

# A Nonparametric Analysis of the Distribution of *Convolvulus arvensis* in Wheat-Sunflower Rotations

Jean Opsomer, Iowa State University (jopsomer@iastate.edu)

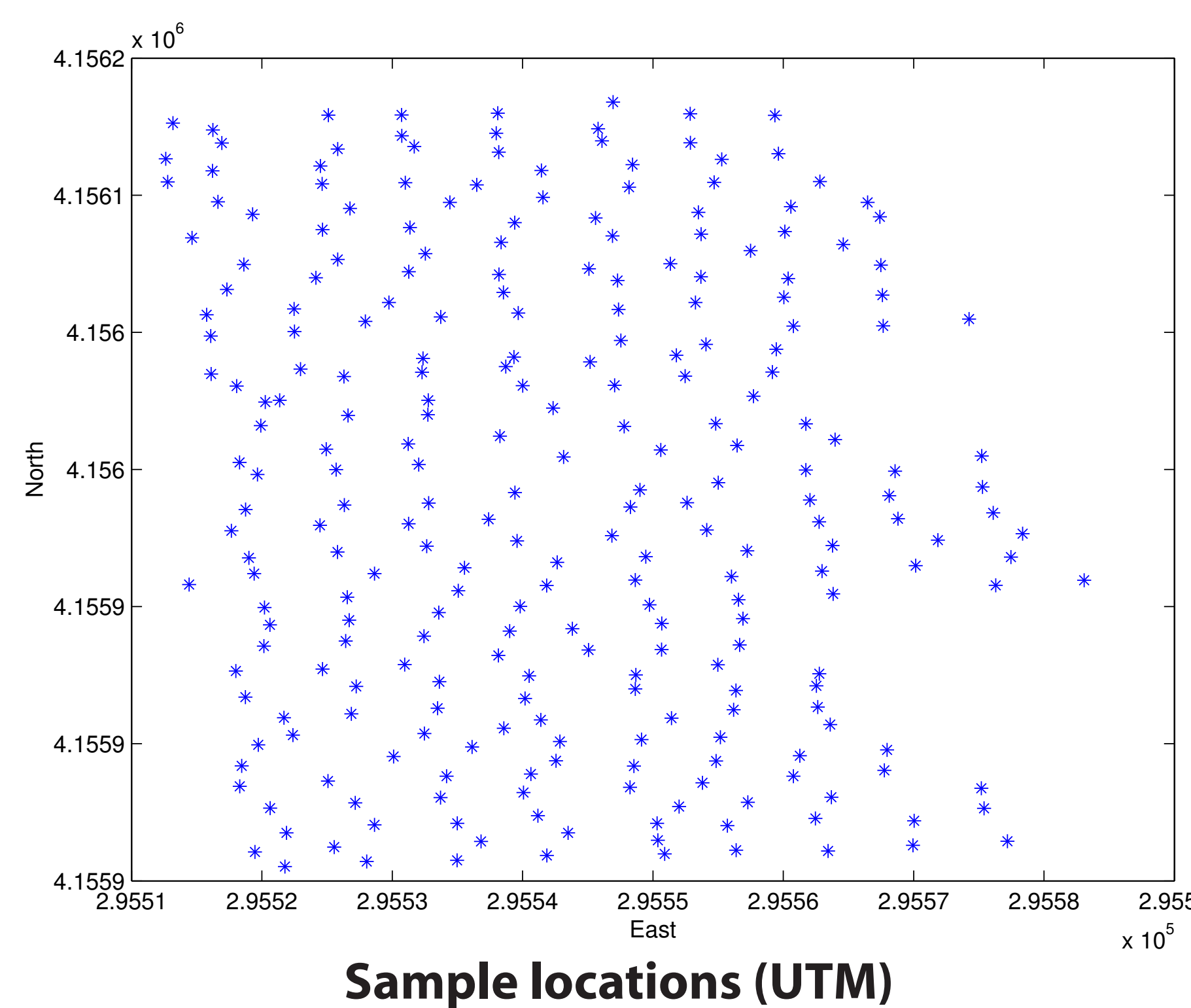
Mario Francisco-Fernández, Universidad de A Coruña; Montserrat Jurado-Expósito and Francisca López-Granados, Instituto de Agricultura Sostenible (Spain)

## 1. Data



C. arvensis in sunflower field

- *C. arvensis* is common perennial weed in Spain
- Infests wheat and sunflower fields
- Significant impact on crop yields when present at high densities
- Difficult to control in no-till fields due to vegetative reproduction
- Exhibits persistent year-to-year patches



- Study area: 1.6ha field in Monclova (Spain)
- Field in crop rotation

1999	wheat
2000	sunflower
2001	wheat
2002	sunflower

- Number of *C. arvensis* plants in 2m x 2m area counted at 261 sample locations and converted to density (#/m<sup>2</sup>)

## 2. Statistical Model

- $Y_{it}$  = recorded weed density at location  $i$ , year  $t$
- $\mathbf{X}_i$  = UTM coordinates (North/South, East/West) for location  $i$
- Model:

$$Y_{it} = m_t(\mathbf{X}_i) + \varepsilon_{it}$$

with

$$E(\varepsilon_{it}) = 0$$

$$\text{Var}(\varepsilon_{it}) = \sigma^2$$

$$\text{Cov}(\varepsilon_{it}, \varepsilon_{jt}) = \sigma^2 \rho(\mathbf{X}_i - \mathbf{X}_j)$$

$$\text{Cov}(\varepsilon_{it}, \varepsilon_{it'}) = 0$$

- Target of estimation:

$$m_t(\mathbf{X}_i) = \text{weed density field at location } i, \text{ year } t$$

## 3. Estimating Annual Fields

- In each year  $t$ , field  $m_t(\cdot)$  is estimated by local linear regression
- For any location  $\mathbf{x}$ , the estimator is defined as

$$\hat{m}_t(\mathbf{x}) = \alpha_t$$

where  $\alpha_t$  is the solution to

$$\min_{\alpha_t, \beta_t} \sum_{i=1}^n (Y_{it} - \alpha_t - \beta_t'(\mathbf{X}_i - \mathbf{x}))^2 K(\mathbf{H}_t^{-1}(\mathbf{X}_i - \mathbf{x}))$$

$K(\cdot)$  = kernel function (Epanechnikov)

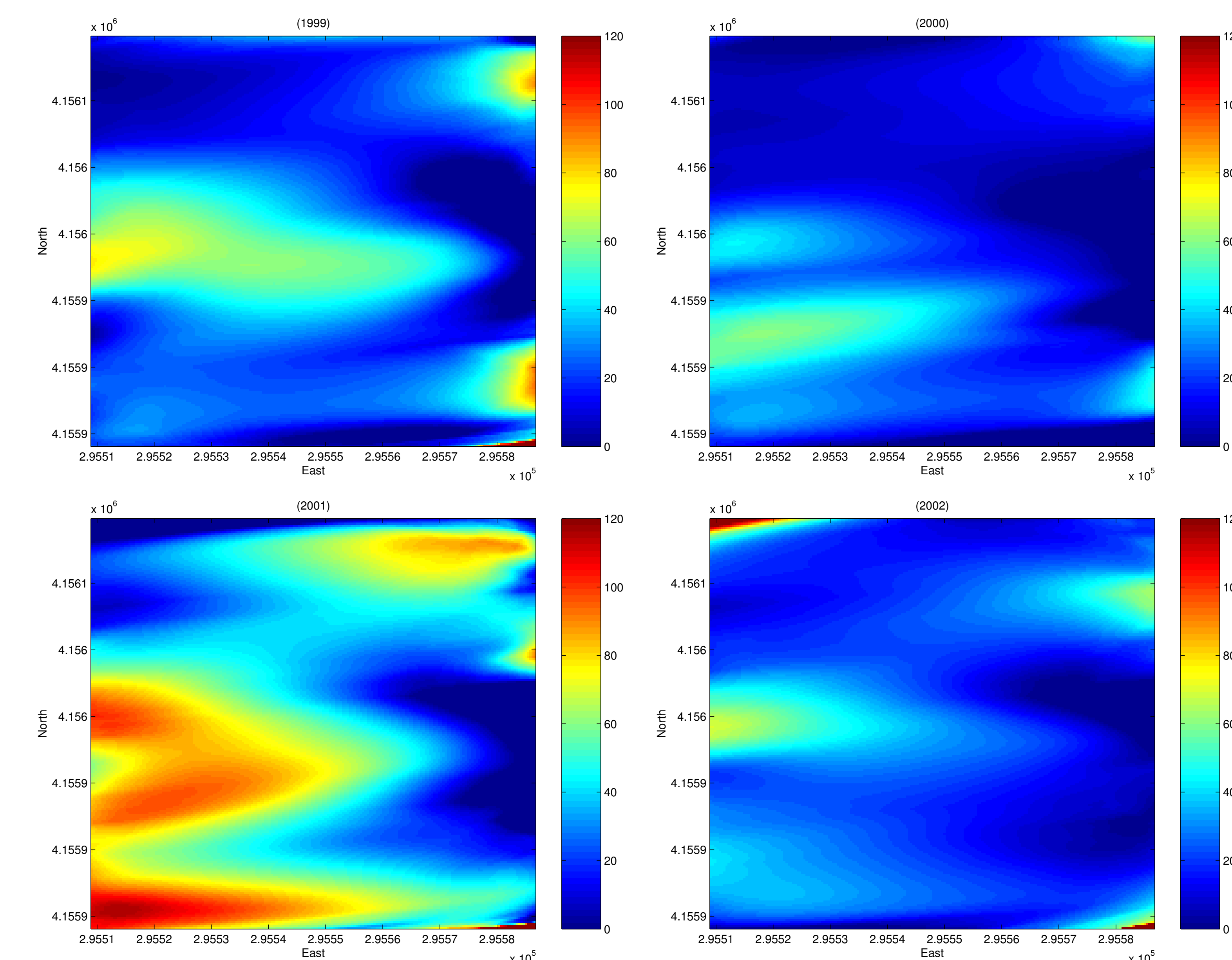
$\mathbf{H}_t$  = bandwidth matrix (2x2) for year  $t$

## In Short...

**Analysis of spatial patterns and identification of persistent structures in distribution of perennial weed *C. arvensis* in agricultural field in Southern Spain**

- Annual spatial distribution maps are estimated by local linear regression
- Multiyear map is obtained by thresholding based on economic impact of weed on crop yields
- Parametric bootstrap is used to construct map of likelihood of exceeding threshold and to conduct sensitivity analysis
- Map can be used in targeting weed control management to most severe year-to-year persistent patches of *C. arvensis*

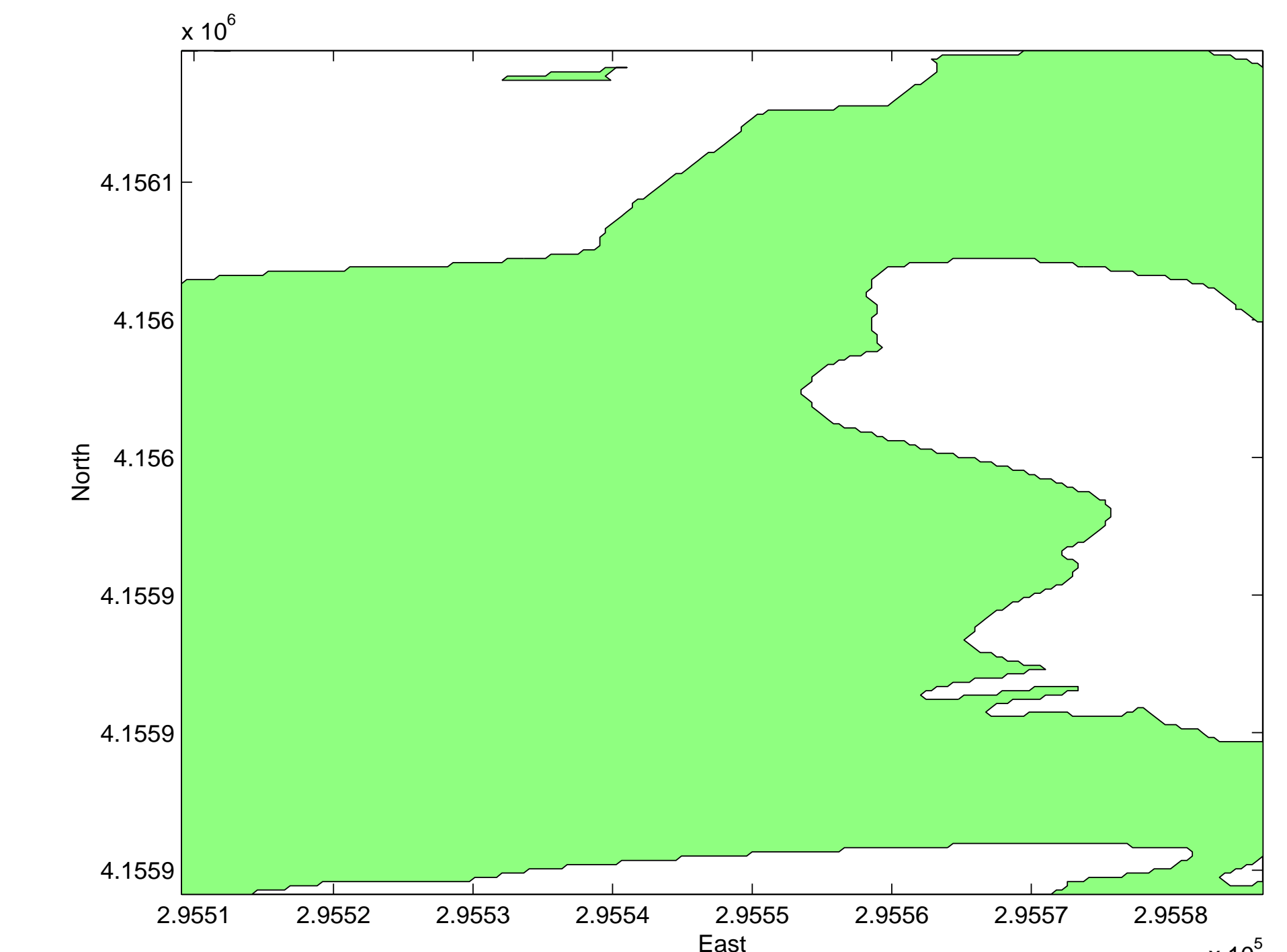
- Annual bandwidth selection by correlation-adjusted Generalized Cross-Validation (Francisco-Fernández and Opsomer, 2003); for final analysis, annual bandwidth matrices are replaced by 4-year mean bandwidth to facilitate cross-year comparisons



Estimated annual weed density fields, 1999-2002

## 4. Economic Thresholding

- *C. arvensis* impact is considered economically significant in wheat/sunflower field if weed density exceeds economic threshold (ET) of 14#/m<sup>2</sup>
- Multi-year index of severity of economic impact is constructed by defining multiyear ET: location  $\mathbf{x}$  is considered severely impacted if annual weed density field at  $\mathbf{x}$  exceeds ET in 3 out of 4 years



Multi-year economic threshold map (green = impacted)

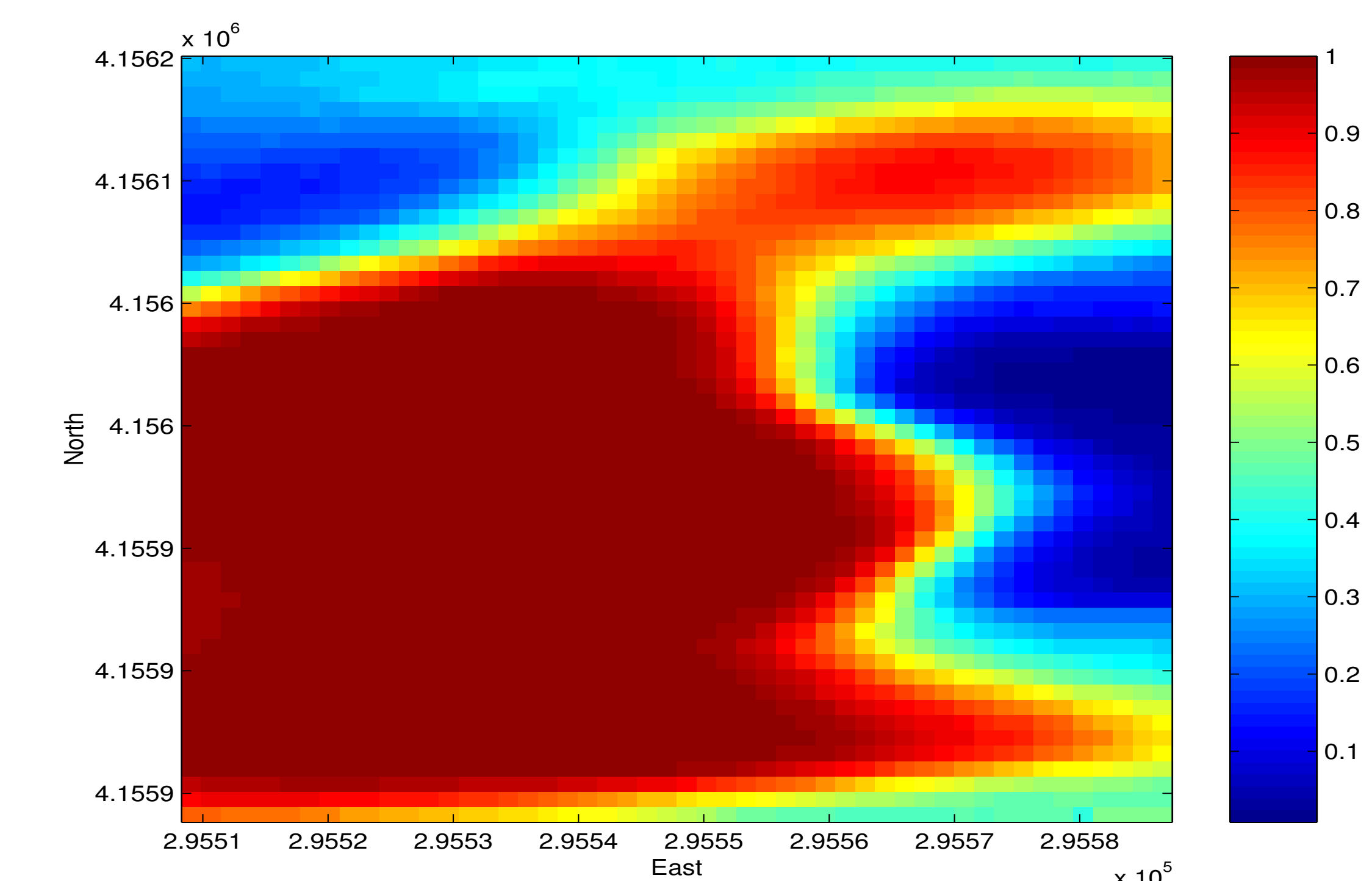
## 5. Bootstrap Inference

- Multi-year index map is sensitive to estimated field values close to ET, and measure of uncertainty is needed
- Parametric bootstrap:

- generate bootstrap sample data with errors for each year generated as exponential model correlated process fitted to residuals from local linear fits

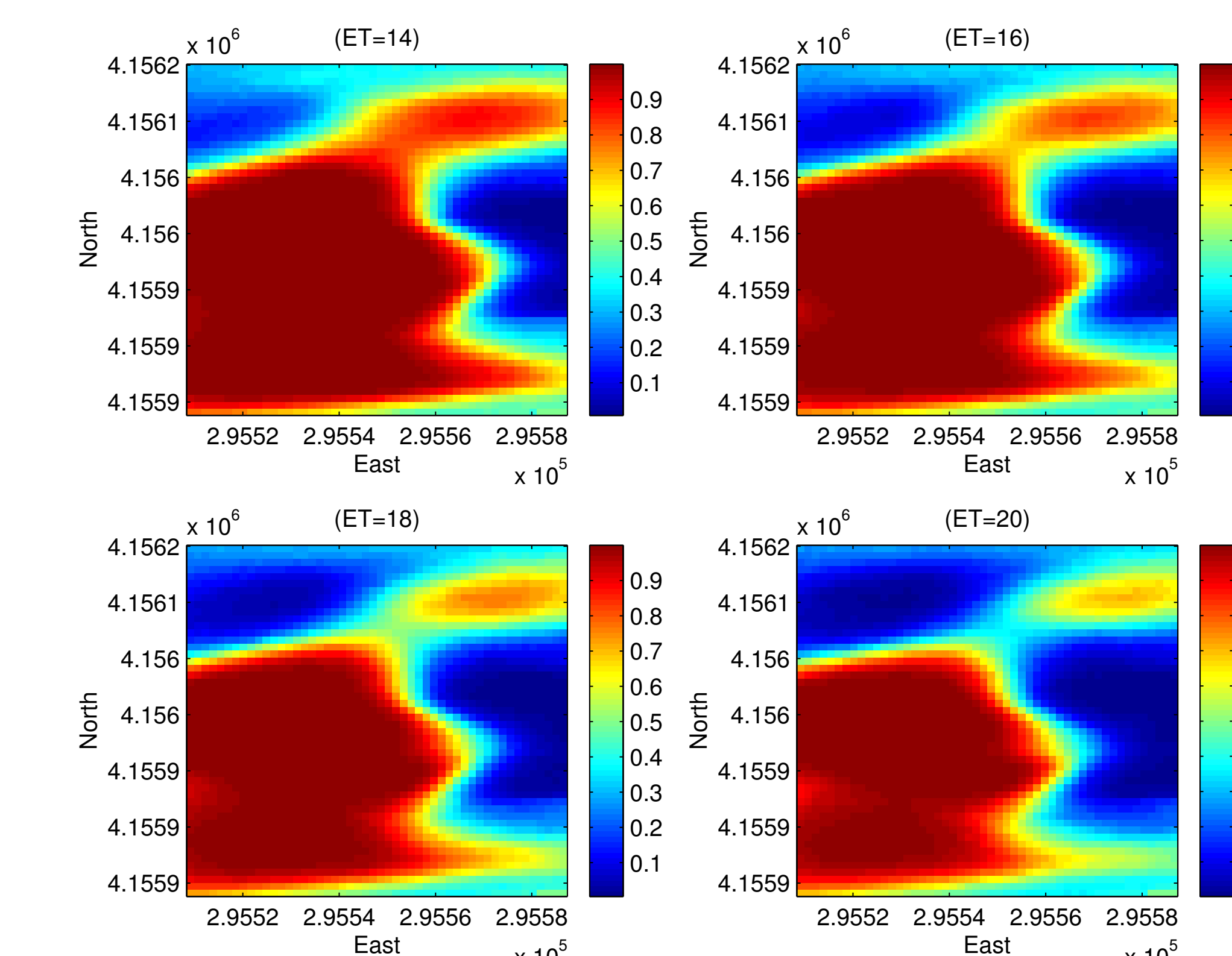
$$Y_{it}^* = \hat{m}_t(\mathbf{X}_i) + \varepsilon_{it}^*$$

- for each bootstrap sample, compute multi-year index map
- probability of exceeding threshold obtained as bootstrap expectation of multi-year maps



Estimated probability of exceeding multi-year economic threshold

- Analysis can be repeated for different values of ET to determine severity of weed infestation problem for different economic scenarios



Sensitivity analysis for varying levels of economic threshold