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# **STONE AGGREGATE EXTRACTION AND SPATIAL PLANNING: EXPERIANCES FROM DALMATIA, CROATIA**

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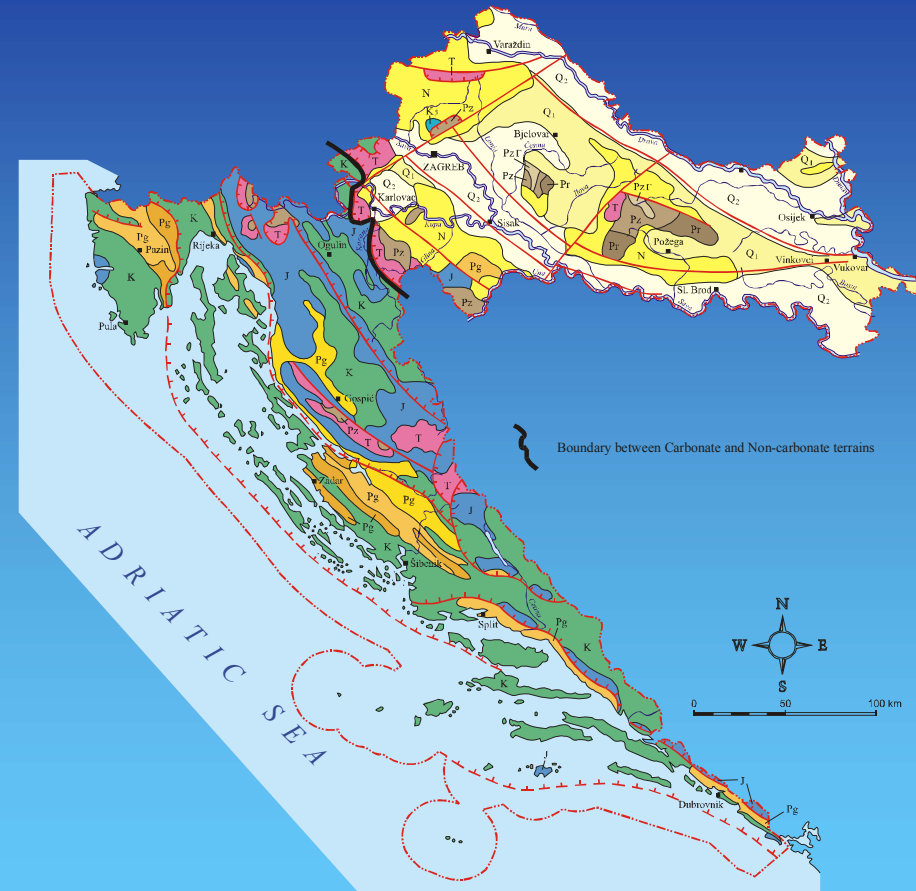
## Outline

- **GIS based modeling for stone aggregate potential**
- **Geology of Croatia**
- **Mineral resources of Croatia and Dalmatia**
- **Extraction sites in Dalmatia and aggregate production (study area)**
- **Method: Weights of evidence (WofE)**
- **Results: areas suitable for aggregate stone quarries in Dalmatia**
- **Mineral aggregate extraction and spatial planning**



# Geology of Croatia

- **>50% carbonate rock**  
(limestone and dolomite mainly of the Mesozoic Adriatic Carbonate Platform)
- **40 % thick unconsolidated Quaternary sedimentary deposits**
- **<5% magmatic and metamorphic rocks**

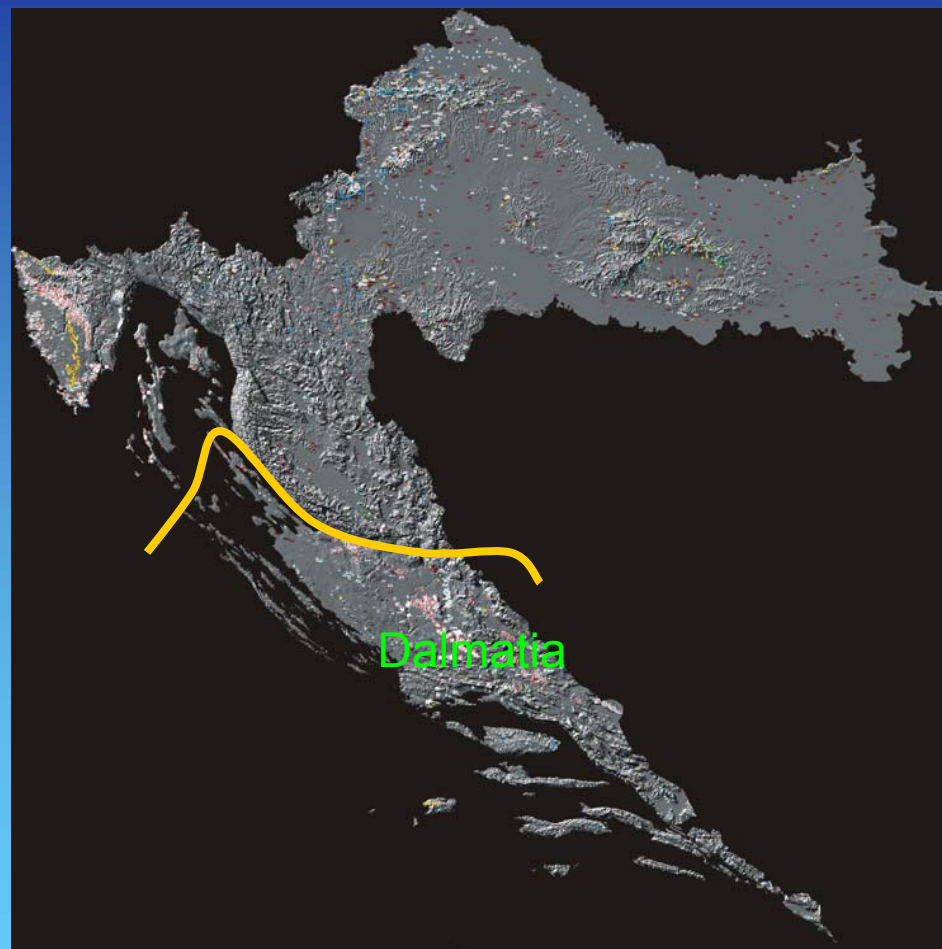


## Mineral resources of Croatia

Mineral commodity:

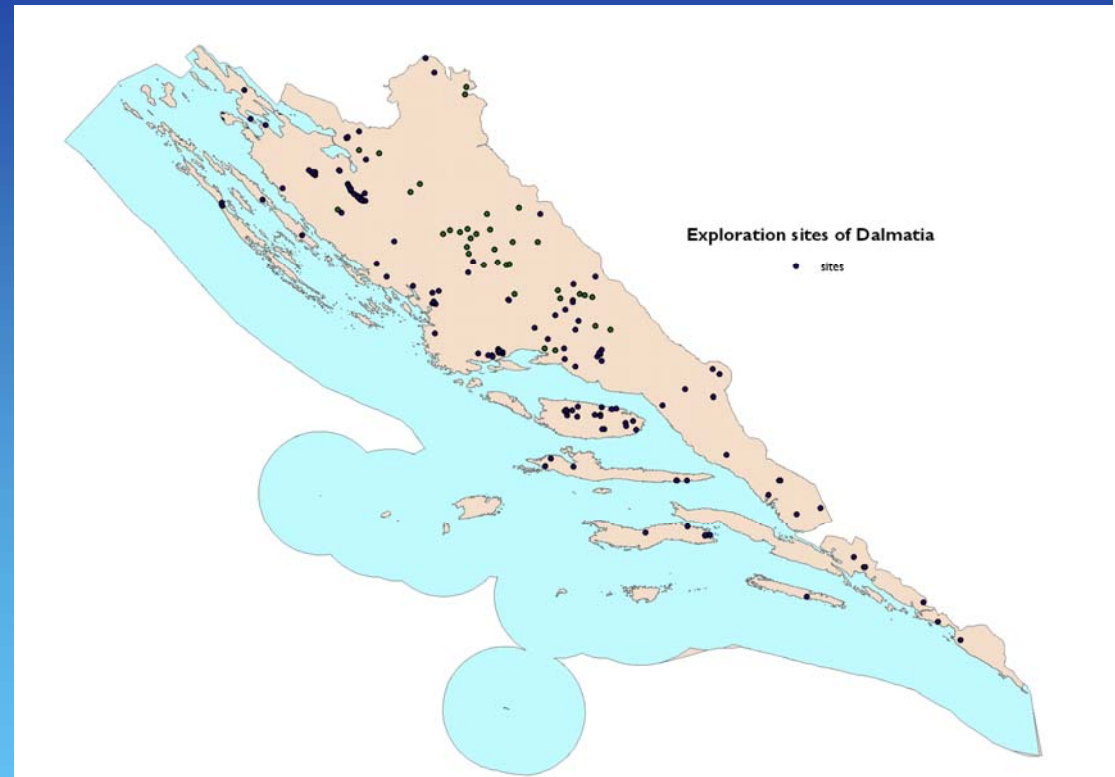
- crushed stone aggregate; 253 sites
- dimension stone aggregate; 103 sites
- sand and gravel; 82 sites
- clay; 49 sites
- bauxite ; 15 sites
- gypsum; 9 sites
- other non metal deposits
- coal in the past

• **626 TOTAL NUMBER OF EXPLOATION SITES IN CROATIA (378 km<sup>2</sup>)**



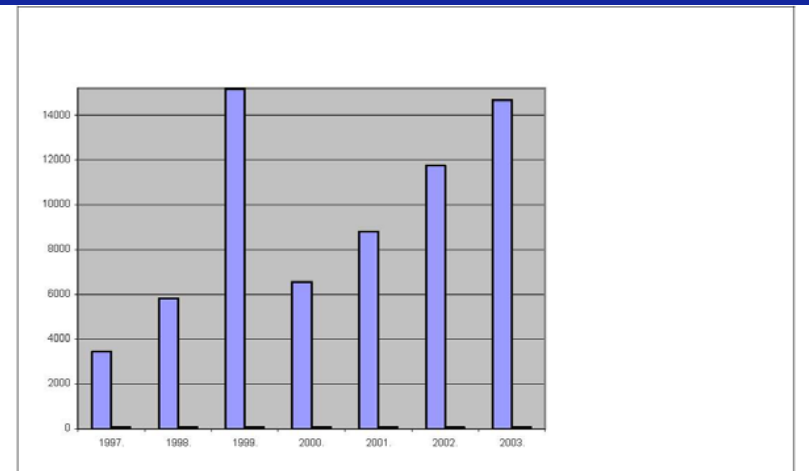
## Quarrying in Dalmatia

- 68 active crushed stone aggregate quarries or 25 % in Dalmatia
- 82 active dimension stone aggregate quarries or 80 % in Dalmatia

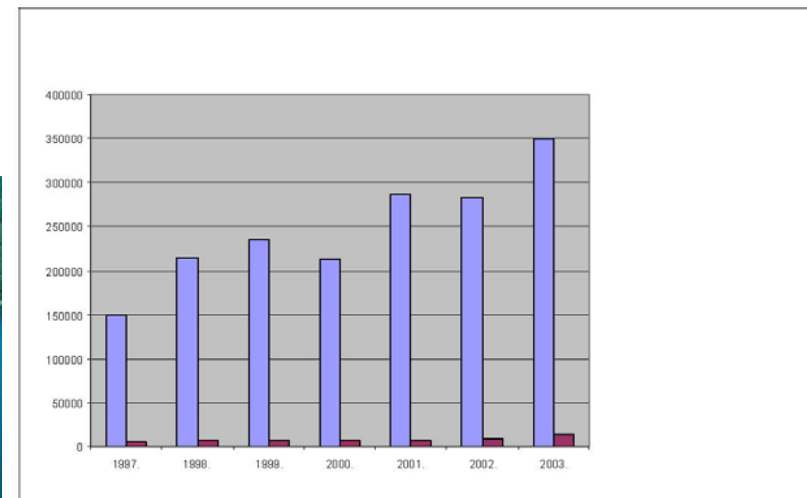


## Quarrying in Dalmatia

- exploitative reserves of dimension stone aggregate 13.5 mill. m<sup>3</sup> in Dalmatia
- exploitative reserves of crushed stone aggregate 350 mill. m<sup>3</sup> in Croatia ( 25% in Dalmatia)
- increasing demand for aggregate in EU, as well in Croatia



dimension stone aggregate



crushed stone aggregate

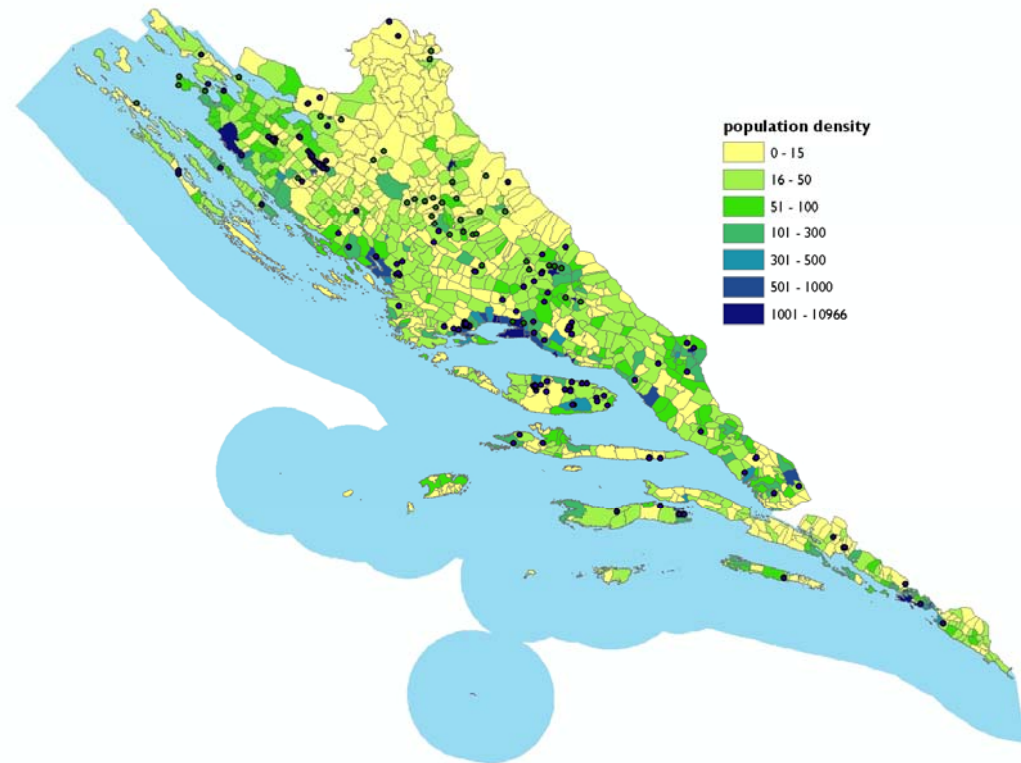
## Weights of evidence (WofE)

- quantitative method
- for mineral-potential mapping by **Bonham-Carter, Agterberg, and Wright (1988)**
- response variable (training points)
- predictor variable (evidential theme)
- analyze spatial associations between variable
- reclassification the evidence categories
- define optimal prediction
- three evidential theme layers were used:
  - bedrock maps with appropriate quality attributes
  - proximity to principal highways and road lines
  - categorical groups define by census tract population density
- all evidential theme layers were prepared in grid format using **Arcview 9.1.** and **ArcSDM** extension which was developed by **Don Sawatzky and Gary Raines (USGS)** and **Graeme Bonham-Carter (GSC)**



## Population density and extraction sites

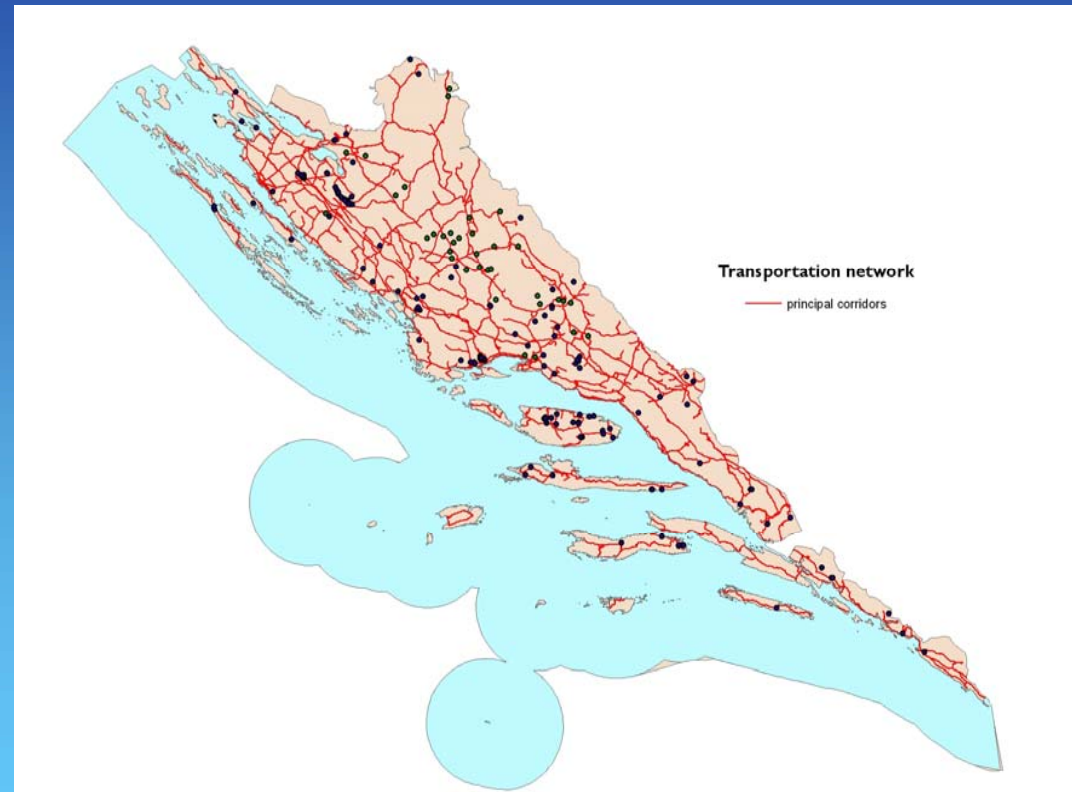
- predictive evidence
- population density (people per square km)





## Transportation network and extraction sites

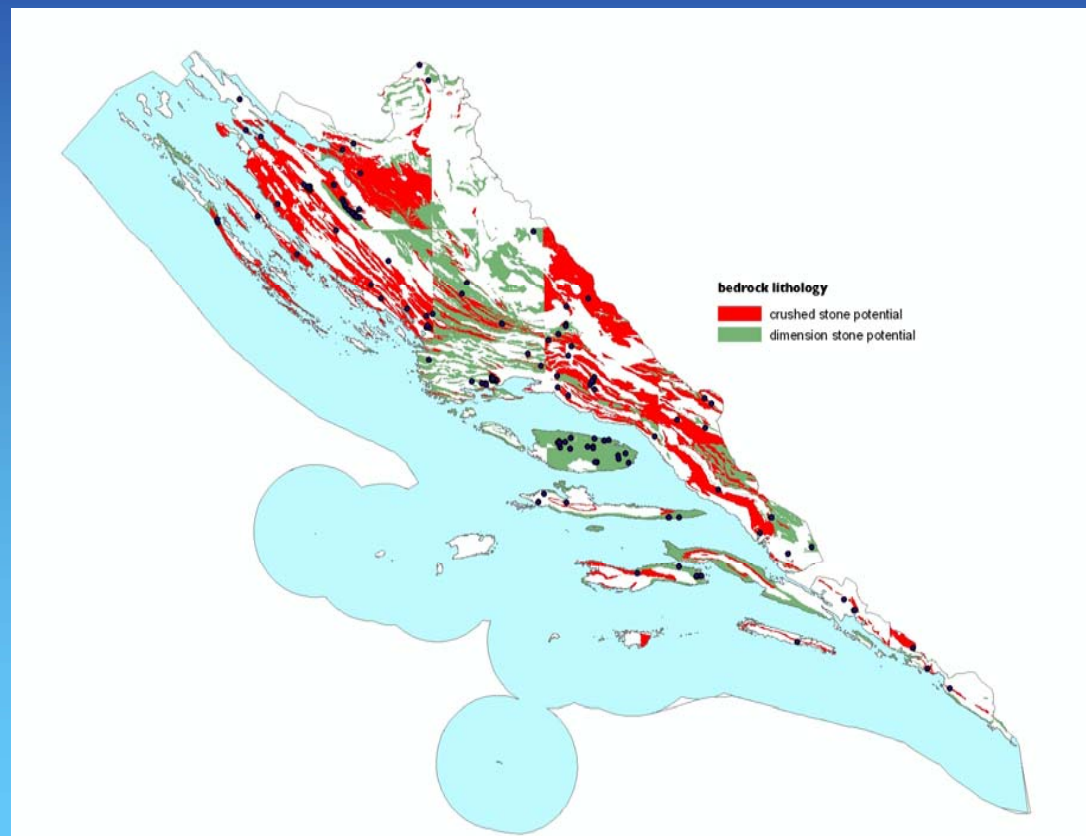
- predictive evidence
- transportation network
- distance from transportation corridors within 2 and 4 km
- 90% crushed stone aggregate quarries are within 2 km of principal roads
- the importance of proximity to transportation roads for the industry



## Bedrock lithology and extraction sites

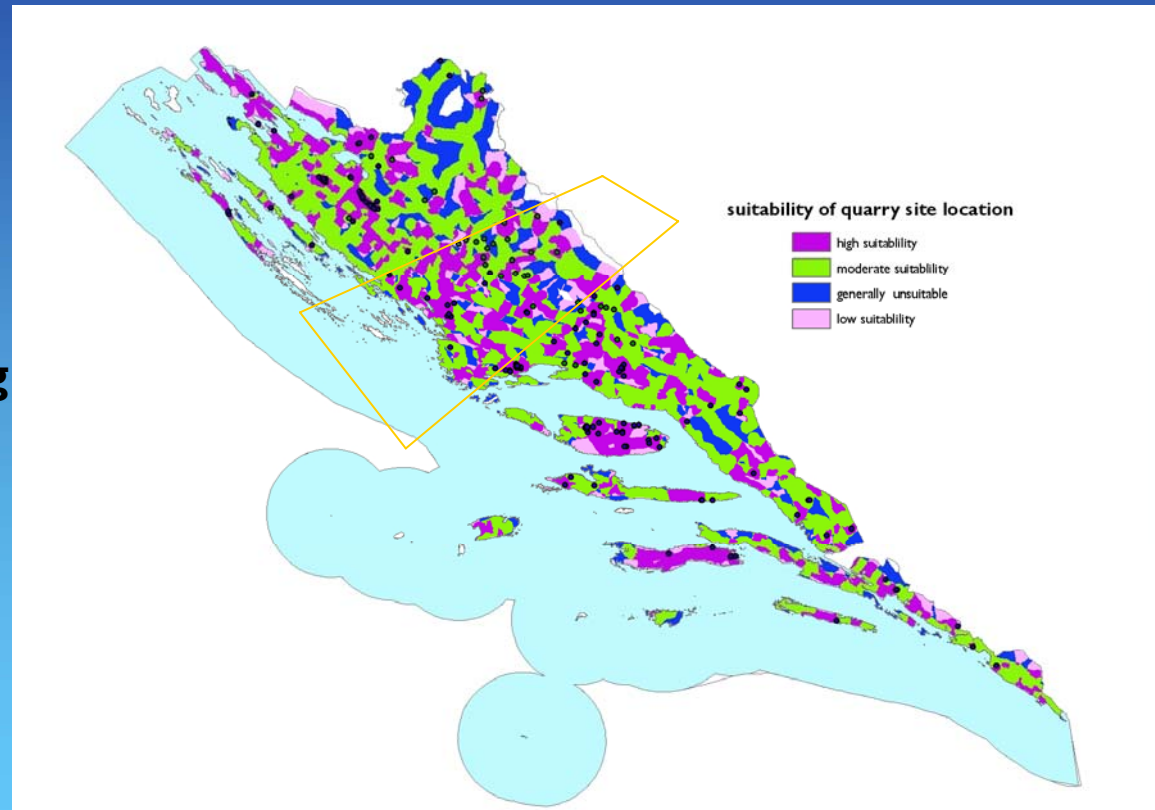
### bedrock lithology

- predictive evidence
- compilation of 1:100 000 scale basic geological maps of Republic of Croatia
- 20 maps sheets in digital format
- potential maps for stone aggregate in the study area



## Suitability for aggregate production

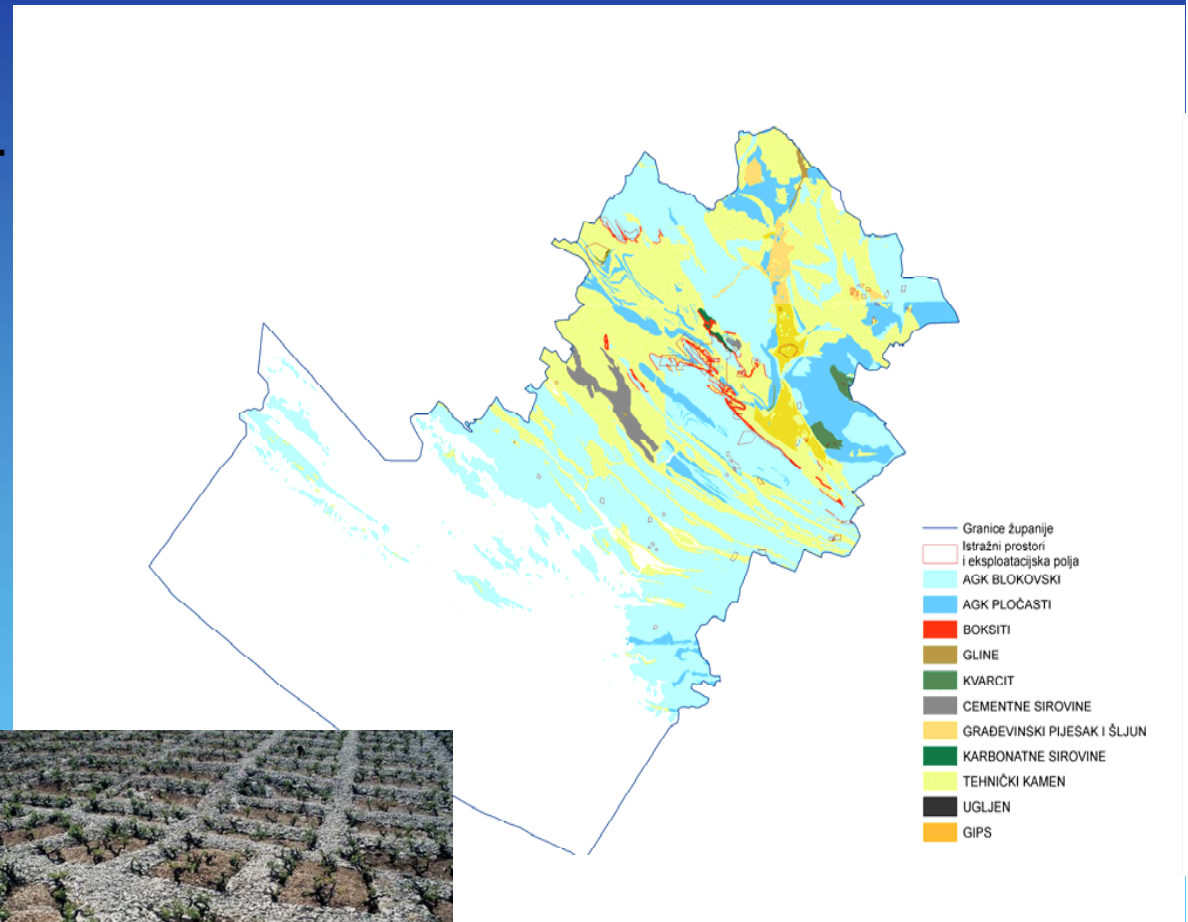
The method demonstrates a technique to define suitable areas for aggregate production using geological map, transportation network and population density spatial data for evidence



# Mineral resource potential and land use restrictions

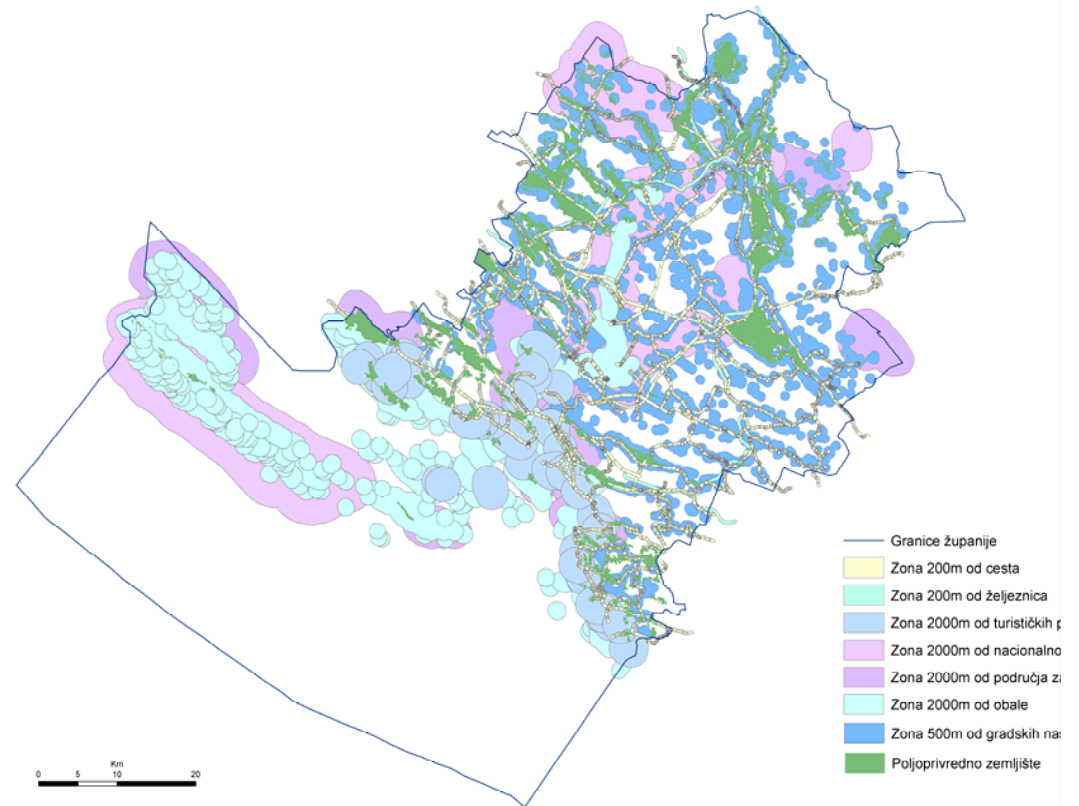
**Case study:**  
**Šibensko-kninska county -**  
**Dalmatia**

- geological potential for  
mineral resources



# Mineral resource potential and land use restrictions

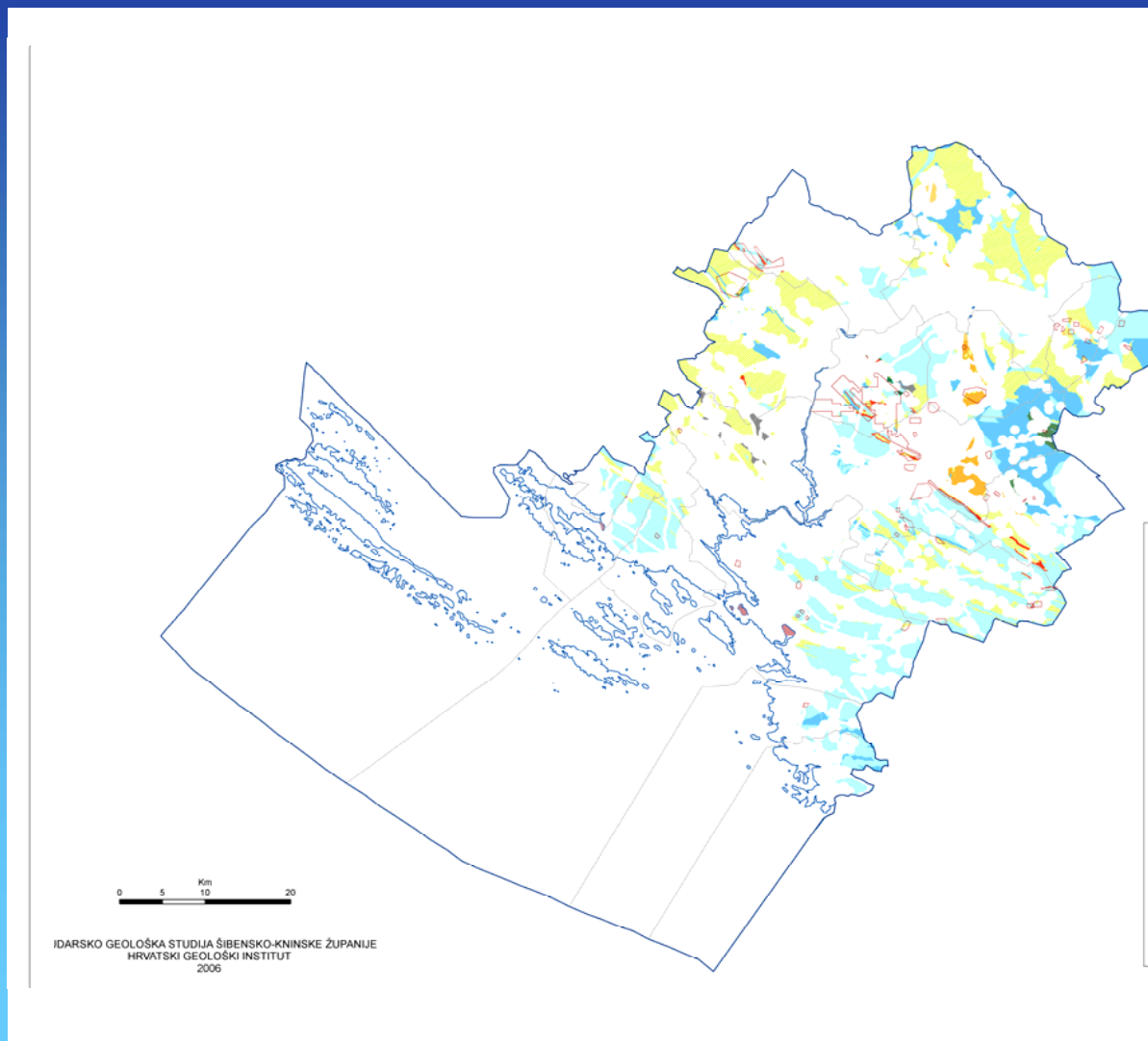
- Šibensko-kninska county**  
- **Dalmatia-**  
**administrative**  
**restrictions in context**  
**of mineral exploitation**  
**(central and local**  
**government agencies)**
- road infrastructure
  - protected areas
  - valuable land
  - 1 km distance from the coast
  - tourist resorts
  - settlements



## Restricted mineral potential and spatial planning

### Šibensko-kninska county - Dalmatia

- road infrastructure
- protected areas
- valuable land
- 1 km distance from the coast
- tourist resorts
- settlements (500 m distance buffer)

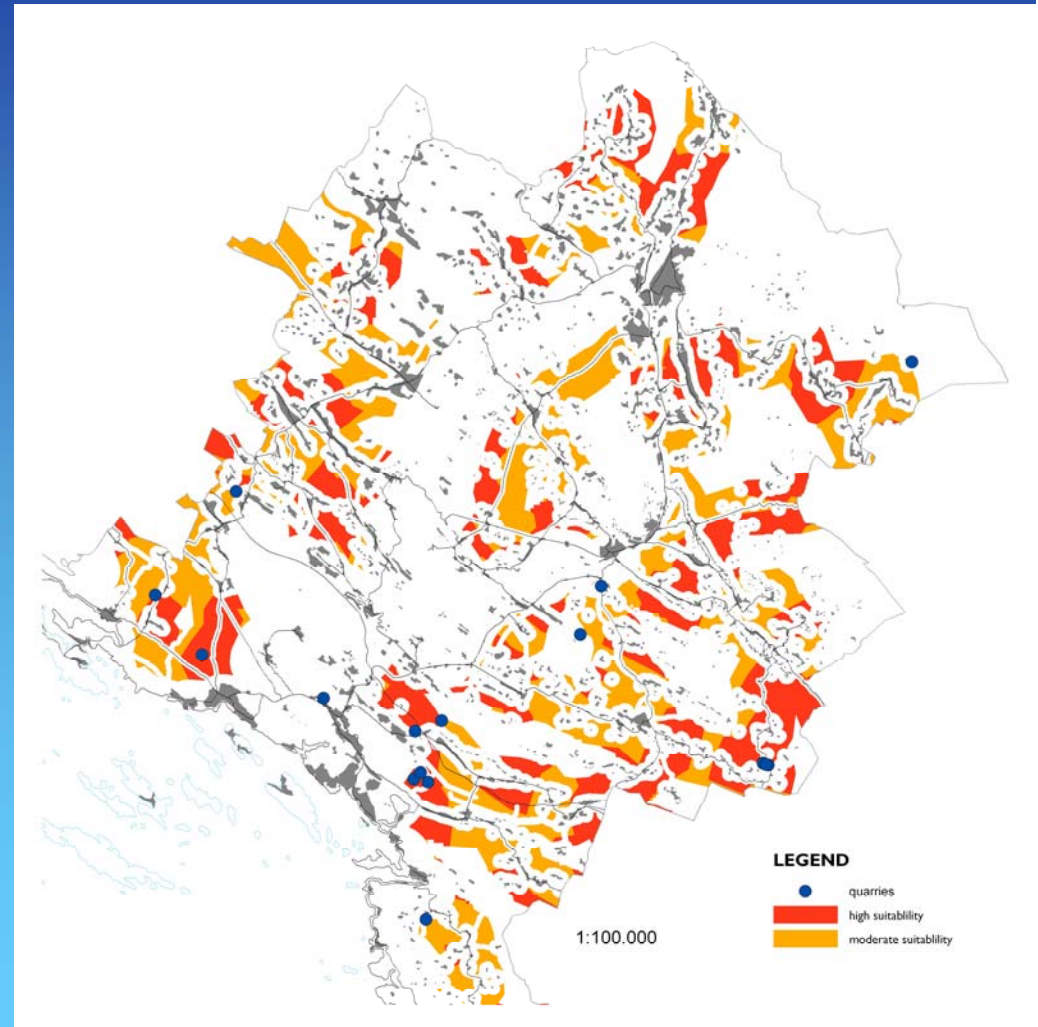


# Restricted mineral potential and most favorable areas for dimension stone extraction

**Arc SDM WofE favorability  
map for dimension stone  
extraction**

**Šibensko-kninska county -  
Dalmatia**

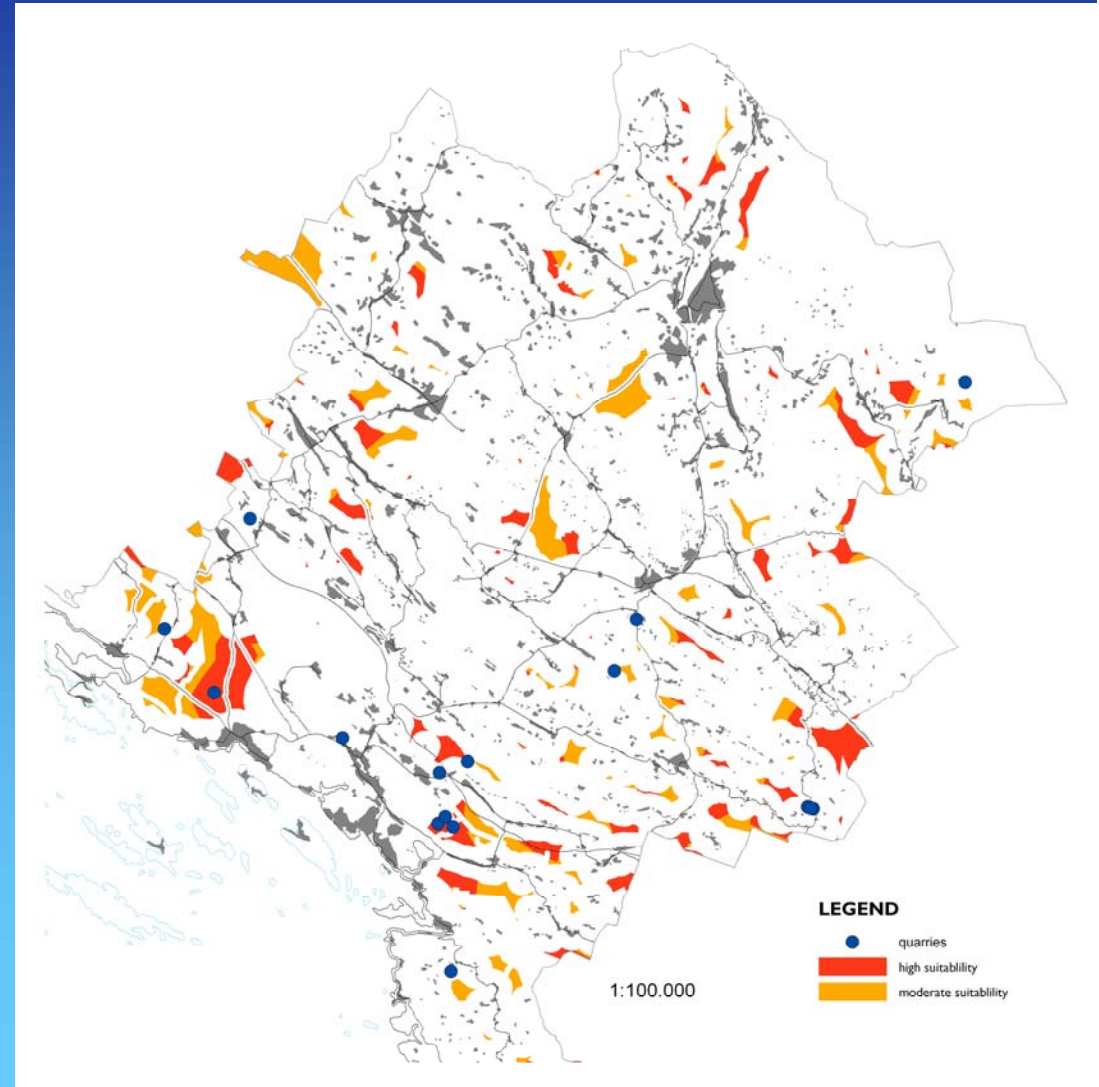
- road infrastructure
- protected areas
- valuable land
- 1 km distance from the coast  
and tourist resorts
- settlements (500 m  
distance buffer)



# Restricted mineral potential and most favorable areas for aggregate extraction

## Šibensko-kninska county - Dalmatia

- road infrastructure
- protected areas
- valuable land
- 1 km distance from the coast
- tourist resorts
- settlements (1000 m distance buffer)





## Goals of HGI-CGS

To rise awareness to various mining problems and impacts on karst and to help manage better the use of mineral resources in Dalmatia based on identification of more suitable areas for stone production taking in account both environmental and marketplace restrictions and to help local environmental policy makers to correctly manage the fragile karst environment and to preserve the natural landscape.

## Achievements of HGI-CGS

- spatial planners (on the county level) have become aware that there is a need to reserve space for mineral resources
- industry and administrations have started a dialog

## Drawbacks

- due to the negative attitude of the Croatian Ministry of Environment towards the extractive industry; a general strategy for mineral planning especially in reserving space on the Croatian scale is still not possible



**Thank you !**

**HGI**

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