Appendix A. Planning Analysis and Modeling Markup Language XML Schema

```
<xs:schema targetNamespace="http://web.mit.edu/rajsingh/www/xml/ns/pamml"
elementFormDefault="qualified" xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:pamml="http://web.mit.edu/rajsingh/www/xml/ns/pamml">
  <!--
  ********************
  Basic Model Types
  ********************
  -->
  <xs:element name="Model" type="pamml:ModelType"/>
  <xs:complexType name="ModelType">
    <xs:annotation>
      <xs:documentation>Basic information for a model</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element ref="pamml:Metadata" minOccurs="0"/>
      <xs:element ref="pamml:Permissions" minOccurs="0"/>
      <xs:element ref="pamml:RemoteInfo" minOccurs="0"/>
      <xs:element ref="pamml:Alternatives" minOccurs="0"/>
    </xs:sequence>
    <xs:attributeGroup ref="pamml:globalAttributes"/>
  </xs:complexType>
  <xs:element name="Models">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="pamml:Model" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <!--
  ********************
  Generic
  ********************
  -->
  <xs:element name="GenericModel" type="pamml:GenericModelType"/>
  <xs:complexType name="GenericModelType">
    <xs:annotation>
      <xs:documentation>an opaque, "black box" model that permits
modification of specified properties</xs:documentation>
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="pamml:ModelType">
        <xs:sequence>
          <xs:element name="InputProperty" type="pamml:ModelType"
maxOccurs="unbounded"/>
          <xs:element name="OutputProperty" type="pamml:ModelType"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:extension>
```

```
        </xs:complexContent>
    </xs:complexType>
    <!--
    ********************
    BooleanData
    ********************
    -->
    <xs:element name="BooleanData" type="pamml:BooleanDataType"
abstract="true"/>
    <xs:complexType name="BooleanDataType">
        <xs:annotation>
            <xs:documentation>a true or false value</xs:documentation>
        </xs:annotation>
        <xs:complexContent>
            <xs:extension base="pamml:ModelType"/>
        </xs:complexContent>
    </xs:complexType>
    <!--
    ********************
    ValueData
    ********************
    -->
    <xs:element name="ValueData" type="pamml:ValueDataType"/>
    <xs:complexType name="ValueDataType">
        <xs:annotation>
            <xs:documentation>a single cardinal numeric value</xs:documentation>
        </xs:annotation>
        <xs:complexContent>
            <xs:extension base="pamml:ModelType">
                <xs:attribute name="units" type="pamml:ValueUnits" use="required"/>
            </xs:extension>
        </xs:complexContent>
    </xs:complexType>
    <!--
    ********************
    TableData
    ********************
    -->
    <xs:element name="TableData" type="pamml:TableDataType"/>
    <xs:complexType name="TableDataType">
        <xs:annotation>
            <xs:documentation>A two-dimensional matrix of data, like a spreadsheet
or relational table</xs:documentation>
            <xs:documentation>number of Attribute elements must match the data
set</xs:documentation>
        </xs:annotation>
        <xs:complexContent>
            <xs:extension base="pamml:ModelType">
                <xs:sequence>
                    <xs:element ref="pamml:AttributeInfo" minOccurs="0"/>
                </xs:sequence>
                <xs:attribute name="key" type="xs:string" use="optional"/>
            </xs:extension>
```

```xml
      </xs:complexContent>
   </xs:complexType>
   <!--
   ********************
   Basic Geographic Models
   ********************
   -->
   <xs:complexType name="GeoDataType">
      <xs:annotation>
         <xs:documentation>A model whose output is geographic
data</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
         <xs:extension base="pamml:ModelType">
            <xs:attribute name="srsName" type="xs:anyURI" use="required"/>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>
   <!--
   ********************
   Vector Data Model
   ********************
   -->
   <xs:element name="VectorData" type="pamml:VectorDataType" abstract="true"/>
   <xs:complexType name="VectorDataType">
      <xs:annotation>
         <xs:documentation>A model whose output is geographic vector
data</xs:documentation>
         <xs:documentation>and whose attributes are in tabular
format</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
         <xs:extension base="pamml:GeoDataType">
            <xs:sequence>
               <xs:element ref="pamml:AttributeInfo" minOccurs="0">
                  <xs:annotation>
                     <xs:documentation>attribute information the model author
chooses to expose</xs:documentation>
                  </xs:annotation>
               </xs:element>
            </xs:sequence>
            <xs:attribute name="geometryType" type="pamml:GeometryType"
use="optional"/>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>
   <!--
   ********************
   Raster Data Model
   ********************
   -->
   <xs:element name="RasterData" type="pamml:RasterDataType"/>
   <xs:complexType name="RasterDataType">
```

```xml
      <xs:annotation>
        <xs:documentation>A model whose output is geographic raster data and
has only one non-geographic attribute</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:GeoDataType">
          <xs:attributeGroup ref="pamml:rasterAttributes"/>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!--
********************
Inline (written directly in PAMML) data encodings
********************
-->
    <xs:element name="SimpleBooleanValue">
      <xs:annotation>
        <xs:documentation>A single true or false value</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:BooleanDataType">
            <xs:sequence>
              <xs:element name="Value" type="xs:boolean"/>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <xs:element name="SimpleIntValue" type="pamml:SimpleIntValueType"/>
    <xs:complexType name="SimpleIntValueType">
      <xs:annotation>
        <xs:documentation>a single cardinal integer value</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:ValueDataType">
          <xs:sequence>
            <xs:element name="Value" type="xs:int"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <xs:element name="SimpleDoubleValue" type="pamml:SimpleDoubleValueType"/>
    <xs:complexType name="SimpleDoubleValueType">
      <xs:annotation>
        <xs:documentation>a single cardinal decimal value</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:ValueDataType">
          <xs:sequence>
            <xs:element name="Value" type="xs:double"/>
          </xs:sequence>
        </xs:extension>
```

```xml
          </xs:complexContent>
      </xs:complexType>
      <xs:element name="SimpleXMLTable">
        <xs:annotation>
          <xs:documentation>An inline table</xs:documentation>
        </xs:annotation>
        <xs:complexType>
          <xs:complexContent>
            <xs:extension base="pamml:TableDataType">
              <xs:sequence>
                <xs:element name="table">
                  <xs:complexType>
                    <xs:sequence>
                      <xs:element name="tr" maxOccurs="unbounded">
                        <xs:annotation>
                          <xs:documentation>a data record, e.g. a
row</xs:documentation>
                        </xs:annotation>
                        <xs:complexType>
                          <xs:sequence>
                            <xs:element name="att" type="xs:anySimpleType"
maxOccurs="unbounded">
                              <xs:annotation>
                                    <xs:documentation>a record data
item</xs:documentation>
                              </xs:annotation>
                            </xs:element>
                          </xs:sequence>
                        </xs:complexType>
                      </xs:element>
                    </xs:sequence>
                    <xs:attribute name="numRecs" type="xs:int"
use="optional"/>
                  </xs:complexType>
                </xs:element>
              </xs:sequence>
            </xs:extension>
          </xs:complexContent>
        </xs:complexType>
      </xs:element>
      <!--
******************
Spatial Operations
******************
-->
<!--
******************
Base Types for operations involving one spatial dataset
******************
-->
<!-- Base Vector Type -->
<xs:complexType name="VectorUnaryOperationType">
  <xs:annotation>
```

```xml
        <xs:documentation>Base Type for Spatial Vector Operations involving
one vector dataset</xs:documentation>
        <xs:documentation>All attributes should be maintained in the new data
set</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:VectorDataType">
          <xs:sequence>
            <xs:element name="InputGeometry" type="pamml:VectorDataType"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!-- Base Raster Type -->
    <xs:complexType name="RasterUnaryOperationType">
      <xs:annotation>
        <xs:documentation>Base Type for Spatial RasterOperations involving one
raster dataset</xs:documentation>
        <xs:documentation>An application may maintain all attributes in the
new data set</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:RasterDataType">
          <xs:sequence>
            <xs:element name="InputRaster" type="pamml:RasterDataType"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!--
*******************
Base Types for operations involving two spatial datasets
*******************
-->
    <!-- Base Vector Type -->
    <xs:complexType name="VectorBinaryOperationType">
      <xs:annotation>
        <xs:documentation>Base Type for Spatial Vector Operations involving
two vector datasets</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:VectorDataType">
          <xs:sequence>
            <xs:element name="BaseGeometry" type="pamml:VectorDataType"/>
            <xs:element name="OpGeometry" type="pamml:VectorDataType"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!-- Base Raster Type -->
    <xs:complexType name="RasterBinaryOperationType">
      <xs:annotation>
```

```xml
        <xs:documentation>Base Type for Spatial RasterOperations involving two
raster datasets</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:RasterDataType">
          <xs:sequence>
            <xs:element name="InputRasterA" type="pamml:RasterDataType"/>
            <xs:element name="InputRasterB" type="pamml:RasterDataType"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!--
********************
Map Algebra
********************
-->
    <!-- Raster Algebra Focal Model -->
    <xs:element name="RasterFocal">
      <xs:annotation>
        <xs:documentation>Basic map algebra.</xs:documentation>
        <xs:documentation>Cell values are calculated based on a constant or
another raster grid</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:RasterUnaryOperationType">
            <xs:choice>
              <xs:element name="OperationRaster"
type="pamml:RasterDataType"/>
              <xs:element name="OperationValue" type="pamml:ValueDataType"/>
            </xs:choice>
            <xs:attribute name="operation" type="pamml:FocalOperation"
use="required"/>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <!-- Raster Algebra Zonal Model -->
    <xs:element name="RasterZonal">
      <xs:annotation>
        <xs:documentation>Cell values are calculated based on operations on
neighboring cell values. neighborhood size is a constant or a value from
another raster grid</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:RasterUnaryOperationType">
            <xs:sequence>
              <xs:choice>
                <xs:element name="NeighborhoodSizeRaster"
type="pamml:RasterDataType"/>
```

```
                    <xs:element name="NeighborhoodSizeValue"
type="pamml:ValueDataType"/>
                </xs:choice>
            </xs:sequence>
            <xs:attribute name="operation" type="pamml:ZonalOperation"
use="required"/>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
  </xs:element>
  <!-- ************************************************************  -->
  <!--    Constructive Spatial Operations                     -->
  <!-- ************************************************************  -->
  <!--
********************
Buffer
********************
  -->
  <!-- the vector case -->
  <xs:element name="Buffer" type="pamml:BufferType"/>
  <xs:complexType name="BufferType">
    <xs:annotation>
      <xs:documentation>Generates a buffer</xs:documentation>
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="pamml:VectorDataType">
        <xs:sequence>
          <xs:element name="InputGeometry" type="pamml:VectorDataType"/>
          <xs:element name="BufferDistance" type="pamml:ValueDataType"/>
          <!-- add choice to use a lookup table to vary the distance based
upon a feature value -->
        </xs:sequence>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
  <!-- the raster case -->
  <xs:complexType name="RasterBuffer">
    <xs:annotation>
      <xs:documentation>Generates a buffer</xs:documentation>
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="pamml:RasterUnaryOperationType">
        <xs:sequence>
          <xs:element name="BufferValue" type="pamml:ValueDataType"/>
          <!-- add choice to use a lookup table to vary the distance based
upon a feature value -->
        </xs:sequence>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
  <!--
********************
Dissolve
```

```
         *******************
         -->
         <!-- the vector case -->
         <xs:element name="Dissolve">
            <xs:annotation>
               <xs:documentation>Generates new geometry by merging adjacent features
where the useFeatureType attribute is the same</xs:documentation>
            </xs:annotation>
            <xs:complexType>
               <xs:complexContent>
                  <xs:extension base="pamml:VectorDataType">
                     <xs:sequence>
                        <xs:element name="FeatureName" type="xs:string"/>
                        <xs:element name="InputGeometry" type="pamml:VectorDataType"/>
                     </xs:sequence>
                  </xs:extension>
               </xs:complexContent>
            </xs:complexType>
         </xs:element>
         <!-- a raster case of dissolve does not make sense-->
         <!-- Relate -->
         <xs:element name="Relate">
            <xs:annotation>
               <xs:documentation>Adds features to GeoData</xs:documentation>
            </xs:annotation>
            <xs:complexType>
               <xs:complexContent>
                  <xs:extension base="pamml:VectorDataType">
                     <xs:sequence>
                        <xs:element name="FeatureName" type="xs:string"/>
                        <xs:element name="InputGeometry" type="pamml:VectorDataType"/>
                        <xs:element name="FeatureTable" type="pamml:TableDataType"/>
                     </xs:sequence>
                  </xs:extension>
               </xs:complexContent>
            </xs:complexType>
         </xs:element>
         <!--
         *******************
         Set-Theoretic Spatial Overlay Operations
         *******************
         -->
         <xs:element name="Union">
            <xs:annotation>
               <xs:documentation>Returns all areas from the two
geometries</xs:documentation>
            </xs:annotation>
            <xs:complexType>
               <xs:complexContent>
                  <xs:extension base="pamml:VectorBinaryOperationType"/>
               </xs:complexContent>
            </xs:complexType>
         </xs:element>
```

```
<!-- Intersection -->
<xs:element name="Intersection">
  <xs:annotation>
    <xs:documentation>Returns all areas from 1st Vector that fall within
2nd</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="pamml:VectorBinaryOperationType"/>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!-- Difference -->
<xs:element name="Difference">
  <xs:annotation>
    <xs:documentation>Returns all areas from 1st Vector that do not fall
within 2nd</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="pamml:VectorBinaryOperationType"/>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!-- Symmetric Difference-->
<xs:element name="SymDifference">
  <xs:annotation>
    <xs:documentation>Areas of 1st and 2nd Vectors that do not intersect
each other. Opposite of Intersection.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="pamml:VectorBinaryOperationType"/>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!--
*******************
Miscellaneous Spatial Operations
*******************
-->
<!--
*******************
Allocate
*******************
-->
<!-- the vector case -->
<xs:element name="Allocate">
  <xs:annotation>
    <xs:documentation>Add an attribute from 2nd Vector to 1st and
calculate its value based on the percentage of overlap.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
```

```xml
          <xs:complexContent>
            <xs:extension base="pamml:VectorBinaryOperationType">
              <xs:attribute name="useFeatureType" type="xs:string"
use="required"/>
            </xs:extension>
          </xs:complexContent>
        </xs:complexType>
      </xs:element>
      <!-- the raster case -->
      <xs:element name="RasterAllocate">
        <xs:annotation>
          <xs:documentation>Add an attribute from 2nd Raster to 1st and
calculate its value based on the percentage of overlap.</xs:documentation>
        </xs:annotation>
        <xs:complexType>
          <xs:complexContent>
            <xs:extension base="pamml:RasterBinaryOperationType">
              <xs:attribute name="useFeatureType" type="xs:string"
use="required"/>
            </xs:extension>
          </xs:complexContent>
        </xs:complexType>
      </xs:element>
      <!-- Convex Hull?? -->
      <!-- Basic arithmetic ops -->
      <xs:element name="Query">
        <xs:annotation>
          <xs:documentation>Generates new attributes on a spatial
model</xs:documentation>
        </xs:annotation>
        <xs:complexType>
          <xs:complexContent>
            <xs:extension base="pamml:VectorUnaryOperationType">
              <xs:sequence>
                <xs:element name="NewAttributes"
type="pamml:AttributeInfoType"/>
              </xs:sequence>
            </xs:extension>
          </xs:complexContent>
        </xs:complexType>
      </xs:element>
      <!-- Quantile -->
      <xs:element name="Quantile">
        <xs:annotation>
          <xs:documentation>Generates aggregate geometry by grouping the values
of an attribute into ranges with equal numbers of members</xs:documentation>
        </xs:annotation>
        <xs:complexType>
          <xs:complexContent>
            <xs:extension base="pamml:VectorUnaryOperationType">
              <xs:attribute name="useFeatureType" type="xs:string"
use="required"/>
              <xs:attribute name="numRanges" type="xs:int" use="required"/>
```

```
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <!-- Reclass -->
    <xs:element name="Reclass">
      <xs:annotation>
        <xs:documentation>Changes attribute value based on a lookup
table.</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:VectorUnaryOperationType">
            <xs:sequence>
              <xs:element name="TableData" type="pamml:TableDataType"/>
            </xs:sequence>
            <xs:attribute name="reclassFeatureType" type="xs:string"/>
            <xs:attribute name="minValFeatureType" type="xs:string"
use="optional"/>
            <xs:attribute name="maxValFeatureType" type="xs:string"
use="optional"/>
            <xs:attribute name="newValFeatureType" type="xs:string"/>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <xs:element name="RasterReclass">
      <xs:annotation>
        <xs:documentation>Changes attribute value based on a lookup
table.</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:RasterUnaryOperationType">
            <xs:sequence>
              <xs:element name="TableData" type="pamml:TableDataType"/>
            </xs:sequence>
            <xs:attribute name="reclassFeatureType" type="xs:string"/>
            <xs:attribute name="minValFeatureType" type="xs:string"
use="optional"/>
            <xs:attribute name="maxValFeatureType" type="xs:string"
use="optional"/>
            <xs:attribute name="newValFeatureType" type="xs:string"/>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <!-- ************************************************************ -->
    <!--    Spatial Binary Predicate Operations              -->
    <!--    these all return true or false                        -->
    <!-- ************************************************************ -->
    <!-- Base Vector Type -->
    <xs:complexType name="VectorBooleanBinaryOperation">
```

```xml
    <xs:annotation>
      <xs:documentation>Base Type for Spatial Vector operations that compare
two vector datasets</xs:documentation>
    </xs:annotation>
    <xs:complexContent>
      <xs:extension base="pamml:BooleanDataType">
        <xs:sequence>
          <xs:element name="InputGeometry" type="pamml:VectorDataType"
minOccurs="2" maxOccurs="2"/>
        </xs:sequence>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
  <!-- Equals -->
  <xs:element name="Equals" type="pamml:VectorBooleanBinaryOperation">
    <xs:annotation>
      <xs:documentation>Interiors intersect and no part of the interior or
boundary of one intersects the exterior of the other</xs:documentation>
    </xs:annotation>
  </xs:element>
  <!-- Intersects -->
  <xs:element name="Intersects" type="pamml:VectorBooleanBinaryOperation">
    <xs:annotation>
      <xs:documentation>The data sets share at least one point in common--
opposite of disjoint</xs:documentation>
    </xs:annotation>
  </xs:element>
  <!-- Disjoint -->
  <xs:element name="Disjoint" type="pamml:VectorBooleanBinaryOperation">
    <xs:annotation>
      <xs:documentation>The data sets share no points in
common</xs:documentation>
    </xs:annotation>
  </xs:element>
  <!-- Touches -->
  <xs:element name="Touches" type="pamml:VectorBooleanBinaryOperation"/>
  <!-- Crosses -->
  <xs:element name="Crosses" type="pamml:VectorBooleanBinaryOperation"/>
  <!-- Within -->
  <xs:element name="Within" type="pamml:VectorBooleanBinaryOperation"/>
  <!-- Contains -->
  <xs:element name="Contains" type="pamml:VectorBooleanBinaryOperation"/>
  <!-- Overlaps -->
  <xs:element name="Overlaps" type="pamml:VectorBooleanBinaryOperation"/>
  <!--
  ********************
  Non-Geographic Data Access Models
  ********************
  -->
  <!-- Simple ASCII Table -->
  <xs:element name="SimpleASCIITable">
    <xs:annotation>
```

```xml
            <xs:documentation>An ASCII text file where: the first line is a tab-
separated list of attribute names, the second line is a tab-separated list of
data types, and the remaining lines are tab-separated lists of data
(records)</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:TableDataType">
            <xs:attribute name="dataFile" type="xs:anyURI"/>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <!-- Value Table -->
    <xs:element name="ValueTable">
      <xs:annotation>
        <xs:documentation>A table that uses ValueModels for
data</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:TableDataType">
            <xs:sequence>
              <xs:element name="table">
                <xs:complexType>
                  <xs:sequence>
                    <xs:element name="tr" maxOccurs="unbounded">
                      <xs:annotation>
                        <xs:documentation>a data record, e.g. a
row</xs:documentation>
                      </xs:annotation>
                      <xs:complexType>
                        <xs:sequence>
                          <xs:element name="Value"
type="pamml:ValueDataType" maxOccurs="unbounded">
                            <xs:annotation>
                              <xs:documentation>a record data
item</xs:documentation>
                            </xs:annotation>
                          </xs:element>
                        </xs:sequence>
                      </xs:complexType>
                    </xs:element>
                  </xs:sequence>
                  <xs:attribute name="numRecs" type="xs:int"
use="optional"/>
                </xs:complexType>
              </xs:element>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
```

```
<!-- Relational Database as a Table -->
<xs:element name="GenericRDBMSTable">
  <xs:annotation>
    <xs:documentation/>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="pamml:TableDataType">
        <xs:sequence>
          <xs:element name="User" type="xs:string"/>
          <xs:element name="Passphrase" type="pamml:PassphraseType"/>
          <xs:element name="Host" type="xs:anyURI"/>
          <xs:element name="Port" type="xs:int"/>
          <xs:element name="Driver" type="xs:string"/>
        </xs:sequence>
      </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!--
********************
Geographic Data Access Models
********************
-->
<!--  -->
<!-- ASCII Grid Models -->
<!--  -->
<xs:element name="ASCIIIntegerGridReader"
type="pamml:ASCIIIntegerGridReaderType"/>
<xs:complexType name="ASCIIIntegerGridReaderType">
  <xs:annotation>
    <xs:documentation>A raster data model whose source is an ESRI ASCII
Grid export file with integer data</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="pamml:RasterDataType">
      <xs:sequence>
        <xs:element name="DataFile" type="pamml:DataFileCompressable"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:element name="ASCIIDoubleGridReader"
type="pamml:ASCIIDoubleGridReaderType"/>
<xs:complexType name="ASCIIDoubleGridReaderType">
  <xs:annotation>
    <xs:documentation>A raster data model whose source is an ESRI ASCII
Grid file with decimal data</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="pamml:RasterDataType">
      <xs:sequence>
        <xs:element name="DataFile" type="pamml:DataFileCompressable"/>
```

```
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!--    -->
    <!-- Shapefile Model  -->
    <!--    -->
    <xs:element name="ShapefileReader" type="pamml:ShapefileReaderType"/>
    <xs:complexType name="ShapefileReaderType">
      <xs:annotation>
        <xs:documentation>A vector data model whose source is an ESRI
Shapefile</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:VectorDataType">
          <xs:sequence>
            <xs:element name="ShpFile" type="pamml:DataFileCompressable"/>
            <xs:element name="DbfFile" type="pamml:DataFileCompressable"/>
            <xs:element name="ShxFile" type="pamml:DataFileCompressable"/>
            <xs:element name="SbnFile" type="pamml:DataFileCompressable"
minOccurs="0"/>
            <xs:element name="SbxFile" type="pamml:DataFileCompressable"
minOccurs="0"/>
            <xs:element name="PrjFile" type="pamml:DataFileCompressable"
minOccurs="0"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <xs:element name="ShapefileWriter" type="pamml:ShapefileWriterType"/>
    <xs:complexType name="ShapefileWriterType">
      <xs:annotation>
        <xs:documentation>A vector data model whose output is an ESRI
Shapefile</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:ShapefileReaderType">
          <xs:sequence>
            <xs:element name="VectorModel" type="pamml:VectorDataType"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!--    -->
    <!-- Inline Well-Known Text Model  -->
    <!--    -->
    <xs:element name="InlineWKTReader" type="pamml:InlineWKTReaderType"/>
    <xs:complexType name="InlineWKTReaderType">
      <xs:annotation>
        <xs:documentation>A vector data model whose source is
WellKnownText</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
```

```
          <xs:extension base="pamml:VectorDataType">
            <xs:sequence>
              <xs:element name="WKTGeometry" type="xs:string"
maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
    </xs:complexType>
    <xs:element name="InlineWKTWriter" type="pamml:InlineWKTWriterType"/>
    <xs:complexType name="InlineWKTWriterType">
      <xs:annotation>
        <xs:documentation>A vector data model whose output is
WellKnownText</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:InlineWKTReaderType">
          <xs:sequence>
            <xs:element name="VectorModel" type="pamml:VectorDataType"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!-- GML 2.1 file Model -->
    <xs:complexType name="SimpleGML2.1Reader">
      <xs:annotation>
        <xs:documentation>A vector data model whose source iconforms to OGC
GML v2.1 </xs:documentation>
        <xs:documentation>and having the same FeatureTypes for every
Feature.</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:VectorDataType">
          <xs:sequence>
            <xs:element name="XMLFile" type="pamml:DataFileCompressable"/>
            <xs:element name="XMLSchemaFile"
type="pamml:DataFileCompressable" minOccurs="0"/>
          </xs:sequence>
        </xs:extension>
      </xs:complexContent>
    </xs:complexType>
    <!-- Relational database spatial data Model -->
    <xs:complexType name="RDBVectorDataType">
      <xs:annotation>
        <xs:documentation>A vector data model whose source is a relational
database</xs:documentation>
      </xs:annotation>
      <xs:complexContent>
        <xs:extension base="pamml:VectorDataType">
          <xs:sequence>
            <xs:element name="User" type="xs:string"/>
            <xs:element name="Passphrase" type="pamml:PassphraseType"/>
            <xs:element name="Host" type="xs:anyURI"/>
            <xs:element name="Port" type="xs:int"/>
```

```xml
      <xs:element name="Driver" type="xs:string"/>
    </xs:sequence>
  </xs:extension>
 </xs:complexContent>
</xs:complexType>
<!-- PostGIS spatial data Model -->
<xs:element name="PostGISReader" type="pamml:PostGISReaderType"/>
<xs:complexType name="PostGISReaderType">
  <xs:annotation>
    <xs:documentation>A vector data model whose source is a PostgreSQL
PostGIS database</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="pamml:RDBVectorDataType"/>
  </xs:complexContent>
</xs:complexType>
<xs:element name="PostGISWriter" type="pamml:PostGISWriterType"/>
<xs:complexType name="PostGISWriterType">
  <xs:annotation>
    <xs:documentation>A vector data model that provides a connection to a
PostGIS database</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="pamml:PostGISReaderType"/>
  </xs:complexContent>
</xs:complexType>
<!-- Oracle Spatial spatial data Model -->
<xs:element name="OracleSpatialReader">
  <xs:annotation>
    <xs:documentation>A vector data model whose source is an Oracle
Spatial database</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="pamml:RDBVectorDataType"/>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!-- ESRI SDE spatial data Model -->
<xs:element name="ESRISDEReader">
  <xs:annotation>
    <xs:documentation>A vector data model whose source is an ESRI SDE
database</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:complexContent>
      <xs:extension base="pamml:RDBVectorDataType"/>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!-- VectorToRaster Model -->
<xs:element name="VectorToRaster">
  <xs:annotation>
```

```xml
                <xs:documentation>A vector to raster conversion
model</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:RasterDataType">
            <xs:sequence>
              <xs:element name="ConversionInfo">
                <xs:complexType>
                  <xs:attribute name="cellValue" type="xs:string"
use="required"/>
                  <xs:attribute name="dataType" type="xs:anySimpleType"
use="optional"/>
                  <xs:attribute name="cellSize" type="xs:double"
use="required"/>
                </xs:complexType>
              </xs:element>
              <xs:element name="InputVector" type="pamml:VectorDataType"/>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <!-- RasterToVector Model -->
    <xs:element name="RasterToVector">
      <xs:annotation>
        <xs:documentation>A raster to vector conversion
model</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="pamml:VectorDataType">
            <xs:sequence>
              <xs:element ref="pamml:RasterData"/>
            </xs:sequence>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <!--
    *******************
    Alternatives Models
    *******************
    -->
    <xs:element name="Alternatives">
      <xs:complexType>
        <xs:sequence>
          <xs:element ref="pamml:Alternative" maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="Alternative" type="pamml:ModelType"/>
    <!--
```

```
  ********************
  Helper components
  ********************
  -->
  <!-- ******************************** -->
  <!-- *****   RemoteInfo     ***** -->
  <xs:element name="RemoteInfo" type="pamml:RemoteInfoType"/>
  <xs:complexType name="RemoteInfoType">
    <xs:annotation>
      <xs:documentation>Information about remote location and execution
possibilities</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Name" type="xs:string" minOccurs="0"/>
      <xs:element name="ModelLoc" type="xs:anyURI"/>
      <xs:element name="ModelRunnerLoc" type="xs:anyURI" minOccurs="0"/>
      <xs:element name="LocalCache" type="pamml:LocalCacheType"
minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
  <!-- ******************************** -->
  <!-- *****   LocalCacheType  ***** -->
  <xs:complexType name="LocalCacheType">
    <xs:annotation>
      <xs:documentation>Information about local caching of the model and its
data</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Cached" type="xs:boolean"/>
      <xs:element name="CachedTime" type="xs:dateTime"/>
      <xs:element name="NextUpdateTime" type="xs:dateTime" minOccurs="0"/>
      <xs:element name="LocalModel" type="pamml:ModelType"/>
    </xs:sequence>
  </xs:complexType>
  <!-- ******************************** -->
  <!-- *****   Attribute    ***** -->
  <xs:element name="Attribute">
    <xs:complexType>
      <xs:attribute name="name" type="xs:string" use="required"/>
      <xs:attribute name="dataType" type="xs:anySimpleType" use="required"/>
      <xs:attribute name="minVal" type="xs:string" use="optional"/>
      <xs:attribute name="maxVal" type="xs:string" use="optional"/>
      <xs:attribute name="query" type="xs:string" use="optional"/>
      <xs:attribute name="note" type="xs:string" use="optional"/>
      <!-- string, double or int -->
      <!-- XPath expression -->
    </xs:complexType>
  </xs:element>
  <!-- ******************************** -->
  <!-- *****   AttributeInfo   ***** -->
  <xs:element name="AttributeInfo" type="pamml:AttributeInfoType"/>
  <xs:complexType name="AttributeInfoType">
    <xs:annotation>
```

```
            <xs:documentation>metadata for record attributes. ordered list of
names and data types</xs:documentation>
        </xs:annotation>
        <xs:sequence>
            <xs:element ref="pamml:Attribute" maxOccurs="unbounded"/>
        </xs:sequence>
    </xs:complexType>
    <!-- ******************************** -->
    <!-- *****   Metadata     ***** -->
    <xs:element name="Metadata" type="pamml:MetadataType"/>
    <xs:complexType name="MetadataType">
        <xs:annotation>
            <xs:documentation>Helpful info</xs:documentation>
        </xs:annotation>
        <xs:sequence>
            <xs:element name="Description" type="xs:string"/>
            <xs:element name="Reference" type="xs:anyURI" minOccurs="0"/>
            <xs:element name="VisualPreview" type="xs:anyURI" minOccurs="0"/>
            <xs:element name="FGDCMetadata" type="xs:anyURI" minOccurs="0"/>
        </xs:sequence>
    </xs:complexType>
    <!-- ******************************** -->
    <!-- *****   Permissions    ***** -->
    <xs:element name="Permissions" type="pamml:PermissionsType"/>
    <xs:complexType name="PermissionsType">
        <xs:annotation>
            <xs:documentation>collection of user, group and other
Permissions</xs:documentation>
        </xs:annotation>
        <xs:attribute name="user" type="pamml:PermissionType" use="optional"/>
        <xs:attribute name="group" type="pamml:PermissionType" use="optional"/>
        <xs:attribute name="other" type="pamml:PermissionType" use="optional"/>
    </xs:complexType>
    <!-- A sequence of characters similar to Unix permissions.
        Characters that are understood are 'r', 'w', 'x', 'a' and '-'.
        r=read, w=write, x=execute, a=create alternative, -=no permission
        Full permission would be specified as rwxa. A '-' instead of
        one of those letters means no permission. For example:
        r-xa gives read, execute and create alternative permissions. -->
    <xs:simpleType name="PermissionType">
        <xs:annotation>
            <xs:documentation>A sequence of characters similar to Unix
permissions, rwx, plus an 'a'</xs:documentation>
            <xs:documentation>for alternatives allowed. 'u' is for
undefined.</xs:documentation>
        </xs:annotation>
        <xs:restriction base="xs:string">
            <xs:pattern value="[rwxau]{4}"/>
        </xs:restriction>
    </xs:simpleType>
    <xs:simpleType name="GeometryType">
        <xs:annotation>
```

```
        <xs:documentation>A string identifying the geometry type of all
vectors in the data set</xs:documentation>
        <xs:documentation>taken from the "Simple Features for SQL" OGC
specification</xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string">
        <xs:enumeration value="point"/>
        <xs:enumeration value="linestring"/>
        <xs:enumeration value="polygon"/>
        <xs:enumeration value="multipoint"/>
        <xs:enumeration value="multilinestring"/>
        <xs:enumeration value="multipolygon"/>
        <xs:enumeration value="geometrycollection"/>
      </xs:restriction>
    </xs:simpleType>
    <xs:simpleType name="CompressionType">
      <xs:annotation>
        <xs:documentation>A string identifying a type of
compression</xs:documentation>
      </xs:annotation>
      <xs:restriction base="xs:string">
        <xs:enumeration value="zip"/>
        <xs:enumeration value="gzip"/>
        <xs:enumeration value="targzip"/>
        <xs:enumeration value="bzip"/>
        <xs:enumeration value="tarbzip"/>
      </xs:restriction>
    </xs:simpleType>
    <xs:attributeGroup name="globalAttributes">
      <xs:attribute name="name" type="xs:string" use="required"/>
      <xs:attribute name="id" type="xs:string" use="required"/>
      <xs:attribute name="altOK" type="xs:boolean" use="optional"
default="true"/>
    </xs:attributeGroup>
    <xs:attributeGroup name="rasterAttributes">
      <xs:attribute name="numCols" type="xs:int" use="required"/>
      <xs:attribute name="numRows" type="xs:int" use="required"/>
      <xs:attribute name="minX" type="xs:double" use="required"/>
      <xs:attribute name="minY" type="xs:double" use="required"/>
      <xs:attribute name="cellSize" type="xs:double" use="required"/>
    </xs:attributeGroup>
    <xs:complexType name="PassphraseType">
      <xs:attribute name="word" type="xs:string"/>
      <xs:attribute name="cryptoType" type="xs:string"/>
    </xs:complexType>
    <xs:complexType name="DataFileCompressable">
      <xs:attributeGroup ref="pamml:DataFileCompressableAtts"/>
    </xs:complexType>
    <xs:attributeGroup name="DataFileCompressableAtts">
      <xs:attribute name="dataFile" type="xs:anyURI" use="required"/>
      <xs:attribute name="compression" type="pamml:CompressionType"
use="optional"/>
    </xs:attributeGroup>
```

```xml
<xs:simpleType name="ValueUnits">
   <xs:restriction base="xs:string">
      <xs:enumeration value="abstract"/>
      <xs:enumeration value="meters"/>
      <xs:enumeration value="kilometers"/>
      <xs:enumeration value="miles"/>
      <xs:enumeration value="feet"/>
      <xs:enumeration value="grams"/>
      <xs:enumeration value="liters"/>
   </xs:restriction>
</xs:simpleType>
<xs:simpleType name="FocalOperation">
   <xs:restriction base="xs:string">
      <xs:enumeration value="add"/>
      <xs:enumeration value="subtract"/>
      <xs:enumeration value="multiply"/>
      <xs:enumeration value="divide"/>
   </xs:restriction>
</xs:simpleType>
<xs:simpleType name="ZonalOperation">
   <xs:restriction base="xs:string">
      <xs:enumeration value="add"/>
      <xs:enumeration value="subtract"/>
      <xs:enumeration value="multiply"/>
      <xs:enumeration value="divide"/>
      <xs:enumeration value="mean"/>
      <xs:enumeration value="variance"/>
      <xs:enumeration value="stddev"/>
      <xs:enumeration value="variety"/>
   </xs:restriction>
</xs:simpleType>
</xs:schema>
```

Appendix B. Glossary

C#: The preferred programming language for Microsoft's .NET Web services architecture.

COM: Component Object Model. A software architecture used by Microsoft's Windows operating system that allows applications to be built from binary software components.

CORBA: Common Object Request Broker Architecture. A platform-independent protocol for building distributed, platform-independent enterprise applications.

DCOM: Distributed Component Object Model. An extension of Microsoft's Component Object Model (COM) to that permits the sharing of program components across a network.

DSS: Decision Support System. Information technology and software that taps database resources to present information in a form that helps people at all levels of the organization make decisions.

EDI: Electronic Data Interchange. The exchange of highly standardized electronic versions of common business documents between computer systems through communications lines with standard contracts. Generally the contracts are formulated within each industry.

HTML: Hypertext Markup Language. A formatting language used for documents on the World Wide Web. HTML files are plain text files with formatting codes that tell HTML clients (e.g. Web browsers) how to display text, position graphics and form items, and display links to other pages.

HTTP: Hypertext Transfer Protocol. HTTP is the set of rules for exchanging files on the World Wide Web. Relative to the TCP/IP suite of protocols—the basis for information exchange on the Internet—HTTP is an application protocol.

GIS: Geographic Information Systems. Lately used to stand for Geographic Information Sciences, suggesting a true scientific discipline separate from the technology.

GML: Geography Markup Language.

IT: Information Technology. Includes all matters concerned with the furtherance of computer science and technology and with the design, development, installation, and implementation of information systems and applications [San Diego State University]. An information technology architecture is an integrated framework for acquiring and evolving IT to achieve strategic goals. It has both logical and technical components. Logical components include mission, functional and information requirements, system configurations, and information flows. Technical components include IT standards and rules that will be used to implement the logical architecture (from http://www.ichnet.org/glossary.htm).

.NET: Both a business strategy from Microsoft and its collection of programming support for what are known as Web services, the ability to use the Web rather than your own computer for various services.

OWL: Web Ontology Language. OWL builds on RDF and RDF Schema and adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes.

RDF: Resource Description Framework. A formal data model from the World Wide Web Consortium (W3C) for machine understandable metadata used to provide standard descriptions of web resources.

SOAP: Simple Object Access Protocol. A message layout specification that defines a uniform way of passing XML-encoded data.

SQL: Structured Query Language. A standard interactive and programming language for getting information from and updating a database.

UML: Universal Modeling Language. A standard notation and modeling technique for analyzing real-world objects, developing systems, designing software modules in object-oriented approach.

URL: Universal Resource Locator. The address of a resource, or file, available on the Internet. Consists of the protocol of the resource (e.g. http:// or ftp://), the domain name for the resource (e.g. www.example.com), and an identifying string. Most strings hint at their

underlying content. They often look like a file path (e.g. /pages/2003/song.mp3) or a command (e.g. /servlet/StockTicker?symbol=EFF).

WSDL: Web Services Description Language. Defines services as collections of network endpoints whose abstract definition of interfaces and messages is separated from concrete network deployment or data format bindings.

XML: Extensible Markup Language. The universal format for structured documents, messages, and data on the Web. XML is a meta-language (a way to define tag sets) that allows you to design your own customized markup language for many classes of information.

Appendix C. Bibliography

Alexander, Christopher, Sara Ishikawa and Murray Silverstein. 1977. *A pattern language: towns, buildings and construction*. Oxford, UK: Oxford University Press.

Anselin, Luc. 1992. *Spatial data analysis with GIS: an introduction to the application in the social sciences*. Santa Barbara, CA: National Center for Geographic Information and Analysis.

Armstrong, Joe. 2003. *Making reliable distributed systems in the presence of software errors*. Ph.D. dissertation, Swedish Institute of Computer Science. Dept. of Microelectronics and Information Technology.

Azad, B, and Lyna Wiggins. 1995. *Dynamics of Inter-Organizational Geographic Data Sharing: A conceptual framework for research*. In Harlan J. Onsrud and Gerard Rushton (eds). *Sharing Geographic Information*. New Brunswick, NJ: Rutgers Center for Urban Policy Research, 22-43.

Ba, Sulin, and Jan Stallaert. 2002. *Designing IT-Supported Market Mechanisms for Organizational Coordination*. Edited by Clyde Holsapple and Varghese Jacob. *Business Modeling: Multidisciplinary Approaches*. Boston: Kluwer.

Carlton, Dennis, W., and Jeffrey M. Perloff. 1990. *Modern Industrial Organization*. Glenview, IL: Scott, Foresman and Company.

CERN. 2004. "Engineering Data Management Glossary." <http://cedar.web.cern.ch/CEDAR/glossary.html>. June, 2004.

Curbera, Fransisco, William Nagy, and Sanjiva Weerawarana. 2001. *Web Services: Why and How*. IBM T.J. Watson Research Center. August 9, 2001.

Delen, Dursun, and Perakath C. Benjamin. 2000. *An Enterprise Modeling and Analysis Toolkit*. Edited by J. A. Joines, R. R. Barton, K. Kang, and P. A. Fishwick. *Proceedings of the 2000 Winter Simulation Conference*.

Egenhofer, Max, and T. Bruns. 1995. *Visual Map Algebra: A Direct-Manipulation User Interface for GIS*. Edited by S. Spaccapietra and R. Jain. *Visual Database Systems 3, Visual Information Management,*

Proceedings of the Third IFIP 2.6 Working Conference on Visual Database Systems, Lausanne, Switzerland: Chapman & Hall, 235-253.

Evans, John D. and Joseph Ferreira, Jr. 1995. *Sharing Spatial Information in an Imperfect World: Interactions between technical and organizational issues*. Edited by Harlan J. Onsrud and Gerard Rushton. *Sharing Geographic Information*. New Brunswick, NJ: Rutgers CUPR, Chapter 27.

Evans, John D. 1997. *Infrastructures For Sharing Geographic Information Among Environmental Agencies*. Ph.D. diss. Massachusetts Institute of Technology.

Executive Office of Environmental Affairs. 2001. *Buildout Book: Where do you want to be at buildout?* Boston, MA: Executive Office of Environmental Affairs.

Foot, David. 1981. *Operational urban models*. London: Methuen.

Forsberg, Kerstin, and Lars Dannstedt. 2000. "Extensible use of RDF in a business context." *Computer Networks* 33, 347-364.

Gahegan, Mark, Masahiro Takatsuka, Mike Wheeler and Frank Hardisty. 2002. "Introducing GeoVISTA Studio: an integrated suite of visualization and computational methods for exploration and knowledge construction in geography." *Computers, Environment and Urban Systems* 26, 267-292.

Goodchild, Michael, Max Egenhofer, Robin Fegeas. 1997. "Interoperating GISs: Report of a specialist meeting held under the auspices of the Varenius project." Panel on Computational Implementations of Geographic Concepts December 5-6 Santa Barbara, California.

Goodchild, Michael, Max Egenhofer, Karen Kemp, David Mark, and E. Sheppard. 1999. "Introduction to the Varenius project." *International Journal of GIS* 13:8 731-745.

Gottschalk, Karl. 2000. "Web Services architecture overview: The next stage of evolution for e-business." *IBM Developerworks*. September 2000. <http://www-106.ibm.com/developerworks/web/library/w-ovr/>. March 18, 2004.

Gouin, D. & P. Morin. 1997. "Solving the Geospatial Data Barrier." *Geomatica* 51:3, 278-287.

Guhathakurta, S. 2002. "Urban modeling as storytelling: using simulation models as a narrative." *Environment and Planning B: Planning & Design* 29, 895-911.

Heinz, Center for Science, Economics and the Environment. 2002. *The state of the nation's ecosystems: measuring the lands, waters and living resources of the United States*.

Hodges, Christopher J. 2004. Fostering Land Use Dialog: Community preservation as a growth management strategy in Massachusetts. Masters thesis, Massachusetts Institute of Technology Dept. of Urban Studies and Planning.

Hopkins, Lewis. 1999. "Structure of a planning support system for urban development." *Environment and Planning B: Planning & Design* 26, 333-343.

Hopkins, Lewis. 2001. *Urban Development: the logic of making plans*.

Hopkins, Lewis, Nikhil Kaza, Varkhi George. 2003. "Planning Markup Language: Representing the Meanings of Plans and Regulations." July 2003. Leuven, Belgium: AESOP/ACSP Joint Conference.

Jacobs, Alan B. 1993. *Great Streets*. Cambridge, MA: MIT Press.

Jacqz, Christian, MassGIS Director, and Jane Pfister, Community Preservation Initiative GIS Coordinator. 2004. Interview by author. May, 2004.

Keller, S. F. 1999. "Modeling and sharing geographic data with INTERLIS." *Computers & Geosciences* 25, 49-59

Kock, Christopher. 2004. "Nike rebounds: how (and why) Nike recovered from its supply chain disaster." *CIO Magazine*. June 15. <http://www.cio.com/archive/061504/nike.html>. July 2, 2004.

Klosterman R. E. 1997. "Planning support systems: a new perspective on computer-aided planning." *Journal of Planning Education and Research* 17, 45-54.

Klosterman, R. E. 1998. "Computer applications in planning." *Environment and Planning B: Planning & Design* 25, pp.32-36.

Ledeczi, Akos, Miklos Maroti, Gabor Karsai, and Greg Nordstrom. 1999. *Metaprogrammable Toolkit for Model-Integrated Computing*. Nashville, TN: Engineering of Computer Based Systems (March), 311-317.

Lee, Douglass B. 1973. "Requiem for large scale models." *Journal of the American Institute of Planners* 39, 163-178.

Lynch, Kevin. 1960. *The Image of the City*. Cambridge, MA: MIT Press.

Lynch, Kevin and Gary Hack. 1984. *Site Planning*. Cambridge, MA: MIT Press.

Mark, D., N. Chrisman, A. Frank, P. McHaffie, J. Pickles. 1997. *The GIS History Project*. <http://www.geog.buffalo.edu/ncgia/gishist/bar_harbor.html>. November 27, 2003.

March, James G., and Johan P. Olsen. 1976. *Ambiguity and choice in organizations*. Bergen, Norway: Universitetsforlaget.

McHarg, I. 1969. *Design with Nature*. New York: Wiley.

Meredith, P. H. 1995. *Distributed GIS: If its time is now, why is it resisted?* In Harlan J. Onsrud and Gerard Rushton (eds). *Sharing Geographic Information*. New Brunswick, NJ: Rutgers Center for Urban Policy Research, 7-21.

Muller, P. 2000. *Instant UML*. Chicago: Wrox.

MuniWireless.com. 2004. "New York City to deploy massive wireless broadband network." June 19, 2004. <http://www.muniwireless.com/archives/000369.html>. May 28, 2004.

Nedovic-Budic, Zorica, and Jeffrey K. Pinto. 1999. "Interorganizational GIS: Issues and prospects." *Annals of Regional Science* 33, 183-195.

Nedovic-Budic, Zorica, and Jeffrey K. Pinto. 1999. "Understanding Interorganizational GIS Activities: A conceptual framework." *Journal of Urban and Regional Information Systems Association* 11(1): 53-64.

Obermeyer, Nancy J., and Jeffrey K. Pinto. 1994. *Managing Geographic Information Systems*. New York: The Guilford Press.

Object Management Group. 2003. OMG Unified Modeling Language Specification. <http://www.omg.org/cgi-bin/doc?formal/03-03-01>. March 1, 2003.

Object Technology International, Inc. 2003. "Eclipse Platform Technical Overview". <http://www.eclipse.org/whitepapers/eclipse-overview.pdf>. March 1, 2003.

OpenGIS Consortium. 1999. *OpenGIS® Simple Features Specification for SQL: Revision 1.1*. <http://www.opengis.org/docs/99-049.pdf>. December 15, 2003.

OpenGIS Consortium. 2001. *OpenGIS® Geography Markup Language (GML) Implementation Specification*. <http://www.opengis.net/gml/01-029/GML2.pdf>. December 15, 2003.

OpenGIS Consortium. 2002a. *OpenGIS® Abstract Specification, Topic 12: The OpenGIS Service Architecture*. <http://www.opengis.org/techno/abstract/02-112.pdf>. December 15, 2003.

OpenGIS Consortium. 2002b. *OpenGIS® Web Feature Service Implementation Specification*. <http://www.opengis.org/techno/specs/02-058.pdf>. December 15, 2003.

Preston, Michael, Peter Clayton, and George Wells. 2003. "Dynamic run-time application development using CORBA objects and XML in the field of distributed GIS." *International Journal of Geographical Information Science* 17:4, 321-341.

Schuur, J. 1994. "Analysis and Design in Computer-aided Physical Planning." *Environment and Planning B: Planning & Design* 21, 97-108.

Shiffer, Michael. 1992. "Towards a collaborative planning system." *Environment and Planning B: Planning and Design* 19, 709-722.

Steinitz, Carl. 1995. "Design is a verb; Design is a noun." *Landscape Journal*.

Tomlin, C. D. 1983. "A Map Algebra." *Proceedings of the 1983 Harvard Computer Graphics Conference*, Cambridge, MA.

Waddell, Paul, Alan Borning. 2004. "UrbanSim." May 24, 2004. Seattle, Washington, USA: National Conference on Digital Government Research.

Weston, A. 1992. *A Rulebook for Arguments*. Indianapolis: Hackett.

Wiggins, Lyna, and Michael Shiffer. 1990. "Planning with Hypermedia." *APA Journal* (Spring), 226-235.

World Wide Web Consortium. 2001. *XML Schema Part 0: Primer. W3C Recommendation*. 2 May 2001. <http://www.w3.org/TR/2001/REC-xmlschema-0-20010502/>. June 23, 2003.

World Wide Web Consortium. 2001. *XML Linking Language (XLink), version 1.0. W3C Recommendation*. 27 June 2001. <http://www.w3.org/TR/2001/REC-xlink-20010627>. June 23, 2003.

World Wide Web Consortium. 2004. *XML Query 1.0 and XPath 2.0 Full-Text. W3C Working Draft*. 09 July 2004. <http://www.w3.org/TR/2004/WD-xquery-full-text-20040709>. June 23, 2003.

World Wide Web Consortium. 2004. *Web Services Definition Language (WSDL), version 2.0 Part 1: Core Language. W3C Working Draft*. 26 March 2004. <http://www.w3.org/TR/2004/WD-wsdl20-20040326>. June 23, 2003.

Yeh, Anthony. 2004. "Guest editorial: Planning, government, information, and the Internet" *Environment and Planning B: Planning & Design* 31 pp.163-165.