The Application of Terrestrial Ecosystem Ecology Concepts to Management Strategies of Farmers in Southeastern Ontario

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Introduction

According to a recent report by Oliver De Schutter (2012), "Canada has been moving to large-scale, input-intensive modes of production, leading to increasingly unsustainable farming practices". Sustainable agricultural strategies include diversifying species to internally manage pests, integrating crops and livestock, and maintaining natural resources to rely on minimal artificial inputs (De Schutter 2011). Terrestrial ecosystem ecology is a recently developed branch of biology that offers fundamental insights towards developing more sustainable agricultural practices by the farmers we met on this course. Three of these significant ecological concepts include ecosystem stability in relation to crop diversity, trophic cascade effects on plants and livestock, and changes in carbon and nitrogen cycling with trees. The application of these concepts to the farmer's management strategies will allow them to achieve a "triple win", by increasing productivity, food security, and natural resource sustainability.

Ecosystem Stability through Crop Diversity

A central theme to terrestrial ecosystem ecology is the study of increased biodiversity to enhance ecosystem stability. In farming, the sampling effect suggests that systems with greater crop diversity are more likely to have at least one crop that possesses a specific trait resistant to a particular disturbance, such as drought. In addition, the niche complementarity theory suggests that greater species diversity leads to more complete use of resources and deters pests and diseases. Furthermore, the multi-national BIODEPTH project (2001) found that greater numbers of crop species significantly increased plant growth and harvest yield (Minns et al., 2001). One important application of increased crop diversity is the practice of intercropping, which involves the production of more than one crop in adjacent strips. Titia already utilizes intercropping in her garden to improve crop resilience to drought, improve natural pest management, and attain greater yield stability. Each crop she plants has an added benefit to the overall functioning of the ecosystem. For example, the Jerusalem artichoke acts as both a carbon producer and develops a fungal community that increases soil fertility for the surrounding crops. For Charlie, replacing large fields of monocultures with high diversity intercropping systems would reduce the need for expensive pesticide. Overall, increased crop biodiversity through intercropping will improve resilience to disturbances and maintain overall ecosystem stability.

Trophic Interactions: Crops and Livestock

In addition, understanding trophic interactions between livestock and crops is essential to developing sustainable agricultural practices. An example of a trophic cascade is when the extermination of large predators by humans enhances the abundance of lower herbivores, leading to overgrazing on crop fields. However, a recent paper by Allan Savory (2013) suggests that using high concentrations of livestock over brief periods of time to mimic natural migration patterns will not lead to overgrazing, but will instead break soil surfaces, compact soil to ensure seed germination, and increase cycling of plant material through dung and grazing. Savory (2013) also addresses the importance of considering trophic cascade effects in planned grazing systems, because the presence of major predators to livestock is essential to keeping wildlife moving. This planned grazing strategy could be applied to farmers such as Titia who already utilize livestock on their farms. For example, using her goats to break the soil crust of relatively unproductive areas would allow greater absorption of water and improve aeration, leading to enhanced soil quality. Overall, increasing trophic interactions between crops and livestock can improve soil fertility of relatively unproductive lands.

Nutrient Cycling with Trees

Lastly, the integration of trees in agricultural systems has a positive impact on nutrient cycling. Agroforestry with nitrogen fixing trees is one strategy to increasing nitrogen and carbon content in the soil while also reducing external artificial inputs (Rosenstock et al., 2014). The nitrogen fixing bacteria on the root nodules of these trees convert free nitrogen into ammonia, which is then integrated into tree tissues, and eventually decomposed to readily available forms. In addition, trees also accumulate large amounts of carbon in their biomass, and are able to store carbon deeper in the soil profile, due to their deep roots. Although Titia has already has carefully chosen the location of her garden based on the proximity to surrounding trees, she could also implement this strategy in other areas of her land that are less productive. Evan could also plant trees in close proximity to his crop fields to improve nutrient cycling, which would reduce the need for him to produce compost piles that take significant amounts of time and labor to develop. Finally, in addition to the production of specialized "pellets" from wood chips, Charlie could also use intercropping with trees to further enhance soil carbon content. This system allows the trees to be cut back to ground level periodically, so these tree products could contribute to the production of his wood pellets. Overall, the integration of trees into cropping systems is essential to improving carbon and nitrogen cycling in the soil.

Implications and Limitations

In conclusion, terrestrial ecosystem ecology offers significant fundamental insights towards developing more sustainable agricultural practices by the farmers we have met on this course, including increased crop diversity to enhance ecosystem stability, trophic cascades in crops and livestock, and the integration of trees to improve carbon and nitrogen cycling. However, there are a few limitations. For one, intercropping to improve species diversity can be harder to manage on larger areas than conventional agricultural practices that use efficient machines. Furthermore, there is a time constraint to planned grazing that largely impacts whether the system will be successful or not. Finally, the initial labor costs associated with tree planting and pruning maintenance are high, and there are not generally immediate rewards to these strategies. Further research on how to cost effectively increase crop diversity for larger farms, as well as on the duration required for successful planned grazing in Canadian farming systems would increase the implementation of these strategies.

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