iCASP Response to the Environment, Food and Rural Affairs Select Committee Inquiry into the scope, provisions and powers proposed in the Agriculture Bill

October 2018

iCASP

1. Yorkshire Integrated Catchment Solutions Programme (iCASP) is a five-year (2017-2022) Natural Environment Research Council-funded partnership established to support the UK Industrial Strategy. iCASP aims to generate £50 million+ of benefits to Yorkshire's economy by influencing investments, informing policies and strategies, identifying cost savings, and creating new products and jobs. It will do this through projects that support the use of environmental science in catchment management. As well as regional impact, iCASP is aspiring for national and international influence through sharing the experience of regional projects at the national level, and by exporting catchment management expertise and products internationally.

2. iCASP partners are: University of Leeds, University of Sheffield, University of York, National Centre for Atmospheric Science, Arup, Bradford Metropolitan Borough Council, City of York Council, Dales to Vales River Network-Yorkshire Dales Rivers Trust, Environment Agency, IUCN UK Peatland Programme, JBA Trust, Leeds City Council, Linking Environment and Farming, Met Office, Natural England, National Farmers' Union, Pennine Prospects, Yorkshire Water, Yorkshire West Local Nature Partnership, and Yorkshire Wildlife Trust. iCASP is also looking to work with additional organisations through its projects.

3. iCASP is based out of water@leeds at the University of Leeds, one of the largest interdisciplinary centres for water research in any university in the world.

4. iCASP has already had success in informing regional policies and national guidance, and providing scientific evidence to >£120 million public-sector investment plans.

5. Further information about iCASP can be found at https://icasp.org.uk/

Response to Inquiry

6. **This response is from the iCASP Programme Office based at the University of Leeds, rather than on behalf of the iCASP partners.**

7. There is little detail in the Agriculture Bill on the new Environmental Land Management Scheme. Therefore the 'devil will be in the detail' as this is developed. When co-designing the new system, an understanding of the evidence associated with different agri-land management activities and their delivery of public goods will be important.

8. iCASP has completed a review of the evidence that exists in the academic literature on how ten land management activities benefit the public good of soil health.

9. The land management activities included popular options within the Countryside Stewardship Scheme and those suggested by a stakeholder workshop: agroforestry, beetle banks, buffer strips, cover crops, hedges, grass leys in arable rotations, land use change - agricultural land to woodland, organic amendments, overwinter crop stubble, and conservation tillage.

10. Soil health was quantified using eight soil health indicators: soil organic carbon, bulk density, porosity, stable aggregates, water holding capacity, infiltration rate, hydraulic conductivity and earthworms. Changes in these indicators can be linked to key soil functions and delivery of other public goods, such as improved water quality, flood alleviation and climate change mitigation.

11. The final review will be made available in November 2018, together with summaries targeted at different audiences, including Defra. However, interim results (by land management activity) are summarised below.

12. **Agroforestry (growing trees in combination with crops or pasture).** *Key messages:* Strong evidence that agroforestry in arable systems increases the soil's capacity to store organic carbon. Agroforestry may improve other soil health indicators with reduced bulk density, increased hydraulic conductivity and increased earthworm population all being reported. More data is urgently needed from temperate agroforestry systems to make this a reliable conclusion. *Gaps in evidence:* While long-established in sub-tropical and tropical climates, there is urgent need for greater understanding of how planting trees in temperate agricultural systems impacts upon soil health indicators. Very few studies have investigated the effects of agroforestry on physical components of soil health such as bulk density, hydraulic conductivity and infiltration, which are important for regulating water flow and quality.

13. **Buffer strips (strips of permanent vegetation either around or within agricultural fields).** *Key messages:* There is strong evidence that soil health (using the indicators outlined in paragraph 10) within buffer strips established around or within arable fields is improved compared to the rest of the arable field. In particular, soil organic carbon, bulk density and aggregate stability are improved. *Gaps in evidence:* Very few studies have compared soil health indicators of buffer strips within or around grassland fields with the rest of the field. There is limited indication of improved soil health in arable fields with buffer strips compared to those without buffer strips, more empirical evidence is needed to verify this.

14. **Cover crops (grown in period between harvest and next main crop).** *Key messages:* There is strong evidence that the use of cover crops in the short term (<10 years) does not lead to an improvement in soil health (using the indicators outlined in paragraph 10), however they do not lead to a deterioration in soil health either and are important in reducing soil erosion and leaching of nutrients. There is some evidence that cover crops may improve soil health in the long term (greater than 10 years), but the effectiveness of cover crops in improving soil health depends on many interacting factors such as cover crop species, soil texture, climate, crop rotation, cover crop species, fertilizer rate, planting

date, and whether and how the cover crop is incorporated into the soil. *Gaps in evidence:* There is limited evidence of the impact of cover crops on soil hydrological properties.

15. **Land use change – agricultural land to woodland.** *Key messages:* There is strong evidence that converting grassland to woodland has no significant effect on soil organic carbon stock. There is strong evidence that converting arable land to woodland significantly increases soil carbon stock. *Gaps in evidence:* There is limited information on the impacts on soil health of converting agricultural lands to deciduous tree cover in temperate climates; most studies have been on coniferous afforestation. There is indication that converting agricultural land (arable and grassland) to woodland increases soil infiltration and hydraulic conductivity; however this is based on four studies only.

16. **Hedges (shrubs and trees of 1-5 metres wide around field boundaries).** *Key messages:* There is medium evidence that soil under hedges stores more carbon than adjacent arable soil. In contrast to our understanding of above-ground hedgerow function, little evidence exists about how hedgerows affect soil health (using the indicators outlined in paragraph 10) and functions. *Gaps in evidence:* Very few studies have investigated the impacts of hedges on soil infiltration and hydraulic conductivity which have implications for water retention and loss. Important knowledge gaps are the effects of hedges on water flows out of fields in terms of rates of water flows, and storage and filtering capacity of soils under hedges. Only one study compared soil health indicators under hedges with those in grassland soils. There are no studies that have investigated the rate of change in soil health indicators after planting new hedges. This is important given that planting hedgerows is a popular option in agri-environment schemes.

17. **Grass leys in arable systems (temporary areas of agricultural grassland as part of rotation).** *Key messages:* There is strong evidence that using grass-clover leys in arable rotation increases soil organic carbon stock and the number of earthworms. *Gaps in evidence:* There is limited research on the effects of introducing grass leys into arable rotation on soil structure and hydrological properties, which are important if we want to understand the impact of grass leys on the public goods of flood mitigation and water quality.

18. **Addition of organic amendments (animal manure/crop residues added to soil).** *Key messages:* There is strong evidence that organic amendments increase soil organic carbon stock, aggregate stability and earthworm population. *Gaps in evidence:* No studies included data on the impact of organic amendments on hydrological soil properties.

19. **Leaving crop stubble overwinter.** *Key messages:* Stubble retention in arable fields has no consistent impact on soil organic carbon storage and earthworm population, but the evidence for this is based on a limited number of studies. *Gaps in evidence:* Very few studies compared the soil health of arable fields with and without stubble retention. However it could be considered a type of cover crop as it protects the soil from erosion during the winter.

20. **Tillage practice (conventional vs. conservation preparation of soil).** *Key messages:* There is strong evidence that conservation tillage can significantly improve soil health. The effects of conservation tillage on some soil health parameters such as bulk density and hydraulic conductivity can vary depending on the type of conservation tillage and site characteristics. *Gaps in evidence:* There are many types of conservation tillage, and it not

clear from the literature how the effects of the various practices within conservation tillage compare. For example, very few studies compared the effects of direct drilling and harrowing on soil health.

21. **Beetle banks (strip of land planted with grasses and/or perennial plants, within an arable field, that provides habitat for beneficial insects, birds, and other fauna that prey on pests).** *Key messages/Gaps in evidence:* No evidence found.

22. **Overall summary:** The land management activities reviewed can be split into (i) land use change, (ii) arable practices, and (iii) linear features.

    i. The results from the review indicate that soil health can be improved the most through (not rank ordered): conversion of arable land to woodland; conservation tillage; introduction of grass-clover leys into arable rotations; addition of organic amendments. All of these options lead to an increase in soil organic carbon and thus help to mitigate climate change (and may also build soil resilience and improve yields). All of these options also encourage infiltration due to an improvement in soil structure and thus reduce surface runoff and help to mitigate flooding. Whether increased infiltration leads to an increase in leaching of nutrients is unclear; many studies show that leaching losses from conventional and conservation tillage are similar. The addition of organic amendments may lead to water quality issues if the amendment contains high concentrations of nutrients, heavy metals, pathogens and emerging contaminates.
    ii. Cover crops and over-winter stubble do not appear to lead to an improvement in soil health (using the indicators outlined in paragraph 10) in the short term (<10 years). However, they do not lead to deterioration in soil health either and so could be promoted to maintain soil health, especially as they are important in reducing soil erosion and leaching of nutrients and thus help protect water quality.
    iii. The database for evaluating the introduction of linear features into the environment on soil heath is limited and more data are urgently needed given that hedges and buffer strips are both popular options in the current Countryside Stewardship Scheme. In addition, both hedges and buffer strips can have an impact on multiple public goods. For example, buffer strips are known to improve water quality, in the absence of field drains, and biodiversity. However, they do not improve air quality or mitigate climate change due to the increased emissions of nitrous oxide resulting from their installation.

Conclusions

23. Strong, scientific peer-reviewed evidence is needed when deciding which land management activities to prioritise for public money for public goods in the new Environment Land management Scheme (ELMS).

24. This review helps to identify which land management activities/intervention lead to an improvement in some key indicators of soil health and the delivery of other public goods, such as climate change mitigation, improved water quality and flood alleviation. Our approach has focussed on a set of soil health indicators that are important for soil functions and the delivery of public goods and services, but is not exhaustive, and has not included components such as biodiversity and soil microbiology which are complex to interpret, but may also be important.

25. The final review will be made available in November 2018: Chapman, P.J., Eze, S., de Bell, S., Barlow-Duncan, F., Holden, J., Leake, J., Kay, P., Brown, C., White, P., Little, R., Reed, M., Ziv, G., (2018) Agricultural Land Management for Public Goods Delivery: iCASP Evidence Review on Soil Health. Yorkshire Integrated Catchment Solutions Programme (iCASP) Report.

26. The gaps in evidence that the report highlight can provide a focus for current/future research, including Defra-funded trials/tests, use of transition period funding, and UK Research and Innovation-Natural Environment Research Council programmes.

27. It is critical that this current/future research is done with stakeholders to enable immediate use in informing the new ELMS.

28. There is a need for critical assessment of the ability of different interventions to deliver multiple public goods. This information is currently lacking in the literature and urgently needed. The same mitigation option will not result in the same impact everywhere due to variations in soil type, climate, crop rotation, fertilizer application and land management practices. Sometimes although we may see an improvement in one targeted public good, e.g. soil health, it may result in the deterioration of another public good. For example, while riparian buffer strips are effective at reducing nitrate leaching to surface and ground waters and thus improve water quality, the main mechanism by which this occurs, denitrification, releases nitrous oxide into the atmosphere, which is a greenhouse gas and contributes to global warming and thus climate change. This phenomenon is known as pollution swapping and highlights the difficulties of using public money for the delivery of public goods.

29. We need to be realistic about time frames as many soil health indicators take time to respond to changes in land management. For example, benefits of conservation tillage, land-use change to woodlands and agroforestry may take many years to become apparent.

30. Given that there is a lack of evidence on how different interventions impact upon multiple public goods, it may be best to restrict the number of options in ELMS to a narrow range for which robust evidence exists and farmers are most likely to take up, expanding this list of options as sufficiently robust evidence becomes available.

31. Codes of good practice could be made part of ELMS, such as the recent Defra Code of Good Agricultural Practice for Reducing Ammonia Emissions, providing simple, evidence-based ways to reduce ammonia emissions.

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