Using cover crops to reduce soil compaction

1. **What factors contribute most to soil compaction**?

Soil compaction is caused by excess weight and poor soil structure. A lot of soil compaction is actually poor soil structure due to excessive tillage. Tillage disrupts the macro-aggregates which give us good soil structure, releasing carbon and nutrients. The glues that form the macro-aggregates comes from plant roots and microbial waste or byproducts. Bacteria wastes are important for cementing soil particles into microaggregates while fungus are important for producing glomalin that cement macro-aggregates together. Both are important however, their needs to be a balance of bacteria and fungus in the soil. tillage promote bacteria populations over fungal populations, reducing glomalin production. These glues in the soil have two major functions, they promote good soil aggregation and they serve as a source of food for the microbes. When you till the soil, farmers increase the oxygen content of the soil, increasing the microbial population level (especially the bacteria) which then are hungry and they consume these glues as a food source. We end up with more micro-aggregates and bacteria in the soil and the soil tends to set up like a brick wall. Farmer who excessively till their soil (get it too fine) often find that after a rain, the soil sets up like concrete because the soil becomes so dense.

2. **What are the effects, or symptoms, of soil compaction**?

The soil becomes dense and water infiltration is greatly reduced. The pore space in the soil is decreased with soil compaction and poor soil structure leading to less movement of air and water in the soil profile. Soil compaction and poor soil structure creates problems with standing water, soil erosion from the surface due to increased surface runoff and a loss of nutrients. Denitrification increases as soils become saturated with water due to a lack of oxygen. Plants tend to turn yellow and grow less vigorously and become stunted when N is limited. Plant root soil penetration become limiting when the bulk density reaches 1.6 g/cm3 and totally restricted when bulk density reaches 1.8 g/cm3. With less vigorous root systems, plant roots are shallow rooted and tend to lodge. Shallow rooted plants tend to have difficulty surviving any type of extreme weather events (drought, wind, excessive moisture) and decreased crop yields (0-30% reduction).

3. **Why take a biological approach rather than a mechanical approach to dealing with compaction?**

Mechanical solutions are short-lived lasting one year and actually contribute to soil compaction and poor soil structure in the long-run. Plant roots and a healthy soil microbial population (especially fungus which contribute glomalin) create the glues to form the macro-aggregates. Macro-aggregates are constantly forming, breaking down, and then reforming in the soil. The glues are a source of food, so they have to be continually restocked in the soil. When we keep a soil barren of plants for 8-9 months out of the year, there are less glues produced by the roots and the microbial population tends to be dominated by bacteria which typically consume these glues. The biological approach may be a slower process (2-3 years) to dealing with soil compaction, but it is more long lasting and beneficial in the long-term because the macro-aggregates are a major storehouse for soil carbon and soil nutrients which promotes soil productivity. The soil residue on the surface also acts like a cushion and keep the soil carbon in the soil profile when these macroaggregates naturally decompose or are broken down. Soil residue on the soil surface is as important as a roof on a house or barn to keep the soil pore space open for air and water movement within that soil profile.

4. **What are the key biological steps to take to address the issue? What does each of these contribute to the restoration of soil health?**

The first biological step is to limit or totally reduce tillage. Tillage destroys soil structure and does not allow plants to grow. It also totally disrupts the microbial population and tends to promote bacteria populations over fungus. Second, plant cover crops after each crop every year to maximize organic matter accumulation. What is missing in most of our soils is the active organic matter that comes from the roots and the microbial wastes. This active carbon in the soil keeps our microbial populations healthy but they

are also form some of the glues that hold together and promote macro-aggregates formation. Keeping a soil covered with live plants promotes good soil structure because we have live roots living year round which supports a balanced and healthy microbial population. We need a microbial mixture that has a healthy balance of bacteria and fungus in the soil profile. Third, plant a mixture of legumes, grasses and brassica cover crops. Grass roots tend to be fibrous and supply carbon and phosphorous. Legume roots tend to have a deeper tap root and supply nitrogen to balance the C:N ratio. Brassica's tend to reduce weeds and greatly promote beneficial microbial populations. Fourth, keep your soil surface covered with a thick layer of crop residue. The crop residue on the soil surface is important for acting like a cushion to reduce the soil compacting weight of the wheel and implement traffic. The residue is also important for reducing soil erosion, improving water infiltration, and for regulating oxygen and carbon levels in the soil. If you remove the residue, it is like removing the roof on your house or barn. The house or barn will soon rot out and collapse just like our soils tend to break down and collapse when we do tillage.