Precision conservation in North America

SPECIAL SECTION INTRODUCTION

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Population growth and increasing demands on water resources make effective soil and water conservation essential to sustaining agricultural production and environmental quality. Berry et al. (2003) defined *precision conservation* as a set of spatial technologies and procedures to implement conservation management practices that integrates spatial and temporal variability across natural and agricultural systems. This definition integrates spatial technologies including global positioning systems, remote sensing, geographic information systems, and the capability to analyze and map these spatial relationships. Precision conservation is broader than precision agriculture since precision conservation contributes to soil and water conservation in agricultural and natural ecosystems. Berry et al. (2003; 2005) reported that precision agriculture focuses on maximizing yields, while precision conservation focuses on interconnected cycles and flows of energy, materials, chemicals, and water to reduce environmental impacts, off-site transport, and water pollution, while integrating practices that maximize conservation and productivity. The Berry et al. (2003) publication generated enough interest that the Soil Science Society of America, Canadian Soil Science Society, Mexican Soil Science Society and the Division of Soil Water and Management and Conservation organized and held a joint symposium titled "Precision Conservation in North America" at the November 1-4, 2004 annual meeting of the Agronomy Society of America in Seattle, Washington.

Sixteen presentations from that symposium are published in the special section. Together, they demonstrate a wide range of specific conservation issues that precision conservation can address as well as a variety of methods and approaches that can be employed. Founded on these successes, the purpose of this special section is to spur further development and adoption of these promising new technologies and promote the dual benefits of sustainable agricultural production and environmental health.

The papers in this issue address the integration of spatial and temporal variability across natural and agricultural systems and their spatial links from field to watershed scale or regional context. The papers also address the fundamental concepts of precision conservation and how it can be applied to soil and water management systems. This technology-based management approach can be applied to reduce nitrate leaching, increase carbon sequestration, reduce trace gas emissions that can impact the biosphere, and develop management plans that are site specific. Also discussed are the theories underlying the concepts of spatial patterns of erosion, the effect of spatial erosion patterns on yield productivity, and how management practices can be more effective across the landscape to reduce these spatial erosion patterns while maintaining yield productivity. These papers present several techniques that can be used to identify spatial patterns of erosion for use in precision conservation (Schumacher et al., 2005; Mueller et al., 2005).

Precision conservation links site specific field management to off-site environmental management, by accounting for spatial hydrologic characteristics to reduce flows and off-site transport. This concept integrates the hydrologic surface patterns which control flows from the field with the off-site patterns, allowing for a better buffer design to reduce off-site transport (Dosskey et al., 2005). Berry et al. (2005) showed an example of using a buffer map that constricts and expands as a function of the intervening conditions using erosion potential and distance from a stream.

There is potential to identify high risk areas in the landscape so that management can be tailored to target those locations. We can implement conservation practices, considering spatial patterns across the landscape to reduce field erosion and to maximize and sustain yields (Papiernik et al., 2005; Terra et al., 2005; Balkcom et al., 2005). Precision conservation can also help to develop conservation management plans that accounts for patterns of elements such as carbon and nitrogen to maximize their management for environmental benefits and positive impacts to our biosphere.

Precision conservation considers patterns across the landscape to increase carbon sequestration at landscape positions that may have a higher sink capacity (Pennock, 2005; Clay et al., 2005). Pennock (2005) reported that by applying precision conservation techniques, conservation managers and agronomists can develop management plans that target areas of higher carbon sequestration potential on the Canadian prairies. He also reported that these techniques can also be used for nitrogen (N) management to increase N use efficiency in the areas of higher nitrous oxide (N_2O) emissions, contributing to a spatial conservation management plans that increase the reduction of greenhouse gasses from the Canadian prairies. Goddard (2005) also noted the need to integrate landscape positions to implement precision conservation practices. He reported that computer models can be used to assess the impacts of precision-designed conservation practices on the landscape.

We can develop precision conservation plans using the spatial information collected across the field (Kitchen et al., 2005; Lerch et al., 2005). Delgado et al. (2005) reported that site specific management zones (SSMZ) characterize the variability of factors that affect NO_3-N leaching, and that N management based on SSMZ produces less NO_3-N leaching than uniform strategies, while maintaining maximum yield. Delgado and Bausch (2005) also reported that by using precision

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conservation techniques, N use efficiency can be increased by almost fifty percent while sustaining yields and reducing NO_3-N leaching by 47 percent. They reported that productivity zones delineated using precision agriculture technologies identify areas within corn production fields that differ in residual soil NO_3-N and NO_3-N leaching potential. Sadler et al. (2005) reported that we can use precision conservation to save up to 50 percent in applied water, or average between eight to 20 percent savings in water depending on the region.

Taken together, these papers illustrate that the concept of precision conservation can be used at the field scale in irrigated and non-irrigated systems to: 1) increase nutrient use efficiencies; 2) reduce trace gas emissions; 3) increase carbon sequestration; and 4) reduce soil erosion and off site transport across the watershed. Precision conservation may enable us to increase soil and water conservation while maintaining maximum yields. It was also suggested that we can use models to evaluate site specific precision conservation practices spatially across the field and their potential to increase carbon sequestration (Goddard, 2005) and to reduce NO_3-N leaching (Delgado et al., 2005). We could also use modeling approaches to evaluate the effects of best management practices across watersheds to precisely identify the hot spots within a watershed to target precision conservation management practices at these locations (Renschler and Lee, 2005).

These reports demonstrate how precision conservation can be used to integrate management practices in space and time and to evaluate how management practices contribute to conservation. These technologies can identify high benefit and risk areas, and help target optimum management practices to specific locations across fields and watersheds. It is clear that advances of the last decade have contributed to the development of the concept of precision conservation. In the next decade, as technologies and models improve, we can expect that the capability to collect, integrate, and use precision information will be even easier and faster. The papers in this section provide examples of advances in the use of spatial tools for conducting precision conservation. These new tools are changing conservation research and management across the land and create a vision for how to sustain agricultural production and to conserve our natural resources into the new century.

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