Glossary
Land cover change: the replacement of one land cover type by another, e.g., due to expansion of croplands, deforestation, or a change in urban extent.
Land management change: a change in how humans treat vegetation, soil, and water for a specific purpose – for instance the use of fertilizers and pesticides, irrigation, use of introduced grass species for pasture, the tree species used in reforestation and livestock movement.
Albedo: is the fraction of solar energy (shortwave radiation) reflected from the Earth back into space. It is a measure of the reflectivity of the earth's surface.

Guo and Li (2014) present a fascinating study of the history of agriculture in the Chinese Semiarid Loess plateau, and suggestions for sustainable future management options.

The region, and Guo and Li's study are particularly interesting from a climatological perspective because of the two-way interactions between orogeny and land use and the climate in this region.

Himalayan uplift created the Qinling Mountains, with several beneficial climatic effects. The mountains prevented the Northwest cold snap from spreading southwards into the Loess plateau, and also prevented the warm snap from the

Southeast spreading further north, ensuring a more temperate climate in the region.

Wind drift from the Southeast blew dust towards the region in spring, while the Southeast Monsoon and the barrier effect of the mountains mean that the winds deposited their dust along the Yellow River basin, resulting in thick loess deposits.

The existence of these thick loess deposits, and the more moderate climate, were foundations for fertile rain-fed agriculture in the region.

However, subsequent agricultural expansion in the region also had a long-term negative impact on productivity, through knock-on effects of severe deforestation.

The Loess plateau was 50% forest 2000 years ago, but only 6.1% of forest cover remained by 1949, leading to significant soil erosion.

Since 1949, a programme to restore degraded ecosystems attempted to reverse this trend. In the last decade rapid urbanization has also led to lower population pressures in the region, drawing people from rural areas to regional centres.

The “Grain for Green” initiative meant that cultivated land in the region declined by approximately 15% from 1996-2003 although there was been a small increase between 2003 and 2007.

The current focus on agriculture has been on low-cost dryland technologies to make more efficient use of limited precipitation. This has been particularly important given a long-term trend towards drought, and heavy summer rains.

It is estimated that 50-60% of farmland precipitation is lost by evaporation, 30-40% through plant transpiration and 10% through runoff. (Some is retained, especially by green crops.)There is limited potential for widespread irrigation in the region.

Timing water supply to meet crop needs is a critical issue in the Loess plateau. Land management in the region, and the key to a sustainable, productive future therefore focuses on integrated watershed management and water harvesting techniques.

These include terracing and check dams to reduce soil and water loss, and increase fertility and soil moisture, and ridge furrow mulching with plastic films; although the latter may have some negative impacts through lower soil C and N contents due to warmer, wetter soils.

The human-driven changes in land cover (LCC1) and land management (LMC2) in the Loess plateau over the last 2000 years may have led to impacts on climate themselves (e.g. Betts et al., 2007; Raddatz, 2007; Pongratz et al., 2010), potentially by altering biogeochemical processes (e.g. C and N cycling) and biophysical effects (such as surface albedo3, surface roughness and evapotranspiration).

Deforestation to agriculture or grassland (e.g. Davin and De Noblet-Ducoudre, 2010; Lee et al., 2011) tends to reduce evapotranspiration rates, with a warming effect on climate.

The brighter crops have a higher albedo, potentially cooling the climate. A further significant impact of agricultural expansion is during winter and spring in climates where snow cover is significant, as the bare soil allows a much brighter, snow covered surface with higher albedo than the forested regions, to have an additional cooling impact.

Overall, deforestation in cool regions may cool local climate because the effect of increased surface albedo tends to be dominant, while increases in cool-region forest area may have the opposite effect (Falloon et al. 2012).

Outside the tropics, impacts of LCC and LMC on precipitation are often less pronounced (Falloon et al. 2012).

Recent climate modelling studies have indicated that warming resulting from large-scale mid-and-high latitude afforestation may be altered by enhanced transpiration (Swann et al., 2010) and water vapour export (Swann et al., 2011), triggerring further feedbacks and changes to circulation patterns.

For instance, large-scale afforestation in Northern Hemisphere mid-latitudes (45o to 60oN) may warm the Northern Hemisphere and alter the Hadley circulation leading to a northward displacement of tropical rain bands (Swann et al. 2011).

Swann et al. (2010) found that afforestation with deciduous trees at Northern Hemisphere high latitudes led to stronger climate impacts from greater transpiration compared to the effect of albedo changes; warming from increases in atmospheric water vapour content melted sea ice, triggering a positive feedback via ocean albedo and evaporation.

It is therefore possible that historic deforestation in the Loess plateau may have cooled the local climate, depending on the balance between albedo and evapo-transpiration effects, although such impacts may be difficult to detect in observational climate records.

The more subtle recent changes in LMC to prevent soil and water loss and preserve fertility may also have effects on climate.

Although the climate effects of LCC have been much more widely studied than those of LMC, Luyssaert et al (2014) show that LMC may have impacts on surface temperature of a similar magnitude to those of LCC.

The story of the Loess plateau, and future prospects described by Li (2014) tell us that the key to future sustainable food production in challenging environments is to harness our knowledge of how land use, soil, water, and climate interact with each other (Falloon & Betts, 2010) to make the best use of limited natural resources.

References

Davin, E. L. and de Noblet-Ducoudre, N.: Climatic impact of global-scale deforestation: radiative versus non-radiative processes, J. Climate, 23, 97–112, doi:10.1175/2009JCLI3102.1, 2010.

Falloon, P. D., Dankers, R., Betts, R. A., Jones, C. D., Booth, B. B. B., and Lambert, F. H.: Role of vegetation change in future climate under the A1B scenario and a climate stabilisation scenario, using the HadCM3C Earth system model, Biogeosciences, 9, 4739-4756, doi:10.5194/bg-9-4739-2012, 2012.

Falloon, P., and Betts, R. (2010). Climate impacts on European agriculture and water management in the context of adaptation and mitigation: the importance of an integrated approach. Science of the Total Environment 408(23): 5667-5687.

Lee, X., Goulden, M. L., Hollinger, D. Y., Barr, A., Black, T. A., Bohrer, G., Bracho, R., Drake, B., Goldstein, A., Gu, L., Katul, G., Kolb, T., Law, B. E., Margolis, H., Meyers, T., Monson, R., Munger, W., Oren, R., Paw U, K. T., Richardson, A. D., Schmid, H. P., Staebler, R., Wofsy, S., and Zhao, L.: Observed increase in local cooling effect of deforestation at higher latitudes, Nature, 479, 384–387, 2011.

Li, F (2014) Climate change and agro-ecosystem management in arid areas: experiences from the Semiarid Loess Plateau, World Agriculture (in press)

Luyssaert S et al. (2014), Land management and land-cover change have impacts of similar magnitude on surface temperature, Nature Climate Change, doi:10.1038/nclimate2196

Swann, A. L., Fung, I. Y., Levis, S., Bonan, G., and Doney, S.: Changes in Arctic vegetation induce high-latitude warming through the greenhouse effect. P. Natl. Acad. Sci. USA, 107, 1295–1300, doi:10.1073/pnas.0913846107 , 2010.

Swann, A. L. S., Fung, I. Y., and Chiang, J. C. H.: Mid-latitude afforestation shifts general circulation and tropical precipitation, PNAS, 109, 712–716, doi:10.1073/pnas.1116706108 , 2011.

1415
Dr Pete Falloon
27th October 2014

Comments