# Briefing Paper

F lexible emission fees applied to phosphorous(P)  and nitrogen(N),


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# Applying the Höglund model to phosphorous(P) and nitrogen(N)

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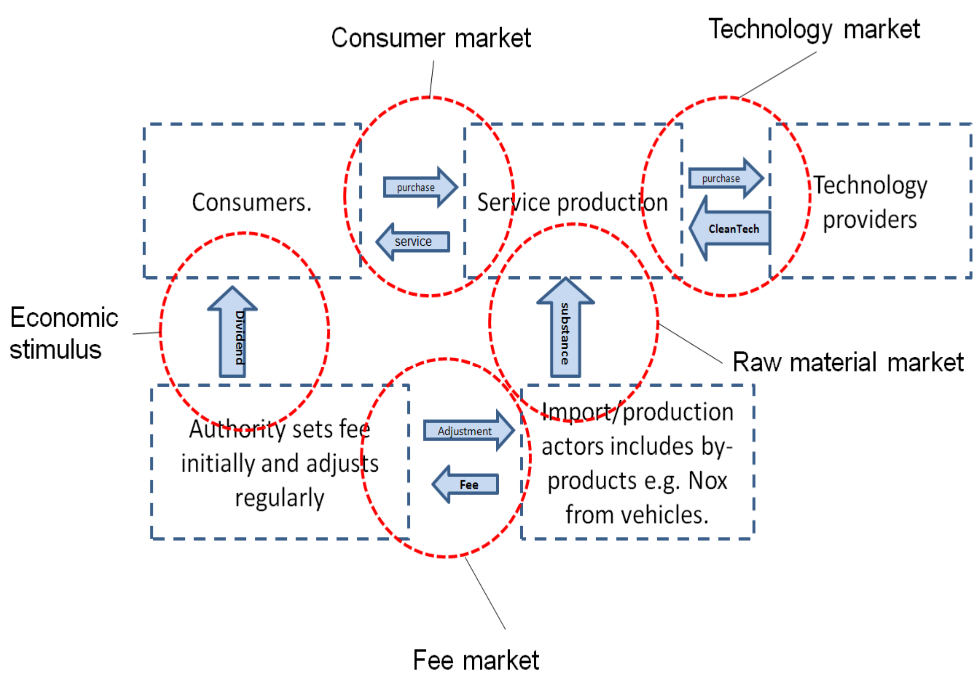
This paper takes the reader through how the Höglund mechanism might be applied to phosphorous(P) and nitrogen(N),  giving the reader enough detail to be able to compare the flexible fees approach with other mechanisms.

A general description of the mechanism is available on our website, and in our White paper. It is useful to read these first to gain some background.

**An overview of the mechanism**




Exactly how the fee could be levied needs to be worked out – many factors can play in including the effects on cross border trade. Redistribution needs to be considered at this stage – what will the monies be used for and how will they stimulate the desired behaviour of the system?

As shown in the diagram above, the authority decides on the fee mechanism and levies a fee. This fee is adjusted depending on how the market reacts. If there is no reduction in pollution, the fee is raised until a change in the right direction occurs.

The fee collected is fully or partly returned to the economy as a stimulus dividend to consumers. Consumers are free to spend the money how they wish, but thanks to the fee, products using the polluting element are more expensive. This stimulates producers to purchase alternate, green technologies and services.

As these services become competitive, the demand for the pollutant based solution declines, but at a pace that actor invested in the substance can develop alternatives and retain economic stability.

## Phosphorous

This element belongs to the category of recyclable but scarce. Phosphorous is finite and like oil it will peak sooner or later. In his frightening book Eating Fossil Fuels [1] Dale Allen Pfeiffer shows that conventional agriculture is as oil-addicted as the rest of society. A decline in oil production raises questions about how we will feed ourselves.

In the same way, agriculture is addicted to mined phosphates [2]and would be threatened by a peak in phosphate production. As the U.S. Geological Survey (USGS) wrote in summary on phosphates (PDF) [3]: There are no substitutes for phosphorus in agriculture.

Fortunately, phosphorus - unlike oil - can be recycled. Responses to a phosphorus peak include re-creating a cycle of nutrients, for example, returning animal (including human) manure to cultivated soil as Asian people have done in the not-so-distant past[4].

As can be seen in the diagram below, phosphorus enters the supply chain in most countries through import as it is mined in just three main places. Phosphorus is an essential component of fertilizer and is applied in agriculture. Some leaks into the surface water and into rivers and eventually into the sea. Once in the sea it is difficult to recover and return to agriculture. It remains in the supply chain in food until it is excreted as urine and taken care of by sewage treatment plants. Inevitably, phosphorus leaks into the sea stimulating among other things algal blooming. This problem is especially prevalent in the Baltic Sea area, creating problems for the fishing industry and damaging the tourist industry by closing beaches.

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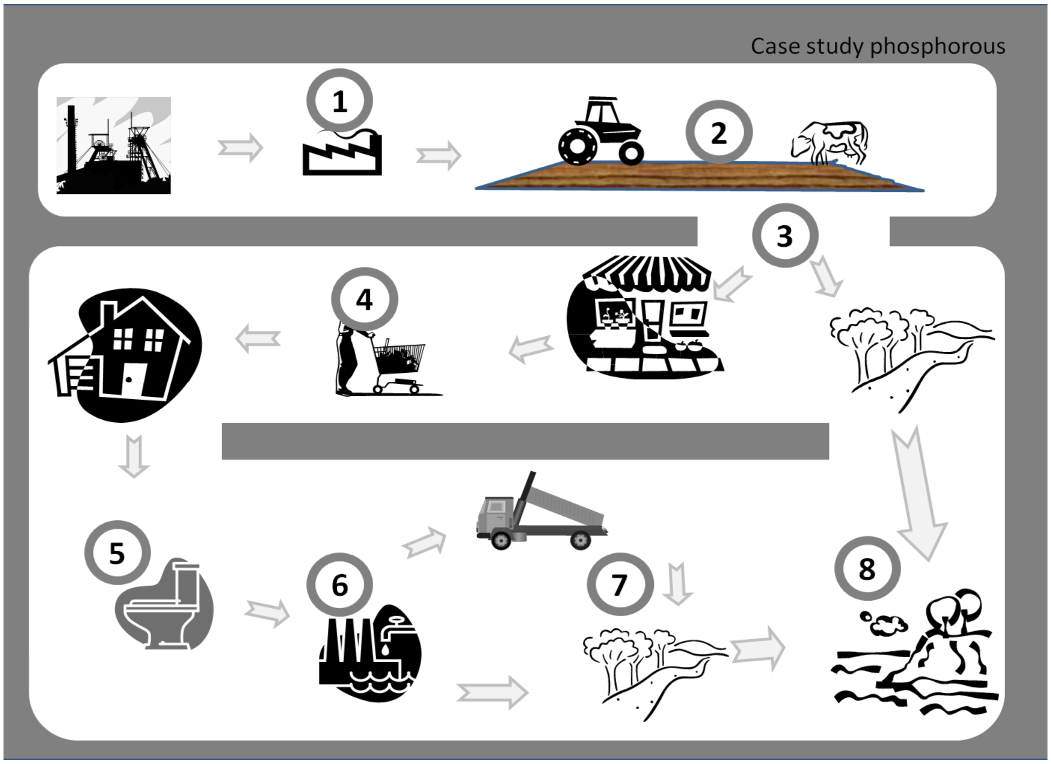
1 http://www.amazon.com/Eating-Fossil-Fuels-Coming-Agriculture/dp/0865715653

2 Abelson, Philip H. "A Potential Phosphate Crisis." *Science*. 26 March 1999: Vol. 283. no. 5410, . 2015.

3 http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/phospmcs07.pdf

4 F.H. King. Farmers of Forty Centuries: Organic Farming in China, Korea and Japan , Dover Publications, NY, 1911 (ed. 2004)




1. Phosphorus is mined and processed into fertilizer along with other nutrients like potassium and nitrogen.
2. Applied to the fields, it is incorporated into vegetables and sold direct or into animal feed.
3. Phosphorus leaks from agriculture into waterways and is exported to shops as food.
4. Consumers purchase food for consumption.
5. Phosphorus leaves the body mainly as urine.
6. Sewage is processed at water purification plants.
7. Some phosphorus is dumped as waste from purification, some ends up in waterways.
8. Eventually phosphorus travels to the sea where it is in principle unrecoverable.

As phosphorus supplies are finite, it would be beneficial to the national economy to encourage recycling - lack of supply will cause food price hikes. It would also reduce damages to waterways and sea ecology.

Using the Höglund approach we go through the main steps to construct the fee mechanism:

| | |
|---|---|
| Identify system boundaries: | **Entry:** import of phosphorous in fertilizer and as minerals as well as in food.<br><br>**Exit:** release from water treatment plants, leakage from agriculture, release from homes not connected to sewer system. |
| Plan reasonable phase-out of emissions over time: | **Some of the issues that might inform the decision:** small amounts of leakage may be tolerable from a waterway ecology viewpoint. On the other hand, dependency should be cut to protect long term viability of the food industry. The technology for recycling phosphorous is widely available. Based on this a zero emissions target could be achieved in say 30 years, with the aim to reduce emission by half within ten. |
| Set up fee mechanism: | Initially, a fee charged bimonthly on imports of phosphorous-containing compounds for agricultural use. Imported food contains phosphorous – and so does exported food, factors to consider. |
| Set up redistribution: | **Issues for consideration**: As food price stability is central to the transformation, redistributing the money via general alleviation of personal taxes could be brought about. More disposable income gives more money to spend on food.<br><br>The current sewage infrastructure stems from designs of the 1800s. Massive investments are needed to enable phosphorous recycling. Some fee income could be used to stimulate development in this area. |
| Monitor market behaviour: | **Things to look for:** that the fee is sufficiently high to encourage firms with low abatement costs to change operations. Areas where abatement costs appear prohibitive. Monitoring import of food and other ways for phosphorous to enter the country and affect the competitiveness of home grown food.<br><br>Making sure food prices do not affect inflation. |

Using this approach we might arrive at the following:

A fee is levied on phosphorous import nationally. This means classes of goods, identified by their commodity codes, that contain phosphorous would be taxed, for example:

- Fertilizers
- Food

As estimates put the availability of phosphorous at 30 years, a 20 year phase-out time might be deemed reasonable.

At the same time, release of phosphorous occurs in human and animal urine. Here a fee might be needed if a market for phosphorous containing soil additives from urine did not arise.

The authority sets the fee and monitors imports and emissions. It returns the money to taxpayers via a monthly tax rebate, for example. If imports rise or do not fall to any significant extent at the next round the authority raises the fee. This continues until market behaviour shows a decline.

There should also be an increase in sales of, for example, organic food, which should become more competitive. It is important that food prices do not drive inflation. However, with organic food production favoured, and more money in the pockets of consumers we can expect that food prices can remain stable.

Authorities need to monitor emission of phosphorous to waterways and phosphorous burden on waste water treatment.

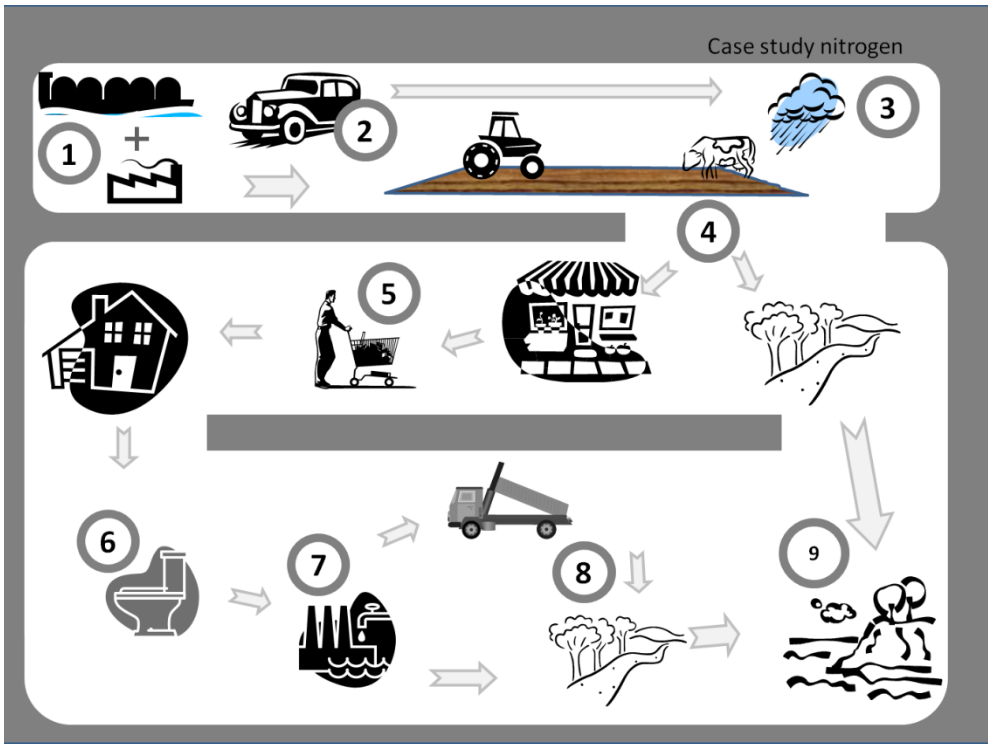
We would hope to see a market for phosphorous-rich products like urine. Entrepreneurs might start to offer urine-separating toilets with special collection facilities. This would be especially interesting if fees on direct release of sewage were increased as indicated earlier.

As the market for recycling develops, there should be a decrease in emissions to water and a decrease in the burden to waste-water. This reduces water treatment costs and should result in lower taxes.

## Nitrogen

Nitrogen is interesting because it is abundant, is in the air and is brought into the soil by plants and lightening. The main sources of pollution in nature are from industry and combustion engines (possibly around a fourth of all nitrogen pollution) and agriculture (3/4). Like the first two pollutants, nitrogen is an essential element of the living system. Unlike the others it is in abundant supply – presenting new challenges for fee-based regulation.

The diagram below illustrates the flow of nitrogen through our communities.




1. Natural gas is combined with various minerals and nitrogen from the air to create fertilizers for the agricultural industry.
2. Combustion engines and industrial processes combine nitrogen from the air and release nitrogen gasses into the atmosphere.
3. Nitrogen compounds in the air return to earth.
4. Nitrogen in food is transported for sale. Some leaks to watercourses from the fields.
5. Food is consumed and nitrogen exits the body.
6. Nitrogen travels through the sewer system.
7. Water purification plants release some nitrogen to natural watercourses; the rest is dumped where it leaks slowly into groundwater.

8. Nitrogen flows via natural waterways into the sea.

9. In the sea, excess nitrogen contributes to eutrophication.

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| Identify system boundaries: | **Entry:** N combines in combustion engine and industrial process to form gasses. Also taken from air to create fertilizer. Enters country in food, too.<br><br>**Exit:** release from water treatment plants, leakage from agriculture, release from vehicles and industrial processes |
| Plan reasonable phase-out of emissions over time: | **Some of the issues that might inform the decision:** small amounts of leakage may be tolerable from  a waterway ecology viewpoint. The technology for recycling is widely available. Based on this, a zero emissions target could be achieved in say 30 years, with the aim to reduce emission by half within ten. |
| Set up fee mechanism: | Initially, a fee charged annually on all combustion engines and industrial processes that remove nitrogen from the air. Fee could be charged on import of food. |
| Set up redistribution: | **Issues for consideration**: As food price stability is central to the transformation, redistributing the money via general alleviation of personal taxes could be brought about. More disposable income gives more money to spend on food.<br><br>The current sewage infrastructure stems from designs of the 1800s. Massive investments are needed to enable nitrogen recycling. Some fee income could be used to stimulate development in this area. |
| Monitor market behavior: | **Things to look for:** that the fee is sufficiently high to encourage firms with low abatement costs to change operations. Areas where abatement costs appear prohibitive. Monitoring import of food and other ways for nitrogen to enter the country and affect the competitiveness of home grown food.<br><br>Making sure food prices do not affect inflation. |

The mechanism might be applied to nitrogen as follows:

A fee would be place on substances entering the country with high levels of nitrogen in them, these would include

- Fertilisers
- Foods

It would be of interest to explore putting a fee on combustion processes that converted atmospheric nitrogen to NOx. These include

- Combustion engines
- Industrial processes
- Artificial fertilizer production in the country

Import fees could be changed regularly. However, as cars last for many years, the fee would need to be changed every year to cover that year's model range.

Again, monitoring is needed to check imports and to see how emissions directly to waterways respond. There is also a good source of nitrogen in urine and with fees on imported nitrogen rising, recycling would be encouraged by the price pressure.

Some monitoring of the vehicle industry will be needed to see how quickly technical progress reduces NOx.

**A simulation**

It might be helpful to try a thought experiment to see how the nitrogen and phosphorous flexible fee might be introduced in practice.

**Introduce a fee at fertiliser and food import**

A suitable point early in the supply chain could be levied on import of fertiliser. At the same time, the amount of food (and thereby nutrients) is large and a similar import tax should be put on food, possibly with the exception of organically labelled food.

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| Likely effects:<br><br>Key figures: total sales of food in shops and to public sector is 36 Billion SEK/yr[5]<br><br>(food purchase by restaurants and hotels not included)<br><br>Total import of chemical fertilisers is 730 000 000 kg[6]<br><br>At 2- 20 SEK a kilo the total market value is 1.5 -15 Billion SEK/yr<br><br>Note that latrine-based fertilisers introduced in the early 1900's would at today's prices be equivalent to 230kr/kg. |

[5] SCB, Statistics Sweden

[6] Jordbruksverket, the Swedish Ministry of agriculture

**A fee of 100% would raise food prices significantly**

Some estimates put the total cost of fertilisers at 25% of total food costs

For Sweden, estimates by IVL say that a 15-20% increase in bread prices coming from a 100% increase in fertiliser prices would trigger investment in alternatives. This is inline with estimates that puts organic food 15-300% more expensive than conventional food that uses artificial fertiliser.

**A dividend back to the public would mean no net increase in food costs**

An import fee of 100% would not, however in effect make food more expensive if the fee were to be paid back to taxpayers through a general tax dividend. Food costs as percentage of monthly costs would increase, but so would disposable income.

**Organically-produced food would become more competitive**

Organically produced food would become more price competitive. Add to this that demand for organic, recycled fertilisers would increase, and technology for capturing nitrogen and phosphorous from waste would become more attractive.

**Three scenarios indicate how technology might respond**

Scenario possibilities

1) Imports continue. The fees are raised but no change in import. This would mean that there was no business case for introducing green technology. Should this happen more government intervention would be needed in investment in technology.

2) Already at a 15% gross increase in food prices, investment in green practices accelerates. Approaches include both organic agriculture but also bionutrient recycling. Emission to watercourses decline, reducing municipal water treatment costs. Many Swedish green tech companies thrive and become more competitive internationally. [7]

3) New cheap sources of phosphorous are discovered, making raised fees ineffective. Fee setting moves to fee on agricultural land (to compensate run-off) and toilets ( to encourage recycling).[8]

[7] Of the 1,095,000 tons of N reaching the Baltic(1996 figures), some 11% or 120,000 tons come from Sweden. Together with P emissions, Sweden emits 122,880 tons. This is equivalent to some 16% of all import of chemical fertilizers are released into the Baltic. Half of all emissions are anthropogenic.

[8] A good reference for total emissions burden on Sweden is http://www.smed.se/wp-content/uploads/2011/10/SMED-56-2011.pdf

4) Fossil fuel price increases drive the cost of fertiliser and food. Having introduced the phase -out strategy, Sweden is well prepared to meet the challenge of nutrient recycling.

**Several existing green technologies would be favoured**

Some thoughts on available technology

- Using computer technology to reduce waste when applying artificial fertilisers
- Domestic urine separation and collection by farmers
- Collecting all biowaste and converting it to compost instead of incinerating it[9]

**Notes on the Höglund mechanism applied to phosphorous and nitrogen:**

**The mechanism works to engage market behaviour to reach system behaviour goals**

In this case, reaching independence from mined phosphorous and stimulating recycling are handled by market forces. There is no need for local authorities to enter into expensive end of pipe clean up measures.

**The mechanism is a form of control engineering, using feedback mechanisms and control signals**

The change to independence is controlled. This makes sure that for example food prices remain stable and that industry has time to change to, for example, recycling. The control mechanism ensures that policy does not nullify investment or create rapid bankruptcies but rather engages the force of the market in a positive way to change at the pace technical development allows. It also creates a market "pull" for innovation.

**The mechanism is concentrated on ensuring that society functions for the long-term benefit of citizens**

By putting into place the control, feedback and stimulus in appropriate places in the supply chain, the mechanism succeeds in stimulating the change of behaviour to satisfy economic, environmental and social goals.

**Höglund's method is potentially popular as it is fair and puts money in people's pockets**

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[9] Phosphorous recovery has been investigated as a possibility for Sweden, see the report http://naturvardsverket.nu/Documents/publikationer/620-5221-7.pdf

As people who use the product that pollutes are also the ones who pay increased costs due to fees, and as the fees return to taxpayers, the mechanism can be seen and being fair and positive. Thus, it would be easy politically to introduce it.

**Discussion on import and export**

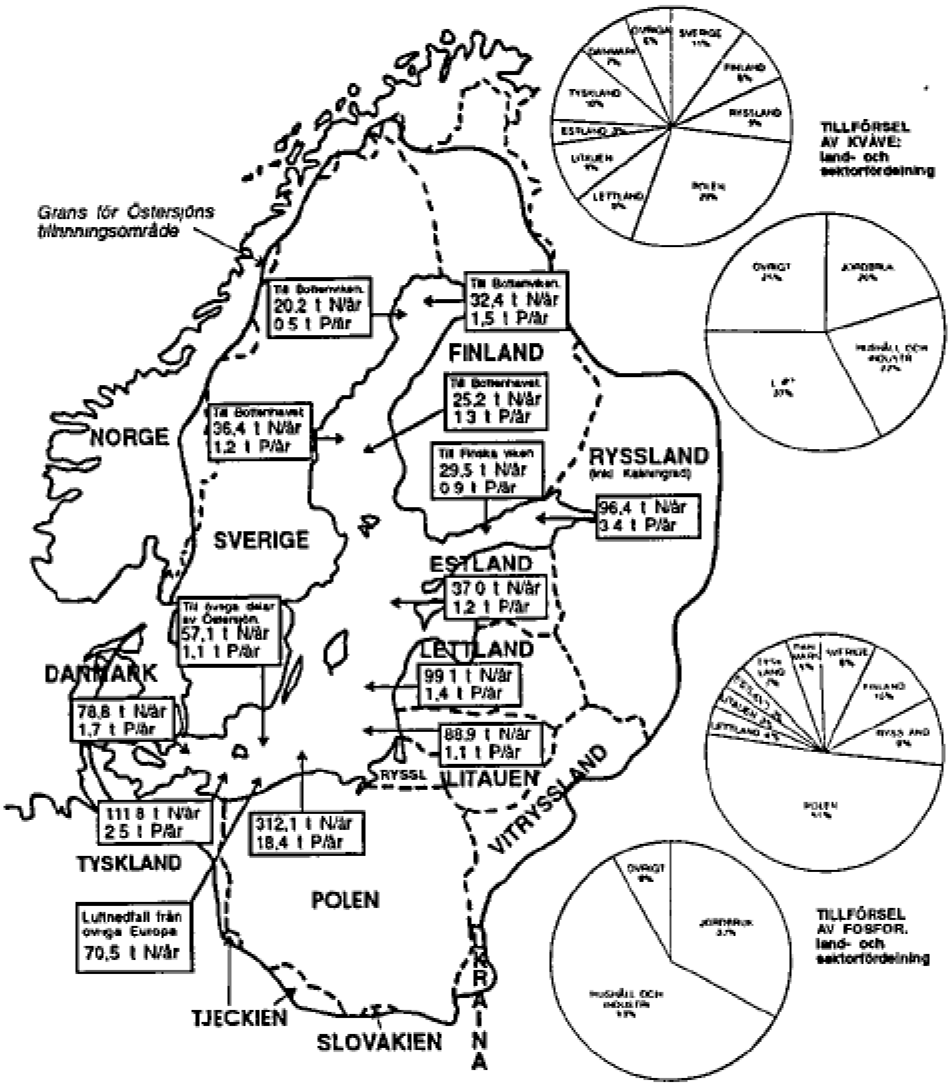
Many have asked if placing import duties on imported fertilizer or food might affect trade, or even be unfair. The answer is that Swedish nature is very sensitive to acidification and Swedish soils are, with some exceptions, rather poor. It is incumbent upon authorities to protect nature if the conditions are so.

By building up organic agriculture, Swedish food exports will become more competitive as prices in other countries rise due to phosphorous shortages.

Phosphorous balance is very important. The same amount of phosphorous needs to remain in the country recycling. With sources of rock phosphorous limited it is plausible that fees and controls are put in place to ensure the same amount of phosphorous is imported as exported.

Appendix: Figures for Sweden and the Baltic sea

*Figur 1* **Östersjöns tillrinningsområde och tillförseln av kväve (N) och fosfor (P) till havet, tusentals ton per år**




http://www2.ne.su.se/ed/pdf/24-8-tsimgfw.pdf


Fig 1. Samtliga källors relativa bidrag till de svenska utsläppen av kväve.
Rödmarkerad källor beror på mänsklig påverkan, övrigt är naturligt läckage.
Total nettobelastning ca 121 000 ton N/år (flödesnormerat 1985-2006)
Naturlig belastning ca 60 000 ton N/år (50%)
Källa: Naturvårdsverket 2008, Rapport 5815. Grafik: Lars Sonesten SLU


Fig 2. Samtliga källors relativa bidrag till de svenska utsläppen av fosfor.
Rödmarkerade källor beror på mänsklig påverkan, övrigt är naturligt läckage.
Total nettobelastning ca 3 550 ton P/år (flödesnormerat 1985-2006)
Naturlig belastning ca 2 000 ton P/år (56%)
Källa: Naturvårdsverket 2008, Rapport 5815. Grafik: Lars Sonesten SLU