# Return on Investment Analysis for Statewide Orthoimagery Acquisition

**for the**

# State of Maine

**FINAL REPORT**

August 20, 2012

For the GeoLibrary Board

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# EXECUTIVE SUMMARY

This report supports the **business case for investing in Maine's statewide orthoimagery program**. The program is an outgrowth of the recommendations of the Maine GeoLibrary Board, including the following set of high-level premises:

- The **economies of scale** of a statewide program dramatically reduce the cost per participating organization in both the short and long term
- Collaboration between organizations provides orthoimagery at a **lower cost, higher resolution, and on a better schedule** – all of which improves the availability and usefulness of the data
- There is **no suitable substitute** for meeting the State's business and operational needs – commercial websites popular with citizens, such as Google Earth and Microsoft Bing, depend largely on publicly funded imagery as a resource

The burden for investing in this program is shared across levels of government, and **the Maine GeoLibrary Board has taken the initiative to coordinate participants and build the business case**. The costs for the program are well documented and are included in this report. The primary focus of this study was to quantify the benefits of the statewide orthoimagery program and help justify investments to cover the costs. The study identified thirteen statewide examples of how orthoimagery can be beneficial, but narrowed its scope to an in-depth treatment of only **three use cases of statewide importance: Forestry; Stormwater; and Transportation**. From an economic perspective, this was a conscientiously conservative approach – i.e., all costs were included, but only a subset of benefits.

To enumerate **benefits over a five-year period**, the team relied heavily on interviews with subject matter experts to articulate the uses and benefits of orthoimagery for the three specific examples. **Low and high estimates were made for each use case**, and then summed. The results, based only on these three use cases, make an economically compelling case for investment in a statewide orthoimagery program.

Combined benefits from the use of orthoimagery for Forestry, Stormwater, and Transportation applications range from **approximately $10 million on the low-end, to $30 million on the high-end**. This range compares very favorably to the expected **costs for the corresponding five-year time period of $2.4 million**. The resulting **return on investment (ROI) is projected to be 4.21 to 12.64** based on this

range, which would exceed the returns on many other alternative financial investments. If all thirteen use cases were similarly analyzed, it is safe to say that the total ROI would be substantially higher.

Given that there is no suitable substitute for a statewide orthoimagery program as proposed by the Maine GeoLibrary Board, and market forces are not filling the need, a strong case can be made that the **public sector should make the investment**, for the benefit of all.

# 1 OVERALL PROJECT SCOPE & PURPOSE

The State of Maine, Library of Geographic Information Board (the GeoLibrary Board) worked with the AppGeo team to conduct this Return on Investment Analysis regarding statewide orthoimagery purchases and programs. The project was funded by a Federal Geographic Data Committee (FGDC) Category 5 Cooperative Assistance Program (CAP) grant in 2011.

The project scope included the following:

- The FGDC Category 5 ROI training in Albany, NY
- Interviews with subject matter experts to determine the value of orthoimagery
- Real examples of cost savings due to the availability of orthoimagery
- An ROI case study
- ROI spreadsheets, analyses, and multi-agency business cases and presenting these results in a final report
- Findings to the Maine GeoLibrary Board

The purpose of this project was to realistically assess and document the value of orthoimagery to the agencies, communities, residents, businesses and other organizations in the State of Maine in quantifiable terms. The quantifiable results of this project are intended to provide a tool to decision-makers as they weigh the cost of statewide, recurring orthoimagery capture against other countless opportunities for investment in the State. In addition, the spreadsheets that were developed as an artifact of the project will be useful to the State to measure and analyze actual benefits going forward.

# 2 OVERALL TRENDS IN ORTHOIMAGERY & USAGE IN MAINE

## 2.1 HISTORY OF ORTHOIMAGERY ACQUISITION IN MAINE (1996 TO PRESENT)

### 2.1.1 Late 1990's

Like many states, Maine's first statewide orthoimagery was made available by the US Geological Survey (USGS) digital orthophoto quarter-quads (DOQQs) in the late 1990s. The arrival of this 1-meter imagery was valuable for a variety of applications, and for the first time, provided the coarse detail required to see structures, roads, edges to land uses, and more.

### 2.1.2 2002-2005 – Maine GeoLibrary Statewide Orthoimagery Program

Before 2002, cities, towns and industries in Maine spent large sums of money to obtain orthoimagery to support their local, state and private programs. This data was costly, inconsistent and often created a duplication of efforts. Seeing the need for improved data, Maine GeoLibrary initiated a statewide project to produce high resolution digital orthoimagery. The project was the largest thus far in Maine at a cost of $3.2 million dollars. The Maine Library of Geographic Information (GeoLibrary) provided $1.6M, the United States Geological Survey (USGS) contributed $1.2M and the U.S. Department of Agriculture (USDA) provided the remaining $400K.

Although this program provided a starting point for orthoimagery acquisition in Maine, a consistent, planned approach to acquiring orthoimagery that reduced costs and provided consistent statewide results was still lacking. The piecemeal approach had worked well for some municipalities but there were still problems with obtaining data for larger regional or statewide uses as well as small municipalities.

### 2.1.3 2006-2009 – Maine GeoLibrary Strategic Plan

Seeing the need for new and improved data, the Board applied for funding from the USGS Federal Geographic Data Committee (FGDC) Cooperative Assistance Program (CAP) to update the 2002 strategic plan. Surveys, interviews and work groups identified the need to "Establish a program to provide continual updates of digital orthoimagery across the State". This priority became the overall goal of the strategic plan constructed by their subcommittee -- a group that provided a broad base of technical

expertise and ensured that all demographic and geographic populations in Maine were reflected in the final product.

### 2.1.4 2009-2012 – State of Maine Orthoimagery Program

With the completion of the subcommittee's plan, the Maine GeoLibrary Board began to implement the recommendations. Their effort was aimed at collecting new imagery over a 5 year period including a base collection of 2-foot and 1-meter imagery, re-flights every 3-5 years and buy-up opportunities for local government or other entities interested in a higher quality end-products. The program is split into 11 groups flown on a rotating basis. The first flyovers began in 2012.

## 2.2 CURRENT STATEWIDE ORTHOIMAGERY ACQUISITION PROJECT

In Spring 2011, the GeoLibrary began discussions with the Greater Portland Council of Governments (GPCOG) to implement the first phase of this project. The program started in 2012 with $10,000 in seed money from the GeoLibrary. The subcommittee's proposal outlined 11 groups, containing the entire geographic area of Maine. Each group was provided a flyover year and base resolution of orthoimagery. The extensive project outline allows for areas to be mapped in three or five year cycles at varying resolutions. By outlining the year of the flyover, the towns and counties could better manage their budgets to pay for the expense of the orthoimagery.

The update and resolution schedule is as follows:

**Update Cycle:**

Groups 1-3: every 3 years

Groups 4 – 8: every 5 years

Groups N1 – N3: every 5 years

**Resolution:**

Groups 1 – 8: 2 foot resolution

Groups N1 – N3: 3.3 foot resolution

The geographic areas in each grouping are as follows:

**2012: Group 3** (Cumberland and York Counties, partial Androscoggin and Oxford)

**2013: Groups 2, 5 & N2** (Androscoggin, Kennebec, Sagadahoc, Lincoln, Knox, Waldo Counties)

**2014: Groups 1, 6 & N3** (Hancock, Washington, and southern Penobscot Counties)

**2015: Groups 3 & 7** (Partial Aroostook, Penobscot, Piscataquis Counties)

**2016: Groups 2, 4, 8 & N1** (Franklin, Oxford, Somerset, partial Aroostook and Piscataquis and Washington Counties)

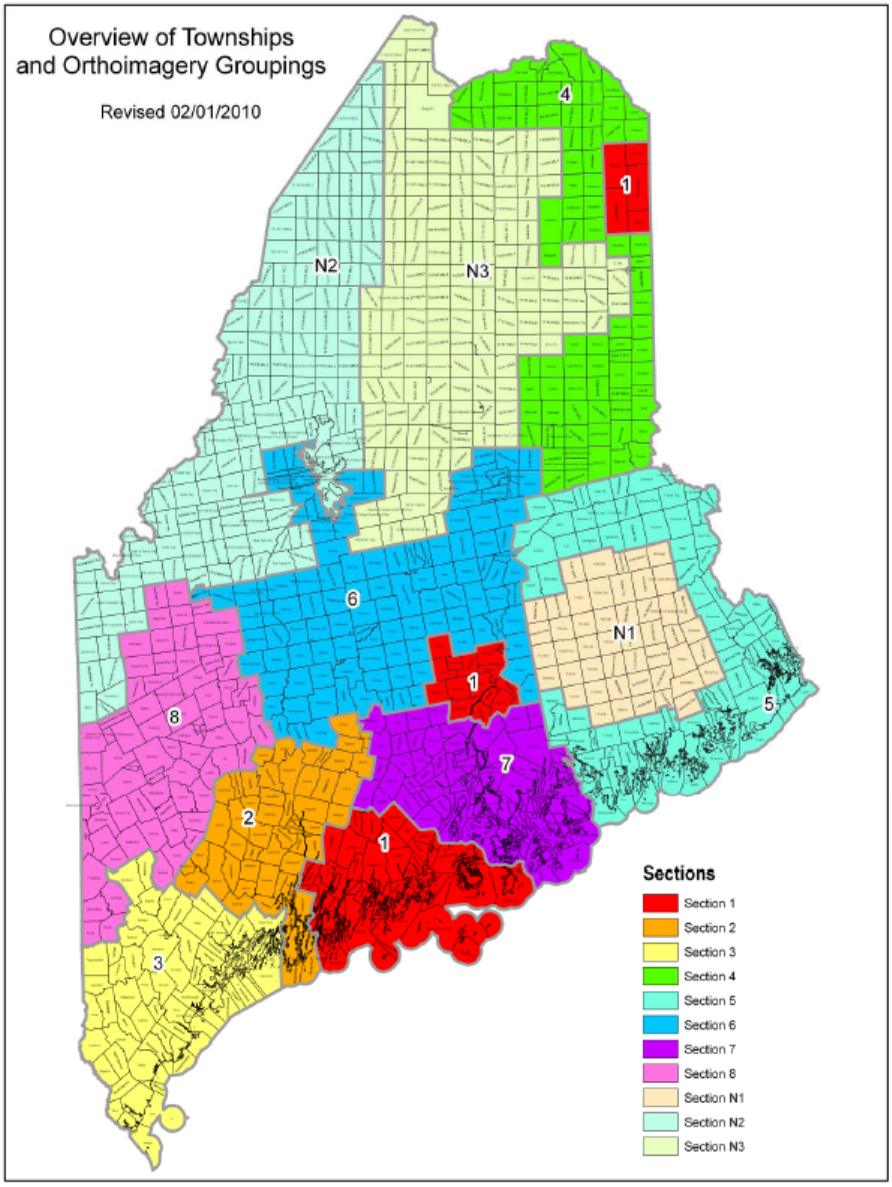



Figure 1. Overview of Townships and Orthoimagery Groupings

The contractor chosen for the project is Woolpert, Inc. from Dayton, Ohio who has partnered with Kappa Mapping and Bradstreet Consultants from Maine. According to the contract, areas greater than 1,000 square miles will cost $52.90 per square mile for 2' orthoimagery, with the cost being split between federal, state and county budgets. For towns that want to "buy up"[1], Maine GeoLibrary pre-negotiated costs with Woolpert and displayed the information in well-organized, readily-available tables on the Maine GeoLibrary Project Website. Each chart describes the cost of "buying up" to the next highest resolution with the explanation of less cost the higher resolution the county purchases. For example:

**2013 State of Maine Ortho Prices**

*These are prices suitable for budgeting.*
*The actual price may be up to 30% less if several contiguous towns or counties buy together.*

**By County**

| | | | | *Additional buy-ups at county-wide prices (add this to the base cost)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| County | Area (SqMi) | 24" base | county 1/3 | 12" L2 | 12" L1 | 6" L2 | 6" L1 | 3" L2 | 3" L1 |
| Androscoggin | 434 | $37,500 | $12,500 | $33,500 | $52,500 | $75,500 | $137,500 | $240,500 | $468,000 |
| Kennebec | 951 | $63,500 | $21,167 | $52,500 | $89,500 | $148,000 | $270,000 | $477,500 | $930,000 |
| Knox (except Isle au Haut) | 499 | $50,500 | $16,833 | $41,500 | $66,000 | $87,500 | $159,500 | $269,000 | $523,500 |
| Lincoln | 546 | $44,000 | $14,667 | $39,000 | $61,500 | $88,000 | $161,000 | $280,000 | $545,000 |
| Penobscot (two towns) | 67 | $6,500 | $2,167 | $5,500 | $9,000 | $11,500 | $21,000 | $35,500 | $69,000 |
| Sagadahoc | 304 | $26,000 | $8,667 | $22,500 | $35,500 | $50,000 | $90,500 | $157,000 | $305,500 |
| Waldo | 782 | $60,500 | $20,167 | $54,500 | $86,500 | $124,000 | $226,000 | $396,500 | $772,500 |

**By Town**

*These are buy-up prices for budgeting purposes assuming the County buys the base product. If a county buys up to higher than the base product, a town can figure out a further buy-up cost by simply subtracting. For example if Androscoggin Co. bought up to 6"L2, then Lewiston's further buy-up to 3"L1 would be their 3"L1 cost minus their 6"L2 cost, or $38,000 - $6500 = $31,500. For 3" buy-ups we can further subdivide out urban areas within a large town such as Auburn, which may need the urban center at 3"L1 but not the entire town area. This subdividing can only be done on a very limited basis.*
*Additionally, the final price may be reduced by up to 30% if several contiguous towns buy up together to the same product.*

| Town | County | Area (SqMi) | 12" L2 | 12" L1 | 6" L2 | 6" L1 | 3" L2 | 3" L1 |
|---|---|---|---|---|---|---|---|---|
| Auburn | Androscoggin | 66 | $6,000 | $9,000 | $12,000 | $21,500 | $35,500 | $69,000 |
| Durham | Androscoggin | 39 | $4,500 | $7,000 | $8,000 | $14,000 | $22,000 | $42,500 |
| Greene | Androscoggin | 35 | $3,500 | $5,000 | $6,500 | $12,000 | $19,500 | $37,500 |
| Leeds | Androscoggin | 43 | $4,000 | $6,500 | $8,000 | $14,500 | $23,500 | $46,000 |
| Lewiston | Androscoggin | 36 | $3,500 | $5,500 | $6,500 | $12,000 | $19,500 | $38,000 |
| Lisbon | Androscoggin | 24 | $2,500 | $4,000 | $5,000 | $8,500 | $14,000 | $27,000 |
| Livermore | Androscoggin | 39 | $4,000 | $6,000 | $7,500 | $13,500 | $21,500 | $41,500 |
| Livermore Falls | Androscoggin | 20 | $2,000 | $3,000 | $4,500 | $7,500 | $12,000 | $23,000 |
| Mechanic Falls | Androscoggin | 11 | $2,000 | $2,500 | $3,000 | $5,000 | $7,000 | $13,500 |
| Minot | Androscoggin | 30 | $3,500 | $5,500 | $6,500 | $11,000 | $17,000 | $33,000 |
| Poland | Androscoggin | 47 | $4,500 | $6,500 | $8,500 | $15,500 | $26,000 | $50,000 |
| Sabattus | Androscoggin | 27 | $2,500 | $4,000 | $5,000 | $9,000 | $15,000 | $29,000 |
| Turner | Androscoggin | 63 | $5,500 | $8,500 | $12,000 | $21,000 | $34,000 | $65,500 |
| Wales | Androscoggin | 17 | $2,500 | $3,500 | $4,000 | $6,500 | $10,000 | $19,500 |
| Albion | Kennebec | 39 | $3,500 | $5,500 | $7,500 | $13,000 | $21,500 | $41,500 |
| Augusta | Kennebec | 58 | $5,000 | $7,500 | $10,000 | $18,500 | $31,000 | $60,000 |
| Belgrade | Kennebec | 58 | $5,500 | $8,000 | $10,500 | $19,000 | $31,500 | $61,000 |

These are the buy-up prices for budgeting purposes assuming the County buys the base product. If a county buys up to a higher than the base product, a town can figure out a further buy-up cost by simply subtracting. For example if Androscoggin Co. bought up to6"L2, then Lewiston's further buy-up to 3"L1 would be their 3"L1 cost minus their 6"L2 cost, or $38,000-$6,500 = **$31,500**.

Figure 2. 2013 Orthoimagery prices for buy-up purchasing from the Maine GeoLibrary website

[1] A "buy-up" is an opportunity for a participant to pay an incremental amount to get a higher resolution product, without bearing the full cost.

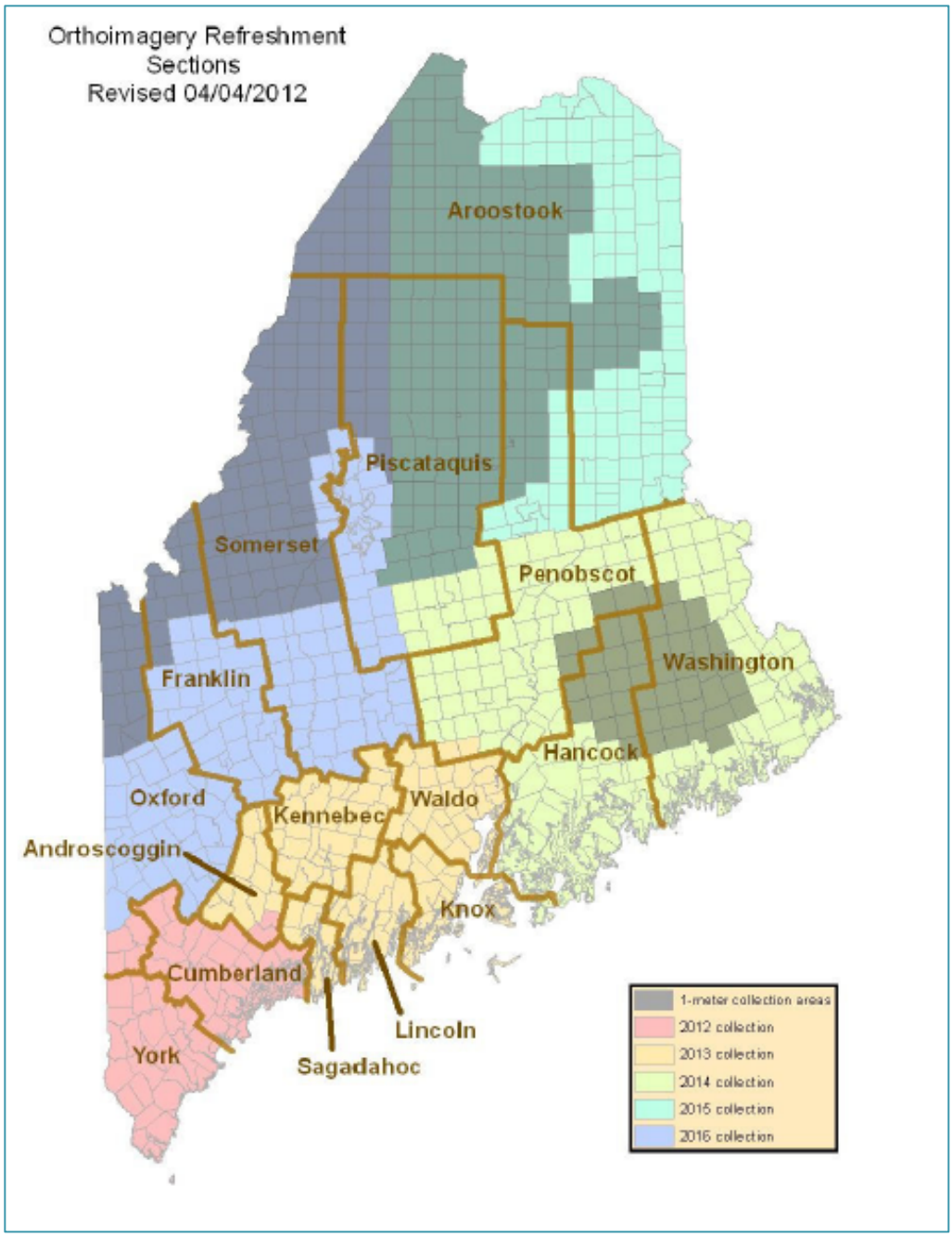



Figure 3. Planned image collection areas by year.

# MAINE GEOLIBRARY

## State of Maine Orthoimagery Program Briefing

### Cost Schedule

### Base Program - to be split between state/federal/counties

| Per square mile costs | | | | | |
|---|---|---|---|---|---|
| **GSD (pixel resolution)** | Accuracy Specification | Horizontal Accuracy | Cost per sq mi Areas 0-30 sq mi | Cost per sq mi 31-1000 sq mi | Cost per sq mi > 1000 sq mi |
| 24" | NMAS 2' | 13.3' | $63.80 | $58.30 | $52.80 |
| 1 meter | NMAS 1m | 16' | $59.40 | $53.90 | $48.40 |

| Base program - Summary costs per county | | | | | |
|---|---|---|---|---|---|
| **County** | **Sq. Mi.** | **County share for one collect** | County | Sq. Mi. | County share for one collect |
| Androscoggin | 500 | $15,000 | Oxford | 2350 | $49,333 |
| Aroostook | 7300 | $145,000 | Penobscot | 3650 | $84,500 |
| Cumberland | 1100 | $24,000 | Piscataquis | 4450 | $97,833 |
| Franklin | 1850 | $41,167 | Sagadahoc | 350 | $8,667 |
| Hancock | 2230 | $48,500 | Somerset | 4300 | $86,167 |
| Kennebec | 950 | $21,167 | Waldo | 850 | $20,167 |
| Knox | 800 | $18,667 | Washington | 3300 | $66,167 |
| Lincoln | 650 | $14,667 | York | 1200 | $22,833 |

### Buy-ups to the base program

| GSD (pixel resolution) | Map Scale | ASPRS Class | Horizontal Accuracy | Buy-up costs per square mile | | |
|---|---|---|---|---|---|---|
| | | | | 0-30 sq mi | 31-1000 sq mi | > 1000 sq mi |
| 3" | 1"=50' | Level 1 | 6" | $919.60 | $908.60 | $897.60 |
| 3" | 1"=50' | Level 2 | 12" | $477.40 | $466.40 | $455.40 |
| 6" | 1"=100' | Level 1 | 12" | $268.40 | $257.40 | $246.40 |
| 6" | 1"=100' | Level 2 | 2' | $151.80 | $140.80 | $129.80 |
| 12" | 1"=200' | Level 1 | 2' | $103.40 | $92.40 | $81.40 |
| 12" | 1"=200' | Level 2 | 4' | $69.30 | $58.30 | $47.30 |
| 24" | 1"=400' | Level 2 | 8' | $46.20 | $35.20 | $24.20 |

***For complete prices lists per town and county see http://www.maine.gov/geolib.***

Figure 4. Maine GeoLibrary cost sheet: Summary costs and buy-up costs by county.

## 2.3 IMAGERY RESOLUTION AND AGE COMPARISON

The perceptions of value related to imagery resolution and age vary, depending on the application requirements, and the level of understanding and experience with the data. Generally speaking, the higher the resolution, the more detail you will be able to see. When it comes to age, an image that is 5 or 10 years old will not show new buildings, roads, and other changes to the landscape that may have occurred since the time the imagery was captured; current imagery is desirable for this reason. And yet, the value of older imagery never diminishes to zero, due to its residual value for change detection; and there is a demand in Maine for historical images that can be compared to newer imagery. As the old saying goes, "a picture is worth a thousand words."

When it comes to understanding what you can see as resolution increases or decreases, the following sequence is illustrative:

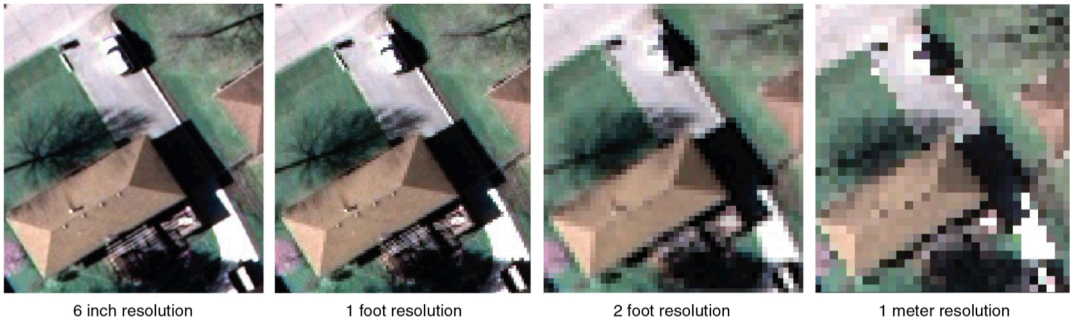
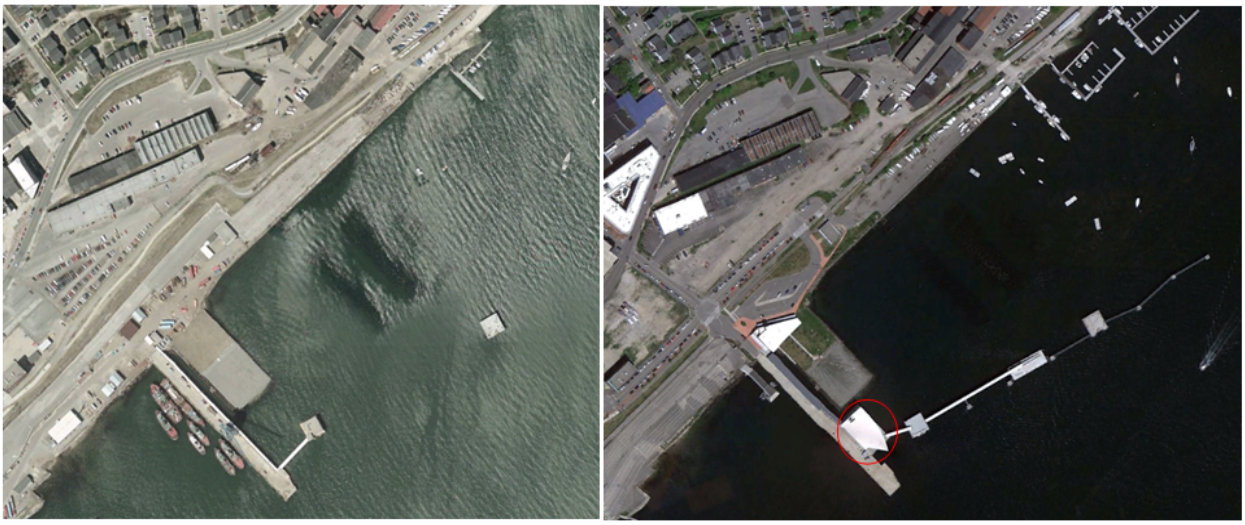



Figure 5. Image resolution comparison
Derived from The Kansas Collaborative "Guidelines for Acquiring Aerial Imagery" (2007, August)

Likewise, when it comes to understanding what you can see based on older or newer imagery, the following examples help to illustrate. One shows Portland seaport in images that are 9 years apart in age, followed by images showing changes to the landscape based on mining (10 years apart), and forestry (also 10 years apart).



2003 – Portland Seaport 2012 – Portland Seaport Improvements

Figure 6. Importance of currency in aerial imagery as source for change detection


Figure 7. Importance of aerial imagery as source for land use change from mining.

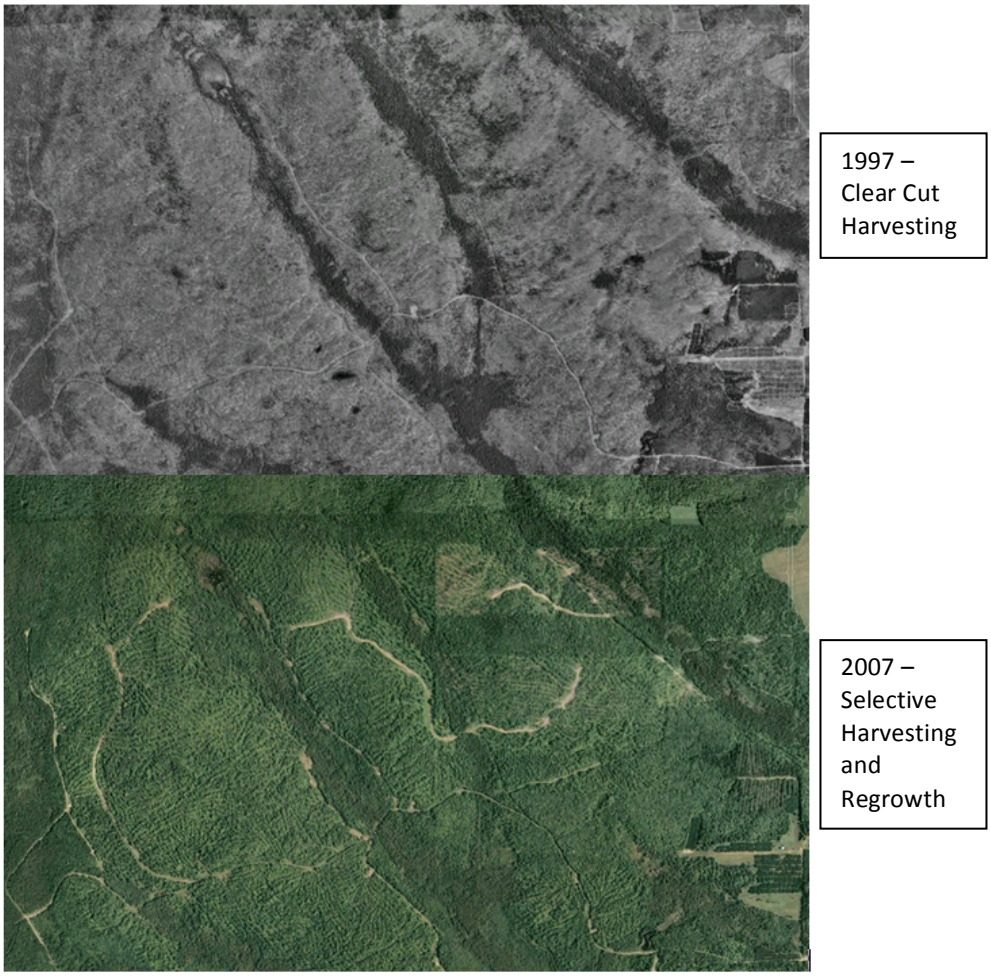



Figure 8. Importance of aerial imagery as source for land use change from harvesting practices.

# 3 BACKGROUND

## 3.1 MEGIS SUBCOMMITTEE REPORT

When the Maine GeoLibrary Board applied for funding in 2006, they formed a subcommittee to develop a program that leveraged federal, state, local and private funding to provide statewide high resolution orthoimagery on an ongoing basis. Their goal was to provide this valuable data resource at a lower per square mile cost, higher resolution and on a more regular schedule than could be accomplished otherwise.

The subcommittee began by reviewing information from the US Geological Survey (USGS) and Federal Geographic Data Committee (FGDC) as well as other companies involved in orthoimagery collection. The goal of this review was to use already documented information to provide context and determine best practice for orthophoto requirements. They determined the most important requirements to be 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 second step of the subcommittee was to create a plan for the **Maine specific orthophoto program** that all stakeholders could afford to continue annually; with the set budget of approximately $500,000. The proposal used attributes of the 2003-2005 program, which had multiple pixel resolutions and varying update cycles. The subcommittee adjusted the previous town groupings based on a reassessment of the development patterns used to create them.

The subcommittee made **three** recommendations based on their findings:

1. Support the **NSGIC ROI Study "Imagery For The Nation":**

Imagery for the Nation (IFTN) is a program created by the National States Geographic Information Council (NSGIC) in conjunction with the National Digital Orthophoto Program Committee and the FGDC that aims to fund, collect and distribute standardized orthoimagery. As part of their recommendations, the subcommittee recommended that the Board send a strong letter of support for IFTN to the Maine Congressional Delegation, the Governor's Office and the FGDC.

2. Support the **National Agricultural Imagery Program (NAIP)**

The National Agricultural Imagery Program funds the acquisition of aerial imagery of agricultural lands during the growing season (i.e. leaf-on) every three years. This imagery provides valuable information

about forested lands and agricultural conditions that could greatly aid Maine's program, even though it is less than ideal for urban and suburban areas (where leaf-off imagery is preferred). Therefore, the subcommittee recommended that Maine monitor and support the NAIP program.

3. Create a **Basic Program** for Maine Orthoimagery

The subcommittee's final recommendation was a basic program for the Maine orthoimagery project that would present a cost-savings for smaller towns and organizations by taking part of a large collection process. The following parameters were set according to the $500,000 annual budget:

- 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 (i.e. 1 meter)
- The imagery will 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
- The content of USGS base orthoimagery specifications will be used as a guide for all contracts

The plan involves a 15 year period of flyovers, with some regions being flown every three years and some being flown every five with varying resolution. The project stays within its $500,000 annual budget by assuming $30/square mile for 3.3 foot pixel resolution and $70/square mile for 2 foot pixel resolution. Buy-up options would be made available for both public and private organizations who want to invest in better quality projects including higher pixel resolution, improved horizontal accuracy or color infrared.

The subcommittee provides a sensible case for investing in this program including:

- The economy of scale of this project would dramatically reduce the cost per organization in the long and short term.
- Collaboration will provide data at a lower cost, higher resolution and on a regular schedule that improves the quality of its usefulness.

- Internet programs such as Google Earth or Microsoft Virtual Earth largely depend on orthoimagery from the GeoLibrary for their imagery of Maine

## 3.2 NSGIC ROI STUDY "IMAGERY FOR THE NATION"

The National States Geographic Information Council (NSGIC) released a Cost Benefit Analysis (CBA) report in July 2007 that explored the return on investment for a nationwide aerial imagery program to meet the needs of local, state, regional, tribal and federal agencies. The proposed **Imagery for the Nation (IFTN)** initiative recommended a collaborative effort between the United States Department of Agriculture (USDA) Farm Service Agency (FSA) and the Department of the Interior (DOI) United States Geological Survey (USGS) to enhance the coverage of their respective imagery programs. The existing National Agriculture Imagery Program (NAIP) and the National Geospatial Intelligence Agency (NGA) Urban Area Imagery Partnership (UAIP) served as the foundation for the expanded goals of the IFTN program. The IFTN CBA examined several alternatives to identify the optimal solution for a national program and scored each alternative in the categories of Business Processes, Non-Quantifiable benefits, Costs, Business Requirements and Risk. Ultimately, the following recommendation (a.k.a. "alternative #4") was put forth in the CBA document as the most viable solution:

**The Recommended Alternative: Original IFTN Concept with Optional 50% Cost Share for 1-ft Program**

- Nationwide coverage of 1-m resolution imagery that is federally funded
- 1-ft resolution imagery that is federally funded with coverage that is determined by a population model
- 6-in resolution imagery of identified urbanized areas that is acquired through a mandatory 50% cost share program
- Optional 50% Cost Share for 1-ft Program: IFTN with 1-ft coverage of lower 48 states and Hawaii with optional cost share
- Federal government will guarantee the availability of 50% funding for coverage according to statewide business plans
- Statewide councils can increase funding to increase program coverage
- Alaska and the Insular Areas will adhere to population model

The resulting findings on Return on Investment and Net Present Value for this alternative were presented in the IFTN CBA report as follows:

- The estimated ROI of 0.37 for Alternative #4 is moderately favorable for investment funding
- The Net Present Value of $31M for the estimated lifecycle benefits represents 2% of the total risk adjusted life cycle costs of Alternative #4
- There is a positive correlation between quantifiable benefits and identification of additional baseline programs; this translates to a direct increase in both ROI and NPV for every additional program respondent
- Bottom line financial conclusion demonstrates program consolidation and IFTN adoption decreases costs for federal, state, and local programs

Following publication of the CBA, the FGDC Executive Committee[2] reviewed the proposed program and established several working groups to focus on the technical, communication, and contracting aspects of implementation. The worsening economy, however, made it unlikely that Congress would fund such a program and the working group reports were never published nor was any consensus reached by the Executive Committee to pursue the program.

In August 2010, a Request for Information (RFI) was issued to the industry to gather information on different approaches that might be pursued to meet the IFTN goals but the results of this RFI were never published. In the meantime, the NAIP program continues to provide 1-meter, 4-band, leaf-on imagery with the option to "buy-up" to half-meter resolution and is meeting the needs of many agricultural states. Recently it was reported that USGS will not be able to participate in cost sharing initiatives for IFTN, except for in urban priority areas related to homeland defense and security.

[2] The FGDC Executive Committee is comprised of designated Senior Agency Officials for Geospatial Information (SAOGI) representatives from federal agencies.

## 3.3 KING COUNTY (WASHINGTON STATE) ROI STUDY

An ROI study was published in March 2012 on the use of Geographic Information Systems (GIS) in King County, Washington.[3] It was focused on benefits from the use of GIS data of all types, not just orthoimagery. There is a synergistic effect when multiple types of GIS data can be used in combination, and the orthoimagery is often used as a basemap for other layers. King County has slightly fewer than 2 million people, which is larger than the population of Maine. The county seat is in Seattle, so it includes an urban seaport, and it has a large GIS program and staff. The ROI study, performed by a team of economists, was funded by King County and the State of Oregon, as a party interested in the methodology (even though King County is in Washington).

The approach taken in the King County study was to look backwards at what was spent, and to measure actual benefits that occurred. Since not all benefits were documented, qualitative interviews and survey methods were used to estimate the value of actual benefits. From 1992-2010, the investment in GIS in King County was approximately $200 million, and the measured benefits were approximately $1 billion dollars. The results of the analysis, for just the year 2010 alone, included a net benefit range of approximately $87 million on the lower bound and $180 million on the upper bound, based on costs of $14.6 million.[4]

## 3.4 FGDC ROI METHODOLOGY

A prerequisite for the Maine ROI study was the use of methodology based on the FGDC Return on Investment (ROI) Workbook. This Workbook was developed by the Geospatial Information and Technology Association (GITA), a non-profit educational association serving the geospatial community, and the American Water Works Association (AWWA), an international nonprofit educational association dedicated to safe water, in collaboration with FGDC. The specific methodologies are published in the "Building a Business Case for Geospatial Information Technology: A Practitioners Guide to Financial and Strategic Analysis" (GITA, 2007). This publication is the result of a long-term project of the GITA Research Division and the AWWA Research Foundation and is intended to communicate the results of their research on Cost-benefit Analysis (CBA) and provide tools to organizations for performing their own such analyses. The methodologies provide a framework for conducting the activities required to conduct ROI studies, including:

[3] Zerbe et. al., "An Analysis of Benefits from Use of Geographic Information Systems by King County Washington," Richard Zerbe and Associates, March 2012.
[4] Ibid., p.4 and Appendices.

- An approach for identifying and presenting a business case for geographic information technology
- Capturing benefits including tangible and intangible benefits
- Calculating tangible benefits
- Dealing with uncertainty
- Capturing start-up, operating, and sunk costs
- Calculating labor costs
- Performing financial analysis

The project team took training in these specific methodologies, and combined the learning with existing knowledge and experience with CBA methods from other sources, such as the federal Office of Management and Budget (OMB), literature review, and industry best practices.

# 4 PROJECT APPROACH

## 4.1 OVERVIEW OF PLAN FOR MAINE ORTHOIMAGERY ROI STUDY

The Maine Orthoimagery Return on Investment Study focused on a subset of specific use cases with particular statewide relevance. The AppGeo team created an Outreach Plan describing potential orthoimagery use cases, and prioritized three of these use cases for in-depth information gathering. Input from stakeholders and subject matter experts informed the assignment of value to orthoimagery benefits for each use case. These values were then "scaled up" to represent the entire state's benefits in the final results. Overall, the following steps were taken:

i. Identified potential quantifiable use cases that are relevant across the state and where orthoimagery is part of an existing workflow, and picked three (3) for in-depth study and characterization.

ii. Identified specific stakeholders for the prioritized use cases and gathered input on the value of orthoimagery. The AppGeo team, with input from the State, identified and contacted specific informants for each use case.

iii. Calculated benefits for each use case using Cost-benefit methodology.

iv. Scaled the use case dollar values to a statewide model according to metrics that suited the use case.

v. Combined the calculated benefits and orthoimagery costs into the ROI calculation.

## 4.2 STEP 1: IDENTIFIED POTENTIAL USE CASES AND SELECTED THREE FOR STUDY

Based on consultation with the state, thirteen (13) potential use cases were identified. They are briefly described in terms of orthoimagery below:

1. Stormwater management
    - Determining impervious surfaces for stormwater mapping for permits
    - Needed by municipalities and industrial facilities
    - Also needed by entities such as hospital campuses, universities, malls, transportation facilities

2. Wildlife habitat modeling
    - Management of moose and deer herds
    - Increase potential tourism
    - Stream fishery and stream water quality management
3. Response to public inquiry about flood plain boundaries
    - Avoid and/or mitigate damage costs
    - Reduce determination costs (bank costs, property owner costs)
4. Support for 'Search and Rescue' missions
    - Not necessarily cost savings, but saves lives
    - More precise and efficient use of resources – less time to objective
5. Forestry
    - Supports multi-million dollar industry
    - Increases revenue from timber sales
    - Identification of stand types and health
    - Improves accuracy and resolution of delineations
    - Reduces need for field work and sample plots
    - Assessing pest/disease spread results in better tree health and lumber
    - Theft investigation
    - Forest fire fighting
6. Agriculture Management
    - Crop delineation
    - Management practices (e.g. planning where to apply chemicals or organic matter)
    - Economic interests (e.g. blueberries, potatoes)
7. Fisheries
    - Eel grass mapping
    - Coastal erosion/shoreline change mapping

- Working waterfront preservation
- Port management
- Recreational marinas

8. Pipelines/Utilities
    - Inventorying existing assets
    - Planning new assets
    - Field maintenance tracking/support
    - Corridor planning/management
    - Broadband infrastructure planning
9. Emergency Response (MEMA and Guard)
    - Natural disaster planning/response (hurricanes, floods, ice storms)
    - Planning prior to events
    - Comparing before/after events
10. Transportation
    - Airport obstruction mapping
    - Asset management (road network management)
    - Environmental assessment
    - Planning
11. Municipal efficiency
    - Operational savings for code enforcement through reduced field visits
    - Improved service to the citizen
12. Economic Development
    - Waterfront redevelopment
    - Main St redevelopment
    - Site selection tools

13. Water and Sewer Infrastructure Planning
    - Delineate runoff surfaces
    - Housing areas and population density

The following chart is a matrix of the potential use cases listed above, and the associated orthoimagery applications.

| | Asset Management | Site Selection | Planning/ Reconnaissance | Code Enforcement | Improved Services | Infrastructure Planning | Support for Field Work/Inspections | Preservation | Change Over Time | Natural Disaster Planning | Assessing Current Conditions | Improving Spatial Data Accuracy | Encroachment | Monitoring | Operations/Management | Harvesting/Managing Resources | Attractive Procurement Efficiencies |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forestry | | | X | | | | X | X | X | | X | X | X | X | | X | |
| Stormwater | | | X | X | | X | X | | | | X | X | | | X | | X |
| Transportation | X | X | X | | X | X | X | | | X | X | X | X | | X | | X |
| Wildlife Habitat | | | X | | | | X | X | | | X | X | X | X | | | X |
| Flood Management | | | X | X | | | X | | X | | X | X | | | | | X |
| Search & Rescue | | | X | | X | | X | | | X | | | | | X | | X |
| Agriculture | | X | X | | | | X | | X | | | X | X | X | | X | X |
| Emergency Response | | | X | | X | X | X | | | X | | X | | | X | | X |
| Utilities/Pipelines | X | | X | | X | X | X | | | X | | X | X | | X | | X |
| Fisheries | | | X | | X | | X | | | | | X | | X | | X | X |
| Municipal Government | X | X | X | X | X | X | X | | X | X | X | X | X | | X | | X |
| Economic Development | | X | X | | X | | X | | X | | X | X | | | | | X |
| Broadband | X | | X | | | | X | | | | | X | | | | | X |

Figure 9. Table of potential use cases.

Shaded teal squares indicate use cases that were studied and documented as part of this report.

By picking only three use cases for full analysis, it is ensured that the state will receive a very conservative estimate of benefits. If each and every potential use case was enumerated, it is safe to say that the State's ROI on orthoimagery would be substantially higher than the ROI on the subset of three use cases. The three priority use cases: forestry, stormwater management and transportation, were chosen in consultation with the State for their variety and overall relevance to Maine.

### 4.2.1 Forestry

Orthoimagery has been established and proven as a practical data source that provides a level of information detail suitable for detecting, identifying, interpreting, inventorying, and mapping forest tree stands, forest strata types, and associated attributes. It is a data source that provides a foundation for a consistent and reliable representation and analysis of the forest environment, including the interpretation of visible characteristics that allow for the delineation of stand boundaries and meaningful descriptive information for both commercial and ecological values of the forest.

### 4.2.2 Stormwater Management

Regulatory requirements to map stormwater systems, as part of stormwater management programs, include mapping above and below ground infrastructure with a goal of identifying all stormwater flows and discharges. Stormwater management also requires the ability to map and model land cover and land use characteristics as they affect stormwater runoff.

### 4.2.3 Transportation

Orthoimagery is a valuable and practical data source that provides transportation planners with a level of detail suitable for assessing current conditions and making informed decisions. In general terms, a transportation asset management program, supported by orthoimagery can:

- Monitor system condition, needs, and performance
- Clearly identify costs for maintaining and preserving existing assets
- Clearly identify public expectations and desires
- Directly compare needs to available funding, including operating and maintenance costs
- Define asset conditions so that decisions can be made on how best to manage and maintain assets

- Determine when to undertake action on an asset such as preservation, rehabilitation, reconstruction, capacity enhancement, or replacement.

## 4.3 STEP 2: IDENTIFIED SPECIFIC STAKEHOLDERS FOR CONTACT

Outreach for each use case, including interviews with subject matter experts and stakeholders, was conducted by the AppGeo team. Details are provided as part of the more detailed summaries for each use case, respectively. In addition, a list of interviews for each use case is provided as an Appendix to this report.

## 4.4 STEP 3: CALCULATED BENEFITS BASED ON INPUT FROM INTERVIEWS

For the Orthoimagery ROI Study, interviews were conducted based on use cases to develop quantifiable answers from respondents to inform benefit valuation. Examples of actual answers from the study include:

- **Cost Savings:** "I save about 2-4 hours per week on plot recon for forest management plans using orthos before I go out into the woods for timber cruising."
- **Better Results:** "When I'm in the woods, by avoiding obstacles and sensitive areas spotted during my recon using orthos, my productivity is higher for the number of trees per plot sample that I can get measured for harvest potential."

Other answers across the set of case studies suggested cost avoidance (e.g. better defense of legal cases) and revenue generation (e.g. fees from encroachment penalties) as additional benefits from the use of orthoimagery. Procedures for identifying and reaching out to respondents included in-person and telephone interviews, and e-mail correspondence. Defensible dollar values were used by the team so as not to overstate the value of orthoimagery for any particular use case.

## 4.5 STEP 4: SCALED RESULTS STATEWIDE

For the Forestry use case, benefits were calculated based on forestry activity and the related use of orthoimagery and then were scaled to represent the relative impact of these benefits in different regions of the state.

For Stormwater management, the municipal benefits calculated were scaled to represent all 29 Maine communities participating in the Municipal Separate Storm Sewer System (MS4) program. Private

sector benefits were scaled to represent all 36 civil engineering firms involved in stormwater management.

For Transportation, benefits calculated for the Maine DOT were considered to be statewide. Benefits calculated for the Greater Portland Council of Government were scaled to represent all of the Council of Governments potentially involved in orthoimagery procurement. Benefits calculated for private sector engineering firms serving the airport sector were scaled to represent all private firms in the state potentially achieving these benefits.

## 4.6 STEP 5: COMBINED BENEFITS AND COSTS FOR ALL THREE USE CASES

The combination of benefits for all three use cases, and the associated costs for the orthoimagery program were processed to yield a Return on Investment (ROI) using Cost-benefit Analysis (CBA) techniques. These techniques produced a net present value (NPV) dollar amount, and the terms for the ROI equation (benefits minus costs, divided by costs), to derive the ROI ratio for the orthoimagery project. The CBA techniques were based on the FGDC ROI Workbook methodology and the experience and knowledge of the consultants and their informants.

The final worksheet result brings together all information collected and calculated for each use case, to compare project costs to benefits over the 5 year project period; and it outputs the final "Net Present Value" and "Return on Investment" ratio. A detailed explanation of CBA, and the ROI calculation, is provided in the following section of this report.

# 5 COST-BENEFIT ANALYSIS (CBA) METHODOLOGY

This section describes the Cost-Benefit Analysis (CBA) Methodology used to estimate return on investment (ROI) for orthoimagery in the state of Maine. An Excel workbook was developed for each selected case study (i.e. Forestry, Stormwater, and Transportation). Each workbook contains several worksheets (tabs) which were used to estimate the benefits of using orthoimagery for the particular case study, and then perform a cost-benefit analysis, using cost data supplied by the state of Maine.

## 5.1 CONCEPTUAL DIAGRAM

The diagram below provides an overall conceptual view of CBA for orthoimagery in Maine. The items in teal are example use cases for estimating benefits. Benefits also accrue to applications that were not developed in the same detail as the ones in the fully-developed case studies. Care was taken not to double-count the benefits. The costs were provided by the state.

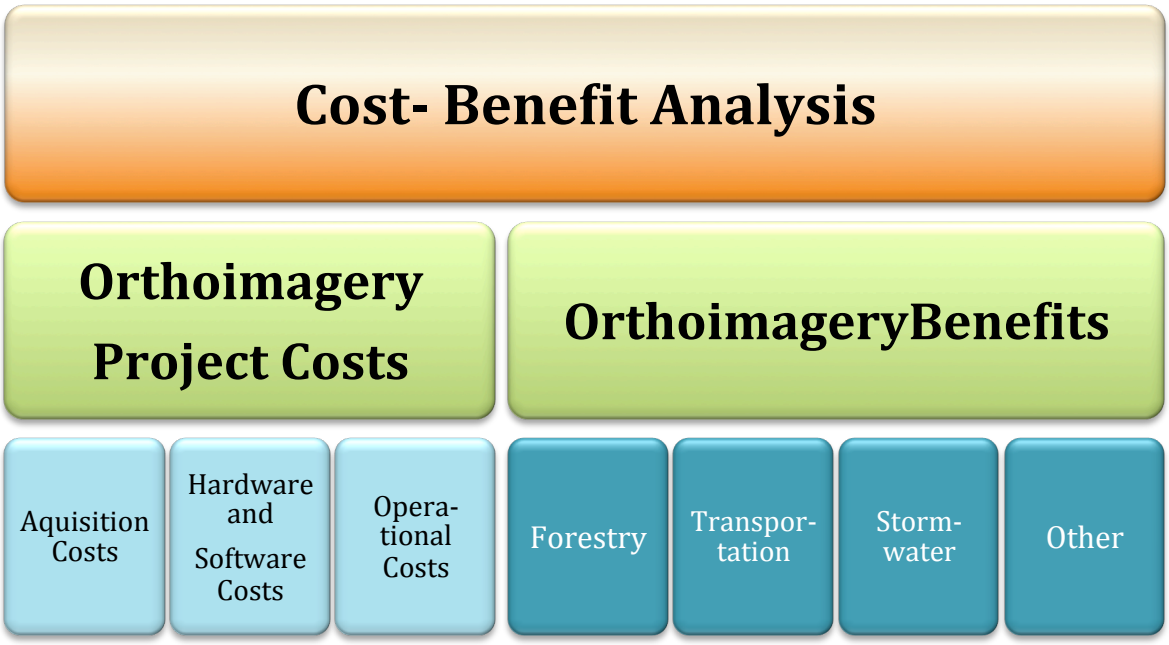



Figure 10. Conceptual diagram of Cost-Benefit Methodology

## 5.2 OVERVIEW

The methods described in this document for developing Return on Investment (ROI) metrics are based on CBA. CBA techniques, when properly applied, yield both a net present value (NPV) dollar amount,

and the terms for the ROI equation (benefits minus costs, divided by costs), to derive the ROI ratio for the project being analyzed. The level of effort associated with developing a comprehensive CBA is a significant part of the cost of developing a business case based on financial considerations.

ROI and CBA are briefly explained in the tutorial accompanying the **Strategic and Business Planning Guidelines** (FGDC/NSGIC, c. 2006) entitled "Economic Justification: Measuring Return on Investment (ROI) and Cost Benefit Analysis". A more in-depth explanation is included in the **ROI Workbook** (FGDC/GITA/AWWA, c. 2007), entitled "Building a Business Case for Geospatial Information Technology." Another reference, developed with support from the Library of Congress for building a business case for digital geospatial data preservation, is the "Geoarchiving Comprehensive Cost-Benefit Analysis Guidance," (December 2011). Further details on CBA are provided in the federal **OMB Circular A-94** (RE: Executive Order No. 12291, c. 1992), entitled "Guidelines and Discount Rates for Cost-benefit Analysis of Federal Programs." There are also a number of textbooks on CBA that were referenced during this study, including: Boardman et. al., Cost-Benefit Analysis (Prentice Hall 2011); Brent, Applied Cost-Benefit Analysis (Elgan Publishers, 2006); and Mishan, Cost-Benefit Analysis (Praeger Publishers, 1976). In addition, the recent King County Study by Richard Zerbe et. al., "An Analysis of Benefits from Use of GIS by King County, Washington" (Zerbe & Associates, 2012) was reviewed.

## 5.3 COMPONENTS OF COST-BENEFIT ANALYSIS

If stakeholders are to support investment at the enterprise level, they need to be convinced it is worthwhile, and that the justification is clear. The basic components to CBA are listed below and explained in subsequent paragraphs:

- Costs
- Benefits
- Time Period
- Inflation Rate
- Opportunity Cost of Capital
- Discount Rate
- Net Present Value
- Sensitivity Analysis
- Return on Investment (ROI) Calculation
- Opportunity Cost Analysis

### 5.3.1 Costs

Calculating costs is fairly straightforward as compared to benefits. Briefly, costs amount to the money that you must spend to establish the orthoimagery program, including data and product acquisition, hardware, software, and personnel. Their dollar value is a function of documented market prices and known compensation and expenses. The following items are representative of the basic costs:

- Staff costs (initial and recurring)
- Consulting support (if required)
- Initial Hardware and software costs
- System design and development costs
- Ongoing maintenance costs for software and hardware
- Ongoing operational costs for personnel
- Technology refreshment & modernization costs
- Ongoing program management costs
- Processing and storage costs
- Data acquisition costs

The costs of acquiring orthoimagery used in this study are based on a competitive procurement conducted by the state, with the duration of acquisition spread over 5 years at different frequencies of update, depending on the location and other factors. Other costs were estimated and provided by the state.

### 5.3.2 Benefits

While the dollar value of costs is a function of documented market prices and known compensation and expenses, the same cannot as easily be said of benefits. The main focus of this study was on enumerating defensible benefits, by asking subject matter experts to answer specific questions based on their experience, professional opinion, and prevailing views in the industry. For example, what is the estimated dollar value of the sample benefits listed below?

- Providing reconnaissance of forests for planning timber harvests
- Enabling better monitoring of threats to healthy forests and conservation easements

- Supporting policy development through the discovery and analysis of trends, cycles, changes, and other patterns in space and time dimensions

There is no directly observable market valuation that places a dollar amount on any of the benefits listed above. When there is no obvious value as a function of market prices, there are methods to make an estimate based on "shadow" prices. These methods include looking at observable markets for analogous things that can be measured (market analogies), or asking people for their opinions on what something is worth using various survey methods (contingent valuation), such as interviews.[5] In each case, some level of bias is unavoidable from either the researcher or the informant, or both; and it is hereby acknowledged as part of the process. Therefore, the benefits findings were intentionally kept conservative to balance any optimistic bias.

For the Orthoimagery ROI Study, interviews were conducted based on use cases to develop quantifiable answers from respondents to inform benefit valuation. Answers across the set of case studies suggested the following types of benefits:

- Time savings (e.g. more efficient field visits due to reconnaissance in advance)
- Higher quality results (e.g. increased harvest values from better planning)
- Cost avoidance (e.g. better defense of legal cases)
- Revenue generation (e.g. fees from encroachment penalties)

Procedures for identifying and reaching out to respondents include in-person and telephone interviews, and e-mail correspondence. To make the questions as realistic as possible, and to narrow-down the target population for garnering responses, case studies were developed for important statewide applications. Specifically, the following case studies were developed for this study:

- Forestry
- Stormwater
- Transportation

Once benefits were identified based on the case studies and interviews, they were entered into a spreadsheet. Depending on the professional opinion of the interviewer of the certainty of the information being collected, a probability factor could be applied to reduce the value of the calculated

[5] Boardman, Greenberg, Vining, and Weimer. Cost-Benefit Analysis Concepts and Practices: 4th Edition. Prentice Hall, Boston, 2011.

benefits accordingly. However, the calculated benefits were judged to be very conservative without factoring them down, and therefore, the probability factor for the estimated outcomes was assumed to be 100%. Examples are included to illustrate the methodology, which varied somewhat from case-to-case, to fit the findings. For example, not all case studies "scale" the benefits in the same way, given that they do not necessarily cover the same geographic areas or features of interest.

### 5.3.3 Time Period

To compare investment alternatives in terms of net present value (NPV) it is necessary to discount the future stream of benefits and costs for a certain time period. **The time period selected for the Maine Orthoimagery ROI project is 5 years**, even though the potential project life could be longer. This time horizon is based on the state's requirement to base justification for information technology projects on no-longer-than five years. Using the contractually specified "FGDC ROI Workbook"[6] as prescribed for this study, values also needed to be selected for inflation and the opportunity cost of capital, to be used in discounting.

### 5.3.4 Inflation Rate

There are a range of estimates on inflation, and as a result, a range of potential values. On the low-side, the US Treasury long-term averaged inflation index is .27% (www.treasury.gov ) – in fact, they are projecting negative inflation over the next 5 years (i.e., -1.22%). Many inflation-watchers base their estimates on the Consumer Price Index (CPI) from the US Bureau of Labor Statistics, which was estimated to be 2.3 % in April 2012 (www.bls.gov/cpi/). Most economists believe that the CPI tends to overstate inflation, since it is tied to large pension funds from which people get payments. In addition, inflation varies by type of expenditure, month, and geographic area.

**For the Maine Orthoimagery ROI, the inflation rate used in the cost-benefit analysis (CBA) is 2.3%.** Using a rate that is higher than CPI has the effect of more greatly discounting future benefits and costs. Since the benefits tend to accrue downstream from when the costs are incurred, this is a fiscally conservative posture.

[6] Building a Business Case for Geospatial Information Technology: A Practitioner's Guide to Financial Strategic Analysis. (a.k.a. "FGDC ROI Workbook") Copyright by Geospatial Information Technology Association (GITA) and American Water Works Association (AWWA) Research Foundation, 2007.

### 5.3.5 Opportunity Cost of Capital

The opportunity cost of capital (OCC) is equivalent to the return that investors could get if their dollars were not spent on the contemplated project, but instead, put into an alternative investment. Often, the interest rate that investors could earn in financial markets is the OCC value used in CBA. And, similar to inflation rates, interest rates will vary from lower to higher values; but since they are actually quoted to investors and borrowers as specific values, published interest rates are not contingent estimates.

On the low-end of interest rates are what banks use amongst themselves. For example, the current Federal Funds interest rate at which banks lend money to each other is .16%; and the Federal Reserve "prime" interest rate, which is charged to banks who borrow from the Fed, is .75% (www.federalreserve.gov ). The oft-quoted Wall Street Journal (WSJ) consensus "prime" interest rate, which banks charge their most favored customers, is currently 3.25% (www.wsj.com ) – many interest rates that consumers see are pegged to the WSJ rate. Most of these interest rates have been very consistent for several years.

**For the Maine Orthoimagery ROI, the interest rate used as the OCC in the CBA is 2.7%.** Although this is slightly less than the WSJ "prime" rate, it is more than many rates used for public investments, given the inherently conservative posture that is taken to minimize public risk. It is also significantly more than the investment yield on US Treasury Bills, which is currently quoted at .2 % for the 52 week bond or coupon equivalent (www.treasury.gov ), and higher than the average rate of .7% for a one-year certificate of deposit (CD) with a bank (www.bankrate.com ). Generally speaking, higher interest rates are associated with higher risk private investments. The selected rate of 2.7% assumes a positive return on alternative investments, after subtracting the inflation rate.

### 5.3.6 Discount Rate

Discount rates also vary. This is largely due to the use of different inflation and interest rates, in various combinations. The time to use a discount rate is when you want to calculate the present value (PV) of a future value, to convert the amount to equivalent current dollars. The US Office of Management and Budget (OMB) publishes a memorandum every year on discount rates to be used in cost-benefit analysis for federal programs. The memo goes to the heads of federal departments and agencies. The published OMB discount rate for 2012 is .4% for a 5-year project time horizon ("Discount Rates for OMB Circular No. A-94," Memorandum M-12-06, January 3, 2012, at www.whitehouse.gov/omb ).

| 3-Year | 5-Year | 7-Year | 10-Year | 20-Year | 30-Year |
|---|---|---|---|---|---|
| 0.0 | 0.4 | 0.7 | 1.1 | 1.7 | 2.0 |

Figure 11. 2012 Discount Rates for OMB Circular A-94.
Source: Executive Office of the President (Jan 3, 2012)

**For this CBA study, the combination of a 2.3% inflation rate and 2.7% interest rate result in a calculated discount rate of .39%.** This is approximately equivalent to the published OMB rate of .4% for projects of 5 year duration. These values are used to calculate the multiplier that is used in computing the present value (PV), and are shown in the following table.

| Factors for Discounting to Calculate Present Value (PV) | | | | | |
|---|---|---|---|---|---|
| Inflation Rate = i = | 2.30% | | | | |
| Opportunity Cost of Capital = c = | 2.70% | | | | |
| Discount Rate = (i-c)/(1+i) = r = | 0.39% | | | | |
| **Time Horizon** | | | | | |
| Year | 1 | 2 | 3 | 4 | 5 |
| t = | 0 | 1 | 2 | 3 | 4 |
| **PV Multiplier (PVM)** | | | | | |
| Workbook PVM = $((1+i)/(1+c))^t$ = | 100.00% | 99.61% | 99.22% | 98.84% | 98.45% |
| OMB PVM = $1/(1+r)^t$ = | 100.00% | 99.61% | 99.22% | 98.84% | 98.45% |
| Difference = | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Figure 12. Factors for discounting to calculate Present Value (PV)

### 5.3.7 Net Present Value

The Net Present Value (NPV) is the difference between the present value of benefits and the present value of costs. The future stream of benefits and costs is discounted in this calculation using the discount rate, which was previously discussed. The following equation and factors was used for this study:

$$\mathbf{NPV = \sum [(B_t - C_t) / (1 + r)^t]}$$

Notation: B = Benefits; C = Costs; r = discount rate; t = time period. The summation ∑ in the equation above is from t = 0 (the initial start-up of the program) to t = n (the final year of the program).

### 5.3.8 Sensitivity Analysis

By changing the time horizon and the discount rate in the NPV equation, different results will occur. Depending on the magnitude of changes to these numbers, the variation in results can be fairly substantial. Also, the benefits can be increased by researching more use cases and quantifying more value, or they can be factored down by applying or increasing probability factors to their likelihood. Overall, a conservative but realistic posture was taken when performing cost-benefit analysis for this study; and additional sensitivity analysis can be performed by the state to validate or change the choice of variables.

### 5.3.9 Return on Investment Calculation

The Return on Investment (ROI) for a given financial alternative is a ratio that indicates whether the investment results in more benefits than costs. The ROI result should be greater than zero for a program to be economically attractive. A sub-zero ratio may not automatically "kill" a project, because it may result in a required capability that does not currently exist. Not all government functions are required to have a positive ROI as they are in the business world, given that government is required to provide certain services and protection to the public.

The formula for calculating the ROI, using the results of the NPV calculations as inputs, is:

$$\frac{\text{Discounted Benefits - Discounted Costs}}{\text{Discounted Costs}}$$

### 5.3.10 Opportunity Cost Analysis

Although this study has factored-in the Opportunity Cost of Capital (OCC), it has not specifically compared the ROI for Orthoimagery Acquisition to actual alternatives for spending the same amount of money. This is because it is not common for other state programs to have a well-documented ROI, using the same standard methodology, as a basis for comparison.

# 6 ESTIMATING ORTHOIMAGERY PROJECT COSTS

The following image (next page) shows the spreadsheet used to estimate Orthoimagery project costs, taking into account acquisition, operational, and hardware/software costs.

## Maine ROI Study for Orthoimagery

**Project Costs Worksheet**

Applied Geographics, Inc.

**SHOWING GEOLIBRARY ORTHOIMAGERY SUBCOMMITTEE FIVE-YEAR COST & NPV ESTIMATES (ALL COSTS)**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | **Discount Rate = r =** | | 0.4% | **NPV=** | $Cost_t/(1+r)^t$ |
| | | | **(1+r)=** | 1.0040 | **t=** | {0,1,2,3,4} |
| **t=** | 0 | 1 | 2 | 3 | 4 | |
| **Cost Items** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **TOTAL** |
| Orthoimagery Acquisiton Costs | | | | | | |
| Section 1 | $135,643 | | | $135,643 | | **$271,286** |
| Section 2 | | $95,938 | | | $95,938 | **$191,875** |
| Section 3 | | | $131,261 | | | **$131,261** |
| Section 4 | $158,717 | | | | | **$158,717** |
| Section 5 | | $173,026 | | | | **$173,026** |
| Section 6 | | | $220,018 | | | **$220,018** |
| Section 7 | | | | $115,157 | | **$115,157** |
| Section 8 | | | | | $155,707 | **$155,707** |
| Section N1 | $92,492 | | | | | **$92,492** |
| Section N2 | | $258,214 | | | | **$258,214** |
| Section N3 | | | $275,928 | | | **$275,928** |
| **Acquisition Subtototals** | $386,852 | $527,177 | $627,207 | $250,800 | $251,645 | $2,043,681 |
| State Operating Costs | | | | | | |
| Data loading and handling | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | **$25,000** |
| Quality assurance | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | **$125,000** |
| OrthoViewer application tech suppport | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | **$25,000** |
| OrthoViewer application maintenance and upgrades | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | **$25,000** |
| Ongoing outreach and coordination | $10,000 | $10,000 | $10,000 | $10,000 | $10,000 | **$50,000** |
| Contract administration | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | **$25,000** |
| **Operating Subtotals** | $55,000 | $55,000 | $55,000 | $55,000 | $55,000 | $275,000 |
| Hardware & Software | | | | | | |
| Server costs, 4 year life-cycle | $20,000 | | | | $20,000 | **$40,000** |
| Hosting fees to State OIT | $14,000 | $14,000 | $14,000 | $14,000 | $14,000 | **$70,000** |
| Software upgrades | | | | | | **$0** |
| **Hardware and Software Subtotals** | $34,000 | $14,000 | $14,000 | $14,000 | $34,000 | $110,000 |
| **TOTALS:** | **$475,852** | **$596,177** | **$696,207** | **$319,800** | **$340,645** | **$2,428,681** |
| **NPV:** | **$475,852** | **$593,802** | **$690,670** | **$315,993** | **$335,249** | **$2,411,566** |

These are the total project costs that factor into the final Cost-Benefit Analysis worksheet.

| **Section Worksheet** | **Freq.** | **Res.** | **No. mi²** | **Cost/mi²** | **Iterations** | **Yr 1-5 $s** |
|---|---|---|---|---|---|---|
| Section 1 | 3 yrs | 2 ft | 2,569 | $52.80 | 2 | $271,286 |
| Section 2 | 3 yrs | 2 ft | 1,817 | $52.80 | 2 | $191,875 |
| Section 3 | 3 yrs | 2 ft | 2,486 | $52.80 | 1 | $131,261 |
| Section 4 | 5 yrs | 2 ft | 3,006 | $52.80 | 1 | $158,717 |
| Section 5 | 5 yrs | 2 ft | 3,277 | $52.80 | 1 | $173,026 |
| Section 6 | 5 yrs | 2 ft | 4,167 | $52.80 | 1 | $220,018 |
| Section 7 | 5 yrs | 2 ft | 2,181 | $52.80 | 1 | $115,157 |
| Section 8 | 5 yrs | 2 ft | 2,949 | $52.80 | 1 | $155,707 |
| Section N1 | 5 yrs | 3.3 ft | 1,911 | $48.40 | 1 | $92,492 |
| Section N2 | 5 yrs | 3.3 ft | 5,335 | $48.40 | 1 | $258,214 |
| Section N3 | 5 yrs | 3.3 ft | 5,701 | $48.40 | 1 | $275,928 |
| **TOTALS:** | | | **35,399** | | | **$2,043,681** |

The values in this section of the table feed into the annual section costs above.

Figure 13. Project costs worksheet explanation

# 7 ESTIMATING ORTHOIMAGERY PROJECT BENEFITS

## 7.1 FORESTRY HARVESTING BENEFITS EXAMPLE

The image below shows the spreadsheet used to estimate benefits of the Orthoimagery project for Forestry Harvesting, as an example. The total estimated Forestry benefits (next section) are based on estimated benefits for Harvesting *plus* Monitoring.

Maine ROI Study for Orthoimagery
**Forestry Use Case Benefits Worksheet**
Applied Geographics, Inc.

I. BENEFITS FOR FOREST **HARVESTING** SCENARIO

| Harvesting Benefit Category | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total |
|---|---|---|---|---|---|---|
| *Plot Sample Savings (Labor + Travel) "Low"* | $131,100 | $131,100 | $131,100 | $131,100 | $131,100 | $655,500 |
| *Plot Sample Savings (Labor + Travel) "High"* | $327,750 | $327,750 | $327,750 | $327,750 | $327,750 | $1,638,750 |
| *Increased Harvest Value "Low"* | $100,000 | $100,000 | $100,000 | $100,000 | $100,000 | $500,000 |
| *Increased Harvest Value "High"* | $500,000 | $500,000 | $500,000 | $500,000 | $500,000 | $2,500,000 |
| ***Total Harvesting "Low"*** | **$231,100** | **$231,100** | **$231,100** | **$231,100** | **$231,100** | **$1,155,500** |
| ***Total Harvesting "High"*** | **$827,750** | **$827,750** | **$827,750** | **$827,750** | **$827,750** | **$4,138,750** |

The values in this table are based on high/low final values coming from section A and B.

Use "Low" and "high" values for sensitivity analysis.

A. PLOT SAMPLE SAVINGS WITH ORTHOIMAGERY

*General Information*

| | | | |
|---|---|---|---|
| Number of acres managed per year for harvest | 500,000 | | |
| Number of **plot samples** per harvest (one plot sample per 5 acres) | 100,000 | | |
| Cost per per plot sample | $45 | | |
| Harvest Plot Sample Total Cost (Approx) | $4,500,000 | | |

*Plot Sample Requirements Overview*

| | | | |
|---|---|---|---|
| Typical number of plots per day per forester (Hi/Med/Lo) | 25 | 22.5 | 20 |
| Number of plots per week per forester | 125 | 112.5 | 100 |
| Number of Forester weeks needed to complete plot samples | 800 | 889 | 1000 |
| Number of Foresters per harvest year working on plots | 15 | 17 | 19 |
| Typical cost of professional forester per hour | $75 | | |
| Typical cost of professional forester per week | $3,000 | | |
| Estimated cost per harvest for plot samples (labor only) | $2,400,000 | $2,666,667 | $3,000,000 |

*Plot Sample Improved Recon - Labor Costs Saved*

Hours saved per week per forester from use of orthos for plot recon:

| | | |
|---|---|---|
| "Low" | 2 | hours |
| "High" | 4 | hours |
| Consulting Rate for Professional Forester Per Hour | $75 | |

| | | | |
|---|---|---|---|
| Labor Savings per Harvest "Low" | $120,000 | $133,333 | $150,000 |
| Labor Savings per Harvest "High" | $240,000 | $266,667 | $300,000 |

*Plot Sample Improved Recon - Travel Costs Saved*

Mile saved per week per forester from use of orthos for plot recon:

| | | |
|---|---|---|
| "Low" | 25 | miles |
| "High" | 50 | miles |
| Travel Cost Per Mile | $0.56 | |

| | | | |
|---|---|---|---|
| Travel Savings per Harvest "Low" | $11,100 | $12,333 | $13,875 |
| Travel Savings per Harvest "High" | $22,200 | $24,667 | $27,750 |

TOTAL PLOT SAMPLE SAVINGS WITH ORTHOIMAGERY

| | | | |
|---|---|---|---|
| **Plot Sample Savings (Labor + Travel) "Low"** | $131,100 | $145,667 | $163,875 |
| **Plot Sample Savings (Labor + Travel) "High"** | $262,200 | $291,333 | $327,750 |

B. INCREASED HARVEST VALUE WITH ORTHOIMAGERY

*General Information*

| | | |
|---|---|---|
| Number of Harvest Acres per year | 500,000 | |
| Total Harvest Value (mill value less logging and trucking costs) | $159,665,000 | *Source: MFS Estimates 2010 Stumpage Reports* |
| Harvest Value per acre (pre-mill) | $319 | |
| Harvest value of 500,000 acres per year | $22,500,000 | |

*Increase Harvest Value*

Increased value of harvest per 5 acres per year based on better recon due to orthoimagery

| | | |
|---|---|---|
| "Low" | $1 | $.20 per acre |
| "High" | $5 | $1.00 per acre |

| | |
|---|---|
| **Increased Harvest Value "Low"** | $100,000 |
| **Increased Harvest Value "High"** | $500,000 |

The final values for each section (A and B) are highlighted in blue, and feed into the summary table at the top.

Figure 14. Benefits for forest harvesting as sample worksheet

## 7.2 BENEFITS SUMMARY

The worksheet below displays the final estimated totals benefits, “Low” and “High”. In this example, it only contains estimated benefits to Forestry. Other use cases would be filled in as the benefits are determined, which was done for Forestry, Stormwater, and Transportation later in this report.

**Maine ROI Study for Orthoimagery**

**Use Case Benefits Summary Worksheet**

Applied Geographics, Inc.

**SHOWING ESTIMATED BENEFITS BASED ON ACTUAL USE CASES**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Discount Rate = r = | 0.4% | NPV= | Benefit$_t$/(1+r)$^t$ |
| | | | (1+r)= | 1.0040 | t= | {0,1,2,3,4} |
| t= | 0 | 1 | 2 | 3 | 4 | |
| **Use Cases "Low" Benefit Values** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **TOTAL** |
| Stormwater | $1,975,896 | $1,975,896 | $1,975,896 | $1,975,896 | $1,975,896 | **$9,879,481** |
| Transportation | $416,010 | $266,250 | $266,250 | $416,010 | $266,250 | **$1,630,770** |
| Forestry | $231,100 | $231,100 | $231,100 | $231,100 | $231,100 | **$1,155,500** |
| Wildlfe Habitat Modeling | | | | | | **$0** |
| Floodplain Boundaries | | | | | | **$0** |
| Search & Rescue | | | | | | **$0** |
| Agricultural Management | | | | | | **$0** |
| Forest Fire Fighting | | | | | | **$0** |
| Fisheries | | | | | | **$0** |
| Pipelines/Utilities | | | | | | **$0** |
| Emergency Response (MEMA & Guard) | | | | | | **$0** |
| Municipal Efficiency | | | | | | **$0** |
| Economic Develoment | | | | | | **$0** |
| Water & Sewer Infrastructure Planning | | | | | | **$0** |
| **TOTALS:** | **$2,623,006** | **$2,473,246** | **$2,473,246** | **$2,623,006** | **$2,473,246** | **$12,665,751** |
| **NPV:** | **$2,623,006** | **$2,463,393** | **$2,453,578** | **$2,591,780** | **$2,434,067** | **$12,565,824** |

| **Use Cases "High" Benefit Values** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **TOTAL** |
|---|---|---|---|---|---|---|
| Stormwater | $5,226,852 | $5,226,852 | $5,226,852 | $5,226,852 | $5,226,852 | **$26,134,258** |
| Transportation | $712,140 | $487,500 | $487,500 | $712,140 | $487,500 | **$2,886,780** |
| Forestry | $827,750 | $827,750 | $827,750 | $827,750 | $827,750 | **$4,138,750** |
| Wildlfe Habitat Modeling | | | | | | |
| Floodplain Boundaries | | | | | | |
| Search & Rescue | | | | | | |
| Agricultural Management | | | | | | |
| Forest Fire Fighting | | | | | | |
| Fisheries | | | | | | |
| Pipelines/Utilities | | | | | | **$0** |
| Emergency Response (MEMA & Guard) | | | | | | **$0** |
| Municipal Efficiency | | | | | | **$0** |
| Economic Develoment | | | | | | **$0** |
| Water & Sewer Infrastructure Planning | | | | | | **$0** |
| **TOTALS:** | **$6,766,742** | **$6,542,102** | **$6,542,102** | **$6,766,742** | **$6,542,102** | **$33,159,788** |
| **NPV:** | **$6,766,742** | **$6,516,037** | **$6,490,077** | **$6,686,186** | **$6,438,466** | **$32,897,508** |

These “Low” and “High” benefit totals feed into the final Cost-Benefit Analysis worksheet.

Figure 15. Use case benefits worksheet explained

## 7.3 ORTHOIMAGERY COST-BENEFIT ANALYSIS

The final worksheet brings together all information collected and calculated in the previous worksheets to compare project costs to project benefits over the 5 year period, and outputs the final "Net Present Value" and "Return on Investment" ratio. There is only a single input on this worksheet for "Discount Rate", which is used to discount future costs and benefits into the present context. The discount rate can be determined using the following table. In the context of this analysis, which is based on 5 years, the real discount rate (adjusted for inflation) is 0.4%.

**Maine ROI Study for Orthoimagery**

**Cost-Benefit Analysis**

Applied Geographics, Inc.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **Discount Rate = r** | 0.4% |
| **Cost-Benefit Analysis - "Low"** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **TOTAL** |
| Benefits Summary - "Low" | $2,623,006 | $2,473,246 | $2,473,246 | $2,623,006 | $2,473,246 | $12,665,751 |
| Cost Summary | $475,852 | $596,177 | $696,207 | $319,800 | $340,645 | $2,428,681 |
| Discounted Benefits - "Low" | $2,623,006 | $2,463,393 | $2,453,578 | $2,591,780 | $2,434,067 | $12,565,824 |
| Discounted Costs | $475,852 | $593,802 | $690,670 | $315,993 | $335,249 | $2,411,566 |
| **NET PRESENT VALUE** | **$2,147,154** | **$1,869,591** | **$1,762,908** | **$2,275,787** | **$2,098,818** | **$10,154,258** |
| **Return on Investment (ROI) "Low"** | **4.21** | If this result is greater than "0" it is favorable for investment | | | | |
| **Cost-Benefit Analysis - "High"** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **TOTAL** |
| Benefits Summary - "High" | $6,766,742 | $6,542,102 | $6,542,102 | $6,766,742 | $6,542,102 | $33,159,788 |
| Cost Summary | $475,852 | $596,177 | $696,207 | $319,800 | $340,645 | $2,428,681 |
| Discounted Benefits - "High" | $6,766,742 | $6,516,037 | $6,490,077 | $6,686,186 | $6,438,466 | $32,897,508 |
| Discounted Costs | $475,852 | $593,802 | $690,670 | $315,993 | $335,249 | $2,411,566 |
| **NET PRESENT VALUE** | **$6,290,889** | **$5,922,235** | **$5,799,407** | **$6,370,193** | **$6,103,218** | **$30,485,942** |
| **Return on Investment (ROI) "High"** | **12.64** | If this result is greater than "0" it is favorable for investment | | | | |

Figure 16. Cost-Benefit Analysis Worksheet

This document explains the Cost-benefit Analysis (CBA) Methodology used to estimate return on investment (ROI) for orthoimagery in the state of Maine. An Excel workbook was developed for each selected case study (i.e. Forestry, Stormwater, and Transportation). Each workbook contains several worksheets (tabs) which were used to estimate the benefits of using orthoimagery for the particular case study, and then perform a cost-benefit analysis, using cost data supplied by the state of Maine.

# 8 USE CASES

## 8.1 FORESTRY

Maine's forests are valuable resources with important economic and environmental value to the citizens and businesses of the state, as well as visitors who come for vacation. For example, harvestable timber, scenic beauty, outdoor recreation, cultural and historical attributes all generate economic value while creating jobs and revenue in the forest-based economy of Maine. The well-being of communities and industries in Maine depends upon good forest management to yield sustainable benefits from these forest attributes, including both commercial and ecological values. Good data are needed to optimize these efforts, including orthoimagery for reconnaissance to support both harvesting and monitoring of the forests.

**FOREST FACTS.** The following information relates to the importance of the forestry use case for orthoimagery in Maine, and was compiled from a variety of sources (see list in Appendix "E"):

- There are over 17 million forested acres in Maine – around 90% of the total land area
- Maine has the most contiguous forested area of any state east of the Mississippi
- When forested area is compared to total area, Maine is the most densely forested state in the United States
- Ownership of forest land in Maine is approximately 59% corporate forest industry and large investors; 33% family ownership; 5% public ownership; and 3% other ownership
- Maine can claim the largest contiguous and largest non-contiguous conservation easements on forest lands in the nation
- Northern, Western, and Eastern "megaregions" have average forest parcel size greater than 1000 acres
- Probability of a "Management Plan" by a professional forester estimated to be 50% or greater when parcel ownership exceeds 1000 acres
- The parcelization and fragmentation of forests is increasing in areas where forests are being converted to developed uses

**STATE FORESTRY GOALS:** The Maine Forest Service stated seven (7) specific goals in the "Maine State Forest Assessment and Strategies" document, 18 June 2010, as follows:

- Keeping forests as forests
- Improving and diversifying markets
- Protecting forests from harm
- Maintaining healthy trees and woodlands in urban and community areas
- Maintaining the capacity of the Forest Service as an institution to serve the citizens of Maine
- Increasing the environmental literacy of Maine citizens
- Maintaining and enhancing forest biodiversity

### 8.1.1 What Comprises "Forestry" in This Context?

For this study, forestry was split into two sub-cases: harvesting and monitoring. Each sub-case has characteristics that support splitting the benefits from using orthoimagery into separate entities for quantifying. (Their unique properties support their separation into two different sets of quantifiable characteristics) In general terms, harvesting is producing timber and revenue from the trees, whereas monitoring describes observing and assessing the growth and health of the forests for a multitude of purposes, including sustainability. These two sub-cases are not mutually exclusive; but for purposes of measuring benefits, they have different metrics to consider.

1) **Harvesting: Producing timber and revenue from trees**

- About 500,000 acres of timber are harvested in Maine annually
- Orthoimagery is beneficial as initial reconnaissance information for preparation in advance of field visits, but not for detailed species identification and measurement
- It saves time by enabling more efficient timber cruising through planning and reconnoitering in advance of going into the forest
- Before an area is harvested, it is visited by foresters for tree measurements and plot sampling
- Current orthoimagery helps improve decision-making on where to collect measurements and collect plot samples

- ★ Current imagery can also help reduce the number of plot samples for inventories, based on interpretation and scaling of forest strata types
- ★ Orthoimagery helps to locate access routes (e.g. roads), obstacles (e.g. beaver flowages), and sensitive areas (e.g. vernal ponds)
- ★ Good backdrop for other data (e.g. Land Use Regulation Commission "LURC" polygons of sensitive areas)

2) **Monitoring: Observing and assessing forest health to support sustainability**

- ★ Statewide extrapolation based on patterns identified through analyzing data that is captured with remote sensing and ground surveys
- ★ In 2011, approximately 14.3 million acres were monitored under state and federal programs (approximately 72% of total land area) using available orthoimagery, including the National Agriculture Imagery Program "NAIP" data
- ★ Orthoimagery is good for conservation easement work, such as finding encroachments
- ★ Visual interpretation and coarse classification of forest landscapes can be done with orthoimagery, but not species identification to a forester's satisfaction
    - Crown measurement and broad typing (i.e. hardwood vs. softwood)
    - Remote change detection and reconnaissance (e.g. spotting things without being in the field)
- ★ Use in hand-held devices that are taken into field
- ★ Use in tablets that are taken into the air for sketch mapping
- ★ Presentation support (public meetings and management meetings)
- ★ Holistic, synoptic overview of an area
- ★ Assessing access routes and obstacles to field work
- ★ Reference material or backdrop for forest research and health monitoring:
    - Habitat analysis (e.g. forest gaps and edges)
    - Finding disturbances and infestations
    - Assessing storm damage

- Carbon studies

### 8.1.2 Why is Orthoimagery Important to Forestry?

Orthoimagery and its application across the state helps maintain and improve the long-term viability of the forest-based economy in Maine. It helps answer the question, **"**How much forest do we have, and what is its type and condition?" Many stakeholders engaged in forestry need to know the answer to this question to support their decision-making and business processes, for example: harvesting timber; forest health monitoring and research; or state assessments to delineate priority rural and urban forest landscape areas for state resource strategy and policies.

**BRIEF DESCRIPTION.** Orthoimagery is a proven and a practical data source that provides detailed information that is valuable for reconnaissance of forest tree stands, forest strata types, and associated attributes. It can also be used as a visual backdrop or basemap onto which other information is overlaid. It is a data source that provides a foundation for a consistent and reliable representation and analysis of the forest environment, including the interpretation of visible characteristics that allow for the delineation of forest types (i.e. hardwood or softwoods), general condition, and other descriptive information for both commercial and ecological values of the forest. This is valuable for both assessing current forest health and productivity, and monitoring long-term conditions and detecting change.

**STAKEHOLDERS AND INTERESTS OR GOALS:**

| APPLICATION STAKEHOLDERS | |
|---|---|
| **Application Stakeholders** | **Interests or Goals** |
| Maine Forest Service | State agency responsible for state forest assessment and strategy for Maine's goals, issues, and opportunities related to forest resources; includes urban and community forestry programs, too |
| North East State Foresters Association (NEFA) | NEFA is the state foresters of Maine, New Hampshire, Vermont and New York cooperating with the USDA Forest Service State and Private Forestry |
| USDA Forest Service | Representing the federal interests in the nation's forest resources |
| Subject Matter Experts | For example, forestry photo-interpretation analysts, professional foresters, consulting foresters |
| Timber Investment Management Organizations (TIMO) | The primary responsibility of TIMOs are to find, analyze and acquire investment properties that would best suit their clients, and to actively managing the timberland to achieve adequate returns for the investors; most of Maine's large industrial landowners have been replaces by TIMOs |

| APPLICATION STAKEHOLDERS | |
|---|---|
| **Application Stakeholders** | **Interests or Goals** |
| Forest Land Managers | These provide forest management services to TIMOs and other customers |
| Small Woodland Owners Association (SWOAM) | There are more than 120,000 small woodland owners in Maine, people who own between 10 and 1,000 acres of forest land; these landowners own more than 5.5 million acres, or 33% of Maine's woodlands; SWOAM promotes sound forest management to strengthen long-term woodland stewardship |
| Municipalities | Local government resource managers |
| Forest Products Companies | These companies manufacture forest products aside from pulp and paper, e.g., sawmill owners; interested in the reliable and sustainable supply of forest resources |
| Pulp and Paper Companies | These companies manufacture pulp and paper products; interested in the reliable and sustainable supply of forest resources |
| Keeping Maine's Forests | Keeping Maine's Forests brings together a diverse coalition of interests who believe forest conservation must strengthen economic, ecological, recreational, community, and tribal benefits to sustain Maine's forest-based economy |
| Nature Conservancy | The Nature Conservancy is the leading conservation organization working around the world to protect ecologically important lands and waters for nature and people. Recently, they collaborated with the Forest Society of Maine and Plum Creek on a massive easement pact in the Moosehead Lake region to protect 363,000 acres. |
| Forest Society of Maine | The Forest Society of Maine (FSM) is a statewide land trust particularly focused on protecting and conserving large tracts of Maine's North Woods. Its mission is to conserve Maine's forestlands in a manner that sustains their ecological, economic, cultural, and recreational values. |
| University of Maine's Cooperative Forestry Research Unit (CFRU) | The University of Maine's Cooperative Forestry Research Unit (CFRU) conducts applied scientific research in order to provide Maine's policy makers and forest landowners with the information necessary to ensure both sustainable forest management practices and effective public policy. |

### 8.1.3 How is Orthoimagery Applied to Forestry?

Orthoimagery supports analytical applications that are beneficial to forestry. As mentioned previously, for the purposes of this ROI study, applications are divided into two major sub-cases (i.e. harvesting and monitoring). The following tables describe these applications for both harvesting and monitoring, respectively.

| HARVESTING | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| FOREST STAND CLASSIFICATION<br>▪ Species identification<br>▪ Structure (crown form and cover)<br>▪ Age and growth stages<br>▪ Size and height<br>▪ Stand boundaries<br>▪ Contrast with adjacent stands<br>▪ Location of gaps in forest canopy<br>▪ Timber cruising and plot sampling | While useful for reconnaissance work before entering the field to perform timber cruising and plot sampling, orthoimagery is generally not used for detailed species identification and associated measurements. It is useful for broad typing, such as determining if an area is mostly hardwoods or softwoods; overall structure characterization; and edge and gap detection. Foresters doing species identification and measurement prefer to use stereoscopic imagery and plot sampling on the ground. The preference is for "first blush" imagery (i.e. when the leaves are just coming into bloom), as compared to leaf-off (the state's planned imagery) or leaf-on (the USDA NAIP imagery). Forest land managers who pay to have their areas flown typically hire an aerial survey firm to get this done once every five years for their overall area, and perhaps more frequently for special project areas. |
| HARVEST PLANS<br>▪ Pre-harvest inventories<br>▪ Location of logging roads and other transport<br>▪ Location of saw mills and other commercial resources<br>▪ Protection of hydrological, cultural, and environmentally significant features<br>▪ Landing and skid trail planning, construction, and maintenance<br>▪ De-activation activities | Orthoimagery is useful for assessing access routes and obstacles for harvesting timber and getting it to processing facilities while protecting sensitive areas and conservation easements. It is also valuable for inventory applications, potentially reducing the number of plot samples by doing imagery interpretation and scaling of forest strata types. |

| MONITORING | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| FOREST HEALTH MONITORING<br>▪ Recording of manmade disturbances:<br>○ Burning<br>○ Logging<br>○ Tree poaching<br>○ Encroachment<br>▪ Insect infestation (e.g. spruce budworm)<br>▪ Deforestation and degradation of habitat<br>▪ Weather damage<br>▪ Urban tree inventories | Orthoimagery is useful for spotting signs of disturbances. It is a useful backdrop for "sketch map" applications, where aerial reconnaissance from a plane is used by an observer to "sketch" areas where defoliation, discoloration, or dead trees can be seen from the air. For identifying insect infestation, the ideal imagery is taken between mid-June and mid-July – a very narrow window of time. Weather damage assessment and other forms of change detection require imagery for both before and after; and, relatively close in time to when the change event occurred. Forest health monitoring is a major program within the USFS, providing support to states for annual surveys, including Maine. |
| BIODIVERSITY STUDIES | Orthoimagery is useful for the study of forest landscape characteristics that correlate to types of habit and associated species. It is often used in combination with field work. |
| MONITORING EASEMENTS FOR ENCROACHMENT | Orthoimagery is beneficial for seeing signs of encroachment in areas with conservation easements, without having to walk or drive every mile of an easement. It does not totally replace the need for field investigations. |
| ASSESS FOREST CHANGE AND CONVERSION TO DEVELOPED USE | As population increases, the need for land increases. Also, as the population ages and deaths occur, the subdividing of land between heirs typically occurs, leading to a fragmentation of forest land. Orthoimagery is a useful data source to detect changes in land use and land cover due to these factors. |

**MAIN ACTORS.** The following *human* actors perform mapping and assessment of forests using orthoimagery:

- Image analyst or interpreter
- Forestry business process owner and decision-maker (e.g. managers of forest lands or concessions)
- Professional forester or consulting forester
- Woodlot owner
- Resource economist
- Wildlife biologist
- Entomologist
- Planner
- Land developer

The following *system* actors are used to perform mapping and assessment of forests using orthoimagery:

- GIS system
- Orthoimagery applications
- Recent imagery with sufficient resolution
- Access to imagery and other geospatial data (e.g. web services)

**DATA DEPENDENCIES.** The following data is needed to perform mapping and assessment of forest areas, and it needs to be less than 5 years old (unless depicting historic data for change detection):

| DATASET | PURPOSE IN USE CASE | AUTHORITATIVE DATA SOURCE |
|---|---|---|
| Orthoimagery | Needed for large area reconnaissance for broad typing and planning field work, and as a backdrop to other types of data | Federal, State, Local, & Private |
| Land Use | Needed as basis for analyzing changes in land-use over time | State & Local |
| Hydrography | Used for locating stream networks and watersheds | State |
| Transportation | Needed for timber harvest plans and market studies | State, Local, & Private |
| Elevation | Indicator of species type and location | Federal, State, Local, & Private |
| LiDAR | Intensity images and point cloud to identify species and measure height and volume, and bare earth elevation models | Federal, State, Local, & Private |

### 8.1.4 What if Orthoimagery Was Not Available for Forestry Applications?

In addition to orthoimagery derived from airplane fly-overs, imagery from satellites is also used for forestry applications. However, it is not a direct substitute for aerial imagery due to its typically lower spatial resolution; but it is sometimes useful for its spectral resolution, particularly for forest monitoring applications.

The state currently makes several sources of orthoimagery available through the MEGIS Data Catalog, including statewide NAIP imagery from USDA. While useful for forestry applications, it is less than ideal, and is not considered a replacement for higher resolution, more frequent imagery. Nonetheless, it is valuable to foresters with no alternatives. Larger private companies require something better than NAIP.

Sources of imagery such as Google Maps and Microsoft Bing Maps are widely available, but they are generally a collection of images from multiples sources and timeframes, collected from both publicly funded and proprietary sources. These commercial websites are popular for general purposes – not specific applications such as forestry. Similar to NAIP, such imagery is useful to foresters with no alternatives, but not adequate for more demanding requirements.

### 8.1.5 What Benefits Accrue from Using Orthoimagery for Forestry Applications?

**MAIN BENEFITS.** The main types of benefits for forestry include: 1) time savings when on the ground based on better preparation related to finding access routes and avoiding obstacles and sensitive areas; and, 2) higher quality results afforded by reconnaissance in advance of field work, to focus attention on high-probability areas for finding the target trees or disturbances, depending on what is being hunted. How these specifically relate to harvesting and monitoring is described, below.[7]

- **Harvesting**
  - About 500,000 acres of timber are harvested in Maine each year
  - A rule-of-thumb is 1 plot sample for every 5 acres, or about 100,000 per year for harvest planning

[7] Details on numerical values and calculations are included in spreadsheets prepared for this study, and delivered separately from this report. Tables derived from these spreadsheets are included in the appendices.

- Potentially, the number of necessary plot samples for inventorying can be reduced, based on the interpretation of forest strata types from imagery, and then scaling-up the interpretation – this potential savings was not quantified as part of this study
- A forester generally completes about 20-25 plot samples per day
- A professional forester's consulting rate is approximately $600 per day, or $75/hour
- The number of "forester weeks" needed for the annual plot sampling for harvest acres is approximately 500 to 625 weeks, of the equivalent of 10-12 full-time foresters
- The volume of wood harvested in Maine in 2010 was 14.5 million green tons
    - Pulpwood: 8.5 million green tons
    - Biomass: 3.5 million green tons
    - Sawlogs: 700 million board feet
- The total harvest value in 2010 was approximately $159.7 million
- The approximate harvest value per acre was $319 in 2010

## TIME SAVING BENEFITS

*Estimates for time* ***savings range from 2-4 hours per forester per week, based on 20-25 plots per forester per day***[8]*, using current orthoimagery for reconnaissance before going into the woods*

- ★ At 2 hours less time per week and *20 plots per day* per forester, the commensurate savings from orthoimagery are: **Low estimate of $131,100 per yr.**
- ★ At 4 hours less time per week and *25 plots per day* per forester, the commensurate savings are: **High estimate of $327,750 per yr.**

[8] A forester's productivity may vary depending on site conditions, expertise, and motivation.

## HIGHER QUALITY RESULTS: INCREASED HARVEST VALUE BENEFITS

- *Annual estimates for increased value based on using current orthoimagery for reconnaissance range from **$100 -$500 per 1000 acres***
- Increased value for 500,000 harvested acres / year on low-end of range ($0.20 / acre): **Low estimate of $100,000**
- Increased value for 500,000 harvested acres / year on high-end of range ($1.00 / acre): **High estimate of $500,000**

- **Monitoring**
  - In 2011, approximately 14.3 million acres were monitored under state and federal programs (approximately 72% of total land area)
  - For a conservative estimate of benefits from using orthoimagery, the following assumptions are made:
    - Monitoring will lag imagery acquisition by a year
    - All areas that get covered by imagery will be monitored for one reason or another (e.g. forest health, biodiversity, carbon storage, insect infestations, storm damage assessment, and other examples of forest research and assessment)
    - To be conservative, annual benefit accruals cover an area that on average is approximately one-third of what is actually monitored
    - Marginal demand for orthoimagery decreases as it gets older, but it retains positive value for change detection when comparing snapshots over time

### TIME SAVING BENEFITS

- *While it is a fair assumption that the availability of orthoimagery results in time savings associated with field visits for forest monitoring,* ***none of the subject matter experts were able to comfortably quantify this time savings****, so no specific benefits were included in this category for the monitoring part of the benefits calculation for the forestry use case.*

### HIGHER QUALITY RESULTS BENEFITS

*Conservative estimates range from* ***$10-$15 of benefits per square mile from improved monitoring results*** *across all types of forest research and assessment (not including the plot sampling benefits for the annual harvest, which are measured separately)*

- Average estimated value, annually; since only a portion of the total square mileage will have new orthoimagery each year, the estimates are factored down based on the assumption that monitoring activity will decrease as the imagery ages, although there will be some level of monitoring and change detection:
    - ***Low estimate $70,038***
    - ***High estimate $105,057***

## 8.2 STORMWATER

Regulatory requirements to map stormwater systems, as part of stormwater management programs, include mapping above and below ground infrastructure with a goal of identifying all stormwater flows and discharges. Stormwater management also requires the ability to map and model land cover and land use characteristics as they affect stormwater runoff.

Phase II of NPDES (National Pollutant Discharge Elimination System) stormwater program applies to MS4 (Municipally Separated Storm Sewer System) communities and anyone disturbing between 1 acre and 5 acres of soil. The following towns in Maine are considered MS4 communities because they operate separated storm sewer facilities: Auburn, Bangor, Berwick, Biddeford, Brewer, Cape Elizabeth, Cumberland, Eliot, Falmouth, Freeport, Gorham, Hampden, Kittery, Lewiston, Milford, Old Orchard

Beach, Old Town, Orono, Portland, Sabattus, Saco, Scarborough, South Berwick, South Portland, Veazie, Westbrook, Windham, and Yarmouth. Additionally, the Maine DOT and Maine Turnpike Authority operate separated storm sewer facilities throughout the state of Maine and both are affected by similar requirements to NPDES Phase II.

In addition to MS4 owners and operator, there are a large number of entities in the state which discharge non-ground water flows to the State's waters. These discharges include stormwater runoff which can affect water quality of surface and ground water supplies due to pollutants and erosion due excessive volumes and rates of stormwater runoff.

**STORMWATER FACTS.** The following information relates to the importance of the stormwater use case for orthoimagery in Maine:

- There are 1,379 Multi Sector General Permit (MSGP) holders in Maine
- MSGPs typically are for industrial activities discharging stormwater to state waters
- Of the 1,379 MSGPs, 711 need to be inspected annually to ensure that the terms of the permit holder's stormwater management plan are being met and to provide technical assistance to permit holders
- 28 of the 711 MSGP holders are municipalities that own or operate separate storm sewer systems
- MS4s are defined as a separate storm sewer system including many means of stormwater conveyance such as, but not limited to streets, roadway drainage systems, catch basins, curbs, gutters, ditches, storm drains, and human-made channels, but not publicly owned treatment works and combined sewer systems
- MS4s are owned and operated by Maine municipalities, sewer/sewerage districts, the Maine Department of Transportation (MEDOT), Maine Turnpike Authority (MTA), State and Federal agencies, and any public entity that discharges other than ground water directly to waters of the state
- MSGPs encompass municipal and industrial discharges of sanitary waste water and process water from industrial or commercial activities

- Stormwater management is increasingly important to mitigate the transport of pollutants from developed areas of watersheds, which are typically but not always impervious surfaces, to public water bodies
- Orthoimagery provides information about volume and rate of stormwater runoff from developed areas which aids in management and documentation of erosion, storm related damage and water quality issues

**STATE STORMWATER GOALS:** The Maine Department of Environmental Protection (MEDEP) and local government agencies pursue stormwater management for a variety of reasons including aiding in the protection of surface and groundwater resources and management of stormwater runoff from developed areas of Maine. Before state programs were set in place for stormwater management, municipalities dealt with the issues themselves. Their primary concern is to ensure stormwater facilities are designed properly to transport stormwater away critical areas. The State of Maine received delegated authority under the National Pollutant Discharge Elimination System (NPDES) program of the Federal Clean Water Act to administer permit requirements associated with NPDES. As such, the goals of their program have moved beyond simply transporting stormwater runoff to:

- Protecting and restoring surface and groundwater resources impacted by stormwater runoff
- Mitigating pollution carried by stormwater runoff from developed areas into receiving water bodies
- Managing the rates and flows of stormwater runoff from developed areas of a watershed to impacted water bodies elsewhere within the watershed
- Increasing the awareness of stormwater related impacts and issues to the general public, the business community, and throughout state and local government agencies
- Eliminating and tracking illicit discharges

### 8.2.1 What Comprises "Stormwater" in This Context?

For this study, stormwater issues involving the use of orthoimagery were examined at the state, municipal, and private sector levels. The stormwater use case study looked at how orthoimagery aided stormwater management activities within MEDEP, in a large municipality (the City of Portland), a small municipality (the Town of Hampden), and in the services offered by a private sector consulting firm (FB

Environmental Associates, Inc ) impact each organization. In general, orthoimagery is a valuable tool which enables each interviewed orthoimagery user to gain large scale as well as small scale perspectives on stormwater management conditions immediately and efficiently. Common themes among the individuals interviewed were:

- The use of orthoimagery to inspect and measure critical aspects of a site without the need to travel to the site in person, saving money from avoided travel in the field
- The ability to view numerous sites from an office before traveling to the sites for more in depth ground observations, increasing the effectiveness of field visits with more thorough understanding of site conditions
- As a photograph, orthoimagery presents a less subjective view of a site then for example, a map, which may not represent recent conditions
- Assists with making more equitable calculations of impervious areas when mapping the size of impervious areas
- Enables more work to be done given existing staff and resources when compared to the alternatives of hardcopy maps and photos, as well as more expensive photogrammetrically captured topographic mapping

### 8.2.2 Why is Orthoimagery Imagery Important to Stormwater

Orthoimagery has a demonstrated role as an efficient and effective stormwater management tool when applied to stormwater management in the state for the ongoing protection of water resources from runoff pollution, erosion, and ineffective land use policies. Due to the fact that stormwater management requires the ability to see what is happening across a watershed as well as what is occurring at specific sites within the watershed, orthoimagery can be used to depict land use activities which can help or hinder water quality issues. Few other geospatial tools can provide the clarity and resolution that orthoimagery provides to users to answer questions about what is going on in the landscape and at both a macro and micro level.

Current, high resolution, leaf-off orthoimagery data sets are informative to public and private sector decision-makers. Viewable aerial image data have all the inherent characteristics and ease of understanding of a photograph. They can answer the what, where, and how's of what is occurring in our

statewide landscape as it affects the state's water in the form of a photomap. The photomap or orthoimagery supports the accurate depictions of ground features and reliable measurement of mapping data for the location, length and extent of ground features affecting stormwater runoff and water quality.

**BRIEF DESCRIPTION.** Orthoimagery and its ongoing creation and renewal across the state helps maintain and improve a valuable and practical mapping tool to assess and record existing conditions that affect stormwater management in every corner of the state. In rural and urban areas, the ongoing availability of orthoimagery data sets supports private and public sector decisions about stormwater management issues which affect surface and ground water quality, such as erosion, flooding, land cover mapping, and development activities. It helps answer questions posed by regulators and private sector land development professionals such as, "where the new building site going and what is are its impacts on the nearby water bodies?" Many stakeholders engaged in stormwater management need to know the answer to this question to support their decision-making, for example: with regards to Federal, State and local regulations and business decisions; for better site selection of new developments; as a cost effective large scale and common digital base map of Maine; as an illustration of current conditions as of a certain date; as a means to map open space and land cover types; and to provide publicly available data to support public and private business processes related to stormwater management.

**STAKEHOLDERS AND INTERESTS OR GOALS:**

| APPLICATION STAKEHOLDERS | |
|---|---|
| **Application Stakeholders** | **Interests Or Goals** |
| MS4 Communities | Individually responsible for implementing the regulations at the municipal level, implementing best management practices (BMPs), as well as operating, maintaining, and constructing sewer and storm water infrastructure |
| ILSG (Inter-local Stormwater Group) for Cumberland County | Regionally responsible for implementing the regulations at the municipal level and implementing BMPs in Cumberland County |
| BASWG (Bangor Area Stormwater Group) | Regionally responsible for implementing the regulations at the municipal level and implementing BMPs in the greater Bangor area |
| Maine DEP | Implement delegated federal regulations (EPA) for Maine |
| Cumberland County Soil and Conservation District | Maintain subject matter expertise. Facilitate Inter-local meetings and manage aspects of the summer intern program |
| EPA (Region 1) | Federal Regulator |
| Municipal Stormwater (MS4) Utility | Collect fees to help build, operate, and maintain storm sewers. Ensure equitable fee assessment |

| APPLICATION STAKEHOLDERS | |
|---|---|
| Local water districts | Maintain awareness of water-quality protection issues |
| Engineering Consultants | Increase business; calculate impervious surfaces for clients; write stormwater management plans; provide CAD and text-based data to stormwater authorities about reduction and increases in impervious areas on individual development sites |
| Maine DOT | Manage stormwater from Maine DOT storm sewers statewide |
| Maine Turnpike Authority | Manage stormwater from Maine Turnpike Authority storm sewers for the length of the Maine Turnpike (over the 100 hundred miles) |

### 8.2.3 How is Orthoimagery Applied to Stormwater?

Orthoimagery supports a variety of analytical applications that are beneficial to stormwater. These applications are described below.

| STORMWATER MANAGEMENT | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| SUPPORT FOR MAPPING OF UTILITY ASSETS AND FEATURES | Orthoimagery is used daily as an image background. Map visible storm and sewer infrastructure (manhole covers, catch basin covers, detention ponds, visible, channels/ditches, outfalls, etc.), open space, water resources, and to identify obvious visible wetlands. Additionally, new orthoimagery allows monitoring of previously mapped features for detecting feature changes in successive years in which orthoimagery is collected. New orthoimagery is also used to update out of date mapping to reflect changes on the ground such as new developments. |
| CALCULATE IMPERVIOUS SURFACE AREAS | Derive impervious cover from orthoimagery. In some cases such as Lewiston the assessments are made on each individual parcel. In Augusta however, the assessment is carried out by use of an ERU (Equivalent Residential Unit) method that assumes one residential lot equals one ERU. ERU calculations are based on a study conducted several years ago that established the percentage of imperviousness for a typical residential parcel. The main impediment to use of orthoimagery to assist with ERU calculation or site-specific impervious assessments is the age |

| STORMWATER MANAGEMENT | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| | of most orthoimagery datasets. Its age becomes a liability to its use to support equitable assessments the older it gets. Other municipalities are looking at creating stormwater utilities in the coming years. |
| RESOLVE DISPUTES AND APPEALS OF CURRENT ASSESSMENTS | Orthoimagery is viewed as an important tool to better assess impacts to current sewer and storm sewer capacity and any future assessment calculations. This reduces costs to the general public and public agencies during the initial calculation and appeals of impervious areas. |
| SUPPORT AND VALIDATE TAXPAYER INQUIRES | Show lay people and non-technical audiences how various GIS data layers relate to features visible in aerial imagery (i.e. orthoimagery combined with easements/boundaries and buried infrastructure). |

**MAIN ACTORS.** Typically, stormwater management is the responsibility of the Public Works, Engineering, and/or Streets and Utility departments. Sometimes, a multi-town organization, such as the Greater Augusta Utility District, is responsible.

The following roles use orthoimagery to perform mapping and assessment of impervious areas for managing stormwater and assessment of stormwater utility fees:

- Municipal or Water District GIS technician
- Municipal or Water District CAD technician
- Tax Assessor's Office
- Engineering consultant

**PRE-CONDITIONS/PREREQUISITES.**

- **Recent imagery with sufficient resolution** - Municipalities support sewer-engineering activities with available state imagery when it has sufficient resolution or currency. However, in cases where the imagery was deemed too coarse or too out of date individual towns would purchase new imagery for their specific local government business needs.
- **Access to imagery** - In house copies are often more efficient to use than strictly relying on a web-mapping service (WMS). Actors will download local copies of imagery data depicting areas they use and access on a regular, frequent basis.
- **Established business processes –** A requirement for review and creation of stormwater related data within a municipality or utility district.
- **Orthoimagery program exists** – The municipalities would consider the use of State sponsored imagery programs in lieu of town-sponsored efforts, as long as the programs are predictably funded, and can accommodate "buy-up" options for existing users who have specific local agency resolution requirements or other data needs.

### 8.2.4 What if Orthoimagery Was Not Available for Stormwater Applications?

Orthoimagery used for stormwater applications typically comes from data collected by aircraft, and not from satellites. This is primarily due to the ability of aircraft based imagery acquisition to be collected at lower altitudes yielding higher resolution imagery and to collect imagery more readily in a leaf-off condition. Satellite based imaging platforms have less flexibility, due their orbits, in their ability to collect

imagery during the narrow leaf-off window each spring in the Northeastern United States. This narrow time period is in the spring when the snow has melted, the leaves have yet to come out, and there are no clouds in the sky. Satellite based orthoimagery is useful for its ability to provide multispectral imagery data for general land cover classification exercises on a large, watershed wide basis. This sort of data allows large areas of the state to be classified by varying land cover types. Land cover data serves an important role in modeling and monitoring the impact of stormwater runoff at the state and regional levels.

Low resolution orthoimagery captured in a leaf-on state is less useful to stormwater management because many of the details about land use and man-made features affecting stormwater runoff are not visible due to low resolution imagery and leaf canopies. Imagery sources such as the USDA's NAIP program, Google's Google Earth, and Microsoft's Bing Maps are good supplemental imagery sources for stormwater management, but are captured for more general mapping purposes and at the wrong time of the year to resolve details obscured by extensive tree canopies found in the state. In the case of the NAIP program, while it has been acquired about every 2-3 years, its need to be collected at the height of the growing season for agriculture assessment purposes makes it less suitable for stormwater related mapping uses.

Traditionally aerial photography from aircrafts has been the mainstay of orthoimagery at the county and local level in the state. Such projects require imagery to be captured during a specific and narrow time frame each spring when conditions are just right to collect imagery in a leaf-off state and with an absence of snow cover. Combine this with the need to capture imagery on cloudless days and at higher resolutions, typically referred to as ground sample distances (GSD), and only aircraft have proven reliable and flexible enough to wait out the weather and fly at low enough altitudes to capture the detailed orthoimagery needed to address local stormwater management mapping needs.

Prior to the advent of widespread orthoimagery data during the 1990's and early 2000's, mapping data detailed enough to support stormwater modeling and management issues was created through photogrammetric based topographic mapping and hardcopy aerial photos. While very detailed, photogrammetric based topographic mapping is a more expensive and labor intensive method of creating detailed mapping data. The use of hardcopy aerial photos in the state goes back several decades further, but they too are less useful than orthoimagery as they don't provide the same level of utility in present day GIS software. Hardcopy aerial photo prints are less accurate due to their

uncorrected nature and are a physical, non-digital data source not easily utilized in mapping software such as GIS.

At higher GSDs found in many orthoimagery datasets captured by aircraft, typically in the range of 0.25ft to 1 ft GSD (i.e. 3 in. to 12 in. GSD), there is enough resolution to reveal land use details, the extent and size of impervious areas, and utility structures in the resulting orthoimagery. These details are paramount when trying to discover what is affecting water quality data and where the nearest infrastructure and man-made improvements are in relation to a given water body. The NAIP program's 1 meter GSD and leaf-on requirement make it generally ill-suited to applications involving the mapping of features affecting stormwater runoff. Similarly even though Google Earth and Bing Maps are widely available and sometimes at higher resolutions than the NAIP program provides, their imagery is created for more general purposes and are captured whenever it is convenient during the spring to fall timeframe. In many cases this orthoimagery has simply been recycled from already publicly available imagery captured at the regional and local level. Thus efforts like NAIP, Google Earth and Bing Maps should not be considered a replacement for higher resolution and leaf-off orthoimagery developed at the state or local level.

### 8.2.5 What Benefits Accrue from Using Orthoimagery for Stormwater Applications?

**MAIN BENEFITS.** The main types of benefits for stormwater management are: 1) Time savings over alternative methods trying to meet more regulatory oversight with existing or shared resources; and, 2) Efficiency gains from the use of orthoimagery to give individuals involved with stormwater management a detailed impression of remote sites without always traveling to multiple sites hours each day. This study looked at costs at high and low estimates to better account for seasonal shifts encountered in stormwater management activities. In regard to stormwater utilities, there is growing interest in establishing such bodies to equitably cover operational costs of publicly owned and operated separate storm sewer systems. This allows for the large contributors of stormwater runoff to contribute to the public costs of maintaining and operating stormwater infrastructure on a more equitable basis and remove some of the burden from those with a low impact on stormwater runoff.

- ★ **<u>Main Success Factors</u>**
  - Improved stormwater management and the attainment of regulators' goals
    - There are 3 full-time inspectors in the MEDEP Stormwater Program who each annually inspect between 170 to 200 permit holders annually

## TIME SAVINGS BENEFIT

- ★ At 1 to 4 hours of orthoimagery use per day, the Stormwater Program saves **between $67,095 and $357,840 annually** over using alternative mapping data
- ★ Municipal officials working under MS4 permit requirements utilize orthoimagery as well for about 1 to 4 hours daily, saving **between $6,213 and $24,850 annually**.

- Reduction in costs for administering, maintenance, operation, and construction that are borne by the local stormwater authorities and land developers
    - In a typical, larger MS4 town, municipal officials are able to use orthoimagery based data to meet the MS4 requirements for an estimated 1.5 times less than non-orthoimagery based methods would allow

## LOWER COST BENEFITS

- ★ The same multiplier can be applied to smaller MS4 towns to account for similar saving in Maine's 28 MS4 communities: Statewide this savings would **ranges $173,964 to $695,800 in lower costs** to municipal operations associated with being an MS4 permit holder

- Availability of effective (accurate and complete) geospatial data to map stormwater infrastructure and points of interest

## EFFICIENCY GAINS

- ★ MS4 permit holders use orthoimagery to map stormwater infrastructure proactively (e.g. manholes, catch basins, culverts, etc.) and on an as-needed basis to address specific issues; efficiency gains using orthoimagery for such activities range from a low of **$12,425 to a high of $49,700** each year. Across the state's 28 MS4 permit holders that amounts to an aggregate of **$347,900 to $1,391,600 worth of efficiency gains** related to orthoimagery use in meeting the requirements of the MS4 permits.

- Two recent statewide stormwater related projects conducted by an environmental consulting firm used between $15,000 and $30,000 worth of orthoimagery based upon the time and value of the imagery as a way to cost effectively provide the requested services to their client. If such imagery was provided by the state for all needs, services could be rendered more affordably by consulting firms.

- Reduced number of trips to perform field assessment and better preparation for field work before arriving on site
  - On a typical water quality research project in Maine, an environmental consulting firm saves about 4 hours per project per stream through orthoimagery based pre – planning, determining access points, and examining visible land use characteristics.

★ **Qualitative Benefits**

- Accurate assessment of impervious areas within a jurisdiction
- Perception of fairness of equitable assessments
- Reduced/avoided appeals from reliable, up to date, and defensible assessments which are based on current aerial imagery
- Availability of current data as basis for calculating assessments
- Reduced number of trips to perform field assessment and investigations

## 8.3 TRANSPORTATION

The demands on Maine's transportation network are greater than ever with an increase in average miles traveled, a growing population, greater congestion, aging infrastructure and escalating operating costs. Orthoimagery supports these demands on asset management and helps to minimize the life-cycle costs for managing and maintaining transportation assets, including roads, bridges, tunnels, rails, roadside features, and airports.

**TRANSPORTATION FACTS.** The following information relates to the importance of the transportation use case for orthoimagery in Maine:

★ Maine has population of 1.3 million people

★ Maine covers 2,295 square miles and contains over 2,000 coastal islands

- Maine contains 1,400 miles of Railroad tracks
- Maine has three major sea ports – Portland, Searsport and Eastport which are open year round and rely on freight rail and highway connections
- Maine has six commercial airports and more than 60 small public airports. Maine's largest airport, the Portland International Jetport, transports about 1.7 million passengers per year
- The State of Maine has 23,450 miles of public roadway, more miles per person than any other New England state
- 78% of the $32.4 billion worth of commodities delivered annually from sites in Maine are transported by trucks on the state's highways
- From 2009 to 2018, the Maine Department of Transportation (Maine DOT) estimates that $6.5 billion will be needed to improve road and bridge conditions, relieve congestion and enhance safety and economic development. However, during that time, only $3.2 billion will be available under current funding, leaving a funding shortfall of $3.3 billion
- Driving on roads in need of repair costs Maine motorists $286 million a year in extra vehicle repairs and operating costs – $285 per motorist
- 32% of Maine's major roads are in poor or mediocre condition
- 34% of Maine's bridges are structurally deficient or functionally obsolete
- 91% of Maine's major roads are two lanes. Nationally, 76% of fatal crashes occur on two lane roads
- An average of 178 people were killed each year in crashes on Maine's roads from 2004 to 2008. Improving safety features on Maine's roads and highways would likely result in a decrease in traffic fatalities in the state. Roadway design is an important factor in approximately one-third of fatal and serious traffic accidents
- Roadway conditions are a significant factor in approximately one-third of traffic fatalities. There were 169 traffic fatalities in 2005 in Maine
- Vehicle travel in the state is expected to increase by 20% by 2025. Commercial trucking in Maine is projected to increase by 28% by 2020

- Maine's 488 municipalities, 16 counties, and 3 reservations have winter road maintenance responsibility for approximately 81% of the total road mileage
- Annual cost of clearing winter roads is $98 million dollars total or $76 per person
- Average annual snowfall in Maine ranges from 45 inches by the coast to up to 121 inches in higher latitudes and altitudes

### 8.3.1 What Comprises "Transportation" in This Context?

Orthoimagery has wide reaching uses and benefits for transportation-related activities. For the purposes of this study, the transportation discussion is limited to the use of orthos for road inventory maintenance, site delineation and reconnaissance, and private sector support for airport engineering and planning. There are certainly additional quantifiable benefits that could be demonstrated if the study were expanded to cover all benefits realized for transportation. For the private sector alone, if time savings were scaled to account for all engineering firms focused on transportation, not just airport transportation, the benefits would potentially be quadrupled. In keeping with the conservative approach to benefits calculation, transportation benefits and this corresponding use case narrative are limited to the areas where informants had particular experience and expertise.

### 8.3.2 Why is Orthoimagery Important to Transportation?

**BRIEF DESCRIPTION.** Orthoimagery is a valuable and practical data source that provides transportation planners with a level of detail suitable for assessing current conditions and making informed decisions. In general terms, an asset management program, supported by orthoimagery can:

- ★ Perform site delineation and reconnaissance with less field work.
- ★ Track system condition, needs, and performance.
- ★ Clearly identify costs for maintaining and preserving existing assets.
- ★ Clearly identify public expectations and desires.
- ★ Directly compare needs to available funding, including operating and maintenance costs.
- ★ Define asset conditions so that decisions can be made on how best to manage and maintain assets.
- ★ Determine when to undertake action on an asset such as preservation, rehabilitation, reconstruction, capacity enhancement, or replacement.

**STAKEHOLDERS AND INTERESTS OR GOALS:**

| APPLICATION STAKEHOLDERS | |
|---|---|
| **Application Stakeholders** | **Interests or Goals** |
| Maine Turnpike Authority | Quasi-state agency responsible for the management, maintenance, and operation of the state toll highway from Kittery to Augusta |
| Maine Port Authority | Quasi-state agency responsible for developing transportation facilities that allow the intermodal movement of people and cargo in support of statewide economic development |
| Timber Companies | Companies reliant on the State's transportation network for the distribution and sales of timber |
| Private Firms (DeLuca-Hoffman, Hoyle Tanner, AMEC, VHB) | Transportation oriented consulting and engineering firms that support transportation planning activities at the local and state level |
| Maine DOT | State agency responsible for efficiently and effectively preserving and maintaining Maine's existing transportation system, maximizing operational efficiencies, and expanding economic opportunity through transportation investments |
| Portland International Jetport | Responsible for the operations, maintenance, infrastructure planning and management at the state's busiest airport |

| APPLICATION STAKEHOLDERS | |
|---|---|
| **Application Stakeholders** | **Interests or Goals** |
| Municipalities | Local governments responsible for local transportation planning and asset management activities |
| Forest Products Companies | Manufacturers of forest products aside from pulp and paper reliant on the state's transportation system for the distribution of products. |

### 8.3.3 How is Orthoimagery Applied to Transportation?

Orthoimagery supports analytical applications that are beneficial to transportation in the State of Maine. The following tables describe these applications as a communication tool, as a site assessment and planning tool, and as a source for important derived data such as the road network throughout the State.

| TRANSPORTATION | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| COMMUNICATION & INFORMATION GATHERING TOOL<br>• Support for public meetings and presentations<br>• Visual description of site location and delineations including distances, obstructions, and proximity to other features<br>• Context and background for viewing other features such as parcels and roads<br>• Support for land acquisition decision making<br>• Rights of Way (ROW) mapping<br>• Context and visual information for use in web-based GIS viewers<br>• Encroachment detection | Orthoimagery serves as a communication tool providing context and details not otherwise available. Whether communicating site location and delineation details to field crews or sharing project information at a public meeting, orthoimagery tells the story more effectively than words or diagrams are able to. When viewed with other vector data layers such as parcels or roads, the impact is even greater as it gives context to these already rich and important data sets and provides powerful decision-making tools for land acquisition efforts.<br><br>Currently the ME DOT has 75 users accessing the GIS viewers, including the orthoimagery, on a daily basis. These users are able to rapidly collect the information they need, create a customized site map, and send the information to the citizen or colleague. Orthoimagery enhances these web-enabled tools and makes this process efficient and effective. |
| | |

| TRANSPORTATION | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| PLANNING & SITE ASSESSMENT<br>• Pre-project site reconnaissance and site measurement<br>• Response to public inquiries and complaints<br>• Confirmation of compliance with NEPA requirements<br>• Support for transit studies<br>• Project cost estimating<br>• Project cost reduction<br>• Bicycle and pedestrian route planning | Orthoimagery is useful for reconnaissance work before entering the field to perform site assessment or in response to a public inquiry or complaint. Field work is typically required to confirm compliance with NEPA requirements, as well as collect project site measurements and observe potential project obstructions. With orthoimagery, much of this field work can be avoided. As initial site assessment can be conducted efficiently, this often results in more accurate project cost estimates, both internally and from consultants as well as and better decisions about project approach. Orthoimagery can actually reduce cost estimates by significantly reducing the effort required during planning and conceptual phases. |
| DATA MAINTENANCE & ASSET MANAGEMENT<br>• Road network maintenance<br>• Bus routes, bus stops/shelter, sidewalk, and curb data maintenance<br>• Quality Control for asset data collected in field<br>• Access points<br>• Verify airport pavement markings<br>• Airport pavement inventory<br>• Transportation asset management | Without access to orthoimagery, the state's road network would be maintained solely through the field collection of GPS points. Orthoimagery can accurately identify the location of new roads and driveways thus supporting the maintenance of the road network and inventory of access points. A more accurate inventory of access points allows better safety planning as the likelihood of an accident increases with every new access point on a road and increased accidents results in increased cost for the state. |
| OPERATIONS & MAINTENANCE<br>• Road network maintenance<br>• Bus routes, bus stops/shelter, sidewalk, and curb data maintenance<br>• Quality Control for asset data collected in field | Orthoimagery is useful to operations and maintenance at the DOT and the international and regional airports in Maine providing important context and detail to support facility and vegetation management. Current orthoimagery is also essential to the development of a Common |

| TRANSPORTATION | |
|---|---|
| **Requirement** | **Use of Orthoimagery** |
| • Access points<br>• Verify airport pavement markings<br>• Airport pavement inventory<br>• Transportation asset management | Provides "Common Operational Picture" (COP) for emergency response. |

**MAIN ACTORS.** The following *human* actors perform transportation planning, operations, maintenance, and or asset management using orthoimagery:

- ★ Image analyst or interpreter
- ★ Transportation planner (public and private sector)
- ★ Decision-maker
- ★ Field crew member
- ★ Facility manager
- ★ Engineer

The following *system* actors are used to perform transportation planning and asset management activities using orthoimagery:

- ★ GIS system
- ★ Orthoimagery applications
- ★ Asset Management Tracking Software
- ★ Web viewer

**WORKFLOWS AND ACTIONS.**

- ★ Inventory and describe new transportation features
- ★ Accurately location and delineate new transportation features
- ★ Assess current conditions of transportation features

- Evaluate features in proximity to transportation network that may impact the operational decisions and or planning decisions related to that particular area

**PRE-CONDITIONS/PREREQUISITES.**

- Recent imagery with sufficient resolution
- Access to imagery and other geospatial data

**DATA DEPENDENCIES.** The following data is needed to support transportation planning and asset management. To be relevant and useful, these data must be less than 5 years old:

| DATASET | PURPOSE IN USE CASE | AUTHORITATIVE DATA SOURCE |
|---|---|---|
| Orthoimagery | Needed to assess current infrastructure | Federal, State, & Local |
| Land Use/Land Cover | To assess vegetation management requirements | State, & Local |
| Conservation and/or Environmentally Sensitive Land | To assess proximity to transportation right-of-ways and delineate areas requiring special vegetation management activities. | State, & Local |
| Transportation | For delineating current infrastructure, tracking assets and associated descriptive information about type, ownership, maintenance history, construction materials, etc. | Federal, State, & Local |
| Elevation | For transportation network planning | State, & Local |
| LiDAR | To further assess current infrastructure | Federal, State, & Local |

### 8.3.4 What if Orthoimagery Was Not Available for Transportation Applications?

Without access to current and reliable orthoimagery, transportation requirements described above would often require extensive and expensive ongoing field work to collect data, assess current conditions and track transportation-related infrastructure. While these in-field assessments and information gathering activities could be shared among stakeholders, the information would be of varying quality and accuracy due to the "piece-meal" method of collection. Decision makers trying to assess and plan, maintain and operate a statewide resource would not have access to a consistent, reliable statewide "picture" of current conditions. Without orthoimagery, information sharing within and outside of transportation organizations would be cumbersome, time consuming, and less effective. Even widely available sources of imagery such as Google Maps and Microsoft Bing Maps are generally a

collection of images from multiples sources and timeframes and would not provide a reliable basemap for transportation planning, maintenance or operations.

### 8.3.5 What Benefits Accrue from Using Orthoimagery for Transportation Applications?

**MAIN BENEFITS.** The main benefits for transportation-related applications are(1) time savings through reduced number of field visits, more efficient communication, and expedited data collection and (2)enhanced planning and decision making tools through improved basedata providing valuable contextual information as well as more accurate and up to date derived data sets such as the State's road network. Additional time and cost savings are achieved as a result of the recurring statewide program as mobilization, administration, and quality control efforts are consolidated. The statewide program will also result in significant reduction of time spent planning for and administering the many individual procurements across the state.

- Accurate inventory of current transportation network
- Availability of accurate and complete orthoimagery and other geospatial data
- Successful asset management that results in the proper allocation of resources required to maintain the current transportation infrastructure
- Support at public meetings
- Communication tools
- Improved data accuracy and completeness
- Support for project planning and cost estimating
- Support for land assessment and acquisition
- Support for access management (resulting in fewer traffic accidents)

The following benefits have been quantified and used in the Cost Benefit Analysis calculations:

1. Use of Orthoimagery to support maintenance of statewide road inventory
    a. The State's road inventory is maintained as a road centerline layer. Prior to the availability of orthoimagery, all new roads were captured through field GPS.

b. New road field GPS capture required 1 full time staff person

c. Average loaded salary of GPS field crew member equals $45,000

d. Number of GIS staff using orthoimagery to maintain road inventory using orthoimagery equals 8

e. GIS staff use orthoimagery to perform their job functions approximately 50% of their time

**TIME SAVINGS FOR MAINTENANCE OF STATEWIDE ROAD INVENTORY**

★ Resulting value of orthoimagery equals salary of 1 full time field crew member or an approximate **savings of $45,000 of per year**

2. Time savings through improved communication tools

   a. ME DOT staff are required to communicate detailed site information internally in order to prepare field crews as well as answer public inquiries and communicate effectively at public hearings.

   b. ME DOT staff members are saving, on average, an estimated 1-2 hours per week as a result of improved communication and information gathering tools made possible through access to orthoimagery.

**TIME SAVINGS THROUGH IMPROVED COMMUNICATION TOOLS**

★ With 75 ME DOT staff members accessing orthoimagery through web-based GIS viewers at a conservative cost of $21.63 per hour, this results in a cost **savings between $84,375,000 and $168,750 annually.**

3. Time savings through avoided trips to the field

   a. ME DOT field crews are required collect information about project sites including location, surroundings, potential obstructions, and delineations.

   b. These activities are conducted on a daily basis, if not multiple times each day

   c. On average, a site visit takes about 3 hours to complete.

d. With orthoimagery, many of these site visits can be eliminated resulting in a time savings of 260 to 520 hours per year.

**TIME SAVINGS THROUGH AVOIDED TRIPS TO THE FIELD**

★ At an average hourly rate of $21.63, these time savings result in **cost savings of $16,875 to $33,750 annually.**

4. Avoided coordination costs for regional or municipal based orthoimagery acquisition

   a. There are 8 regional entities that have conducted individual orthoimagery capture during the past 10 years.

   b. Coordination of such a program, including education and outreach, management of buy-ups, procurement, quality control, planning and communication requires approximately 25% of one full-time staff person for six months (or 200-300 hours for each flight)

   c. This results in a cost of $18,720 to $28,080 with an hourly loaded rate of $90.

**TIME SAVINGS THROUGH STREAMLINED PROCUREMENT**

★ If the coordination cost for one flight is scaled across the 8 regional entities that conduct these projects, the statewide cost is **between $149,760 to $224,640 every 3 years.**

5. Private sector use of orthoimagery for airport transportation planning

   a. Orthoimagery provides greatest value at proposal and concept stages of projects which are, on average, 5% of a project budget.

   b. The average engineering project cost is $50,000.

   c. A conservative estimate of the number of projects that can benefit from orthoimagery annually at a private sector firm is 6-12.

   d. This results in a cost savings of $15,000 to $30,000 annually.

## TIME SAVINGS FOR PRIVATE SECTOR PROJECT WORK

- ★ There are approximately 8 private sector firms comparable to DeLuca-Hoffman performing airport transportation planning in the State of Maine. If project cost savings are scaled up to account for these additional firms, the **cost savings statewide is $225,000 to $450,000.**

# 9 FINDINGS

The following table incorporates the discrete results from each of the individual use cases, including Forestry, Stormwater, and Transportation, as well as combined results. There is both a low estimate and high estimate of the potential benefits, and both estimates use the same costs for the statewide orthoimagery program. All costs are included in the analysis, but only a subset of benefits, which is economically conservative.

It is worth noting that the investment in statewide Orthoimagery acquisition could be justified based on the ROI for the Stormwater use case, alone; and the high estimates on ROI for both Forestry and Transportation are above zero, which is also favorable for investment. When the benefits for all three use cases are combined and compared to the given cost for the program, the business justification for investment is considerably stronger.

| USE CASE | BENEFITS (Lo/Hi) | NPV | ROI |
|---|---|---|---|
| *Stormwater* | $9,879,481 | $7,389,507 | 3.06 |
| | $26,134,258 | $23,515,278 | 9.75 |
| *Forestry* | $1,505,690 | ($918,398) | (.38) |
| | $4,664,035 | $2,214,596 | .92 |
| *Transportation* | $1,630,770 | ($793,144) | (0.33) |
| | $2,886,780 | $453,194 | 0.19 |
| **Combined** | **$12,665,751** | **$10,154,258** | **4.21** |
| | **$33,159,788** | **$30,485,942** | **12.64** |

Figure 17. Comparison of benefits for all three programs.

When combined, the calculated benefits from the use of orthoimagery for Forestry, Stormwater, and Transportation applications range from approximately $10 million on the low-end to $30 million on the high-end across five years. This range compares very favorably to the expected costs for the corresponding five-year time period of $2.4 million. The resulting return on investment (ROI) is projected to be 4.21 to 12.64 based on this range, which would exceed the returns on many other potential financial investments. If all thirteen use cases were similarly analyzed, it is safe to say that the total ROI would be substantially higher, since the benefits would increase while costs stayed the same; but a conservative posture has been taken. The following table combines the results of the three

selected use cases, showing both benefits and costs, and the calculated Net Present Value (NPV) and ROI.

**Maine ROI Study for Orthoimagery**

**Cost-Benefit Analysis**

Applied Geographics, Inc.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | Discount Rate = r | 0.4% |

| Cost-Benefit Analysis - "Low" | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
|---|---|---|---|---|---|---|
| Benefits Summary - "Low" | $2,623,006 | $2,473,246 | $2,473,246 | $2,623,006 | $2,473,246 | $12,665,751 |
| Cost Summary | $475,852 | $596,177 | $696,207 | $319,800 | $340,645 | $2,428,681 |
| Discounted Benefits - "Low" | $2,623,006 | $2,463,393 | $2,453,578 | $2,591,780 | $2,434,067 | $12,565,824 |
| Discounted Costs | $475,852 | $593,802 | $690,670 | $315,993 | $335,249 | $2,411,566 |
| **NET PRESENT VALUE** | **$2,147,154** | **$1,869,591** | **$1,762,908** | **$2,275,787** | **$2,098,818** | **$10,154,258** |

| | | |
|---|---|---|
| **Return on Investment (ROI) "Low"** | **4.21** | If this result is greater than "0" it is favorable for investment |

| Cost-Benefit Analysis - "High" | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
|---|---|---|---|---|---|---|
| Benefits Summary - "High" | $6,766,742 | $6,542,102 | $6,542,102 | $6,766,742 | $6,542,102 | $33,159,788 |
| Cost Summary | $475,852 | $596,177 | $696,207 | $319,800 | $340,645 | $2,428,681 |
| Discounted Benefits - "High" | $6,766,742 | $6,516,037 | $6,490,077 | $6,686,186 | $6,438,466 | $32,897,508 |
| Discounted Costs | $475,852 | $593,802 | $690,670 | $315,993 | $335,249 | $2,411,566 |
| **NET PRESENT VALUE** | **$6,290,889** | **$5,922,235** | **$5,799,407** | **$6,370,193** | **$6,103,218** | **$30,485,942** |

| | | |
|---|---|---|
| **Return on Investment (ROI) "High"** | **12.64** | If this result is greater than "0" it is favorable for investment |

Figure 18. Cost-Benefit Analysis combined findings.

# 10 APPENDICES

## A. TOTAL BENEFITS FOR FORESTRY WORKSHEET

**Maine ROI Study for Orthoimagery**

**Forestry Use Case Benefits Totals**

Applied Geographics, Inc.

**BENEFITS FOR FORESTRY SCENARIO**

| Forestry Benefits Category | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
|---|---|---|---|---|---|---|
| Harvesting | | | | | | |
| Time Savings "Low" | $131,100 | $131,100 | $131,100 | $131,100 | $131,100 | **$655,500** |
| Time Savings "High" | $327,750 | $327,750 | $327,750 | $327,750 | $327,750 | **$1,638,750** |
| Better Results (Higher Value Harvest) "Low" | $100,000 | $100,000 | $100,000 | $100,000 | $100,000 | **$500,000** |
| Better Results (Higher Value Harvest) "High" | $500,000 | $500,000 | $500,000 | $500,000 | $500,000 | **$2,500,000** |
| Monitoring | | | | | | |
| Time Savings and Better Results "Low" | $0 | $74,860 | $104,290 | $123,540 | $47,500 | **$350,190** |
| Time Savings and Better Results "High" | $0 | $112,290 | $156,435 | $185,310 | $71,250 | **$525,285** |

| Forestry Benefits Totals | | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
| **Forestry Total "Low"** | **$231,100** | **$305,960** | **$335,390** | **$354,640** | **$278,600** | **$1,505,690** |
| **Forestry Total "High"** | **$827,750** | **$940,040** | **$984,185** | **$1,013,060** | **$899,000** | **$4,664,035** |

## B. TOTAL BENEFITS FOR STORMWATER WORKSHEET

**Maine ROI Study for Orthoimagery**

**Stormwater Use Case Benefits Totals**

Applied Geographics, Inc.

**BENEFITS FOR STORMWATER SCENARIO**

| Stormwater Benefits Category | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
|---|---|---|---|---|---|---|
| Stormwater Plan Inspections | | | | | | |
| Time Savings "Low" | $67,095 | $67,095 | $67,095 | $67,095 | $67,095 | **$335,475.00** |
| Time Savings "High" | $357,840 | $357,840 | $357,840 | $357,840 | $357,840 | **$1,789,200.00** |
| Municipal Stormwater Management | | | | | | |
| Time Saving Across 29 MS4s Statewide "Low" | $90,081.25 | $90,081.25 | $90,081.25 | $90,081.25 | $90,081.25 | **$450,406.25** |
| Time Saving Across 29 MS4s Statewide "High" | $700,211.53 | $700,211.53 | $700,211.53 | $700,211.53 | $700,211.53 | **$3,501,057.63** |
| Orthoimagery Applications for Stormwater Management in the Private Sector | | | | | | |
| Time Saving Across 36 Civil Engineering Firms Statewide "Low" | $1,818,720.00 | $1,818,720.00 | $1,818,720.00 | $1,818,720.00 | $1,818,720.00 | **$9,093,600.00** |
| Time Saving Across 36 Civil Engineering Firms | $4,168,800.00 | $4,168,800.00 | $4,168,800.00 | $4,168,800.00 | $4,168,800.00 | **$20,844,000.00** |

| Stormwater Benefits Totals | | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
| **Stormwater Total "Low"** | **$1,975,896.25** | **$1,975,896.25** | **$1,975,896.25** | **$1,975,896.25** | **$1,975,896.25** | **$9,879,481.25** |
| **Stormwater Total "High"** | **$5,226,851.53** | **$5,226,851.53** | **$5,226,851.53** | **$5,226,851.53** | **$5,226,851.53** | **$26,134,257.63** |

## C. TOTAL BENEFITS FOR TRANSPORTATION WORKSHEET

**Maine ROI Study for Orthoimagery**

**Transportation Use Case Benefits Totals**

Applied Geographics, Inc.

**BENEFITS FOR TRANSPORTATION SCENARIO**

| Transportation Benefits Category | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
|---|---|---|---|---|---|---|
| Avoided GPS Field Capture To Support Road Network Maintenance | | | | | | |
| Time Savings "Low" | $45,000 | $45,000 | $45,000 | $45,000 | $45,000 | **$225,000.00** |
| Time Savings "High" | $45,000 | $45,000 | $45,000 | $45,000 | $45,000 | **$225,000.00** |
| Communication Tool | | | | | | |
| Time Savings "Low" | $84,375 | $84,375 | $84,375 | $84,375 | $84,375 | **$421,875.00** |
| Time Savings "High" | $168,750 | $168,750 | $168,750 | $168,750 | $168,750 | **$843,750.00** |
| Avoided Trips to Field | | | | | | |
| Time Savings "Low" | $16,875 | $16,875 | $16,875 | $16,875 | $16,875 | **$84,375.00** |
| Time Savings "High" | $33,750 | $33,750 | $33,750 | $33,750 | $33,750 | **$168,750.00** |
| Avoided Coordination for Ortho Aquistion | | | | | | |
| Time Savings "Low" | $149,760 | $0 | $0 | $149,760 | $0 | **$299,520.00** |
| Time Savings "High" | $224,640 | $0 | $0 | $224,640 | $0 | **$449,280.00** |
| Orthoimagery for Transportation Planning in the Private Sector | | | | | | |
| Time Savings "Low" | $120,000 | $120,000 | $120,000 | $120,000 | $120,000 | **$600,000.00** |
| Time Savings "High" | $240,000 | $240,000 | $240,000 | $240,000 | $240,000 | **$1,200,000.00** |

| Transportation Benefits Totals | | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | TOTAL |
| **Transportation Total "Low"** | **$416,010.00** | **$266,250.00** | **$266,250.00** | **$416,010.00** | **$266,250.00** | **$1,630,770.00** |
| **Transportation Total "High"** | **$712,140.00** | **$487,500.00** | **$487,500.00** | **$712,140.00** | **$487,500.00** | **$2,886,780.00** |

## D. LIST OF INTERVIEWEES

**FORESTRY**

| NAME | NUMBER | EMAIL | ORGANIZATION | POSITION | DATE OF INTERVIEW |
|---|---|---|---|---|---|
| Lance Case | 207-827-7195, ext. 133 | l.case@huber.com | Huber Resource Corporation | IT/GIS Support Specialist | 1/13/2012 |
| Tom Doak | 207-626-0005 | tom@swoam.org | Small Woodland Owner's Association of Maine | Exec. Director | 1/13/2012 |
| Dr. Brian Roth | 207-581-2861 | brian.roth@maine.edu | Cooperative Forestry Research Unit at UMaine | Asst. Director | 1/16/2012 |
| Dr. Steve Sader | 207-581-2845 | sasader@maine.edu | Maine Image Analysis Lab (MIAL) | Director | 1/16/2012 |

| NAME | NUMBER | EMAIL | ORGANIZATION | POSITION | DATE OF INTERVIEW |
|---|---|---|---|---|---|
| Greg Miller | 207-287-2791 | greg.t.miller@maine.gov | Maine Forest Service | GIS Programmer/ Analyst | 1/17/2012 |
| Harold Burnette | 207-377-7196 | harold@twotreesforestry.com | Two trees Forestry | President/ Owner | 1/17/2012 |
| Steven West | 201-947-0541 | swest@sevenislands.com | Seven Islands Land Company | GIS Analyst | 1/18/2012 |
| Dr. Aaron Weiskittel | 207-581-2857 | aaron.weiskittel@maine.edu | Cooperative Forestry Research Unit at UMaine | Cooperating Scientist | 1/20/2012 |
| Dan Boss | 207-827-4456 | dan.boss@sewall.com | James W. Sewall Company | Senior Consultant | 1/24/2012 |
| Allison Kanoti | 207-287-2431 | allison.m.kanoti@maine.gov | Maine Forest Service | Forest Entomologist | 2/2/2012 |
| Bill Frament | 603-868-7707 | wframent@fs.fed.us | USDA, US Forest Service | FHP Aviation | 2/8/2012 |

**STORMWATER MANAGEMENT**

| NAME | NUMBER | EMAIL | ORGANIZATION | POSITION | DATE OF INTERVIEW |
|---|---|---|---|---|---|
| Gretchen Heldmann | 207-862-4500, ext.42 | gheldmann@hampdenmaine.gov | Town of Hampden, ME | GIS/IT Specialist | 12/8/2011 |
| Aaron Dumont | 207-215-7346 | Aaron.Dumont@maine.gov | Maine Department of Environmental Protection | Industrial Stormwater Inspector | 1/24/2012 |
| Cayce Dalton | 207-221-6699 | cayced@fbenvironmental.com | FB Environmental Associates, Inc. | Project Manager | 1/24/2012 |

**TRANSPORTATION**

| NAME | NUMBER | EMAIL | ORGANIZATION | POSITION | DATE OF INTERVIEW |
|---|---|---|---|---|---|
| Donna Tippett | 207-774-9891 | dtippett@gpcog.org | Greater Portland Council of Governments | GIS Manager | 1/17/2012 |

| | | | | | |
|---|---|---|---|---|---|
| Paul Bradbury | 207-874-8877 | PHB@portlandmaine.gov | Portland International Jetport | Airport Director | 1/18/2012 |
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