Maine GeoLibrary Orthoimagery Subcommittee

Report and Recommendations

May 24, 2010

Subcommittee:

Dan Walters - Chair, US Geological Survey
Sarah Tucker - Town of Bethel
Tom Marcotte - Maine DOT, Office of Information Technology
Brett Horr - Town of York
Greg Miller - Maine Forest Service
John Root - City of Rockland
Larry Harwood - Maine Office of GIS, Office of Information Technology
Brian Norris - James W. Sewall Company
Ken Murchison - Northern Maine Development Corporation
Sean Gambrel - City of Bangor

Table of Contents

I. Introduction

The Maine GeoLibrary formed a subcommittee to develop a program that leverages federal, state, local and private funding to provide statewide high resolution orthoimagery on an ongoing basis. The GeoLibrary's goal is to establish a program that will provide this valuable data resource at a lower per square mile cost, at higher resolution and on a more regular schedule than could be accomplished by ad hoc projects of limited geographic area and funding.

A. 2003 – 2005 orthoimagery program

Digital orthoimagery has become the foundation for state, local and private programs across the country. It is an essential data product that is sought after by many organizations and until recently had been acquired by only the state's larger cities and towns. Small towns could not afford orthoimagery leading to a situation of haves and have-nots, higher overall costs for those who could afford it, products of varying resolution, duplication of effort, and a patchwork of products.

With this in mind, the Maine GeoLibrary initiated a statewide project to produce high resolution digital orthoimagery in 2002. The $3.2M project is by far the largest project undertaken to date by the Maine GeoLibrary Board. The work was completed through a cooperative agreement with the U.S. Geological Survey (USGS). The USGS provided funding and in-kind services totaling $1.2 M and the U.S. Department of Agriculture provided $400,000. Maine funded the remainder of the project through a 2002 bond issue.

Large area contracting methods kept the cost to taxpayers as low as possible, improved the availability of standardized, high-quality products, and ensured that all Mainers have access to current orthoimagery for their community. In fact Google uses these data as a major imagery source for Maine in Google Maps and Earth where tens of thousands of Mainers access them each year. *These data have not been updated and need to be refreshed.*

Testimonials from organizations around the state which have used that 2003-2005 orthoimagery can be reviewed at the following link. Samples from the survey are listed in Appendix A.
http://www.maine.gov/geolib/orthosurveyresults.htm.

B. 2009 Maine GeoLibrary Strategic Plan

The Maine GeoLibrary was established in 2002 as part of the process to develop a comprehensive strategic plan for GIS in Maine. The $2.3 M bond request funding the state's share of the 2003 – 2005 orthoimagery project was part of this overall legislative package.

By 2006 much had changed and the Board applied for funding from the USGS Federal Geographic Data Committee (FGDC) Cooperative Assistance Program (CAP) to update the 2002 strategic plan. The Maine

GeoLibrary Board engaged the James W. Sewall Co. to provide a clear strategy for it to pursue. The Board also established a Project Team composed of representatives from the Board and federal, state, county and local government and an independent project manager to oversee the project, provide reviews of submissions, respond to questions and set direction for the project.

Stakeholders were invited to forums across the state to provide input on what needed to be done to improve the use of GIS in their organizations. Various on-line surveys, personal interviews and small work groups were also used to gather information for the plan. The need to "***Establish a program to provide continual updates of digital orthoimagery across the State"*** was a recurring theme throughout the data gathering process and ultimately identified as a priority in the strategic plan adopted by the GeoLibrary Board.

II. Process

Subcommittee members were recruited to provide a broad base of technical expertise, ensure that all levels of government and the private sector were represented and reflected the widely varying geographic and demographic characteristics of Maine.

A. Standards and Specifications

The subcommittee reviewed technical information published by well known authoritative sources including the USGS and FGDC, and interviewed companies involved in the production of orthoimagery. Documents reviewed included the National Map Accuracy Standards (NMAS), the Content Standards for Digital Orthoimagery, the National Standard for Spatial Data Accuracy (NSSDA) and the model USGS Orthoimagery specification published for the American Recovery and Reinvestment Act Orthoimagery program. The goal of the subcommittee was to pull relevant information from published standards, model specifications and local resources rather than re-invent the wheel.

The documents listed above relate best practices for specifying orthoimagery requirements as well as the standards for judging the quality of the final products relative to these requirements. Important requirements include pixel resolution (ground sample distance), horizontal accuracy, metadata, radiometry, ground collection conditions (e.g., snow, clouds), sun angle, datum, projection, ground control, camera station control, quality control and data delivery.

The required pixel resolution drives the scale of the source imagery which is largely determined by flight height and the scanning methods in film based systems. The flight height and type of camera are the most important to pixel resolution in digital cameras.

The NMAS specifies minimum threshold horizontal accuracies based on the proposed published map scales and a comparison of the deliverable to locations of well defined points on the ground. The NSSDA presents a statistical and testing methodology for estimating the positional accuracy of points in an orthoimagery dataset based on user defined accuracy thresholds. The capacity to achieve specific horizontal accuracies depends on the digital elevation model used, ground control, the aerotriangulation control and methods, the camera calibration (different for digital and film based systems), scanner calibration (not applicable to digital cameras), and quality of the aerial photographs or digital images.

B. Orthoimagery Program Development

Once a review of the state-of-the-art of orthoimagery standards, specifications and processes was complete, the subcommittee turned its attention to the specifics of the Maine program. To stimulate discussion a "straw man" was presented to the subcommittee based on the 2003 – 2005 program. The straw man

proposal was a multi-year orthoimagery program with multiple pixel resolutions and varying update cycles. It drew from the 2003-2005 GeoLibrary project plan that divided the state into town groups with the update cycle (refreshment) of each group being determined by the previously (i.e., 2002) estimated rate of development in Maine. All groups would be covered by 2 foot or 3.3 foot pixel resolution imagery with the same standard as now exists. There would be "buy-up" options for groups of towns to, for example, acquire higher resolution orthoimagery by adding funding.

An additional consideration of the straw man was financial. The goal is to develop a plan that the state and other stakeholders (e.g., USGS, utilities, large land owners) could afford to sustain on an annual basis. Considering this, an annual budget target of approximately $500,000 was set and average costs per square mile by pixel resolution were assumed.

The subcommittee endorsed the approach, but chose to revisit the development patterns to make sure the groups, pixel resolution and update cycles reflected the current situation. The subcommittee decided to use the following parameters as a measure of change or development:

- Population change 1990 - 2008
- Parcels count change 2001 - 2008
- New residential electric connections 1990 - 2008
- New commercial electric connections 1990 - 2008

The following information was also used to help guide the creation of sectors.

- Location of regional service centers
- Unorganized territory area
- Town and county boundaries

Individual thematic maps were developed and an overall "combination" map was made. After reviewing the maps, the subcommittee adjusted the groups based on the trends shown in the thematic maps. After revision and then further inspection, additional adjustments were requested by the subcommittee and new maps were developed. Regional service centers and county boundaries were also added to the maps at this time. Based on these adjustments, additional changes were made at the final meeting to align some groups with county boundaries to facilitate the potential buy-ups by county groups. The unorganized territories were also broken out into 3 sectors to assist potential vendors with project planning. The final maps are shown in Appendix B.

III. Recommendations

A. Imagery for the Nation (IFTN)

The National States Geographic Information Council is working with the National Digital Orthophoto Program Committee and the FGDC to fund a new nationwide aerial imagery program that will fund, collect and disseminate standardized multi-resolution orthoimagery products on "set" schedules. Local, state, regional, tribal, and federal partners will be able to exercise "buy up" options for enhancements that are required by their organizations.

The Maine program models IFTN and as a result IFTN would clearly support the goals of the GeoLibrary Board. The subcommittee recommends that the Board send a strong letter of support for IFTN to the Maine Congressional Delegation, the Governor's Office and the FGDC. IFTN will provide a strong foundation for an ongoing Maine program.

http://www.nsgic.org/hottopics/imageryforthenation.cfm

B. National Agricultural Imagery Program (NAIP)

The National Agriculture Imagery Program (NAIP) acquires aerial imagery during the agricultural growing seasons in the continental U.S. Aerial Imagery is acquired and orthoimagery is produced every three year with the next acquisition scheduled for 2012. NAIP provides one meter, leaf-on, color orthoimagery with a horizontal accuracy that matches within six meters of photo-identifiable ground control points. Currently the US Geological Survey provides funding to ensure all nonagricultural areas within a state are acquired. Near color infra-red is a buy up option.

Although leaf-on, the NAIP imagery has value for many organizations including those in the forest products industry. In addition, the imagery provides a valuable record of ground conditions that will supplement Maine's program. The subcommittee recommends that the GeoLibrary monitor and support the NAIP program and proactively engage stakeholders about this program well in advance of the scheduled acquisition.

http://www.apfo.usda.gov/Internet/FSA_File/naip_2010_infosheet.pdf

C. Basic program

Past experience has demonstrated that cooperative efforts to purchase statewide orthophotography is far more cost efficient than individual towns and organizations purchasing smaller areas of aerial coverage. A large portion of the fixed cost for producing orthophotography is developing a contract, planning the project and getting a pilot and plane off the ground. This program is designed to meet the minimum needs of state government on a statewide basis, but allows municipal governments to purchase upgrades to meet their needs on an incremental cost basis, thereby saving them significant dollars. Groups of towns (e.g., counties) will realize the greatest cost saving. They will realize savings from the economies of scale in addition to the funds allocated to the basic orthoimagery program by the state and other large stakeholders. Furthermore, by providing quality control and contract administration centrally through the state, a higher overall quality product will result. The following describes the basic state program and buy-up options recommended by the subcommittee.

The subcommittee recommends a competitive process that will retain vendors for a contract period of 5 years assuming good performance.

After completing the analysis, examining a number of scenarios and in light of the $500,000 annual budget target, the following basic program parameters were set by the subcommittee:

- The state is divided into 11 groups each of which would be flown on a rotating cycle of either 3 or 5 years
- The base resolutions chosen were 2 foot and 3.3 foot
- The imagery would be natural color and flown leaf-off in the spring without snow
- Airborne GPS and IMU will be used for control
- The 10 meter USGS DEMs will be used at a minimum for orthorectification of base products. If available more accurate elevation data should be used (NOTE: This may increase the per unit cost)
- The content of USGS base orthoimagery specifications will be used as a guide for all contracts

The following maps and documents illustrate the program. The project spreadsheet illustrates the program over a 15 year period assuming orthoimagery production costs of $30/square mile for 3.3 foot pixel resolution and $70/square mile for 2 foot pixel resolution orthoimagery.

- Map A1 shows the town groups on a town basis.
- Map A2 shows the town groups on a county basis.
- Map B - towns that will be flown every 3 years with 2 foot pixel resolution followed by a list of the towns
- Map C - towns that will be flown every 5 years with 2 foot pixel resolution followed by a list of the towns
- Map D - areas that will be flown every 5 years with 3.3 foot pixel resolution

As an example, referring to the map and table, groups 1 and 4 would be flown in year 1 at a cost of $179,830 and $210,420, respectively. Group 1 would be flown again 3 years later, but group 4 would not be flown again until 5 years later.

1. Project Spreadsheet - 15 year project cycle

Groups 1 through 3 - leaf-off, color, 2 foot pixel resolution with 3 year update cycle
Groups 4 through 8 - leaf-off, color, 2 foot pixel resolution with 5 year update cycle
N1 through N3 - leaf-off, color, 3.3 foot pixel resolution with 5 year update cycle
All work done to National Map Accuracy Standards

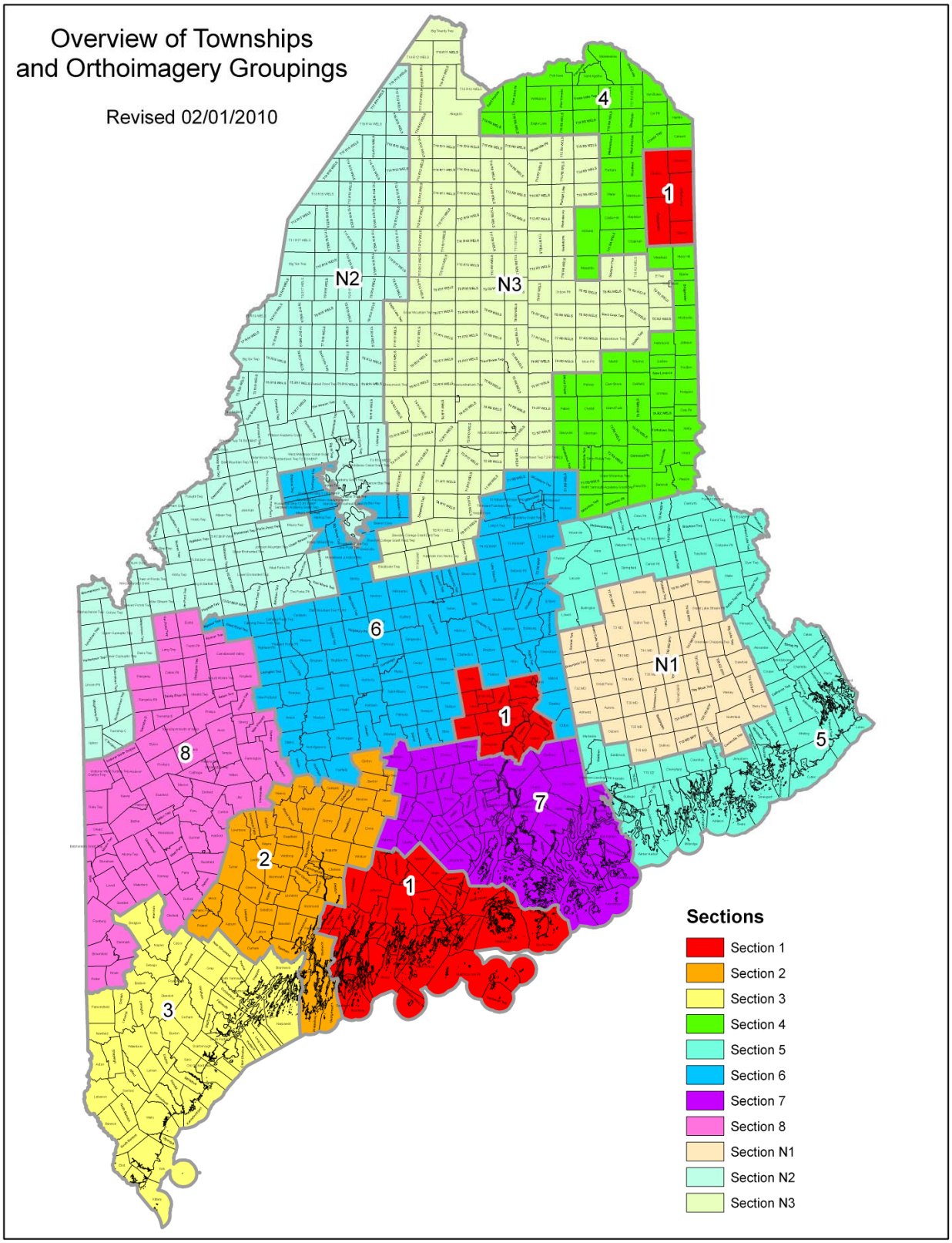
$/sq. mi. - estimated costs	
30	3.3 foot resolution, color leaf-off
70	2 foot resolution, color leaf-off

Costs for 15 year cycle

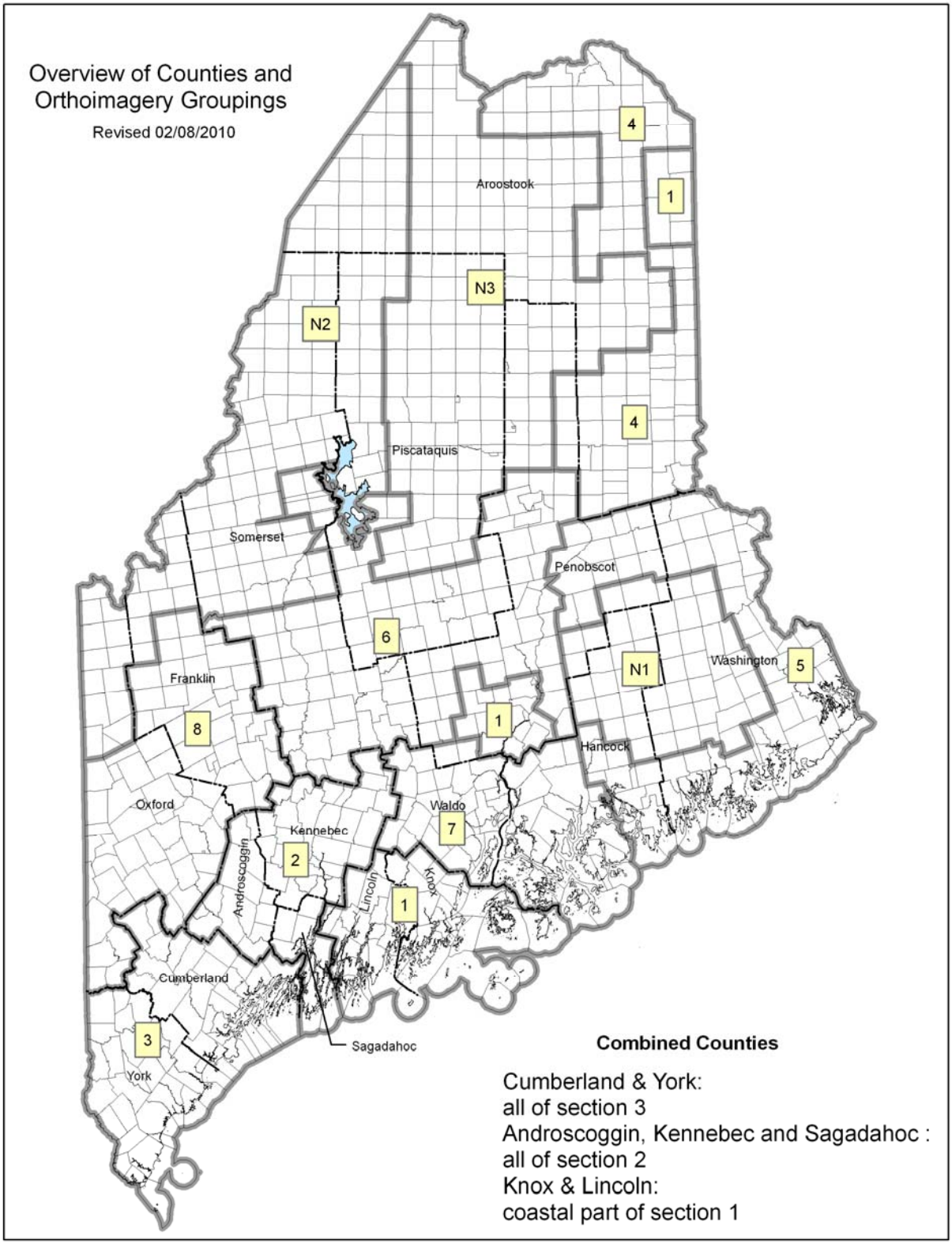
Year		area sq. mi.	area $	annual $
1	N1	1,911	$57,330	
	group 4	3,006	$210,420	
	group 1	2,569	$179,830	$447,580
2	N2	5,335	$160,050	
	group 5	3,277	$229,390	
	group 2	1,817	$127,190	$516,630
3	N3	5,701	$171,030	
	group 6	4,167	$291,690	
	group 3	2,486	$174,020	$636,740
4	group 7	2,181	$152,670	
	group 1	2,569	$179,830	$332,500
5	group 8	2,949	$206,430	
	group 2	1,817	$127,190	$333,620
6	N1	1,911	$57,330	
	group 4	3,006	$210,420	
	group 3	2,486	$174,020	$441,770
7	N2	5,335	$160,050	
	group 5	3,277	$229,390	
	group 1	2,569	$179,830	$569,270
8	N3	5,701	$171,030	
	group 6	4,167	$291,690	
	group 2	1,817	$127,190	$589,910
9	group 7	2,181	$152,670	
	group 3	2,486	$174,020	$326,690
10	group 8	2,949	$206,430	
	group 1	2,569	$179,830	$386,260
11	N1	1,911	$57,330	
	group 4	3,006	$210,420	
	group 2	1,817	$127,190	$394,940
12	N2	5,335	$160,050	
	group 5	3,277	$229,390	
	group 3	2,486	$174,020	$563,460
13	N3	5,701	$171,030	

	group 6	4,167	$291,690	
	group 1	2,569	$179,830	$642,550
14	group 7	2,181	$152,670	
	group 2	1,817	$127,190	$279,860
15	group 3	2,486	$174,020	
	group 8	2,949	$206,430	$380,450
	Average cost per year			**$456,149**

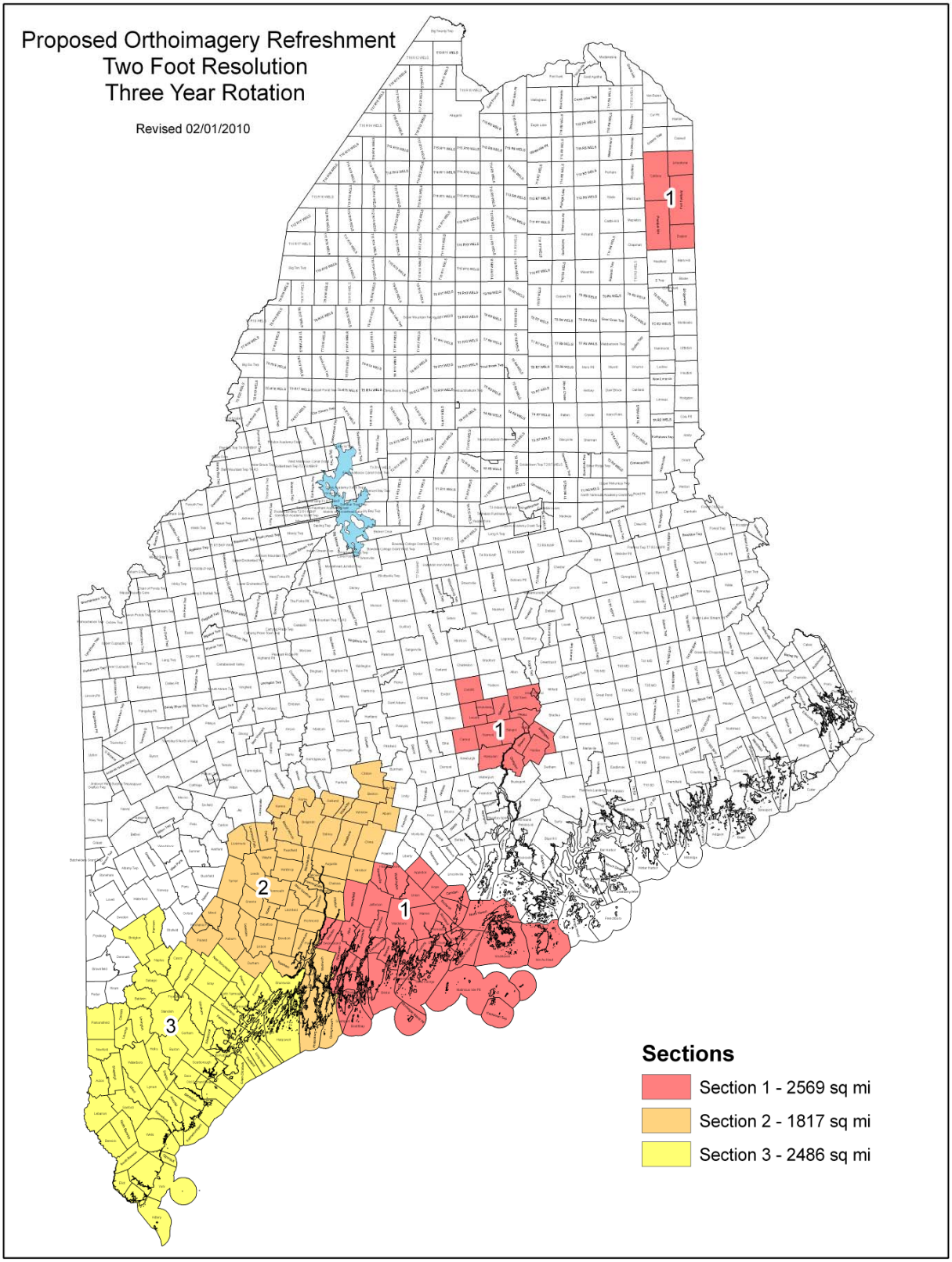
2. Map A1 – Town grouping by towns



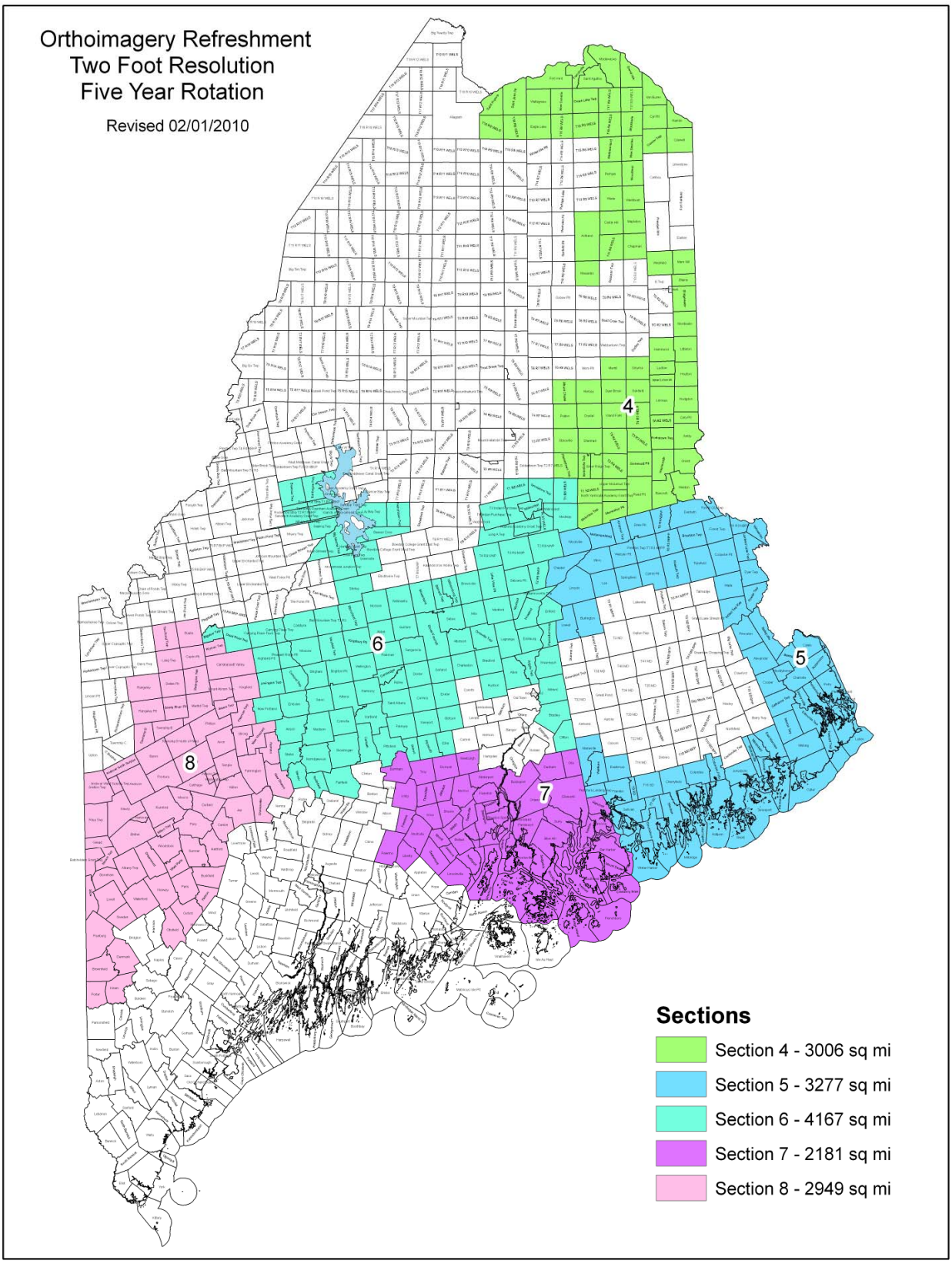
3. Map A2 – Town groupings by county



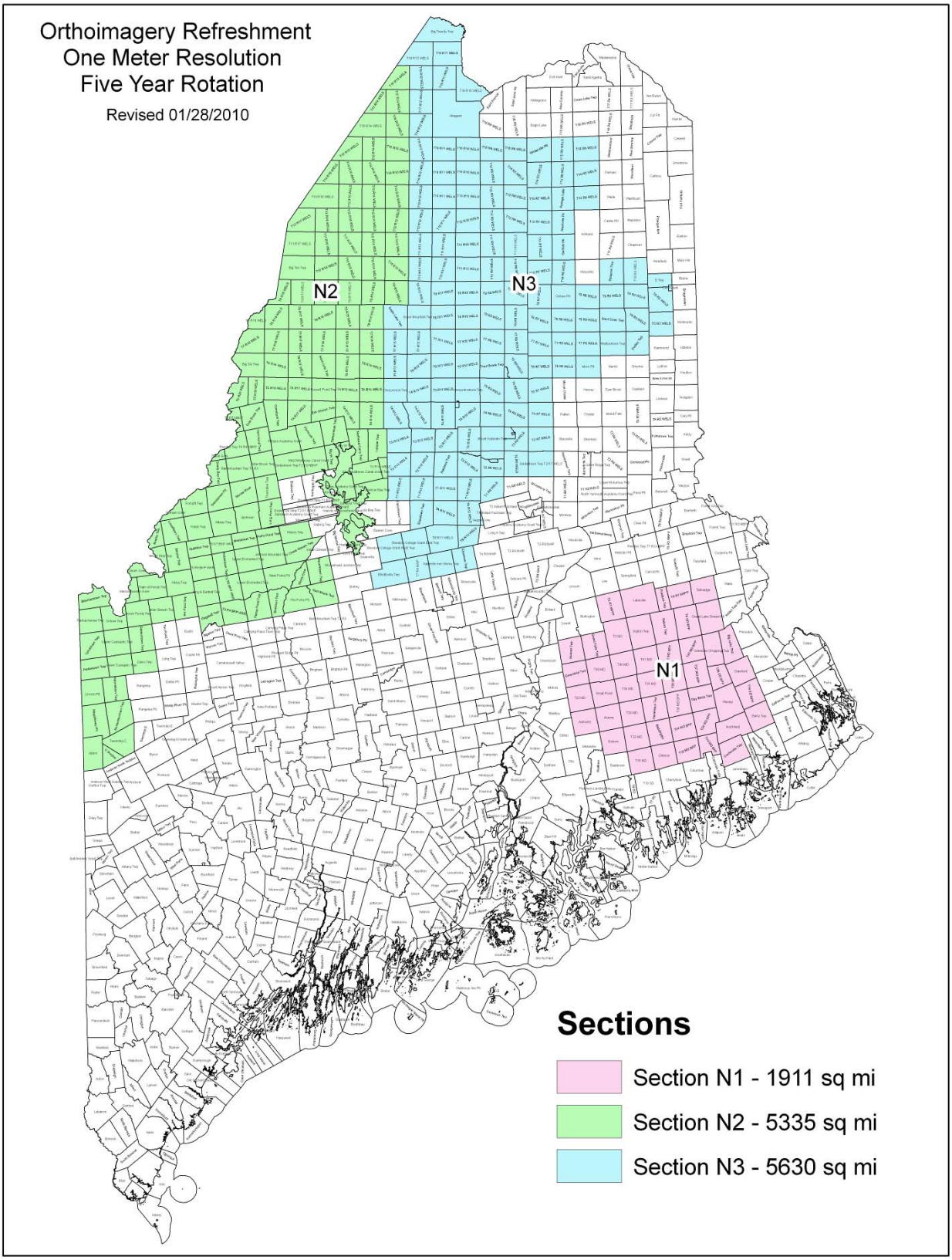
4. Map B – Two foot resolution and three year rotation



5. Map C – Two foot resolution and five year rotation



6. Map D – 3.3 foot resolution and five year rotation



All the towns covered by sections N1, N2 and N3 are in the unorganized territories of Maine and managed by LURC.

D. Alternatives

The subcommittee discussed various options over the course of the project. Many scenarios are possible, but the following are general alternatives the subcommittee felt could be explored.

- Increase the length of the update cycle to 5 and 7 years, for example, rather than 3 and 5 years and use the savings to increase the pixel resolution to 1 foot in selected areas.
- Accept leaf-on orthoimagery from the National Agricultural Inventory Program (NAIP), which is to be flown every three years for Maine, as the standard product for sectors N1, N2 and N3 and use the savings to increase the pixel resolution to 1 foot in selected areas.
- Some combination of the above

E. Buy-up Options

Public and private organizations will want to leverage the investment in the base program to produce more accurate and higher resolution products for their purposes. The subcommittee recommends that the program accommodate individual buy-ups as well as group buy-ups (e.g., counties). The total cost of the buy up will be funded by the organization(s) requesting the buy-up. The committee also recommends that the buy-ups be negotiated directly with the vendor but in consultation with an agent of the GeoLibrary Board. Available buy-ups include but may not be limited to the following. The final list will be set in the contract negotiated with the vendor.

- Pixel resolution – 1 foot, 6 inch, 3 inch
- Improve horizontal accuracy
- Color infrared

IV. Estimated Program Costs

The estimated cost of acquiring 2 foot and 3.3 foot orthoimagery to the specifications related above through a five year contract covering the entire State of Maine is estimated to be $70/square mile and $30/square mile, respectively. The average cost to the state for this program is estimated to be approximately $460,000 per year. The calculation was done considering a 15 year period which provides 5 complete updates of groups 1 through 3 and 3 complete updates for groups 3 through 8 and N1 through N3. The subcommittee is comfortable with the estimates for the first five year period. Budget estimates beyond 5 are projections that can change significantly due to the economy and changing technology.

V. Potential Program Partnerships

As stated earlier in the report orthoimagery has become an essential product for many private and public programs and is used for many purposes. The following is a short list of the functions using high resolution orthoimagery:

- Tax Parcel Mapping

- Transportation Management, Operations & Planning
- Economic Development
- Utilities Management, Operations & Planning
- Land Planning and Zoning
- Drainage Planning & Management
- Code & Permit Enforcement
- Agriculture
- Insurance
- Surveying & Mapping
- Environmental Management, Planning & Regulation
- Education
- Natural Resource Inventories and Assessments
- Homeland Security & Emergency Management
- Public Safety Planning, Response & Mitigation
- Education and research

Collaboration by the spectrum of stakeholders to establish and fund a statewide program in Maine will provide this valuable data resource at a lower per square mile cost, at higher resolution and on a more regular schedule which in turn improves public health and safety, the overall quality of government decision-making and the efficiency of business.

State agencies including Transportation, Planning, Environmental Protection, Marine Resources, Conservation and the Turnpike Authority all use existing orthoimagery on a daily basis saving time and money on field work, inventory and analysis. Sending people into the field is expensive and information extracted in the office from orthoimagery is productive and efficient. The same is true for federal agencies including USGS, the Federal Emergency Management Agency, the Natural Resource Conservation Service and many more.

Private concerns including electric and utilities, telecommunication companies and large landowners such as the forestry industry rely on state produced orthoimagery for many purposes. Academia and not-for-profit groups such as land trusts, watershed associations and energy concerns also use orthoimagery on a day-to-day basis.

The GeoLibrary on-line orthoimagery survey results clearly document the widespread use and benefits of statewide orthoimagery. See Appendix A of this report and go to http://www.maine.gov/geolib/orthosurveyresults.htm for the complete results.

The economy of scale provides a very compelling case for producing the data on a statewide basis, rather than town-by-town or agency-by-agency. The cost for acquiring and processing the 2003 – 2005 orthoimagery was $3.2 million and

covered 56% of the state or about $160/square mile. Several communities in Maine recently acquired similar orthoimagery products on their own and the average cost was approximately $500/square mile. Sharing the reduced costs with the multitude of stakeholders dramatically reduces the cost per organization in the short and long-term without considering the significant qualitative savings from better decision-making.

There is a common misconception that the State's efforts to upgrade its orthoimagery are redundant, since third party providers are already making this imagery available for free. This is not true. For states like Maine, the market does not compel companies to develop the scope of geographic information that the Maine public will need. Internet resources such as Google Earth or Microsoft's Virtual Earth acquire the information from the Maine GeoLibrary. Without an orthoimagery program funded by the State of Maine, publicly available orthoimagery for the entire state, whether through private or government sources, would become outdated, and in many regions would remain at unacceptably low quality levels. Failure to promote high quality orthoimagery in Maine will put the State at a disadvantage in the economic marketplace.