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Explanatory pamphlet accompanies map

SURFICIAL GEOLOGIC MAP OF THE SALEM DEPOT - NEWBURYPORT EAST - WILMINGTON - ROCKPORT 16-QUADRANGLE AREA IN NORTHEAST MASSACHUSETTS

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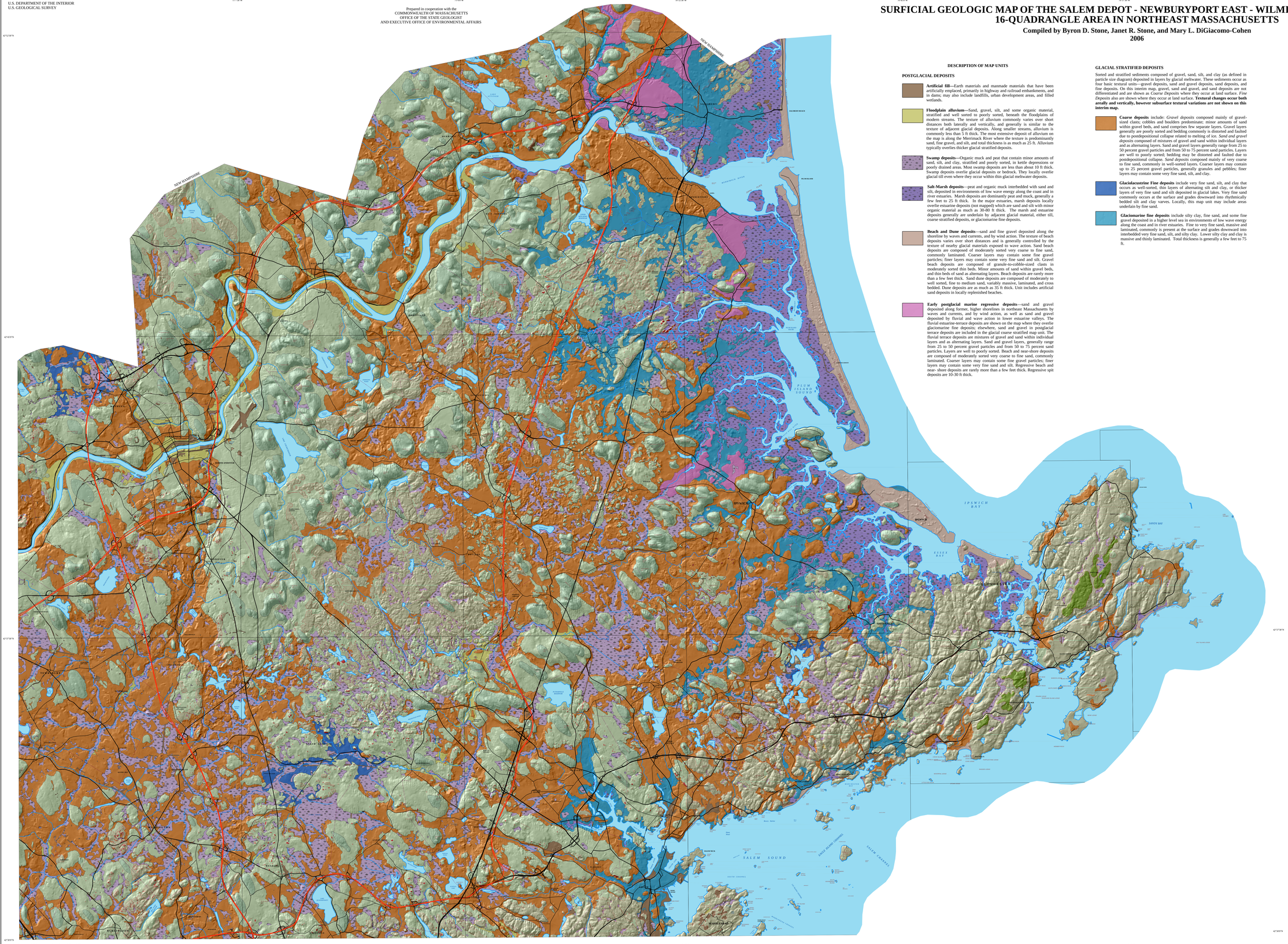
2006



DESCRIPTION OF MAP UNITS

POSTGLACIAL DEPOSITS

Artificial fill—Earth materials and manmade materials that have been artificially emplaced, primarily in highway and railroad embankments, and in dams; may also include landfills, urban development areas, and filled wetlands.

Floodplain alluvium—Sand, gravel, silt, and some organic material, stratified and well sorted to poorly sorted, beneath the floodplains of modern streams. The texture of alluvium commonly varies over short distances both laterally and vertically, and generally is similar to the texture of adjacent glacial deposits. Along smaller streams, alluvium is commonly less than 5 ft thick. The most extensive deposit of alluvium on the map is along the Merrimack River where the texture is predominantly sand, fine gravel, and silt, and total thickness is as much as 25 ft. Alluvium typically overlies thicker glacial stratified deposits.

Swamp deposits—Organic muck and peat that contain minor amounts of sand, silt, and clay, stratified and poorly sorted, in kettle depressions or poorly drained areas. Most swamp deposits are less than about 10 ft thick. Swamp deposits overlie glacial deposits or bedrock. They locally overlie glacial till even where they occur within thin glacial meltwater deposits.

Salt-Marsh deposits—peat and organic muck interbedded with sand and silt, deposited in environments of low wave energy along the coast and in river estuaries. Marsh deposits are dominantly peat and muck, generally a few feet to 25 ft thick. In the major estuaries, marsh deposits locally overlie estuarine deposits (not mapped) which are sand and silt with minor organic material as much as 30-80 ft thick. The marsh and estuarine deposits generally are underlain by adjacent glacial material, either till, coarse stratified deposits, or glaciomarine fine deposits.

Beach and Dune deposits—sand and fine gravel deposited along the shoreline by waves and currents, and by wind action. The texture of beach deposits varies over short distances and is generally controlled by the texture of nearby glacial materials exposed to wave action. Sand beach deposits are composed of moderately sorted very coarse to fine sand, commonly laminated. Coarser layers may contain some fine gravel particles; finer layers may contain some very fine sand and silt. Gravel beach deposits are composed of granule-to-cobble-sized clasts in moderately sorted thin beds. Minor amounts of sand within gravel beds, and thin beds of sand as alternating layers. Beach deposits are rarely more than a few feet thick. Sand dune deposits are composed of moderately to well sorted, fine to medium sand, variably massive, laminated, and cross bedded. Dune deposits are as much as 35 ft thick. Unit includes artificial sand deposits in locally replenished beaches.

Early postglacial marine regressive deposits—sand and gravel deposited along former, higher shorelines in northeast Massachusetts by waves and currents, and by wind action, as well as sand and gravel deposited by fluvial and wave action in lower estuarine valleys. The fluvial estuarine-terrace deposits are shown on the map where they overlie glaciomarine fine deposits; elsewhere, sand and gravel in postglacial terrace deposits are included in the glacial coarse stratified map unit. The fluvial terrace deposits are mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers, generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles. Layers are well to poorly sorted. Beach and near-shore deposits are composed of moderately sorted very coarse to fine sand, commonly laminated. Coarser layers may contain some fine gravel particles; finer layers may contain some very fine sand and silt. Regressive beach and near- shore deposits are rarely more than a few feet thick. Regressive spit deposits are 10-30 ft thick.

GLACIAL STRATIFIED DEPOSITS

Sorted and stratified sediments composed of gravel, sand, silt, and clay (as defined in particle size diagram) deposited in layers by glacial meltwater. These sediments occur as four basic textural units—gravel deposits, sand and gravel deposits, sand deposits, and fine deposits. On this interim map, gravel, sand and gravel, and sand deposits are not differentiated and are shown as *Coarse Deposits* where they occur at land surface. *Fine Deposits* also are shown where they occur at land surface. **Textural changes occur both areally and vertically, however subsurface textural variations are not shown on this interim map.**

Coarse deposits include: *Gravel deposits* composed mainly of gravel-sized clasts; cobbles and boulders predominate; minor amounts of sand within gravel beds, and sand comprises few separate layers. Gravel layers generally are poorly sorted and bedding commonly is distorted and faulted due to postdepositional collapse related to melting of ice. *Sand and gravel deposits* composed of mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles. Layers are well to poorly sorted; bedding may be distorted and faulted due to postdepositional collapse. *Sand deposits* composed mainly of very coarse to fine sand, commonly in well-sorted layers. Coarser layers may contain up to 25 percent gravel particles, generally granules and pebbles; finer layers may contain some very fine sand, silt, and clay.

Glaciolacustrine Fine deposits include very fine sand, silt, and clay that occurs as well-sorted, thin layers of alternating silt and clay, or thicker layers of very fine sand and silt deposited in glacial lakes. Very fine sand commonly occurs at the surface and grades downward into rhythmically bedded silt and clay varves. Locally, this map unit may include areas underlain by fine sand.

Glaciomarine fine deposits include silty clay, fine sand, and some fine gravel deposited in a higher level sea in environments of low wave energy along the coast and in river estuaries. Fine to very fine sand, massive and laminated, commonly is present at the surface and grades downward into interbedded very fine sand, silt, and silty clay. Lower silty clay and clay is massive and thinly laminated. Total thickness is generally a few feet to 75 ft.

GLACIAL TILL DEPOSITS

Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders; in areas where till is generally less than 10-15 ft thick and including areas of bedrock outcrop where till is absent. Predominantly upper till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies are present in some places; a looser, coarser-grained ablation facies, melted out from supraglacial position; and an underlying more compact, fine-grained lodgement facies deposited subglacially. In general, both ablation and lodgement facies of upper till derived from fine-grained bedrock are finer grained, more compact, less stony and have fewer surface boulders than upper till derived from coarser grained crystalline rocks. Fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut River lowland, marble in the western river valleys, and fine-grained schists in upland areas.

Thick till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered gravel clasts and few large boulders at the surface; in the shallow subsurface, compact, nonsorted matrix of silt, very fine sand, and some clay containing scattered small gravel clasts in areas where till is greater than 10-15 ft thick, chiefly in drumlin landforms in which till thickness commonly exceeds 100 ft (maximum recorded thickness is 230 ft). Although upper till is the surface deposit, the lower till constitutes the bulk of the material in these areas. Lower till is moderately to very compact, and is commonly finer grained and less stony than upper till. An oxidized zone, the lower part of a soil profile formed during a period of interglacial weathering, is generally present in the upper part of the lower till. This zone commonly shows closely spaced joints that are stained with iron and manganese oxides.

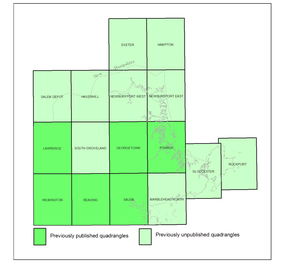
End moraine deposits – Composed predominantly of boulders and ablation facies sandy upper till; lenses of stratified sand and gravel occur locally within the till. Surface boulders on end moraine deposits are generally more numerous than on adjacent till surfaces; dense concentrations of boulders are present in some places. Deposits occur as free-standing hummocky landforms, commonly in ridges that trend NE – SW, and range in thickness from 10 to 60 ft.

BEDROCK AREAS

Bedrock outcrops and areas of abundant outcrop or shallow bedrock— Solid color shows extent of individual bedrock outcrops; line pattern indicates areas of shallow bedrock or areas where small outcrops are too numerous to map individually; in areas of shallow bedrock, surficial materials are less than 5-10 ft thick.

PARTICLE DIAMETER										
10	2.5	0.16	0.08	0.04	0.02	0.01	0.005	0.0025	0.00015	in.
256	64	4	2	1	0.5	0.25	0.125	0.063	0.004	mm
Boulders	Cobbles	Pebbles	Granules	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
GRAVEL PARTICLES				SAND PARTICLES					FINE PARTICLES	

Grain-size classification used in this report, modified from Wentworth (1922)



7.5-minute quadrangles in this compilation

SOURCES OF DATA

See explanatory pamphlet for references

Exeter Quadrangle
Map units were reproduced from Goldsmith (2001)

Hampton Quadrangle
Map units were reproduced from Koteff, Carl, Gephart, G. D., and Schaefer, J.P. (1989)

Salem Depot Quadrangle
Stone, B.D., 1982, Unpublished field map

Haverill Quadrangle
Stone, B.D., 1982, Unpublished field map

Newburyport West Quadrangle
Stone, B.D., 1982, Unpublished field map

Newburyport East Quadrangle
Stone, B.D., 1982, Unpublished field map

Lawrence Quadrangle
Map units were reproduced from Castle (1958); Glacial Stratified Deposits in this quadrangle include deposits of glacial Lake Methuen, and other glaciofluvial and glaciolacustrine deposits. Fine-grained glacial stratified deposits at land surface include lake-bottom deposits of glacial Lake Methuen (unit Qml of Castle, 1958); the fine-grained unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Deposits mapped as morainal ice-contact deposits (unit Qml of Castle, 1958) have been included here as coarse stratified deposits. Thick till areas were reproduced from the drumlin till unit (Qgd of Castle, 1958); other areas of thick till were inferred from photographic image and topographic analysis.

South Groveland Quadrangle
Stone, B.D., 1982, Unpublished field maps

Georgetown Quadrangle
Map units were reproduced from Cuppels (1969); Glacial Stratified Deposits in this quadrangle include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine-grained glacial stratified deposits at land surface include parts of marine and estuarine deposits (unit Qm of Cuppels, 1969); the fine-grained unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Thick till areas shown on this map were inferred from photographic image and topographic analysis and drumlin symbols shown by Cuppels (1969).

Ipswich Quadrangle
Map units were reproduced from Sammel (1963); Glacial Stratified Deposits in this quadrangle include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine-grained glacial stratified deposits at land surface include marine and estuarine clay deposits (unit Qmc of Sammel, 1963); this unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Thick till areas were reproduced from the drumlin till unit (Qd of Sammel, 1963); other areas of thick till were inferred from photographic image and topographic analysis.

Wilmington Quadrangle
Map units were reproduced from Castle (1959); Glacial Stratified Deposits in this quadrangle include glaciofluvial and glaciolacustrine deposits. Thick till areas were reproduced from the drumlin till unit (Qgd of Castle, 1959); other areas of thick till were inferred from photographic image and topographic analysis.

Reading Quadrangle
Map units were reproduced from Oldale (1962); Glacial Stratified Deposits in this quadrangle include glaciofluvial and glaciolacustrine deposits. Fine-grained glacial stratified deposits at land surface include glacial lake deposits (unit Qf of Oldale, 1962); the fine-grained unit has been extended beneath adjacent water bodies and postglacial deposits on this map. Thick till areas were reproduced from the drumlin till unit (Qgd of Oldale, 1962) and other areas of thick till were inferred from photographic image and topographic analysis\.

Salem Quadrangle
Map units were reproduced from Oldale (1964); Glacial Stratified Deposits in this quadrangle include glaciofluvial, glaciolacustrine, and glaciomarine deposits. Fine-grained glacial stratified deposits at land surface include marine clay deposits (unit Qmd of Oldale, 1964); the fine-grained unit has been extended beneath adjacent water bodies and postglacial deposits on this map.

Marblehead North Quadrangle
Map units were reproduced from Carnevale (1979)

Gloucester Quadrangle
Stone, B.D., 1982, Unpublished field maps

Rockport Quadrangle
Stone, B.D., 1982, Unpublished field maps

All base map data from MassGIS:

1:5,000-scale Shaded Relief
1:100,000-scale Hydrography
1:5,000-scale EOT Major Roads
1:25,000-scale Digital Quadrangle Template
1:25,000-scale Community Boundaries (Towns)

SCALE 1:50,000

1 0.5 0 1 2 3 4 Miles

1 0.5 0 1 2 3 4 Kilometers

Geology mapped by authors of individual quadrangles , 1958-1982.
Geology compiled by Byron D. Stone, Janet R. Stone, and Mary L. DiGiacomo -Cohen, 2004-2006.
Vectorization of published quadrangles by the Office of the Massachusetts State Geologist, 2003.
Digital compilation and cartography by Mary L. DiGiacomo-Cohen, 2005-2006.