United States Department of Agriculture

Methodological aspects of forest disturbance-damage reporting

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Forest Service

Introduction: moving from concept to practice


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- Objectives of forest disturbance-damage reporting (from prior chapter)
  - Identify sources and extent of harm
  - Identify meaningful departures from expected conditions and dynamics
  - Identify and initiate specific management responses
  - Ultimately, enhance understanding of forest ecosystems to guide policy and management action
- Practical goal for this chapter: accomplish these objectives in a <u>harmonized</u> way
  - Using analytical methods that can be implemented similarly by everyone
  - Applied to data sources available universally… or if not, data measured and recorded consistently between nations / organizations
  - We want <u>innovation</u> but also <u>cost-effectiveness</u> and <u>feasibility</u>

Defining frames of reference for harmonization


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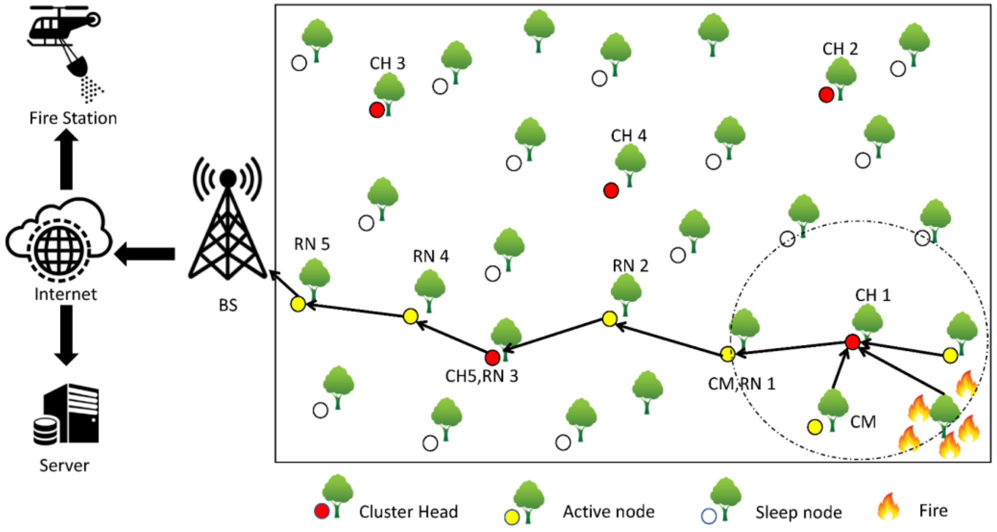
- Must resolve several issues to enable harmonized reporting
- Issues of scale
  - Reference time period (Last 20 years? Last 50 years?)
  - Reporting resolution (How long is the reporting interval? 5 years? 10 years?)
  - Minimum area of detectable damage
  - Threshold of detectable damage severity
- Issues of attribution
  - Is there an identifiable causal agent?
  - Cases of multiple interacting agents
- Issues of data
  - Direct vs. indirect measurement
  - Type of damage (e.g., mortality, defoliation)
  - Will damage signal persist or will it be short-lived?
- Different answers for different damage agents and types…but that's OK

Existing data sources provide a foundation

- Large-scale forest inventories
  - Strengths: detailed, systematic, comprehensive, statistically valid
  - Weaknesses: long measurement intervals, delay in data availability, expensive per unit area
- Field-based automated sensor systems
  - Examples: insect trapping systems (electronic or optical sensors), Wireless Sensor Networks (WSNs)
  - Strengths: inexpensive, systematic, essentially real-time
  - Main weakness: depend on quality of communications/data transfer



From Biabani et al. 2020. Sensors 20(9): 2647.
https://doi.org/10.3390/s20092647

Existing data sources provide a foundation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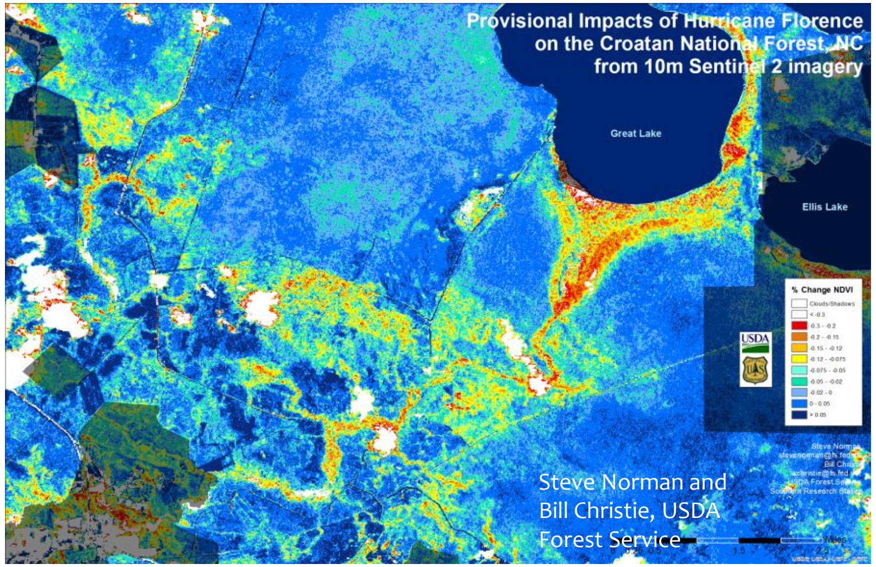
- Aerial surveillance (e.g., aircraft, drones)
  - Strengths: close to real-time, inexpensive, useful to forest health personnel
  - Weaknesses: targeted instead of systematic, rarely supports statistical analysis, observations must be verified
- Satellite remote sensing
  - Examples: multispectral, hyperspectral, RADAR, thermal imaging
  - Strengths: near real-time, systematic, comprehensive, statistically valid, inexpensive (usually)
  - Weaknesses: measures damage indirectly, utility can depend on quality of developed algorithms


Ronald F. Billings, Texas A&M Forest Service, Bugwood.org
USDA Forest Service



Steve Norman and Bill Christie, USDA Forest Service

Existing analytical methods also provide a foundation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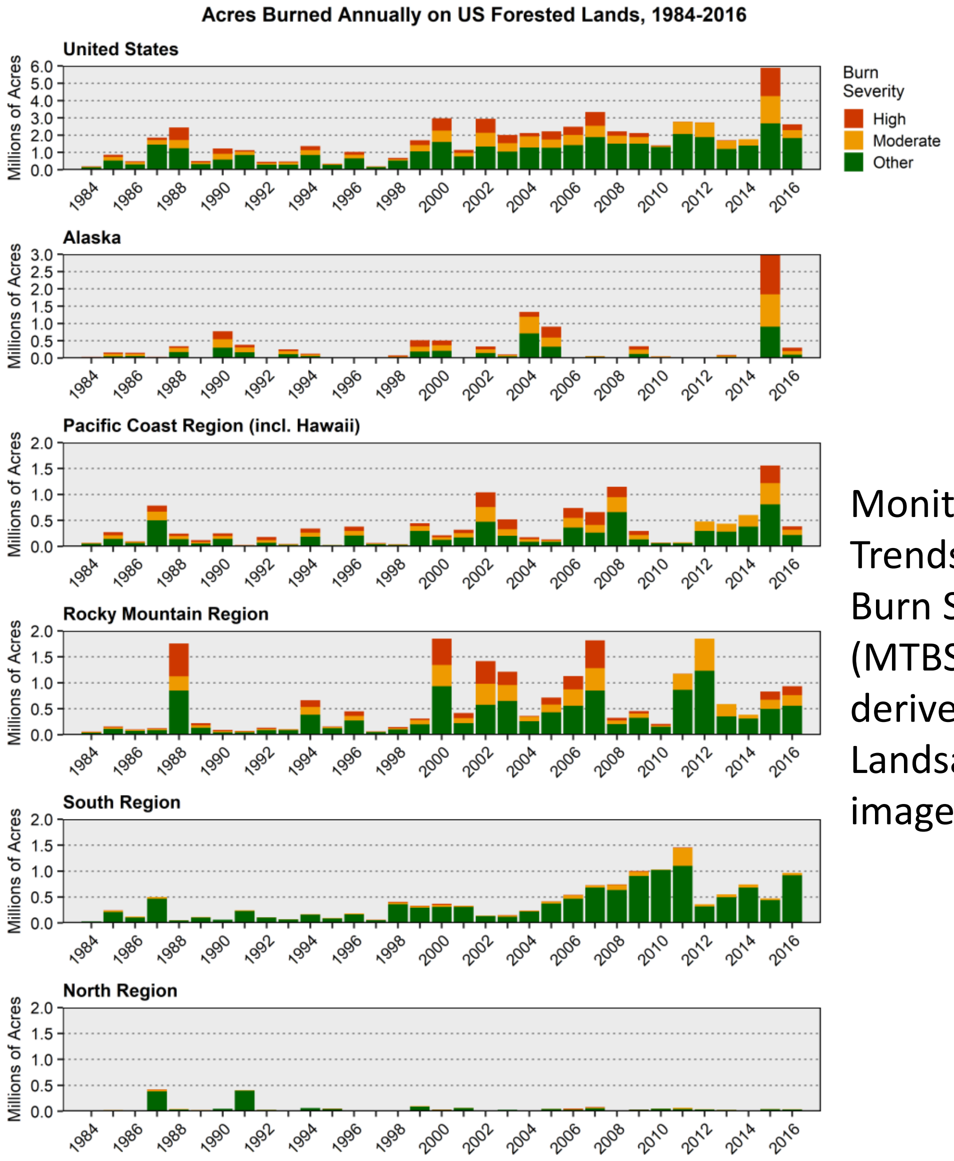
- From forest inventories:
  - Population-level estimation of damage metrics
  - Spatial analysis of inventory plots
    - Hot-spotting methods based on spatial autocorrelation, point pattern analysis
- From remote sensing:
  - Data transformations and indices
    - Tasseled Cap, NDVI, Normalized Burn Ratio, spectral mixture analysis, etc.
  - Supervised / unsupervised classification
  - Change detection methods
  - Time series analysis
- Indeed, trend analysis valuable regardless of data source



Monitoring Trends in Burn Severity (MTBS) data, derived from Landsat imagery

Importance of integration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- Strengths and weaknesses of these various data sources and methodologies point to integrated approaches or workflows
  - Strengths complement each other, should offer opportunity to overcome weaknesses and enable harmonization
  - Ancillary data sources (e.g., insurance payouts) could be useful, too
  - Latter portion of this chapter will focus on case studies of integration
  - Must remain mindful of what is cost-effective and feasible for everyone
- Other considerations:
  - Approaches to upscaling analyses
  - Disturbance-damage prediction under a changing climate
  - Knowledge sharing and communication
  - Prevention: use of early warning indicators signaling loss of system resilience or undesirable regime shifts

Example: innovation in rangeland monitoring


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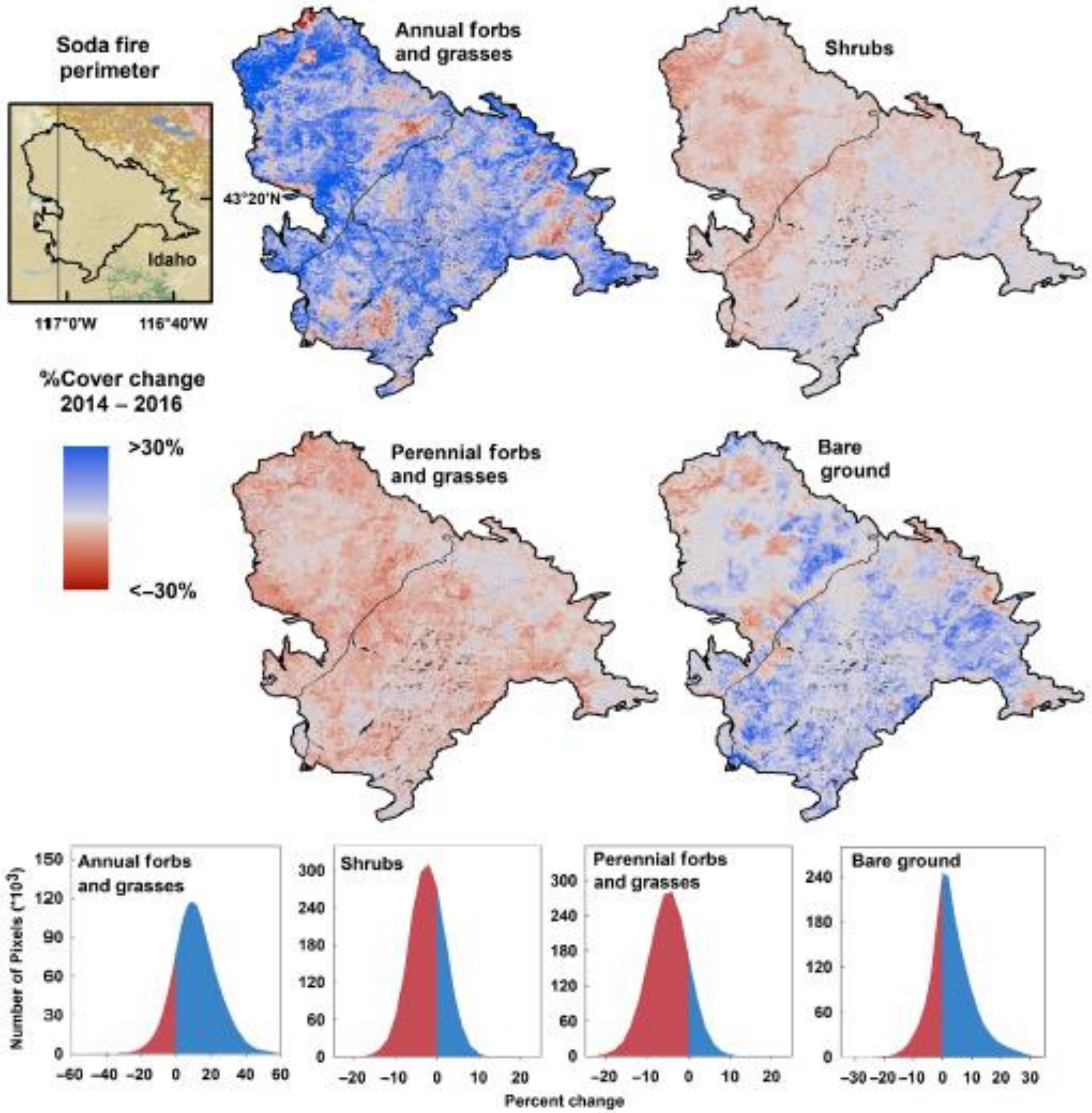
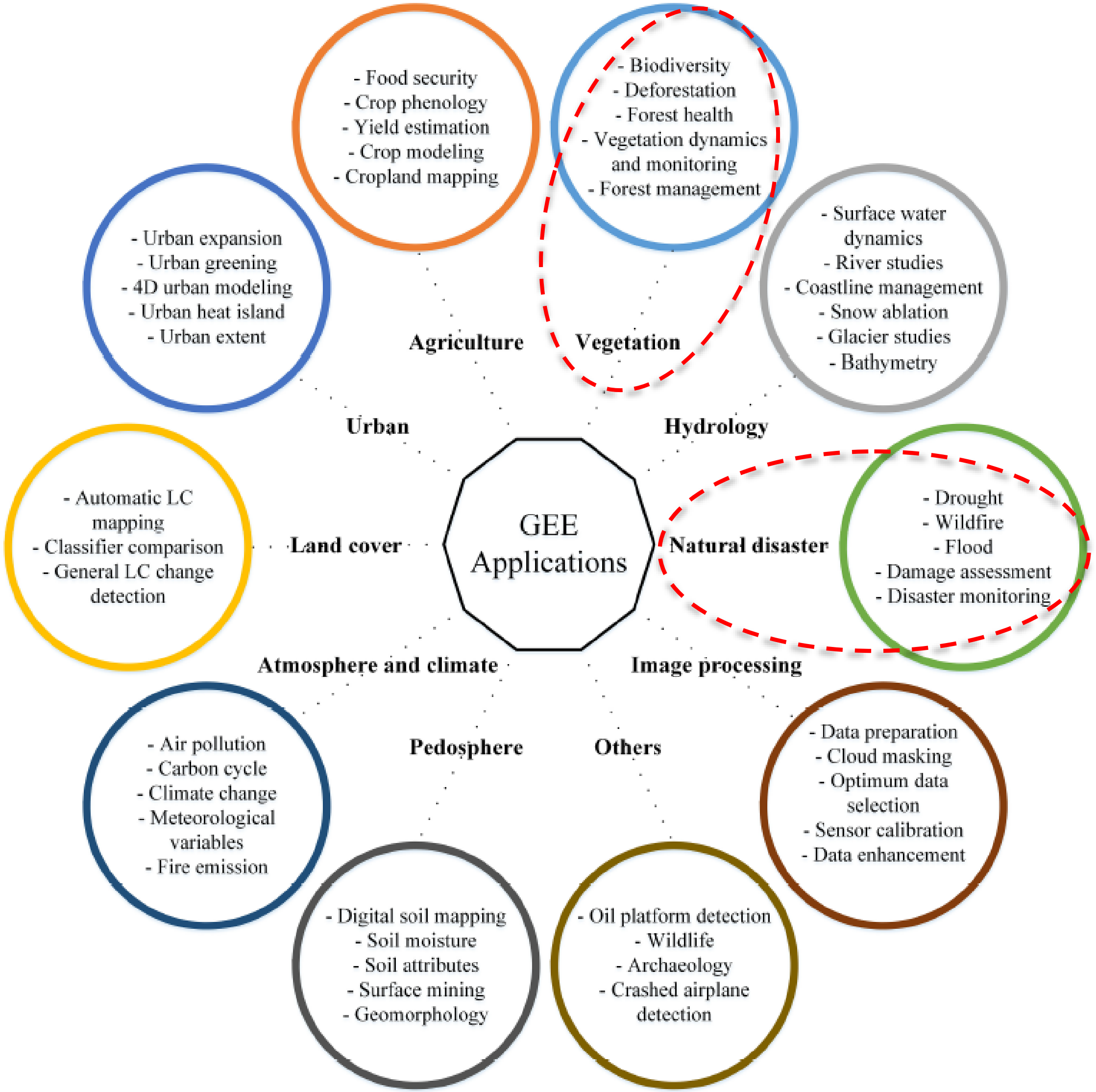
- Jones et al. 2018. Ecosphere 9(9): e20430. https://doi.org/10.1002/ecs2.2430
  - Plant functional type percent cover maps for US rangelands, 1984-2017
  - Based on historical Landsat record, gridded meteorological data, abiotic land surface data, and 30,000 field plots
  - Random Forests model
  - Maps display land cover variation in response to changes in climate, disturbance, and management
- For rangelands but approach should translate to forests
  - Notably, used Google Earth Engine (see next slide)



From Jones et al. 2018

Google Earth Engine (GEE)

- Cloud computing platform for big data analysis
- Amani et al. 2020. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 13: 5326-5349
  - Reviewed 450 articles, published 2010-2020, about remote sensing applications of GEE
  - Landsat and Sentinel datasets used extensively
  - Mostly utilized Random Forests or similar machine learning algorithms
  - Numerous relevant examples



From Amani et al. 2020. https://doi.org/10.1109/JSTARS.2020.3021052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Summary points

- Again, chapter goal is to establish harmonized methods for forest damage-disturbance reporting
- Must identify aspects of forest damage-disturbance that are (or can be) measured universally
- Must develop appropriate methods that everyone can implement
- Will need innovative and integrated approaches combining varied data sources

- Questions or comments?

- Thank you!