Highlights of "A Perennial Revolution of Agriculture—is it desirable, possible, imminent?"
Lennart Olsson (Lund U, Sweden), Fengyi Hu, Shilai Zhang (Yunnan U, China), Omar Tesdell (Birzeit U, Palestein), Anna Westerbergh (Swedish U of Ag Sci, Sweden) Pheonah Nabukalu, Aubrey Streit Krug, Tim Crews (The Land Institute, USA)

A Perennial Revolution in agriculture promises to address the most severe ecosystem disservices associated with annual crop production. The most salient feature of this re-making of grain agriculture is the dominance of perennials with highly developed root systems planted in diverse mosaics. Advances in research and plant breeding in recent decades have demonstrated that it is possible to develop diverse perennial cropping systems in which more energy is harvested than used to grow the crops, soils are enriched not mined, weeds are suppressed not killed, insect and disease pests are regulated not fought with agrochemicals, cropping systems are vernacular rather than standardized, farmers are able to break out of the agricultural treadmill and improve their economic viability, and rural communities are enriched not impoverished. However, continued research on all aspects of such a radical shift of agriculture is urgently needed in order to improve yields of the new crops, optimize agroecological practices, and for developing products and markets that can revitalize rural communities.

Plant breeders at an increasing number of institutions around the world are taking two generalized approaches to developing new perennial grain crops. The first, is de novo domestication, in which breeders carry out repeated cycles of selection on wild perennial plants to improve on important crop traits such as not dispersing seed, also called non-shattering, or evenness of seed maturation. This process of domestication is similar to how our current annual crops were developed from wild species. The second approach is wide hybridization in which an elite annual crop, such as rice, wheat, sorghum or barley is crossed with a wild perennial relative in order to introduce genes coding for perennialism into the annual. Wide hybridization can in a way be thought of as perennializing an annual crop.

Perennial sorghum is an example of wide hybridization that is currently under development at The Land Institute in Salina Kansas and the University of Georgia. Work on breeding perennial sorghum is also being extended to the tropics involving researchers at universities and other institutions in Uganda, Kenya and Mali. Perennial rice is another example of wide hybridization. Thirty years after the first cross was made, the perennial rice (PR) program is thriving at Yunnan University in Kunming, China. PR varieties have been released to farmers, and in some areas have yielded similar to annual varieties over three years and 6 harvests. PR is now being evaluated in Laos, Cambodia, Myanmar and Vietnam, and well as Uganda.

Development of perennial cereal grain crops related to wheat and barley for cultivation in temperate regions is also advancing rapidly. Domestication and breeding of the wild perennial wheat relative intermediate wheatgrass have resulted in the release of cultivars by The Land Institute, and the University of Minnesota, USA. For the development of perennial barley, the wild perennial relative At the Swedish University of Agricultural Sciences, the perennial relative of barley, *Hordeum bulbosum*, has been selected as the candidate species and a domestication and breeding program. It is also being crossed with annual barley in an attempt to obtain a wide hybrid cross. Similarly, plant breeders at The Land Institute and University of Washington are improving on wide hybrid crosses between annual wheats and perennial cousins such as intermediate wheatgrass.

Perennial grain polycultures inspire a new possible vision for future communities in which humans live and eat in alignment with ecological processes--and relate to each other in more fair and just ways. To realize such a "social perennial vision," human social learning and cultural change is necessary to spark, scale, and sustain the scientific research needed to realize diverse perennial grain crops and cropping systems. We investigate how to engage many people in the process of transformation. The Makaneyyat project in Palestine, with support from Birzeit University, demonstrates a social perennial vision for agricultural landscape change through scientific and community-based research and education. The Land Institute's Ecosphere Studies, Civic Science, and Crop Stewardship programs are also growing transdisciplinary research, community learning, and sustainable supply chain development. Finally, New Roots International is The Land Institute's initiative to grow the infrastructure for a global movement that links localized perennial grain research hubs. Low-input perennial grain agriculture could help communities as they learn to persist through crisis and remake their local and regional food systems to achieve perennial food security within ecological limits.