AGROFORESTRY AND GRASS BUFFER INFLUENCES ON MICROCLIMATE

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Introduction:

Agroforestry practices have been considered to be more environmentally friendlier than row-crop agriculture due to improvements in soil and water quality. Research shows that agroforestry and grass buffers on corn-soybean watersheds reduce non point source pollution in runoff and improve soil properties (Udawatta et al., 2002; Seobi et al., 2005; Udawatta et al., 2006). These improvements have been attributed to organic matter addition, roots of the permanent vegetation, nutrient uptake, water use, and changes in soil parameters.

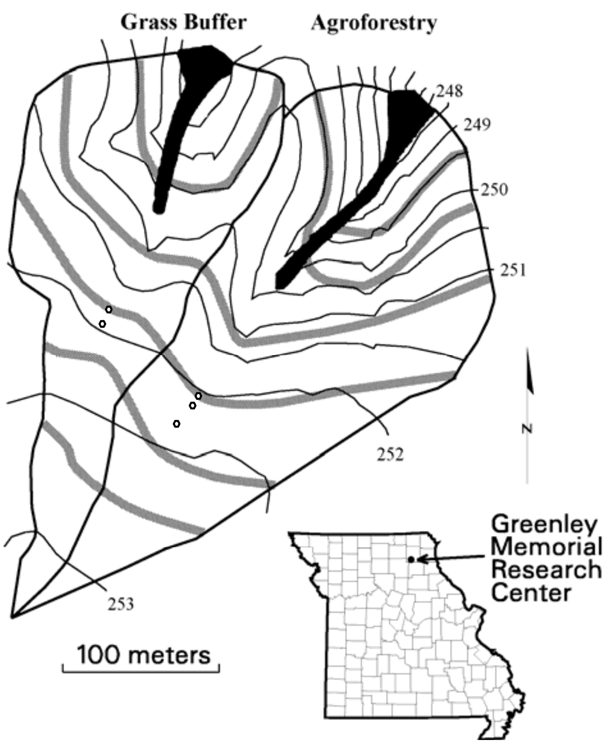

Figure 1. Grass buffer (grass only) and agroforestry (grass+trees) buffer watersheds with 0.5 m interval contour lines (black), buffers (gray), grass waterways (wide black) and microclimate station locations (circle). The inset map shows the study watershed location at the Greenley Research Center, Missouri.

The permanent vegetation within the buffers may also change microclimate and thus directly and indirectly influence evapotranspiration, soil water dynamics, soil enzyme activities, carbon sequestration, and nutrient dynamics. Research shows that larger trees act as a barrier to wind speed and thereby reduce evapotranspiration and crop damage from crop fields as compared to open fields (Bird, 1998). Studies speculate that reduced energy levels under buffers and adjacent areas promote more soil moisture storage, less evaporation, and diverse microbial activity. Studies on windbreaks have shown increased crop yields, yield quality, on the leeward side (Bird, 1998; Huth et al., 2002), however this varies with crop, windbreak type, geography, moisture and soil properties (Brandle, et al., 2004).

The objective of this study was to evaluate differences in microclimatic parameters among crop, grass buffer, and agroforestry buffer areas. It is anticipated that the differences in microclimatic parameters could be used to explain water use, soil properties, enzyme activities, and carbon sequestration as well as environmental quality.

Microclimate Data Collection
Treatments are crop areas, grass buffers (CGS), and agroforestry (AGF) buffers. Observations were made of solar radiation, temperature, humidity, wind speed and direction each 10 minutes and averaged to hourly values. These are the meteorological parameters required to estimate the potential evapotranspiration (Monteith, 1981). For this paper we will be concerned with the observations of wind speed, which are expected to be directly affected by the buffers, and the temperature and humidity, which may be affected by changes in turbulence. Average solar radiation, wind speed, humidity, and temperature were calculated for each day to compare differences among the three treatments and differences among the three crop areas with varying distances from buffers. For the second analysis the data was averaged for ten-day periods (dekads). Results were analyzed and graphical products created using Matlab.

In the plots presented each data field has been averaged over ten days and the points plotted at the center of the ten day period. For example, the mean temperature for the ten day period from day 200 to 210 is plotted at day 205. The mean fields for each parameter were calculated for the twenty-four hour periods, and then also for daytime hours (estimated as 0700 – 1900 CDT). The first of these is to identify whether trends are more noticeable if one removes the night-time hours for which the various fields are expected to show less variation between sites such that the inclusion of overnight observations only serves to smooth the readings and reduce the differences. The second limited period corresponds to the mid-day period during which there is the greatest insolation and highest temperatures which produce the largest fluxes of moisture and energy.

In the first year of the study (2006) the crop in place was corn and the instruments were installed in June. When the instruments were set up on day 160 the canopy was already at a height of 1m and as the crop grew through the season it approached the height of the instruments. The crop was harvested around day 268.

RESULTS AND DISCUSSION:

WIND

The most interesting field is that of wind. One would expect that the different buffer strips would have a direct impact on the wind velocity and turbulence. The question is whether this influence produces a significant difference between the crop areas. The indirect impact of turbulence variations could be reduced mixing between the canopy and the atmosphere leading to differences in near-surface humidity and temperature. The major influence on the wind speed in all locations is that of the growing crop. What is observed is a consistent reduction in wind speed as the distance between the canopy top and the anemometer decreases at all sites. However, as shown in Figure 2, there is no significant difference between the speeds observed at each of the sites until the time the corn is cut. In fact the observations between agroforestry buffers show slightly higher speeds than between the grass buffer, but as the crop canopy is so close to the instrument height this may well be due to extreme microscale influences of the canopy morphology in the vicinity of the anemometers. After the crop is cut on day 268 there is a clear signal that the wind is reduced in the crop area by the presence of the tree buffer, and this may be a precursor of what will be found when soybeans are planted.

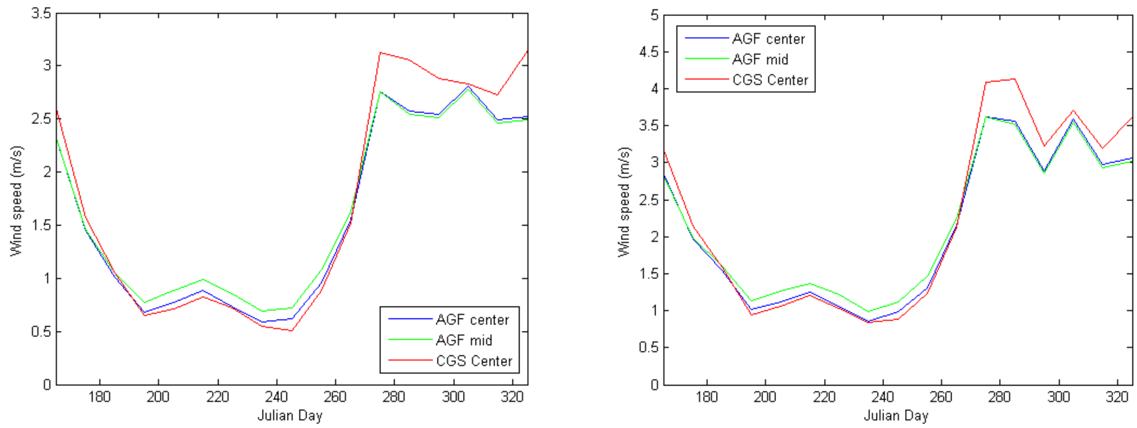

Figure 2: 10-day mean wind speeds over corn at center of agroforestry buffered crop (blue), 3m into agroforestry strip (green) and center of grass buffered strip (red). The first plot shows the averages using all data, while the second plot uses only data taken during the daytime hours (0700-1900 CDT).

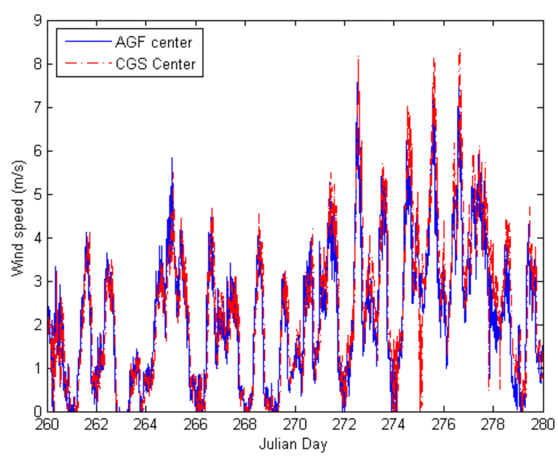

Figure 3: 10-minute wind speed observations for the 20-day period over the time the corn is cut. The red line shows the observations in the center of the area bordered by the grass buffer, and the blue line shows the wind speed at the center of the tree-buffered strip.

When the crop is cut there is a sharp rise in the wind speed at all three locations as the canopy height changes rapidly from instrument height to surface level, 3 m below instrument level. However, the increase in wind speed over the crop with grass buffers is greater than that observed over the crop with forestry buffers. Figure 3 shows detailed wind speed observations from the period around harvest time. At the start of the period the two observations are similar with the speeds observed in the tree buffered area slightly greater at times. Then, after the crop is cut, around day 268, it is clear that at most times stronger winds are observed at the site within strip bordered by the grass buffers.

TEMPERATURE

As shown by the temperature record in figure 4 there is no observable significant difference in the temperatures observed at the three sites.

HUMIDITY

In the observed humidity record it is seen that the grass buffer site generally has a greater relative humidity. It is unclear what causes this while the corn is in place, as the impact of the canopy being extremely close to the instruments makes unequivocal data interpretation problematic. However, after the corn is cut the relative humidity between the grass buffers is still greater than that between the tree buffers. Increased humidity can be a result of lesser turbulence, therefore it is possible that turbulent mixing caused by the row of tree acts to reduce the humidity in their wake. Although one might expect the instruments to lie in the 'quiet zone', the necessity of placing the instruments high enough to remain above the crop canopy, also results in the instruments being close to the height of the windbreak at this stage in the growth of the trees. Also, the trees appear quite porous so that they may again act more to increase turbulence in their wake rather than produce a less turbulent 'quiet zone'. In order to resolve this issue it will be necessary to stratify the various observations based on the wind direction. The instrument that is 3 m south of the agroforestry, is also approximately 30m north of the next buffer strip. Therefore one would expect the observations at this site to be different depending on whether the wind is generally northerly or southerly.

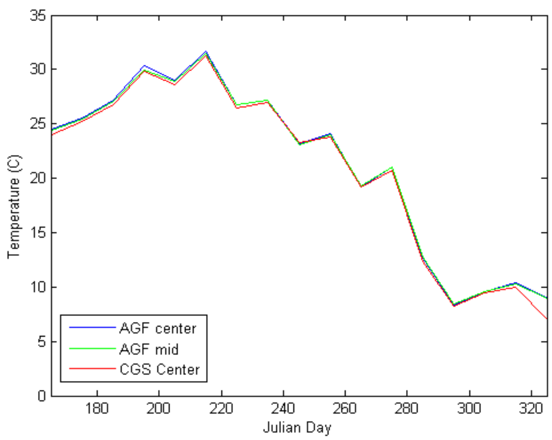

Figure 4: 10-day mean temperatures over corn at center of agroforestry buffered crop (blue), 3m into agroforestry strip (green) and center of grass buffered strip (red).

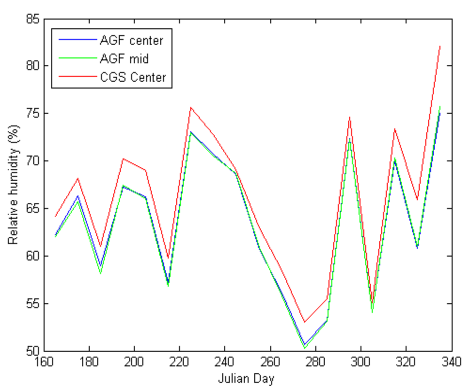

Figure 5: 10-day mean relative humidity over corn at center of agroforestry buffered crop (blue), 3m into agroforestry strip (green) and center of grass buffered strip (red).

SUMMARY/CONCLUSIONS:

As the microclimatological instrumentation was not in place at the start of the growing season there is no information from that crucial crop development period regarding the variation of the atmospheric conditions over the crop that may have been caused by the different buffer types. Once the instrumentation is in place the corn has grown to an extent where it dominates the microclimate and any impact of the buffers in not discernable. However, the changes observed at and after harvest time act as an indication of the influence of the buffers on the conditions over the crop.

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