# Optimal Phosphorus (P) Abatement – The Role of the Metric

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NutriTrade
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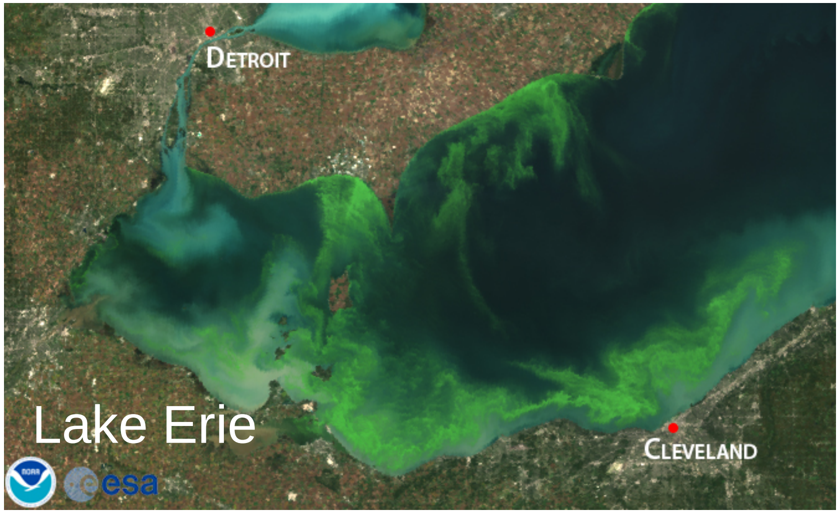
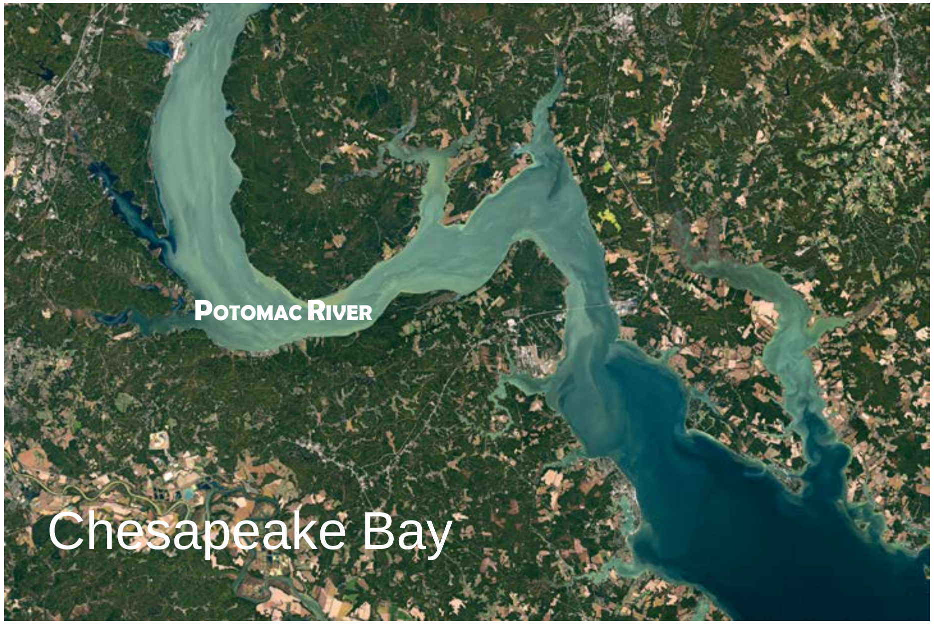
# Eutrophication and P

# Eutrophication and different forms of P

Total P =

Soluble P + Particulate P (PP)

Soluble P =

Soluble Reactive P (SRP)

Solube Unreactive  P

SRP fully available to algae

PP partly available, even in the long run



# Agriculture, conservation measures and different forms of P

Dodd & Sharpley (2016):

Conservation measures that reduce PP tend to increase SRP loading considerably.

Jarvie et al (2017):

Substantial increases in SRP loading to Lake Erie most likely due to land use changes (no-till, conservation tillage)

Table 1 USDA-NCRS promoted conservation practices to minimize the loss of P from agriculture and the range of effectiveness for dissolved P (as DRP) and particulate P found in field experiments across the U.S. and Canada

| Practice | Description | Effectiveness (% reduction) | | References |
|---|---|---|---|---|
| | | Dissolved P | Particulate P | |
| Farm inputs | | | | |
| Dietary P | Match animals nutritional requirements to feed | 13–89 | <1 | Ebeling et al. (2002)[b], Ghebremichael et al. (2007)[a], Hanrahan et al. (2009)[b] and Jokela et al. (2012)[b] |
| Corn hybrids | Use of low phytic-acid corn in feed to reduce manure P | 45–48 | Negligible | Leytem et al. (2008)[a], Penn et al. (2004)[f] and Smith et al. (2004a)[b] |
| Feed additives | Addition of phytase enzyme to increase P utilization | n.s.—52 | Negligible | Penn et al. (2004)[f] and Smith et al. (2004a, b)[b] |
| Source management/Avoid | | | | |
| Nutrient management | Rate—based on soil testing. P inputs are based on crop requirements | 10 % reduction for every 10 % reduction in STP | n.d. | Vadas et al. (2005)[a] |
| | | >80 % reduction moving from N based to STP based litter application | Negligible | Sharpley et al. (2009a)[f] |
| | | 60–88 % reduction moving from N based to P based litter application | Negligible—67 | Eghball and Gilley (1999)[f], Miller et al. (2011)[b] and Sweeney et al. (2012)[b] |
| | Application timing—apply during seasons with low runoff potential | 41–42 | Negligible | Schroeder et al. (2004)[f] and Sharpley (1997)[f] |
| | Application method—incorporate, band or inject P into conservation tilled soil | 20–98[1] | n.s.—60 % increase | Eghball and Gilley (1999)[f], Kibet et al. (2011)[b], Kimmell et al. (2001)[f], Little et al. (2005)[b], Rotz et al. (2011)[f], Tarkalson and Mikkelsen (2004)[f] and Sweeney et al. (2012)[b] |
| Conservation crop rotation | Sequence different rooting depth and plant acquisition mechanisms to optimize soil P uptake | 85 | Negligible | Smith et al. (2015a)[a] |
| Soil inversion | Reduce P enrichment in topsoil | n.s.—92 | Negligible—89 % increase | Quincke et al. (2007)[f], Sharpley (2003)[f] and Smith et al. (2007)[b] |
| Transport management/Trap | | | | |
| Conservation cover | Permanent vegetative cover to increase soil infiltration and remove sediment bound P | n.s.—63 | 65–90 | Sharpley and Smith (1991)[d] and Zhu et al. (1989)[f] |
| Buffer strips/riparian zones | Slows flow, increases infiltration and removes sediment bound P | −258 to 88 | 35–96 | Abu-Zreig et al. (2003)[f,k], Blanco-Canqui et al. (2004)[b], Chaubey et al. (1995)[f], Daniels and Gilliam (1996)[f], Dillaha et al. (1989)[b], Schmitt et al. (1999)[f], Lee et al. (2000)[b], Lowrance and Sheridan (2005)[f,k] |
| Constructed wetlands | Removes sediment bound P | −72[f] to 94 | 47–70 | Beutel et al. (2014)[f,k], Jordan et al. (2003)[f,k], Kovacic et al. (2000)[f,k], Maynard et al. (2009a, 2009b)[f,k] and Pietro and Ivanoff (2015)[f,k] |
| Transport management/Control | | | | |
| Strip cropping/contour tillage/terraces | Reduces erosion and transport of sediment bound P | Negligible—63 | 32–91 | Alberts et al. (1978)[f], Gassman et al. (2006)[f] and Langdale et al. (1985)[f] |
| Conservation tillage | Reduces erosion and increases infiltration | −308 to −40 | −33 to 96 | Gaynor and Findlay (1995)[f], Schreiber and Cullum (1998)[f], Sharpley and Smith (1994)[f], Shipitalo et al. (2013)[f] and Smith et al. (2015a)[a] |
| Grass waterways | Slows flow, increases infiltration and removes sediment bound P | −83 to 81 | 45–89 | Gassman et al. (2006)[f] and Smith et al. (2015a)[f] |
| Drainage water management | Controls drainage to reduce outflow volumes | Negligible—68 | 15–31 | Evans et al. (1995)[f], Littlejohn et al. (2014)[f,k], Tan and Zhang (2011)[a] and Williams et al. (2015)[b] |

[a] Model simulation of P loss following implementation of a 25 % reduction in dietary P intake







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# SRP-PP trade-off, impact on efficiency of conservation measures? Example.

Consider a parcel (one hectare) with initial P loading:

- PP 2kg
- SRP 0.5kg

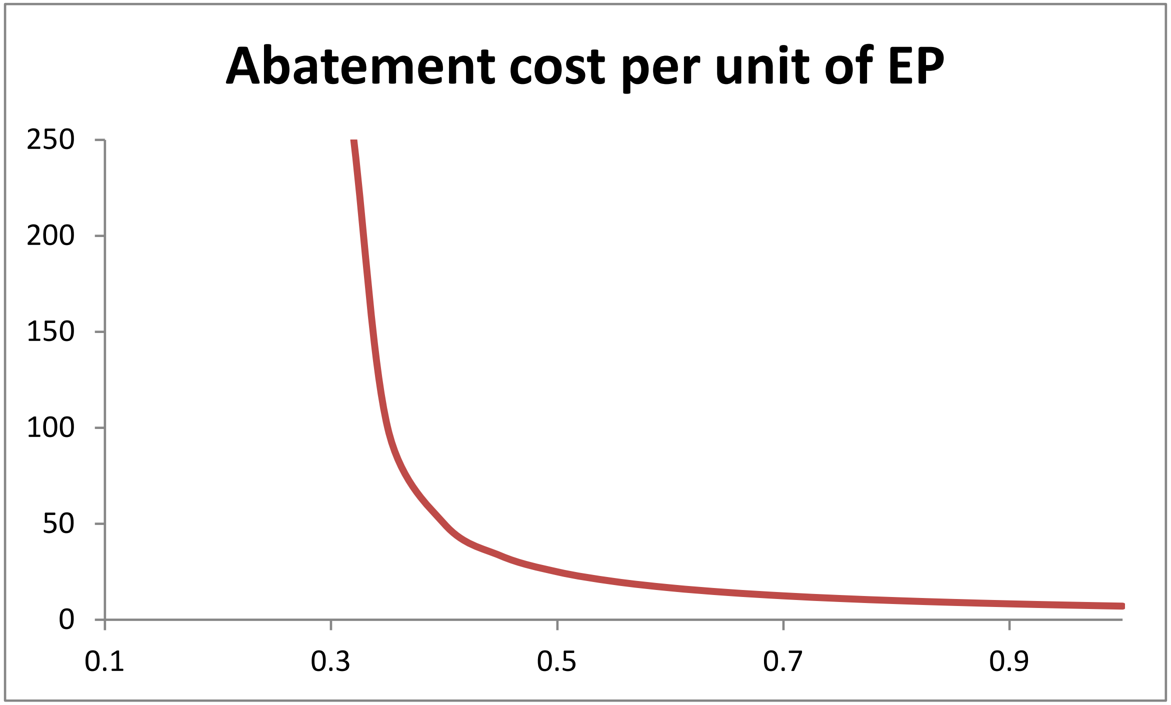
A measure, say permanent vegetative cover:

- Costs 5$/ha
- Reduces PP by 1kg
- Increases SRP by 0.3kg

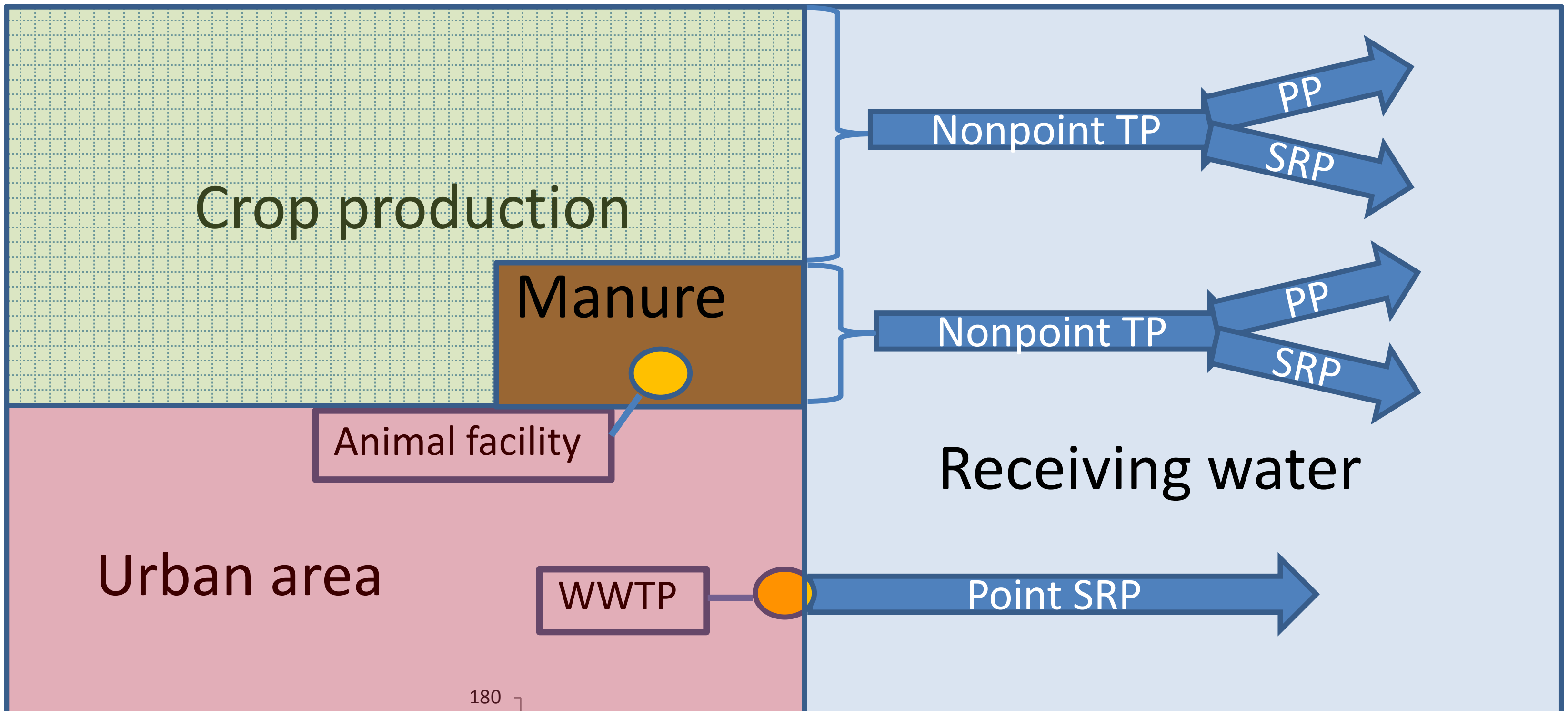
TP reduction 0.7kg; Abatement cost 7 $/kg

# SRP-PP trade-off, impact on efficiency of conservation measures? Example.

| Bioavailability of PP | 100% | 90% | 80% | 70% | 60% | 50% | 40% | 30-0% |
|---|---|---|---|---|---|---|---|---|
| Abatement in terms of Eutrophying P (EP) | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.1 | ≤ 0 |
| Abatement cost ($/kg EP) | 7 | 8 | 10 | 13 | 17 | 25 | 50 | → INF |

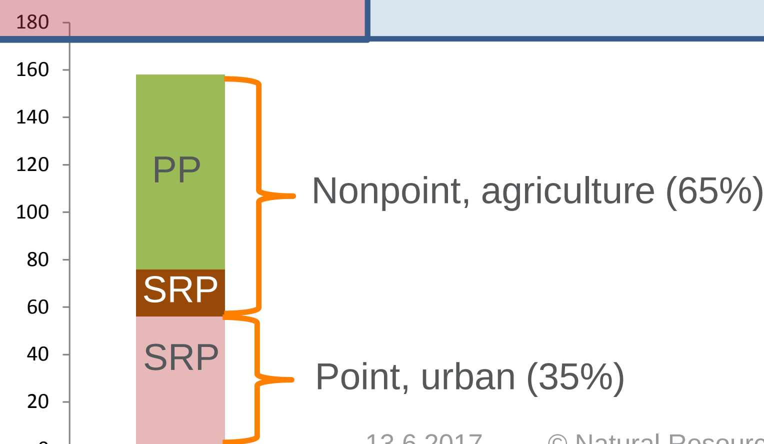


# Efficiency and bioavailability of PP, illustration




Total P loading 158 kg.

Distribution:





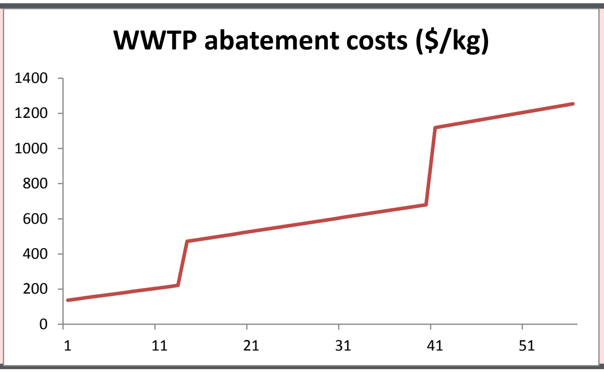
# Abatement measures and their costs

Three measures:

1) **”No-till”** Permanent vegetative cover (currently all ploughing)
2) **”Manure”** Hauling manure beyond economic threshold distance
3) **”WWTP”** Further investments in point source abatemet

Costs:

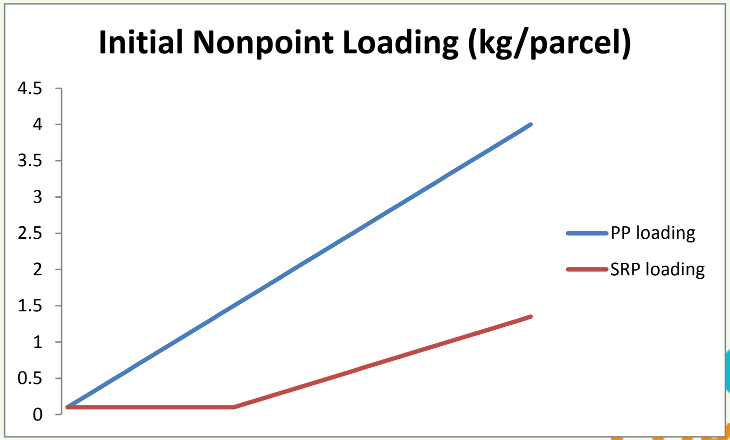
1) **”No-till”** 1$/ha
2) **”Manure”** 20$/ha
3) **”WWTP”** Lumpy investment & unit costs:




Effects:

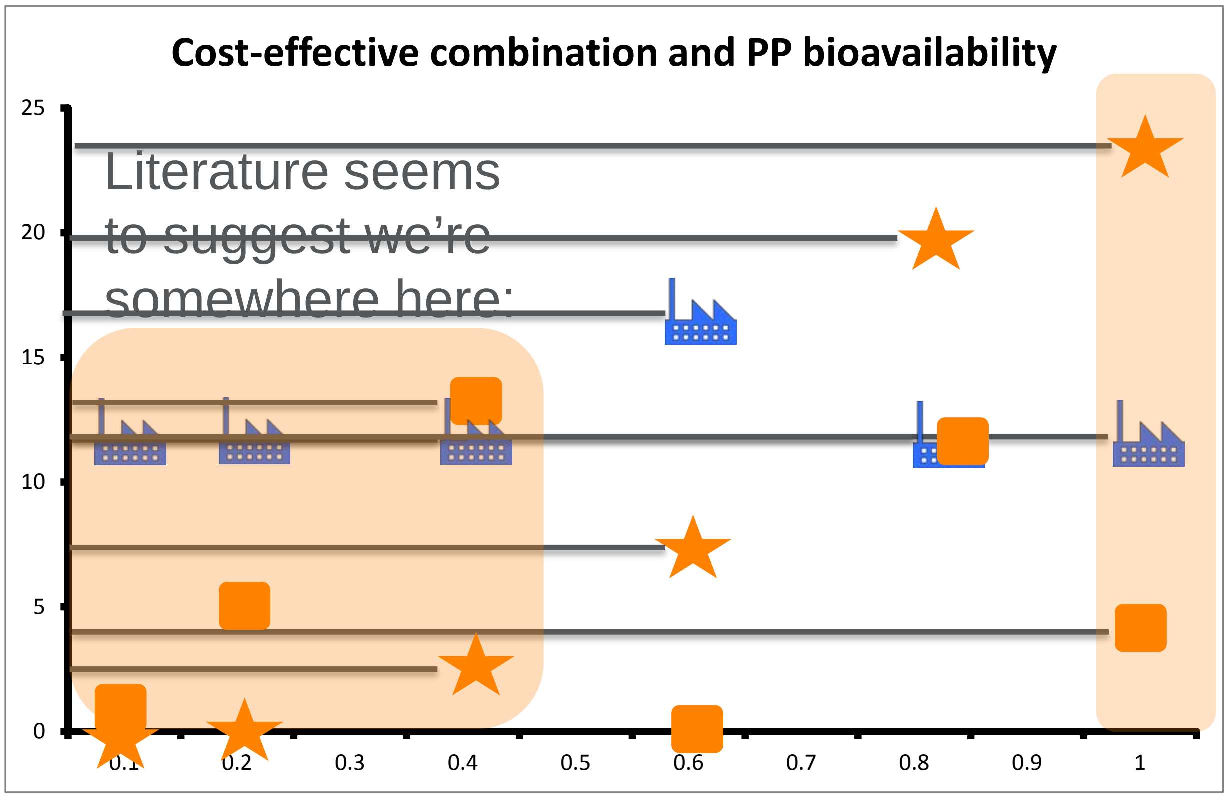
1) **”No-till”** Reduce PP 30%, incerase SRP by 0.5kg/ha

2) **”Manure”** Reduce SRP 30%, no effect on PP



# How to cut down eutrophying P loading by 15% with the least costs?

Depends on the bioavailability of PP.



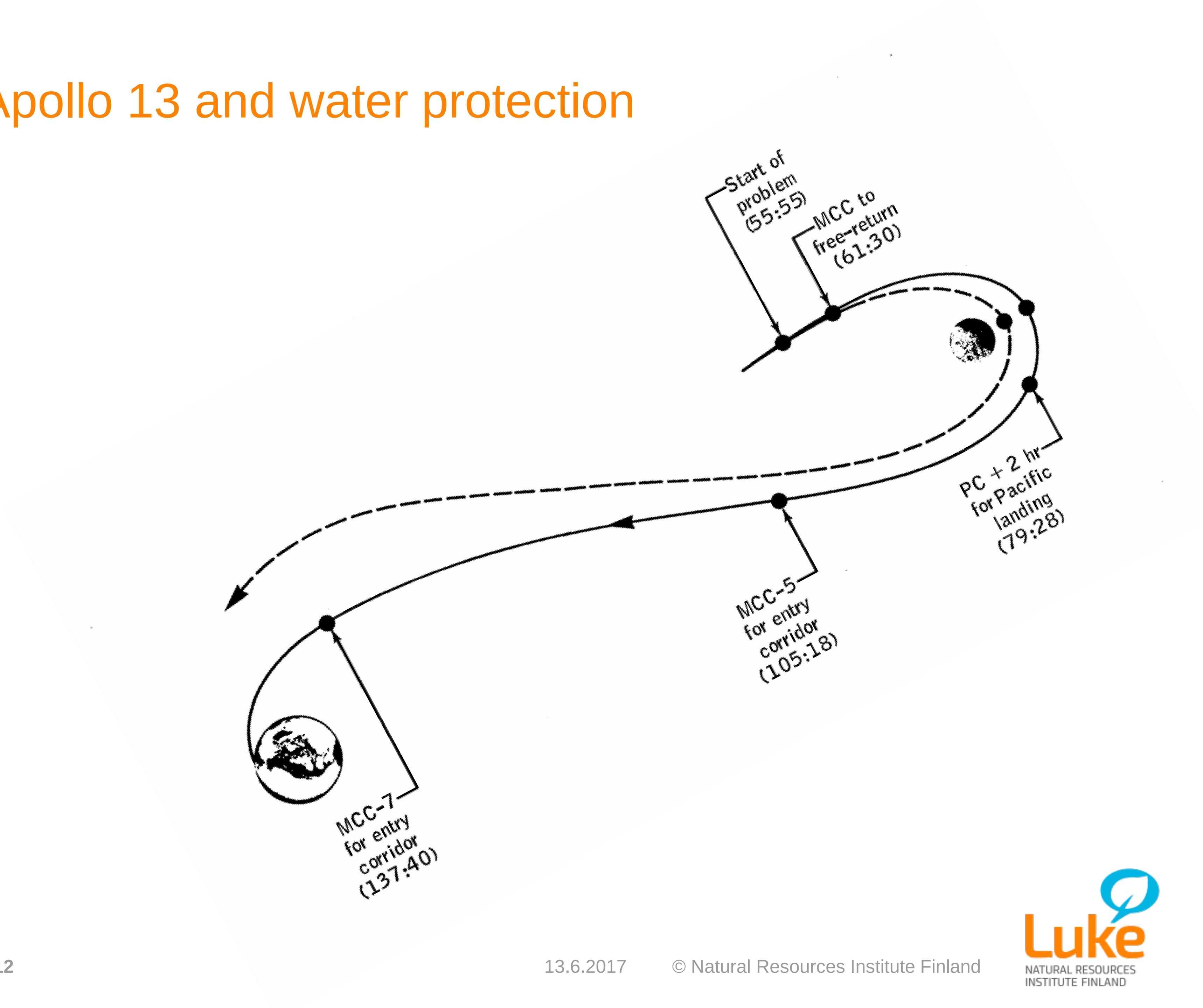

Bioavailability 100%, current (implicit) assumption: TP=PP+SRP

# Mimic $CO_2$-equivalents of GHGs? P fractions summed up as phosphate equivalents?

- Upper level targets the most important
- TMDL / BSAP units cascade to all levels of government
- Challenge: GHGs global whereas phosphorus fractions' eutrophying potential depends on, e.g.
  - Source area soils
  - Morphology, ecological status of the receiving water body
- But: best uncertain guess beats the certainly wrong one.
- Unambiguity of $CO_2$ conversion?

| GWP of methane and Nitrous oxide as indicated by IPCC rapports | Time horizon 20 | 100 | 500 |
|---|---|---|---|
| Carbon dioxide | 1 | 1 | 1 |
| Methane (1990) | 63 | 21 | 9 |
| Methane (1995) | 56 | 21 | 6.5 |
| Methane (2001) | 62 | 23 | 7 |
| Methane (2007) | 72 | 25 | 7.6 |
| Methane (2013) | 84-86 | 28-34 | |
| Nitrous oxide (1990) | 270 | 290 | 190 |
| Nitrous oxide (1995) | 280 | 310 | 170 |
| Nitrous oxide (2001) | 275 | 296 | 156 |
| Nitrous oxide (2007) | 289 | 298 | 153 |
| Nitrous oxide (2013) | 264-268 | 265-298 | |

# Apollo 13 and water protection



# Thank you!

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