



System of
Environmental
Economic
Accounting

Session 4b: Scaling and Aggregation

Michael Bordt

2019 Technical Expert Meeting on SEEA Experimental Ecosystem Accounting
Glen Cove, NY, 28-29 June 2019



United Nations

Overview

- Spatial units \leftrightarrow scaling \leftrightarrow aggregation (they're related)
- **Scaling what? Extent, condition, services supply (physical and monetary), services use...**
 - > Representation in the SEEA-EEA
 - > Recommendations from paper: *A summary and review of approaches, data, tools and results of existing and previous ecosystem accounting work on spatial units, scaling and aggregation methods and approaches*
([http://unstats.un.org/unsd/envaccounting/workshops/eea_forum_2015/98. SEEA EEA Tech Guid 8 Spatial units, scaling and aggregation \(21Jan2015\).pdf](http://unstats.un.org/unsd/envaccounting/workshops/eea_forum_2015/98_SEEA_EEA_Tech_Guid_8_Spatial_units_scaling_and_aggregation_(21Jan2015).pdf))

Spatial units \leftrightarrow scaling \leftrightarrow aggregation

- **Spatial data infrastructure (Spatial units):** hierarchical & BSU is MMU
- **Scaling:** Attributing information from one spatial, thematic or temporal scale to another (thematic = ecosystems, households, industries...)
- **Aggregation:** a special case of scaling (i.e., scaling up, reducing many measures to fewer)
- **Not all spatial, but much is:**
 - > Extent: Spatial (BSU, EA, EAA)
 - > Condition: Spatial/statistical/conceptual
 - > Services supply & use (physical): spatial/statistical/conceptual
 - > Services supply & use (value/monetary): value-based
- **Note that scaling multiplies the error**
 - > If two maps are 80% accurate, interpretation of change is 36% wrong!

Ecosystem extent

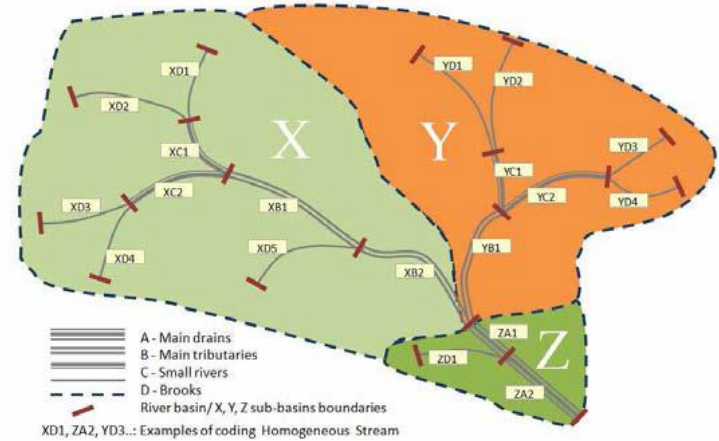
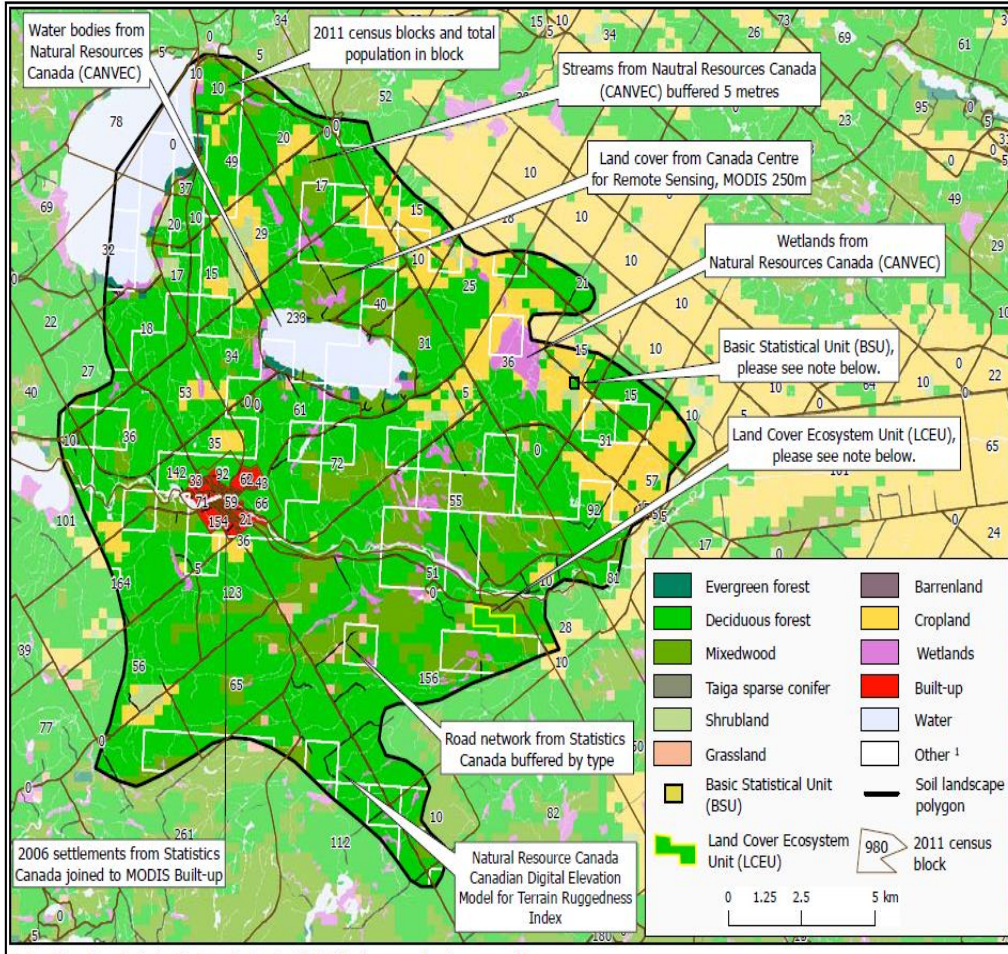
- **BSU may still be heterogenous (30m BSU may be 51% tree covered and 49% grassland)**
 - > Proportions may change with scale and shape (think jerrymandering, MAUP)
 - > Some features may be smaller than BSU (prairie potholes at 10m, streams at 10-15m, roads, power lines)
 - > A “tree covered area” in one BSU may be quite different from that in another (e.g., coniferous/deciduous; dense/open)
- **Recommendations**
 - > Keep spatial data at highest resolution, classification detail and original scale (e.g., deciduous vs coniferous)
 - > Create standard aggregates & disaggregates (sub-sub drainage area, eco-region, national) from most detailed data (avoid [ecological fallacy](#))
 - > Keep track of sources of error (interpretation/classification, scaling)
 - > Incorporate non-BSU data to delineate EAs (e.g., streams from hydrology, roads from road network)
 - > Aggregate streams & rivers by upper/middle/lower drainage basin

Ecosystem extent

Appropriate scales for ecosystem data

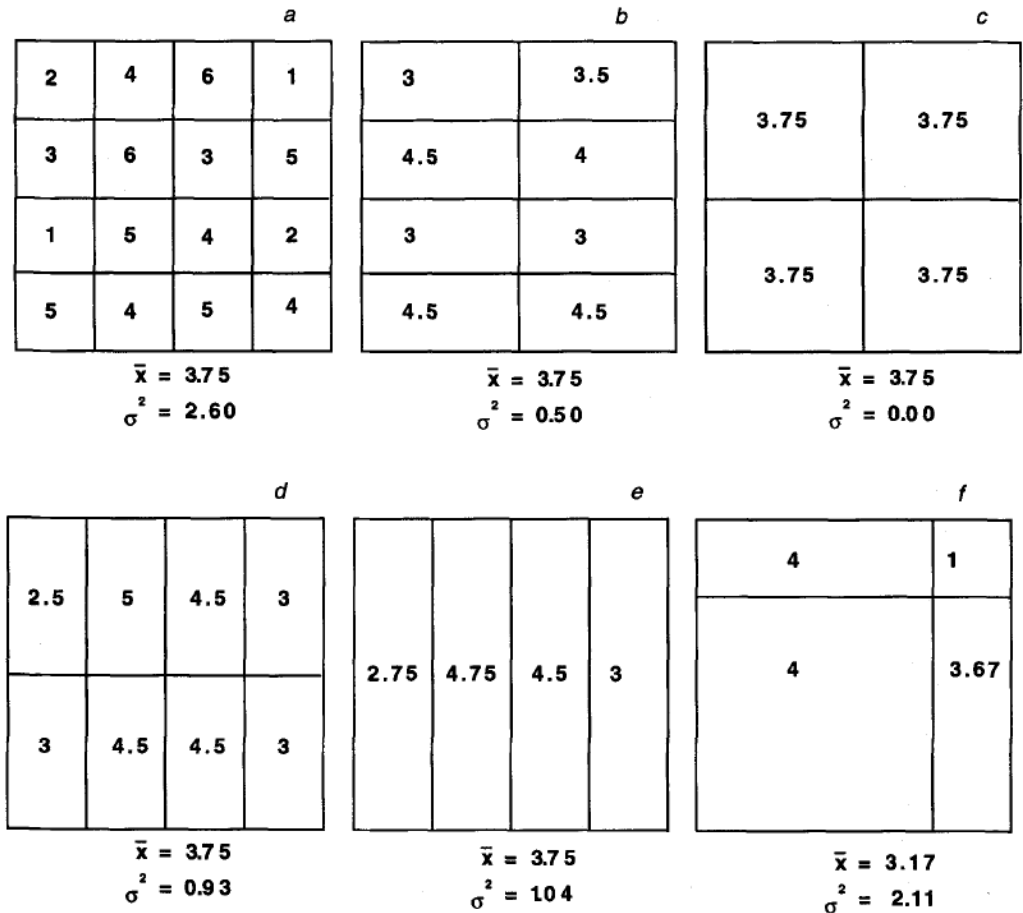
Spatial scale	Data	Type of analysis
BSU	Land cover, location	Land cover change
EA	Land use, soil type, slope, elevation, location within catchment, species abundance, biomass	Local service production, local service-beneficiary linkages
Landscape	Barriers, habitats, ecological interactions, beneficiaries, micro-climate, local drivers of change (e.g., population, industry), visitor rates, streamflow, erosion rates	Fragmentation, heterogeneity, inter-ecosystem flows, biodiversity
Drainage area	Freshwater availability, recharge rates	Water-based phenomena such as flow of water, pollutants and nutrients.
EAA	Management regime, environmental activities (expenditures, management), beneficiaries	Aggregate of all of the above.
National	Socio-economic drivers, beneficiaries	Trends in all of the above; national beneficiaries
Global	Climate, socio-economic drivers, beneficiaries	Global trends in all of the above; global beneficiaries;

Ecosystem extent



Ecosystem extent

- A contrived example showing the two interrelated aspects of the modifiable area unit problem (MAUP)
- Note: Box **a** represents the underlying data, which when grouped according to two different spatial patterns (**b** and **c**) show the same average, but different variances.
- Boxes **d**, **e** and **f** show additional effects of using different spatial zones. Since **d** and **e** are divided into zones of the same size, their averages are retained. However, box **f** contains zones of different sizes, so the average value is not retained.
- Source: Jelinski and Wu (1996).



Ecosystem extent

Good advice?

When the scale of the observational window matches the characteristic scale of the phenomenon of interest, we will see it; otherwise we miss it. These arguments form the premise of a hierarchical approach to the modifiable areal unit problem. A suggested procedure to deal with the MAUP is simply thus: first to identify the characteristic scales using methods such as spatial autocorrelation, semivariograms, fractal analysis, and spectral analysis, and then to focus the study on these scales.

Jelinski and Wu (1996)

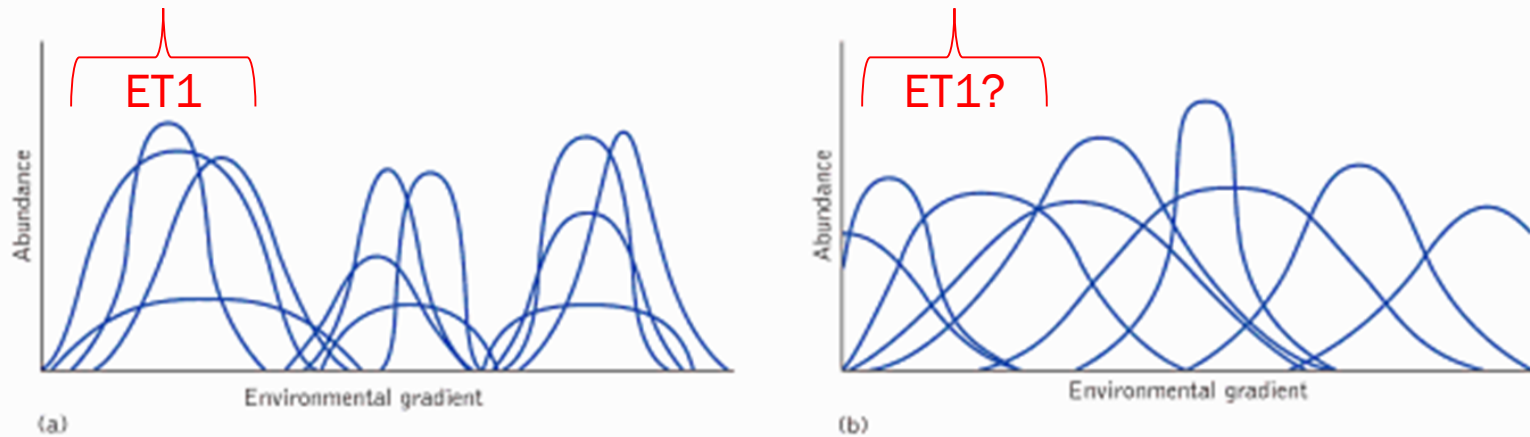
Ecosystem condition

- **Besides same issues in aggregating measures spatially...**
 - > Ecosystems exist on gradients of environmental conditions (e.g., temperature, moisture, soil, sunlight, ...)
 - > Indices of condition may be calculated, but what are the weights? what is the reference state? is the result meaningful?
 - e.g., measures may be correlated, more/less important to condition or services provision
 - e.g., toxicity index rates pollutants with respect to relative toxicity to humans
 - e.g., CO₂ equivalents rate GHGs with respect to global warming impact
 - > Conditions change on their own spatial and temporal scales: *My backyard is flooded half the year and in drought the other half, but on average, it's fine.*
- **Recommendations**
 - > As with Jelinski and Wu (1996), determine the appropriate spatial, temporal and thematic scale for analysis (includes temporal)
 - > Understand the correlations between variables (e.g., with principal component analysis)

Ecosystem Condition

Does it make sense to aggregate?

Figure 9 Two models of vegetation communities



Note: (a) represents the Clementsian model in which species' requirements coincide, leading to the identification of discrete communities. The Gleasonian model, wherein each species is distributed independently is shown in (b)

Source: Cox and Moore (2010)

Also in terms of location (i.e., ecotones, gradients). Clementsian more like Europe.

Ecosystem condition

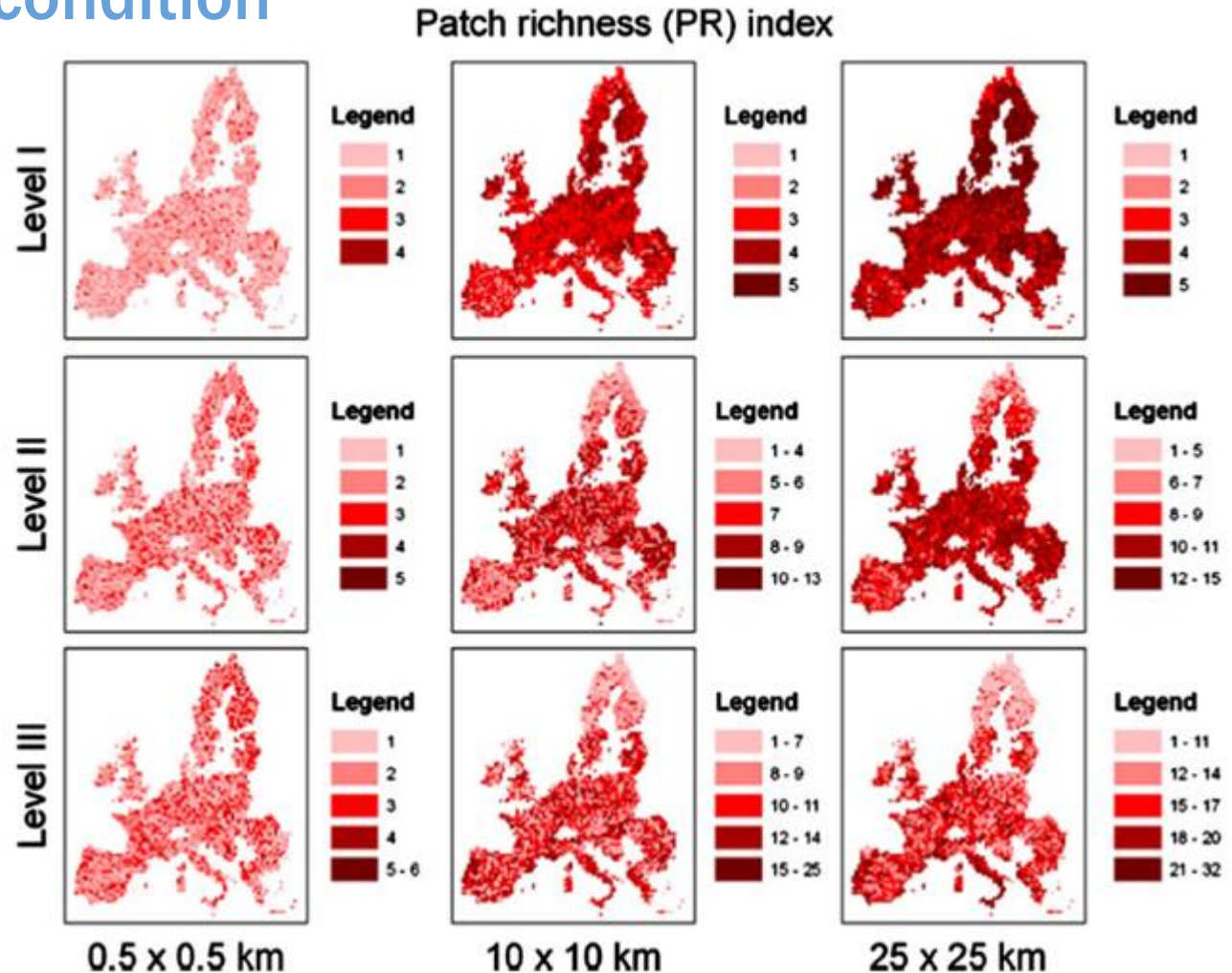
PR increases with increasing scale & increasing detail of classification:

Level I = CORINE 5 classes

Level II = 15 classes

Level III = 44 classes

Note: Norway has highest PR if Level I;
Lowest if Level III



PR equals the number of different patch types present within the landscape boundary

Ecosystem services supply

- **Besides same issues in aggregating measures spatially and same precautions about conditions...**
 - > Ecosystem services are measured in different physical units and have different “kinds” of values (economic, environmental, social...)
 - > They can be complementary, conflicting or independent
 - e.g., ↑crops → ↓habitat
 - > “Valuation” depends on many factors other than monetary value (value to whom? for what?)
- **Recommendations**
 - > Think about “dashboards” rather than single indicators
 - > Dashboards could contain aggregates of groups of services under different future scenarios and sets of social preferences (e.g., LCA, “types” of ES)

Ecosystem services supply

		Enjoyed, consumed or used	
		Directly	Indirectly
Ecological processes	Strongly	Contribute directly to <i>economic and household production functions</i> (e.g., the water and fauna consumed by livestock, wild foods and materials, some cultural services for which exchange values can be established). These are largely the intersection of FECS-CS and CICES. [value directly]	Contribute to <i>ecological production functions</i> (e.g., biodiversity, primary productivity). These correspond with many of the CICES “Regulation and Maintenance” services. [Value in terms of ecological integrity]
	Weakly	Removed from ecosystem processes, either by cultivation or by other means. These correspond with many of the CICES “Provisioning Services”. [value in terms of contribution of ecosystem]	Contribute to <i>social production functions</i> (e.g., existence, transformational, relational values). [value in terms of social preference]

Bordt M (2016) Concordance between FECS-CF and CICES V4.3. Presented at the Expert group meeting - Towards a standard international classification on ecosystem services. New York, June 20-21, 2016. URL: https://unstats.un.org/unsd/envaccounting/workshops/ES_Classification_2016/FECS_CICES_Concordance_V1.3n.pdf

(Bonus idea) Ecosystem services use

- **Disaggregate beneficiaries (how?)**
 - > Tend to consider beneficiaries as aggregates (businesses, household, Rest of the World...)
 - > Ecosystem services supply impact different sub-populations differently (male/female, high/low income, resource dependent/independent, employees/self-employed, urban/rural, coastal/inland, risk zones, distance to ecosystem services)
- **Recommendations**
 - > Locate beneficiary target populations **spatially** (e.g., low income living in risk zones or degraded ecosystems)
 - > Link SEEA accounts and spatially-disaggregated household surveys (e.g., source of water by income group → quantity used by income group)



Questions & Thank you