Optimizing the collocation of field sampling activities and tower-based instrument measurements

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neon
National Ecological Observatory Network

Background

The National Ecological Observatory Network (NEON) is a continental-scale research platform with a projected operation of 30 years. NEON's purpose is to provide high quality data products that will facilitate discovering and understanding the impacts of climate change, land-use change, and invasive species on terrestrial ecosystems. For this purpose NEON will operate a terrestrial observation system (TOS) parallel to a terrestrial instrument system (TIS) at 60 research sites across the contiguous U.S., Alaska, Hawaii and Puerto Rico.

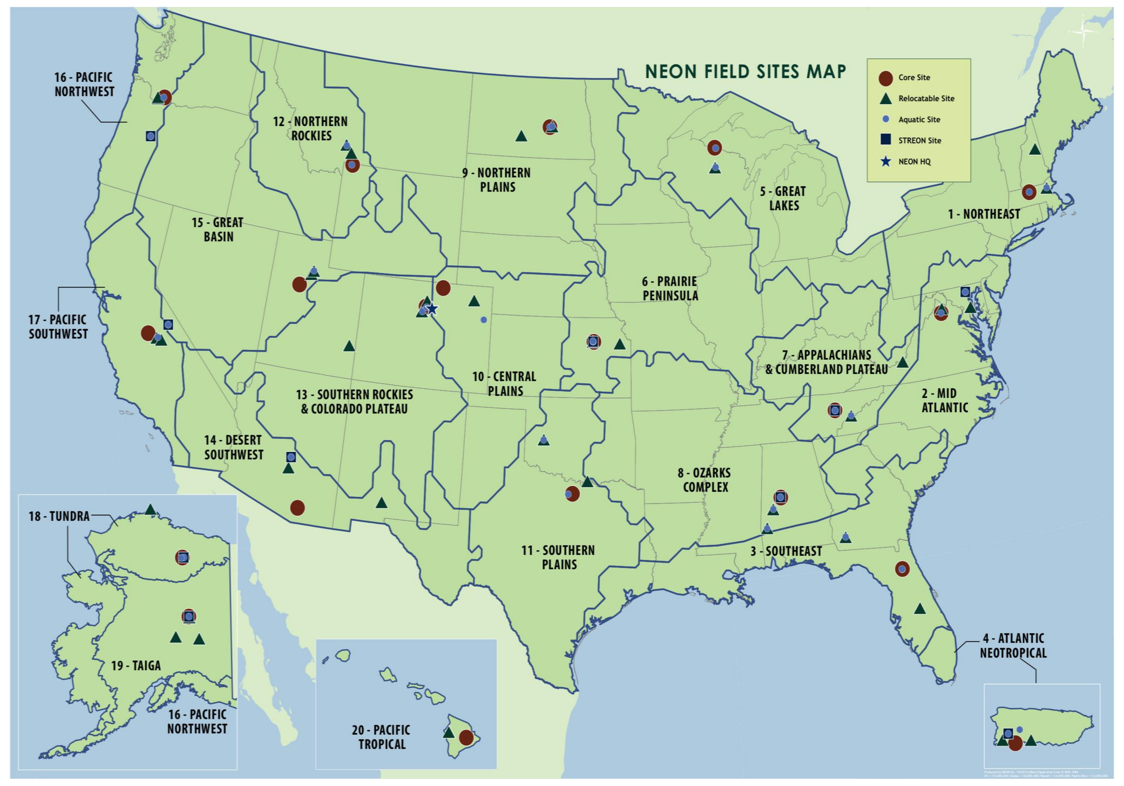


Figure 1. A map of the 20 different NEON eco-climatic domains with indicators for different sites.

Objective, TOS, TIS

Valid relationships between ecosystem drivers and responses

- Minimizing observer effect: Gauging a system without significantly changing its properties
- **TOS and TIS shall be representative of the same ecosystem, but not significantly influence one another**

Terrestrial observation system

Human-based observations of ecosystem drivers as boundary conditions for biophysical processes, e.g.:

- Bird, insect and mammal populations
- In-situ biomass
- Plant phenology
- Soil and plant biogeochemistry…

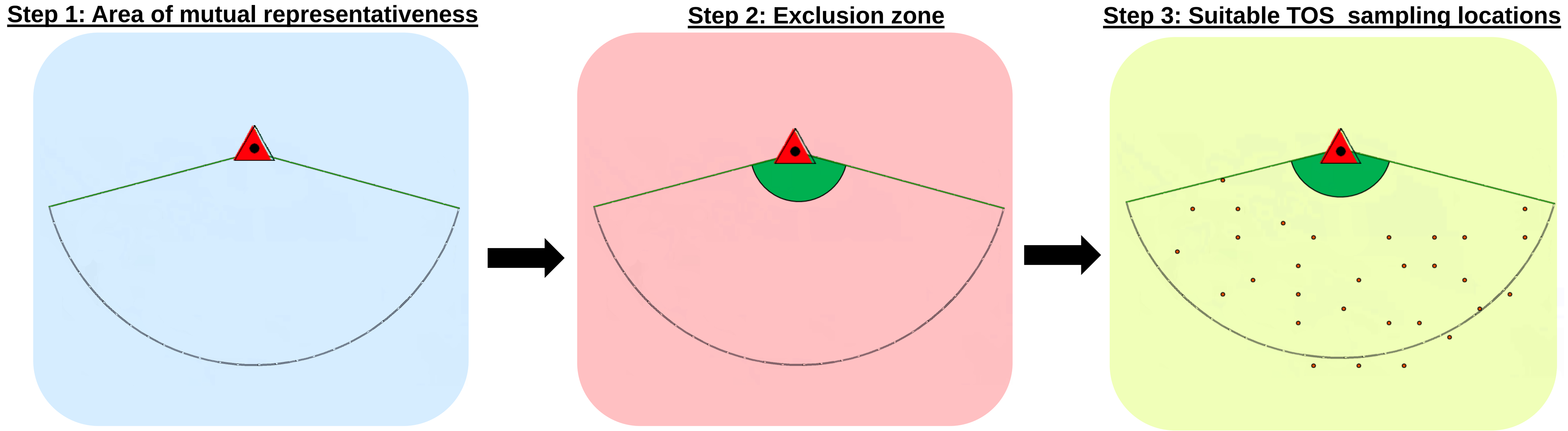
Terrestrial instrument system

Sensor-based observations of the biophysical processes of an ecosystem, e.g.:

- Aerodynamic, bulk and canopy conductances
- Evapotranspiration
- Light and water use efficiency
- Net ecosystem exchange…

Figure 2. An example of a TIS system (tower) and an impact from sampling activities (trail) at NEON's CPER site.

Steps to optimize collocation



Step 1: Area of mutual representativeness

Step 1: Determine tower location and area of mutual representativeness of TIS and TOS.

- Flux footprint after Kormann and Meixner (2001) [ppm m−2].
- Radiation footprint after Schmid (1997) [ppm m−2].
- Concentration source area after Schmid (1994) [ppm m-2].

Step 2: Exclusion zone

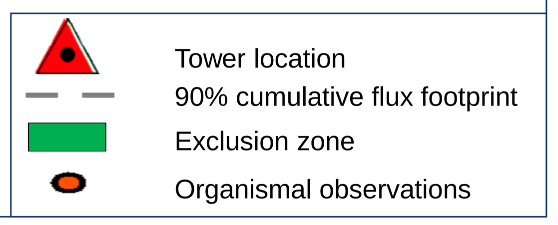
Step 2: Determine exclusion zone to minimize interference among TIS and TOS.

- User-defined impact threshold 10%.
- Effective impact area calculated as a function of area disturbed by sampling, climate decomposition index (CDI), trail parameters, etc.

Step 3: Suitable TOS sampling locations

Step 3: TOS sampling locations are selected using a stratified random sampling design.

- With preference in the area of mutual representativeness.
- Outside the exclusion zone.



Important drivers for exclusion zones

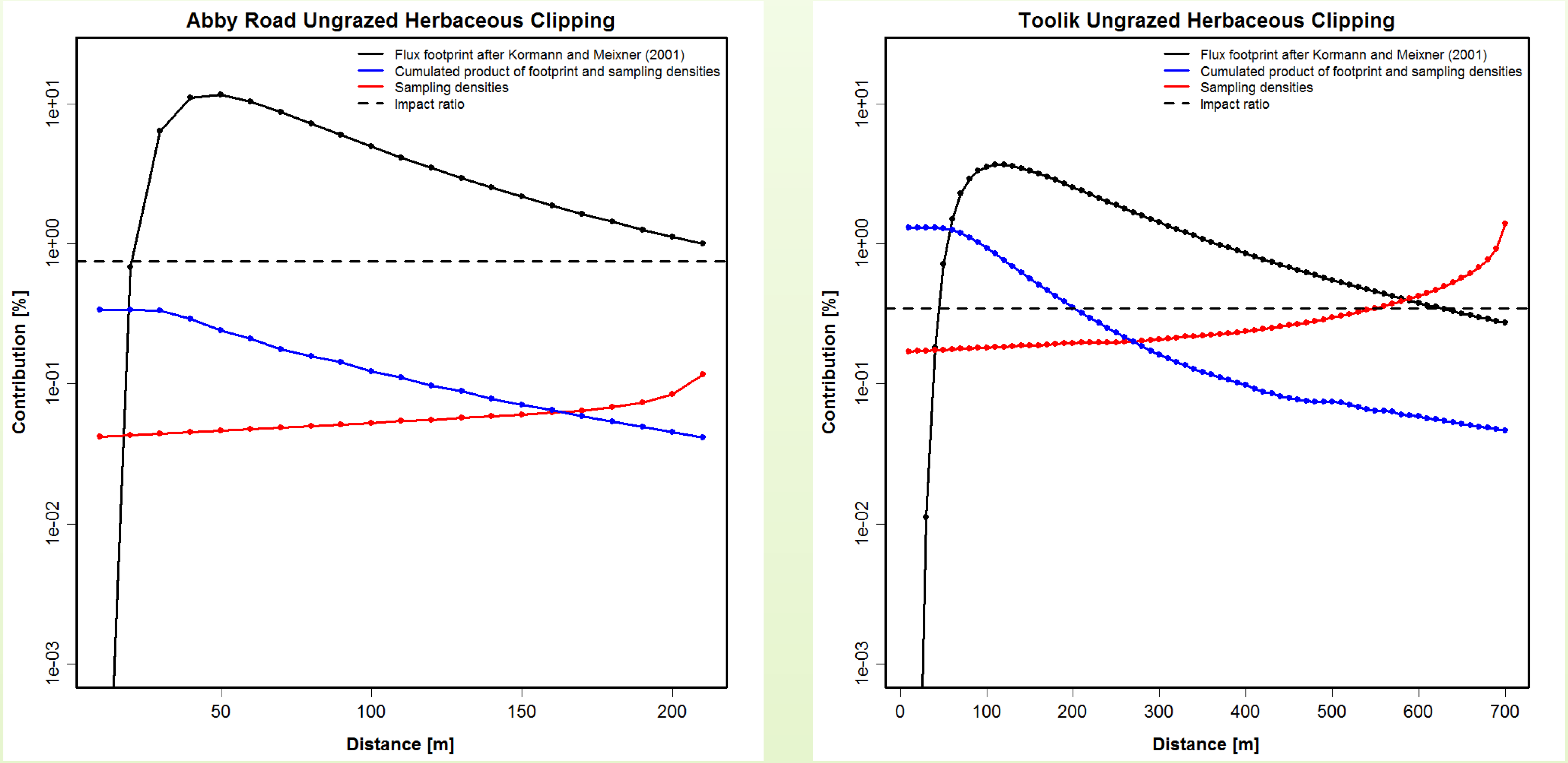


Figure 3. Example calculation s for the activity "ungrazed herbaceous clipping" at NEON's Abby Road site in Washington, U.S.A. and the Toolik Lake site in Alaska. The intersection of the impact threshold (dashed horizontal line) with the convolution of the sampling densities and source area distribution function (blue line) defines the minimum radius of the collocation area. For Toolik Lake, this is 220m, and for Abby Road, there is no intersection, so a minimum exclusion zone distance of 30m is applied.

Methods for testing model sensitivity

- A correlation matrix for the 24 variables in question was calculated to create a covariance structure using +/- 1 sigma.
- A multivariate normal distribution was developed, preserving the covariance structure.
- Simulation data was generated from the multivariate normal distribution (77,000 unique combinations of variables).
- The optimization workflow was run with the data points, using exclusion zone distance.

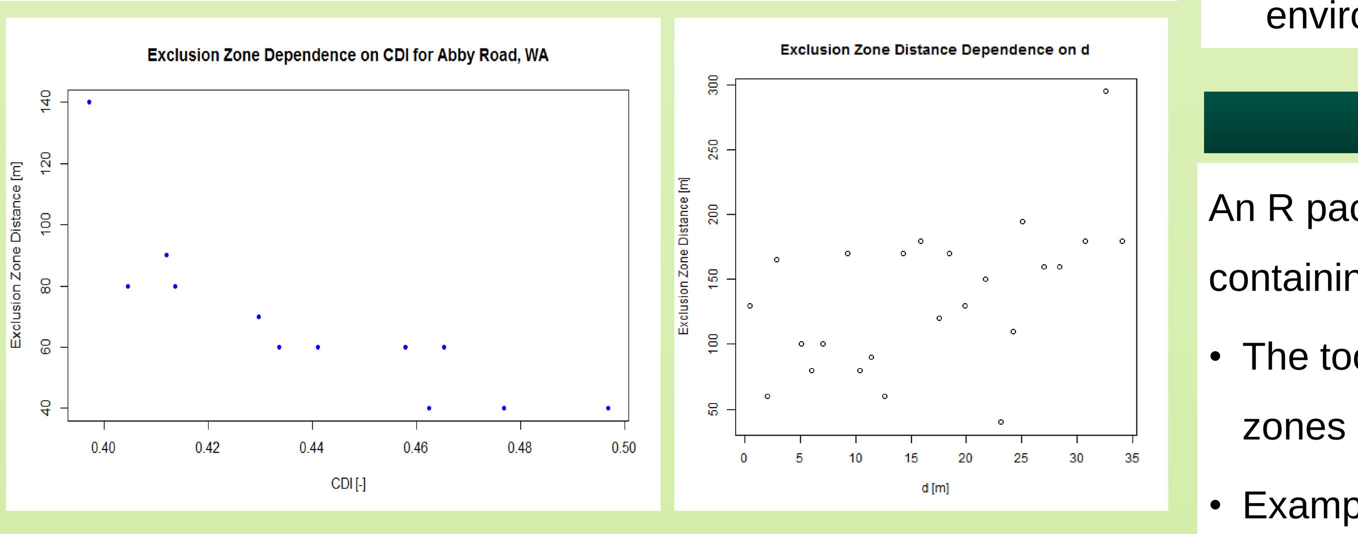


Figure 4. The left panel suggests a relationship between climate decomposition index (CDI) and exclusion zone distance. The right panel indicates a dependence of exclusion zone distance on displacement height.

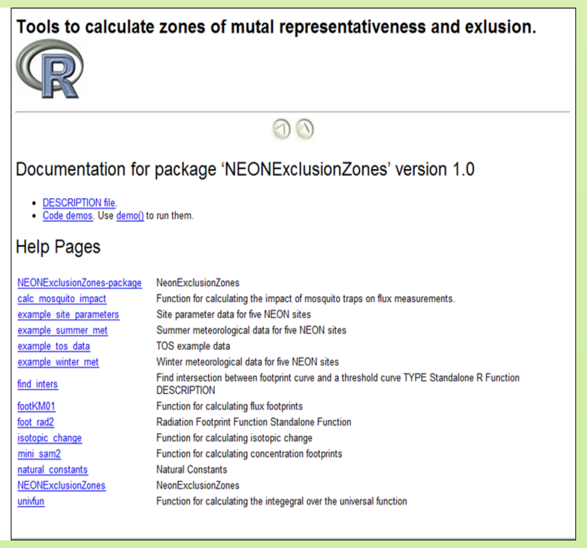
Conclusions

- A quantitative model has been developed for placing field sampling activities in close proximity to instrument measurements.
- In 90% of all cases the model was shown to be robust against 10% (1 σ) deviations in its inputs, continuing to yield a minimum distance of 30 m.
- For the remaining 10% of all cases, preliminary results suggest a prominent dependence of the minimum distance on climate decomposition index, an indicator for the sensitivity of an environment to disturbance.

Future Work

An R package will be released containing:

- The tools calculate exclusion zones
- Example data
- Vignette documenting variables and functions



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