The Island of Pellestrina: Case Study for the Environmental Atlas of the Venetian Lagoon

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ABSTRACT

The Island of Pellestrina: Case Study for the Environmental Atlas of the Venetian Lagoon project developed a methodology for collecting traffic and beach use data on Pellestrina and a structure for presenting this information. The methodology and structure were generalized to propose the Environmental Atlas of the Venetian Lagoon. The *Osservatorio Naturalistico* will use the Atlas to verify environmental impact assessments for sustainable urban development and to plan for the future of Venice and its lagoon.

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AUTHORSHIP

The Island of Pellestrina: Case Study for the Environmental Atlas of the Venetian Lagoon was the product of all four students: Scott, Caitlin, Jeffrey, and Natalie. Data collection was done as a group. Scott and Caitlin focused more creating databases and GIS maps. Jeffrey dealt with all aspects of presentation: pictures, maps, and making everything aesthetic pleasing, while Natalie did most of the actual writing of the paper. However, no one person's job would have been possible without the assistance and input of each of the other members of the group.

1. EXECUTIVE SUMMARY

Around the world there is a problem with an increasing destruction of green space. Undeveloped and open lands are continuously being targeted for habitation and industrial development. Today, the world's population has grown to over 6 billion and is expected to reach 10 billion by the year 2050.[1] This rapid change in population is part of a larger concern for the stability and sustainability of world resources. There is an increasing demand for housing and urban infrastructure around the world. The subsequent expansion of urban areas cannot continue without the removal of native ecology. Therefore forward looking development plans must be produced and implemented in order to ensure necessary resources for future generations.

Sustainable urban development is a method through which development and environmental preservation can be balanced. It is a structured plan for the future of a city that attempts to preserve the way of life of its residents. Sustainable urban development requires a great deal of information about the urban space, its inhabitants, and the economy. The *Comune di Venezia* in Italy would like to be able to provide for its citizens while preserving and protecting the complex lagoon environment around it, and has proposed the development of an Environmental Atlas of the Venetian Lagoon as an informational tool to help establish and maintain this balance.

The Environmental Atlas of the Venetian Lagoon has been designed to incorporate existing data as well as to provide methodologies for the collection of previously unavailable data. All data is meant to be georefereneced and represented in such a way to allow several data types to be layered on top of one another. This enables the user to illustrate the relationships between several different data sets. In order to facilitate data collection and coordination for the atlas, a differentiation is made between permanent, or static, data, and changing, or dynamic, data. This allows for the coordinated collection and periodic update of various data types according to their dynamic nature. The Venetian Atlas will be published online with world wide accessibility, and therefore can be updated and added to over time.

To test the methodology for data collection and the structure of the Environmental Atlas of the Venetian Lagoon, we conducted a case study on the island of Pellestrina. We collected environmental and socio-economic data on the island between June 1st and July 31st, 2003. Sites of interest on the island were monitored over the two-month period, with data being collected at various times throughout the day. A more general methodology for the atlas grew out of the specific methods created for Pellestrina.

The first step in collecting data about the island of Pellestrina was to identify and contact organizations that may already have had existing data. This required research about organizations

[1] "World Population at a Glance: 1998 and Beyond". U..S. Department of Commerce. January 1999. IB/98-4.

associated with the *Comune di Venezia,* such as the *Assessorato all'Ambiente* and the *Assessorato all'Urbanistica,* as well as public and private organizations outside the municipal government. A questionnaire or email was sent out to each contact requesting information such as location, job description, types of data collected, methods of collection, and possible use in our project. The email simply requested a meeting with the addressee to discuss these topics in person. Additionally, an agreement for the exchange of information or an arrangement for the acquisition of data was made, if relevant. We acquired information from these groups on the dunes of Venice, vegetation zoning and phytosociological groupings, and bird population information. We processed this information by analyzing the data and constructing Geographic Information System (GIS) layers to be included in our prototype of the Atlas. Our team collected data from the case study topics list we received from our sponsor *Osservatorio Naturalistico*, working on the island to collect data that had not been previously available. These data types included vehicular traffic onto and off of the island from the Lido, land traffic volume and patterns, movement of people on and off the island at the north and south ends, bus stop use, and beach use.

We recorded the traffic flow on and off the ferry for five and a half hours from 9am-2:30pm on Friday, June 27th. Two students rode the ferry for the duration of the collection period. They recorded the time of arrival and departure at each stop, the Lido or Pellestrina. They also recorded and classified the vehicles present on these trips. They distinguished between several vehicle types: bicycles, mopeds, hatchback cars, sedans, Apè trucks, vans or small trucks, hatch-trucks, busses, and large trucks.

We collected weekend traffic data on Sunday, July 6th. Weekday traffic was collected on Tuesday, July 8th and Wednesday, July 9th. Data was collected both in the morning, from 7:30am-9:30am, and in the evening, from 5:30pm-7:30pm. At each of four intersections one student recorded the type, direction of origin, and the direction of destination of every vehicle that passed through the intersection. This data was collected continuously in eight fifteen-minute intervals in each of the two-hour data collection sessions. The time of peak traffic was located in the same manner through a 14-hour data collection on July 23rd.

To determine the total flow of people onto and off of the island, we gathered data on the number of people arriving to and departing from the island at the two possible locations: the ferry to the Lido at the north end and the *vaporetto* to Chioggia at the south end. The data was collected on June 27, 2003, from the hours of 9am-2:30pm. Two students were posted on the ferry between Lido and Pellestrina to count the number of people on the ferry. The remaining two students were each on one of the two *vaporetti* at the south end of the island counting the number of people traveling between Pellestrina and Chioggia.

We collected bus use data for the island in order to obtain baseline information about the current situation. We rode the bus the entire length of the island for four hours on June 16th, counting the number of people who exited and entered the bus at each stop. We then extrapolated a data set from this distribution by counting the number of people entering and exiting the bus at one stop for 14 hours on July 23rd.

Weekend beach use was taken over two Saturdays, June 28th and July 5th, for six hours each: once from 10am-4pm and again from 4pm-10pm. The number of people at each beach area was recorded every two hours during the six hours of data collection. Each student used visual inspection, either by monocular or eye sight to record the number of people performing each of the following activities: swimming in the water or sitting on a boat in the water, laying on the beach or jetty in the sun or under tents and umbrellas, playing games, or cooking dinner and gathering in large groups. We collected weekday beach use by counting the number of people every hour at one jetty section of the beach and one count of the entire length of the beach at 4:00pm on July 23rd. The entire beach use for the weekday was extrapolated from these data sets.

We generalized our methodologies for identification and classification of Atlas topics, data collection procedures, and presentation of final product. These generalizations are meant to serve as guidelines for the Environmental Atlas and its continued development. This will also simplify the process of working on the Environmental Atlas of the Venetian Lagoon by creating a plan and course of action to sustain the Environmental Atlas in the future.

The usefulness of our work on the Environmental Atlas of the Venetian Lagoon was shown by using the data collected about Pellestrina to create an example of the Atlas, by using this Atlas to illustrate the issues that will result from the construction of the MOSE project, and by presenting it to the residents of Pellestrina to give them the facts to support their concerns about the island.

For each of the methodologies mentioned above, a unique set of results was produced. Thematic groups of these data sets were each used to illustrate one facet of the construction of the MOSE project, since the island is sandwiched between two of the construction sites. This was done to simultaneously analyze the data and show how it may be used for the purposes implied by the Environmental Atlas.

Over the course of five hours, we found a total of 1,139 people entering the island and 840 exiting. This was further broken down into totals of 788 people entering and 561 people exiting at the north on the ferry. There were also 352 people entering and 279 people exiting the island at the southern end on the *vaporetto*. This showed that generally more people enter and exit the island through the north. Many of these people, especially in the morning, may be workers commuting to and from the island.

We found from our investigation of the bus stop usage on the island that Stop 2, in San Pietro in Volta, and Stop 15, in Pellestrina were the most used over the course of the day. Additionally, we found that noon was the peak hour for bus usage. This is likely attributed to the movement of people to and from work for lunch.

Because the MOSE project is estimated to employ 1,000 workers over 8 years at three inlets, there is a possibility of a dramatic increase in the number of people traveling to and from the island. This influx will occur at the ends of the island as workers will be traveling to and from the Lido or Chioggia to reach the construction sites. These workers will be moving around the island in the morning, when the foot traffic to the island on the ferry is at its greatest, and at lunchtime, when the bus stop usage is at its highest. This may strain the ACTV transportation system on the island and is a topic that will need to be further researched in the near future.

In addition to the numbers of people traveling around the island, we also investigated the number of vehicles moving around the island. This began with the quantification of the number and types of vehicles entering and exiting the island at the ferry in the north. For the same five and a half hour period mentioned before, there were 143 vehicles coming to the island and 117 leaving. The distribution of vehicle types throughout this time period was steady, with approximately 45% of them being automobiles.

Over a morning and evening on both a weekday and weekend, we counted the turning movement of vehicles at four intersections. This gave us an idea of the traffic patterns on the island during those times. We found that most traffic was traveling north to south or south to north on the *Strada Comunale dei Murazzi*, with approximately 500 vehicles traveling in each direction during a one hour period on the weekend and only approximately 200 vehicles turning at the intersection.

From this data we extrapolated the total volume of each vehicle type passing through the intersection for the same time periods. We found high volumes of total traffic: 877 vehicles in one hour at the intersection of *Calle Chiesa S. Vito e Modesto* on a weekday evening. We also observed that the predominant vehicle types included bicycles, mopeds, and automobiles. This trend and high traffic volume continued throughout other areas of the island, especially in the evening.

In addition to information on the traffic volume and patterns, we calculated the peak hours for general traffic movement throughout the day. These peaks include the time between 11am and noon and again around 7pm to 8pm. These are abnormal as compared to the typical traffic peaks around 7:30am and 5:30pm in other locations. This may be attributed to the longer commute needed to get to and from the island for those who do not work on Pellestrina, or to the earlier work hours for the large number of islanders involved in the fishing and clamming industry.

The presence of an increased number of large trucks to transport goods for the MOSE construction will affect many aspects of traffic on the island. There will be more heavy trucks traveling to and from the island transporting supplies. This will put a strain on the ACTV ferry at the north end of the island by calling for more ferries or different types of transport equipped to handle the larger load. These trucks may be traveling the length of the island to Ca'Roman and as such will amplify the current traffic patterns on the island. There will be more large vehicles with destinations at the ends of the island. These vehicles will travel north to south or south to north, creating increased traffic volumes along the length of the island. Additionally, the scheduling of shipments of goods will need to be carefully planned so as not to coincide with the pre-exiting peak traffic hours. The travel of workers around the island for lunch, will only intensify the current peak at noon, and is of considerable concern for the transportation system of the island.

The percentage of impermeable surfaces in the villages of San Pietro in Volta and Pellestrina were calculated to be 37% and 23% respectively. The village of San Pietro has more green space than Pellestrina because there is more available land for agriculture. During the construction of MOSE, there will likely be a need to build temporary housing for workers from outside the region. This housing may come in the form of apartments or hotels which will increase the percentage of impermeable surfaces in both parts of the island. This increase will cause two significant problems. First, there will be less surface area for the collection of ground pollutants to facilitate the natural filtration into the soil. This causes the pollutants to pool up and damage the ecology more drastically than if they were allowed to naturally be absorbed and processed by the soil. An increase in impermeability will significantly change the direction and efficiency that rainwater is absorbed into the ground.

From the weekday and weekend beach use data we collected, we found trends for the most popular beaches on the island and the most popular times for their use. On a weekday, the most frequently used beach was in the southern part of the village of Pellestrina. The peak hour of usage was approximately 6pm. However, on the weekend, the most popular beach was in Ca'Roman. This is likely attributed to day trippers we observed arriving to the beach in their personal watercraft from Chioggia. The peak hour of usage is earlier on the weekend, at around 4pm.

In addition to our own data collection, we manipulated data that we acquired from outside sources. This included information on bird populations in the Venetian Lagoon from the Venetian Natural History Museum. From their database, we were able to illustrate the locations of the major bird species on the island: the *Passera d'Italia*, the *Rondone*, and the *Storno*. There are a total of 157 *Passere d'Italia* found over the entire island, 137 *Rondone* spotted in the upper 2/3 of Pellestrina, and 20 *Storni* found in the upper 1/3.

We also acquired the vegetation zoning, total vegetation coverage, and phytosociological data for Ca'Roman from a biologist working with the *Assesorato all'Ambiente* in the area. From this we reconstructed the vegetation zoning on a GIS layer for use in the future as well as visually representing the total coverage of vegetation and phytosociological relationships in parts of Ca'Roman. We observed a 90-100% total coverage of vegetation in the areas investigated and less than 10% on average of each species in a phytosociological grouping.

We received data about the dunes of Ca'Roman from the 2002 WPI project group, and used their final data to show the four different defining dune regions in Ca'Roman. The areas of each of these regions, as well as the percentage of the total dune area, were calculated. Bands number 1 and 2 covered 21,224 m^2 and 8.1% of the total area, Band 3 covered 41,021 m^2 and 15.6% of the dunes, Band 4 covered 128,124 m^2 and a dominating 48.7% of the total, and Band 5 covered 72,705 m^2 or 27.6% of the total area.

The construction of the MOSE gates calls for a widening of the inlet of Chioggia. In fact, 1/6 of the land on Ca'Roman, or 1.16 km^2, will be excavated. This will result in a loss of beach for use by residents and tourists alike. Because of this, the beaches on other parts of the island will be visited more and will have to accommodate for an increase in usage. Unfortunately, the plant and animal life in Ca'Roman will be more drastically affected. With the planned construction, the *Passere d'Italia* that live in the area may be forced to relocate to other parts of the lagoon. Approximately eight phytosociological groups at the southern tip of the island will be eradicated. Similarly, 6,700 m^2, or 2.5% of the total coverage of dunes will be destroyed.

Through our results and analysis, we have come to several conclusions. First, the prototype we constructed for the Environmental Atlas was a success. We were able to represent several of our datasets in layerable maps to show pertinent relationships between data sets. However, we realized that representing more specific data sets, such as the vehicle distribution for traffic volume, posed a challenge; we also realized how difficult it was to acquire existing data from organizations within the lagoon. These are both challenges that will be faced in the future by those constructing the Environmental Atlas. Once the data sets were compiled, we were able to easily illustrate the pressures facing the island of Pellestrina in relation to the MOSE project. This demonstrates that the Atlas as proposed can easily serve as a tool in sustainable urban development.

Several recommendations also came out of our experience in Venice. We feel that a complete data set on the topics proposed by the *Osservatorio Naturalistico* would create a better picture of the current state of the island of Pellestrina. This would be facilitated by acquiring the newest map layer, including the recently reconstructed beaches, from *Consorzio Venezia Nuova* (CVN). This layer should be used in conjunction with other layered data types to organize data collection and presentation, with regions being made by subdivision to define the unit of measurement for data collection on the island. For the future of the Environmental Atlas of the Venetian Lagoon, we suggest using our generalized methodologies as a guideline for data acquisition and collection in the future. This methodology can be expanded and improved as needed. We would like to encourage collaboration between the organizations concerned with the lagoon to facilitate the creation of the Atlas. Lastly, we feel the guidelines for the Atlas, such as the implementation of GIS, layerable thematic maps, thematic topic classification, and Internet presentation are ideal for the uses of the atlas and should be continued throughout the future development of the Atlas.

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2. INTRODUCTION

The world's population is growing at an unprecedented rate. By the year 2050 the United Nations estimates there will be over 10 billion people living in the world.[2] This increase will create new demands for food, shelter, transportation, and the expansion of existing residential and urban lands. These demands stress world resources and force cities to expand to accommodate new residents. This results in the removal of green spaces and consumption of world resources at rates that cannot be sustained by the planet. This type of growth cannot continue unchecked; the world's green spaces and resources must be preserved while still fulfilling the need of the growing population. This can be done through sustainable urban development, a structured plan for the future of a city while preserving or improving the quality of life. However, sustainable urban development cannot happen without information being made available to city planners and developers. Data on the environmental and socio-economic attributes of the location in question illustrates the current state of the area so that a future plan can be formulated.

The island of Pellestrina in the *Comune di Venezia* serves as an example of the need for sustainable urban development. It is one of the littoral islands, approximately 11 km in length and it protects the inner islands of the lagoon from the sea. Despite its length, Pellestrina has an area of only 2 square kilometers[3] on which 4,500 inhabitants make their homes.[4] The island has close ties to the environment with the Adriatic Sea on the eastern shore, the Venetian Lagoon on the western shore, and the Ca'Roman nature preserve at the southernmost tip of the island. Currently, the island of Pellestrina is being considered for urban expansion and development by the *Assessorato all'Urbanistica* of the *Comune di Venezia*. This poses a need for sustainable urban development in order to preserve the balance between growth, the environment, and the unique way of life. In order to do this, environmental and socio-economic information is required to illustrate a complete picture of the current state of the island.

There are several public and private organizations within the Venetian Lagoon region that collect these types of data about the island of Pellestrina and its surrounding waters. There is information about the air, water, climate, soil, traffic, energy, biology, history, population and land use of the island that already exists. Unfortunately, this data was collected by any one of many organizations for their own purposes. Generally, it is not shared with other organizations or

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[2] "World Population at a Glance: 1998 and Beyond". U..S. Department of Commerce. January 1999. IB/98-4.
[3] "With Water and Against Water: Measures for the Safeguarding of Venice and its Lagoon." International Centre Cities on Water. Compact Disc. 1996.
[4] Ibid.

distributed publicly and as such may not be available to the urban planners for use in sustainable urban development.

In order to solve the problem of availability of information, a system of organization is required. It has been proposed that this system be in the form of an Environmental Atlas. This Atlas would integrate data from several different resources into one repository accessible to the urban planners and others involved in sustainable urban development, as well as the public. With this Atlas of pertinent environmental and socio-economic data, a complete picture of the current state of the island of Pellestrina could be made. This would be directly applicable to the upcoming developments in the area; it would also serve as a resource to plan for the future.

Our work while in Venice was a step in filling this need. We identified the sources of existing data through Internet searches, questionnaires, and personal meetings. Once this information was located, it was catalogued in a database so that it would be easily located in the future. Some types of data we located were made available to us, while others were not. The available data was allocated through written or personal requests or a fair trade of information; existing but unavailable data was noted as unavailable. We personally collected some of the nonexistent data for the island of Pellestrina, such as summer weekend beach use, traffic volume, movement of people on and off the island, and vehicular movement on and off the island. All of these data types were then processed so they could be presented as Geographical Information System (GIS) layers. These layers can be put together to create a sample Environmental Atlas and illustrate the situation on Pellestrina. This Atlas will serve as a tool for the urban planners in creating the urban development master plan for the island, a means of conveying significant environmental and socio-economic information to the public, and a case study for how data can be collected and integrated for the rest of the lagoon.

3. BACKGROUND

The impact of urban development on the environment has become of increasingly prevalent concern to city planners worldwide. As cities grow larger, the threat to the surrounding environment is also increased. This creates a need for sustainable urban development, a structured plan to control change that takes into account environmental information. An Environmental Atlas is a tool used to provide information to planners. This has been used in several cities around the world, but best known is the one developed for the city of Berlin, Germany. The *Comune di Venezia*'s *Assessorato all'Ambiente* has proposed a similar Atlas for the Venetian Lagoon. Before the final Atlas is completed, a case study on the island of Pellestrina has been proposed to test the feasibility of the Atlas. The following topics will bring a familiarity with information necessary to comprehend the reasoning behind the Atlas and the Case Study on Pellestrina.

3.1 Environmental Awareness and Sustainable Urban Development

Beginning with the Industrial Revolution in the late 19th Century, cities started growing at an unprecedented rate and urban populations skyrocketed. Factories were moving into the cities for accessibility and resources, and workers followed them. Housing complexes and large settlement areas were constructed to accommodate all of the people moving into the cities from more rural areas, causing the rate at which cities were growing to further increase. Along with these developments came increased amounts of pollution in the air, water, and soil, but compared with the technological and industrial advancement that was occurring, the protection of the environment fell by the wayside.

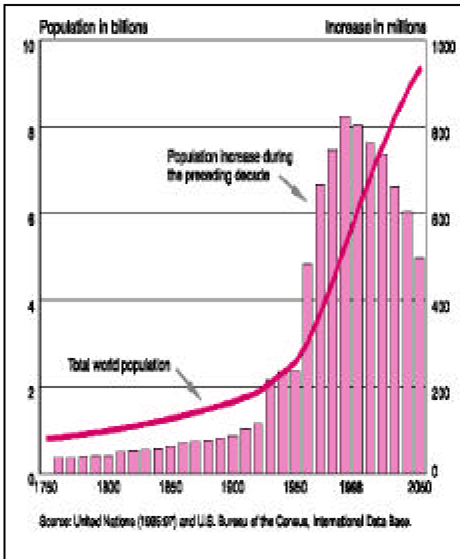

Figure 1 - Worldwide Population Increase

In the 1970s and 80s there was growing concern for environmental issues and a heightened awareness of the environmental impact of populations around the world. The United States passed the Clean Air Act in 1970, coinciding with demonstrations demanding provisions to ensure the health and safety of the public and the environment. The Act had been met with opposition in many industrial cities. One small-town mayor is quoted as saying: “If you want this town to grow, it has got to stink.”[5] Despite this and other forms of opposition, Congress succeeded in passing the Clean Air Act, deeming air quality and public health a national responsibility. Through this legislation, Congress “signaled its firm belief that economic growth and a clean environment are not mutually exclusive goals.”[6]

To balance these goals, however, a system to show how the different components of a city were related was needed. Zoning and regulatory agencies in most cities made decisions on a case-by-case basis, reviewing only the documents included with the application. This led to poorly structured zones and incongruous thematic designs throughout many cities. With the mass urbanization of the 20th century, it became apparent that simply understanding relationships between different land use practices and major zoning concerns would not be enough, but that a structured plan for the future development of cities was needed.

By creating a forward-looking plan of the city’s image and needs, the regulatory agencies had a better set of guidelines to use when deciding if a proposed building or public works project would suit the grand scheme of the city, and whether it would be a worthwhile endeavor for the city to approve. By consistently referring to the master plan, and revising it in light of the continuously changing nature of cities, urban planners were able to allow cities to grow and mature at a sustainable rate while maintaining a consistent image.

The most recent developments in urban planning have been in response to the fact that even with a master plan and better zoning and regulation practices, there are still many areas of urban planning that need improvement to allow for a balance with the environment to last into the future. The impacts of urban planning decisions have not been fully studied, and as a result the environmental and socio-economic systems of most urban areas have been negatively affected by continuous construction and development. Current technology and analysis techniques allow urban planners to collect a broad base of knowledge, everything from exact environmental data of the area in question to businesses types and buildings in the vicinity. This information can be compiled and analyzed in the form of an environmental impact assessment, which many city governments require of developers before any project is approved. With this available before approval of even the smallest project, regulators have a well-informed understanding of the direct consequences, both good and bad, of any decision they make.

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[5] Qtd. In Rogers, Paul G. “Clean Air Act 1970” EPA Journal February 1990 <www.epa.gov/history/topics/caa70/11.htm> (July 01 2003)

[6] Rogers, Paul G. “Clean Air Act 1970” EPA Journal. February 1990. <www.epa.gov/history/topics/caa70/11.htm> (July 01 2003).

3.2 Development of a Venetian Atlas

As the pressures of regulating both "sustainable resource protection and regional economic development"[7] were being felt worldwide, the city of Berlin, Germany, passed the Berlin Conservation Law in 1979, creating what they called a "Landscape Program."[8] The program was dedicated to "preserving, securing and restoring the functional capabilities of the natural balance."[9] In 1981, the Berlin Department of Urban Development and Environmental Protection was established as a governing body to maintain this balance:

> The lack of environmental information in a form suitable for planning purposes soon became apparent. There was no ecological planning instrument - there was not even a green area inventory or a map of uses. These deficits stimulated a research and development project with the Federal Environmental Office - the 'Environmental Atlas'.[10]

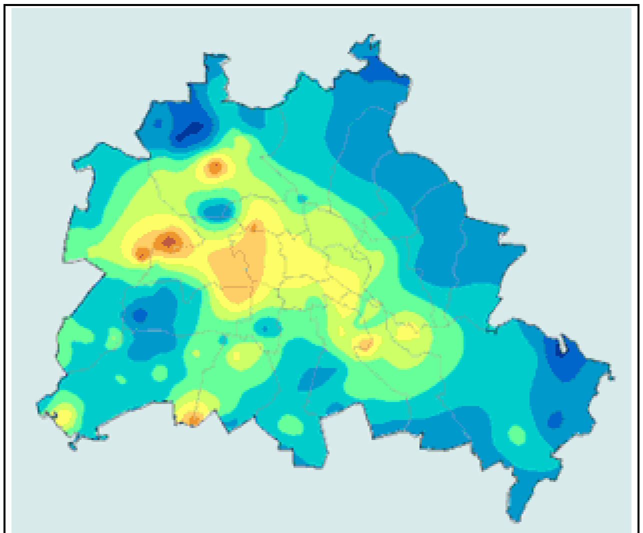

Figure 2 - Thematic Map

The Berlin Digital Environmental Atlas[11] is Internet accessible and is divided into eight fundamental topics: Soil, Water, Air, Climate, Biotopes, Land Use, Traffic/Noise, and Energy. Subtopics are introduced with a simple description that continues to explain in more depth the scientific relevance of the information. This makes the information in the atlas comprehensible to both researchers and the general public. The atlas data is presented in the form of tables or thematic maps.

Most of the data contained in the Berlin Atlas was collected by the Senate Department of Urban Development, the Environmental Protection and Technology Organization, as well as numerous scientific institutions located in Berlin. Data from each of these organizations and

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[7] Senate Department of Urban Development, "Berlin Digital Environmental Atlas," n.d., <http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/evorwort.htm> (March 20, 2003)

[8] Ibid.

[9] Qtd. In Senate Department of Urban Development, "Berlin Digital Environmental Atlas," n.d., <http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/eeinleit.htm> (March 20, 2003)

[10] Senate Department of Urban Development, "Berlin Digital Environmental Atlas," n.d., <http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/eeinleit.htm> (March 20, 2003)

[11] Senate Department of Urban Development, "Berlin Digital Environmental Atlas," n.d., <http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/edua_index.shtml> (March 20, 2003).

institutions were compiled to form the complete atlas. The specific methods employed in the data collection are presented as an additional section of the Atlas. This allows the reader to understand the exact process that was followed to achieve the presented results, ensuring the validity and repeatability of data collection methods. This has resulted in a tool for the urban planners of Berlin to use in maintaining a balance between growth and the protection of the environment.

The Berlin Digital Environmental Atlas has inspired and laid the groundwork for an Environmental Atlas of the Venetian Lagoon. Because of the similarities between the situations in Venice and Berlin, there are many concepts introduced in the Berlin Digital Environmental Atlas that are also being employed in the Environmental Atlas of the Venetian Lagoon. The digital implementation of the Berlin atlas has many advantages over printed atlases. While the Berlin Atlas is available in printed form, the Internet-based presentation of the atlas is useful because it makes it globally accessible, granting public access to the data it contains. This is important because it facilitates the dissemination of current information and will be realized in the Environmental Atlas of the Venetian Lagoon.

However, the Berlin and Venice atlases cannot be executed in the exact same manner. Before the creation of The Berlin Department of Urban Development and Environmental Protection there were no organizations dedicated specifically to the environment and as a result government agencies were the main contributors to the Atlas. In Venice, several institutions dedicated to the environment such as Co.Ri.La and *Consorzio Venezia Nuova* existed prior to the proposal of the Atlas. Therefore, the Atlas is structured more as a means of communicating and exchanging information among institutions rather than being the culmination of works carried out by a few groups, as is the case in Berlin. The representation of the information in the Venetian Atlas also varies slightly from that of the Berlin Atlas. In the Berlin Atlas, the maps are presented thematically, but do not allow the user to choose desired data types to be presented concurrently. The views and data presented in the digital atlas are predetermined, making the presentation of data rather inflexible. In the Venetian Atlas, the maps can be layered, in order to allow the users to compare only the data they are concerned with, and draw their own conclusions as to the implications of this information.

The organization of data collection differs as well. The Berlin Atlas was constructed with the assumption that the data would need to be recollected periodically, and thus the entire Atlas would be updated every five years. In the Venetian Atlas, a differentiation is made between permanent, or static, data, and changing, or dynamic, data.[12]

[12] For the purposes of our methodology, we made a distinction between static and dynamic data. Static data is classified as any information that does not significantly change over time; the change must be

By building on the model used in Berlin, and developing new criteria for the collection, organization and presentation of data, the Environmental Atlas of the Venetian Lagoon has the potential to be a useful, customizable tool for many institutions in Venice. This tool can also assist in sustainable urban development.

3.3 Current Research

The Environmental Atlas of the Venetian Lagoon is important because it is a means of presenting regional information to urban planners, the public, and even the researchers collecting and reporting the information. Several organizations and institutions exist in Venice who could benefit from, and contribute to, the Environmental Atlas of the Venetian Lagoon.

The *Consorzio per la Gestione del Centro di Coordinamento delle Attività di Ricerca inerenti il Sistema Lagunare di Venezia* (Co.Ri.La) is an organization that was created in 1998. They are responsible for distributing public funds to researchers and institutions for conducting studies and collecting data on the lagoon. Through Co.Ri.La, each researcher is required to provide the data they collect in its rawest form, and also to have an international partner institution to encourage collaboration and communication. All of the data that Co.Ri.La receives from its researchers is put into a database called RIVELA, which uses GIS mapping to display the information.[13] At present, the RIVELA system is private and only accessible to researchers.

The *Istituto Veneto di Scienze Lettere ed Arti* has a department dedicated to compiling information in a similar manner to Co.Ri.La. They have created an online database of environmental information called *Banca Dati Ambientale sulla Laguna di Venezia*, from which all information and maps are accessible to, and downloadable by, the public. The information is not in GIS format, but included on the website are external links to sites that provide additional information, as well as downloadable scientific articles and images. Their main goal is to gather information from various institutions, but without the proper amount of funding, they find it very difficult to persuade researchers to freely give up their data.

The *Consorzio Venezia Nuova* is an institution created by the Ministry for Infrastructure and Transport to be responsible for implementing measures to safeguard Venice and its lagoon. The *Consorzio* consists of a group of large national companies, cooperatives and local firms, as well as national and international organizations and institutions. They use information collected from these worldwide sources to make decisions to protect the Venetian Lagoon Region. The *Consorzio* has

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so slow that it can be considered almost permanent. This information need only be collected once. Dynamic data is any information that is constantly changing or requires regular updates.

[13] GIS, or Geographical Information System, is a method for organizing data that allows correlation and display by geographic location.

created a department called "PuntoLaguna," which is intended to provide the public with information about Venice, its lagoon, and the measures being undertaken to preserve the ecological balance while safeguarding the city.

L'Ombrello is a small group based in Venice that coordinates participatory planning processes. They are organizing an urban development plan for the littoral island of Pellestrina and are working with the *Assessorato all'Urbanistica*, the Neighborhood Council of Pellestrina, and the inhabitants of the island to formulate the foundation of the urban development master plan for Pellestrina. They coordinated a general meeting with the residents of Pellestrina to voice their opinions of the problems on the island, a walking tour of the island to meet with community members and expand upon the problems previously voiced, and the formation of small focus groups to brainstorm solutions to the problems presented. This information will then be used by the *Comune di Venezia* to finalize the urban development plan for the island.

The *Assessorato all'Urbanistica*, the Department of Urban Planning for Venice, is part of the *Comune di Venezia*, and is in charge of approving or denying the applications for all construction projects in the municipality of Venice. They work closely with the *Assessorato all'Ambiente*, the Environmental Department, to approve these projects. The *Assessorato all'Ambiente* has created a smaller department called the *Osservatorio Naturalistico*, which is in charge of verifying environmental impact assessments. Each time a project is proposed, the *Osservatorio Naturalistico* must analyze its stated impact on its surrounding community and environment. However, all of these groups have encountered the same problem as the many other organizations in Venice: there is a lack of accessible information that would greatly assist them in their work. This lack of information is the underlying motivation for the *Osservatorio Naturalistico's* proposal for the Environmental Atlas of the Venetian Lagoon. Before the final Atlas is developed, a Case Study is being conducted on the island of Pellestrina to test the feasibility of the Atlas.

3.4 The Island of Pellestrina

Pellestrina is one of the barrier islands of the Venetian Lagoon. Its eleven kilometers of flat coastland protect the lagoon from the Adriatic Sea. Besides the natural protection that Pellestrina offers against the sea, a manmade method of protection, the "*Murazzi*," exists as well.

Figure 3 - The Island of Pellestrina

In 1716, after several severe storms impacted the area, the Doge of Venice, Father Vincenzo M. Coronelli, suggested that a stone sea wall be built to protect the entire lagoon region from storms and flooding. In 1744, architect Bernardino Zendrini began the construction of the *Murazzi*. It was made of a combination of Istrian stone, cement, and compact layers of pebbles. Once completed in 1782, the *Murazzi* stood 4.3 meters above the average tide level, and had a width of 14 meters. The *Murazzi* succeeded in protecting the lagoon until 1966, when an unprecedented amount of flooding overcame the wall and allowed the flood to pass onto the island of Pellestrina and across the lagoon into the historical center of Venice. These floods severely damaged the *Murazzi*.[14]

The flood of 1966 was the main impetus for developments to protect the lagoon from the hostile environment. Recently, many projects have been proposed to help solve the problem of flooding. A significant beach intervention was performed on the island, which increased the area of beach on the island, added jetties, and inserted a rock wall along the sea floor to prevent the sea from tunneling into the lagoon. The *Murazzi* was also repaired and extended. Another of these projects that has been recently approved is the MOSE project. The *Consorzio Venezia Nuova* developed the MOSE system of floodgates designed to lie under the sea at the three inlets to the lagoon and rise up when an unusually high tide is expected, acting as yet another barrier of protection to the lagoon.

[14] "Travel Guide: Venice – Off the Beaten Track," n.d. <http://sg.travel.yahoo.com/guide/europe/italy/obt.html> (29 March 2003).

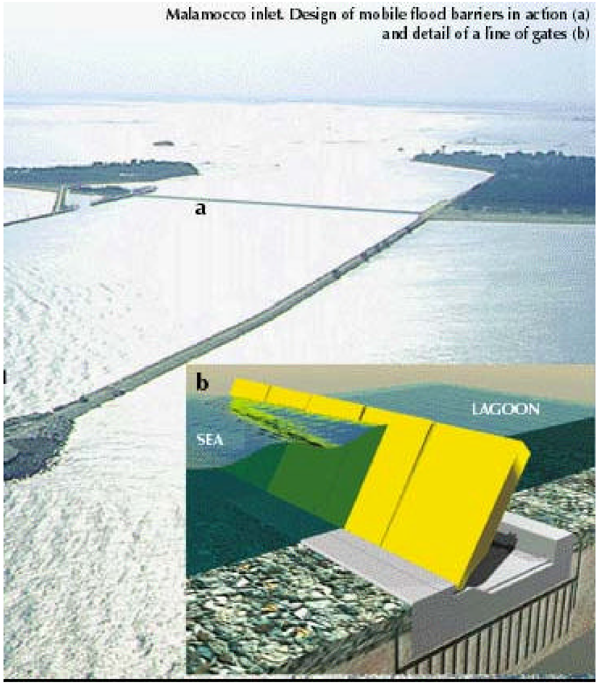

Figure 4 - Flood Gate at Malamocco

The MOSE system will be constructed at the sea inlets of Lido, Malamocco, and Chioggia. These inlets are delimited by long jetties built in the 19th century that will serve as the support for the defense system. The system will protect against tides over 110 cm. At each inlet there will be a breakwater and the gates themselves. The breakwater's purpose is twofold: it will reduce the intensity of tidal currents as well as protect the lagoon inlets from wave motion. The gates will lie below the sea in caissons in the bed of the lagoon inlet, filled with water. When a tide level exceeding 110 cm is expected, the gates will be filled with compressed air, causing them to expel the water and begin to rise to the surface of the sea. The gates will remain in position for the duration of the high tide, and then again be filled with water, causing them to return to rest in the seabed. The entire system will cost € 2.3 billion, and € 9 million per year for maintenance and management.[15]

Pellestrina is extremely important to the MOSE project because of its location. It will act as a base station for the construction of the floodgates and will be used for the offloading of supplies from trucks, a dock for ships traveling out into the sea to install the gates, as well as a place for the workers to live for the duration of the construction.

MOSE adds significant challenges for the people and infrastructure of Pellestrina. The logistics of supporting the estimated 1,200 workers for the projected eight-year venture is of concern to planners. Predictions must be made to assess the impact of the project on the island's ecology, as well as on its inhabitants and their way of life.

Pellestrina and the *Comune di Venezia* as a whole face these and other changes, and the Environmental Atlas of the Venetian Lagoon will allow developers and residents alike to anticipate, plan, and control change.

[15] "Venice. The MOSE System for the defence against high water." Venezia: Ministry of Infrastructure and Transport, n.d.

4. METHODOLOGY

The purpose of this project was to provide the *Osservatorio Naturalistico*, a department of the *Assessorato all'Ambiente,* with information to use in verifying environmental impact assessments by assisting in the initial stages of the development of the Environmental Atlas of the Venetian Lagoon. We aided in the development of the Atlas structure and tested the feasibility of data acquisition. By conducting a case study on the island of Pellestrina, we were able to create an example of the Environmental Atlas.

The primary objectives of our project were:

1. Conduct a case study on the island of Pellestrina
    a. Identify important topics for collection
    b. Incorporate external data
    c. Collect field data
2. Generalize our case study methodology for use in the future of the Environmental Atlas
3. Demonstrate the usefulness of collected data and of the Environmental Atlas

4.1 Scope of Project

The scope of the Environmental Atlas of the Venetian Lagoon is limited to certain types of information; we were only concerned with environmental and socio-economic data within the Venetian Lagoon region. Our data collection on Pellestrina focused on the environmental and socio-economic attributes affecting the residents of the island.

To clarify our methodology, we have defined necessary terms. The Environmental Atlas of the Venetian Lagoon is a means for presenting environmental and socio-economic information. This information originates from various sources, including researchers and other organizations connected to the *Comune di Venezia*, as well as public and private organizations and institutes.

For the purposes of our methodology, we made a distinction between static and dynamic data. Static data is classified as any information that does not significantly change over time; the change must be so slow that it can be considered almost permanent and need only be collected once. Dynamic data is any information that is constantly changing or requires regular updates.

We collected environmental and socio-economic data on the island of Pellestrina between June 1st and July 31st, 2003. Sites of interest on the island were monitored over the two-month period, with data being collected at various times throughout the day.

4.2 Case Study on the Island of Pellestrina

Our sponsor, the *Osservatorio Naturalistico*, is the organization that verifies the environmental impact assessments set forth by the developers in the *Comune di Venezia*. Their job requires up-to-date environmental and socio-economic data. Unfortunately, this data is not always readily available because their department does not collect it. As a result, much of the *Osservatorio Naturalistico*'s time is spent acquiring the needed information from outside sources rather than verifying the environmental impact assessments. The Environmental Atlas of the Venetian Lagoon is intended to house current information relevant the *Osservatorio Naturalistico*'s work.

The case study on the island of Pellestrina is meant to demonstrate the feasibility of the Environmental Atlas of the Venetian Lagoon. This included testing the ability to locate, catalogue, and acquire existing data, collecting field data on the island, and presenting this information in a simple and comprehensive manner. A more general methodology for the Environmental Atlas grew out of the specific methods created for Pellestrina.

4.2.1 Identifying Topics for Collection

A list of data topics to be collected was gathered from various sources. A master list of topics to be included in the Environmental Atlas from the *Osservatorio Naturalistico* was the basis of our list.[16] Topics of interest to the *Assessorato all'Urbanistica*, such as fence, shed, and garage classification, as well as ground impermeability, were considered. Topics needed for the *l'Ombrello* organization's planned scenario for the future of the island of Pellestrina were also taken into account. A final list of data topics to be collected about the island of Pellestrina was compiled based on these needs. This information was collected in two forms: external data that already existed from outside organizations and our own field data collection

4.2.2 Incorporation of External Data

The first step in collecting data about the island of Pellestrina called for identifying and contacting organizations that work with this kind of information. This required research about organizations associated with the *Comune di Venezia*, such as the *Assessorato all'Ambiente* and the *Assessorato all'Urbanistica*, as well as external public and private organizations. These organizations house a number of researchers and analysts who had relevant information. We received the contact information of various individuals within the *Comune di Venezia* from the *Osservatorio Naturalistico*. Additionally, some sources of external data were identified through Internet searches and recommendations from our advisors and sponsors. These organizations included *Co.Ri.La.*, *Consorzio*

[16] Please see Appendix B for this list in both Italian and English.

Venezia Nuova, Puntolaguna, Istituto Veneto di Scienze Lettere ed Arte, Lega Italiana Protezione Uccelli, and the Museo Civico di Storia Naturale.[17]

A questionnaire or email was sent out to each contact. The questionnaire requested information such as location, job description, types of data collected, methods of data collection, and the possibility of data for use in our project.[18] The email simply requested a meeting with the addressee to discuss these topics in person.[19] Additionally, an agreement for the exchange of information or an arrangement for the acquisition of data was made, if relevant. We used the same methods in contacting and questioning all organizations.

Through these communications, an initial list containing contact information, organization name, location, description of work, data types available, database existence and location, and accessibility for use with the Environmental Atlas was compiled. We compiled these sources into a contact database for use by our project group and the *Osservatorio Naturalistico.*

4.2.3 Compiling External Data

We processed information gathered from these groups by analyzing the data and constructing GIS layers to be included in our prototype for the Atlas. For future use, we referenced these data layers by contributing source. When necessary, other graphical depictions, including charts and thematic maps, were made to show relationships within the data sets. We extrapolated and interpolated when specific data was not available.

4.2.3.1 Dunes

We had access to a previous Interactive Qualifying Project that studied the dunes of Venice with the intent of having this information included in the Environmental Atlas of the Venetian Lagoon, upon development. We incorporated the data and GIS maps from this project into our prototype for the Atlas.

4.2.3.2 Vegetation Zoning and Phytosociological Groups

We received data from biologist Ulrike Gamper, who worked for the *Osservatorio Naturalistico*, which contained an aerial photograph of Ca'Roman with the defining areas of vegetation zones numbered. We translated this aerial photo into a GIS layer with the same numbering for each vegetation zone. The data also contained the percentage of total coverage in each of the vegetation zones investigated completely, zones 2 and 10. This information was translated into a GIS layer with a color gradient in each vegetation zone representing the percentage of total coverage. In addition,

[17] Please see Section 3.3 for more information about these organizations.
[18] Please see Appendix C for this questionnaire.
[19] Please see Appendix D for this email.

the data collected contained a breakdown of the phytosociological groups within each vegetation zone studied. This yielded approximate percentages of coverage of each species exiting in that zone. This information was made into a thematic map with bar charts in each of the vegetation zones representing the relative percentages of coverage of the species found in that zone.

4.2.3.3 Bird Populations

We received a database from researchers with the Venetian Natural History Museum that contained information about bird nesting locations of every bird species in the Venetian Lagoon. It included the grid number where the species was found, the locality, the total number of birds sighted, a rating of the possibility of a nesting location, and information on the date the data was collected, as well as the researcher involved. From this, we reconstructed the grid system used for the island of Pellestrina. The number and total population of major bird species, defined as 12 or more sighted, were calculated for these regions. The number of minor bird species was extracted at the same time.

A thematic map was made using bar charts at each of the grid locations on the island. This bar graph represented the total number of birds sighted for each major bird species that lived in that area. Additionally, three thematic maps were created to show the location of the major bird species using a different color and hatch mark system for each species to allow for a layered presentation in the Environmental Atlas.

4.2.3.4 Impermeable Surfaces

The *Assessorato all'Urbanistica* provided our group with five GIS layers in order to calculate the amount and location of impermeable surfaces on the Island. Impermeable land is any area of land that does not allow water and pollutants to be absorbed by the underlying soil; this is most often found in the forms of paved areas and buildings. Impermeable surfaces lead to runoff problems if the developed areas are not suitably drained. They also create a problem with pollutants that would be processed naturally if they were allowed to seep into the ground. Impermeable surfaces force these pollutants to be pooled into a much smaller region that is incapable of processing them. The *Assessorati all'Urbanistica e all'Ambiente* require information on land impermeability to understand where potential environmental problems are and also decide whether proposed developments will further increase these problems.

By overlaying the two paved surfaces layers, one each for San Pietro in Volta and Pellestrina, with the two buildings layers, again with one for each village, it was possible to determine the total surface area of the villages that was impermeable. All of the buildings were combined into one polygon, and the same was done for all of the paved surfaces. MapInfo© was then used to calculate the total area of each feature. MapInfo© was also used to calculate the total area of the island where the layers contained information, and with these numbers it was possible to calculate the percentage of impermeable surfaces for each village. All of the combined regions were saved as a new layer that contained the island area, the building area, and the paved area.

4.2.4 Field Data Collection

Our team collected data from the case study topics that were not available from outside sources. The purpose of our field data collection was to collect a sample of information to demonstrate the Atlas. We collected a few data types on the island so that we could construct thematic map layers representative of the current situation on the island. These included vehicular traffic on and off of the island from the ferry, land traffic volume and patterns, movement of people on and off the island at the north and south ends, ACTV bus usage, and summer weekend and weekday beach use.

4.2.4.1 Vehicular Movement onto the Island

There is only one means for transporting vehicles on and off the island of Pellestrina; this is the ferry that runs from the north end of the island to the Lido.[20] In order to quantify this ferry's usage and the effect it has on traffic on the island we recorded the traffic flow on and off the ferry for five and a half hours, from 9am-2:30pm on June 27th.

Two students rode the ferry for the duration of the collection period. They recorded the time of arrival and departure at each island, the Lido or Pellestrina. They also recorded and classified the vehicles present on these trips. They distinguished between several vehicle types: bicycles, mopeds, hatchbacks, sedans, Apè trucks, vans or small trucks, hatch-trucks, busses, and large trucks.[21]

Figure 7 - Bikes

Figure 5 - Moped

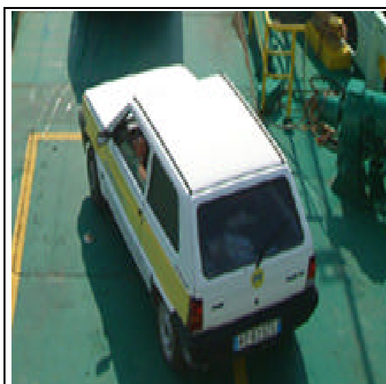

Figure 6 - Hatchback

[20] Please see Appendix E for the ferry schedule
[21] Please see Appendix F for this data collection sheet.

Figure 9 - Sedan

Figure 10 - Van

Figure 8 - Apè Truck

Figure 11 - Small Truck

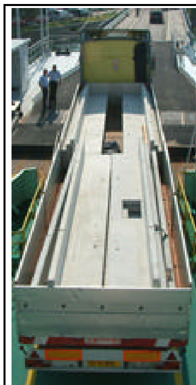

Figure 12 - Large Truck

Figure 13 - Bus

This method of classification allows not only a total number of vehicles to be calculated, but also a calculation of the percentage of each vehicle type. With this extra information, other types of analyses are possible, such as an estimate of air pollution based on the type of vehicle.

4.2.4.2 Land Traffic Volume and Patterns

There are very few roadways on Pellestrina. The *Strada Comunale dei Murazzi* is the primary road that runs along the west side of the island; the *Strada Comunale della Lagunare* is the secondary roadway that runs along the east side of most of the island; there are only six paved crossroads for vehicular traffic that run between these two roads. This leads to an excess of vehicular traffic along most of these roadways. To determine the level of this phenomenon, traffic volume and turning movements along these roads were collected.

On June 29, 2003, we collected data to determine the intersections on the island with the highest volume of traffic and to note the ideal locations to collect traffic data in each of the two villages, S.Pietro in Volta and Pellestrina. Each of the six intersections with the *Strada Comunale dei Murazzi* was observed for an hour on June 29th. These six intersections were broken down by city: *Carizzada Belvedere, Senza Nome*, and *Carizzada di Portosecco* in S.Pietro in Volta; and *Via S.Antonio, Carizzada no. 35,* and *Calle Chiesa S.Vito e Modesto* in Pellestrina. The first hour, 1:30pm-2:30pm, was spent in S.Pietro in Volta; while, the second hour, 3pm-4pm, was spent recording traffic movement in the city of Pellestrina. At each intersection one student recorded the type, direction of origin, and the direction of destination of the vehicles passing through the intersection.[22] This provided enough information to determine the two most frequently used intersections in each village: *Senza Nome*, and *Carizzada di Portosecco* in S.Pietro in Volta, and *Via S.Antonio*, and *Calle Chiesa S.Vito e Modesto* in Pellestrina.

These four intersections were visited again several times to collect a more complete data set. We collected weekend traffic data on Sunday, July 6th. A Sunday was chosen due to previous concerns expressed by residents about high volumes of traffic on Sundays. Weekday traffic was collected on Tuesday, July 8h and Wednesday, July 9h. The use of a Tuesday and Wednesday ensured a solid data set for a weekday, as compared to a Monday or Friday which do not provide a reliable data set since traffic patterns do not always follow weekday tendencies on these days. Data was collected both in the morning, from 7:30am-9:30am, and in the evening, from 5:30pm-7:30pm. These times were chosen based on a specific methodology created for the collection of traffic information on the island.[23] At each intersection one student recorded the type, direction of origin, and the direction of destination of every vehicle to pass through the intersection. This data was collected continuously in eight fifteen-minute intervals in each of the two-hour data collection sessions. This allowed us to identify a trend of traffic volume and direction within these two-hour periods.

On July 23, 2003, we collected data to determine the times of peak traffic on Pellestrina. We chose *Calle Chiesa S. Vito e Modesto* in the village of Pellestrina because it is the largest intersection, and is close to a bus stop and a popular beach, which facilitated coordination of data collection. Data was collected concerning type, direction of origin, and direction of destination of every vehicle to pass through the intersection. The data was collected in fifteen-minute intervals from 6:00am until 8:00pm.

4.2.4.3 Movement of People on and off the Island

Many people travel from the Lido, through Pellestrina to the city of Chioggia, and people from Chioggia pass through Pellestrina on their way to the Lido. To determine the total flow of

[22] Please see Appendix G for this data collection sheet.
[23] Zoccarato, P. "Metodologia Generale Dello Studio Proposto." P.U.T. Pellestrina. n.d.

people onto and off of the island, we gathered data on the number of people exiting and entering the island at the two possible locations: the ferry at the north end and the *vaporetto* to Chioggia at the south end. Correlating this data gives a full picture of passengers traveling to or from the island. The data was collected on June 27, 2003, from the hours of 9am-2:30pm.

The ferry at the north end of the island transports vehicles and passengers between the Lido and Pellestrina.[24] Two students were posted on the ferry to record the total number of people entering and exiting the island via this route. Because the time to travel from Pellestrina to the Lido is only approximately eight minutes, a strict method was used to effectively count the total number of people on the ferry. Both students started on the third deck of the ferry and waited for it to leave the dock. After one minute counting began; this allowed people to move freely on the boat and find a seat for the duration of the ride. Student One counted the number of passengers on the third deck and then both headed down staircases on opposite sides of the ferry. On the second deck, each student counted the number of passengers on their side of the ferry while walking toward the rear of the boat. Both students proceeded down the stairs to the bottom deck and the extreme rear of the boat. There are three rows of vehicles on the bottom deck; this usually includes one or two busses full of passengers. To accommodate this, each student first counted the number of people standing or in vehicles in the outside row on their side of the ferry then met at the front of the ferry by the middle row. Student One counted the number of people standing or in vehicles from the front of the ferry up to and including the first bus on board. Student Two counted people standing or in vehicles behind the first bus to the rear of the boat, including the second bus if applicable. With this thorough and efficient method, an accurate count of total passengers riding the ferry was made.[25]

The *vaporetto* at the south end of the island stops in Pellestrina once every hour. However, during the hours of 6am-8am, 9am-11am, 4pm-7pm, two *vaporetti* are running alternately, and so stop at Pellestrina every half hour. The boat proceeds from the Pellestrina stop to the Ca'Roman boat stop at the extreme south end of the island. It then crosses the Port of Chioggia and proceeds to the city of Chioggia. To ensure an accurate total number of people entering and exiting the island in this manner, one student was posted on each *vaporetto* between 9am-11am, and both students rode the same boat between 11am and 2:30pm. Each student noted the time entering and exiting each boat stop, as well as the number of people entering and exiting the boat at each stop.[26]

[24] Please see Appendix E for the ferry schedule.
[25] Please see Appendix H for the data collection sheet for this method.
[26] Please see Appendix I for the data collection sheet.

4.2.4.4 Bus Usage

The bus usage on Pellestrina was determined by positioning one student at the bus stop near *Calle Chiesa S. Vito e Modesto* (stop 15) to record the number of people that entered and exited the bus each time it passed. Data was recorded from 6:00am until 8:00pm on July 23, 2003. Additionally, two students rode the bus for three hours, from 8:00am until 11:00am on June 16, 2003. One student recorded the number of people that entered the bus at each stop, and the other recorded the number of people that exited the bus at each stop.[27] Using these two data sets, the number of people exiting and entering the bus at each stop along the island was extrapolated. The total number of people getting on at each bus stop and getting off at each bus stop between 8am-10am was calculated for each of the 17 bus stops from the June 16th data set. Additionally, the total number of people getting on and off at each bus stop between 8am-10am was calculated for stop 15 from the July 23rd data set. Separate ratios were made between Stop 1-17 to Stop 15 for the number of people getting on and getting off at each stop. This ratio was then used to project the number of people getting on and off at each bus stop over the course of the 14 hours. The total number of people getting on and off at each bus stop over the entire day was calculated as the sum of the separately extrapolated data sets.

4.2.4.5 Summer Beach Use

The weekend beach use was taken over two similarly sunny Saturdays, June 28 and July 5, 2003, for six hours each. The collection on June 28 was from 4pm-10pm while the collection on July 5 was from 10am-4pm. The island of Pellestrina is broken into sections of beach by jetties. There are 18 numbered jetties consistently 400-500 meters apart down the main coast of the island, and three unnumbered jetties, including one at the north end of the island and two at the south end in Ca'Roman, also 400-500 meters apart. One person was stationed in Ca'Roman to count people along the shoreline while the main coast was divided evenly among the remaining students collecting that day, three on June 28 and four on July 5. Jetty divisions were used as the unit of measurement for data collection. One jetty division was defined as the area from the north end of a jetty to where the beach meets the next southernmost jetty. The number of people at each beach area was recorded every two hours during the six hours of data collection.

The weekday beach use was collected on July 23, 2003. One student was positioned at jetty number 14 for the hours of 10:00am to 8:00pm to keep a record of the number of people using the beach every hour. At 4:00pm two students walked the entire length of the beach, each taking half of the distance, counting the number of people using each jetty section at that time. By assuming that the number of people on the beach was the most important factor to be concerned with, as it has a

[27] Please see Appendix J for this data sheet.

higher impact on the ecology of the island, a ratio between the number of people at jetty 14 to the number of people at each other jetty was derived from the full beach collection at 4pm. We chose to use 4pm as the full collection due to the fact that it was the peak hour of usage found during our weekend collection. This ratio was applied to the data for the number of people on the beach at jetty 14 throughout the day to obtain an extrapolation of the number of people at each jetty section over the entire day. A ratio between the number of people in the water and on the beach was created for each collection time based on the data from the 14th jetty collection site. This ratio was applied to the number of people at each jetty section to get an estimate of the number of people in the water throughout the day.

Each student used visual inspection, either by monocular or eye sight to record the number of people performing each of the following activities: swimming in the water or sitting on a boat in the water, laying on the beach or jetty in the sun or under tents and umbrellas, playing games, or cooking dinner and gathering in large groups.[28]

There was no distinction made between local and visiting beachgoers because this would require a personal interview, which was impossible due to the language barrier. While the amount of tourism may not be easily represented using this data, the total effect on the environment could, because it does not depend on the origin of the beachgoer, only the total number or type of activity.

4.3 Generalization of Case Study Methodology

An important aspect of our project was to plan for the future of the Environmental Atlas of the Venetian Lagoon, in both a structure for the Atlas and for acquisition of data. Through our case study, we tested methods of acquiring external data and presenting the final product. We generalized our methodologies for identification and classification of Atlas topics, data collection procedures, and presentation of final product. These generalizations will serve as guidelines for the Environmental Atlas in the future; they are meant to aid the *Osservatorio Naturalistico* by laying out a step by step process to follow. Of course, this generalized methodology has room for modification, because it is likely that it will be improved over time. This generalization simplifies the process of working on the Environmental Atlas of the Venetian Lagoon with the hope of ensuring its continuation in the future.

4.4 Demonstration of Usefulness of Collected Data

The usefulness of our work on the Environmental Atlas of the Venetian Lagoon was shown in three ways: by using the data collected about Pellestrina to create an example of the Atlas, by using

[28] Please see Appendix K for this data sheet.

the Atlas to illustrate the problems that will be caused by the construction of the MOSE project,[29] and by using our results to give the residents of Pellestrina facts to support their concerns about the island. Creating an example of the Environmental Atlas demonstrated the true feasibility of data collection and appropriateness of our data structure and presentation system. Additionally, the validity of creating the Atlas was shown by using it to illustrate the problems associated with the MOSE project. This illustration included touching upon several known facts about the progress of the MOSE project in comparison to the way of life on Pellestrina as it is today. These facts include the estimated number of workers involved in the project, the destruction of land associated with the installation of the gates, and the types of land traffic associated with the construction process. Our information was presented to the residents of Pellestrina in a town meeting, which allowed them to have the facts to defend their claims of traffic and related problems on the island.

[29] Please see Section 3.4 for details on the MOSE project.

5. RESULTS

Using the methodologies we developed, we found results for each topic looked into. There are results related to the specific outcomes of identifying data topics and incorporating external data, field data collection, as well as the product of the generalization of our methodologies for future use. Each of these types of results stands alone as a contribution to the Environmental Atlas of the Venetian Lagoon, but together, they give a more complete picture of the island of Pellestrina and the Atlas's future.

5.1 Case Study on the Island of Pellestrina

The results from the case study on the island of Pellestrina touch upon several topics: the outcome of our data identification and collection methodologies, the data sets we were able to acquire from existing sources and the specific results of the field data work performed while in Venice.

5.1.1 Identifying Topics for Collection

A final list of data collection topics was created for our field work on Pellestrina. From the list of topics presented to us, we used a set of criteria in order to finalize this list and make further plans for collecting the data. We decided that it was important to collect data that could aid in the evaluation of future scenarios and the implementation of urban plans for the sustainable development of the island. Our finalized list included the movement of vehicles on and off the island, traffic turning movements, and traffic volume on the island. We decided to collect information on bus stop usage in order to assess the state of the current public transportation system. Due to recent changes to the beaches on the island and their potential as future tourist destinations, we decided to include beach usage as one of our topics.

Following our methodologies for seeking existing data from external sources, we used bird population information for the island, vegetation location data including phytosociological relationships in the southern part of the island at Ca' Roman. We also acquired land impermeability data as it was specifically requested by the *Assessorato all'Urbanistica* for their work.

5.1.2 Incorporation of External Data

After interviews with several researchers and organizations in the city of Venice, we made a list of the existing data topics we could acquire from the various sources we had encountered. We obtained data for the dune structure of Ca'Roman through previous research by Worcester Polytechnic Institute students. We acquired vegetation zoning and phytosociological relationship information for Ca'Roman from Ulrike Gamper, a biologist from the University of Venice who is working with the *Osservatorio Naturalistico*. We met with Mauro Bon, a researcher from the Venetian Natural History Museum, who gave us his data on bird populations and nesting locations for the Venetian Lagoon. Utilizing existing data from the *Assessorato all'Urbanistica*, we were able to calculate and present impermeable surfaces for the Villages of Pellestrina and San Pietro in Volta. All of the acquired data was manipulated to fit into the context of our Environmental Atlas case study. As part of collecting data from external organizations, we developed and implemented a database to house all of the contacts we made during our stay in Venice in order to organize information about the different types of data they collect.

5.1.3 Compiling External Data

The three data sets we acquired from external sources allowed us to manipulate and analyze the data for use in our prototype atlas. The data was organized and then processed into GIS layers for representation in the atlas. For our own data analysis, these GIS layers were overlaid to help us determine the trends and relationships among the various data.

5.1.3.3 Dunes

A group of Worcester Polytechnic Institute students performed extensive research on the dunes of Ca'Roman in 2002. They categorized the dunes by vegetation type, naming the vegetation zones as bands 1-5, and calculated the area for each band. Their data was presented in GIS format and was integrated into our prototype for the Environmental Atlas.

The GIS layers show the bands on the island and are used to represent the different dune structure of each band.

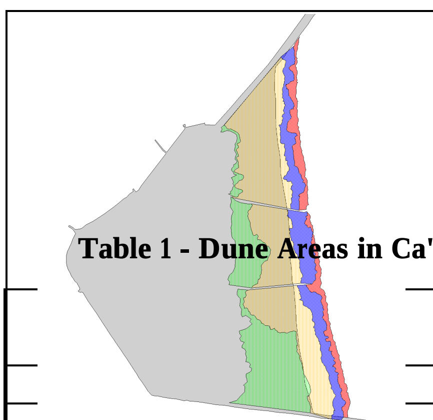

Figure 14 - Ca'Roman Dune Bands Map

The red area represents the combination of Bands 1 and 2; Band 3 is shown in blue, Band 4 in tan, and Band 5 in green. Band 4 is the largest section of the dunes, encompassing approximately 49% of the total dune area of Ca'Roman.

Table 1 - Dune Areas in Ca'Roman

			% Total Area
			27.6%
			15.6%
4	128124		48.7%
5	72705		27.6%

Total Area = 263074 sq.m

5.1.3.2 Vegetation Zoning and Phytosociological Groups

We assisted Ulrike Gamper in collecting phytosociological data in Ca'Roman on June 24, 2003. We received her notes about the different types of plant species that populate Ca'Roman. More specific coverage and phytosociological data was taken for sections 2 and

10 seen on the map in Figure 18.[30] Section 2 had 90% total coverage of vegetation, while section 10 had 100% total coverage of vegetation. This information was processed into a thematic map with varying degrees of color for the different percentages of coverage.

Figure 15 - Arial Photo of Ca'Roman with Vegetation Zoning

Figure 16 - Ca'Roman Vegetation Zoning Map

An analysis of the percentage of different plant species in each divided region was made to complement the data produced for total plant coverage. There was usually less than 5% coverage of any one type of plant species with the exception of one predominant species in each region seen in Figure 17. We represented these percentages with a thematic map, utilizing bar graphs to depict the data.

[30] Please see Appendix L for a table of this data.

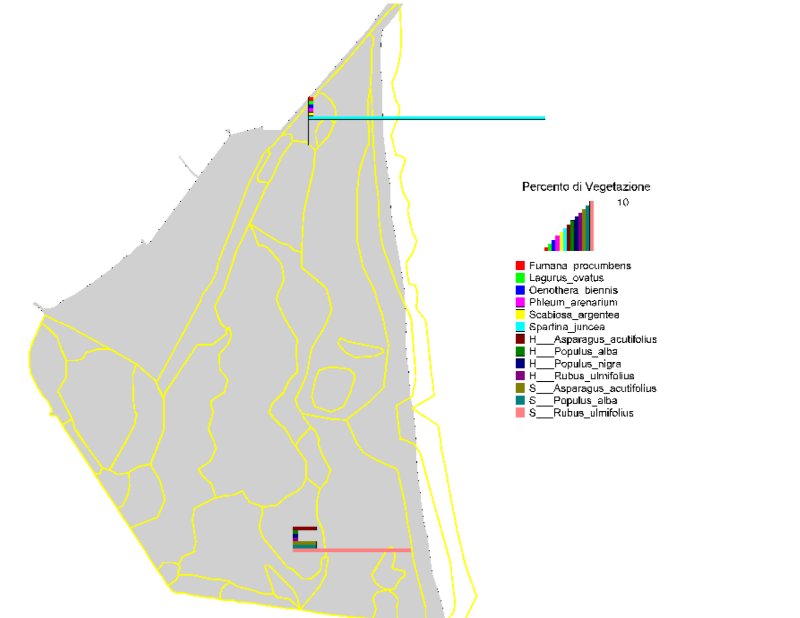

Figure 17 – Phytosociological Groups

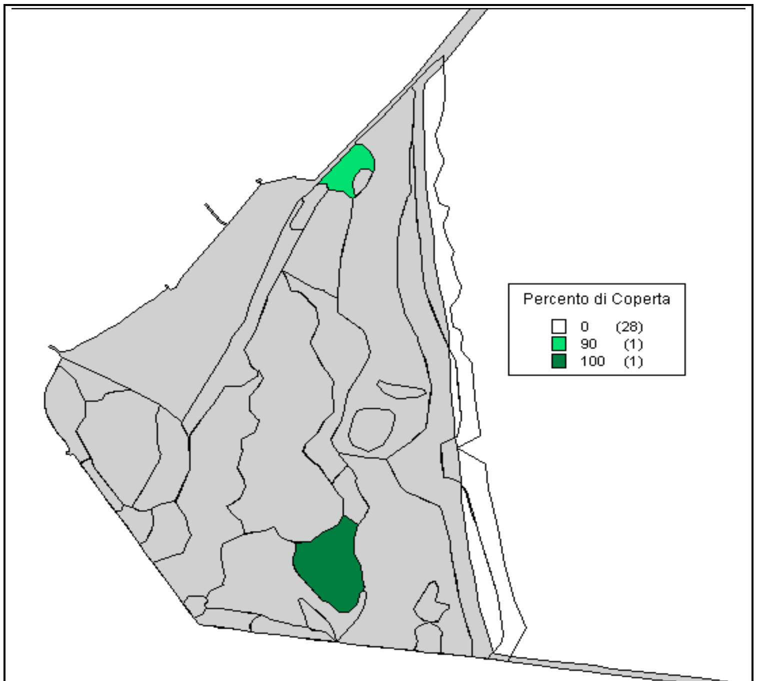

Figure 18 - Percentage of Total Coverage

5.1.3.1 Bird Populations

We received a database from Mauro Bon at the Venetian Natural History which included the locations of bird species and their nests in the lagoon.[31] The database was completed in 1990 and was used to publish an atlas of bird species in the region. We manipulated this database to show the major bird species specifically on the island of Pellestrina. Major bird species are those which have been sighted in a region 12 or more times. Minor birds are those which species have been sighted less than 12 times.

The major bird species on the Island of Pellestrina include the *Passera d'Italia*, the *Rondone*, and the *Storno*. Table 2 shows the number of each bird species found in different parts of the island.

Figure 19 - *Passera d'Italia*

Figure 20 - *Rondone*

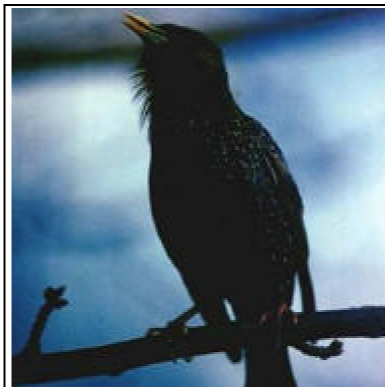

Figure 21 - *Storno*

Table 2 - Major Bird Species on Pellestrina

Species	Number Sighted		
	North	*South*	*Ca'Roman*
Passera d'Italia	14	80	63
Rondone	0	77	60
Storno	0	0	20

This information was translated into several GIS layers to present the data in both a graphic and layerable format. Both maps use the same colors to represent each bird species, but the second set allows for overlapping of data to determine where the species coexist.

[31] Please see Appendix M for this database.

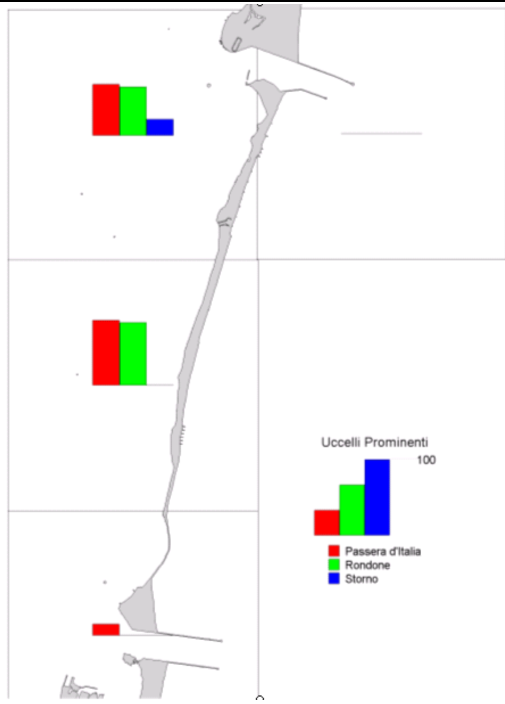

Figure 22 - Major Bird Locations Bar Graphs

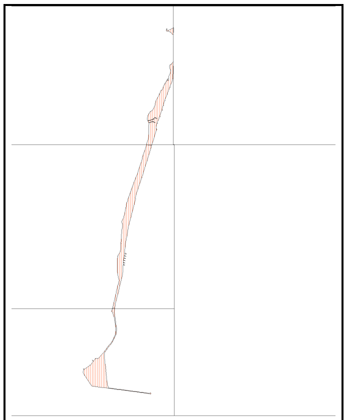

Figure 23 - *Passera d'Italia* Location Map

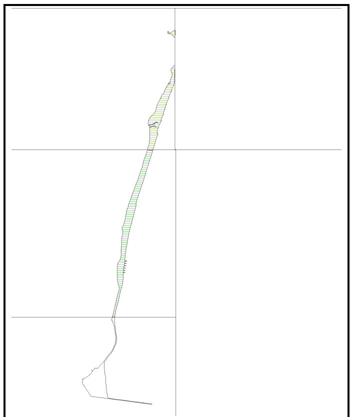

Figure 24 - *Rondone* Location Map

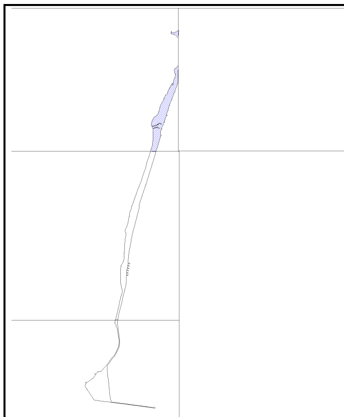

Figure 25 - *Storno* Location Map

The number of minor bird species was also calculated, though not depicted. It was determined that 39 minor species reside in the northern part of Pellestrina, 12 in the southern, and 45 on Ca'Roman. The layers shown in Figures 23 – 25 were overlaid in order to determine which species coexisted in the four regions of Pellestrina. Figure 22 is a thematic representation of this data which depicts the birds coexisting in each region as well as the quantity of each species.

5.1.3.4 Impermeable Surfaces

We produced water impermeability layers for both San Pietro in Volta and Pellestrina. The data acquired from the *Assessorato all'Urbanistica* was depicted as a thematic map layer showing, open spaces in green and the impermeable areas in black.

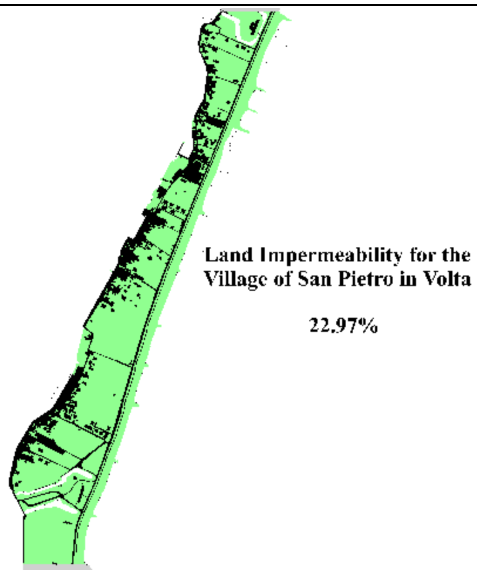

Figure 26 - Land Impermeability in San Pietro in Volta

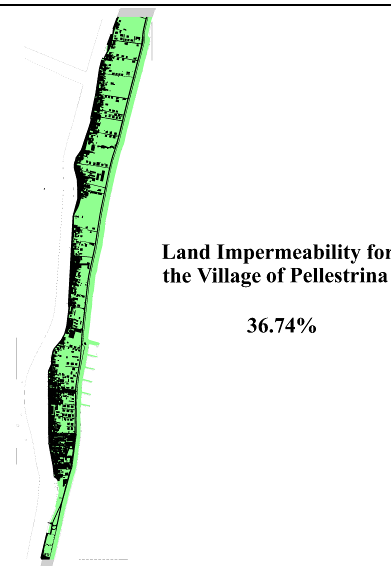

Figure 27 - Land Impermeability in Pellestrina

Impermeable surfaces are an indirect measure of the amount of developed land in a region and can be used as a baseline measurement for future comparison. Through these map layers it was determined that San Pietro in Volta was 23% impermeable, and Pellestrina was 38% impermeable. Pellestrina is more densely populated as shown in Figure 27 whereas San Pietro in Volta has more agricultural and open space.

5.1.4 Field Data Collection

In addition to the results produced from external data sources, we acquired data through our own field collection on Pellestrina. Our field work investigated topics such as vehicular movement on and off of the island, land traffic volume and patterns, the movement of people on and off the island, bus stop usage and beach usage along the length of the island. These results were manipulated into layerable, GIS thematic maps which were used to analyze the relationships and trends in our data.

5.1.4.2 Vehicular Movement onto the Island

On June 27, 2003 from 9am-2:30pm we collected data on the types and number of vehicles entering and exiting the island via the northern ferry. There were a total of 143 vehicles moving onto the island and 117 moving off during the 5.5 hour sampling period. This data was depicted using a thematic map to show the total influx of vehicles.

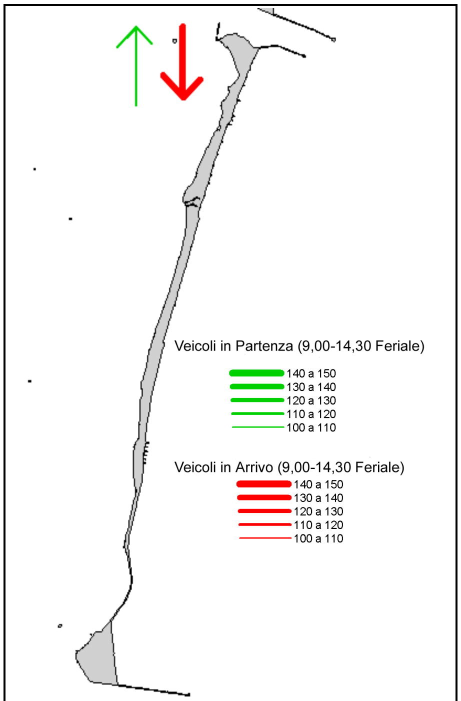

Figure 30 - Entering and Exiting Vehicles

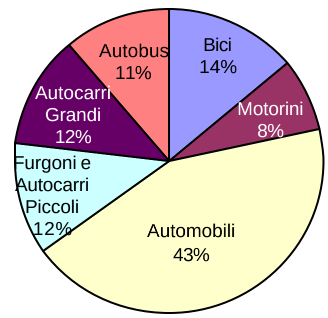

Figure 29 - Entering Vehicle Distribution

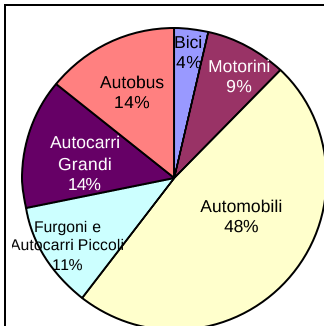

Figure 28 - Exiting Vehicle Distribution

Figures 28 and 29 show that, with the exception of bicycles, there were similar distributions of vehicles entering and leaving the island during our sampling period. Bicycles, or *Bici*, shown in blue, made up 14% of the vehicles entering the island and only 4% exiting. This can be attributed to a bicycle tour of about 30 bicycles heading to the island on a tour. This data can be used as baseline data for future analysis of the ACTV system, and vehicle distributions on the island.

5.1.4.4 Land Traffic Volume and Patterns

Three different types of traffic data were collected: traffic volume, traffic movement, and peak hour. These were collected over several days, the 6h, 8th, 9th, and 23rd of July, 2003. The traffic volume data was translated into several thematic maps to show the trends over the course of the day for both a weekday and the weekend. It was broken down by hour for the four hours that data was collected, 7:30am-8:30am, 8:30am-9:30am, 5:30pm-6:30pm, and 6:30pm-7:30pm. As an example, shown below is the thematic map for a weekend evening from 6:30pm-7:30pm. There were a total of 380 vehicles in that one hour at the intersection of *Calle Chiesa S. Vito e Modesto*, the southernmost intersection on the map. Within these 380 vehicles, 173 of them were bicycles, 124 were cars, 72 were mopeds, and 9 were busses as seen in Figure 31.[32]

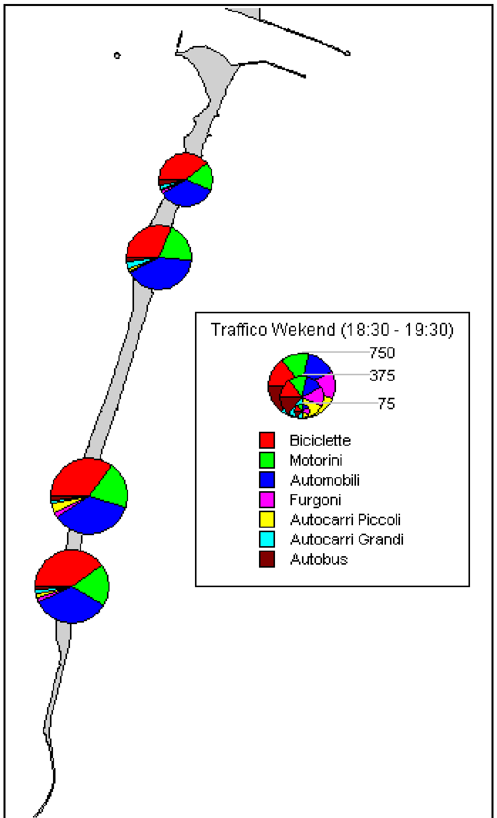

Figure 31 - Weekend Traffic Volume

The data was broken down by two-hour periods for the four hours in which the data were collected, 7:30am-9:30am and 5:30pm-7:30pm. Figure 32 shows a thematic map for a weekend evening from 630pm-7:30pm. It shows that 519 vehicles passed through the northern segment, 531 through the southern segment, and 224 through the western segment. This reveals a trend found throughout the entire set that shows that a significantly greater number of vehicles move north and south while there is much less travel on the road running west.[33]

[32] Please see Appendix N for all of the thematic maps for both the weekday and weekend.
[33] Please see Appendix O for a complete set of figures for all four intersections.

We analyzed our data set, looking at the total vehicles per sampling division and then looked for the maximum for the entire data set. In this way we found the peak traffic hour for the island.

Figure 32 - Weekend Traffic per Intersection

The peak hour of traffic was depicted using a scatter plot. Plots were made for the total traffic volume at one intersection over fourteen hours as well as separate plots for each vehicle type.[34] Each specific vehicle graph was in agreement with the overall total traffic trend showing a peak from 10:30am-12:30pm and again from 7pm-8pm. Heavy vehicles such as vans and trucks showed a peak from 7am-9am, this is attributed to industry vehicle movements and deliveries in the morning. There is also an additional peak around 7am for mopeds and motorcycles. This peak is likely attributed to the change of shift at the shipyard, where there are a large amount of workers arriving to and departing from the island. The overall noon traffic peak is interesting in that it shows that a large number of people are on the road during lunchtime. Typical lunchtime is quieter due to people eating and taking a break from their work schedules. On Pellestrina this can possibly be attributed to the fishing and clamming industry which keeps earlier work hours. Workers are likely returning from work midday and are accounted for by this peak.

[34] Please see Appendix P for a complete set of charts.

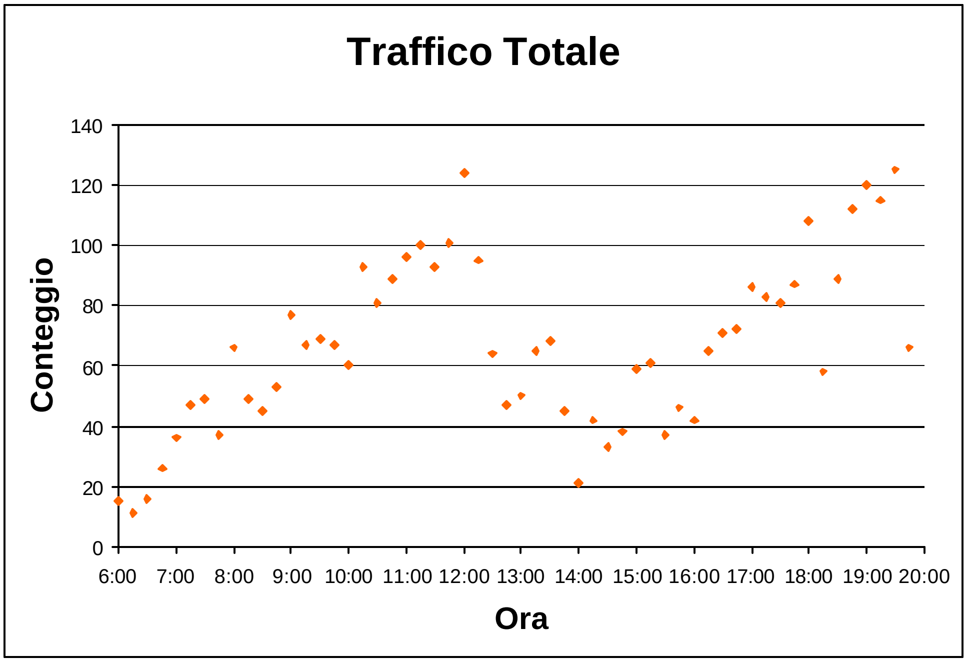

Figure 33 - Total Traffic Peak Hour

5.1.4.3 Movement of People on and off the Island

We sampled the number and type of vehicles entering and exiting the island from 9am-2:30pm on June 27, 2003. On the ferry at the north end of the island, there were a total of 778 people arriving and 561 people exiting the island during that 5.5 hour period. At the south end, via the *vaporetto* to Chioggia, there were a total of 351 people arriving and 279 leaving the island. This data was represented using a thematic map to show the total influx of people at both ends of the island.

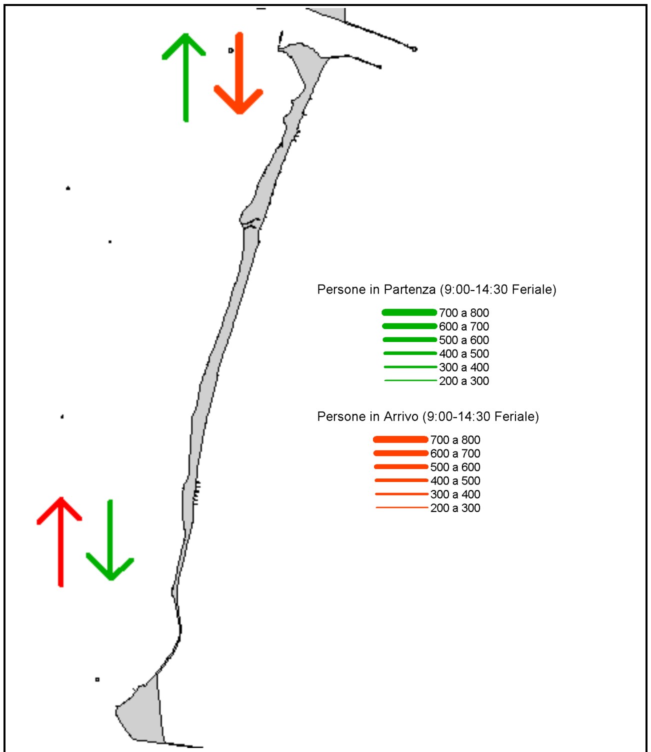

Figure 34 - People Entering and Exiting

This data shows the number of people traveling between Pellestrina Chioggia and Lido. This shows the origins and destinations of people moving through the island and may be important in the analysis of traffic problems and public transportation on Pellestrina.

5.1.4.5 Bus Stop Usage

We collected ACTV bus data on Monday June 16th, 2003 and Wednesday July 23rd, 2003. These two data sets were used to produce an extrapolated data set for a full weekday on the island. This data showed usage at each bus stop in two-hour periods from 6am-8pm and the data was used in order to determine the most used bus stop as well as the peak bus usage hour on the island.

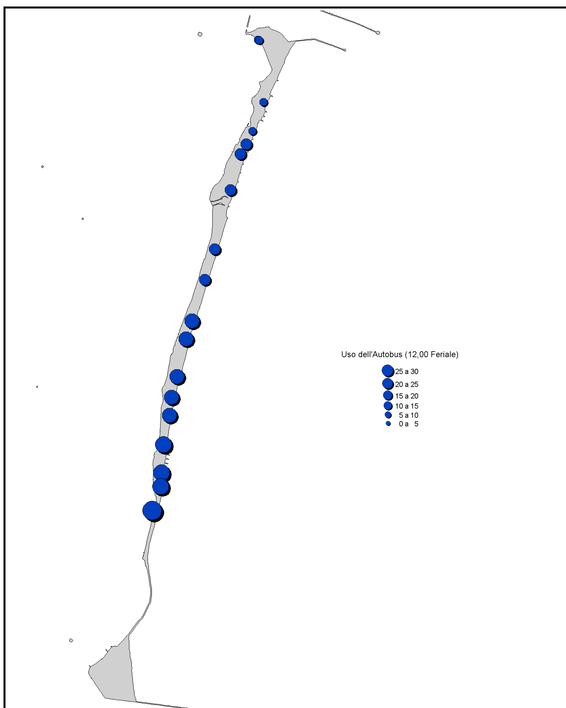

Figure 35 - Weekday Bus Stop Usage

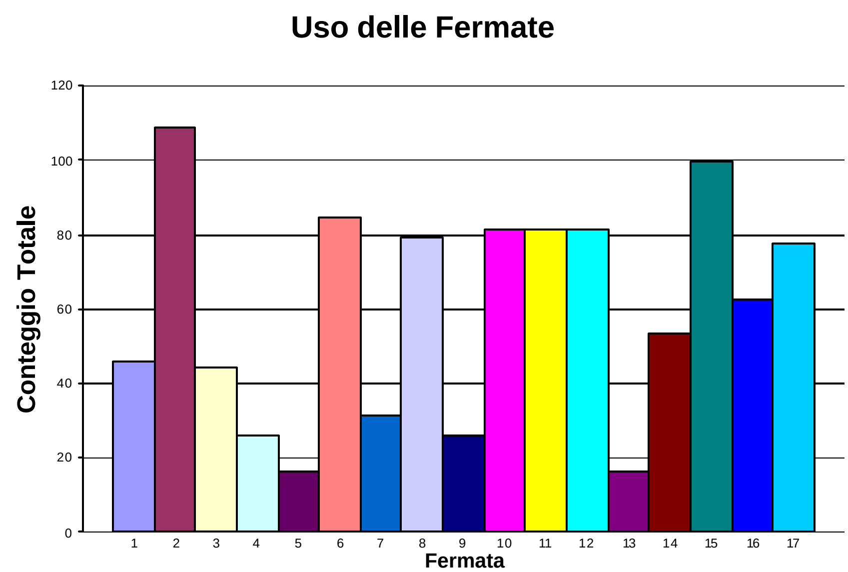

Figure 36 - Bus Stop Usage by Stop

From these three visual representations, it was determined that stops 2 and 15 are the most frequently used and 12pm is the busiest time of the day. The peak for bus stop usage follows and

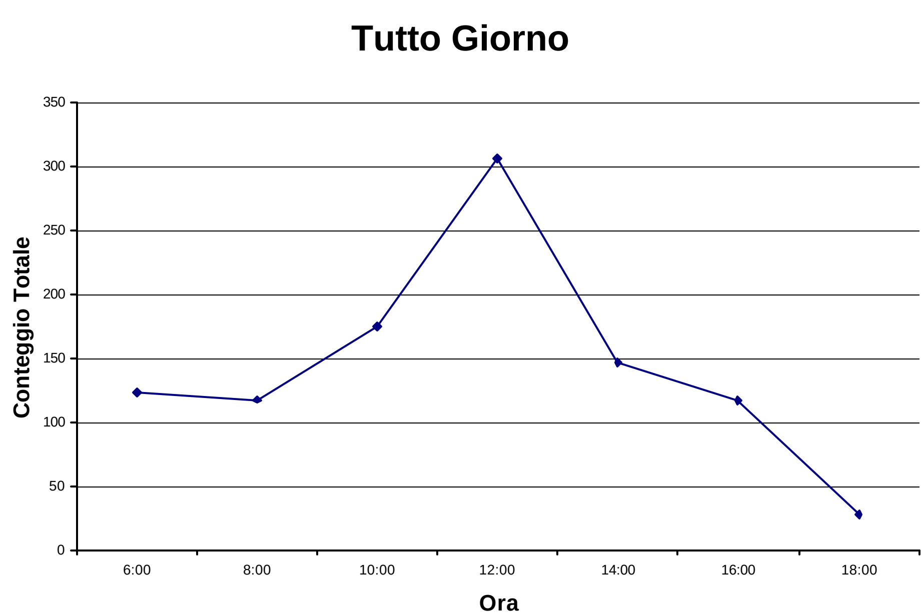

Figure 37 - Bus Stop Usage by Time

supports the noontime peak of the other vehicle traffic we collected.

5.1.4.1 Summer Beach Use

After a full data set was collected for weekend beach use we were able to extrapolate data for weekday beach usage. Data was represented in thematic GIS layers using pie graphs to depict the number of beach users at each section of the beach. The pie graph was selected in order to concurrently show the type of activities taking place on the beach as well as the number of beach goers.

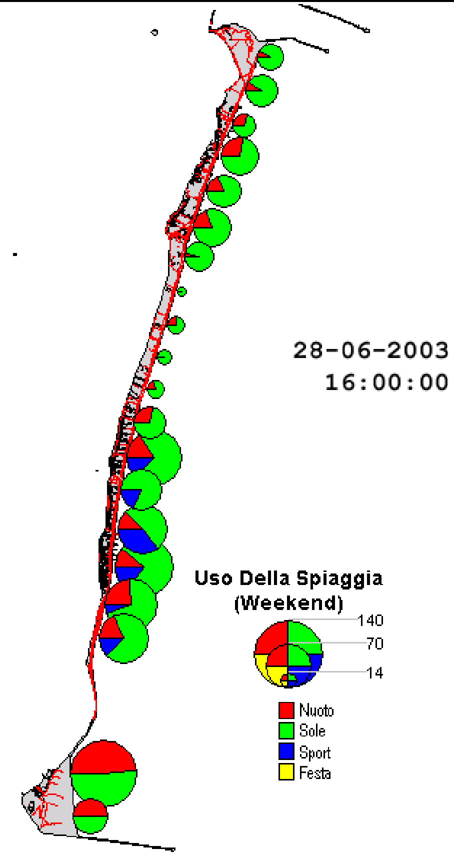

Figure 39 - Weekend Beach Use

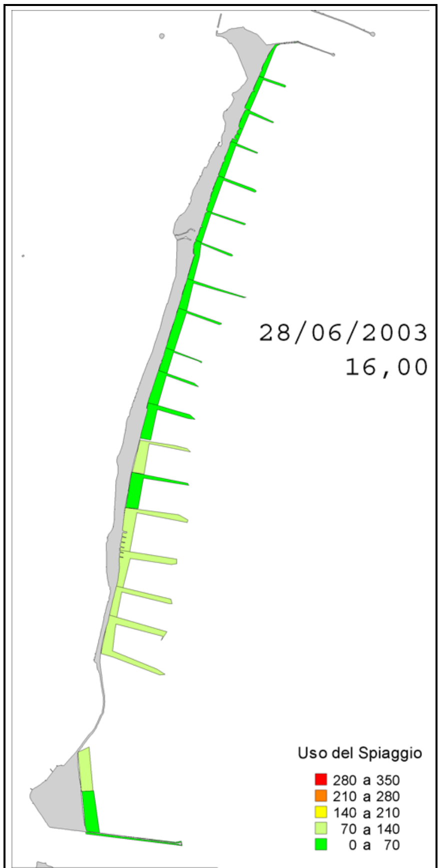

Figure 38 - Weekend Beach Use Regions

For example, beach jetty number 16 in Figure 39 shows beach usage near the village of Pellestrina. For this jetty section, there were a total of 102 people using the beach at 4pm: 11 people in the water, shown in red, 75 people tanning or relaxing on the beach, shown in green, 16 people playing games, shown in blue, and none dining or gathering in large groups, shown in yellow.[35] The GIS layer in Figure 38 represents the same beach usage data but utilizes color gradients instead of pie charts to show the information. This method of display may be more useful to the user depending on the types of data being layered on top of each other. We utilized both methods of display for different

[35] Please see Appendix Q for a comp lete set of these thematic maps over the course of both the weekday and the weekend.

purposes, using the example in Figure 39 for our initial data analysis and Figure 38 for our prototype atlas. Two additional graphs were produced, one showing the most popular beaches on the island, and the other showing the most popular time of day for beach use.

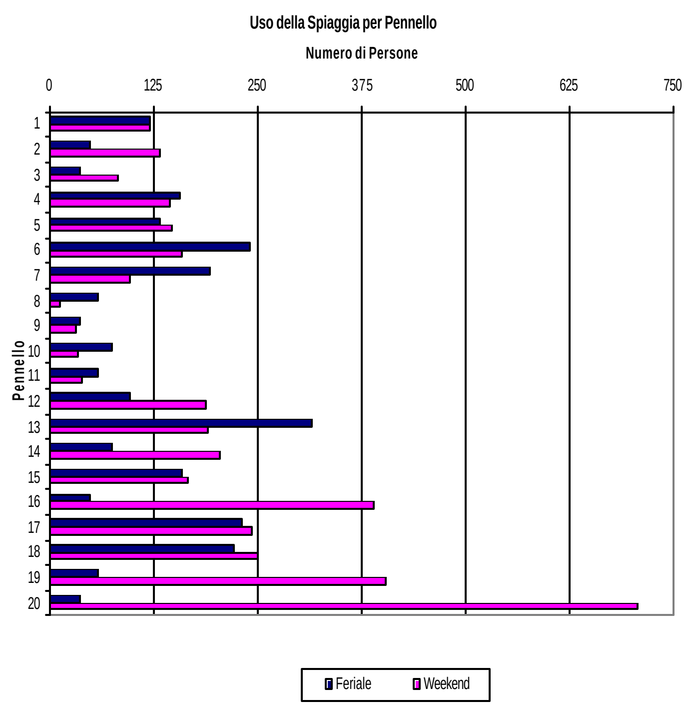

Figure 40 - Weekday and Weekend Beach Usage by Jetty

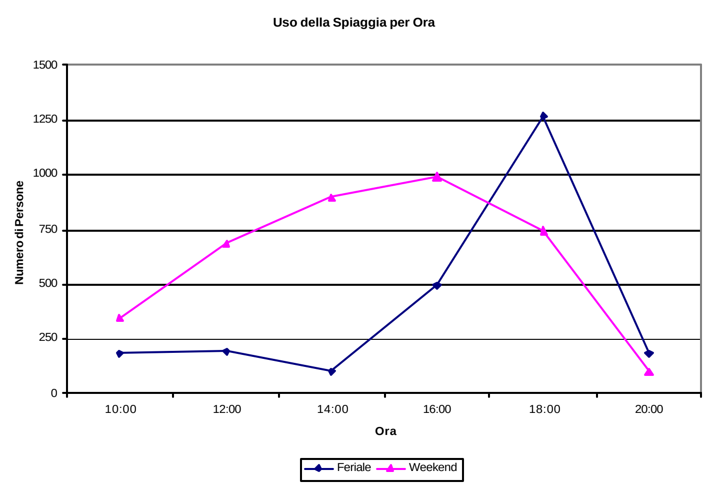

Figure 41 - Weekday and Weekend Beach Usage by Time

From these graphs, we determined that on a weekday, beach use is most popular around jetty number 13. The peak hour for usage on our sample weekday was 6:00pm, with local usage increasing at 4pm. It is apparent that there are a large number of islanders using the beach regularly on weekday evenings. This is supported by the results in figure 25 that shows the highest weekday evening usage occurring on jetty sections 6 and 13. These beaches are located very close to the centers of San Pietro in Volta and Pellestrina. We observed many families walking to the beach around 4pm and leaving the beach at 6:45pm just before dinner. The proximity of these beach sections to the village centers makes them easily accessible to the islanders and encourages their regular use. However, on the weekend, the most popular beach, Ca'Roman, was actually the most inaccessible to the islanders. The weekend beach use results can be seen in Figure 40, with a large number of weekend beach goers at jetty section 20. This can be attributed to day-trippers from Chioggia, who we observed arriving at the island in their personal watercraft, anchoring at Ca'Roman. The peak hour for weekend beach use is earlier on the weekend at approximately 4pm, and the distribution over the day is a smoother curve.

5.2 Generalization of Case Study Methodology

The results and analysis presented in this section are an evaluation of our general methodology for our case study of the Environmental Atlas of the Venetian Lagoon. The results of this case study are a set of tested processes which are a large part of the guidelines and structures we are proposing for the future development of the Venetian atlas. The Atlas is intended to serve as a future tool for the *Osservatorio Naturalistico* and other organizations. These methodologies that have been developed through the case study are the basis for the continued implementation and final completion of the atlas.

5.2.1 Identification and Classification of Atlas Topics

The *Osservatorio Naturalistico* compiled a list of Atlas topics deemed necessary for their work. We were presented with the latest version of these topics when we arrived in Venice.[36] Upon translation and analysis of this list, we determined that two types of classification were necessary. The first is a series of categorizations to aid solely in the collection and periodic update of this data.[37] The second is a classification to be used in the final thematic presentation of the Atlas.

5.2.2 Data Collection Procedure

A specific classification system was followed for categorizing the Atlas topics so that future data collection can be coordinated in a more timely and efficient manner. Each topic was divided into two main groups: environmental or socio-economic data. These two groups were then further broken down into static or dynamic data types. This distinction between static and dynamic data types allows data collection to be prioritized. For example, it is worthwhile to expend any effort to acquire static data, because it is permanent and will not need to be collected again. Likewise, this type of information does not demand immediate attention as it can be collected at any point in time. Dynamic data types must be collected repeatedly over time in order to keep the information current and relevant. Different types of dynamic data will require different periodic collection schedules, thus data with similar collection schedules can be collected at the same time. After this distinction was made, the topics were grouped together under general topic headings in order to visualize further similarities related to data collection coordination.

[36] Please see Appendix B for this list in both Italian and English.
[37] See section 5.2.2 Data Collection Procedure for clarification of this system.

This method of classification is most easily understood with an example. Figure 8 shows how the topic *Climate Zone* was categorized. It was first placed under the *Environmental* main group.

Then it was classified as a *Static* data type, because climate zones do not change over time. It was further grouped under the *Climate* general topic heading so that it can be found with similar data.

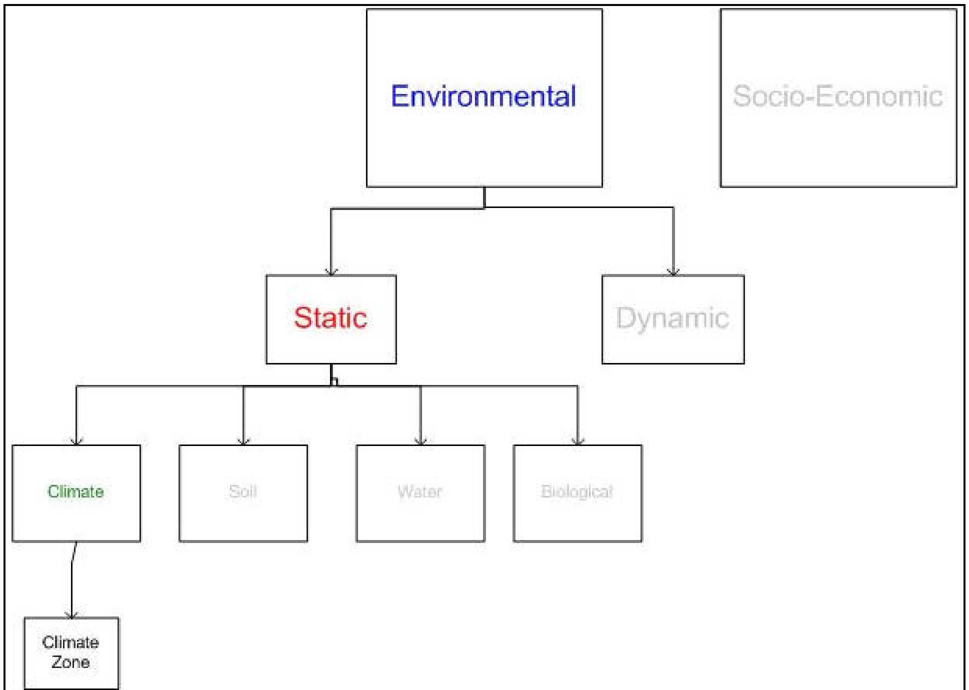

Figure 42 – Example of Methodological Classification of Topics

5.2.2.1 Collecting Existing Data

The first step in collecting data for the Environmental Atlas calls for contacting organizations that may already have existing data. This requires researching organizations associated with the *Comune di Venezia*, such as the *Assessorati all'Ambiente e all'Urbanistica*, and both public and private outside organizations. These organizations work with a number of researchers and analysts who may have relevant information. Determining the location and accessibility of existing data is an important part of the data collection plan. A pre-made questionnaire can be emailed out to the departments asking for the types of data they collect. Additionally, a generic email can be sent out to set up appointments to discuss the collection of similar data topics. The goal of these meetings is to identify what types of data are available, what form they are in, and if they can be used in the Environmental Atlas. Also, an agreement for an exchange of information may need to be arranged in order to expedite the acquisition of relevant data. An effective means of organizing the information gathered from the questionnaire and the meetings is our contacts database. This database is a repository for the contact information of the organizations and departments we have worked with.[38] The database catalogues the type of data these organizations and individuals collect, as well as any existing agreements for the use of their data in the Atlas.

5.2.2.2 Compiling Existing Data

Once the information is located and received from outside organizations it needs to be analyzed by a Process Team. The Process Team is in charge of manipulating and reworking the received data to fit the needs of the Environmental Atlas. The team will represent acquired data in GIS map layers so they can be easily incorporated into the online atlas.

5.2.2.3 Field Data Collection

Any information that is not acquired from outside organizations must be collected through field work. A schedule for collection should be made taking into account the static or dynamic nature of the required information. Long term plans for collecting static data can be put into effect, as well as the coordination of periodic dynamic data acquisition. Subcontracting data collection to outside organizations may be a useful and efficient way of collecting large amounts of data for the atlas. We believe that the *Comune di Venezia* should consider organizing a plan for city based data collection. This could prove useful in facilitating communication between city departments, so that each department collects information they need and makes that data known to other departments. The *Comune di Venezia* could also use their data as a bargaining platform in order to develop stronger relationships with external research institutions. These relationships and the sharing of data could greatly increase the efficiency of data collection and the amount of knowledge about the Venetian lagoon and its communities.

5.2.3 Presentation of Final Product

The Environmental Atlas of the Venetian Lagoon will be an easy to use, publicly accessible, online collection of information. The previously mentioned classification of Atlas topics[39] is intended to make data collection easier, but is not suitable for the final presentation of the Environmental Atlas. The distinction between static and dynamic data is not an intuitive method for locating specific information; therefore, a more thematic classification of topics was devised. This

[38] See Appendix R for the Contacts Database
[39] See Section 4.1

includes the simple collection of specific topics under related general topic headings. For example, topics such as *Humidity*, *Air Temperature*, and *Ground Wind Speed* would all be grouped under the heading *Air*. This simple categorization makes finding desired data simple and intuitive. Data will be presented through selectable, thematic maps that are directly linked to raw data tables. These data tables can be accessed through the atlas interface while the user is simultaneously viewing a thematic map. In this manner the user can see the visual representation of the data as well as access the raw data to find specific information if so desired. Layer selection is an important feature of the Venetian atlas that allows the user to customize the visual representation of data. It allows the user to select the information they are concerned with, and also allows them to layer the visual representations of data in order to make their own analysis. This is an important feature that has grown out of our own analysis of various data types in our case study. We have found that the layering of thematic maps is a necessary feature that makes the presentation of data extremely flexible.

5.3 Demonstration of Usefulness of Collected Data

We compiled the results our case study to form a prototype for the Environmental Atlas of the Venetian Lagoon. The first layer presented was the base map of the entire island; this allowed for easy visualization of and zooming into any location on the island. We were careful to ensure that every layer made from our data was properly georeferenced and depicted as thematic map layers so that data could be illustrated and associated with its origin. A menu interface with the list of available general topics and subtopics was created to allow the user to navigate through and select data sets. Each of our data sets were categorized into this list by the criteria previously set forth by the *Osservatorio Naturalistico*.[40] Our prototype enabled the user to layer several different data sets in order to illustrate certain relationships between them. For example, if the layers for the location of bird populations and weekend beach use were shown one on top of the other, it would be very easy to identify that the *Passera d'Italia*'s habitat is right next to the busiest location for weekend beach use. This allows the users to draw their own conclusions as to the implications of the presented data. The prototype was also designed so that additional information could easily be incorporated in the future. We have found through our case study and our experience working with organizations in Venice, that a systematic implementation of the atlas is very feasible. For example in the Berlin Digital Atlas, a large amount of money and resources were expended initially to collect data and complete the atlas in a timely manner. In Venice the atlas can be developed over a determined period of time at a greater efficiency by utilizing the static / dynamic data classification, local research institutions, and our contact database. By knowing what data exists in Venice, or what is currently being collected, a

[40] Please see as Appendix B for a full list of data topics and how they are to be presented.

detailed plan can be made to acquire the data topics for the atlas. In addition, the internet based presentation of the atlas will enable it to be updated as data is collected. The Atlas does not need to be republished when new data is made available, and therefore the Atlas can be presented online as a work in progress, with more information being added over time. This was not possible in Berlin due to the fact that it was published as a complete paper atlas with an additional digital version presented online. If a plan is made for the periodic update of static data types, the Venetian atlas will require less capital investment, whereas every five years the Berlin atlas is completely remade using newly collected data. The costs of maintaining and adding data to the Venetian atlas will be considerably less then the large scale recollection, manipulation and publication of the Berlin Digital Atlas.

We analyzed the relationships of several topics associated with the construction of the MOSE gates in relation to the island of Pellestrina to show how our prototype could be put to good use. The construction of the MOSE gates poses several pressures to the island of Pellestrina, since it is located between the inlets of Malamocco and Chioggia; the two sites of future MOSE construction. MOSE will require an increase in workers commuting to the island many of whom will be in need of temporary housing. The construction will bring an increase in truck and other heavy vehicle movement to the island as well as need to store these vehicles at the sites of construction. The widening of the inlet of Chioggia will negatively affect the nature preserve of Ca'Roman.

Although the effects of the MOSE project on the ecology and infrastructure of the Venetian Lagoon has been analyzed in great detail, the effect of the project on the daily lives, and quality of life of its inhabitants have, to a great extent, been overlooked. With a large scale project such as MOSE, much of the analysis and concern is focused on the completion of the project, raising questions about the success of the project and its impact after completion. There is much less attention given to the impact this project will have during the construction cycle. There is a high probability that the construction process will disrupt people's daily lives, have economic effects and place developmental pressures on the infrastructures needed to support such a project. Through our case study, we were able to address some of the potential problems of this large scale, long term construction project and analyze its impact on the lives of the people of Pellestrina.

There is an estimated 1,000-1,200[41] workers that will be required for the construction of the MOSE gates. These workers will be distributed at the three sea inlets of the lagoon over the eight-year project. This raises concerns about commuting problems for these workers and the impact this new traffic will have on the current traffic on the island of Pellestrina. Most of the MOSE commuters will move towards destinations at the north and south ends of the island where the gates are being built. This will undoubtedly increase the number of people entering and exiting the island

[41] "With Water and Against Water: Measures for the Safeguarding of Venice and its Lagoon." International Centre Cities on Water. Compact Disc. 1996.

via the ferry at the north and the *vaporetto* at the south. Both the ferry and the *vaporetto* may have to run more frequently if this occurs, causing increases in cost of operation. This will also effect the public transportation on the island, namely the ACTV bus system. According to the data we collected in our case study, bus stops 2 and 15, have the highest amount of passengers on the island. If MOSE worker traffic utilizes stops 1 and 17 near the ends of the island, these two stops will become the most frequently used stops creating a major source of congestion at both ends of the public transportation system. The large influx of workers to the island could also impact the peak hour for bus usage on the island, changing from the current noon peak to around 7am and 6pm, during typical commuting times. As shown by our bus usage data, the ACTV transportation system on the island can currently support a large number of workers in the early morning, as the bus system is not used to its capacity at those hours.

The current traffic volume peak at noon could pose a significant problem in the future. The island traffic system is different from many other cities in that the peak does occur at midday instead of an early morning peak in other cities. This can be attributed to the types of employment on the island. As the income of many residents on the island comes from fishing and clamming, many islanders have work hours and commute schedule that are very different from cities that do not rely on these industries. The traffic peak at midday poses the possible problem of interfering with MOSE workers that may move about the island during their lunch break, either to get food or to go back to temporary housing sites to rest. If this scenario came to fruition it could increase the current total traffic volume. For example on Wednesday, July 23 at 11:00am to 12:30p.m., the number of vehicles at the intersection of *Calle Chiesa San Vito e Modesto* summed to a total of 609 vehicles, with an average of 102 vehicles passing through the intersection every 15 minutes. This is a considerable amount of traffic for the *Comunale dei Murazzi*, which has one lane in each direction. The width of *Calle Chiesa San Vito e Modesto* will only support vehicle traffic in one direction at a time and turning movements from the *Comunale dei Murazzi* onto *Calle Chiesa San Vito e Modesto* often cause backups on the *Comunale dei Murazzi*. The traffic buildup on *Comunale dei Murazzi* would only increase with MOSE traffic due to its proximity to the Chioggia MOSE construction site. These are all problems that will eventually have to be addressed by the islanders and the municipal government in order to maintain and improve the current traffic situation on the island. These traffic problems may also apply to other locations in the lagoon such as on the Lido and in Chioggia where MOSE construction will be taking place. In addition to construction sites, shipment locations for the transport of materials by boats and trucks may have similar impacts on their neighboring communities possibly impacting boat traffic near the 3 inlet opening during construction. Our traffic data can serve as a base line for future comparison. The methods we have utilized in the atlas can help increase awareness of the impact MOSE may have on traffic in the region during and after construction.

Since it is highly likely that many of the MOSE workers will come from foreign countries, there may be a need to erect temporary housing at several locations, including Pellestrina. These include apartments, hotels, or other types of complexes located throughout the island. This mass construction will greatly increase the percentage of impermeable surfaces in both San Pietro in Volta and in Pellestrina. Not only will this housing be present during the eight years of construction, but they may be reused in the future as housing for tourists. This increase in impermeable surfaces causes two major problems. Impermeable surfaces cause pollutants to collect, instead of being absorbed and naturally processed in the ground. Additionally, the increase in paved surfaces creates a water runoff problem, changing natural drainage patterns.

In addition to an increased number of workers, there is also the threat of an increased number of trucks and other heavy vehicle traffic to transport materials to, from, and around the island. This could mean that a greater number of heavy vehicles will be traveling via the ferry. This will significantly increase not only the total number of vehicles entering and exiting the island, but will also increase the percentage of large trucks. This increase in large trucks may require a change in ACTV schedules to run more ferries, or a different style of ferry to accommodate the greater weight associated with large vehicles and machinery. There is also an inherent safety issue on the island of Pellestrina that has a variety of different vehicles sharing a small main roadway, which lacks stoplights and other forms of traffic and speed regulation. The main road, the *Comunale dei Murazzi* lacks sidewalks leaving waiting bus passengers exposed to large and fast moving traffic. Additionally the types of vehicles that share the road are very diverse, in size as well as average speed. At any given time there are bicycles, motorscooters, large trucks, automobiles and three wheeled mini-utility vehicles on the road. The islanders themselves have expressed concerns about traffic through the participatory planning process initiated by *l'Ombrello* on the island.

We have observed that there is a significant amount of joyriding on the island. Motorists will drive up and down the *Comunale dei Murazzi* with no real destination. This reduces the capacity of the roadways and poses a problem during times of heavy traffic congestion. We spoke with some islanders who confirmed our suspicions about joyriding, who also stressed their concerns about pedestrian and bike safety on the island. This unnecessary vehicular traffic caused by joyriding, may be a current cause of traffic problems, and definitely could increase in severity as the island develops and road congestion becomes more prevalent. Some islanders believe that creating one way roads on the island could help solve traffic problems; others believe that outlawing motor vehicles on the island is the solution. Data contained in the future atlas could help to predict the environmental, social and economic impacts of such decisions and would aid in the decision-making process.

The European Union SIC has earmarked Ca'Roman and the area at the Malamocco sea inlet for environmental preservation, yet these areas are will likely suffer the most from MOSE construction. The current plan for construction of the MOSE sea gates at the inlet of Chioggia calls for an initial widening of the sea inlet. This means that 1.18 km^2 of the land in the Ca'Roman nature preserve will be destroyed. This presents a serious threat to the bird and plant species and biotopes near both construction sites. The construction and storage of equipment will significantly decrease the amount of available beach for use at both extremities of the island. These problems may cause a significant change in the baseline beach use patterns we have currently identified. Our collection of baseline beach use data could be used for comparison after the MOSE project is completed.

The destruction of land will also destroy eight phytosociological vegetation groups that cover the southern end of the island at Ca'Roman. This vegetation plays an important role in maintaining the dune structure, preventing erosion and the migration of dune structures. Similar to the impact on vegetation, the dune structure of Ca'Roman will lose 0.67 km^2 when the sea inlet is widened. It will displace the animals that make their homes in the dunes as well as decrease the protection the dunes provide in keeping the beaches from eroding and flooding. Lastly, these plans will significantly impact both the major and minor bird species on the island by destroying their nesting locations and forcing them to move to a different part of the lagoon. The *Passera d'Italia*, *Rondone*, ,and *Storno* bird species that live at the north and south ends of the island may be forced to relocate to other areas when the machinery is moved in.

Having data on the present bird populations and locations will serve as a baseline for comparison in the future and can be used as an indicator.

The topics associated with construction of the MOSE gates are not the only factors affecting the island of Pellestrina. As mentioned previously, *l'Ombrello* is an organization working with the *Assessorato all'Urbanistica*, the neighborhood council of Pellestrina, and residents in establishing a participatory program that will result in a revised urban development plan for the island. Through our work with *l'Ombrello*, we were able to interact with the residents of the island and hear the concerns they have voiced about the future of the island. Some of their concerns include the growth of industry on the island, the need for a food market in the village of Pellestrina, the need for parking lots, the promotion of beach tourism and associated facilities, such as restrooms and hotels.

We presented our work to the residents of Pellestrina on July 21st 2003. The presentation was primarily used to address the concerns of the islanders about the existing and future problems they were facing, and to give our perspective and impressions about the island. We used our collected data in order to show the current trends on the island and to highlight and make predictions about pressures the island will be facing such as MOSE and tourism. We showed how the atlas could be used as an informational tool for both the residents of the island and the urban planners who would be developing master plans for the future of the island. They welcomed our outside perspective and an in depth discussion followed the presentation.

Both the shipyard and the clamming industry on the island have expressed a desire to expand their businesses. The *Cantiere Navale de Poli* wants to be able to produce more ships per year in order to stay competitive in the world market. The clamming industry wants to add canning and freezing facilities on the island so that more goods can be sold and distributed outside of the lagoon. An expansion of these industries in the center of the island will result in an increased number of workers which may have an effect on the ACTV system, similar to that of MOSE.

The increase in workers from these proposed plans may specifically impact the public bus transportation system causing more bus usage near the center industrial area. The traffic volume and patterns in this area will change with the introduction of larger transport trucks to the area. The peak traffic hour may also change to earlier in the morning, around 7:30am, and in the early evening, around 5:30pm, to reflect the movement of these workers to and from their jobs.

There has also been interest expressed by the residents to install a food market in the village of Pellestrina. Presently, the residents of the island must travel to the Lido or Chioggia to do their food shopping. The installation of a food market would greatly reduce this inconvenience. However, if this food market is installed, there will be a noticeable effect on traffic volume, patterns, and peak hour similar to the situation that would arise if the industry on the island were expanded. There may be movement in the early morning and evening to and from the food market to buy groceries for the day. This would especially change traffic patterns on the island since the proposed location of this market is on the western side of the island and most of the traffic currently only passes along the eastern side.

The extra early morning traffic and turning movements at the center of the island could directly interfere with the traffic related to the MOSE project. As Pellestrina is expanding and looking towards the future, it is important that these pressures be taken into account so that extra traffic can be properly planned for.

On a weekday, the most frequently used beach was in the southern part of the village of Pellestrina. The peak hour of usage was approximately 6pm. However, on the weekend, the most popular beach was in Ca'Roman. The peak hour of usage is earlier on the weekend, at around 4pm. These peak hours of beach use and the most popular beach areas may change in the near future. The city officials of Venice are looking to bring tourism to Pellestrina by promoting the use of its beaches. In addition to attracting more people, they are also considering installing sanitary facilities, refreshment stands, and rest areas on the beachfront. By attracting people to the island, and developing the beaches, some islanders speculate their beaches could become similar to those on the Lido. If this were to occur the beaches of Pellestrina would become mostly private and the residents could lose their free access to the beaches. In the nature preserve of Ca'Roman, beach development and increased usage would have a significant impact on the dunes, vegetation and wildlife that populate that area. As the beaches and the dune structures help to protect the island and the lagoon from flooding, the erosion of the beaches and jetty structures must be taken into account before development occurs.

We were able to work with *l'Ombrello* in their participatory urban development program. We presented our findings to the head of the *Assessorato all'Ambiente*, the neighborhood council of Pellestrina, and several residents of the island to show the connections we made between our collected data and local problems expressed previously. We drew parallels between our collected data, the situation in our home towns in America, and possible solutions to their problems. The information and ideas brought up in this presentation will be used when *l'Ombrello* meets with the residents of the island to start discussing solutions to the island's problem. This interaction showed us that the information to be included in the Environmental Atlas can have many applications. It can be used in the context of sustainable urban planning as well as to educate the general public as the current state of their home.

6. CONCLUSIONS

The ultimate goal of The Island of Pellestrina: Case Study for the Environmental Atlas of the Venetian Lagoon was to develop a prototype for the Environmental Atlas by working on Pellestrina and creating a version of the Atlas with this limited scope. Our prototype was a success, but through it we learned of the difficulties that go into presenting data in this unique format. It was simple to locate existing data within the lagoon; however, it was difficult and time consuming to actually acquire this information for our use in our prototype. This may be because we were not formally a part of one of these organizations, we were only in Venice for two months, or because we were not fully aware of the existing practices for data exchange used between these groups. Once we acquired existing data, such as the bird population locations and vegetation locations, and took several data sets of our own, it was difficult to present these in a suitable manner for the Atlas. We aimed to create georeferenced thematic maps that could be layered to show relationships between several data sets simultaneously. We attained this goal for several data sets such as traffic movement, bird location and population, dunes and vegetation location on Ca'Roman, movement of people or vehicles entering and exiting the island, impermeable surfaces, and beach use. However, we were not able to sufficiently represent more specific data such as the distribution of vehicles making turning movements and roadway usage over the course of the day. This same problem will be faced in the future of the Environmental Atlas as it is expanded to other regions of the lagoon and as more data sets are added.

We found that our prototype was a step in the systematic implementation of the Environmental Atlas of the Venetian Lagoon. This method of choosing one location, such as Pellestrina, and collecting information over a period of time to add it to the Atlas can be used well into the future. Gathering data in this manner makes the Atlas easily maintainable as it allows for the addition of new data sets and updated information without having to update the entire Atlas. It also reduces the costs associated with data collection because instead of one large effort up front, the collection can be spread over time more economically.

The Atlas in its complete form will be a useful tool for many organizations in Venice. It will assist the *Osservatorio Naturalistico* in their task of verifying environmental impact assessments by providing them with necessary information. It can be used to predict the effects of the MOSE project on Pellestrina, as well as any other large developments that may take place in the future, just as our prototype was able to illustrate several of the implications of these projects. Though we were not able to quantify the effects of the MOSE construction on the residents of Pellestrina, it was easy to see the implications of the project on their way of life. With full data sets on all the topics suggested for the Atlas, quantification will be possible for the MOSE project, the other concerns expressed by the residents of Pellestrina, and any future development project.

The Environmental Atlas of the Venetian Lagoon can also work to bring together the many organizations that operate in Venice to protect the city and its lagoon. Groups such as Co.Ri.La., *Consorzio Venezia Nuova*, *Osservatorio Naturalistico*, *Assessorati all'Ambiente e all'Urbanistica*, *Istituto Veneto di Scienze Lettere ed Arti*, and others can all use the Atlas as a tool to share information and a resource for the specific information that applies to their work. A formal collaboration between these organizations for the Environmental Atlas could benefit each of them. The online implementation of the Atlas will provide access to the information for city planners, organizations in the Venetian Lagoon, as well as the general public. The Atlas will be helpful in carrying Venice through the problems of development, environmental preservation, and will assist in the preservation of the unique Venetian way of life.

7. RECOMMENDATIONS

Our work while in Venice was only one step towards the completion of the Environmental Atlas of the Venetian Lagoon. We have made recommendations for the *Osservatorio Naturalistico* to use in the future, as well as for any students who will come after us. These recommendations are presented in two sections: one dealing solely with the island of Pellestrina, and one concerned with the Atlas as a whole.

7.1 Case Study on the island of Pellestrina

Through our case study on Pellestrina, we became aware of several ways in which the project could be simplified or improved upon for the future.

7.1.1 Base Layer for Pellestrina

For the purposes of organizing data collection and presentation, a base layer of Pellestrina would be useful. This would need to be done in several steps. First, an accurate GIS map of the outline of Pellestrina is required. This could be acquired from *Consorzio Venezia Nuova*. Once this is received, it needs to be divided. The most useful way of doing this is to use an aerial photograph of the island to verify a print out of the following GIS layers: island area, roadways, property lines, *isolati*, residential, commercial, and incidental use buildings; lakes, ponds, and rivers; tree lines, and historical areas. This information can be used to create outstanding divisions of land on the island. These divisions should be blocks, keeping in mind they will be used in the future as units of measurement for data collection. This could be done using roadways, property lines, tree lines, waterways, and historical areas as lines for creating these division blocks. These blocks should then be numbered for reference. This could be done with 7 placeholders divided into three parts. The first part consists of two letters reflecting the location, for example, Pellestrina would be expressed as PE. The second part consists of three digits representing each large block section. The third and last part consists of two digits for additional division as necessary. The flexibility of making small divisions within the large blocks ensures that data types which do not readily fit into the large blocks can still be represented with this system.

7.1.2 Collaboration with Organizations

To acquire as much information as possible about Pellestrina, it would be useful to contact as many organizations as possible that deal with the island. The Contact Database developed for our project could be used and expanded to allow improved communication with these organizations.

Groups such as *Consorzio Venezia Nuova*, *l'Ombrello*, Co.Ri.La., *Istituto Veneto di Scienze Lettere ed Arti*, and others are dedicated to gathering data about the lagoon region and could provide a great deal of information, as well as access to other groups that may have additional topics.

7.1.3 Data Collection

Data collection could be facilitated either by the use of proper materials for the type of collection being done, and by using the Contact Database to find groups who have already collected the required data and use this information. By carefully selecting the data types to be collected would be possible to collect more than one type at a time. In much the same manner as our group collected roadway traffic, beach use, and bus usage concurrently it would be possible to efficiently collect data with a small data collection team.

7.2 The Environmental Atlas of the Venetian Lagoon

The ultimate goal of the *Osservatorio Naturalistico* is to have an Environmental Atlas of the Venetian Lagoon to use in verifying developers' environmental impact assessments. While we continued previous work on developing this Atlas for their use, it is nowhere near complete. The following recommendations could be useful in the future development of the Atlas.

7.2.1 Incorporation of Outside Data

We recommend that the Atlas be used as a method for organizing and retaining information about Venice and its lagoon. To do this as efficiently as possible, it would be useful to institute a system of sharing information between organizations in Venice. This would allow everyone who needs it to have access to this information. It will also facilitate the data collection process, because the information to be collected will be divided amongst a greater number of researchers. The Contact Database could be used to initiate communication between these organizations.

7.2.2 Presentation Structure

To allow the Atlas to be as useful as possible, it should be presented in the form of thematic maps divided by topics already proposed by the *Osservatorio Naturalistico*. These topics are:

- Climate
- Soil
- Water
- Air

- Biological Component
- Land Use
- Socio-Economic Component
- Energy
- Traffic

These topics can then be further broken down into subtopics.[42] For example, the Beach Use data collected for the island of Pellestrina would fall under Socio-Economic Component. This organization system is useful because it is an intuitive way of searching for information and can be easily understood.

7.2.3 Data Collection

To facilitate the organization of data collection, we recommend that the types of data be divided into one of two categories: static and dynamic. Static data is permanent and need only be collected once; dynamic data changes at a given rate and must be collected periodically to ensure accuracy of the information.[43] Additionally, the generalized methodologies for data collected we developed while in Venice can be used as a guideline for acquiring existing data from organizations in the area. This methodology is meant to be modified and expanded over time to suit the needs of the *Osservatorio Naturalistico*. Through the *Osservatorio Naturalistico*, the *Comune di Venezia* could allocate funds for field data collection needed for the Atlas. Researchers could be hired to collect needed data with the stipulation that the information be accessible to the *Comune* in the future. This would also give the *Osservatorio Natualistico* access to data that could be used in an exchange of information with outside researchers.

7.2.4 General Recommendations for the Atlas

The Environmental Atlas of the Venetian Lagoon should be Internet based. This would allow access worldwide as well as simplify updates. The information should be presented using thematic maps and GIS layers, to allow the user to view only what is desired, and compare data sets easily. These layers should be designed so they can be overlaid to show pertinent relationships between the data sets. Also, these data sets can be collected over time so there is no large initial investment. This will encourage a maintainable structure for the Atlas so that information can be

[42] Please see Appendix B for a complete list of topics and subtopics.
[43] Please see Section 4.1 for more explanation on this subject.

added or changed as time progresses. This allows for the most current information about the lagoon to be presented at all times.

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