Paludiculture - Constraints, knowledge gaps and opportunities

Collated thoughts from the Paludiculture Event, Jan. 2023

At the Paludiculture Event held in Cambridge on 11-12th January 2023, following the presentation sessions, the workshop participants brought together thoughts on the constraints and knowledge gaps for paludiculture in England by reflecting individually on 10 questions posted as flip-charts around the room.

- What are the key constraints and gaps in knowledge for water table management in lowland peat landscapes?
- What are the key constraints and gaps in knowledge for high water table food crops?
- What are the key constraints and gaps in knowledge for livestock management with high water tables in lowland peat landscapes?
- What are the key constraints and gaps in knowledge for machinery in paludiculture systems? Could robotics provide some solutions?
- What are the constraints to developing markets for paludiculture products for the bio-economy?
- What are the key constraints and gaps in knowledge for sphagnum cultivation in lowland peat landscapes? Are there market constraints specific to sphagnum?
- What are the key constraints and gaps in knowledge for Typha cultivation in lowland peat landscapes? Are there market constraints specific to Typha?
- What are the key constraints and gaps in knowledge for reed cultivation in lowland peat landscapes? Are there market constraints specific to reed?
- What are the key constraints and gaps in knowledge for cultivation and use of bio-energy crops for combustion or anaerobic digestion grown with high water tables in lowland peat landscapes?
- Are there un-tapped wetland crops that should be investigated? If yes, then what are the key knowledge gaps?
- Should the voluntary Peatland Code include Paludiculture? What are the key constraints and gaps in knowledge that currently prevent this?

After voting to show the relative importance/urgency of addressing these issues, 6 of these questions were then considered in more depth to identify the opportunities for projects (P) or engagement activity (E) that could remove the barriers identified.

The report provides a report of the notes made during individual reflection and in the groups and is presented by topic in the order of 'importance/ urgency' as indicated by the voting by workshop participants. There has been no attempt to consolidate findings across topics e.g. some project or engagement opportunities

may appear in more than one list. The outputs were sent to workshop participants for review and the final published version has corrected any misunderstanding or error arising from the transcription, but no additional thoughts have been added during this collation stage.

What are the key constraints and gaps in knowledge for water table management in lowland peat landscapes?
60 votes

- Current water management systems are designed to work for drainage (creation and maintenance of dry land) not for facilitation of a range of managed water levels
- Need to increase understanding of how existing structures used for drainage/ flood risk management can be used in new ways
- Large fields with relatively low density drainage mean that actually changing water tables is difficult and slow to respond
- Lack of specialist water engineers that understand agriculture let alone paludiculture
- How to ensure there is enough water in a dry summer. Climate change reducing water availability further?
- Lack of knowledge about evapotranspiration – wide range of estimates in the literature – this has marked impact on water budgets and hence water management planning
- Abstraction licences and permits – IDBs and EA processes can be slow / difficult
- Limited catchment monitoring of water levels – usually only at the low points.
- What about impacts of sea level rise – saline inundation risks
- Acceptance of no-farming communities for large-scale water storage on land / change in overall water levels
- £ - investment in new water management infrastructure at field, IDB and larger scales – who pays?
- Need to improve understanding of time and costs of implementation and realisation of benefits
- Lack of certainty with regard to loss term revenues when seeking investment

Opportunities

E Bringing together diverse users to improve communication and partnership working at a range of scale

E Go where the engineers are to get them interested and excited about these challenges

E There will need to be some changes to primary legislation to allow IDBs to focus more on managing water levels not just drainage – BUT this doesn't need to constrain action at local level

E Engage with partners to ensure funding rules take GHG into account in FDGIA

E Promote conversation with communities on new infrastructure options e.g. wind-powered turbines

P Measure water balance and full hydrological budgets for well-managed established paludiculture sites

P Ensure energy requirements for pumping etc are assessed and compare full GHG budgets in paludiculture trials

P Assess impacts on water quality as well as amounts of water – may be positive and negative impacts)

P Integrate better use of telemetry and more dispersed monitoring across catchments together with variable speed drives as part of improved water level management structures

P Test, evaluate and share different approaches to water level management in a series of trials

P Carry out cost benefit analyses that take flood alleviation, productivity, GHG mitigation, biodiversity etc properly into account

P Put together an evidence base that allows informed discussion of on and off-site impacts of changes on water levels especially, but not only, on:
- food security
- land values
- biodiversity
- infrastructure (buildings, roads)

P More leadership in partnership to show what is possible – demonstrations, provision of guidance

Are there un-tapped wetland crops that should be investigated?
If yes, then what are the key knowledge gaps?
32 votes

- Over 90 species have already been identified as possible plants for paludiculture in the Holarctic (North America, Europe and Northern Asia) as a sub-set of the full DPPP - Database of Potential Paludiculture Plants (https://www.greifswaldmoor.de/dppp-109.html)

- Not enough time to wait for conventional progress from interesting wild plant to crop; this can take centuries

- If they have a value in a niche market, then growing too much erodes economic viability
- Practical steps in agronomy/ cultivation (sowing, optimising productivity quality, harvesting) would need to be resolved for each crop
- What about invasiveness – paludiculture crops will often be close to wetland conservation areas; need to assess likelihood of spread and also opportunity for control
- Is there significant phenotypic plasticity already within an existing wet plant /crop; this could underpin good opportunities for crop development – in the same way wild mustard led to all sorts of diverse brassicas from cauli to OSR
- Glyceria (sweet grass/ manna grass) is a strong possibility to develop a wetland cereal but would need significant selection and breeding activity

Opportunities

P Screen and prospect, in particular for food and fibre crops that have potential for the range of UK lowland peat situations, should be quick by beginning with DPPP – but engage local/folk knowledge to add possibilities

P Basic screening of populations/ species (mesocosm-scale)– improve physiological understanding where required to support development as crops

P Select varieties/ landraces / population mixes – not only about productivity, but also opportunity for GHG mitigation, biodiversity impacts etc

P Pre-breeding programmes at this stage and traditional crossing as well as GE approaches – keep outside walls of IP to allow rapid development

P Two possible focus plants for initial work – Glyceria, wild rice

P Explore plastic potential for an existing wet plant /crops e.g. Typha, mint?

P Successful crops will need a follow-up range of development projects in agronomy, markets etc

E Ensure early conversations about any new crops involve market and wider commercial considerations

E Talk with farmers/ growers to expand conceptions of growing in a new way on lowland peat soils and adjacent non-peats– paludiculture as part of rotations, robotics enabling lighter machinery etc; this is likely to open up new locally adapted innovations to machinery and systems

E May need changes to legislation – involve policy makers early to understand constraints

What are the key constraints and gaps in knowledge for high water table food crops?

27 votes

- Harvest, sowing and application machinery suited to travel over high water table land
- Lack of data on the effects of higher water tables on current food crops – rooting depth, vigour, pests/ disease.
- Does establishment and management at higher water tables increase risk to drought if water management fails?
- No selection or breeding of crops for high water table situations has taken place
- Lack of data of impacts on both productivity and quality – may be OK for some but not all market uses
- What changes in standard agronomy (fertiliser, pesticides) for dryland versions would be needed if water-table depth is raised
- Lack of agronomy expertise that can support the change
- Long-term policy and security to allow farmers to make changes – grants will help support planned change but rarely instigate innovation
- What are the changes in risks of nutrient / pesticide movement to waters (water quality); if increased, can these be cost-effectively mitigated at farm/IDB scale?
- May need new legislative framework – waterlogged soils currently considered poor soil management
- Need to take a full food system view – could sphagnum be grown on the lowland peat then used as a growing medium for food crops in low C vertical/protected cropping systems? Few modelling and assessment techniques to evaluate these complex decisions.

Opportunities

E Need to work with supply chains (supermarkets, food service) to ensure GHG mitigation is considered in sourcing decisions and support is given for transition to farmers on lowland peat

E Need to develop guidance and case studies to provide farmers and agronomists with the knowledge to support change

P Screen range of crops in terms of suitability at higher water tables

P Better data on the implications for productivity, quality, GHG, biodiversity etc on raising water tables – focus on key crops that show potential for higher water tables

P Develop / improve machinery for use in higher water table conditions – focus on electric /low C options

P Agronomic practices developed for key crops with good potential for higher water tables

What are the key constraints and gaps in knowledge for Typha cultivation in lowland peat landscapes?
Are there market constraints specific to Typha?
18 votes

- Lack of seed supply to grow as a crop
- Lack of agronomy knowledge – some information emerging but still lots of knowledge gaps
- How best to manage balance between nitrogen and phosphorus availability
- How to achieve long-term stable biomass production – yield stability not necessarily yield maximisation
- Meeting crop nutrient demand without environmental pollution (GHG, eutrophication)
- Impacts of production inputs on water outputs and other linked wetland systems (especially if conservation sites)
- If growing for seed heads, then how to manage to optimise seed production – drivers of seed head formation and if it can be manipulated not known
- How to harvest and collect without peat damage – machinery improvement needed
- Lots of potential pest issues – how to control? Develop IPM strategies from the outset
- Plant / variety selection needed
- Getting water level tight – too high too much methane, too low lower production especially *Typha Angustifolia*

What are the key constraints and gaps in knowledge for reed cultivation in lowland peat landscapes?
Are there market constraints specific to reed?
9 votes

- Reed productivity dependent on water levels
- Tradition has been 'wild' management - lack of agronomy knowledge – some information emerging but still lots of knowledge gaps
- Variety selection needed
- Modern building materials have displaced use of reed – loss of skill and confidence in construction industry
- Cheaper imports available
- History of use in focussed geographical areas – limited perception of opportunity

- How to harvest and collect without peat damage – machinery improvement needed

When the group, reviewed the lists of constraints and gaps in knowledge for reed and typha, it was felt that

1) A strongly overlapping group of people were interested in both
2) Many of the issues raised related to both

Hence the opportunities were reviewed by one group and are presented below.

Opportunities

- **E** Typha inclusion gives 'bolder reed' for thatching – more discussion and consideration by thatchers.
- **E** More discussion and conversation of the value and constraints of new bioeconomy materials (including but not only typha and reed) needed with wider construction sector.
- **E** Collaboration between existing growers/ cutters (especially redd) to support their ongoing needs (training, apprenticeships. commercial bed set up, £ etc)
- **E** More conversation and linking to water companies to evaluating the nutrient balance and targeted nutrient removal benefits

- **P** Translation and adaption of materials from Griefswald Mires Centre and learning from other international trials to create resources for UK use – sometimes simply translation, sometimes evaluation in practice also needed
- **P** Development of machinery to harvest and collect without peat damage – other machinery improvement also needed
- **P** Need to better understand plant development and growth; taking a more crop-focussed look
- **P** Can nutrient management strategies be developed that support crop productivity while minimising environmental impacts
- **P** Full nutrient balance and uptake studies including impacts on consistency (critical for thatching), other quality characteristics and harvestable components etc
- **P** Can encapsulated methods help crop establishment
- **P** What makes typha flower – detailed physiology / mesocosm work
- **P** How to manage mixed stands? Reed take-over is an issue for typha, but could this be a managed strategy?

What are the key constraints and gaps in knowledge for machinery in paludiculture systems?
Could robotics provide some solutions?
27 votes

- Can water table depth be controlled accurately and how long does change take, for each site / system this determines the trafficability constraints
- Lack of research and development specifically to address travelling on high water table soils
- Can machinery be adapted from dryland use simply by optimising low-ground pressure systems ? May be for some operations
- Need to understand the cycle of wetness in relation to the crop cycle and the potential environmental impacts
- Need to minimise surface damage – need machinery that doesn't sink, doesn't expose bare peat (ruts etc), and minimses compaction
- High cost of developing machines for a small market
- Getting to farm cluster/machinery ring scale is currently difficult
- Currently no economy of scale for development – better machines are needed to meet market demand but market pull is needed to enable their development
- For reed / typha need a machine that cuts and collects in one operation – collection is often the most damaging operation
- Summer harvest after bird breeding
- Robots are suited to some operations e.g. fertiliser application but not all
- Robots may be well suited to weed control in sphagnum beds

Opportunities

E Need to build communication between different skills sets e.g. computing, engineering, growing

E Increase understanding of engineers – get them excited about the challenge; take the problem to them

E Need to increase understanding and engagement of contractors in the regions where farming on wet soils needs to become more common

E More information on the important of access point / transit route planning to reduce crop and soil impacts

E Lots of the component technologies already exist e.g. low ground pressure but these need to be brought together (**P** after **E**, by crop or main operation)

P Machinery to remove water from sphagnum as it is harvested

P Remote controlled mowers exist; they should be tested and adapted for targeted weeding

P Review and then testing of alternative weeding approaches to herbicides e.g. lasers ,high intensity UV

- Machinery using visualisation / satellite imagery to help guide action
- Review of what is out there and can it be adapted – think laterally
- Need to target approaches that get large volumes of material from wet soil without damage. e.g. For reed / typha ideally need a machine that cuts and collects in one operation

Should the voluntary Peatland Code include Paludiculture?

- Yes, but the case for inclusion will depend on whether this is an option that is of value in the C marketplace.

What are the key constraints and gaps in knowledge that currently prevent this?

25 votes

- Lack of data and other gaps in knowledge are the main constraints
- What does successful paludiculture look like in practice - water management, agronomy, etc
- How do paludiculture systems balance productivity and emission reductions in underlying peat or peaty soils? Need to consider roles/ impact on GHG of soil sterilisation or other weed control, pest and disease management, including IPM, fertilisation
- What opportunities are there for other inputs e.g. biochar – and how do these affect C balance.
- Limited robust measurement of biomass offtake; need for routine agreed approach
- If biomass is removed and locked up e.g. insulation in buildings etc does this affect the C credits or will this only apply to the land-based impacts
- Very few measurements of GHG emissions in paludiculture – need confidence that it is reducing GHG emissions.
- Lack data to verify the models that would be needed to interpolate across the land/ practice gradients
- Is water table depth a good enough proxy measure for C (including CH_4) and N input for N_20 ?
- There is no clear definition or distinction from high-water table farming and/or carbon farming and/or lowland peatland restoration.
- The value of paludiculture potentially comes from the stacking of benefits – sales of product, carbon credits, biodiversity credits, nutrient removal credits – but how can this be accounted for in a Code that is solely C balance-focussed.

- Can this work at a landscape level – it may need agreed water management by a number of landowners to achieve the change on one parcel, but we will need simple legal structures that enable clusters to collaborate in risks, efforts and rewards
- Potentially high risk for the land owner. If this is initiated commercially but then unprofitable for the land-owner / manager, how would the issued credits be handled – would a farmer be required to continue and lose money to underpin the credit issued?
- Lack of knowledge / understanding amongst land-owners of the Peatland Code
- Will costs of validation and verification be too high to make it viable?
- How is consumer confidence in these credits built – this is a relatively unknown set of practices?
- Lack of money in the Peatland Code team to carry out research to fill data gaps

Opportunities

E Peatland Code team keep working and talking with all projects active in paludiculture in the UK and Europe to fill evidence gaps; project teams engage with IUCN Peatland Code team.

P Need to work with existing paludiculture projects and collate data across between them

P Identify opportunities where small amount of added monitoring (whether of water tables, biomass production, GHG emissions or other) could add markedly to evidence base

These questions were not considered further – so only possible constraints are listed.

What are the key constraints and gaps in knowledge for sphagnum cultivation in lowland peat landscapes?
Are there market constraints specific to sphagnum?
13 votes

- Need for effective weed control ahead of sphagnum
- Is soil sterilisation viable, sustainable and cost-effective at field scale?
- How does the crop fit in rotationally?
- End use as a growing medium are likely to constrain agronomic options during the cultivation phase
- High set-up costs
- Need for capital-intensive equipment as well as water level control – e.g. overhead misting irrigation
- May be able to draw from conservation-evidence syntheses where relevant – there will be information on success / failure for sphagnum growth arising from conservation/restoration literature. (see conservationevidence.com)

What are the key constraints and gaps in knowledge for livestock management with high water tables in lowland peat landscapes?
8 votes

- Maintaining animal health and welfare – learning lessons from upland systems?
- What livestock types/ breeds are best suited? Selection for the highest water tables vs productivity
- Need for housing/ other locations to allow removal from site e.g at times of flood
- High risk of soil poaching and compaction
- What impacts does changing water table have on forage quality for livestock
- Can grazing quality be manipulated by plant choice/ water table to reduce ruminant livestock emissions?
- Effects of seasonal pattern of grazing on productivity, GHG emissions
- Effects of changing grazing type (e.g. sheep vs cows) on productivity, GHG emissions
- May be able to draw from conservation-evidence syntheses where relevant – marshes/swamps, peatland – though focused on conservation outcomes (see conservationevidence.com)

What are the key constraints and gaps in knowledge for cultivation and use of bio-energy crops for combustion or anaerobic digestion grown with high water tables in lowland peat landscapes?
7 votes

- Crop value – too low to allow the systems to work profitably and sustainably
- Identifying the optimal timing for harvest to get optimum yield and quality but minimal environmental impact
- Harvesting – need machinery development
- Need selection of crops / varieties than can grow with high water tables (and compete with dryland options)
- Should avoid maize cultivation for AD use on lowland peat

What are the constraints to developing markets for paludiculture products for the bio-economy?
0 votes

No general constraints were identified.

- Market issues need to be considered on a crop by crop by basis.