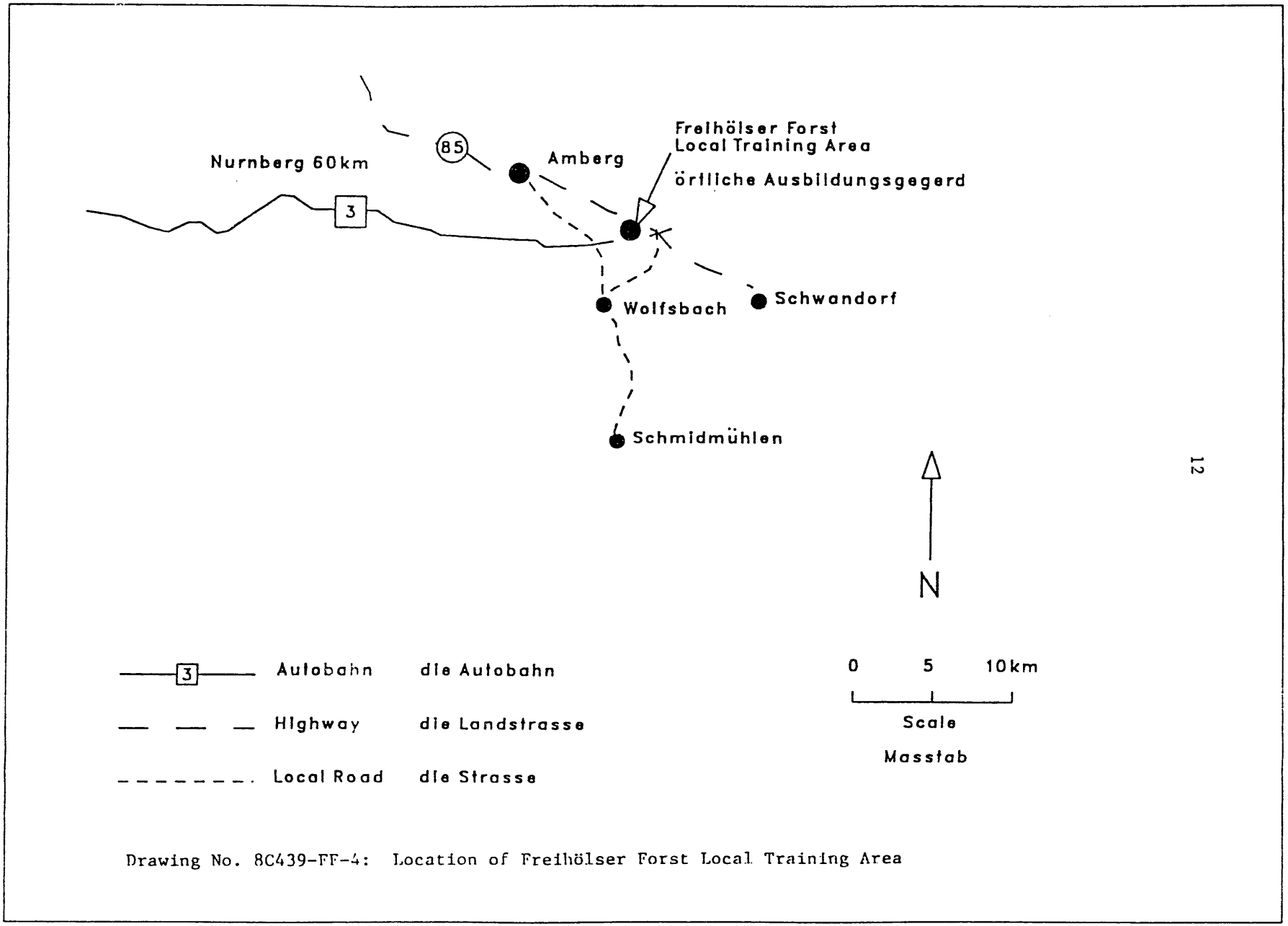
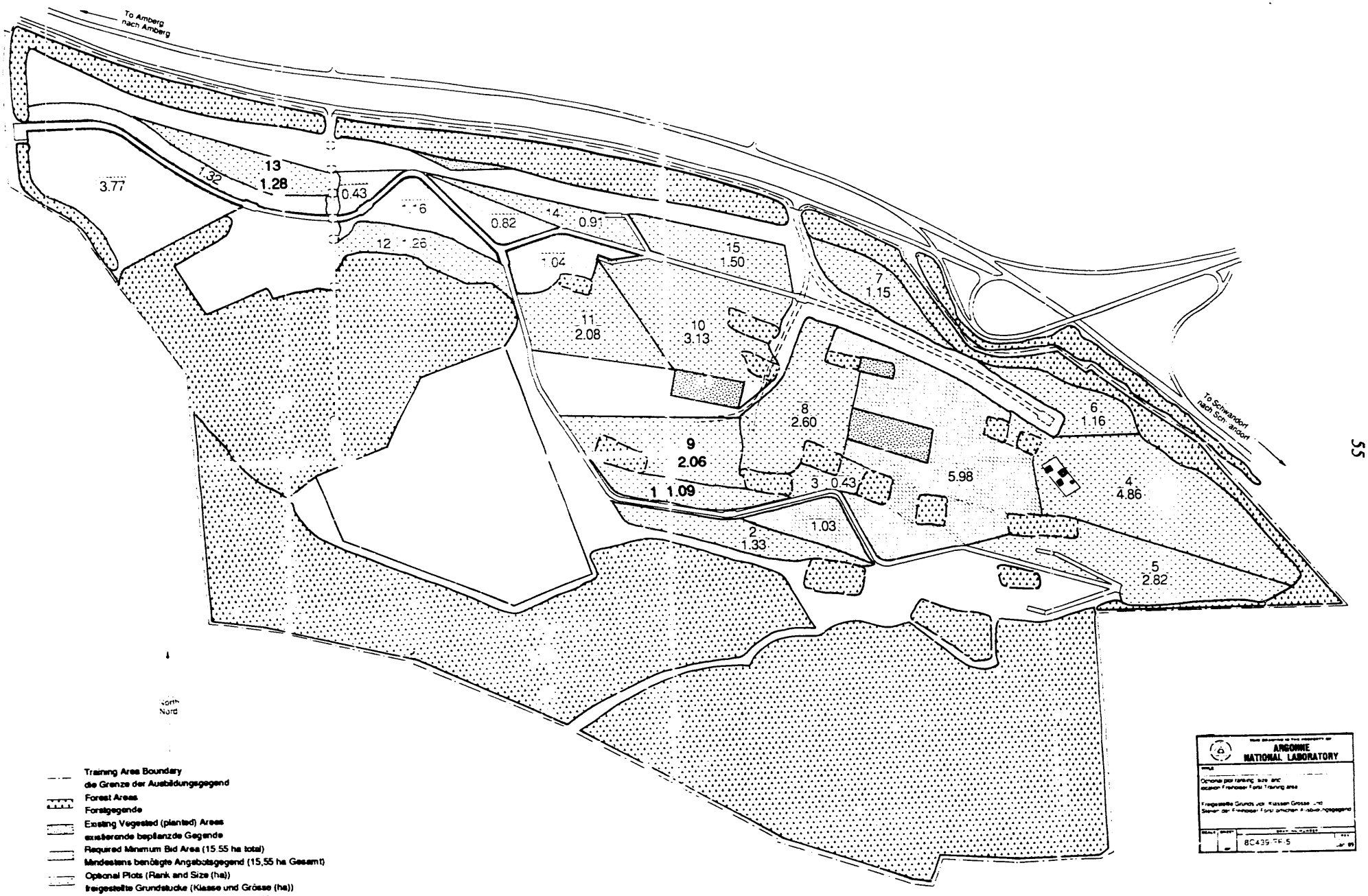
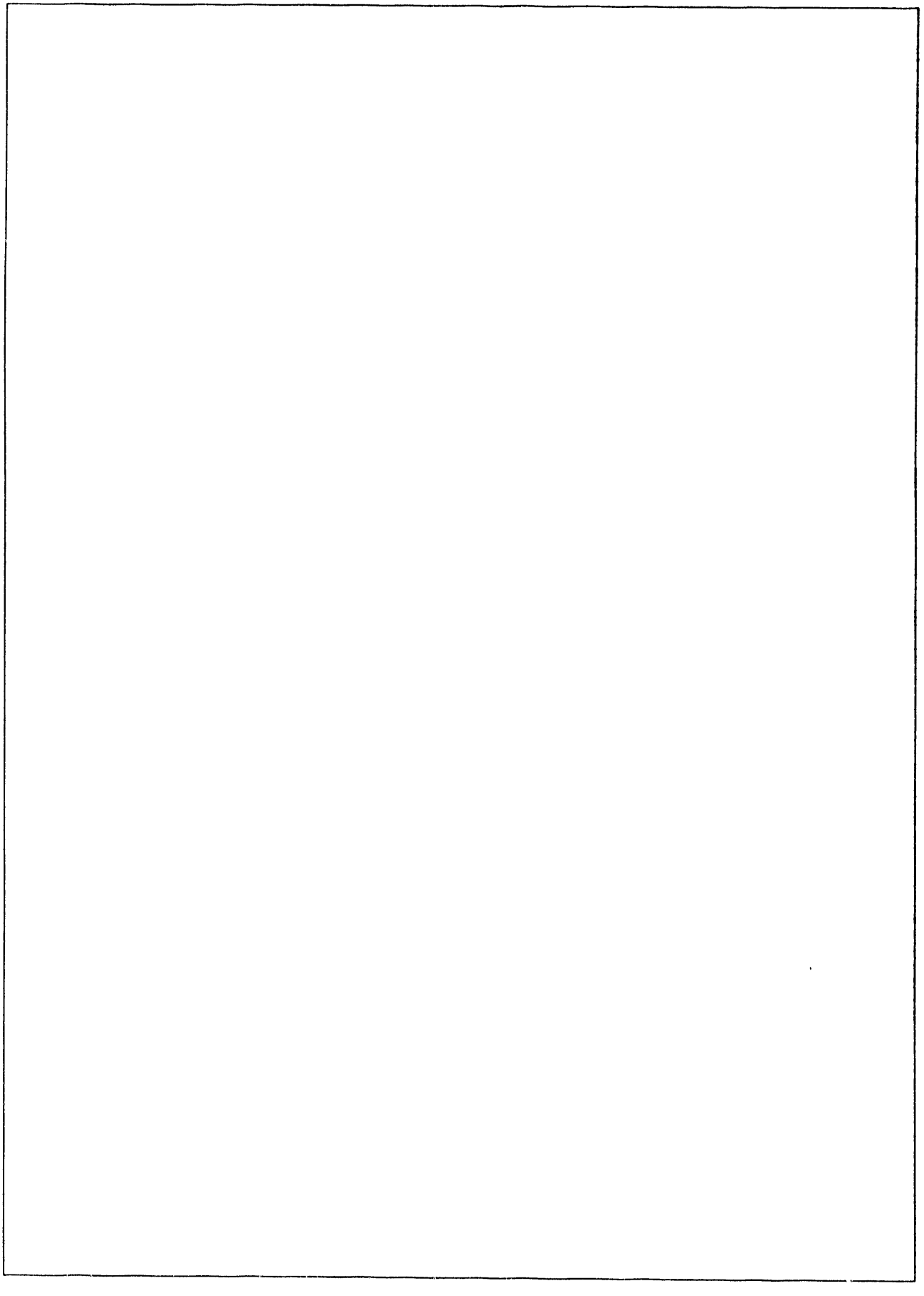
TABLE 2 Seeding Mixture for Freihölser Forst Rehabilitation Project - Phase II (Cont'd)

Scientific Name	Deutscher Name / American Name	Mixture Broadcast kg/ha	Mixture Percent Weight
Legumes			
Spartium scoparium	Besenginster scotch broom	5.0	5.6
Trifolium repens	Weissklee white clover	10.0	11.1
Total		90.0	100.1



Drawing No. 8C439-FF-4: Location of Freihölser Forst Local Training Area


To Amberg
nach Amberg
13
1.28
3.77
1.32
0.43
0.82
0.91
1.04
15
1.50
7
1.15
11
2.08
10
3.13
8
2.60
6
1.16
To Schwandorf
nach Schwandorf
9
2.06
1 1.09
3 0.43
5.98
4
4.86
2
1.33
1.03
5
2.82
North
Nord
Training Area Boundary
die Grenze der Ausbildungsgegend
Forest Areas
Forstgegende
Existing Vegested (planted) Areas
existierende bepflanzde Gegende
Required Minimum Bid Area (15.55 ha total)
Mindestens benötigte Angebotsgegend (15,55 ha Gesamt)
Optional Plots (Rank and Size (ha))
freigestellte Grundstucke (Klasse und Grösse (ha))
0 25 50 100 200
meters
ARGONNE
NATIONAL LABORATORY



BID PACKAGE

FOR

FREIHÖLSER FORST
- REHABILITATION OF A LOCAL TRAINING AREA -
PHASE II PROJECT

AMBERG, BAVARIA, FEDERAL REPUBLIC OF GERMANY

ENGLISH

submitted by

COMPANY NAME: _____

ADDRESS: _____

_____

TELEPHONE: _____

PERSON IN CHARGE OF THIS PROJECT FOR THE COMPANY:

NAME: _____

TELEPHONE: _____

COMPANY EMPLOYEE WHO SPEAKS ENGLISH:

NAME: _____

TELEPHONE: _____

prepared by

Argonne National Laboratory
Energy and Environmental Systems Division
Renewable Resources Section
Argonne, Illinois, USA

prepared for

United States Army Corps of Engineers
Construction Engineering Research Laboratory
Champaign, Illinois, USA

January 1989

CONTENTS

FORMS

1

METHOD OF EVALUATING BIDS

A point system has been developed to evaluate the bids and the companies bidding on the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project. The bidder receiving the highest number of points will be awarded the contract at the established price of $77,000 (DM 134,750) for the rehabilitation project. A minimum cumulative-area bid of 15.55 hectares is required.

Bidders must provide the cumulative-area bid (in hectares), a listing of optional plots included in the bid, and a project schedule. Equipment and personnel, completeness of estimated costs and other information, and work history will be used to determine contractor qualifications. The order or ranking for the rehabilitation of optional plots has been established. Individual plots *must* be bid in the established order or ranking to be considered. This information will be used to award the contract.

Argonne National Laboratory reserves the right to reject any and all bids received for this rehabilitation project.

Points for awarding the contract will be assigned as follows:

Cumulative-Area Bid (Form 1)

A minimum cumulative area bid of 15.55 hectares (ha) is required for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project contract. Optional plots included in the bid *must* be by the established order or ranking to be considered.

One (1) point will be awarded for each one (1) percent difference between the area (in ha) bid by the company and the average area bid. Average area bid is equal to the sum of total area bid (all bids received) divided by the number of bids received. Negative (-) points will be awarded if the cumulative-area bid is less than the average area bid.

Points Awarded = ([cumulative-area (ha) bid - average ha bid]/average ha bid x 100).

Project Schedule (Form 2)

Project Starting Date. The established starting date for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project is *MONDAY, 3 APRIL 1989.* One-half point (0.5) will be subtracted for each working day the rehabilitation project is scheduled to start after 3 April 1989. No points will be awarded for starting the rehabilitation before 3 April 1989.

Total Number of Working Days. An estimated *EIGHT (8) WORKING DAYS* will be required to complete the minimum area of 15.55-ha of the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project. One (1) additional working

day will be allowed for each two (2) ha more than the 15.55 ha minimum bid included in the cumulative-area bid. One-half (0.5) point will be subtracted for each working day more than estimated eight (8) working days required for the minimum bid. One-half (0.5) point will be added for each working day allowed for each two (2) ha more than the 15.55 ha minimum bid included in the cumulative area bid. No points will be awarded for an estimate of less than eight (8) working days, including the one (1) working day credit for each additional two (2) ha more than the 15.55-ha minimum bid included in cumulative area bid.

Equipment, Personnel, Estimated Costs, and Other Information (Forms 3-7)

Equipment and personnel to be used for the rehabilitation project, completeness of estimated costs and other information, and work history will be used to determine contractor qualifications and will be considered in awarding the contract. Any bidder not having the necessary equipment and personnel necessary to perform the rehabilitation effort, in the judgment of the Argonne National Laboratory representative, will be rejected. A second factor in establishing bidder qualifications is the estimated costs of the various constituents of the rehabilitation project. One (1) point will be awarded for each completed form. Because of the nature and combination of information in this section, fractional parts of a point may be awarded. However, no more than a total of five (5) total points will be awarded for Equipment, Personnel, Estimated Costs, and Other Information, (Forms 3-7).

The following information is requested:

- A list of all equipment and implements, together with an estimate of the cost per hour to be used for each operation required by the contract (Form 3).

- A list of the job categories (laborer, equipment operator, etc.) and number of workers in each category, together with an estimate of the cost per hour to be used for each operation required for the contract (Form 4).

- Type of fertilizer to be used, analysis of the fertilizer ($N:P_2O_5:K_2O$), estimated cost per kg, description of the method used for calculating the required application rate, and description of the method used to adjust the equipment to ensure application of the fertilizer at the required rate (Form 5).

- Estimated cost per kg and cost per ha of individual species in the seed mixture, estimated cost per ha of the seed mixture, and description of the method used to adjust the equipment to ensure application of the seed mixture at the required rate (Form 6).

- Estimates of other costs necessary to complete the rehabilitation project. Examples of these costs include, but are not limited to, equipment mobilization and demobilization, storage cost for fertilizer and seed, transport of fertilizer and seed to the project site, and site cleanup costs. *An estimate of value-added (Mehrwertsfeuer) taxes payable to the FRG government is required* (Form 7).

Work History (Form 8)

Information on bidder history is required and may be verified by telephone interviews with persons representing organizations that have had rehabilitation work done by the bidder in the past. Bidders with an average work history will *NOT* be awarded points, bidders with a good work history can be awarded a maximum of two (2) points, and bidders with an excellent work history can be awarded a maximum of four (4) points. Because of the nature and combination of information in this section, fractional parts of a point may be awarded. However, no more than four (4) total points will be awarded for work history.

Work history is defined as follows:

- Average Work History (0 points)
  - Bidder has most of the equipment and personnel necessary to complete the rehabilitation project.
  - Bidder usually completes contracts on schedule.
  - Bidder does acceptable-quality work.
  - Bidder has completed one (1) or more rehabilitation contracts.
- Good Work History (Maximum 2 points)
  - Bidder has all equipment and personnel necessary to complete the rehabilitation project.
  - Bidder completes contracts on schedule.
  - Bidder does above-average-quality work.
  - Bidder has completed several (3-5) rehabilitation contracts.
- Excellent Work History (Maximum 4 points)
  - Bidder has all equipment and personnel necessary to complete the rehabilitation project on schedule.

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- Bidder completes contracts on or ahead of schedule.
- Bidder does exceptional-quality work.
- Bidder has completed many (5 or more) rehabilitation contracts.

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FORM 1 Cumulative Area (ha) Bid and Optional Plots for the Freihölser Forst Rehabilitation of a Local Training Area - Phase II Project Contract

Company Name _____ Telephone _____

Required Minimum Cumulative Area Bid: 15.55 ha

Optional Plot Order or Rank	Optional Plot Area (ha)	Cumulative Area Bid (ha)	Bid Yes or No
1	1.09	16.64	____
2	1.33	17.97	____
3	0.43	18.40	____
4	4.86	23.26	____
5	2.82	26.08	____
6	1.16	27.24	____
7	1.15	28.39	____
8	2.60	30.99	____
9	2.06	33.05	____
10	3.13	36.18	____
11	2.08	38.26	____
12	1.26	39.52	____
13	1.28	40.80	____
14	0.91	41.71	____
15	1.50	43.21	____

Cumulative Area Bid _____ ha*.

Optional plots MUST be bid in order or rank listed.[b]

Optional plots bid: ___,___,___,___,___,___,___,___,___,___,___,___,___,___,___.

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FORM 2 Project Schedule for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Project Starting Date _____

Estimated Completion Date _____

Total Number of Working Days _____

Specification Section No.	Required Operations	Estimated Number of Working Days Required
2.1	Broadcast fertilizing	_____
2.2	Spiketooth harrowing	_____
2.3	Broadcast seeding	_____
2.4	Rolling with a Cambridge disk	_____

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FORM 3 Equipment and Implements to be Used for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Description	Type, Size, Etc.	Number	Estimated Cost Per Hour

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FORM 4 Laborers and Equipment Operators to be Used for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Required Operations	Job Category	Number	Estimated Cost Per Hour
Broadcast fertilizing:			
	Laborers	_____	_____
	Equipment Operators	_____	_____
	_____	_____	_____
	_____	_____	_____
Spiketooth harrowing:			
	Laborers	_____	_____
	Equipment Operators	_____	_____
	_____	_____	_____
	_____	_____	_____
Broadcast seeding:			
	Laborers	_____	_____
	Equipment Operators	_____	_____
	_____	_____	_____
	_____	_____	_____
Rolling with a Cambridge Disk:			
	Laborers	_____	_____
	Equipment Operators	_____	_____
	_____	_____	_____
	_____	_____	_____
Other labor Required:			
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____

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FORM 5 Fertilizer Information for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Type of Fertilizer	Analysis	Cost per kilogram
Blended fertilizer:		
	____ % N ____ % P_2O_5 ____ % K_2O	_____
_____	OR _____	
Individual plant nutrients:		
	____ % N	_____
	____ % P_2O_5	_____
	____ % K_2O	_____

AND:

Description of the method for calculating required kg per ha:

_____
_____
_____
_____
_____
_____
_____
_____
_____

AND:

Description of the method used to adjust the equipment to ensure application of the fertilizer at the required rate.

_____
_____
_____
_____
_____
_____
_____
_____

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FORM 6 Seed Mixture Requirements for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Scientific Name	Cost per kg	kg per ha	Cost per ha
Achillea millifolium	_____	2.0	_____
Agrostis alba/gigantea	_____	2.0	_____
Agrostis stolonifera	_____	2.0	_____
Dactylis glomerata	_____	5.0	_____
Deschampsia caespitosa	_____	5.0	_____
Eragrostis abessinica	_____	1.0	_____
Festuca arundinacea	_____	10.0	_____
Festuca ovina	_____	2.0	_____
Festuca rubra var. rubra	_____	5.0	_____
Lolium perenne	_____	20.0	_____
Phalaris arundinacea	_____	6.0	_____
Lotus corniculatus	_____	15.0	_____
Spartium scoparium	_____	5.0	_____
Trifolium repens	_____	10.0	_____
TOTAL	XXXXX	90.0	_____

Description of the method used to adjust the equipment to ensure application of the seed mixture at the required rate.

_____

_____

_____

_____

_____

_____

_____

_____

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FORM 7 Other Costs for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Description	Estimated Cost
Mobilization of equipment	
Demobilization of equipment	
Storage of fertilizer	
Storage of seed mixture	
Transport of fertilizer	
Transport of seed mixture	
Site cleanup	
Value-added taxes payable to the German Government*	

*Required for bid to be awarded.

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FORM 8 Work History of bidder for the Freihölser Forst - Rehabilitation of a Local Training Area - Phase II Project

Company Name _____ Telephone _____

Name and location of rehabilitation project: _____

Total area included in the rehabilitation project (ha): _____

Type of operation involved in the rehabilitation project (fertilization, type of seedbed preparation, type of seeding, mulching, and other operation):

_____
_____
_____
_____
_____
_____

Individual to Contact: _____ Telephone _____

****

Name and Location of Rehabilitation Project: _____

Total Area Included in the Rehabilitation Project (ha): _____

Type of operation involved in the rehabilitation project (fertilization, type of seedbed preparation, type of seeding, mulching, and other operation):

_____
_____
_____
_____
_____
_____
_____

Individual to Contact: _____ Telephone _____

If necessary, duplicate Form 8 to provide additional WORK HISTORY.

END

DATE FILMED

3 / 19 / 93