Biosphere contribution to renewable resources in the Willamette Valley

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Winter 2018

INTRODUCTION

There are limits to growth. Good planning of land-use and regional sustainability requires having an understanding of the heterogeneous flows of renewable energy that support all life processes.

It can be very hard to compare different types of energy because they represent different densities and histories of process. Because they are not immediately comparable, they can not be combined to show the spatial distribution of renewable energy flows.

However, energy values can be adjusted based on how much the biosphere contibutes to their production. In the eMergy evaluation methods developed by HT Odum and expanded by others, flows, processes and materials are compared by their total required energy (or eMergy), measured in one linked unit such as solar energy. Solar eMergy is measured in 'solar eMjoules' (sej) and the concentration of flows of solar energy are measured in eMpower (sej/ha/ year). Any process can be described in terms of it's Transformity which is the ratio of total contributed energy to unit energy and measure in units such as solar eMjoules per joule (sej/j.) When multiple flows of energy are all adjusted by their transformity values, they can be readily combined.

OBJECTIVE

This project maps the total biosphere contribution density for renewable resources in the Willamette Valley, OR. follow methods similar to those used by Mellino et al 2014 mapping annual, renewable eMpower density (measured in sej/ha/ year) in the Campania Region of Italy.

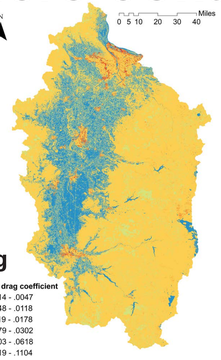
The resulting map shows the spatial distribution of the quality of resources by means of their convergence patterns and biosphere support concentration.

This map and connected data can help with further comparisons and modeling of ecosystem services.

Portland State University

Sunlight

To calculate wind eMergy values, a wind velocity map from was clipped to the watershed.



surface drag

Drag Coefficients were determined by assigning roughness values to a land-class map and applying:

$$\kappa = \left[\frac{k}{\log_e\left(\frac{10}{z_0}\right)}\right]^2$$ (Holmes 2005)

wind velocity and Zo values were entered into the equation :

$$En = A\rho_{\text{air}} C_D v^3 t$$

which resulted in a map of annual wind energy values in Joule per hectare

A is area in m^2

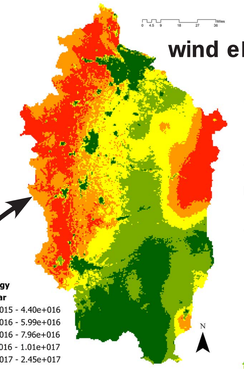
Pair is the air density (1.3 kg m^{-3})

CD is the surface drag coefficient

V is velocity in m s^{-1}

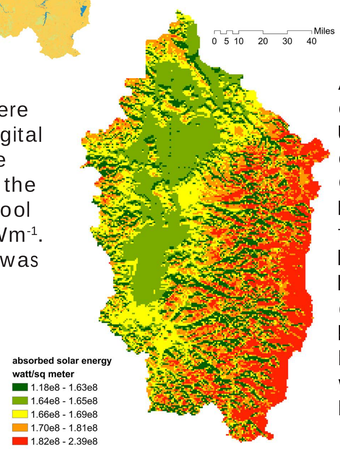
t is the time in seconds

wind eMergy



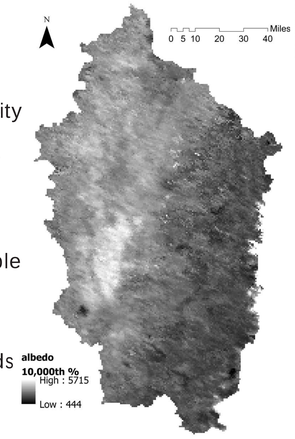
wind emergy was greater in the coast range and northern valley.

Solar eMergy Maps were made by passing a Digital Elevation Model of the Willamette Valley into the Area Solar Radiation tool which calculate the Wm^{-1}. Higher solar radiation was found in the slopes of mountains



solar energy

Albedo maps were obtained from the University of University of Maryland's Global Land Cover Facility which show the reflectivity of light across the landscape. Available data was in square km. Forested areas had lower albedo while farm and feilds had more.

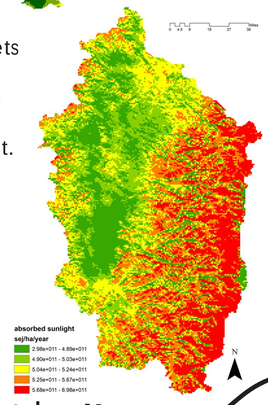


albedo

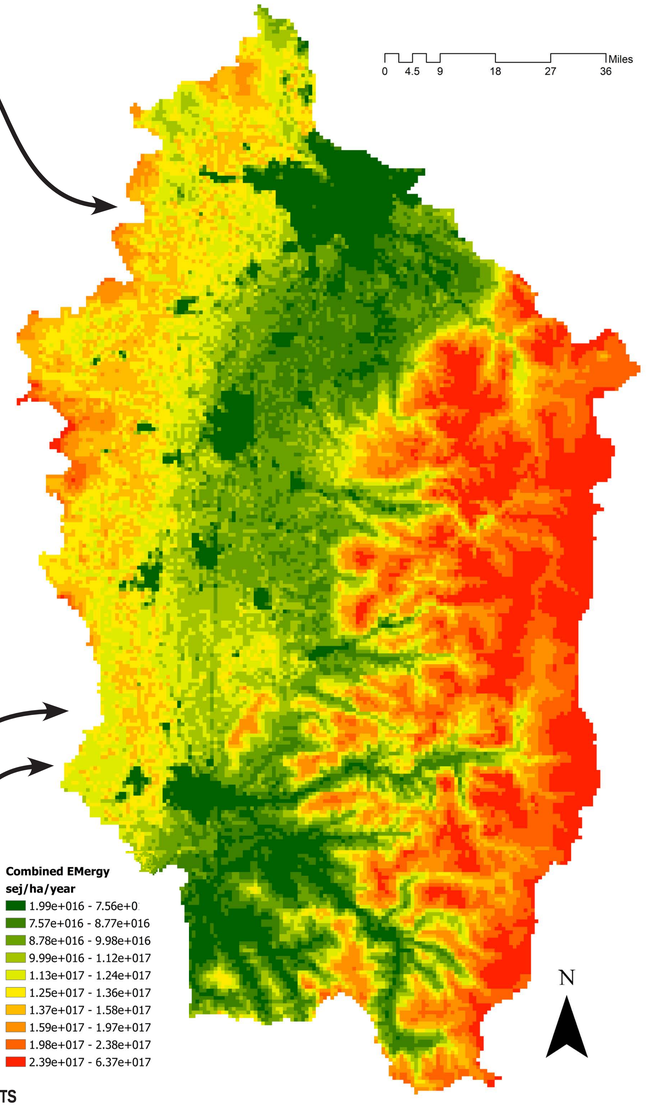
The two data sets were projected and the albedo was subtracted from the sunlight.

Solar energy is already in seJ units.

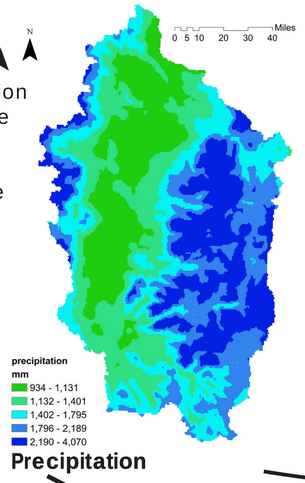
Emergy ranged from 3E11 sej in the valley to 7E11 in the hills.



solar eMergy



Annual precipitation in mm for the state of Oregon was obtained from the PRISM Climate Group at Oregon State University. Precipitation is higher in the mountains.



Precipitation

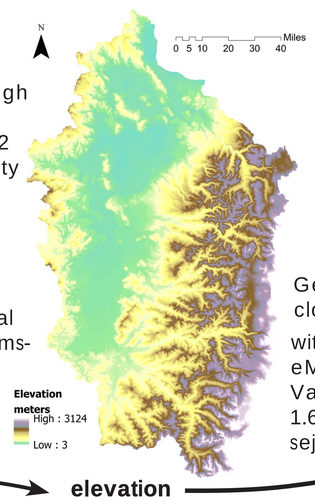
R[J] = A*P*R[m]gh

A = area in m^2
P is water density (1000 kg m-3)

R[m] = runoff in meters

g = gravitational constant (9.81 ms-2)

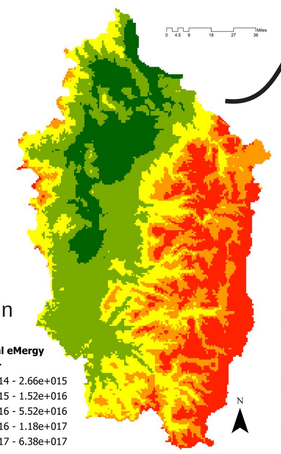
h = height from DEM



elevation

The results were multiplied by a transformity value of 10,909 emJoules per joule resulting in the a map showing seJ per hectare (Odum et al., 2000 - modif by S. Mellino et al.).

Geopotential eMergy closely followed elevation with higher eMergy in the hills. Values range from 1.6E14 sej to 6.38 sej



rain geopotential eMergy

RESULTS

The process of mapping eMergy flows thorugh the Willammette Valley shows that the foothills of the cascades. This is due to the geopotential eMergy behind lifting water into the mountains as well as the solar aspect for the collection of direct sunlight. The is also a great input of eMergy from wind and chemical eMergy, which contribute to the eastern foothills and valley's emergy flows.

CONCLUSIONS

This assessment is lacking a few inputs. most notably, geothermal heat flow.

As a measure of the lowest trophic levels of biosphere inputs into the ecosystem. This assessment also didn't include any biological processes and, for the region, high transformity values behind the life-cycle of Salmon might show a significant input from anadromous fish.

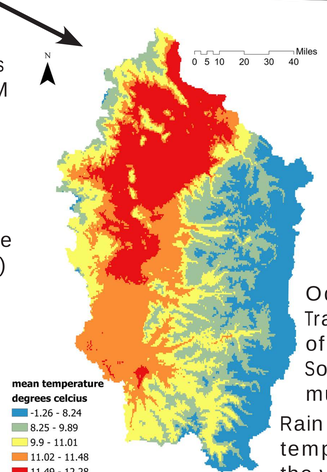
For more detailed eMergy assessment data should be attained with a high level of resolution

Future reserch could also model the eMergy of structures on a more permanent scale such as mountain building, biological systems, and the built environment.

A Temperature layer was also obtained from PRISM Climate Group . Temerpature is higher in the valley and lower in the hills and mountains. Evapotranspiration potential in mm using the Turc equation(Turc, 1954)

$$ET = \frac{P}{\sqrt{0.9 + P^2/L^2}}$$

$$L = 300 + 25T + 0.05T^3$$



mean temperature

To find the chemical evapotranspiration energy of precipitation in J, the resulting layer was entered into:

ET [J] = A*P*G*ET [m]

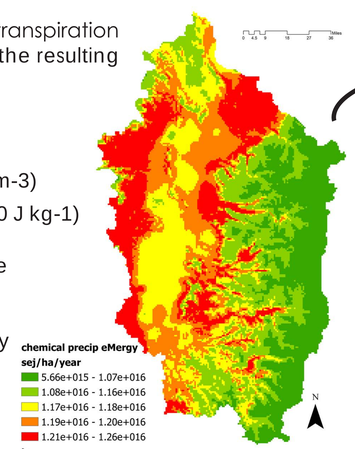
A = area in m^2

P is water density (1000 kg m-3)

G is Gibbs free energy (4940 J kg-1) (Odum 1996)

Odum et al. 2000 determined the Transformity of chemical energy of preciptiation to be 6360 seJ-1 So the emergy map is created by multiplying by that factor.

Rain chemical eMergy followed temperature with higher vallues in the valley reaching 1.3E15 sej.



rain chemical eMergy

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