Implementation of agroforestry on U.S. farmlands can offset predicted increases in soil erosion due to climate change (Walthall et al. 2012). Agricultural tillage exposes soil to erosion by excessive rainfall. Agroforestry practices stabilize and protect soil from erosion. The reduction of erosion will be very large where agroforestry is implemented, but reluctance by many landowners to implement it could severely limit the magnitude of impact at a national scale (fig. B.3).

Figure B.3. Likelihood of occurrence and impact of agroforestry implementation on the predicted increase in soil erosion due to climate change. At the site scale, implementation of agroforestry can offset the predicted increase in soil erosion due to climate change (circle). At a national scale, however, the impact will be low, because most landowners are currently reluctant to implement agroforestry on their farms (triangle). National-scale effectiveness would be higher (arrow) if market conditions and program incentives, among other factors that affect landowner decisions, become more favorable for adoption of agroforestry and the aerial extent of implementation increases.

Soil loss is a major threat to long-term sustainability of agricultural production and other ecosystem services. Erosion by large, high-intensity rainfall events is a major cause of soil loss from cultivated fields (Larson et al. 1997; SWCS 2003, 2006). Climate change is predicted to increase the magnitude and intensity of rainfall events across most of the United States and, in the absence of protective measures, to increase rates of soil erosion (Garbrecht et al. 2014; SWCS 2003, 2006; Walthall et al. 2012).

Implementation of agroforestry practices can reduce soil erosion from cultivated fields and moderate the predicted increases in erosion rates that will come with climate change. The rate of erosion depends on many factors, including precipitation amount and intensity, soil characteristics, topography of the terrain, and land cover characteristics. Climate change is predicted to increase erosion mainly by increasing precipitation intensity. A change in land cover from a completely cultivated condition to an appropriate agroforestry practice can reduce the vulnerability of the soil to erosion and can offset the effects of increased precipitation intensity.

Contour buffers (also called contour stripcropping and buffer stripcropping) (Wischmeier and Smith 1978), in which the protective vegetation cover is placed in a strip configuration on topographic contours, are a recommended practice for reducing soil erosion. They function to reduce the erosive power of overland runoff during large rainfall events and stabilize soil against erosion. Agroforestry in the form of alley cropping can be configured into contour buffers and function like contour buffers.

The potential for erosion reduction by implementing agroforestry can be estimated using concepts and relationships from the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978). In the USLE, soil loss is predicted for a given pattern of precipitation (local amounts, frequencies, and intensities determined from local weather data) on an agricultural field having a standard set of site conditions (soil, topographic, soil cover, and land cover). That soil loss value, called the Rainfall and Erosion Index (R), is adjusted to other site conditions by the amount that those site conditions differ from the standard set. Adjustments are expressed as a ratio of soil loss under actual site conditions compared with that under the standard set. Thus, a site condition that reduces an adjustment factor ratio by, say, 0.25, translates into a reduction of soil loss by 25 percent. Based on the USLE, properly designed contour buffers consisting of fall-planted small grains can reduce the ratio for an otherwise spring-cultivated corn field by about 0.50 (Wischmeier and Smith 1978) and, thus, the erosion rate by about 50 percent. In a field experiment, Udawatta et al. (2011) measured a 28- to 30-percent reduction in annual soil loss over a 5-year period from fields planted with agroforestry contour buffers consisting of perennial grasses and trees.
The impact that alley cropping in a contour buffer configuration can have on climate change-enhanced erosion rates can be estimated by comparing erosion reduction by implementing the agroforestry practice to the magnitude of erosion increase predicted by climate change. The average R (under standard site conditions) for the conterminous United States is estimated to increase between 16 and 58 percent during the 21st century (Nearing 2001, Nearing et al. 2004). Others (e.g., O’Neal et al. 2005, Segura et al. 2014) have predicted similarly large increases in erosion rates. Estimates of future increases in soil erosion are similar in magnitude to the amount by which implementation of alley cropping could reduce soil erosion from a field. On this basis, agroforestry may be capable of completely offsetting any increase in erosion that a future climate would cause (fig. B.3). If combined with additional protective measures, such as no-till, residue management, or cover crops, erosion rates could be reduced still further.

The total mass of eroded soil would be reduced by a greater amount if agroforestry were applied to fields in regions where the increase in soil erosion rate would be relatively greater. Segura et al. (2014) predicted greater increases in the threat of erosion in the Eastern and Northwestern United States and decreases in the Central Great Plains. On this basis, agroforestry for soil erosion control under climate change may provide greater benefit if focused on the northern tier and Eastern U.S. croplands. Uncertainty associated with a regional focus is high, however, because spatial distribution of predicted changes in erosion differs widely, depending on which climate change model is used (Nearing 2001, O’Neal et al. 2005, Segura et al. 2014).

At the national scale, the impact that agroforestry can have may be small—hindered by landowner resistance to adoption and limited extent of sites that are most suitable for alley cropping (fig. B.3). Landowners view agroforestry as more complex than they are willing to deal with. From that perspective, some land is taken out of the cropping system that they are familiar with and put into a system that they do not know as well. This change creates financial risk because they are less familiar with the new crop and it increases complexity because they have to manage for two crops instead of one. Management practices for their traditional crop are made more difficult by having to work around the trees. In combination, agroforestry makes more work for farmers and raises financial risk for the landowner. Incentive programs that offer financial and technical assistance have had very little success in achieving adoption of alley cropping. Furthermore, the magnitude of impact at the national scale will be limited by the aerial extent of implementation. For national-scale estimations of agroforestry impacts, Udawatta and Jose (2012) used a value of 10 percent of U.S. cropland. That would leave 90 percent of U.S. croplands requiring other protective measures to counter soil erosion due to climate change.

Literature Cited


