



**VISUAL 2008**  
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# **Dynamic Buffer Areas Obtained by EFCM Method in GIS Environment**

**by**

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# FUZZY C-MEANS ALGORITHM

**The classical algorithm FCM presents the following two shortcomings:**

- - **the number  $C$  of the cluster prototypes must be defined a priori or one calculates  $C$  as minimum or maximum of a suitable function,**
- - **the centers of the clusters tend to locate in areas with high concentrations of features (but the zones with low density data points could be relevant).**



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# EXTENDED FUZZY C-MEANS ALGORITHM

**The EFCM algorithm has the following advantages:**

- **it finds the optimal number  $C$  of clusters during the iteration process (the use of a validity index in a pre-processing phase in the FCM algorithm does not supply always optimal values of  $C$ ),**
- **the shape of a cluster is a hypersphere (resp. sphere) in case of (resp. bidimensional) Euclidean distance,**

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# EXTENDED FUZZY C-MEANS ALGORITHM

- **robustness to noise and outliers,**
- **linear complexity computational, i.e. the objective function is to be minimized is very simple:**

$$J = \sum_{i=1}^C \sum_{j=1}^N u_{ij}^m (d_{ij}^2 - r_i^2)$$



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- **What is a hotspot?**

- Old definition:

**A Hotspot is an area providing wireless internet access for customers with a wireless-enabled notebook or PDA who want internet access.**

- New definition:

**A Hotspot is an area of clusters of determined features that can exist at different scales.**

For example: in crime analysis, a hotspot represents a localised area that has a large share of the total volumes of crime or disorder incidents w.r.t. a whole region.



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Variations of the term ‘hotspot’ are used at different scales:

- **Hotpoints** – precise locations where there is a high concentration of features
- **Hotplaces** – these are less geographically precise than points, but refer to specific locations where there is a high concentration of features
- **Hotroutes** – these are typically street routes
- **Hotobjects** – these are desirable goods or items around features
- **Hotpeople** – these are certain types of people (not necessarily particular individuals) that suffer from a high concentration of features. For example, this could include a particular portion of the local population who suffer more from burglary than any other group.



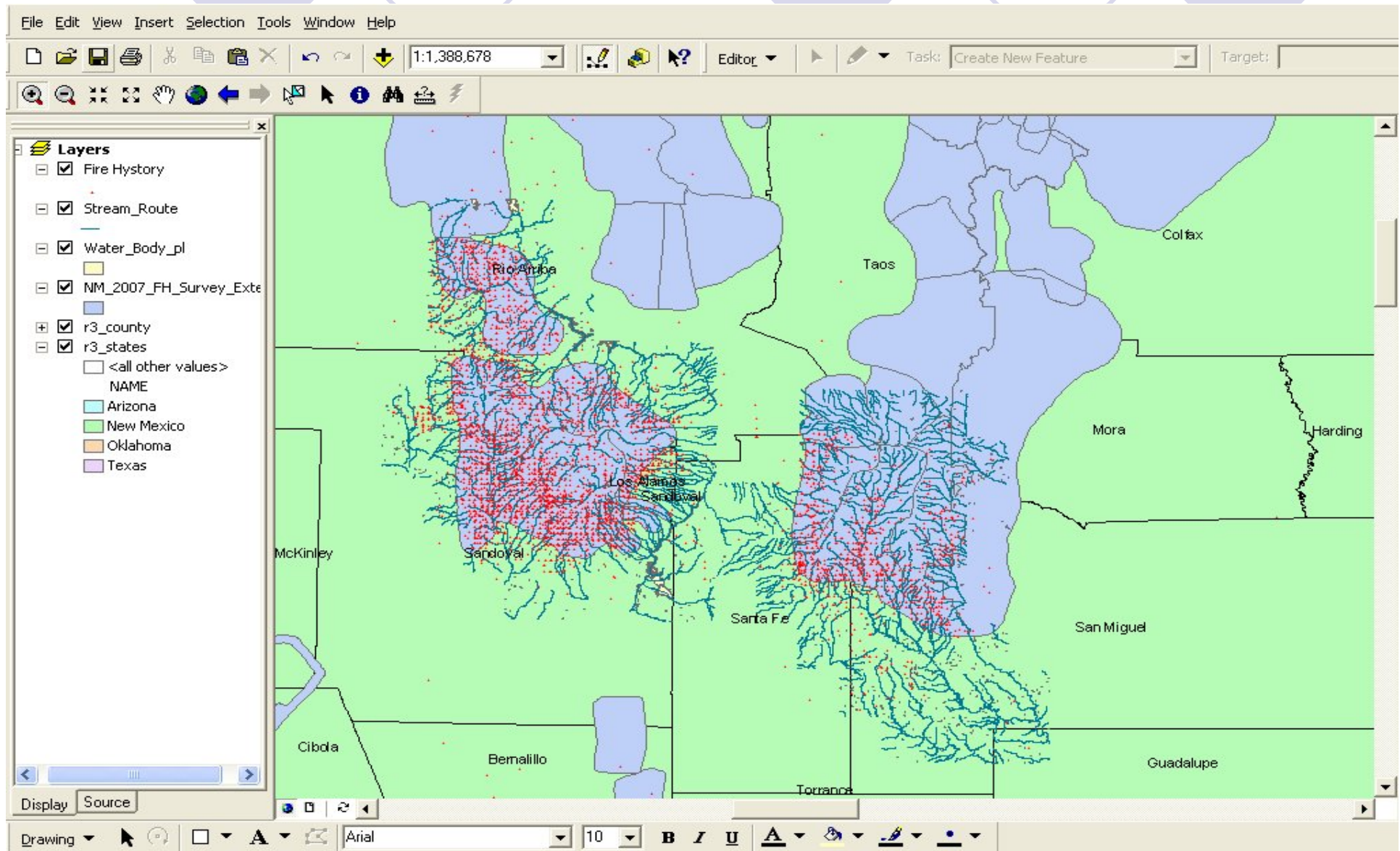
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**The “Fire History” points represent the location at which fires began in the last three years ([http://www.fs.fed.us/r3/gis/sfe\\_gis.shtml](http://www.fs.fed.us/r3/gis/sfe_gis.shtml)).**

**The “Fire History” data are shown on the next slide, where are displayed also the stream routes, the water bodies, the base vegetation location and the surveyed forest areas in New Mexico.**

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# “Fire History” Santa Fe National Forest and related point data





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**Our aim is to use the EFCM method to determine circular areas with high fire frequencies considered as fire dangerous buffer areas.**

**Afterwards we determine their impact, for instance, with the recreation opportunity areas.**

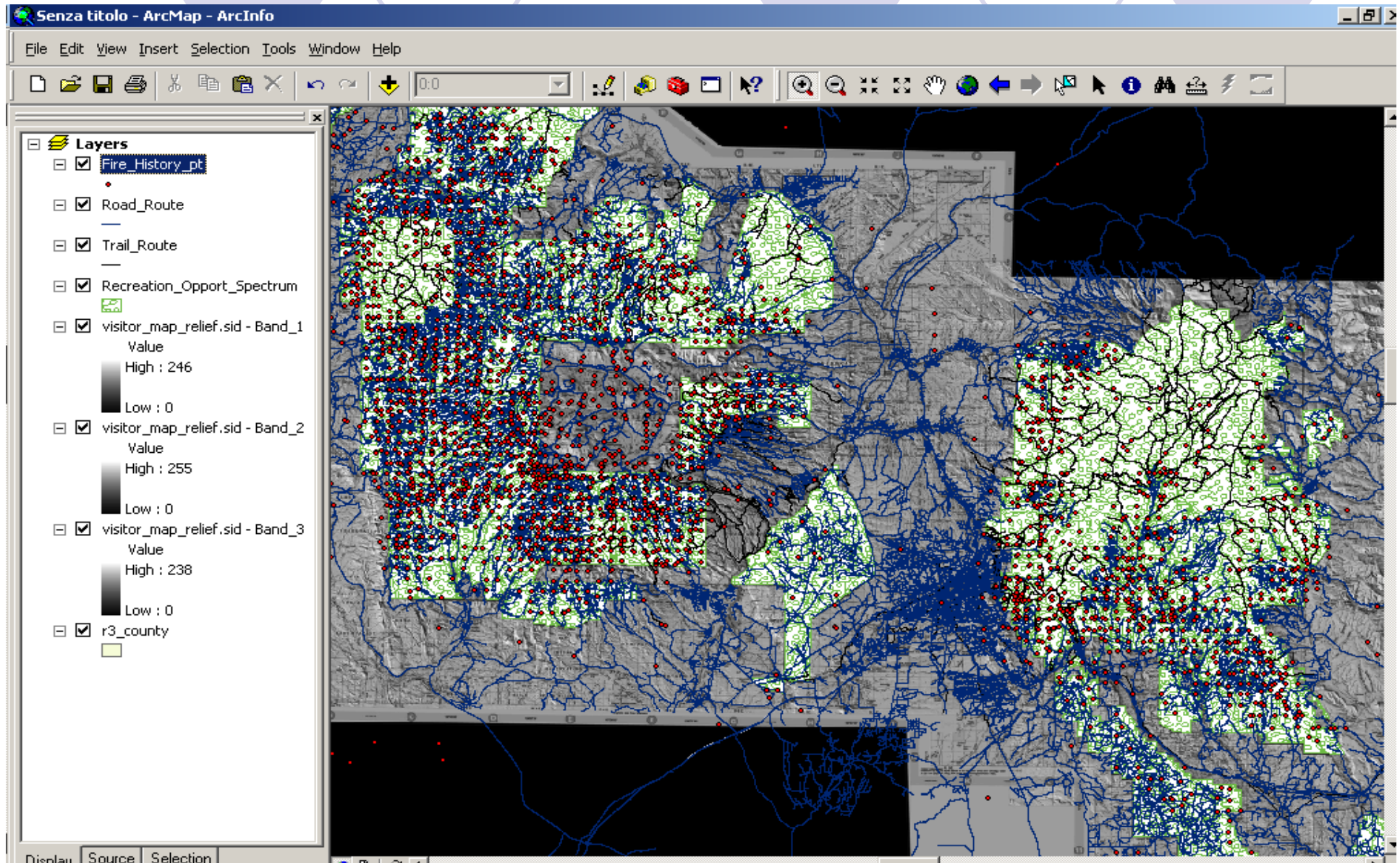


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**In the next slide are shown the Fire History points, the Santa Fe National Forest visitor map revised in 2005, the road and trail routes and the recreation opportunity areas.**

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# Santa FE Visitor Map, roads and route, trial routes and recreation opportunity areas





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**We have tested the use of the EFCM to determine the buffer areas varying the initial number of clusters, as shown in the Table below. The results prove that the EFCM method is quite stable; indeed, the final number of clusters is always 38. The circular volume prototypes are situated geographically on the map as shown in the next slides.**



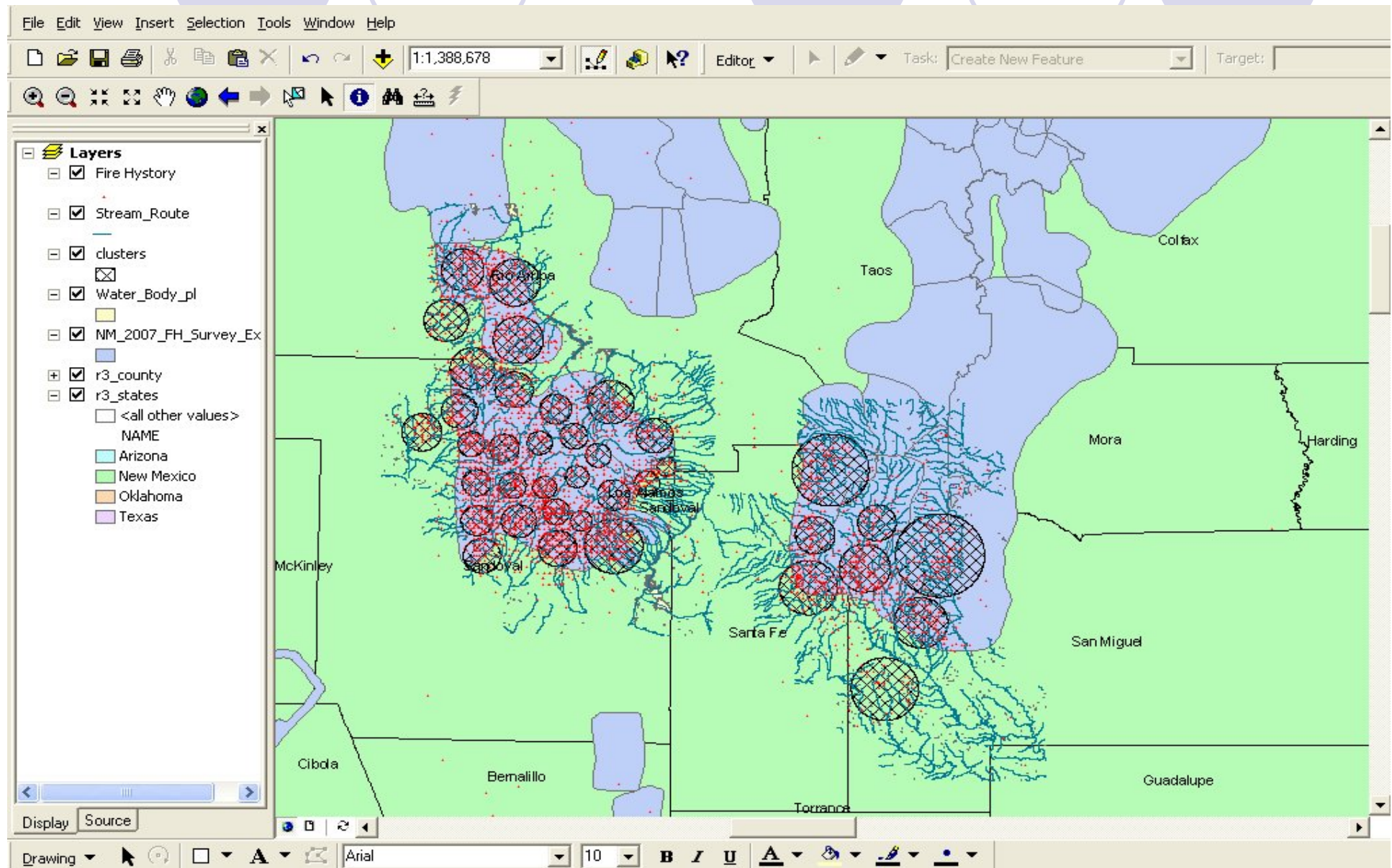
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Initial number of clusters	Final number of clusters	Difference $\ U^{(s)} - U^{(s-1)}\ $
130	38	$0.69 \times 10^{-4}$
120	38	$0.71 \times 10^{-4}$
110	38	$0.67 \times 10^{-4}$
100	38	$0.85 \times 10^{-4}$
90	38	$0.53 \times 10^{-4}$
80	38	$0.49 \times 10^{-4}$
70	38	$0.66 \times 10^{-4}$
60	38	$0.88 \times 10^{-4}$
50	38	$0.72 \times 10^{-4}$

**Table 1.** Number of clusters and corresponding number of features

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# Cluster volume prototypes for the “Fire History” point data



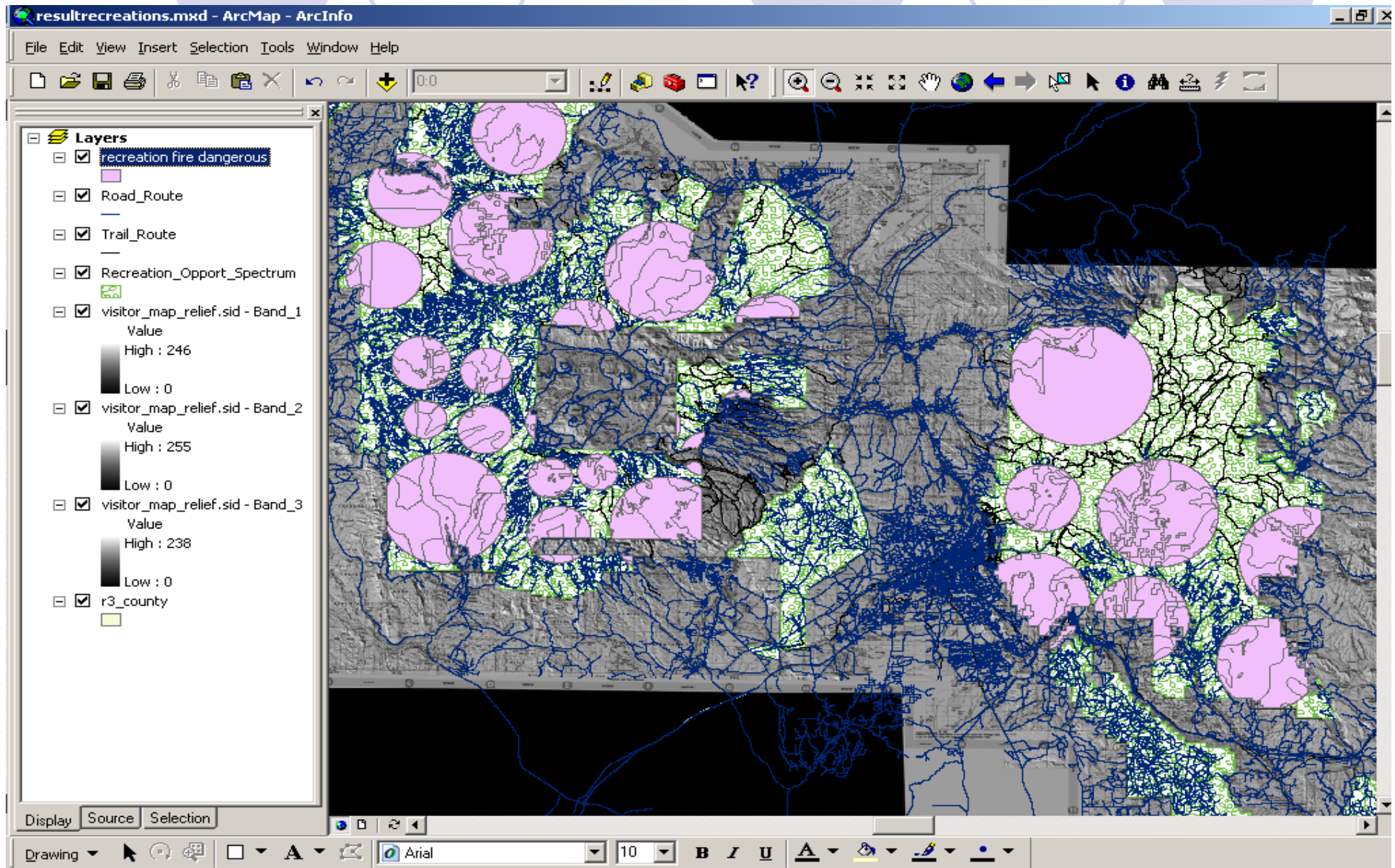


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**In the next slide are shown the recreation areas which are intersected with the cluster prototypes, by obtaining fire dangerous recreation opportunity areas.**

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# Fire dangerous recreation opportunity areas





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## **Improvements:**

**-EFCM is more faster (because of low computational complexity) than the clustering density methods**

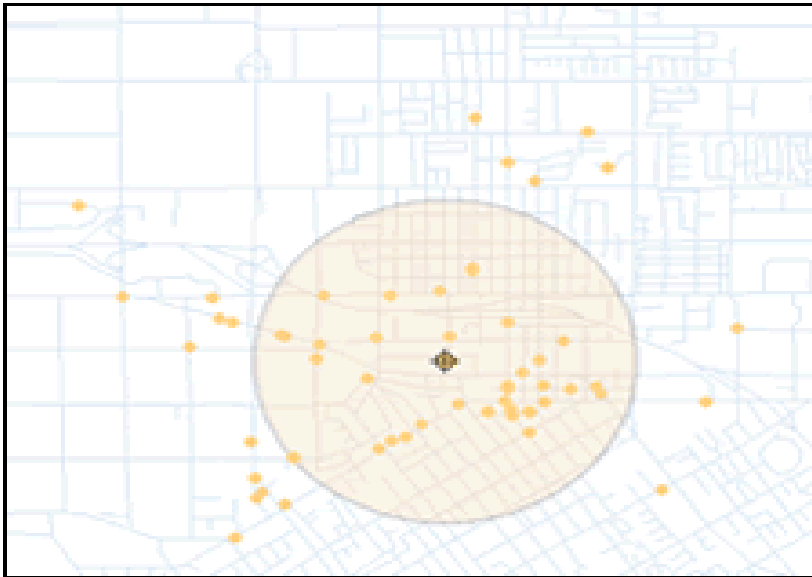
## **Items of discussion:**

- Which applications are possible to crime analysis?**
- Which applications are possible to located geographic items?**

**...**

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**An applicational example from ESRI web pages:  
Extend Crime Analysis with ArcGIS Spatial Statistics Tools  
(by Lauren Scott and Nathan Warmerdam)**



**Daytime burglaries tend to be slightly more concentrated than nighttime burglaries, indicated by the smaller standard distance circle. These circles also highlight the differences in the locations of daytime and nighttime burglaries.**