Abstract
The paper proposes an efficient network of forest belts that can fulfil the multiple roles characteristic to a well-designed intervention: protecting the city against agricultural dust, noise protection, air filtration, stabilization of land, improvement of the quality of agricultural products when growing in protected areas, conservation of the biodiversity following the relief, climate and hydrographical conditions and the development of agricultural landscape. This last goal is very important as in the vicinity of Timisoara one has little natural landscape attractions. The paper also aims to establish a favourable ratio intervention / costs, leading to the actual implementation of the proposal in a short time to have concrete results. The main research methods used are bibliographic documentation, analysis of sampled data provided by institutions in the field and simulation, in order to determine the optimum size of the forest belts for an efficient protection against agricultural dust and other major pollutants which arise from the surroundings of the city. The paper sets a proposal of practical solutions to improve air quality and decrease negative effects on public health due to high levels of allergens coming from plants on vacant lots as well as agricultural plots.

Green belts are accessible ways to improve the quality of the environment of a city and its surroundings. The success of these methods also depends on the existence of programs and organizations that promote measures in the field.

Keywords: green belt, air quality, biodiversity, sustainability

INTRODUCTION
The city of Timisoara has a highly polluted air although it is called the town of parks and gardens. According to the World Health Organization (Arbutina, 2013), Timisoara, along other cities in the Balkans, has exceeded the European Union’s stipulated limit of air pollutants concentration in micrograms per cubic meter, especially the dangerous PM10 dust particles which increase the risk of respiratory and cardiovascular illness (Popescu et al., 2009). Due to this situation, Timisoara, along with other major cities in Romania, was compelled in 2011 to come with strategies for a cleaner air (Istrat, 2010; Cusnir, 2011). Even so, local authorities question (Deaconescu, 2013) the international reports and say that the air quality has improved significantly over the years and that last year the exceeding of the pollution limit was insignificant (ANPM).

However, the bad quality of the air in the city of Timisoara is a fact (Ionel et al., 2008) due to the city’s position in open field with small areas of forest and close to the Hungarian Puszta, on a territory resulting from drained swamp (Ardelean and Zavoianu, 1979; Nedelcu, 2008). According to the experts from the Pollution Control Commission, the causes of air pollution are traffic, construction and demolition waste management, the existence of disused plots between blocks,
thermal plants emissions, agricultural work and lack of green belts. The last two aspects represent the main subject of the paper, as many of the other factors already benefit from laws that regulate and impose limits for them. An effective screen against particles brought from outside the city doesn’t exist, and this leads to pollution even if all traffic sources and other emissions which result from human activity within the city would not be considered (Miron, 2013).

In this case, a protection for the city is indispensable and urgently needed. The paper provides an efficient proposal for developing the green belt network surrounding the city of Timișoara, while taking into consideration the geographical characteristics of the area and preserving its particular land development work – the drainage system which is falling apart if proper measures are not taken.

MATERIALS AND METHODS
In order to come with an adequate green belts proposal for the particular characteristics of Timis County, bibliographical research, concerning various aspects of the area chosen for intervention, was used:
- Laws concerning the realisation of green belts in Romania;
- Historical and geographical characteristics of the area;
- Drainage system;
- Existent studies concerning the problem of green belts around the city of Timisoara and the air quality level;
- Articles highlighting the dangers of agricultural dust;
- Articles highlighting the dangers of low quality air level present in Timisoara.

Data from institutions in the field were obtained by accessing their official websites, discussions with their representatives and gathering of information from documents received from their headquarters.

ANIF (National Agency of Land Development)
ANPM (National Environmental Protection Agency)
OSPA (Soil and Agrochemical Studies Office in Timisoara)
RCUPT (Research Centre for Urban Planning – Timisoara)
Timisoara City Hall
EEA (European Environment Agency)

The data obtained from the above mentioned sources were analysed, processed and compared. Tables and maps were elaborated as support and justification of the forest protection proposal for the city of Timisoara.

An analysis of the intervention perimeter around Timisoara from geographical, historical, and different other points of view was performed, in order to adapt the green belts proposal to local particular characteristics.

Cartographical information (drainage system maps from the ANIF institution and satellite images from Google maps) were used.

The proposal for the green belts is based on a simulation of an optimum layout. Several maps highlight by means of layers the characteristics that should be taken in consideration when proposing forest protection in order to obtain maximum benefits.

RESULTS AND DISCUSSIONS
1. Air pollution. The very poor air quality in the past years in the Timis County is the main reason for the initiatives to create green belts around the city of Timisoara (Fig. 1).
The information issued by the World Health Organization is that the air quality in Timisoara is one of the worst in Europe. The local authorities in the field (ANPM) claim in annual reports that the air quality is quite good and the monthly reports show values from good to excellent.

By analyzing the monthly reports posted on the official site of (ANPM), one can see that in the last 2 years, the air monitored at most stations improved (Tab. 1). There are 7 monitoring stations in Timis County (Fig. 2). Here also the information is contradictory. Two stations are in suburban areas: TM-3 and TM-6, and in the annual report table they measure the air quality on a radius ranging from 25 to 150 km. In this case the areas surrounding the city of Timisoara are taken into consideration. But the description of the types of stations (RNMCA) only mentions a radius of 1-5 km for also for suburban stations. If so, large areas in the county are never covered by air quality monitoring. The analysis of monthly bulletins from the last 2 years shows that TM-3 suburban station has low air quality level in comparison with the one in the city. Normally, traffic air quality monitoring stations, due to car emissions, have the lowest air quality level. However, the suburban TM-3 station located in the northern part of the county, shows quality levels comparable with the ones displayed by traffic stations. Also, TM-3 shows lower values than the other suburban station in the county: TM-6 Moravita.

The air quality values from station TM-3 are constant along the years (Tab. 1, 2), showing that no considerable improvements have been made in the areas outside the city of Timisoara. This brings forth the hypothesis that the air outside the city is highly polluted and wind brings into the city these additional pollutants. The main pollution component in the air brought from outside the city is the agricultural dust, and surprisingly, the (ANPM), does not have any studies on this particular pollutant, which is responsible for many respiratory symptoms (Schenker et al., 2005).

According to Schenker (2000) the agricultural soil generates inorganic dust having in its composition up to 20% particles of crystalline silica and the rest of 80% are silicates which are known to be dangerous if inhaled (Singleton, 1977).

2. Green belts. Outside a city, an efficient way of improving the air quality is by planting forest belts. 1 square m of leaf area of an oak produces 1 g of oxygen/hour and stores 1.5 g of CO2, while on sunny days, 1 hectare of forest produces 180-220 kg of oxygen and absorbs from the air 220-280 kg of CO2 (Negrutiu, 1980). This leads to a positive influence on the environment by reducing the amplitude of diurnal temperature with 2 - 4° C and the annual one with 1 - 2° C. According to local
Green Belts and the Improving of Air Quality – CASE STUDY: Timisoara and its Surroundings

Tab. 1. Comparative air quality values between the 7 stations in the county for 2012 and 2013

<table>
<thead>
<tr>
<th>Station code/type</th>
<th>Monthly air quality values* in 2013 for all 7 stations in Timis County</th>
<th>Value /year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan</td>
<td>Feb</td>
</tr>
<tr>
<td>TM-1 traffic</td>
<td>1.58</td>
<td></td>
</tr>
<tr>
<td>TM-2 urban</td>
<td>1.86</td>
<td></td>
</tr>
<tr>
<td>TM-3 suburban</td>
<td>2.43</td>
<td></td>
</tr>
<tr>
<td>TM-4 industrial</td>
<td>1.88</td>
<td></td>
</tr>
<tr>
<td>TM-5 traffic</td>
<td>2.54</td>
<td></td>
</tr>
</tbody>
</table>

Note: *1=excellent, 2=very good, 3=good, 4=medium, 5=bad, 6=very bad. (RNMCA)

Tab. 2. Comparative air quality values for TM-3 suburban station for 2010 and 2011

<table>
<thead>
<tr>
<th>Station code/type</th>
<th>Monthly air quality values* in 2010 and 2011 for TM-3 suburban station</th>
<th>Value /year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan</td>
<td>Feb</td>
</tr>
<tr>
<td>TM-3 2010</td>
<td>2.48</td>
<td></td>
</tr>
<tr>
<td>TM-3 2011</td>
<td>2.9</td>
<td></td>
</tr>
</tbody>
</table>

studies (ET) Ecological Timisoara in 2008 and (TCLP) Timis County Landscape Plan in 2011, one hectare of forest produces annually about 30 tons of oxygen, of which 13 tons are being consumed for the respiration process of the trees. In matter of chemical pollution, it is mentioned that an air polluted with sulphur dioxide concentration of 0.1 mg/m3 can be fully de-polluted by its slow passage over a hectare of forest, while green belts containing conifers also purify the germs from the air.

Green belts protect the climate on plains, where there are no trees, and create a favourable microclimate during summer heat, reduce wind speed on a distance of five to ten times their width and provide the changing of the wind’s direction. They also provide a recreational place for inhabitants, a favourable environment for the development of wildlife and bird nesting.

Among the positive effects green belts have over crops some of the most notable are: 10-20% higher production growth (Tab. 3), preventing the spreading of weed seeds that can infest the crops and harmful insects; the developing of natural parasite fund which helps reduce the application of insecticides over crops; preventing deflation and thereby preventing dust storms, soil impoverishment and loss of humus and nutrients in the upper layers affected by wind erosion; avoidance of the breaking of stems and leaves and the premature shaking of flowers and fruit.

Green belts also bring multiple other benefits to the area. They heat the air in the space next to them at night and cool it during the day by the air exchange process. The cooling effect is not only due to the decrease of radiation level through the canopy of the trees, but also because of the evaporation which takes place through the leaves, which use an average 60-75% of the energy of radiation to sweat.
There are several types of green belts. The paper focuses on those which are meant to protect human settlements and crops, as the city of Timisoara is in great need of a barrier for particles brought from the agricultural land and unused plots outside the city. Also, the soil and crops from the vicinity of the town would also benefit of a green belt network.

According to the (TCLP), forest protection for human settlements includes:

A category: shelterbelts protecting the cities against nuisance and pollution produced by agro-industrial complexes, which are to be placed around the certain complex, consisting of high and medium forest vegetation (species of trees and shrubs resistant to pollution such as pyramidal and black poplar, acacia, ash, sky, evergreens, maple, mulberry, etc.).

B category: shelterbelts protecting the cities against harmful climatic factors, consisting of wide (generally 20-40 m) and compact green belts. These should surround the city if possible or be placed in the endangered sectors, perpendicular to the harmful climate factors. Wide curtains can be placed close to buildings at distances of 5-10 m, while narrow ones at minimum 50 m distance. The species of trees and shrubs should be adapted to stationary conditions, and present precious wood, flowers, fruit and decorative qualities (acacia, lime, pyramidal poplars, Glade, Japanese acacia, sky, field maple, pear and wild apple tree, turntable, yew, dogwood, hawthorn, sea buckthorn, blackthorn etc.

For Timis County, especially the western and north-western areas, soil and hydrology of the region determine the adoption and application of the following two types of network structures of shelterbelts for agricultural fields:

Classic network: main shelterbelts, oriented perpendicular to prevailing winds direction, at each 600 m, and secondary shelterbelts intersecting the main ones at 1200 m distance (600x1200 = frequent plot dimension in Timis County; 500x1000 = optimum plot size protected by a shelterbelt). In order to compensate the larger surface of the protected plot, and simplify the design and implementation process, all green belts may be 10 m wide.

Polygonal network: portions of shelterbelts forming a closed circuit, with no distinction between main and secondary belt width, located along main and secondary drainage canals, main and access plot roads, delimitating an agricultural area of 200-300 ha and providing good protection from winds blowing from all directions. Speed reduction normally has maximum effect when the

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**Tab. 3** Green belt protected crop production growth estimations (TCLP)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Growth Estimation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>11-143%</td>
</tr>
<tr>
<td>Corn cobs</td>
<td>17-61%</td>
</tr>
<tr>
<td>Winter barley</td>
<td>19-27%</td>
</tr>
<tr>
<td>Spring barley</td>
<td>10-106%</td>
</tr>
<tr>
<td>Beets</td>
<td>12-45%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>15-28%</td>
</tr>
<tr>
<td>Vetch hay</td>
<td>21-47%</td>
</tr>
</tbody>
</table>

These bonuses are equivalent with an increase culture surface of 12-103% in normal years with drought and 275-1382% in the dry out period.

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Fig. 3. Optimum protection distances required for a functional drainage canal section.
wind blows perpendicular on the belt. However, research undertaken in Hungary, placed the protective belts at various angles to the main wind direction, in similar geographical conditions, and showed high effect. If 2-3% of the surface of an agricultural plot is covered by this shelterbelt system, the protection of the crops is assured. This type of network is best suitable for lowlands, where the complexity and density of drainage canals require land division into fragments that can be defined by alignments of trees. According to ANIF (National Agency for Land Improvement), certain distances must be respected next to the drainage canals (Fig. 3).

However, the drainage canal system is no longer maintained and is mostly covered with shrubs and sometimes even trees (blackthorn, field maple, dwarf willows, ash, white poplar, acacia, etc.).

The formerly existing green belts protection of Timis County was affected in the last years, which led to the reducing or loss of the benefits they brought to the environment. All consulted local studies speak of the last 17 years in which existing forest protection has been affected. However, after speaking with an ANIF representative, it appears that there is no record of any remains of this protection for over 30 years. This may prove the low interest of the local authorities in the real status of the problem. According to Danescu (2007), between 1937 and 1961, there have been numerous studies and scientific research concerning required conditions for shelterbelts and their influence on wind, soil, wildlife, crops and agricultural production. After 1961 the planting of protective forest belts suddenly ceased and later has been officially stopped by H.C.M. No. 257 and 385 of 1962. The existing forest belts were almost completely deforested afterwards. Green belt planting started again after 1970, but only on mobile sands in southern Oltenia.

3. Timis County. It is the largest county in Romania, with a total surface of 8,696.7 km². It is situated in the western part of the country, being mostly covered with plains ~76%, hills ~20.5% and only ~3.5% mountain (ANPM). This land configuration also reflects in the forest coverage. Agriculture land areas cover 700.77 ha (80.55 % of the total surface of the county), and only 12% of the county’s surface is covered with forests, of which 2% on plains area, 18% on hills area and 80% on mountain area, therefore, in matter of optimal coverage (10-15% for plains, 30-35% for hills, over 60% for mountains), plains and hills are strongly deficient in forests (TCLP). Without worrying of loosing valuable agricultural lots, there already are areas which can be forested in order to improve land quality and contribute to the green belts network required in the county (Tab. 4).

The 331.45 km² would represent only 3.81% out of the county’s entire surface and would balance the agricultural/forest ratio. According to (TCLP) there are other land areas that could be used for forestation, bringing bigger benefits

| Tab. 4. Types of land unfit for agriculture that could be used for forestation (OSPA) |
|-----------------------------------|-----------------------|
| Permanent moisture excess land areas | 160,14 km²              |
| Strong excessive surface erosion land areas | 71.44 km² (7,144 ha) |
| Landslide, subsidence, leakage land areas | 51.01 km² (5,101 ha) |
| Marginal land areas: landfills, quarries, borrow pits, ponds, etc. | 33.56 km² (3,356 ha) |
| Depth erosion land areas (trenches, ravines, torrents) | 11.8 km² (118 ha) |
| Sandy soils exposed to erosion by wind or water | 3 km² (300 ha) |
| Land areas with boulders, gravel, debris | 0.5 km² (50 ha) |
| Total surface of land unsuitable for agricultural use that could be afforested to protect soil, restore water balance and improve the environmental conditions | 331.45 km² (33,145 ha) |
| Total surface of Timis county | 8,696.7 km² (869,670 ha) |
this way than by using them as agricultural plots, which would require major investments: low quality terrains, terrains polluted with nitrates and nitrites) saline, or acidified land. By adding up all of these categories of terrain, there could be up to 25000 hectares of bad quality land that can be used for forestation, thus helping restoring the soil’s health and ensuring ecological balance.

When the terrain is hilly or uneven, winds change direction according to the forms of relief and the western winds prevailing at heights over 800-1,000 m may be felt during the summer in the plains as well. However, the county is predominantly covered with lowlands free from obstacles, which are open to winds from all directions, the most common ones being the winds of the southern sector (S, SE, SW) and the northern sector (NW, NE) with an average frequency of 10 to 18% (TCLP).

These main winds with variable frequencies are responsible for the transport of agricultural dust inside the city, as air is the fastest way dust particles travel, and also bring pollutants emanating from industrial units on the platforms placed to the West and South of the city. Normally, these effects can be largely reduced by the usage of green belts and forests (Spirn, 1984, p. 56-60). Also, swampy land can benefit from the presence of forests as they help drain the terrain (idem, p. 130, p. 196), thus, help solving the county’s hydrological regime regularization problem and improve soil moisture. Timisoara belongs to the county with the biggest percent of drained areas. The embankment works on water courses, drainage and irrigation improvements constantly changed the geographical landscape giving a particular identity for Timis County (Zavoianu, 1979). Forests and green belts/corridors have also been used in the past to clear away the swampy smell of the area.

Steps for creating green corridors for the protection of Timisoara have already been made. An entire strategy for Timis County’s green protection has been developed (Radoslav and Gaman, 2011), consisting of both large area forests and green belts (Fig. 4).

At present, there is one single green belt for Timisoara, initiated in 2001 with the help of Ph.D. Architect Radu Radoslav, which is situated in the NV area of the city because major winds come from that part. It has seven sections, in chronological order: S1, 7 ha in 2001-2002; S2, 2 ha in 2003-2004; S3, 2 ha in 2004-2005; S4, 3 ha in 2004; S5, 3.2 ha in 2005; S6, 1.6 ha in 2006; S7, 3 ha in 2007, 8 ha in 2007-2011. The green belt is surrounded by a protection fence and is 60 m wide, ensuring inside its width the accumulation of all of the snow brought by wind. There is a distance of 2 m between the tree rows and 1 m between the trees in a row, which means 5000 trees / ha, and it is done in steps in the direction of prevailing winds, thus ensuring penetration.

In 2006, the amount of green space/inhabitant was 15.9 m2, and there were 0.5 trees/inhabitant. Local authorities planed to reach 26 m2/inhabitant and 1 tree/inhabitant by 2013. However, there are only 16.7 m2/inhabitant at present and the solution authorities wish to adopt is consider the entire Green Forest a city park. (Tab. 5) shows that in matter of green belts, planting stagnated in the last 2 years although they could raise considerably the level of green space.

![Fig. 4. Existent green protection proposal for Timis County](image-url)
for the inhabitants. Law force (RP No 289/2002, RG No 81/1998) also support and encourage the planting of green belts around human settlements for protection against harmful climate conditions and on agricultural fields for crop protection and prevention of soil erosion.

**Note:** *Ecological Timisoara study, 2008, ** Gen. Urb. Plan, 2012, ***vice mayor declaration (18) as statistics for 2013 are not available on the website yet*

### 4. Proposal

The proposed green belts network (Fig. 5) is developed along drainage canals, perpendicular on the major winds directions. In order to meet the snow retention requirements, forest belts should have 30 m (15 rows spaced at 2 m), if the belts are designed to totally accumulate the snow, and 14-16 m (7-8 rows spaced at 2 m) if designed to partially accumulate the snow. They can be placed just along the margin of the road if the presence of utilities doesn’t require a 5-10 m withdrawal; along roads, shelterbelts should be placed at a distance of 20-50 m aside the road platform (TCLP).

The proposal consists of a total of 30.52 km long green belt network on the north western part of the city. This would include crop protection belts, the protection of the villages of Sacalaz and Dumbravita and a 6.8 km long green belt sector for the protection of Timisoara, continuing the existent belt. Considering a 30 m width green

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**Tab. 5.** The evolution of green spaces in Timisoara between 2006 and 2013

<table>
<thead>
<tr>
<th>Green spaces</th>
<th>Parks</th>
<th>Green squares</th>
<th>Alignments and neighbourhoods</th>
<th>Green belts</th>
<th>Part of the Green Forest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006*</td>
<td>87.59 ha</td>
<td>12.97 ha</td>
<td>328.58 ha</td>
<td>22.00 ha</td>
<td>50.70 ha</td>
<td>502 ha</td>
</tr>
<tr>
<td>2011**</td>
<td>117.57 ha</td>
<td>21.58 ha</td>
<td>290.15 ha</td>
<td>30.00 ha</td>
<td>50.70 ha</td>
<td>510 ha</td>
</tr>
<tr>
<td>%</td>
<td>+34.22 %</td>
<td>+66.38 %</td>
<td>-11.69 %</td>
<td>+36.36 %</td>
<td>0 %</td>
<td>+1.59% in 5 years</td>
</tr>
<tr>
<td>2013***</td>
<td>92.00 ha</td>
<td>16.00 ha</td>
<td>336.3 ha</td>
<td>30.00 ha</td>
<td>50.70 ha</td>
<td>525 ha</td>
</tr>
<tr>
<td>%</td>
<td>-21.74 %</td>
<td>-25.85 %</td>
<td>+15.9 %</td>
<td>0 %</td>
<td>0 %</td>
<td>+3% in 2 years</td>
</tr>
</tbody>
</table>

---

**Fig. 5** Intervention perimeter of the proposal
belt, for the proposed sector next to Timisoara, on each side of the drainage canal, the surface of the intervention directly related to the city would bring ~41 hectares of green space for the inhabitants. This would add almost 8% to the amount of green space belonging to the city resulting in ~18 m²/inhabitant. The planting of this green belt would be done in several steps, each one continuing the former, in order to develop a growing self-sustaining ecosystem. Also, according to the H.C.L. Annex stipulated in (RG 604/2003) the proposed forest belts network will largely be planted on the rural area belonging to Timisoara (Fig. 5.). This will highly reduce the costs of the intervention, as rural plots are not nearly as expensive as urban plots.

CONCLUSION

The importance of green belts is already well known, but equally important is their location depending on the particularity of the area the intervention is made upon. Timis County’s landscape has been shaped by the drainage canals system which, due to lack of funds, etc., has lost its effectiveness. The forest belt proposal along drainage canals does not only induce a higher air quality, but also brings back the benefits drainage canals does not only induce. The forest belt proposal along drainage canals will largely be planted on the rural area belonging to Timisoara (Fig. 5.). This would add almost 8% to the amount of green space for the inhabitants. Also, according to the H.C.L. Annex stipulated in (RG 604/2003) the proposed forest belts network will largely be planted on the rural area belonging to Timisoara (Fig. 5.). This will highly reduce the costs of the intervention, as rural plots are not nearly as expensive as urban plots.

REFERENCES


