CHAPTER II

FIELD OBSERVATIONS

Field experiments were conducted to determine the potential of various measures for long-term amelioration of excessive compaction of prime farmland soil during reconstruction. The specific objectives of the field study were:

1. To determine the comparative effects of different species of vegetation, planted immediately following reconstruction, on amelioration of excessive subsoil compaction.
2. To determine the effect of deep tillage or ripping on reduction of subsoil bulk density.
3. To determine the effect of placement method on initial subsoil bulk density and on changes in bulk density over time.

Experimental Methods

Experimental plots were reconstructed using prime farmland soils at the River Queen and the Gibraltar surface mines of the Peabody Coal Company in northern Muhlenberg County, Kentucky.

River Queen Plots. A Sadler (Glossic, Fragiudalf, fine-silty, mixed, mesic) silt loam soil was reconstructed at the River Queen site using scrapers and dozers. A mixed fine-silty subsoil (B horizon) material was deposited over graded spoil to an approximate depth of 800 mm (32 in.) in successive layers deposited by scrapers. Approximately 200 mm (8 in.) of low organic matter silt loam topsoil (A horizon) material was then deposited by scrapers and graded by wide-track dozers to minimize ground contact pressure.

A rectangular area 91 m x 145 m (300 ft x 475 ft) of reconstructed soil was established at the site (see Fig. 3a). The area was divided into 16 plots, 7.6 m (25 ft) wide oriented N-S, separated by 1.5 m (5 ft) horizontal strips. Initial deep tillage treatments were then applied using a Rome ripper with parabolic shanks spaced 1.2 m (4 ft) apart to an approximate depth of 610 mm (24 in.). Soil was ripped following reconstruction at three levels of moisture content: dry, 1/2 field capacity and field capacity, with a non-ripped control. Each set of ripping treatments was replicated four times.

Various species of vegetation were superimposed on these experimental plots by subdividing the area in the E-W direction. Parallel strips or plots were established as follows from north to south (see Fig. 3a): 15.2 m (50 ft), local black locust; 15.2 m (50 ft), alfalfa (Vernal variety); 9.1 m (30 ft), KY 31 tall fescue; 21.3 m (70 ft), no-till soybeans; 9.1 m (30 ft), KY 31 tall fescue; and 21.3 m (70 ft), no-till corn.

During 1985 the corn and soybean plots were disked and planted and two-thirds of each plot was ripped in the E-W direction. In 1986, the plots were disked and planted, then 1/3 of each plot was again ripped in the E-W direction. The plots planted in black locust, alfalfa and fescue were mowed in 1985 and 1986. In 1987, the black locust plot was disked to a depth of 150 mm (6 in.) and the alfalfa and tall fescue plots were treated with herbicide. Subareas of each plot were again ripped and the entire area was planted to no-till corn. During 1988-90 the area was planted in no-till corn,

conventional corn and grain sorghum, respectively, with no additional ripping. Additional details concerning the experimentation associated with these plots is given by Powell et al. (1985).

Cylindrical soil cores (50 mm (2 in.) dia., 150 mm (6 in.) long) were collected from each ripping x crop plot area immediately after soil reconstruction (prior to any planting or ripping) in early 1984 using a Giddings hydraulic sampler. Initial bulk density was thus determined for each 150 mm (6 in.) layer of reconstructed soil. Additional core samples were collected in 1985 and 1986 in the corn plots and in 1987 in the alfalfa plots. In 1988 volumetric cores were collected and bulk density was also determined using a gamma ray attenuation gauge. The plots sampled in 1988 were: corn, never ripped; corn, initially ripped dry (N-S), cross-ripped (E-W) in 1985, 86 and 87; alfalfa, never ripped; and, black locust, never ripped. The corn and alfalfa plots were again sampled or measured in the fall of 1990 using a dual probe gamma density gauge.

Gibraltar Plots. Two prime farmland soils were reconstructed at the Gibraltar mine site. In addition to the previously-described Sadler soil, a Belknap (Aeric, Flavaquent, coarse-silty, mixed, acid, mesic) silt loam soil was reconstructed at this site. Table IA shows the horizon designations and depths for these two soils.

Two methods were used to reconstruct the soils in the fall of 1982. Eight parallel strips, 21.3 m x 97.5 m (70 ft x 320 ft) were deposited of each soil using two types of equipment handling and using both direct placement and stockpiling (see Fig. 3b). In the conventional method, 18.3 m^3 (24 cu. yd.) scrapers were used to deposit subsoil in successive layers or lifts of approximately 400 mm as needed. Grading was accomplished by dozers equipped with wide tread to reduce contact pressure. Approximately 200 mm (8 in.) of topsoil was deposited via scrapers and graded.

The other method involved the use of 32 m^3 (35 yd^3) end-dump trucks. The trucks deposited subsoil by horizon without driving on the plots. Grading of each horizon was done using wide track dozers. Topsoil was placed in identical fashion with final grading by dozers.

In the spring of 1983, alfalfa was planted at both ends of the area in 12.2 m (40 ft) strips, perpendicular to the main treatment plots. In the center, 12-row strips of corn and soybeans were alternated giving four replications. In the fall of 1984, one half of each main treatment strip was ripped to a depth of 610 mm (24 in.) in the areas planted in corn and soybeans. Only corn was planted in the interior subplots in 1984 and 1985. In 1986, the entire area was planted in corn, including the end strips which had been in alfalfa for 4 years. During 1987-90, the entire area was planted in corn, soybean, wheat and wheat, respectively. Additional details concerning the experiment plot design at this is given by Barnhisel et al. (1986).

A Giddings hydraulic sampler was used to extract volumetric bulk density cores from each of the soils prior to disturbance. Four replicated samples of 50.8 mm (2 in.) dia. x 152 mm (6 in.) cores were collected at depths of 0-152, 152-305, 457-610, and 762-914 mm (0-6, 6-12, 18-24 and 30-36 in.). Following construction of the plots, four replicated core samples were collected from each treatment strip at 152 mm (6 in.) depth increments to a depth of 914 mm (36 in.).

A dual probe gamma density gauge was also used to measure in situ soil bulk density. In 1989, four replicated measurements were made in interior zone of the following treatment strips for both soil types: a) direct scraper placement, never ripped; and, b) direct truck placement, never ripped. The measurement depths were 203 mm (8 in.), 508 mm (20 in.) and 610 mm (24 in.). In 1990, gamma density measurements were replicated 4 times for both soil types in the following treatment strips: a) direct scraper placement, never ripped; b) direct scraper placement, ripped; c)

direct truck placement, never ripped; and, d) direct truck placement, ripped. Measurements were made at 51 mm (2 in.) depth increments to a depth of 914 mm (36 in.).

Soil moisture content was determined at each bulk density sampling location. When volumetric cores were used to determine soil bulk density (prior to 1989), soil moisture content was determined gravimetrically. In 1989, small samples were collected during the drilling of vertical access holes for the gamma density gauge. In 1990, soil moisture content was determined using a gauge which measured neutron scattering. This method has been shown reliable for measurement, below a depth of approximately 100 mm (Black et al., 1965).

Results and Discussion

River Queen Plots. Figures 3c and 3d present the results of the various determinations of soil bulk density versus depth at this site. Dry bulk density is plotted versus depth for each major treatment examined. Thus, each plot represents the mean of four replicated measurements.

Comparison of bulk density versus depth profiles immediately after reconstruction indicates substantial compaction of subsoils when compared to this soil in its pre-disturbed state. Subsoil bulk density for the natural Sadler soil increase from approximately 1.43 Mg/m^3 at z = 230 mm (9 in.) to 1.63 Mg/m^3 at z = 838 mm (33 in.) (Powell et al., 1985). Subsoil bulk density following reconstruction was approximately 1.8 Mg\m^3 for all plots below the depth of 380 mm (15 in.), except for the non-ripped plots planted in corn, which was approximately 1.7 Mg/m^3.

The corn plots which were never ripped exhibited gradual increase in subsoil density from reconstruction until 1988, followed by a notable decrease between 1988 and 1990. Only in 1988 was subsoil density as high as that in the corn plots which received the most ripping. In these plots, the clear effect of the ripping treatments, as well as other factors operating over time, was to substantially decrease bulk density in the upper subsoil (400-600 mm), while having less effect on the deep subsoil (> 700 mm).

The alfalfa (non-ripped) plots exhibited a slight reduction in subsoil bulk density (500-700 mm) between soil reconstruction and 1988. In the upper subsoil (200-400 mm), bulk density tended to increase over time. On the other hand, the black locust (non-ripped) plots exhibited little change in upper subsoil bulk density, while indicating a modest increase in lower subsoil density.

Comparing the profiles among all plots in 1988 would indicate that ripping resulted in a clear reduction in upper subsoil bulk density, while perhaps increasing density of the lower subsoil (below depth of ripping).

Gibraltar Plots. Figures 3e and 3f present the results of the various bulk density versus depth profiles measured at this site. The bulk density immediately after reconstruction was substantially greater than in the pre-mined state at all depths for both soil types and placement methods. Further, there is no clear indication, in either soil type, that placement method significantly affected bulk density immediately after reconstruction. This was somewhat surprising since only dozer traffic was applied to the plots constructed by truck placement. The results would indicate that for these soils and the conditions which prevailed at the time of placement, dozer traffic compacted subsoil as much as scraper/dozer traffic.

Bulk density measurements taken in 1988 in non-ripped plots indicate that subsoil bulk density increased for $z \geq 500$ mm (20 in.) and decreased for z > 500 mm. The exception to this was

the truck-placed Belknap soil, where subsoil bulk density decreased at all depths, compared with the initial (1984) profile.

The 1990 measurements present contrasting behavior in the two soil types. In the Sadler soil, subsoil bulk density apparently decreased relative to the 1983 and 1989 measurements in both ripped and non-ripped plots. In the Belknap soil, however, subsoil density increased in the non-ripped plots compared to earlier measurements.

Table 1B presents a comparison of mean bulk densities measured in 1990 for the various experimental treatments, i.e. placement method and ripping, using Duncan's New Multiple Range Test (SAS, 1986). In the Sadler soil, ripping resulted in significantly lower bulk density (5% level) at the 610-762 mm (24-30 in.) depth in the truck-placed plots, whereas there was no significant reduction at any depth in scraper-placed plots. In the Belknap soil, ripping produced significantly lower bulk density within all subsoil depths except 610-762 mm (24-30 in.) in the truck-placed plots, while reducing density only in the upper subsoil (305-610 mm (6-18 in.)) in scraper-placed plots. Significantly lower bulk density for truck placement was indicated only in the Belknap soil at the 762-914 mm (30-36 in.) depth in plots which were ripped.

Table 1A. Horizon designation and depths of Sadler and Belknap soils (from Barnhisel et al., 1986)

Soil Series	Horizon	Depth from Surface (mm)
Sadler	Ap	0-180
Sadler	B2t, A'2	180-640
Sadler	Bx (fragipan)	640-1000
Belknap	Ap	0-200
Belknap	B21, B22g, B23g	200-900

Table 1B. The Effect of Placement Method and Deep Tillage on Subsoil Bulk Densities of Two Reconstructed Prime Farmland Soils by Duncan's New Multiple Range Test

Sadler Silt Loam

Depth (mm)	Truck Placement Not Ripped	Truck Placement Ripped (610 mm)	Scraper Placement Not Ripped	Scraper Placement Ripped (610 mm)
305-457	1.56[a]	1.45[a]	1.56[a]	1.55[a]
457-610	1.57[a]	1.49[a]	1.55[a]	1.54[a]
610-762	1.63[a]	1.49[a]	1.55[ab]	1.52[ab]
762-914	--	1.55[a]	1.56[a]	1.57[a]

Belknap Silt Loam

Depth (mm)	Truck Placement Not Ripped	Truck Placement Ripped (610 mm)	Scraper Placement Not Ripped	Scraper Placement Ripped (610 mm)
305-457	1.72[a]	1.55[b]	1.72[a]	1.59[b]
457-610	1.72[ab]	1.56[c]	1.78[a]	1.63[bc]
610-762	1.68[ab]	1.63[b]	1.76[a]	1.72[ab]
762-914	1.77[a]	1.63[b]	1.83[a]	1.79[a]

*At a given depth, mean bulk densities designated by the same letter are not different at the 5% level of significance.

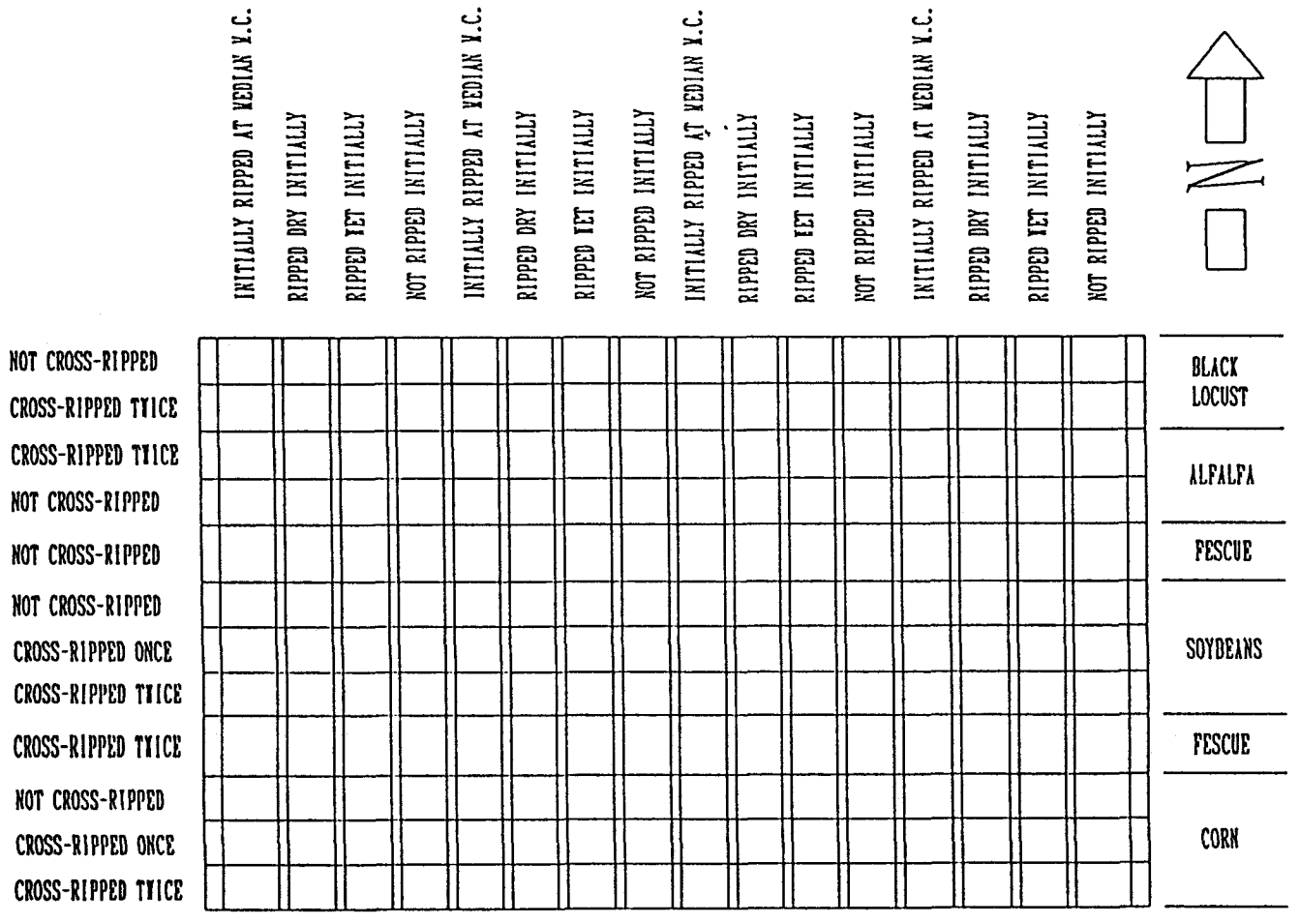


Figure 3a. Diagram of Experimental Reconstructed Prime Farmland (Sadler Silt Loam) Soil at River Queen Mine Showing Vegetative and Ripping Treatments.

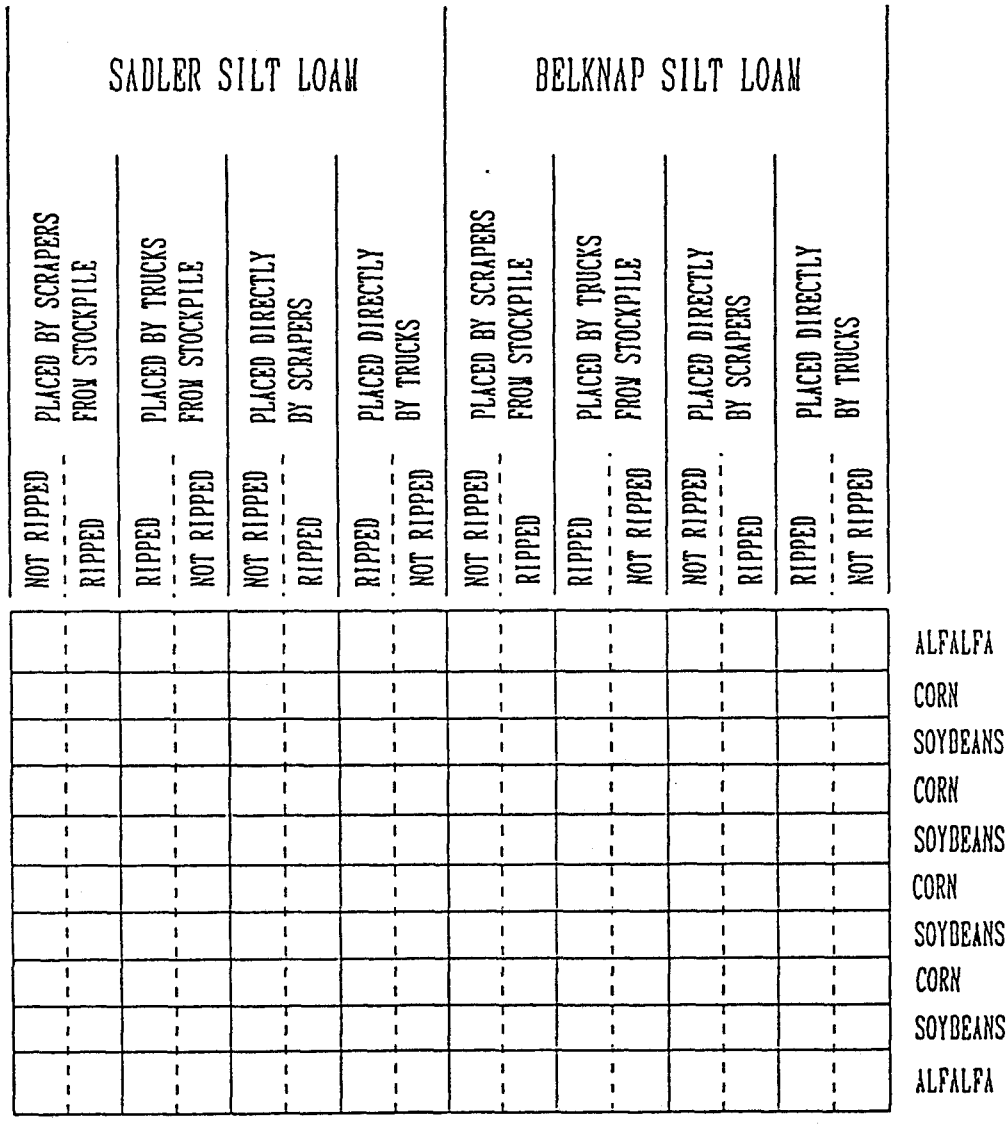
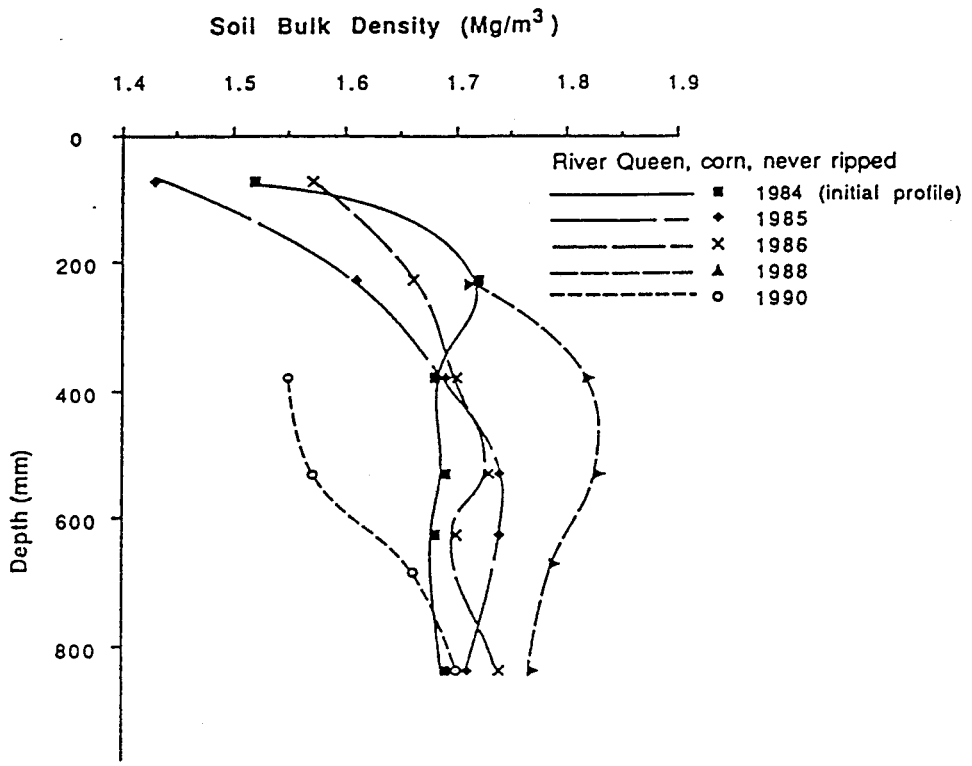


Figure 3b Diagram of Experimental Reconstructed Prime Farmland (Sadler and Belknap Silt Loam) Soils at the Gibraltar Mine Showing Placement and Ripping Treatments.



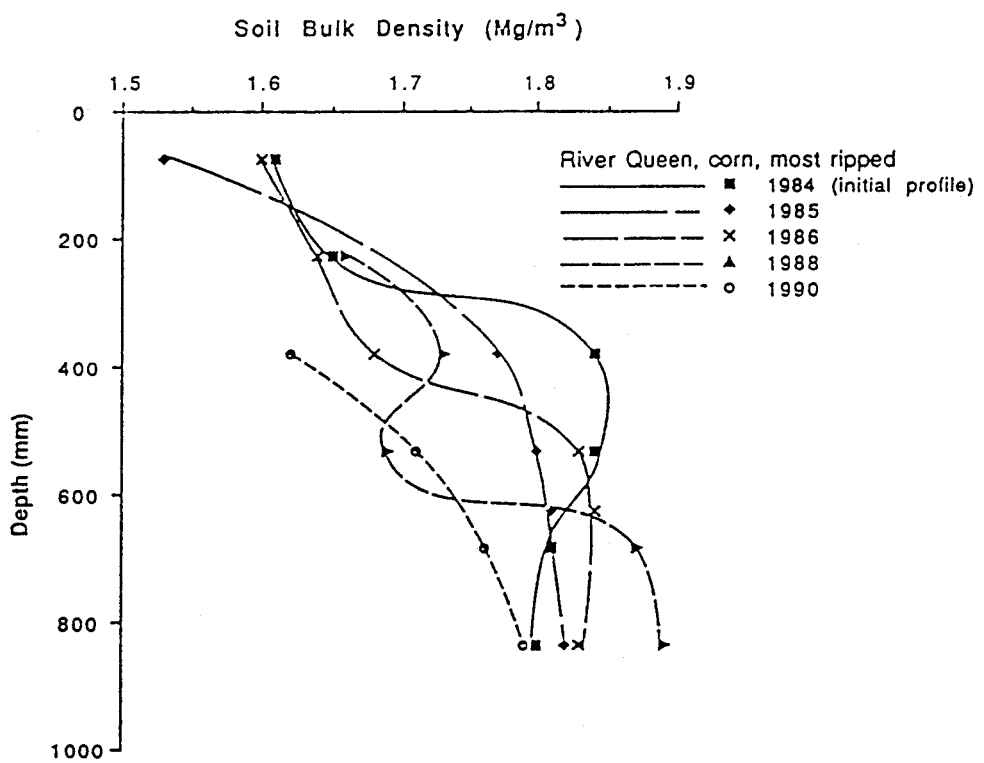
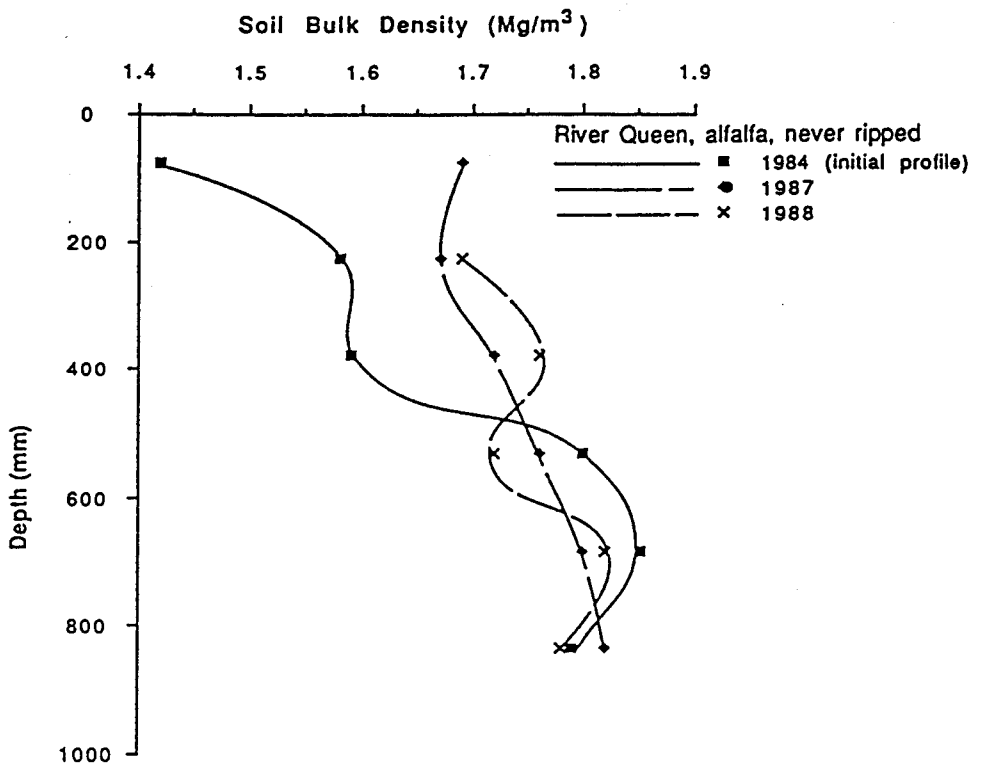


Figure 3c. Soil bulk density profiles at various times in experimental plots, initially planted in corn, at the River Queen mine.



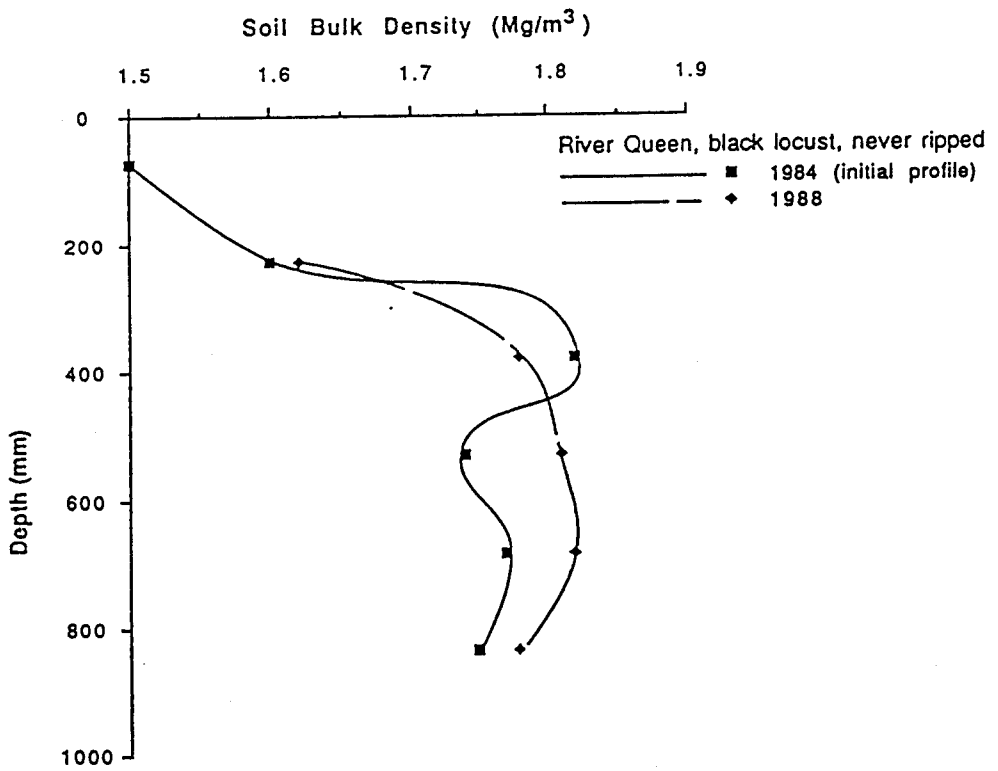
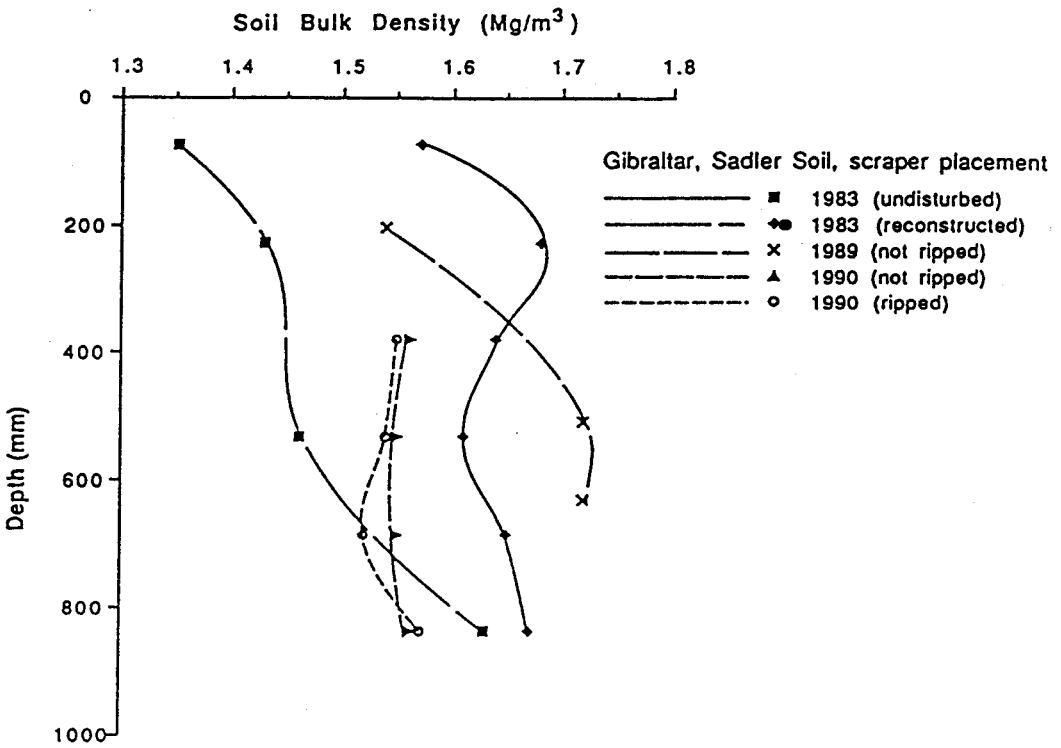


Figure 3d. Soil bulk density profiles at various times in experimental plots, initially planted in alfalfa and black locust, at the River Queen mine.



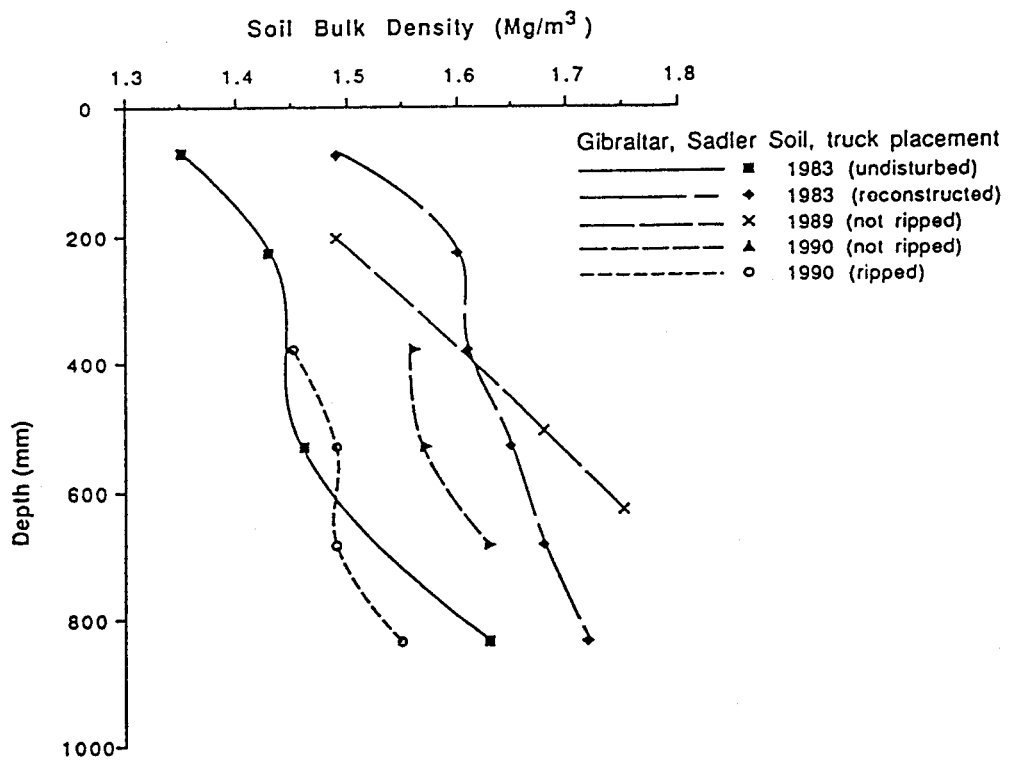
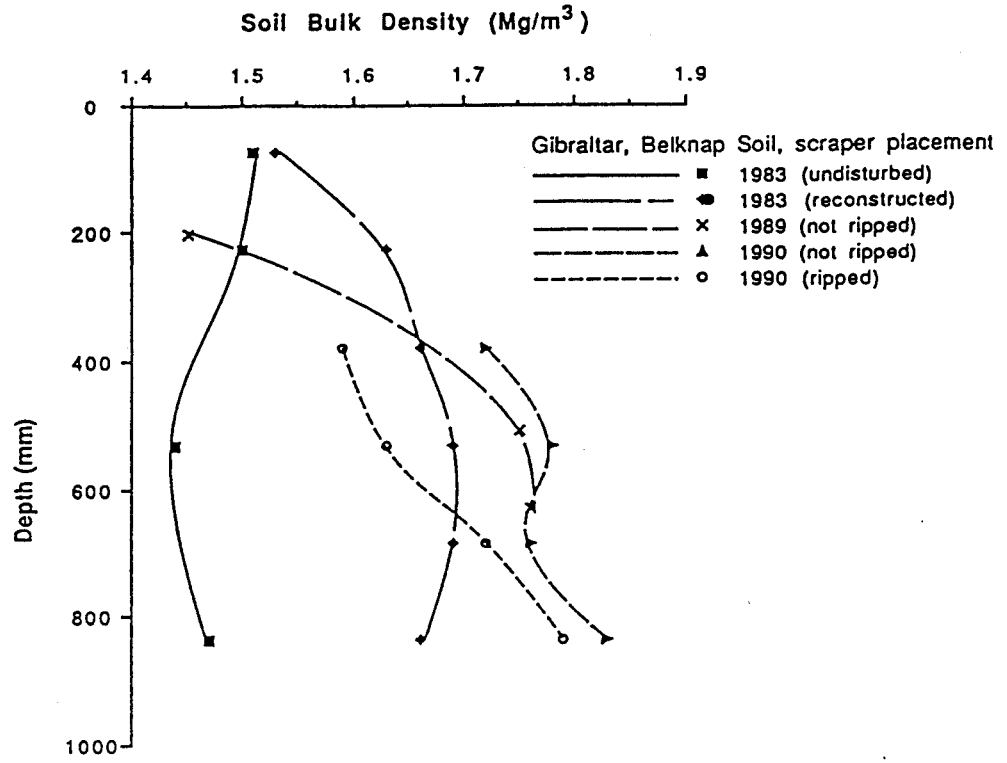


Figure 3e. Soil bulk density profiles at various times in experimental plots, reconstructed by two methods, in Sadler silt loam soil at the Gibraltar mine.



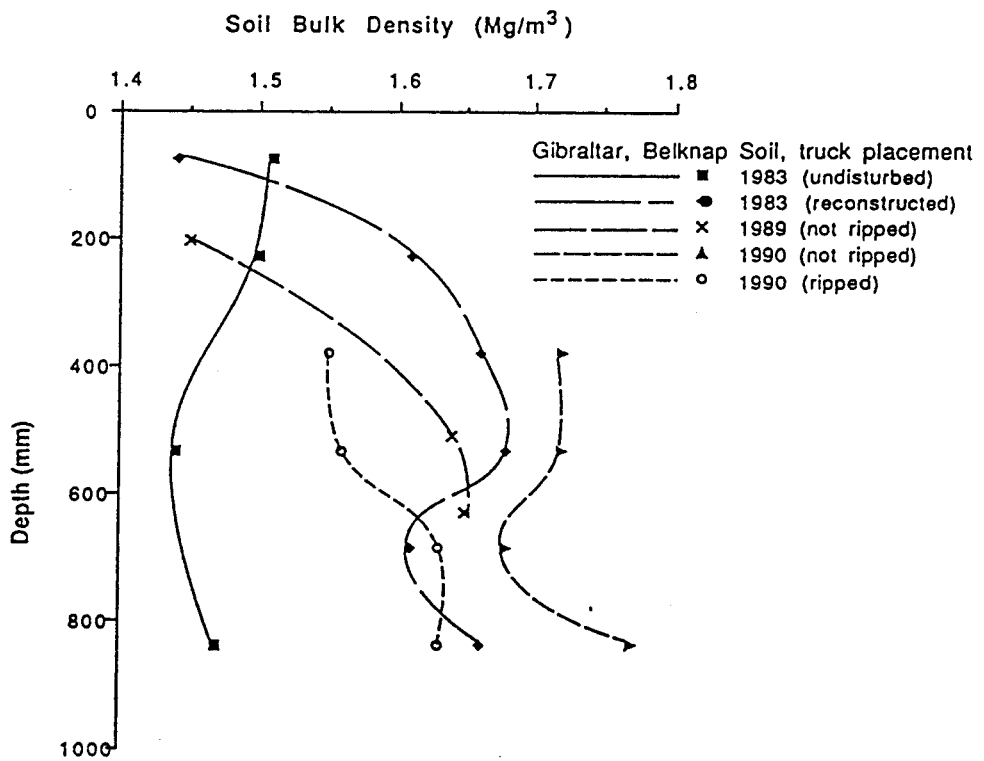


Figure 3f. Soil bulk density profiles at various times in experimental plots, reconstructed by two methods, in Belknap silt loam soil at the Gibraltar mine.