Remote assessment and prediction of workability and trafficability

Mark Kibblewhite

NFU Chief Economist Phil Bicknell

- “The overall fall in farm profitability will not be a surprise for anyone in the industry. The UK recorded its second wettest year ever in 2012, and no farming sector was immune from the weather”
- “On top of delayed planting last autumn, crop development has been slow and spring planting is behind schedule in many parts”



www.nfuonline.com

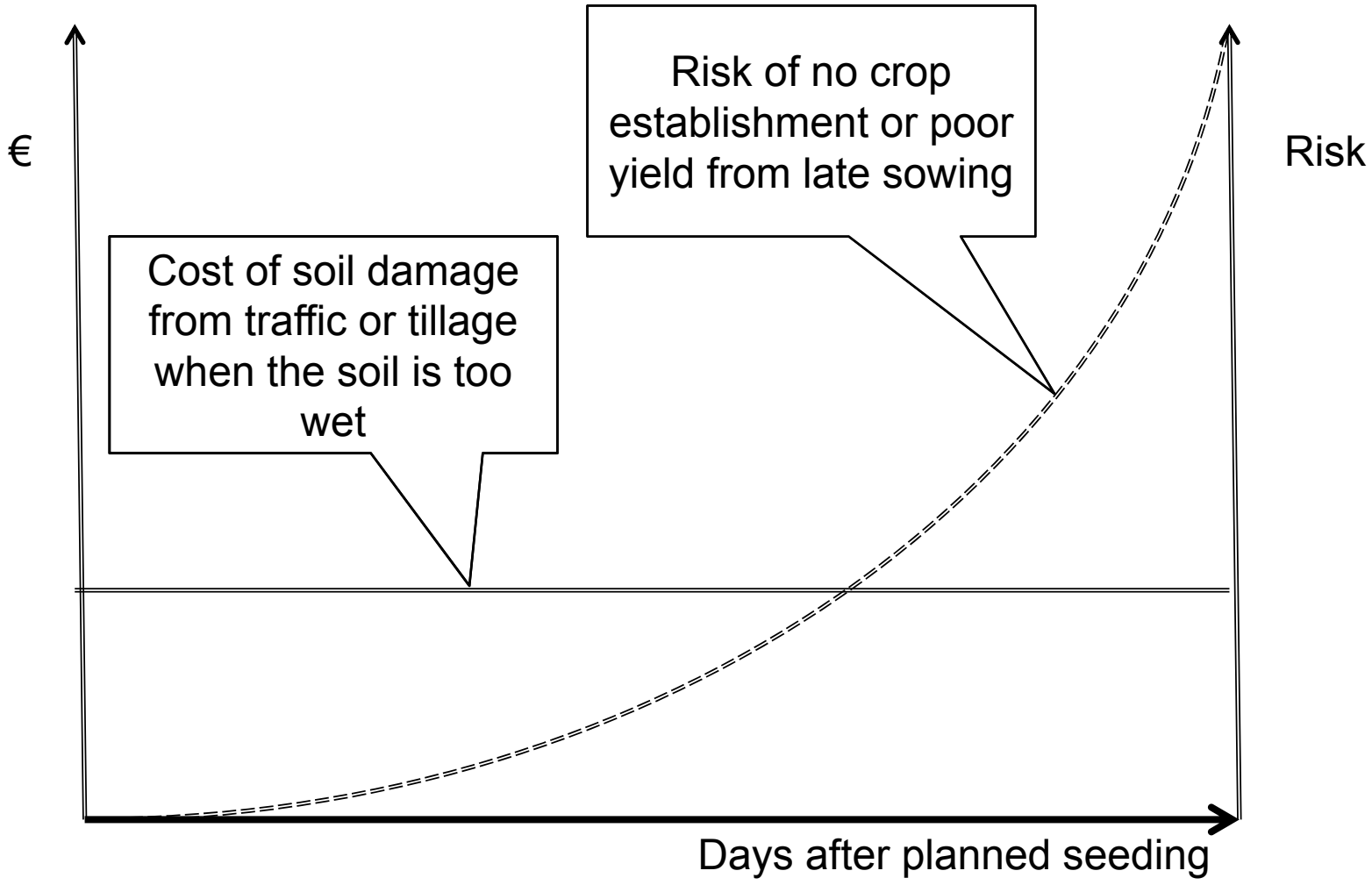
13 /11/12 Stephen Harrison	The short breaks in the weather [are] generally not sufficient to allow sustained progress with drilling on medium to heavy soils.	27 /11 / 12 Bryce Rham	..on the heavier land every time it got within a couple of days of being able to drill, a few mm of rain would scupper the opportunity.
24 02/13 Neil Potts	Wheat drilling has resumed or in some cases started. Due to excessive wet, [earlier drilled crops] are under-tillered and have a poor root system.	11 /03/13 West	There is a large contrast between the best and worst soil conditions. The heavy clays are the most difficult, but even some lighter soils have had problems. It is now 40 years since the last major drainage investment .
13/04/13 Nick Brown	Most rape crops have gone backwards.... spring rape needs drilling into warm soils.... I can't see any spring rape being drilled until the third week of April.	14 /05/13 Bryce Rham	Many crops [are] much later than normal and even where they are at some sort of normal growth stage they are all short (such as wheat with flag leaf starting to poke out, but not above the top of my wellies).

http://www.fwi.co.uk/blogs/crop-watch/

Underlying problems and solutions

- The weather → the new normal? "..it appears that there will be more heavy rainfall events as the climate warms," says the Met Office.
- Lack of drainage → Updated, better maintained and smarter drainage
- Soil physical conditions → Avoiding soil compaction
- Complex trade-off decisions between getting crops drilled vs. risk of poor establishment and soil damage → Monitoring and decision-support for timing of operations

Timeliness costs are the main source of annual variation in total costs of cereal production. They range from 0 to €150 ha^{-1} (de Toro, 2005).



Defining the problem

- Poor trafficability and workability of soils, leading to:
  - Late or abandoned drilling
  - Damage to soils
  - Higher establishment costs
- How can we get better decision-making about where and when operations are done to maximise good use of windows of opportunity?

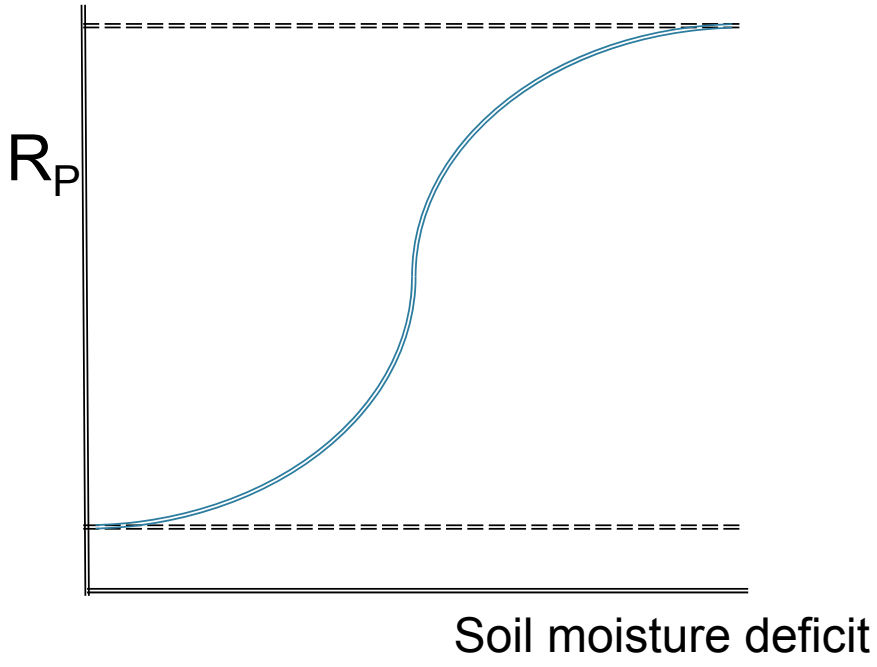
Operational context

- Larger land units over wide areas
  - Need information on the suitability of operations before deploying kit so as to avoid costs from wasted time and journeys or real-time decisions to proceed anyway and cause damage
- Higher work-rate equipment
  - Able to cover more ground during windows of opportunity but combination of weight and power likely to increase risk of damage
- Recent rainfall affects workability
  - Rainfall is variable over short distances and hour by hour so soil status is also variable from day to day. Therefore daily updates on current and forecast workability are needed.

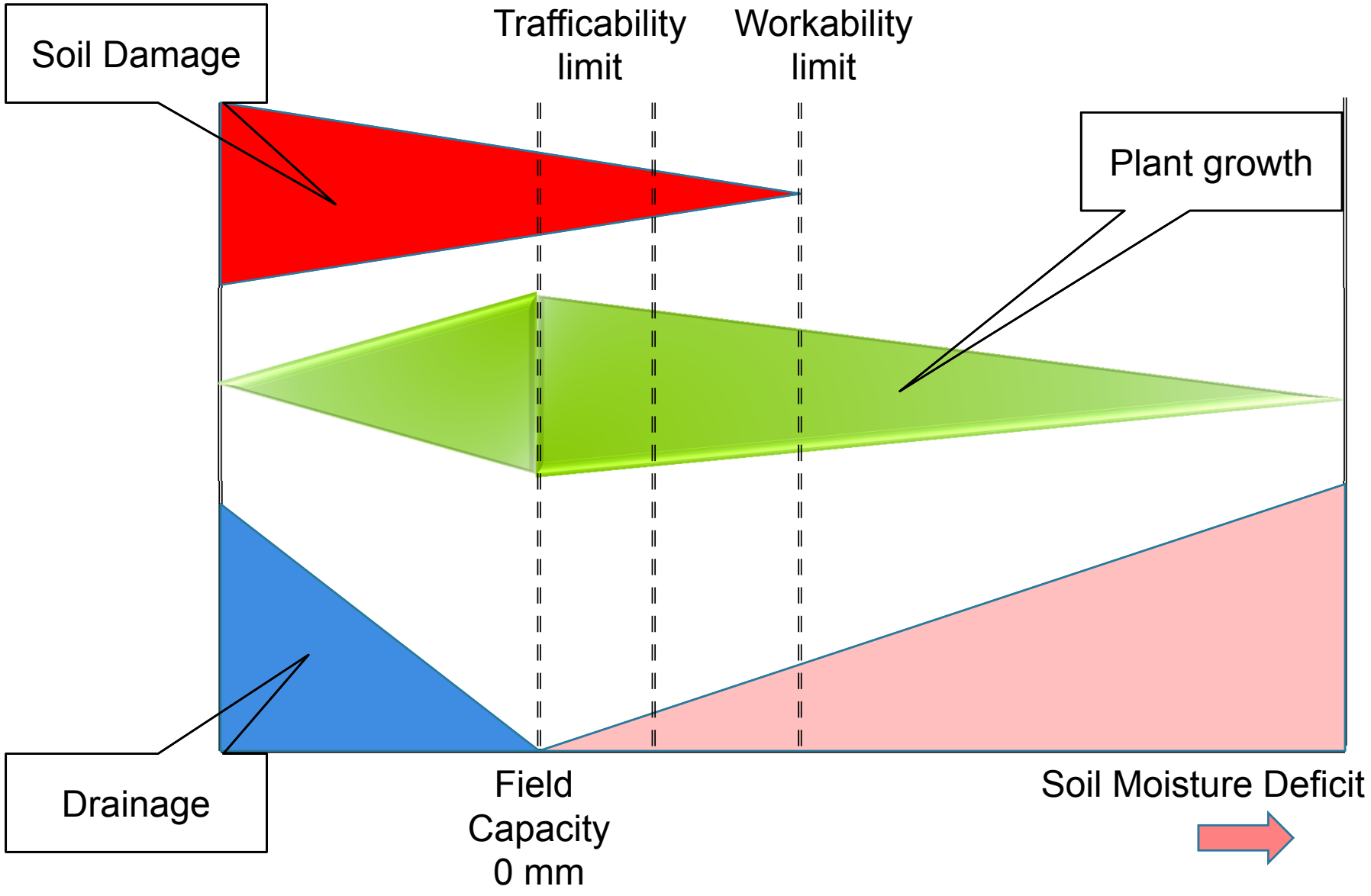
Trafficability and Workability

- Trafficable soil – provides effective traction without excessive compaction or structural damage
- Workable soil – dry enough to give a fine tilth but not wet enough to produce smearing

Earl (1997) demonstrated a relationship between cone penetrometer reading (as an empirical measure of soil mechanical strength) and soil moisture deficit and related this to trafficability and workability.



Schematic of soil water dynamics, plant growth and risk of soil damage as a function of soil moisture deficit (redrawn after Schulte et al., 2012)



Prediction of work days

- Studies before 2000 developed methods to predict the number of ‘machinery work-days” (total days when soil is workable) from soil and climate information.
- This information is useful for strategic planning e.g. choice of farm system, crops, etc. but not for within year operational decision-making.



stephen.mills@peacock.co.uk

Dynamic data inputs via web-based telemetry:
(1)Real time soil moisture data
(2) Local rain and temperature from automatic met station
(3) 5 day local weather forecast

$$SMD_t = SMD_{t-1} - Rain_t + ET_t + Drainage_t$$

$$Workability\ /\ Trafficability = f(SMD_t)$$

Static data inputs
(1) soil properties from soil database

Current and 1- 5 days predictions of Trafficability and Workability

System requirements

- Automated met station
- In-field moisture sensors
- Telemetry
- Field scale mapping of soil properties
- Predictive model for SMD
- Threshold SMDs for trafficability and workability

Summary

- Short term prediction of trafficability and workability can support better prediction and so use of available work days for sowing and crop maintenance.
- Better prediction of soil status will allow
  - optimal timing of crop establishment for the season, reducing the risk of no or late sowing
  - Reduce risk of soil damage
  - Support better equipment scheduling
- It appears technically feasible to construct a prediction system

Thank you

m.kibblewhite@cranfield.ac.uk

markkibblewhite@agritechnologyaction.com