**ECOSYSTEM SERVICE VALUATION**

**Valuing Omni-directional Services**

We assume that the rate of supply of a potential ecosystem service, *Si*, at a supply node is a linear function of the area of the supply node and the effect on supply of connectivity to other supply nodes (including connectivity to itself). The connectivity effect may occur through processes such as species dispersal that enhance population persistence, noting that this may commonly be a positive effects, but could also potentially be negative when considering disservices. We specify the rate of supply as

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where *Ai* is the area of focal node *i*, *α* ≥ 0 is the rate of supply for a single completely isolated supply node of unit area, *β* is the amount that the rate of supply of the potential ecosystem service changes per unit area of supply nodes that the focal node is connected to (i.e., the effect of connectivity on ecosystem service production), *Iij* is an indicator where *Iij* = 1 if there is an ecological-ecological link between supply node *i* and supply node *j* and *Iij* = 0 otherwise, and **S** is the set of all supply nodes.

Then, we assume a negative-exponential demand function that reflects the marginal utility of the ecosystem service () as a function of the quantity of the service used, such that

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where *U* is the utility, *Q* is the amount of the service used, *γ* ≥ 0 is the marginal utility of the service as the amount used tends to zero, and *η* ≥ 0 is the rate of exponential decline in the marginal utility as *Q* increases. Assuming that the densities of beneficiaries in all demand nodes are the same (i.e., the number of beneficiaries is proportional to area), then we can write down the aggregate demand function each demand node, *i*, as

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The value of the ecosystem service for a demand node, *Vi*, can then be calculated as the area under the aggregate demand curve between zero and the amount of the ecosystem service supplied to that node (Fig. 1) {Fisher, 2008 #4329}{Costanza, 1997 #1379}. For a non-rival ecosystem service (i.e., the service is available to everyone equally), the amount of the ecosystem service supplied to a demand node is the total amount of the potential service supplied in the supply nodes that the demand node is connected to. In this case, the value of the ecosystem service at a demand node is

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where the summation in the integral is the sum of the supply at each supply node the demand node is connected to (i.e., the aggregate supply available to demand node *i*). On the other hand, for a rival service, we assume that the supply from a supply node is shared among the demand nodes that each supply node is connected to in proportion to the relative areas of those demand nodes, so that the value of the ecosystem service at a demand node is

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where **D** is the set of all demand nodes.

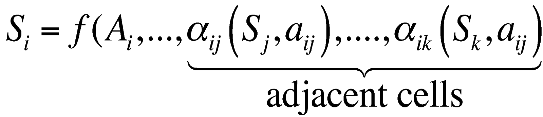


Fig. 1. Illustration of the approach used to value the ecosystem services.

**PREVIOUS STUFF BY RALF AT THE FIRST WORKSHOP**

Supply

The overall supply in a node I is given by the overall area of the cell and possible other site characteristics (such as land use intensity, habit suitability) as well as service supply through the connectedness of adjacent nodes.

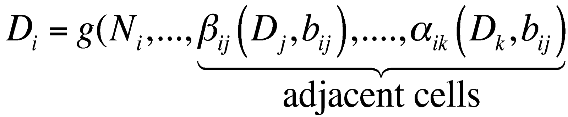


Examples: Consider *S* is be species richness, depending on the area A. A network of more habitat might bring other species in, but these could be the same species, which https://lh5.googleusercontent.com/VMWrOiJw3hBvFOrz20ySvonTvETwYbiQspdd64VGzHSHHa_CHfMlTFuFM2q7nt-Mjpe4kT349ptpjo3pjjoAwa-HmEk0hROqr5UOec3wQRJGAPEdeHRuZ6thu-mOdaCZJZKQA9GN has to correct for.

https://lh5.googleusercontent.com/VMWrOiJw3hBvFOrz20ySvonTvETwYbiQspdd64VGzHSHHa_CHfMlTFuFM2q7nt-Mjpe4kT349ptpjo3pjjoAwa-HmEk0hROqr5UOec3wQRJGAPEdeHRuZ6thu-mOdaCZJZKQA9GNdenotes the (material) flow of a service, while *aij* denote the strength of the link.

Demand

Similarly we define demand in a node *i* by

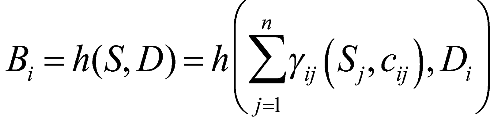


Demand might be mostly driven by population *N* but can change given communication with nodes either increasing or diminishing demands.

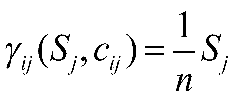
**Benefit**

Benefit *Bi* generated in a node is given by a utility function *h*, which relates demand *D* in a node with available resources.

The latter is calculated by the total resources available through the links to adjacent nodes corrected for certain conflict due to other demanding nodes taking away resources. All this is captured by the function https://lh5.googleusercontent.com/35gd3KW6M2Upz0veKG5rAHsuBJIYaZ2PaPq9iQF-QOd5aqZ1NT2BukRb1K9gxP6X1qP4BzAElgoQb8iX_8hrHEYPKY2yh_zm1gmk9lbk3mluMBDMO-XnsNpDjQof1INxft1s-Czj

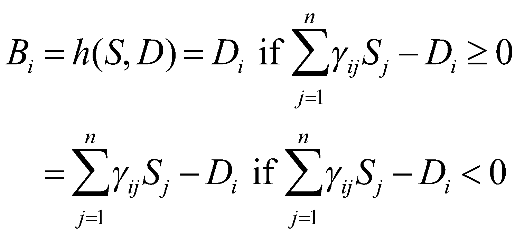


In case of non-rival resources, possible conflicting uses can be ignored. If *S* denotes the supply of a rival service we either follow a simple approach and correcting the flow from all *Sj* to *Si* just estimating the fraction of resources available giving the number of other conflicting demands

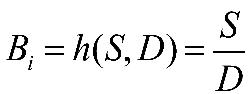
 where *n* is the number of demanding nodes. The more precise estimation however, results from the exact estimation how much resource are taken from that node, which require and iterative calculation estimating an equilibrium of resource distribution (mostly likely depending on the relationships of the *Nj*, *cij*, of the adjacent nodes.

Benefit functions

There are in general three options to estimate the benefit. In the 1st case if demand is met by supply, we assume a maximum Benefit. In all other cases, benefit equals supply.



Second we can calculate a ratio estimation the relation between supply and demand, which equals 1 if supply and demand is met.



In this case B could be increased even beyond demand (economic point of view) and would stimulate people using/demanding more. On the contrary, one could study what has the more impact: fulfilling benefit by either increase supply or by changing demand through introducing more connections between demand patches (more or less communication). Finally, we see, that if *D* decreased to zero this leads to infinite benefit, what was originally proposed by Siddharta Gautama (Buddha, 600 B.C.).

A third option of the utility function *h* is estimate the product of supply and demand at maximization the use

