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for Nature Conservation

Leibniz Institute of
Ecological Urban and
Regional Development

The Biodiversity Existence Value of German Ecosystems based on Total Restoration Cost per Habitat Point

International online workshop
Economic Valuation of Biodiversity Wealth and Debt in National Accounting
20/21 November 2023

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Spatial representation of our results

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Biotope value points and monetary value of biodiversity aggregated to CLC-classes

	Physical value (biotope value points per hectare)	**Monetary stock value** of ecosystem contribution to national biodiversity (thousand euros per hectare)	**Monetary benefit flow** Annuity of stock value, calculated for infinite period and 3% discount rate (euros per hectare per year)
	1 - 2	3.6 - 7.3	109 - 218
	> 2 - 6	> 7.3 - 21.8	> 218 - 654
	> 6 - 8	>21.8 - 29.1	> 654 - 872
	> 8 - 10	>29.1 - 36.3	> 872 - 1090
	>10 - 11.8	>36.3 - 42.9	>1090 - 2186
	>11.8 - 12.3	>42.9 - 44.7	>1286 - 1341
	>12.3 - 13.3	>44.7 - 48.3	>1341 - 1450
	>13.3 - 16.1	>48.3 - 58.5	>1450 - 1755
	>16.1 - 17	>58.5 - 61.8	>1755 - 1853
	>17	>61.8	>1853

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Ecosystem contribution to national biodiversity measured by „Biotope Value Points“ from the National Compensation Ordinance

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Biotope Value Points per hectare from the ecosystem list of the National Compensation Ordinance

based on criteria like:

- naturalness
- age of an ecosystem
- occurrence of endangered species
- threat to the ecosystem type itself

used like ratios (can add or divide)

for defining the extent of compensation measures

➢ Delivering **numbers between 0** (paved ground) **and 24** (intact peat bogs, old (semi-) natural forests) ***for more than 1000 ecosystem (condition) types***

attributed to

Comprehensive and consistent system of nation wide data on ecosystem extent and condition based on:

- Satellite data of the German Land Cover Model LBM-DE, compatible with Corine Land Cover data
- Land use and agricultural land use data from the Federal Statistical Office
- Line based cadastre data for hedges, tree rows, streams, paths, traffic lines etc.
- Federal Forest Inventory
- Reporting on the EU Habitats Directives, Water Framework Directive and Marine Framework Strategy Directive
- Monitoring of High-Nature-Value farmland

- about 300 different ecosystem (condition) types

area weighted aggregation

One physical number (similiar to dBA, Bq or CO2 eq) **for the contribution of ecosystems to nature conservation and a proxy for the (physical) biodiversity wealth of Germany**

Choosing appropriate pricing alternatives

	Pros	Cons
Costs or prices from compensation markets	Market (near)	Can differ significantly due to reasons unrelated to biodiversity (was a caterpillar already at place?) Survey data on market prices will not be available before the end of 2024 No or limited availability of market prices in other countries
Willingness to pay (CV or Choice Experiments) for restoration measures	Reflects individual preferences CV data for a comprehensive set of measures to stop biodiversity decline are available	Validity of CV and CE studies highly controversial
Costs for restoration measures	Detailed estimate of costs to reach the goals of the European Habitat Directives is available	Can over- or underestimate individual preferences Political price that must correspond to individual preferences in order to be acceptable as a simulated market price

We took restoration costs as the basis to calculate biodiversity values

and

compared the results with willingness to pay from CV studies.

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What are the costs of providing additional biotope value points or compensating for lost biotope value points?

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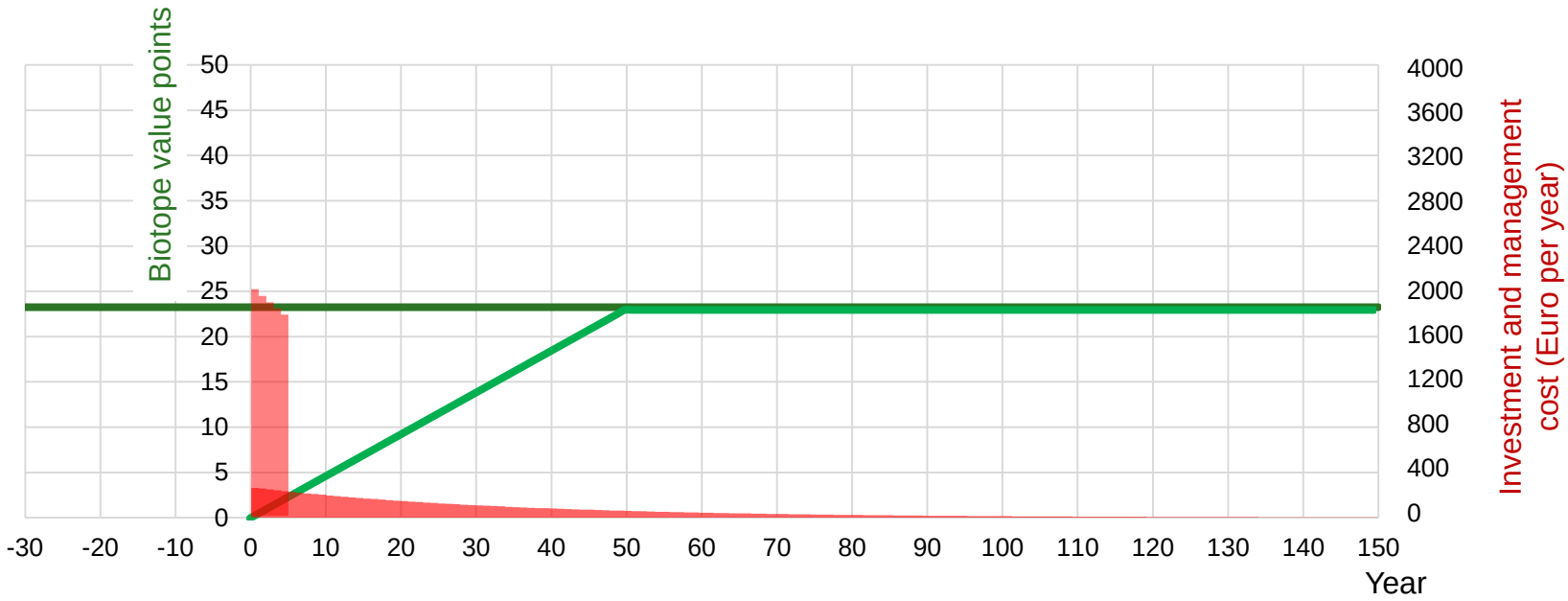

Simple restoration cost can express only a part of the value of an existing ecosystem

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Three ways to calculate cost of total restoration

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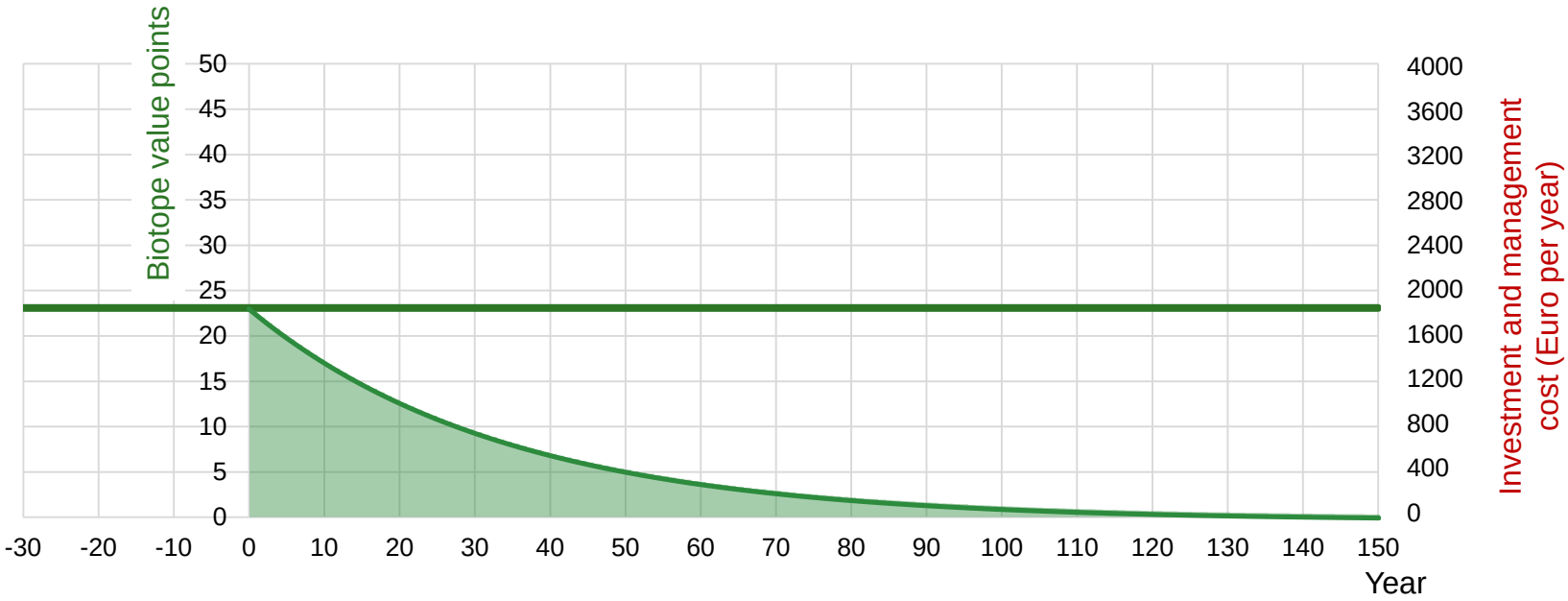
A) Increasing the extent of restoration so that it generates the same amount of discounted future biotope value points as the existing ecosystem

First step: **Discounting future biotope value points of existing ecosystem to calculate their present value**

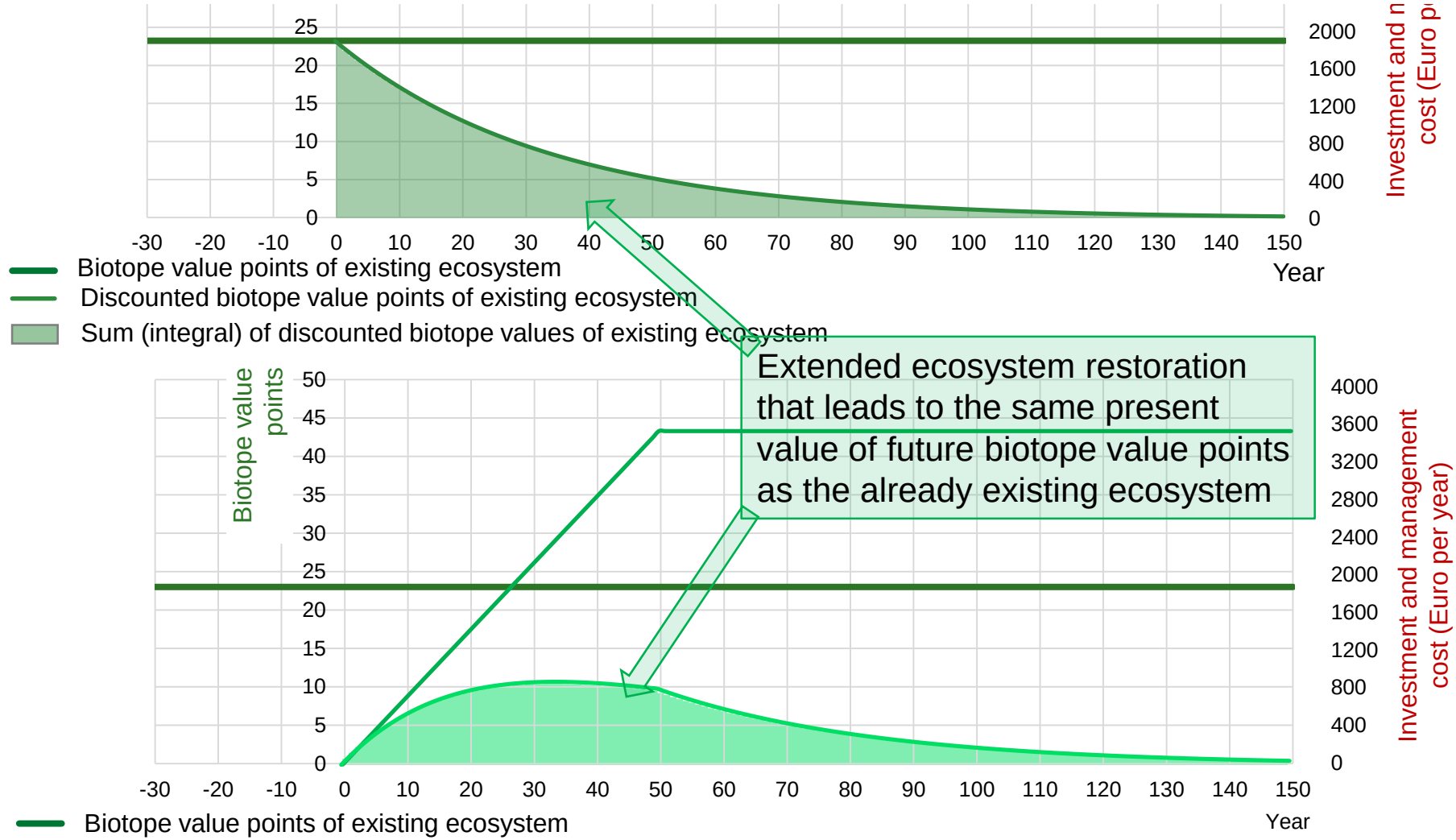


Biotope value points of existing ecosystem

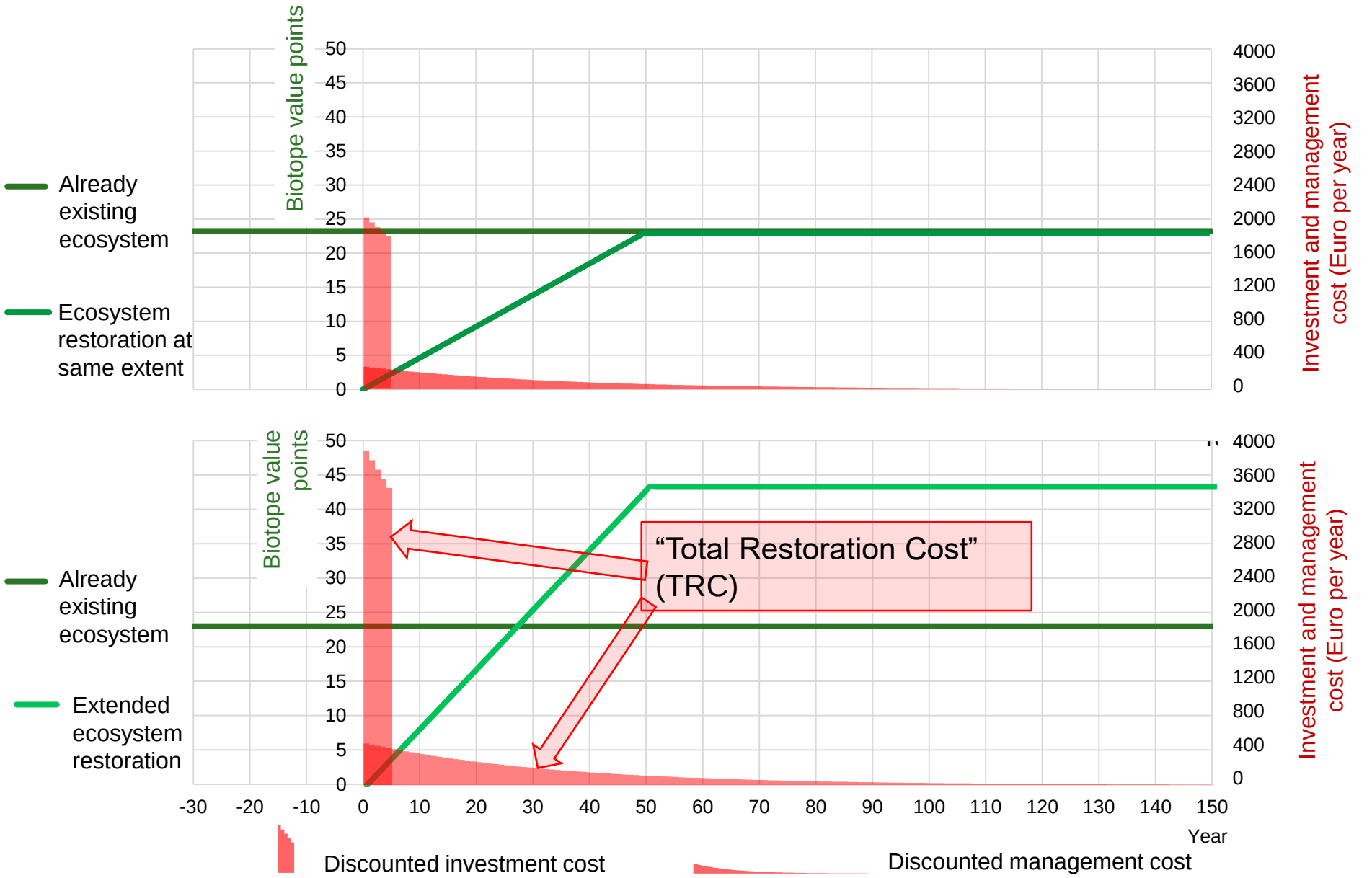
Discounted biotope value points of existing ecosystem

Sum (integral) of discounted biotope values
(present value of future biotope value points)

Second step: Determining increase in ecosystem restoration that yields in the same discounted future biotope value as existing ecosystem



Third step: Comparing cost of extended restoration with restoration at same extent



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Ways to calculate cost of total restoration

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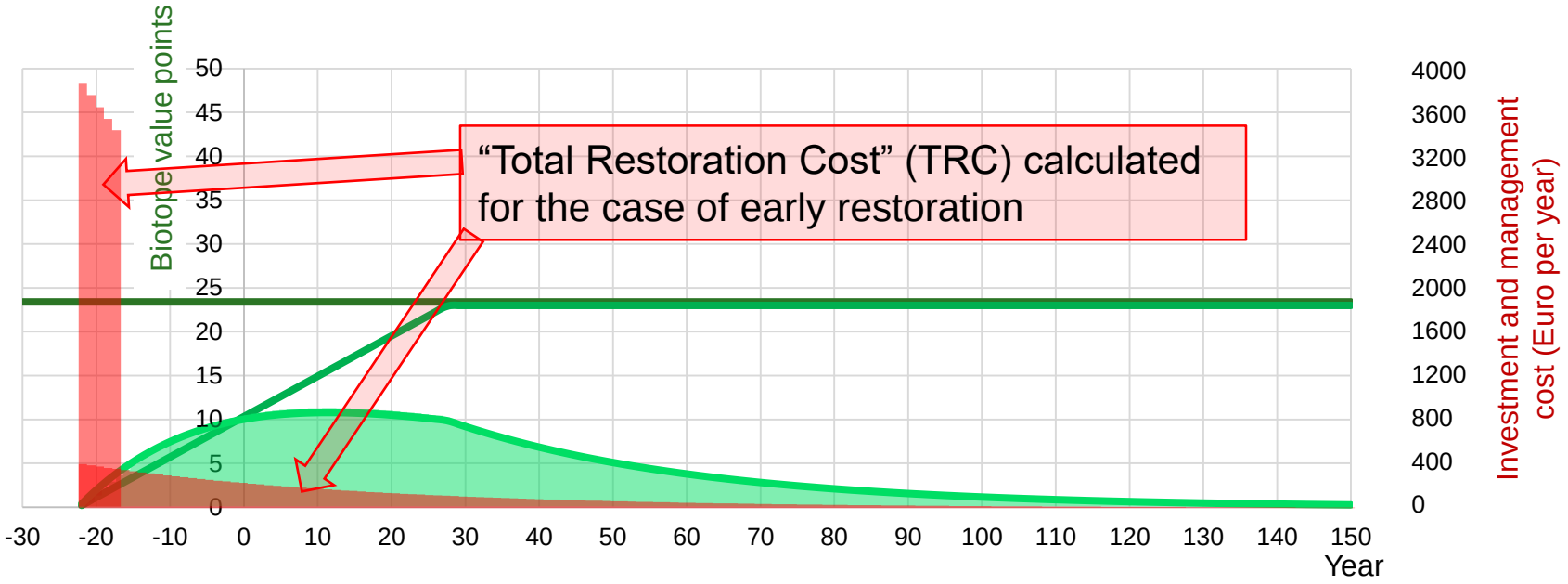
(B) Early restoration at same extent



- Biotope value points of existing ecosystem
- Biotope value points of early restoration
- Biotope value points of early restoration compounded / discounted to year „0“
- Investment cost compounded / discounted to year “0”
- Management cost compounded /discounted to year “0”
- Sum (integral) of biotope value points compounded / discounted to year “0”
  (same value as discounted future biotope points of existing ecosystem)

TRC calculated for the case of extended restoration and for early restoration are of the same value.

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Ways to calculate cost of total restoration

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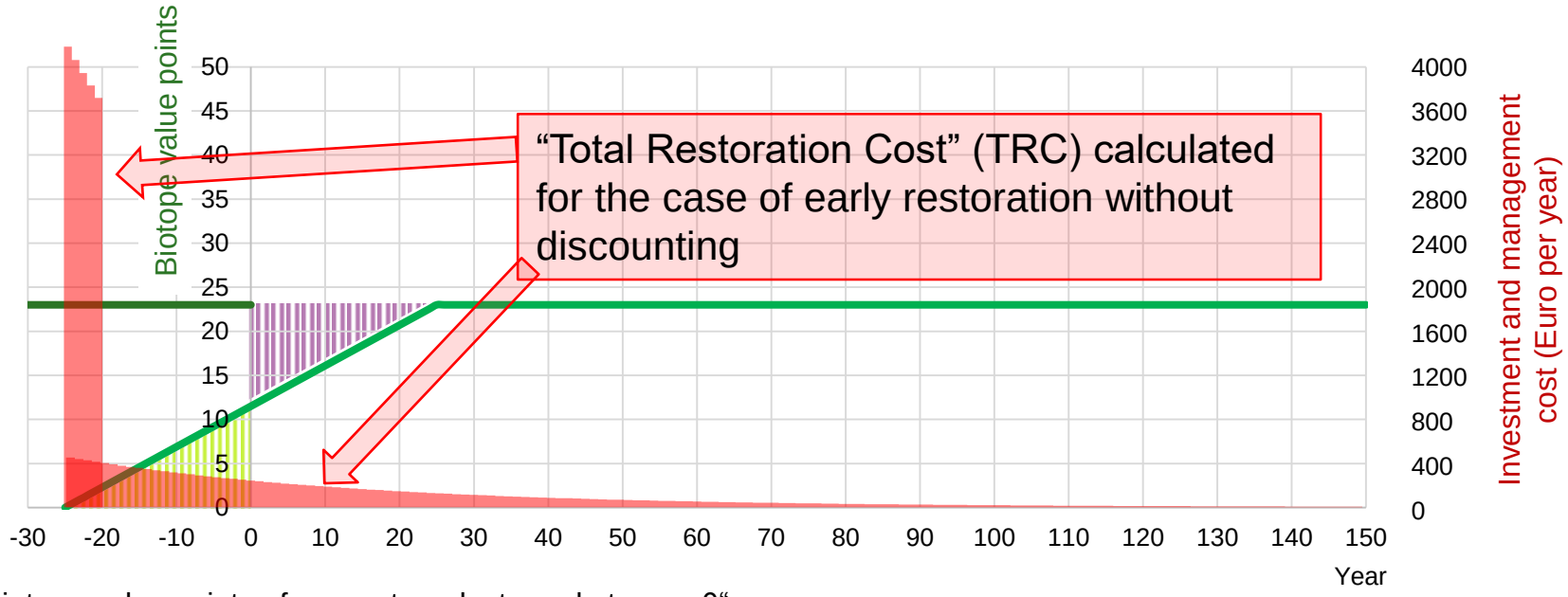
(C) Early restoration at same extent so that the loss of an already existing ecosystem is completely compensated by undiscounted net losses and net gains of biotope value points during development time



Biotope value points of ecosystem destroyed at year „0“

Biotope value points of early restoration

Net-loss of biotope value points after destruction

Net-gain of biotope value points before destruction

Investment cost compounded / discounted to year "0"

Management cost compounded /discounted to year "0"

TRC calculated for early restoration here is a little bit higher than TRC for the two cases before where future biotope value points were discounted

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Does TRC make a difference when compared to restoration cost at same extent?

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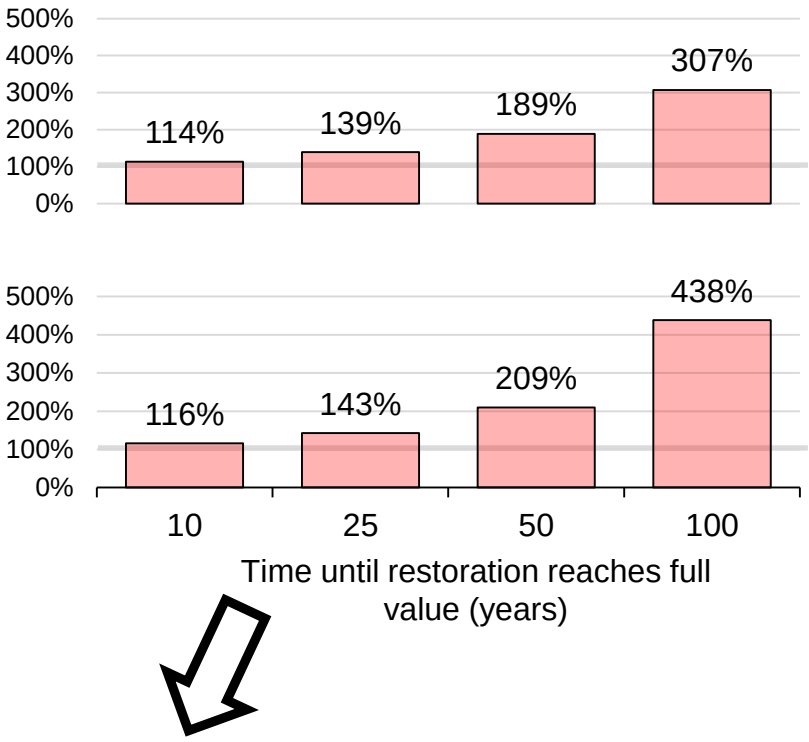
Value of biodiversity of an already existing ecosystem as **percentage** of the present value of investment and management cost of an ecosystem **restoration at same extent**

Additional extent or early restoration with compounding and **discounting** biotope value points

Early restoration weighing out **undiscounted** biotope value loss and gain



substantial differences even at short development periods

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High differences in cost of restoration measures per biotope value point within and between ecosystem types

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⇨ Calculation of mean TRC per biotope point

Target ecosystem		Source ecosystem		Restoration						Cost per biotope point
	Biotope value points per hectare		Biotope value points per hectare	Time to reach the target (years)	Additional biotope value points after reaching the target *	Additional biotope value points during restoration and after reaching the target, discounted to the begin of restoration **	Investment cost (euros per hectare)	Annual management cost and/or compensation for restrictions (euros per hectare per year)	Present value of investment and management cost (euros per hectare)	Present value of investment and management cost per additional discounted biotope value point (euros per hectare)**
Coastal dunes with Calluna Vulgaris	22.00	Meadows and pastures	10.00	100	12.00	3.83	13,650	0	13,650	3,563
Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	18.00	Natural eutrophic lakes	15.00	80	3.00	1.14	20,116	921	50,808	44,517
Active raised bogs	25.00	Degraded raised bogs	17.00	150	8.00	1.78	30,460	0	30,460	17,110
Stellario-Carpinetum oak-hornbeam forests	25.00	Mixed deciduous forest of moist to fresh sites (age: 10-40 years)	19.00	100	6.00	1.28	0	83	2,750	2,154
Species-rich non-intensively used cropland	13.75	Normal cropland	6.00	3	7.75	7.21	0	634	21,120	2,929
...										**...**
In total 43 different types of future restoration measures to fulfil the aims of the European Habitat Directives covering 1.16 million hectares, which is 3.2 % of German land cover										
...										**...**
									Surface area weighted mean value (euros per hectare):	**3,634**

* A linear increase in value is assumed; ** 3% discount rate, infinite calculation period

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Influence of discount rate and calculation period on mean value of TRC per biotope point

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	Calculation period (years)		
Discount rate	**infinite**	**50**	**25**
0.02	4,721	3,556	2,802
0.03	3,634	3,178	2,667
0.04	3,099	2,900	2,555

Average monetary value per biotope value point per hectare in Euro

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Difference between
- price paid for biodiversity and
- value of ecosystem service to provide biodiversity

Total restoration cost (TRC) are the price for a ecosystem restoration that provides biodiversity which is equivalent to the biodiversity provided by an already existing ecosystem.

⇨ **TRC thus is a price for biodiversity** *(not for biodiversity services)***.**

Biodiversity, however, depends not only on the type and condition of an ecosystem but, in some cases, also on annual or periodic management measures.

In such cases biodiversity is a co-product of the biodiversity services of an ecosystem on the one hand and human management on the other hand, very similar to agricultural products which are also a co-product of the inputs from the farmer and the biomass provisioning services of the ecosystem. In consequence, the value of the biomass provisioning service is measured as the price of the product minus price of human inputs and thus is close to the agricultural land rent.

⇨ Therefore it is supposed that **the asset value of the biodiversity services** of an existing ecosystem **should be measured as „TRC minus present value of future management cost of the assessed existing ecosystem“.**

This would be a definition consistent with the valuation of the biomass provisioning services of agricultural land. It would also allow to interprete the value of biodiversity services as rents of ecosystems with high biodiversity services similar to agricultural land rents.

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Biodiversity services asset value in the case that restoration does not require investment

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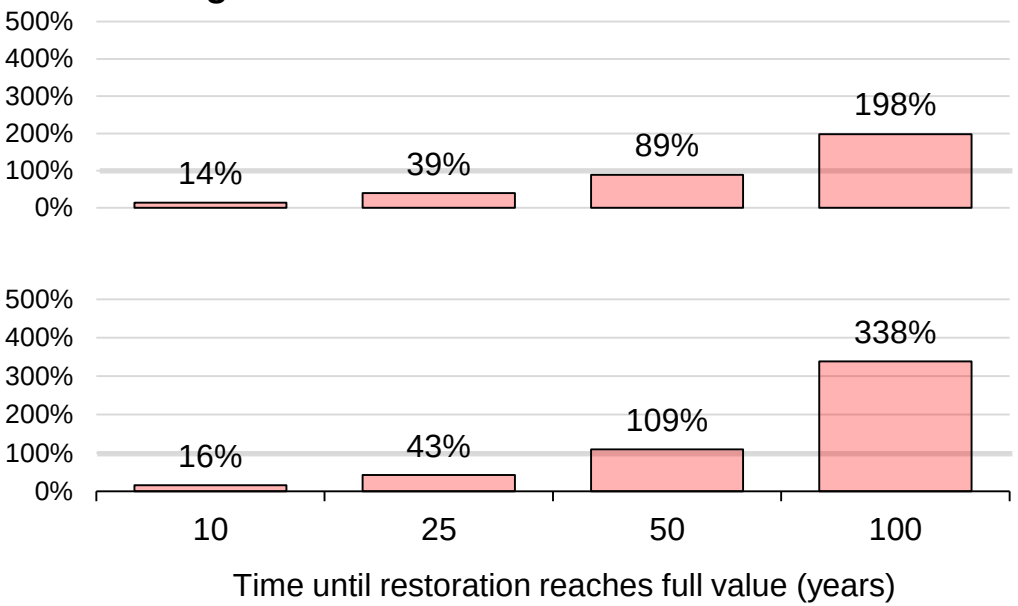
Asset value of the biodiversity services of an ecosystem where restoration causes only management cost expressed as:

percentage of the present value of future management cost

Additional extent or early restoration with compounding and **discounting** biotope value points

Early restoration weighing out **undiscounted** biotope value loss and gain



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Biodiversity benefit flows and ecosystem services for selected ecosystems compared with provisioning services, land rent, and sales values

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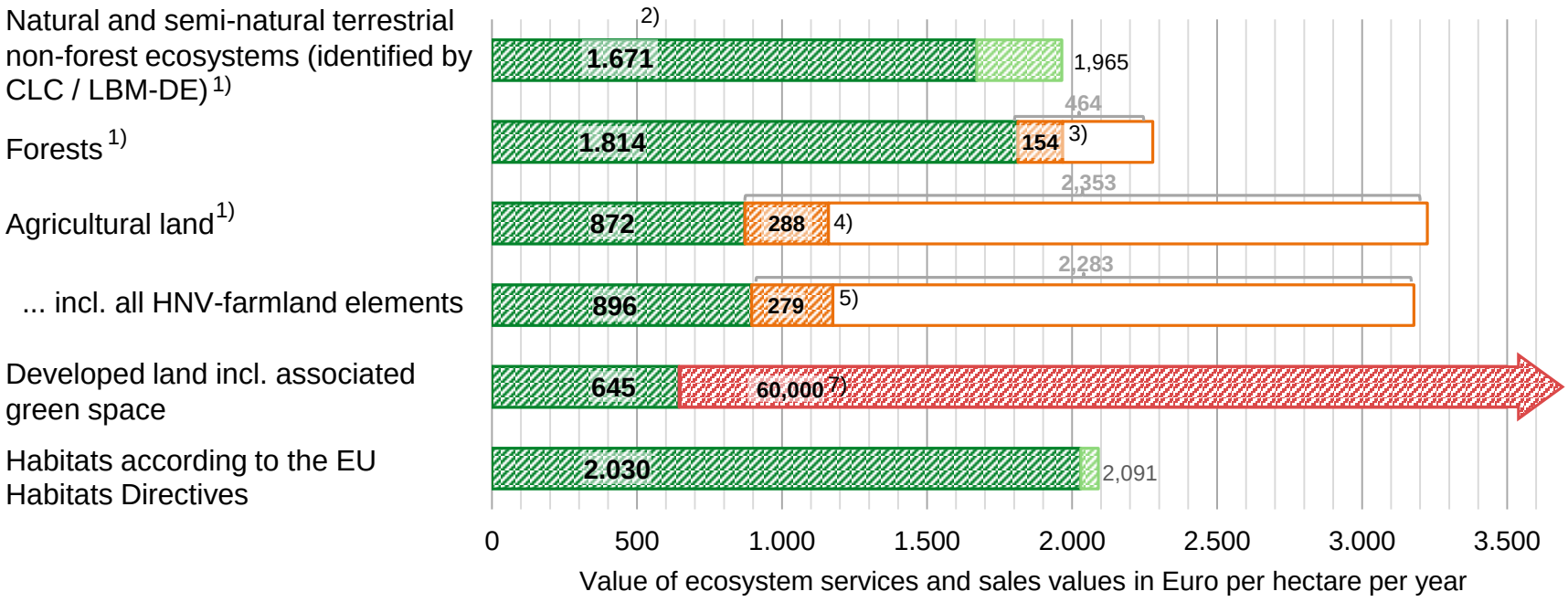
Assumption: return of 3% per year on asset value

(mean values per hectare by 2018 in euros)



Monetary value of biotope points (annuity), incl. management cost **(biodiversity value)**

Monetary value of biotope points (annuity) less average habitat management cost **(biodiversity service value)**

Sales value of agricultural products, timber sales 6)

Value of the provisioning service (timber, agricultural products) accounted as net profit of forestry and agricultural land rent

Annuity of price for land ready for construction (proxy for urban land rent)

Footnotes to the previous slide

1) Including habitats according to the EU Habitats Directives
2) Monetary values of biotope points according to Hirschfeld et al. 2020
3) Profits from forestry operations, timber sales: BMEL 2022b, StBA 2021f (cf. Table 4.3-1)
4) Agricultural land rent, sales of agricultural products: BMEL 2021c, StBA 2021c (cf. Table 4.1-1),
5) Same as 4) corrected according to the larger area
6) In the case of marketed products the value of the ecosystem service is part of the value of product sales
7) Average sales value for 2018, according to StBA 2020b (200 Euro / m^2, interest rate for calculating the annuity: 3%). The value of a site for residential, commercial, industrial or similar use is the land value. Similar to ecosystem services, this value is the difference between the sales value of the final product (e.g., residential rent) minus the total anthropogenic inputs (development costs, construction costs, estate agents, etc.). The land value for real estate is thus calculated in a very similar way to the value of the ecosystem service.

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Specifications and rules of national and ecosystem accounting to which the described methodology of biodiversity valuation can be related

Specifications from national and ecosystem accounting	Corespondence to the method presented here
Prices from similar markets method (SEEA EA 9.33)	Prices from compensation markets are transferred to other ecosystems
Replacement cost method (SEEA EA 9.49)	Replacing an existing ecosystem by a restored one
Valuation of buildings and production facilities for which no market values exist, based on replacement costs taking into account the current condition	Measuring the biodiversity value of ecosystems based on restoration costs
Reporting the production value of owner-occupied properties on the basis of an imputed appropriate rental price	Conversion of the asset value of the biodiversity (services) of an ecosystem into a benefit flow n the basis of an imputed rate of return (here: 3%)

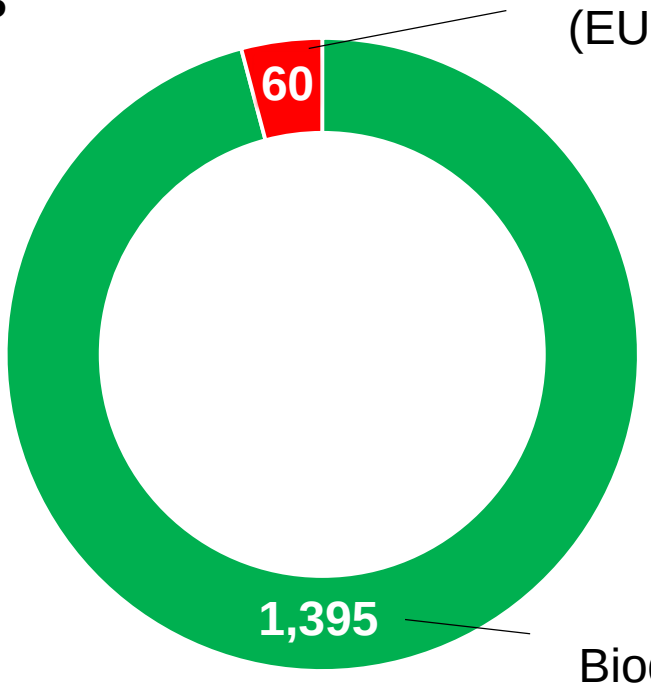
How can the values that are determined using the TRC method be interpreted?

Background	Interpretation of TRC values
Subjective value theory (change in GDP indicates welfare losses and gains)	The change in biodiversity values represents a conservative estimate of benefit losses and gains measured as prices paid for biodiversity, comparable to national income changes
GDP as a measure of the economic strength of an economy	Economic input required to restore biodiversity in the event of losses or required to increase biodiversity

TRC can be used to measure wealth and debt

Biodiversity wealth and biodiversity debt of Germany by 2018

(billion euros)



Biodiversity debt
(EU Habitat Directives only)

Biodiversity wealth

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Many thanks for your kind attention!

Burkhard
Schweppe-Kraft

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