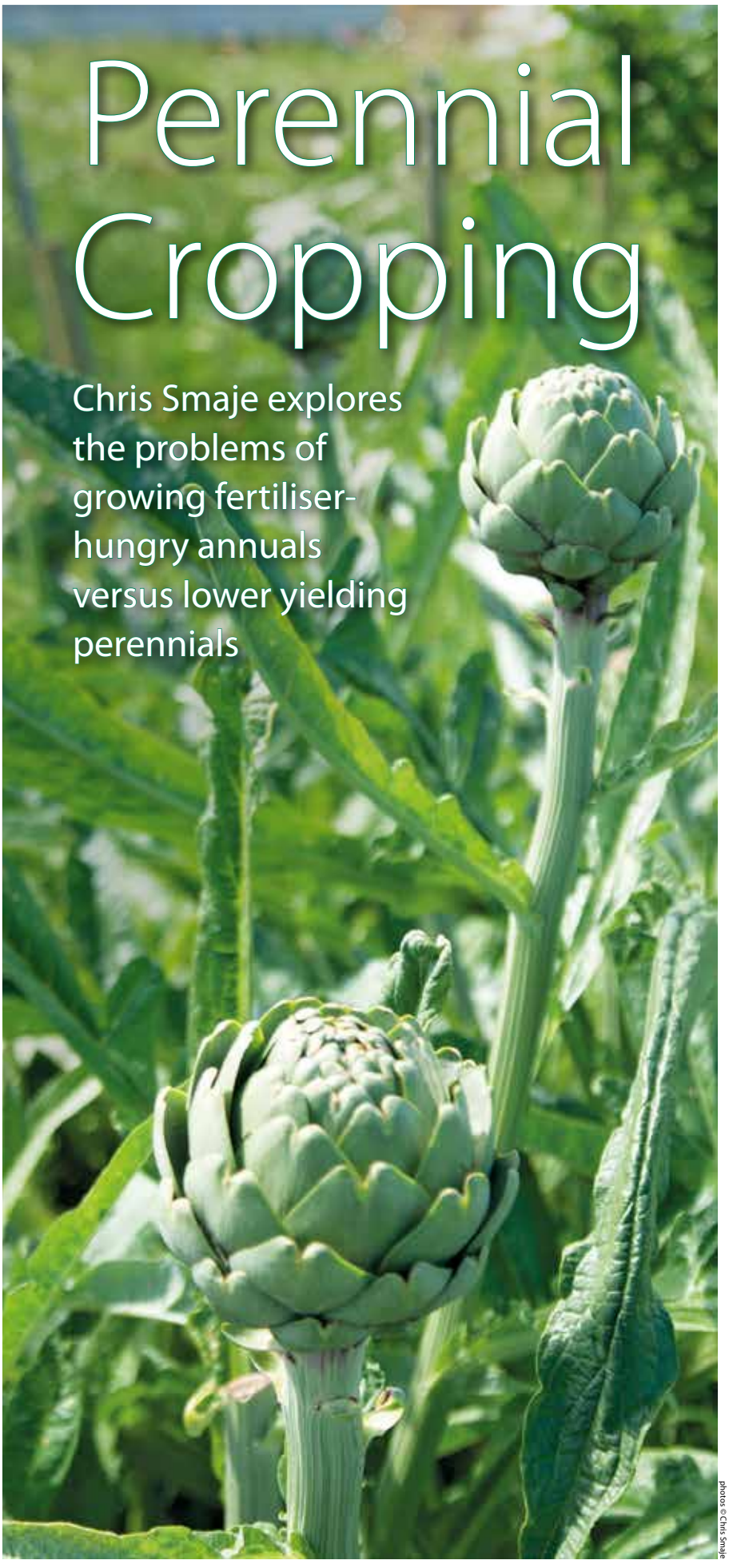
Perennial Cropping

Chris Smaje explores the problems of growing fertiliser-hungry annuals versus lower yielding perennials



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Productive systems present designers with various tradeoffs or dilemmas, whether the 'designer' is a human being or nature itself. Here, for example, are six permaculture rules of thumb:

1. Design at the whole system level
2. Mimic nature's solutions
3. For example, plant perennials not annuals (the former are much more widespread in the natural world)
4. Honour traditional and local mixed farming systems
5. Don't till your soil
6. Seek optimum sustainable productivity for minimum input

But when you try to put these into practice simultaneously, some difficulties emerge.

On a garden scale, you can avoid tillage and build soil from compost. But then you're probably not producing all your own food; at the whole system level you're importing inputs from somewhere else. This becomes more apparent on a farm scale: no-till farming usually involves either synthetic fertiliser and herbicides or inefficiently trucking in muck or compost in bulk. Where is it all coming from? At the whole system level, your sustainable design is probably imposing costs somewhere else.

It's easier to avoid tillage and off-site inputs with perennial plantings, but – despite much wishful thinking to the contrary – you will produce less edible matter per acre, or per farmer, this way than by growing annuals, at least if you live outside the humid tropics. Mark Shepard's work suggests that the calorific productivity of a perennial polyculture in a temperate 'restoration agriculture' farm is only 40% of an annual corn monoculture at most.[1] Current yields of perennial intermediate wheatgrass developed as an alternative to annual grains languish at a similar level, or lower.

Our farming forebears knew these things. That's why they developed systems involving a mix of annual tillage farming and perennial clover/grass (livestock) farming to mediate as best they could the trade-offs involved.

I've recently published an article in the academic journal *Agroecology and Sustainable Food Systems*,[2] where I examine the underlying ecology of annual and perennial plants, which accounts for this unfortunate trade-off. Drawing on the 'Competitor–Stress tolerator–Ruderal' (CSR)[3] framework of plant ecologist Philip Grime, I argue essentially that most of our crops are annuals which are adapted to a regimen of high soil fertility and high soil disturbance, enabling them to quickly complete their life cycle and produce the seeds and fruits we want to eat. Perennials, by contrast, are adapted to their own survival over the long haul in situations of low soil fertility and low disturbance, and avoid compromising that survival by over-investing in the production of the nutrient-dense reproductive tissues of most interest to humans.

Things are more complex in practice, but this distinction explains the basic features of most historic human agricultures: we disturb (plough) and enrich (fertilise) the soil in order to promote fast-growing and highly productive annuals. Then we grow leafy perennial forage crops to restore the soil, making use of the milk, fat, meat and hides of specialist herbivores (ruminants) who are able to process this perennial forage. However, we've recently become quite carried away with the spectacular productivity of our annual crops, especially when supplemented with synthetic soluble fertilisers. As well as ramping up the tillage on arable lands globally, we're now even feeding annual crops in bulk to ruminants in order to increase their productivity. This is creating some major problems in terms of soil loss, fertiliser runoff and so on. It's also becoming increasingly clear that soils and crops ultimately need complex webs of microbial and other life which are compromised by tillage.

Above:
Can we breed perennial grains to match the productivity of these annual ones, without tillage and external fertility? The jury's out.

Below:
To maximise annual yields, most of the plants we eat have been bred to be fast growing in ploughed and fertilised soil.

Productive and/or Sustainable?

Are there any ways out of this trade-off between a productive agriculture and a sustainable one? Possibly, but none are straightforward. A favoured approach in both mainstream and 'alternative'

Below right:
Wood chip composting at Vallis Veg. Almost all approaches to tillage and fertility involve external inputs of some sort.

agriculture, though one in my opinion that's not likely to bear (literal) fruit, is trying to breed plant varieties better suited to the twin goals of high productivity and soil conservation. In mainstream agriculture, this has primarily involved developing GM herbicide-tolerant annual crops and precision soluble fertiliser applications to minimise tillage and runoff. But the consequences in terms of soil health, human health and herbicide resistance seem likely to conspire against this as a workable long-term approach.

Alternatively, it may be possible to breed high-yielding perennial grain crops that require little or no tillage and little or no inputs of fertiliser, pesticides etc. Plant breeders have been attempting this for over a century now, perhaps the best-known example being the work of the Land Institute in the USA. But these attempts have not been conspicuously successful so far, for the reasons implicit in Grime's CSR framework[3] – it's hard to simultaneously maximise annual-type seed allocation traits and perennial-type survival traits.

The Land Institute have published a response to my article disputing the relevance of the CSR framework to their work.[4] In their words, the framework "does not address what happens if humans were to create a new type of habitat never before seen in nature", what they call a 'domestic prairie', involving "a never seen in nature environment with high resource availability, little tillage, and with strict human directed selection for maximum seed yield over several years". They also give examples of perennial plants like certain fruits and early successional perennial sunflowers with high seed/fruit allocation.

The Land Institute's programme excites interest from permaculturists as an example of nature mimicry (copying nature's soil-conserving perennial ground covers) but by their own admission perennial grains are *not* mimetic of nature, which has never developed herbaceous perennials with high yields of starchy seeds. Maybe that doesn't matter if human plant-breeding can fill the gap, but maybe nature's failure to go down this route is a warning sign of the difficulties involved.

The examples the Land Institute cite of high-allocating perennials[4] aren't inspiring – mostly short-lived, nutrient-demanding or non-starchy plants. And human crop-breeding throughout history hasn't escaped CSR trade-offs despite its non-natural character – we've merely pushed plants further in directions they were already disposed to go by their physiology and ecology. It *may* prove possible to juggle the trade-offs and produce perennial grain crops to rival the productivity of annuals. I think it's a long shot, but the interested readers can judge the debate for themselves.

If high-yielding perennial grains aren't an option, what are the other possibilities? One is to plant edible perennials anyway and embrace their lower productivity. The world produces more food than it needs, and squanders much of it on bio-fuels, livestock fodder and waste. A perennial-dominated agriculture could undoubtedly feed us – but, make no mistake, it would require more work and more people for less return. In my opinion that would be no bad thing, but it would require huge social transformations.

Above, below & far right:
Perennials at Vallis Veg: orchards, pasture and wood pasture, with sheep as nutrient carriers.

Alternatively, perhaps we'd do well to follow another permaculture principle: design for local appropriateness. On the erosion-prone American prairie, replacing annual with perennial grains is probably a good idea (and since the prairies are also the world's major breadbasket, this would have the added benefit of reducing the global grain exports that undermine more locally-adapted agricultures). But in moist temperate climates with less erosive weather and heavier soils – such as most of lowland Britain – annual tillage agriculture is much less problematic, if sensibly practised.

That's the position I'd come to on my own small farm: honour the ancestors and follow the old patterns of mixed farming that have demonstrably worked in the past. At Vallis Veg, we have orchards, woodland, permanent pasture and a mixture of the three – wood pasture, as practiced by the commoners of yore, with our sheep grazing among the trees. Indeed, most of our holding is devoted to perennial plants, which conserve soil and build fertility. But a small part features annual vegetables, which we sell to local customers, and as you'd predict from the CSR framework, this part takes up most of our labour but is most productive of both biomass and money per unit area and per unit labour. I'm not that comfortable personally with importing manure or compost from off site and draining nutrients from elsewhere, so the main fertility-building method we've used is temporary legume-rich leys.

But leys require tillage in order to establish a crop. And though annual vegetables grow in bacterially-dominated soils less disturbed by tillage than the fungally-dominated soils of woody perennials, I've come to think we should still preserve soil food webs and avoid the weed treadmill whenever possible by keeping tillage to a minimum. So we're now trying to square the annual-tillage circle in the following ways:

- Developing a 7-8 course vegetable rotation with a red clover ley tilled in for potatoes just once in the cycle.
- Using annual (winter-kill) green manures elsewhere in the rotation, together with low-growing perennial ones which can be knocked back by harrowing to establish certain crops as no till bicultures.
- Using livestock to move fertility from the perennial (fertility-making) to annual (fertility-taking) parts of the holding.
- Composting on site for enriching permanent no-till beds – including vermiculture and mixing wood chips with urine from our source-separating compost toilets (the wood chip compost is sieved using our prototype siever/mini digger combo). We get the wood

chips from local tree surgeons – another off-site input, albeit fairly benign. By my calculations we *could* get by just with our on-site wood, but trying to stay afloat commercially involves a few compromises.

No system is perfect. Trade-offs abound. And of course there's fossil fuel use involved – but that's the case with any system, including a no-till garden with bought-in compost. What I've described above is our best effort to optimise across those various permaculture rules of thumb outlined at the beginning of the article, while trying to stay within the relatively fixed limitations of plant ecologies bequeathed by natural selection. Hopefully, I'll be able to report back in the future on how the system performs

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1 Shepard, Mark (2013). *Restoration Agriculture: Real-World Permaculture For Farmers*. Austin: Acres USA.

2 Smaje, Chris (2015). 'The strong perennial vision: a critical review'. *Agroecology and Sustainable Food Systems* 39: 471–499.

3 Grime, J. Philip (2001). *Plant Strategies, Vegetation Processes and Ecosystem Properties*. John Wiley and Sons, Chichester.

4 Crews, Timothy and DeHaan, Lee (2015). 'The strong perennial vision: a response'. *Agroecology and Sustainable Food Systems* 39: 500-515.