NASA Applied Science Wildfire Program

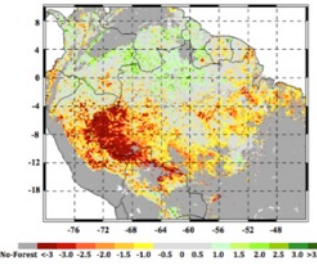
Vince Ambrosia, L. Friedl, A. Soja

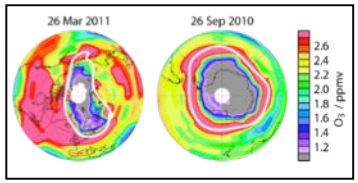
NASA Earth Science Division - Applied Sciences Program

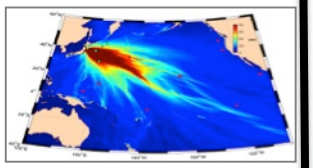
ESRI User Conference, San Diego, CA. 29 June 2016

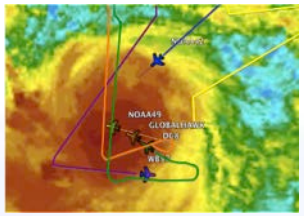
NASA's Earth Science Division

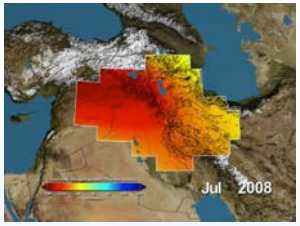
Research

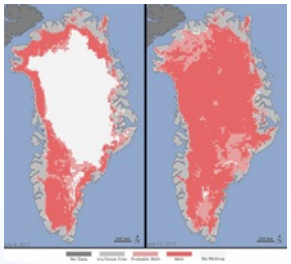




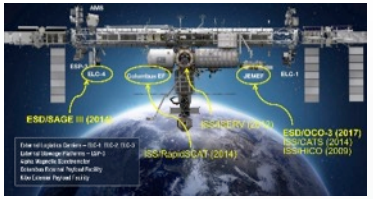




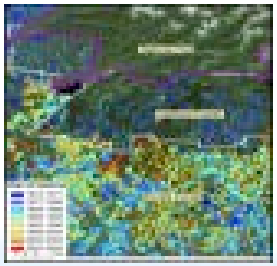


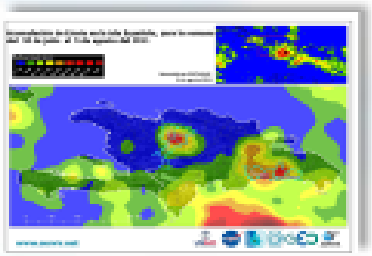


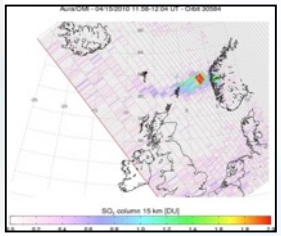
Flight

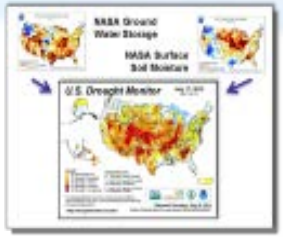


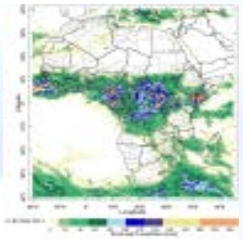
Applied Sciences



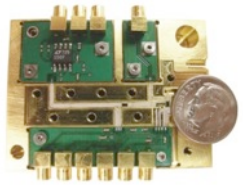


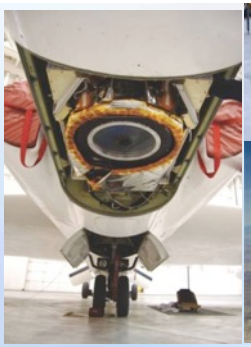






Technology

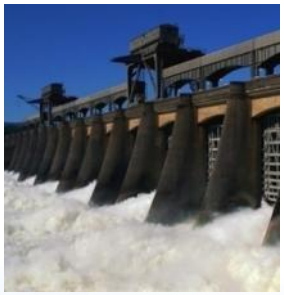




Applications Themes & Societal Benefit Areas

Emphasis in 4 Applications Areas

Health & Air Quality



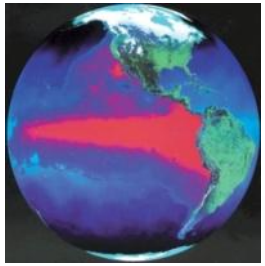
Water Resources

Disasters

Ecological Forecasting

Support opportunities in 5 additional areas

Agriculture



Climate

Weather

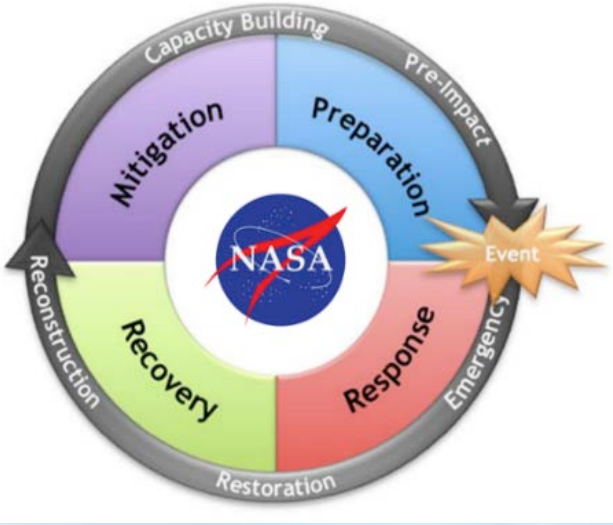
Energy

Oceans

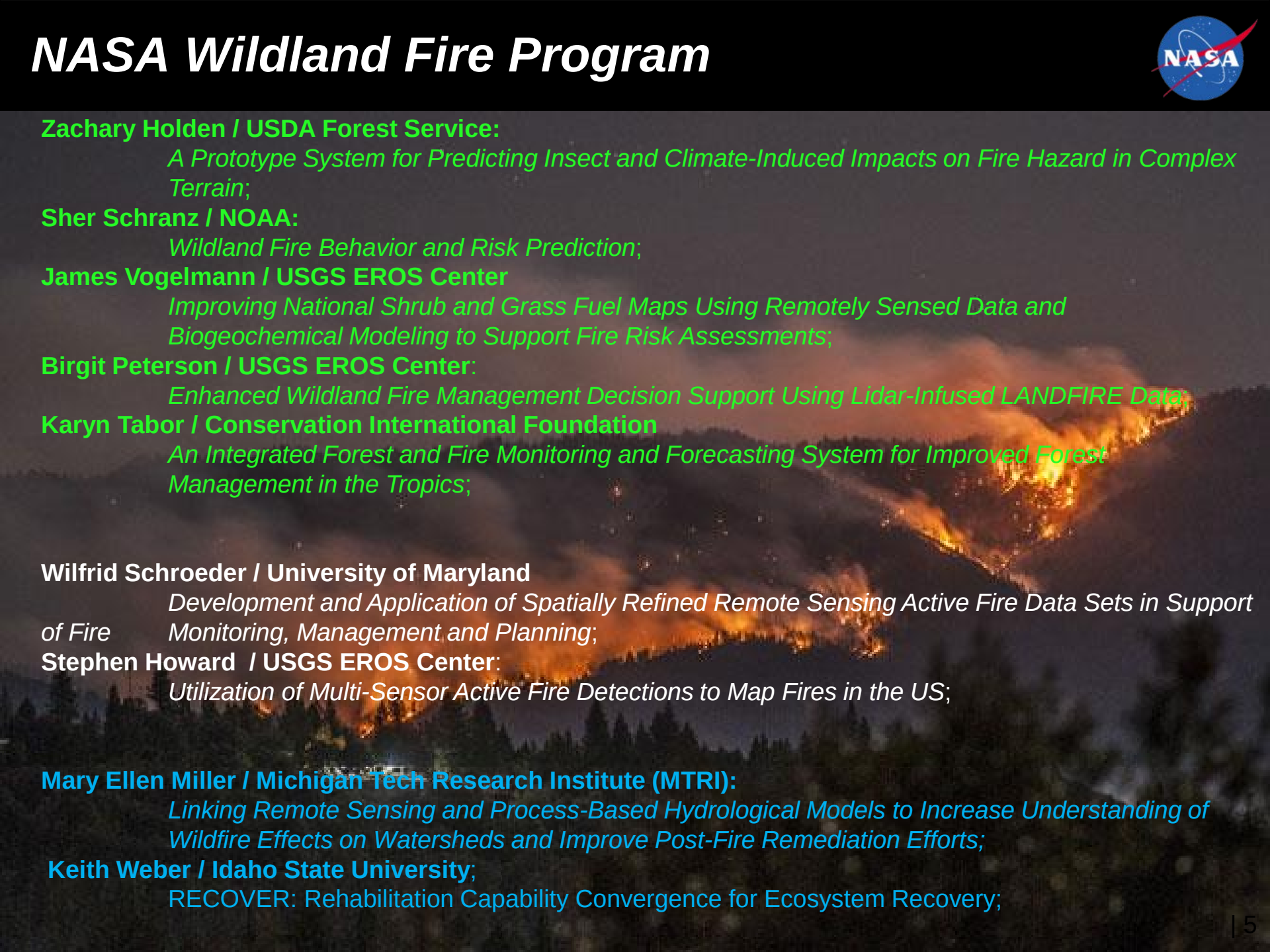
Crosscutting theme: Wildland Fires

Advancing NASA's Wildland Fire Applications Capabilities

- **Wildland Fire application science answering questions and supporting decisions** transforming EO data and research results into environmental intelligence.
- **Coordination and collaboration** informing brokers, managers, and responders with critical products and services .
- **Creation and leverage of partnerships** strengthening and enabling effective response throughout the wildfire lifecycle.



NASA Wildland Fire Program



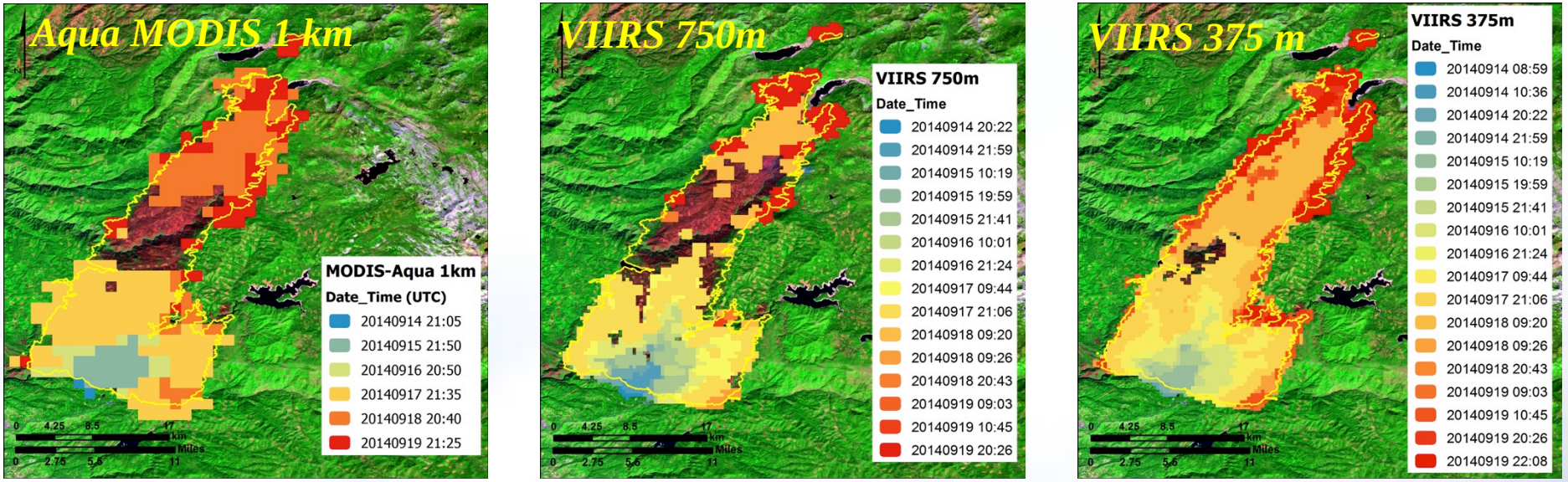
Zachary Holden / USDA Forest Service:
A Prototype System for Predicting Insect and Climate-Induced Impacts on Fire Hazard in Complex Terrain;
Sher Schranz / NOAA:
Wildland Fire Behavior and Risk Prediction;
James Vogelmann / USGS EROS Center
Improving National Shrub and Grass Fuel Maps Using Remotely Sensed Data and Biogeochemical Modeling to Support Fire Risk Assessments;
Birgit Peterson / USGS EROS Center:
Enhanced Wildland Fire Management Decision Support Using Lidar-Infused LANDFIRE Data;
Karyn Tabor / Conservation International Foundation
An Integrated Forest and Fire Monitoring and Forecasting System for Improved Forest Management in the Tropics;

Wilfrid Schroeder / University of Maryland
Development and Application of Spatially Refined Remote Sensing Active Fire Data Sets in Support of Fire Monitoring, Management and Planning;
Stephen Howard / USGS EROS Center:
Utilization of Multi-Sensor Active Fire Detections to Map Fires in the US;

Mary Ellen Miller / Michigan Tech Research Institute (MTRI):
Linking Remote Sensing and Process-Based Hydrological Models to Increase Understanding of Wildfire Effects on Watersheds and Improve Post-Fire Remediation Efforts;
Keith Weber / Idaho State University;
RECOVER: Rehabilitation Capability Convergence for Ecosystem Recovery;

NPP VIIRS: The Next Generation of Fire Support

The new VIIRS 375 m active fire detection product enables early detection of small fires and improved mapping of large wildfires.



King Fire: Comparing MODIS 1 km, VIIRS 750 m, and VIIRS 375 m products

"*These refined data further improve the situational awareness of fire managers and are also ingested into operational modeling, analysis and visualization applications that support fire management decision-making at a landscape scale*." –Brad Quayle, U.S. Forest Service

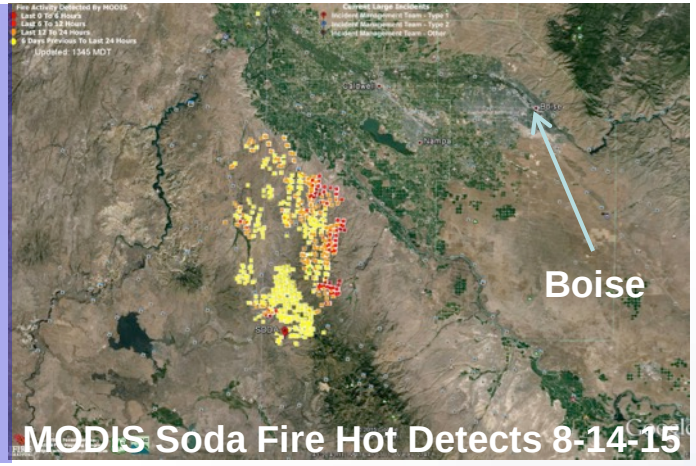
The new VIIRS fire data and algorithm are currently being used operationally to complement limited aircraft and satellite data in time and space, with the ultimate purpose of protecting resources, property and lives.

NASA Support to the Massive Soda Fire, Idaho

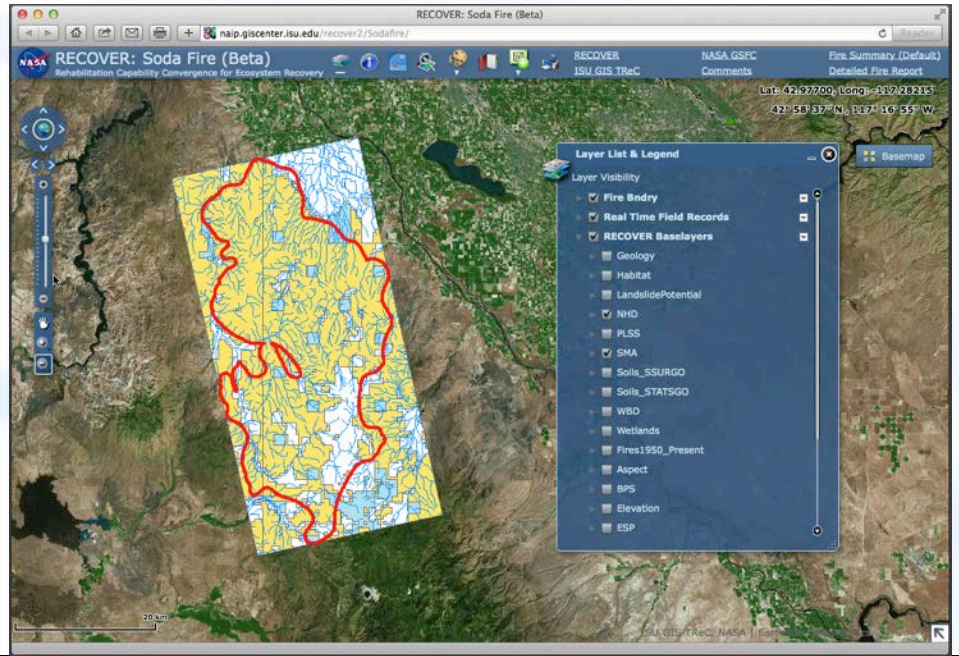
NASA ASP-Funded Project Team – RECOVER, supporting 24/7 operations on Soda Mega-Fire in Idaho with Fire Modeling Capabilities!!!

Image courtesy of Idahopress.com

- Fire started Aug 10
- Grew to 78 k acres by Aug 12
- Grew ~6X from Aug 12 to Aug 13 (to 218.000 acres)!
- RECOVER team requested to support with modeling and mapping efforts on 8-13-15; continued thru end of fire.



MODIS Soda Fire Hot Detects 8-14-15



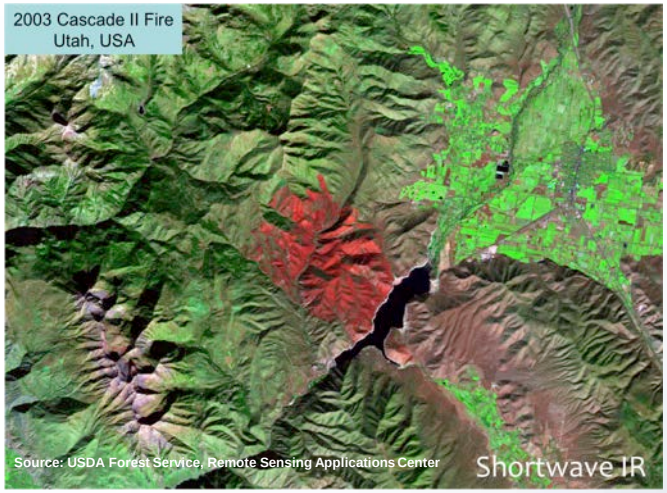
- NASA RECOVER supporting Incident managers with real-time tools (NASA satellite data, cloud-enabled, geospatial modeling tools, critical data layers, etc.) to shorten burn area assessments for remediation operations (from multiple days to minutes!!)
- NASA efforts are helping to pinpoint active fire mitigation strategies and post-fire burn conditions by modeling vegetation cover, terrain, soil, etc., for rapid remediation.
- Positively impacting fire management strategy efficiencies and post-burn planning.

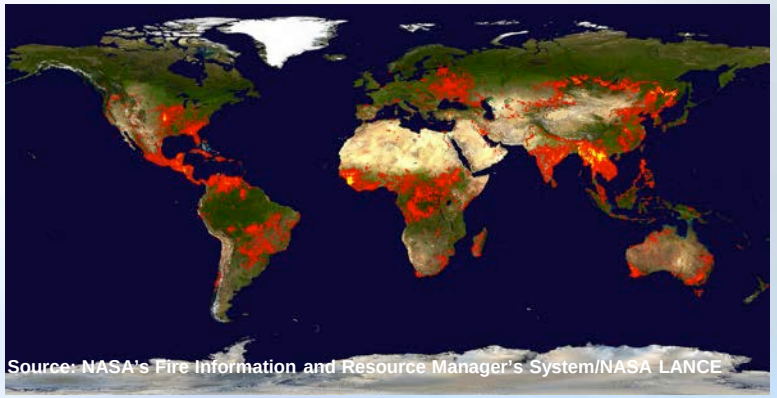
Webinars and Workshops…

Webinar: March 31 - April 28, 2015

- **Objectives:** Provide an overview of relevant NASA Earth science data products, tools, and access portals for wildfire applications for enhanced decision-making and assessment methods.
- **Overview Statistics:** 278 participants, 178 organizations, 42 countries, 33 states
- **Attendees:** USDA Forest Service, National Park Service, National Weather Service, Bureau of Land Management, US Geological Survey, US EPA, CAL FIRE, Idaho Army National Guard, Alaska Fire Science Consortium, Ministry of Environment and Natural Resources, El Salvador (MARN), Risk Management Solutions Inc., Western States Air Resources (WESTAR) Council, United Nations, Nature's Foster, ESRI, African Wildlife Foundation, Conservation International, etc.
- **End-of-Training Survey:** Majority of attendees (73%) indicated that the webinar met their expectations while 23% indicated that it exceeded expectations. 93% showed some level of improvement for understanding specific remote sensing data products appropriate for work needs.

First ARSET webinar focused on wildfire applications

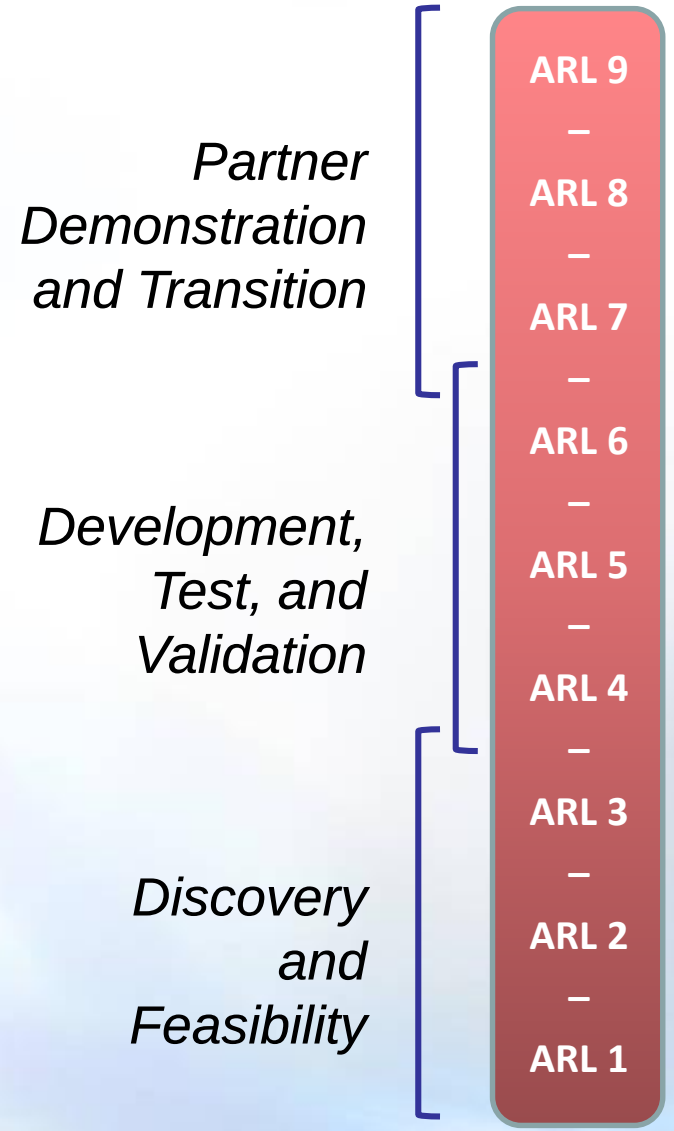




Measures of Project Performance

Applications Readiness Levels (ARL)

9. **Approved, Operational Deployment and Use in Decision Making**
8. **Application Completed and Qualified**
7. **Application Prototype in Partners' Decision Making**
6. **Demonstrate in Relevant Environment**
5. **Validation in Relevant Environment**
4. **Initial Integration and Verification**
3. **Proof of Application Concept**
2. **Application Concept**
1. **Basic Research**



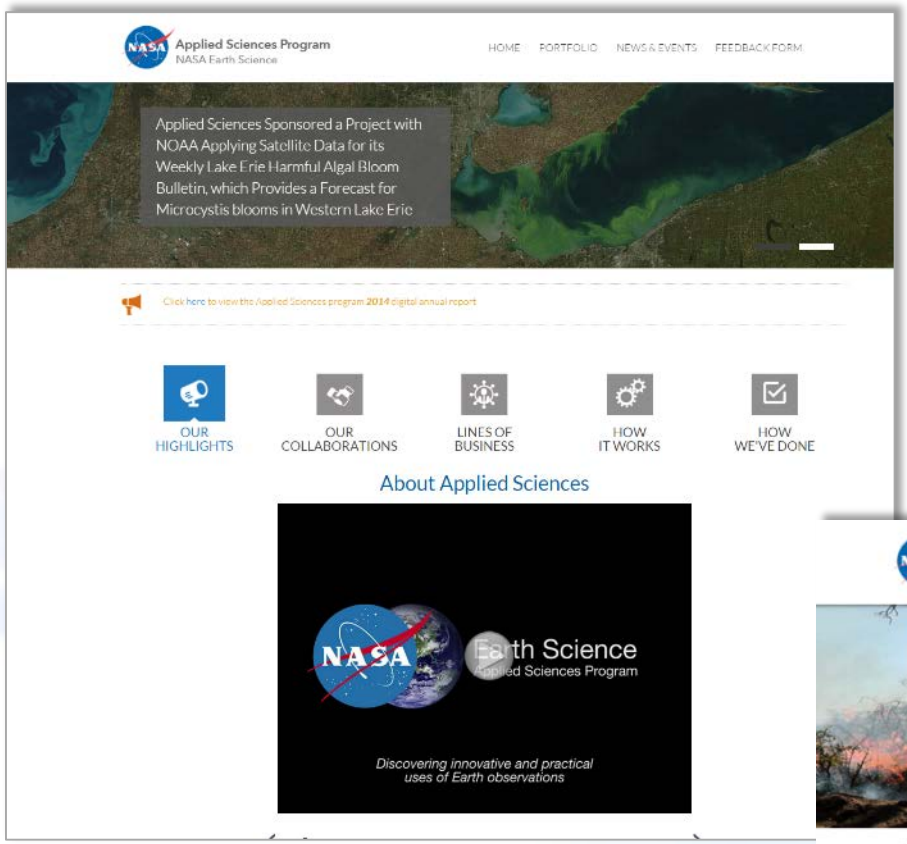
Interagency Partnerships

NASA collaborates with numerous U.S. land management agencies and other partners to improve wildfire characterization

NASA Participates in National / International Fire Committees

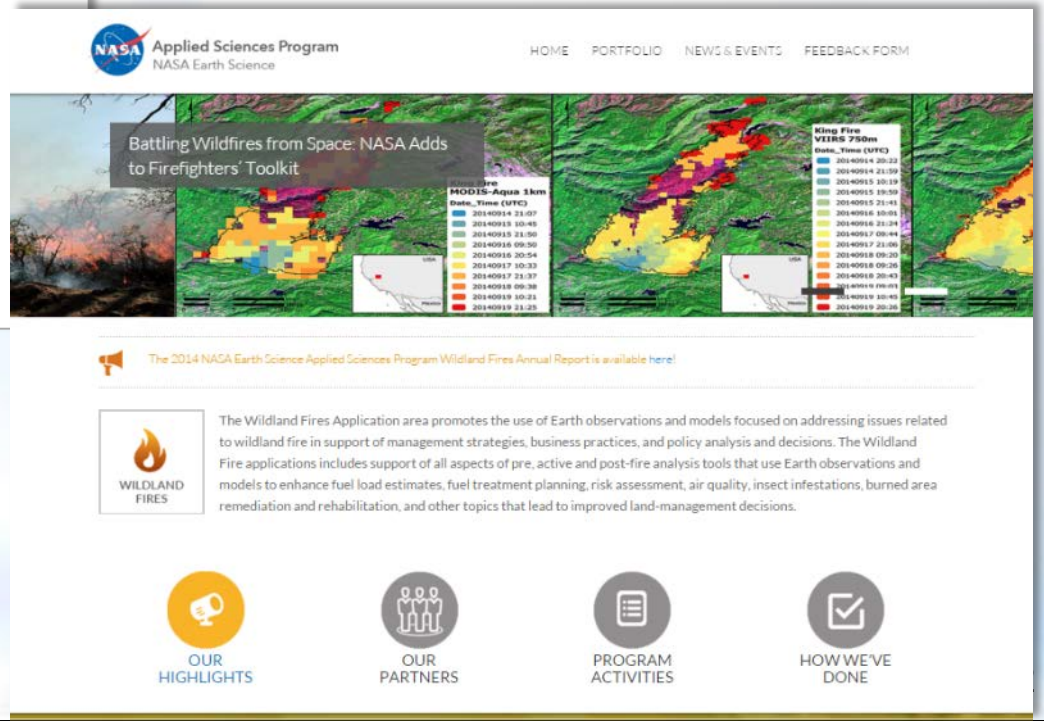
- **Group on Earth Observations (GEO), Global Wildfire Information System (GWIS);**
- **National Science & Technology Council (NSTC) Subcommittee on Disaster Reduction (SDR) Wildland Fire Science and Technology Task Force (WFST TF);**
- **Interagency Arctic Research Policy Committee (IARPC); Wildfire Implementation Team (WIT);**
- **NRC, Div. of Earth & Life Sciences, Wildfire Study Team;**
- **JFS Program, Fire and Smoke Model Evaluation Experiment (FASMEE) Team**

NASA Applied Science – Wildland Fire Website



NASA Applied Science Program website:

http://appliedsciences.nasa.gov/



National Aeronautics and Space Administration

WILDFIRE PROGRAM

http://appliedsciences.nasa.gov/programs/wildfires-program

Wildfire Management Team:
Lawrence Friedl (PM)
Vince Ambrosia (Assoc.),
Amber Soja (Assoc.)

Further Information

http://AppliedSciences.NASA.gov

NASA Earth Science
Applied Sciences Program

NASA Headquarters
Washington, DC
1.202.358.7200

The NASA RECOVER DSS

Keith T. Weber[1], GISP and PI NASA RECOVER

Kindra Serr[1], Jeff May[1], John Schnase[2], Mark Carroll[2], Roger Gill[2], Maggie Wooten[2], Bryan Nicholson[1], and Cody Feldman[1]

1- Idaho State University- GIS TReC
2- NASA Goddard Space Flight Center

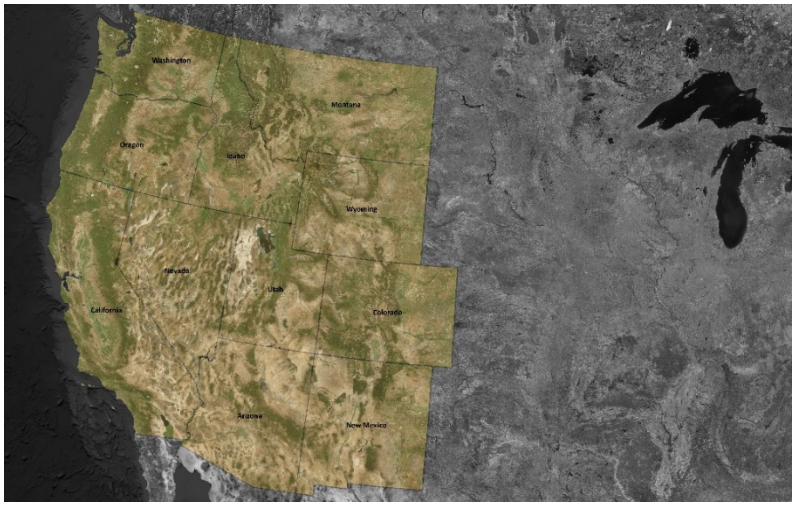
What is RECOVER?

- Customer-driven, Customer-centric*
- Decision Support System (DSS)
  - Rapid assembly of site-specific data
  - Delivered in customized GIS analysis environment
  - Wildfire focus

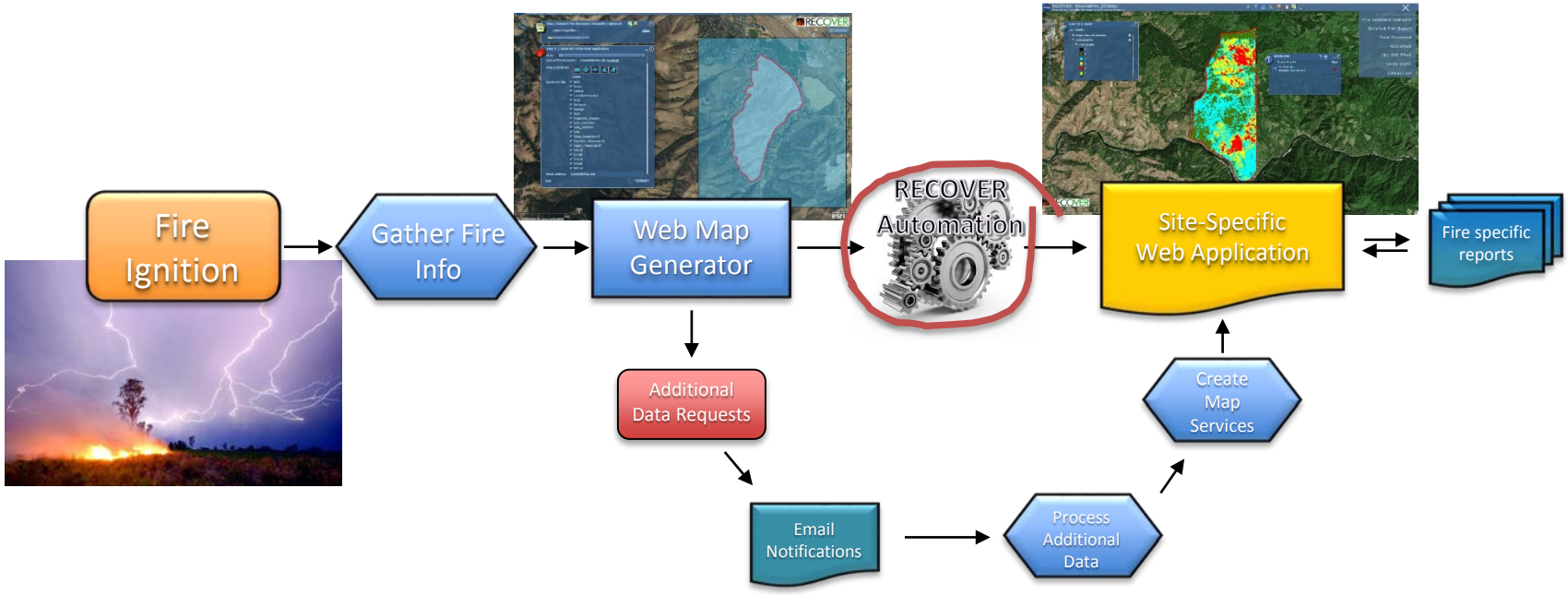
* Our “customer” is anyone with wildfire management responsibilities (BLM, NPS, USFS, State Lands, DOT’s, NGO’s, etc.)

Data Architecture

- RECOVER covers the Western US
- Esri ArcGIS 10.3.1
  - File Geodatabase
  - Vector and raster data
  - Automated Map Services
- Transitioning to 10.4.1



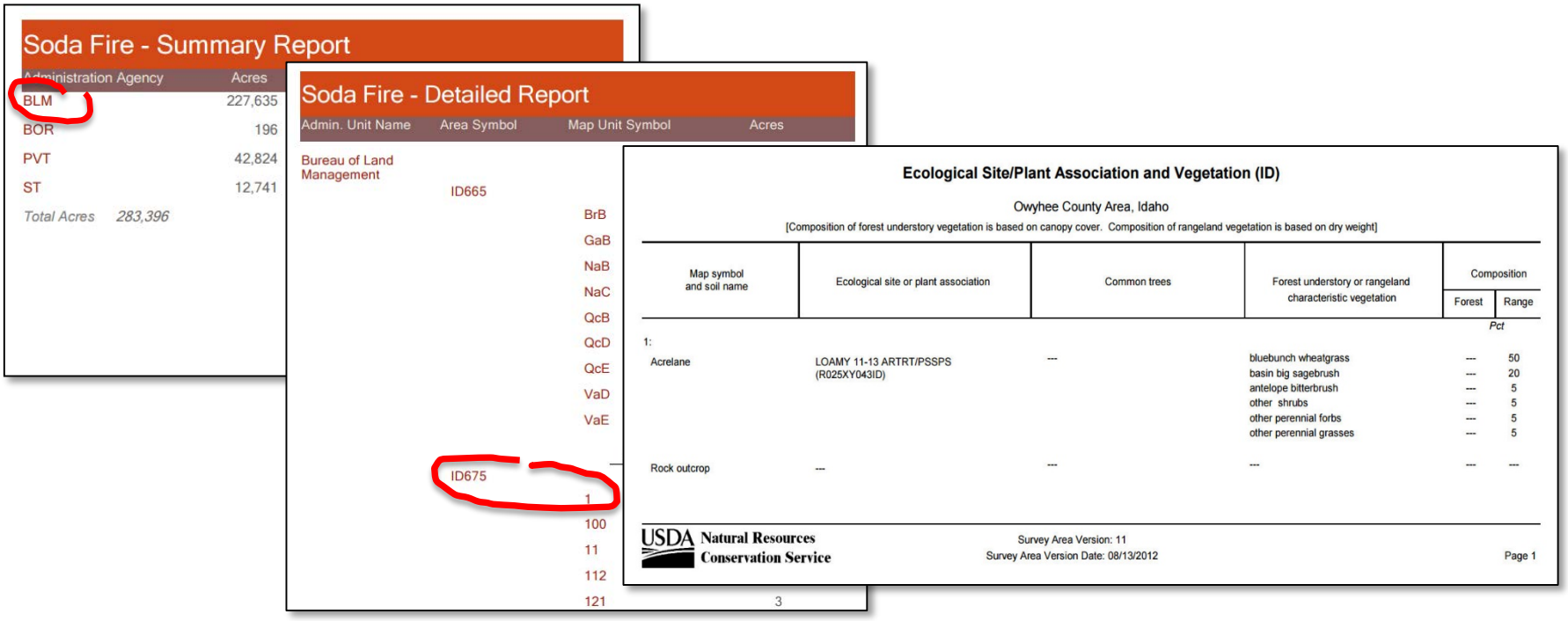
How Does it Work?



GIS Layers

- By default each RECOVER web map contains…
  - 25 base layers automatically clipped to fire extent
  - One real-time data feed (Collector)
  - Fire-specific reports

Fire-specific Reports



Soda Fire - Summary Report

Administration Agency	Acres
BLM	227,635
BOR	196
PVT	42,824
ST	12,741
Total Acres	*283,396*

Soda Fire - Detailed Report

Admin. Unit Name	Area Symbol	Map Unit Symbol	Acres
Bureau of Land Management	ID665	BrB	
		GaB	
		NaB	
		NaC	
		QcB	
		QcD	
		QcE	
		VaD	
		VaE	
	ID675		
		1	
		100	
		11	
		112	
		121	

3

Ecological Site/Plant Association and Vegetation (ID)

Owyhee County Area, Idaho

[Composition of forest understory vegetation is based on canopy cover. Composition of rangeland vegetation is based on dry weight]

Map symbol and soil name	Ecological site or plant association	Common trees	Forest understory or rangeland characteristic vegetation	Composition	
				Forest	Range
				Pct	
1:					
Acrelane	LOAMY 11-13 ARTRT/PSSPS (R025XY043ID)	---	bluebunch wheatgrass	---	50
			basin big sagebrush	---	20
			antelope bitterbrush	---	5
			other shrubs	---	5
			other perennial forbs	---	5
			other perennial grasses	---	5
Rock outcrop	---	---	---	---	---

USDA Natural Resources Conservation Service

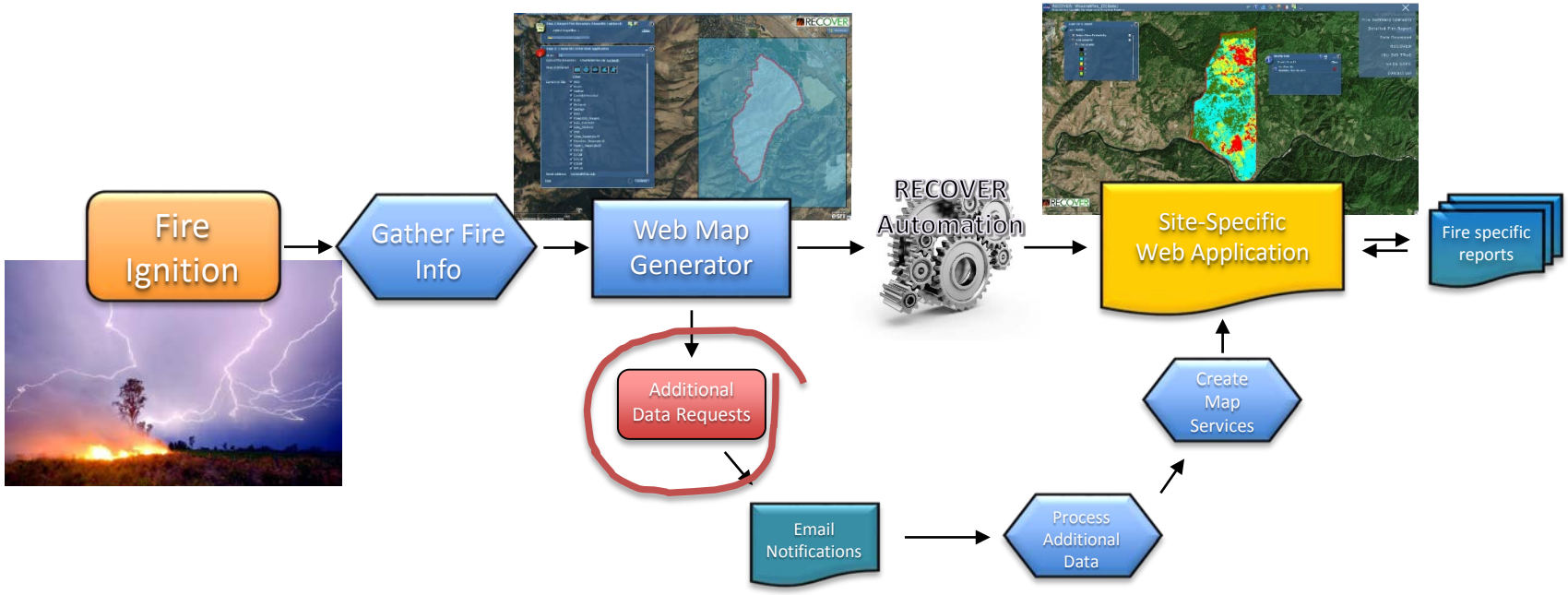
Survey Area Version: 11
Survey Area Version Date: 08/13/2012

Page 1

Done in 5-minutes!

- Once submitted from our Generator, the web map will be ready in about 5-minutes

How Does it Work?

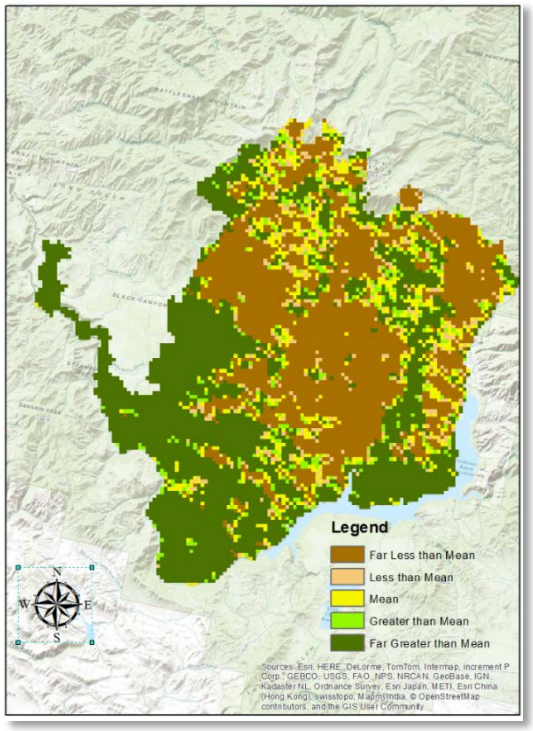


Additional data requests

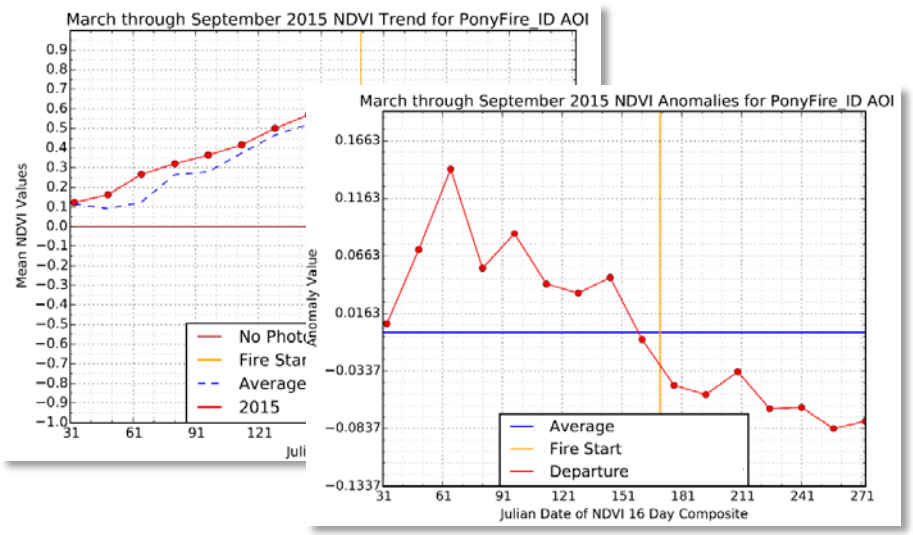
- Fire-affected Vegetation
- Debris-flow probability (AKA mudslide or landslide)
- NDVI vegetation anomaly
  - 16-day MODIS NDVI-composite imagery
  - Long-term average NDVI (2001-present)
  - Current fire season compared against long-term trend

NDVI Anomaly Data

Map layer

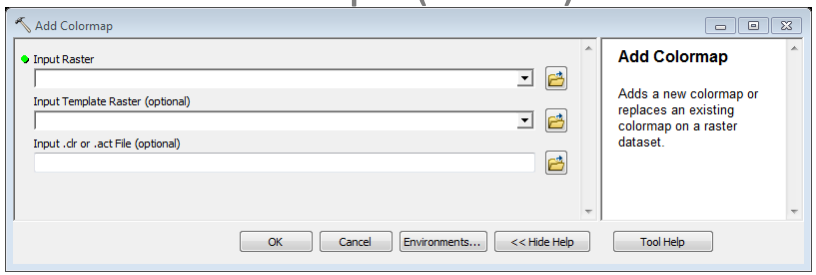


Charts



Transform Data into Information

- Help your data speak to the user
  - Authoritative source data
  - Common sense Colormaps (raster)



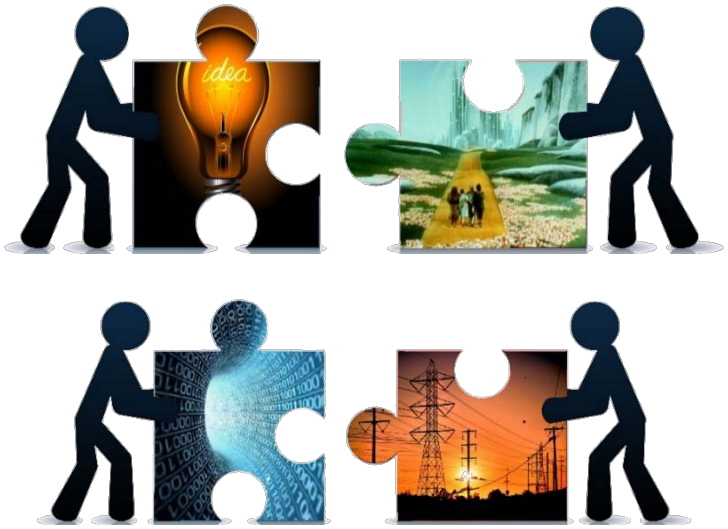
  - Accepted symbology (Map service and Layer files)

Listen to the Customer

- "Make it mobile"
- "High-resolution is nice, but fast is critical"
  – *NIFC*
- "Drowning in Data, but still thirsting for Information"
  – *USFS RSAC*

Assemble a Great Team

- Idea
- Plan
- Infrastructure
- Data
- **People**



How Does it Work?

- You can learn more….
  - Visit YouTube for a full tour
  - http://bit.ly/recoverdemo

Automating wildfire and disaster mapping with ArcGIS and Python

Jeff May[1]

Keith T. Weber[1] (PI NASA RECOVER), Kindra Serr[1], John Schnase[2], Mark Carroll[2], Roger Gill[2], Maggie Wooten[2], Bryan Nicholson[1], and Cody Feldman[1]

1- Idaho State University- GIS TReC
2- NASA Goddard Space Flight Center

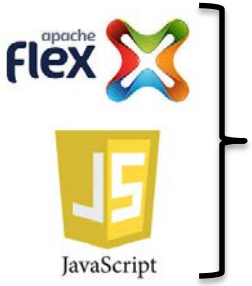
Presentation Overview

1. Technology overview
2. RECOVER workflow review
3. Evolution of RECOVER automation
4. How does it work?

RECOVER Technology

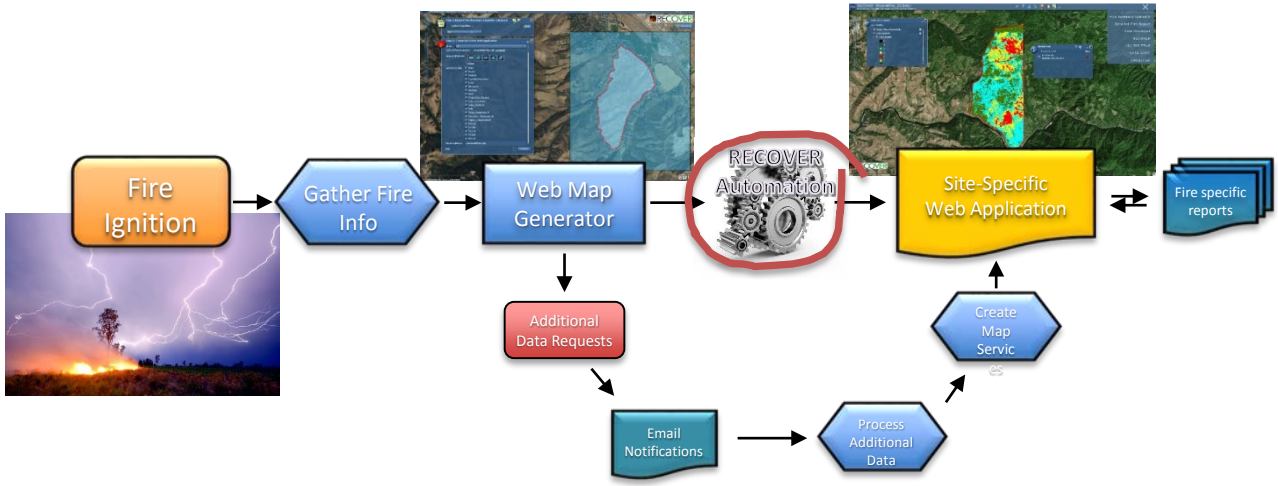
Data management, service rendering, Real time GIS with Collector

Server side processing exposed as an ArcGIS geoprocessing service



Application development

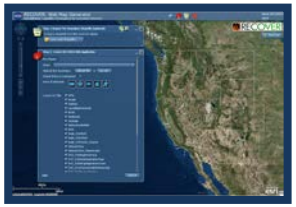
The RECOVER Workflow



RECOVER Evolution

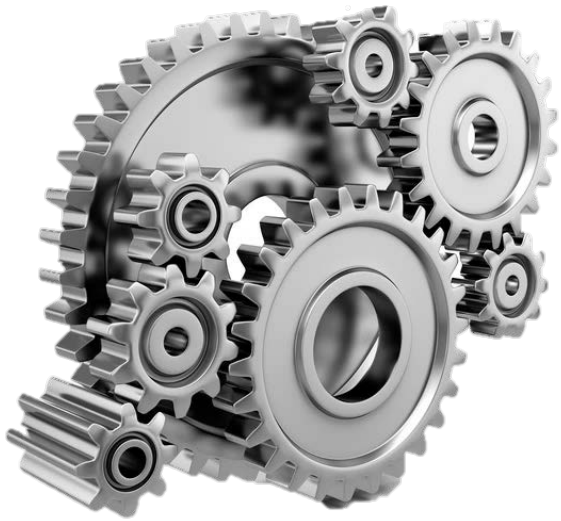
- Stand alone-python script
- Semi-automated process requiring back and forth communication with end-user
- Manual creation of site reports
- 1 hour processing time

- Python script tool
- Leverages locally stored data
- Parameters now variable and selected from toolbox UI
- Back and forth communication with end-user
- Report generation now automated
- 30 minute processing time

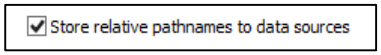


- Geoprocessing service, initiated through a web application
- Leverages data via a map service
- User initiated process
- Notifications sent automatically
- Additional data request still process manually
- 5 minute processing time

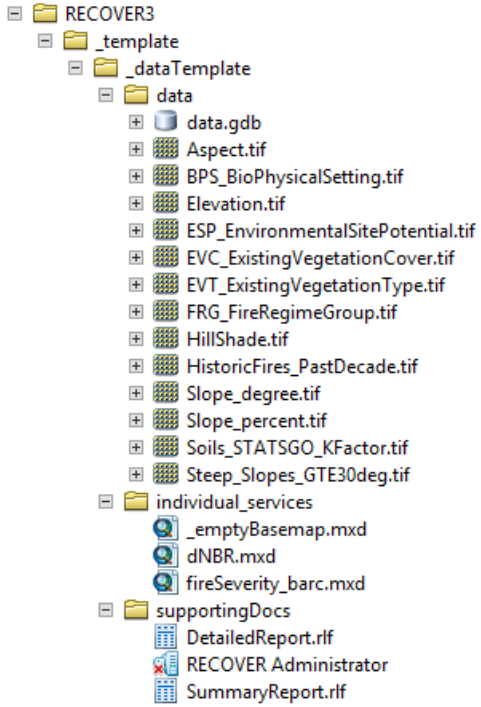
RECOVER Automation: How it works



Automation Space

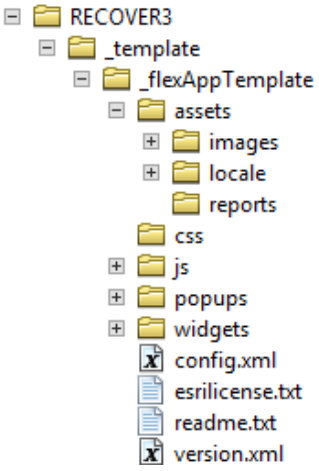
- Data space
  - Contains:
    - Data
    - Map document templates
      - » Applied symbology
      - » 

    - Reports
      - » Report layout files (.rlf)

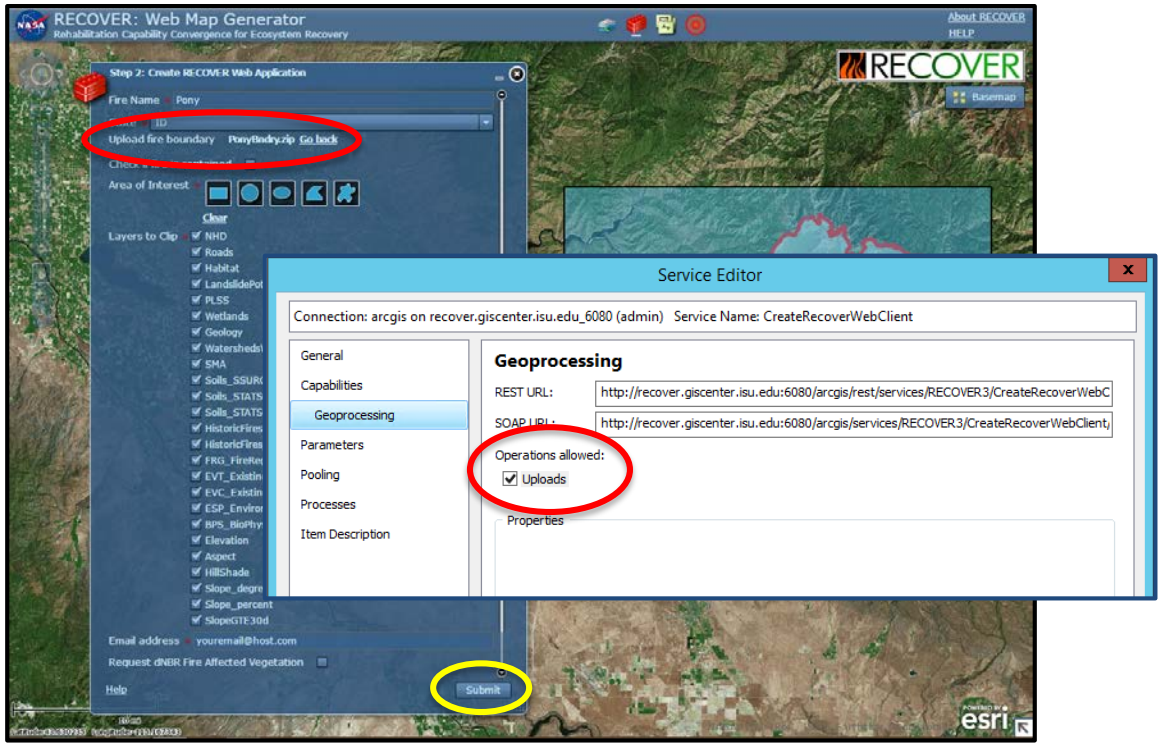


Automation Space

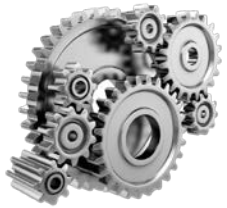
- Website space
  - Contains:
    - Configuration templates
      - » Application
      - » Widgets
        - “Tags”
          - Find and replace “[NAME]”



Initiate a process using the RECOVER "Web Map Generator"



Server Side Processing



The RECOVER automation process can be broken down into these 6 steps:

1. Input validation
2. File system set-up
3. Data processing
4. Service publishing
5. Notifications
6. Post-process tasks

~ 5min processing time

Server Side Processing

Input validation: Area of interest

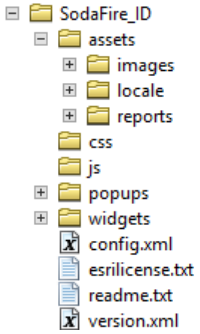
```
if arcpy.Exists(fireBndry):
    # Use search cursor to calculate the area (acres) of areaOfInterest.
    # If AOI area > limit, process will fail.

    limit = 3000000
    AOIAcres = arcpy.CalculateField_management(areaOfInterest, "ACRES", "!shape.area@acres!", "PYTHON")
    SC = arcpy.SearchCursor(areaOfInterest)
    AcresTot = 0
    for row in SC:
        AcresTot += row.getValue("ACRES")
    arcpy.AddMessage("Extent defined is " + str(AcresTot) + " acres.")

    if AcresTot > limit:
        sys.exit(0)
        arcpy.AddError("Extent defined is too large.  Please try again with a smaller AOI (max area = 3 millon acres")
            if zstring.find(".prj") != -1:
                arcpy.AddError("zipfile contains files that are not allowed, please remove unacceptable files and try again" )
                arcpy.AddError("files must end with " + str(allowed))
                sys.exit(0)
            else:
                # shapefile is missing .prj
                arcpy.AddError("Shapefile being uploaded is missing projection (.prj) file, please add projection and try again")
                sys.exit(0)

    arcpy.AddMessage("Zipfile ok")
    # Extract fire boundary zipfile
    z.extractall(fireData)
    arcpy.AddMessage("...fire boundary extracted to " + fireData)
```

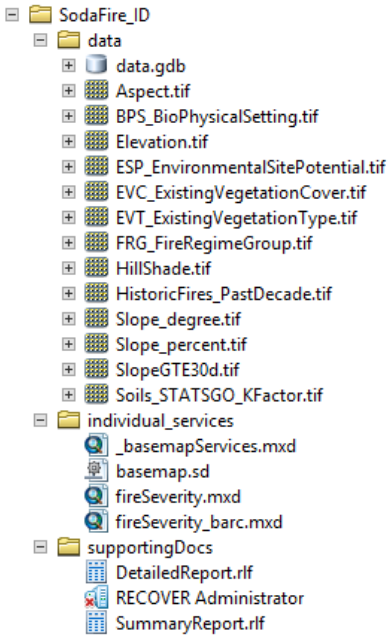
Server Side Processing

File System Set up

Python libs:

1. OS
2. Shutil
3. Zipfile
4. distutils



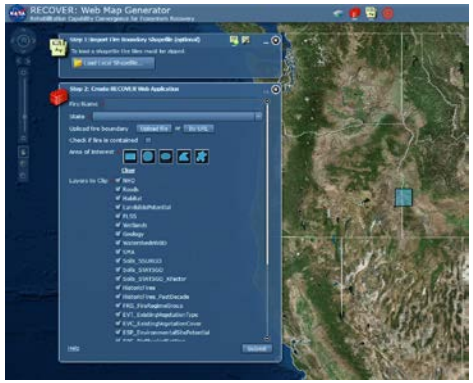



```
def findAndReplace(file):
    arcpy.AddMessage("Updating " + file)
    input_file = open(file)
    contents = input_file.read()
    input_file.close()
    contents = contents.replace("[NAME]", fireId)
    output_file = open(file,"w")
    output_file.write(contents)
    output_file.close()
    del input_file, contents, output_file
    print("..." + file + " updated.")


for inFile in inFiles:
    findAndReplace(inFile)
```

Server Side Processing

Data processing

Select AOI



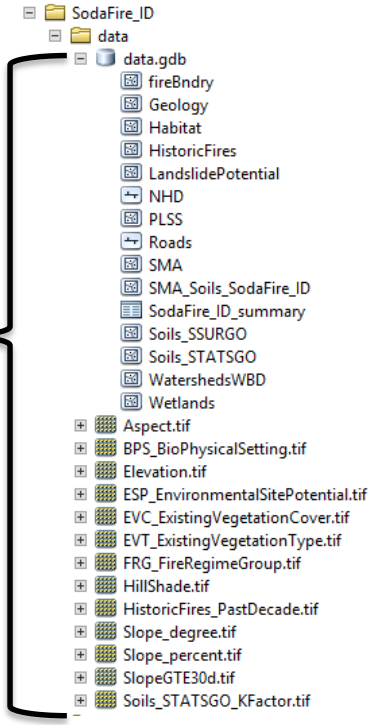
AOI clips against the RECOVER base layers map service

Extracted Data

*ArcMap Data Extract Tool

*☑ Store relative pathnames to data sources

Replace data at source



Server Side Processing

Service publishing: Create a map service

```
        # Create Map Service
        arcpy.AddMessage(".....Creating Basemap Service")
        mxd = arcpy.mapping.MapDocument(wrkspc + "_basemapServices.mxd")
        arcpy.mapping.CreateMapSDDraft(mxd,sddraft,service,"ARCGIS_SERVER",con,False,fireFolder)
        analysis = arcpy.mapping.AnalyzeForSD(sddraft)
def stopStartServices(server, port, adminUser, adminPass, stopStart, serviceName, token=None):
    # Get and set the token
    if token is None:
        token = gentoken(server, port, adminUser, adminPass)

    # modify the services
    op_service_url = "http://{}:{}/arcgis/admin/services/{}/{}?token={}&f=json".format(server, port, serviceName, stopStart, token)
    status = urllib2.urlopen(op_service_url, ' ').read()

    if 'success' in status:
        print (str(serviceName) + " === " + str(stopStart))
    else:
        print status

    return
        # Stage and upload the service if the sddraft analysis did not contain errors
        if analysis['errors'] == {}:
            # Execute StageService
            arcpy.AddMessage(".....Map Service Created")
        else:
            # If the sddraft analysis contained errors, display them
            arcpy.AddMessage(analysis['errors'])
            arcpy.AddMessage("Service could not be published because errors were found during analysis.")
```

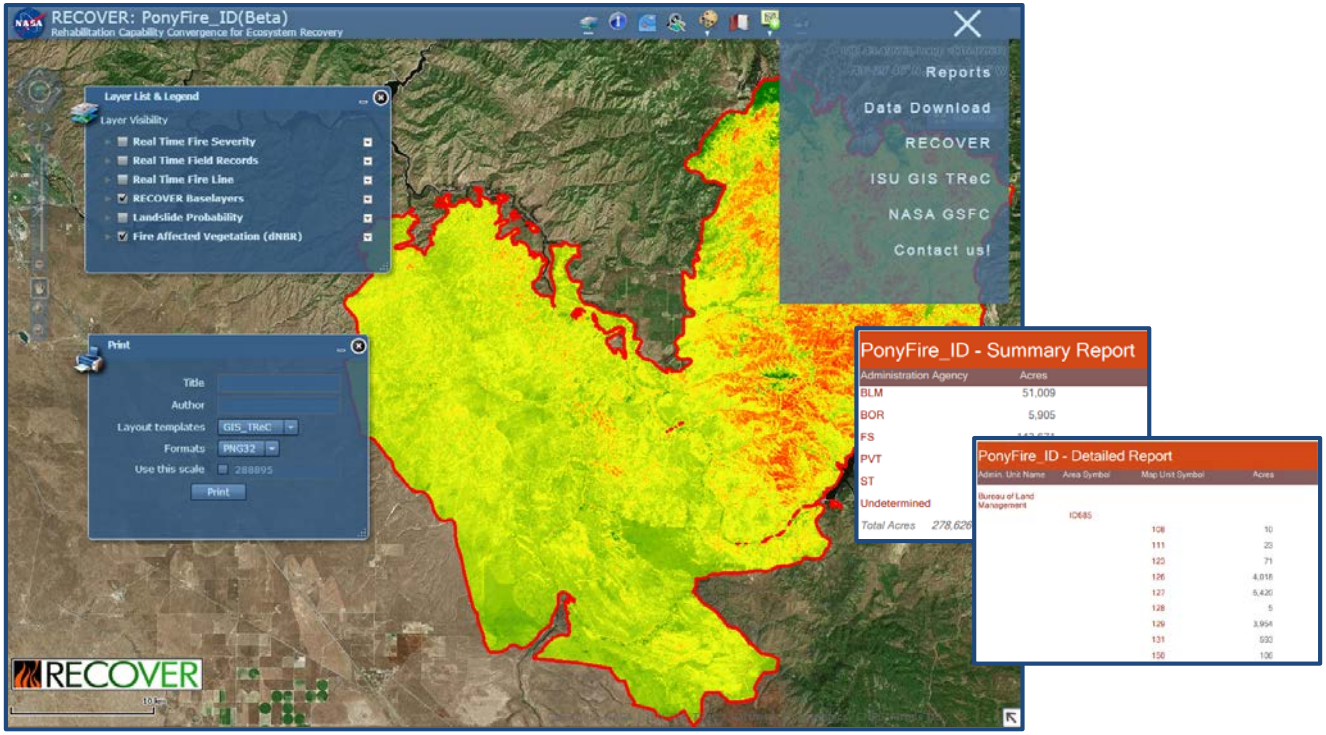
def stopStartServices (server, port, adminUser, adminPass, stopStart, serviceName…)

Server Side Processing

Notifications

```
import smtplib

#define function (use this function in other script that call this script.
# userEmail and URL are required inputs for this function
# userEmail = recipient
# URL = http address for RECOVER web map
def SendMail(userEmail, URL):

    # Define username and password for email account that will send the msg
    gmail_user = xxxxxxxx
    gmail_pwd =  xxxxxxxx

    #initialize the smtp server
    smtpserver = smtplib.SMTP("smtp.gmail.com",587)
    smtpserver.ehlo()
    smtpserver.starttls()
    smtpserver.ehlo()
    smtpserver.login(gmail_user, gmail_pwd)

    #header content of email
    header = 'To:' + userEmail + '\n' + 'From: ' + gmail_user + '\n' + 'Subject:Your RECOVER web map \n'

    #structure message here
    msg = header + ()

    # send mail via smtp
    smtpserver.sendmail(gmail_user, userEmail, msg)
    smtpserver.close()
```

RESULT: A RECOVER Web Client



Post-processing tasks

- Some ArcMap tools are not supported in geoprocessing services.
  - In RECOVER's case:
    - arcpy.mapping.ExportReport()
      - Separate python script tool
      - Task scheduler for automation
- Additional data requests

Questions?

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RECOVER is a NASA Applied Sciences sponsored project. K. T. Weber (PI), J. Schnase (Co-PI) and M. Carroll (Co-PI), Goddard Space Flight Center