Introduction

The Interagency Science Team (IST) for Fire Program Analysis (FPA) was charged with developing a detailed recommendation for a global architecture or conceptual structure to guide the Phase II development of FPA. The IST is composed of fourteen scientists representing USDA Forest Service R&D, U.S. Geological Survey, two universities (Colorado State University, Oregon State University), and IBM; and a senior advisor/facilitator from METI Corporation (see Appendix for listing of IST members). Over the past six weeks, the IST worked together and interacted with members of the FPA Development Team to develop the recommendation described herein. The recommended architecture is intended to be responsive to the vision articulated for FPA, namely that FPA should represent "a common interagency planning and budget information system, with a cost-effective trade-off analysis incorporating land and resource management objectives" (Hubbard and others, 2001). Once fully developed and implemented, the FPA system will provide planning and budget support by displaying key efficiency, effectiveness, and performance measures for various budget scenarios and constraints, and by estimating costs for fire program components for each agency by Fire Planning Unit (FPU) [in this document, the FPA planning and budget information system is referred to as the FPA system for brevity].

The proposed architecture for the FPA system responds to expectations created by the Wildland Fire Leadership Council (WFLC) and senior managers in USDA Forest Service and DOI. These expectations include three broad components:

- the FPA system should inform decisions by national budget leads and fire planners in formulating annual budget proposals regarding budget allocations among fire program components by agency and FPU;

- the FPA system should also support FPU-level analyses that inform decisions made by local agency fire program and resource managers regarding alternative allocations of fire program resources within the geographic area covered by the FPU; and

- results or outcomes of these decisions at each level should be evaluated in relation to five broad management concerns articulated by WFLC, formulated as a series of effectiveness, efficiency, and performance measures, defined in an operationally appropriate manner at national and FPU levels.

The identified WFLC management concerns focus on:

- growing annual suppression costs for large fires,
- fires that occur and cause significant damage within the wildland-urban interface (WUI),
- fires that cause severe impacts to highly valued resources,
- prevention and suppression of unwanted and unplanned fires, and
- attaining fire and fuels management objectives on federal lands.

IST Proposal for FPA Architecture

The proposal summarized herein represents the full consensus of the entire IST; this statement applies strictly to the membership of IST, and does not imply endorsement by others outside IST.

Within the context of the expectations summarized above, the IST proposes a flexible, two-tiered structure for the Phase II development of FPA. That is, the IST envisions a modular set of component models or analytical tools at both national and FPU levels. The architecture described herein specifies the modular structure and component models or tools at each level, the information flows among them, data sources and model outputs, and other aspects of model structure and requirements. The proposed modular architecture could incorporate different models or analytical tools in some component modules. This could allow use of different but comparable approaches for different portions of the U.S. (e.g., use of more detailed process simulations of large fire growth and intensity in the western US, where such fires are common, but an alternative technique in the eastern US where large intense fires are less probable). New or enhanced models or tools could be incorporated into the existing structure of the FPA system without causing major disruptions in model operations or coding. This modular architecture, in combination with specific decision support tools such as Bayesian Belief Networks (BBNs), will also allow models, statistical representations of historical data, and expert opinion to be combined into a single analysis approach at either level.

The following paragraphs provide details on the proposed FPA architecture at national and FPU levels.

FPA Business Flow Model

The proposed approach assumes structured information flow between the two analysis levels (Figure 1). In this construct, information regarding overall goals and objectives of the analysis, constraints, and the specific national budget alternatives being considered in a given budget year is passed between the two levels as part of the annual budget formulation process. Following detailed simulations and trade-off analyses at the FPU level based on an array of budget allocation choices, model results are synthesized in different forms and passed back to the national-level analysis. At the national level, application of decision support tools facilitates strategic choices across all FPUs. National decisions result in FPU-specific allocations by fire program component and agency. Finally, additional simulations and tradeoff analyses at the FPU level inform decisions about allocation of fire resources across the FPU within the chosen budget level.

Overview of National-Level Analysis

At the national level, FPA analyses are designed to inform decisions by national budget leads and fire planners regarding annual agency budget allocations among national fire program components by agency and FPU. Decisions regarding allocation of national fire resources such as air support and hot shot crews might also be examined at this level, or at a regional level embedded within the national-level analysis. The national analysis would typically be run each year during the annual agency budget formulation process, as

well as at less frequent intervals to evaluate longer-term strategic decisions regarding fire program allocations.

The proposed national-level analysis involves application of decision support tools (e.g., goal programming trade-off analyses) that are informed by FPU-level analyses. These tools include formal methods for searching among alternatives, evaluating trade-offs and implications of weighting performance measures differently, and explicitly addressing risk and uncertainty. Detailed simulations of the consequences of different fire program investments at the FPU level are synthesized and used to develop national-level analytical tools (as summarized in Figure 1). The decision support tools used at the national level display the data and model results from FPU-level analyses in a manner that reveals the structure of the decision space and the consequences of the alternative allocation strategies available to national-level managers, as quantified by the effectiveness, efficiency, and performance measures formulated at the national level.

Overview of FPU-Level Model or Analysis

At the FPU level, the FPA system is designed to inform local decisions regarding the distribution of fire program resources within the geographic area covered by the FPU. The FPU level analysis would be run at least twice during a single budget cycle (Figure 1). During the annual agency budget formulation process, the purpose is to explore a wide range of management options at various budget levels. Following passage of a budget by Congress and allocation of funds to the FPU level by agency, the purpose is to explore specific distribution options at a specific appropriated budget level.

The proposed FPU-level analysis involves application of a detailed simulation module linked to a decision support and data synthesis and management module. Simulation allows consideration of complex processes that interact at the FPU level including weather, topography, vegetation, and other factors that influence fire behavior. It also allows consideration of impacts on spatially distributed resource values and other performance measures. Based on national and regional guidance, detailed simulations of the consequences of alternative levels of investment in different fire program components are conducted at the FPU level. Decision support tools (e.g., multi-attribute trade-off analyses) are employed to display data and model results from FPU simulations in terms of consequences of budget alternatives for the various performance measures and for the structure of the decision space available to managers. Results are synthesized and passed back to the national level to inform budget formulation decisions made there. In this case, detailed model simulations would focus on the consequences of different resource distribution strategies on the ground within the FPU within the specific budget allocation to that FPU by agency. Multi-attribute trade-off analyses would be conducted on these results to inform the final decisions regarding resource distribution at the field level within the FPU.

Additional Recommendations and Considerations

The overall approach and architecture proposed by IST incorporates several additional embedded recommendations.

- First, prototyping is a key activity in ongoing development of the FPA system – i.e., development and evaluation or formal review of various prototype model structures as FPA evolves. Prototyping could involve evaluation of individual component models to be incorporated into specific FPA modules, as well as the evaluation of the entire FPA model at either level of analysis at important milestones. Prototyping will help demonstrate feasibility of the recommended FPA system architecture and help resolve residual issues.
- Second, we recommend an ongoing, formal advisory role for the IST as FPA development progresses, either the IST as presently structured, or a restructured IST with new members that add new experiences or analytical skills. The IST could also reach out to bring other scientific and technical skills into this advisory relationship as needed.
- Third, we recommend establishment of a parallel management advisory team for FPA, composed of line managers from the land management agencies. This team could help ensure relevance of the FPA system and manage expectations for involvement of FPU staff in FPA analyses.
- Fourth, we recommend development of a specific audit/quality assurance system within the FPA system, to ensure that models and analyses at the FPU level are run in an appropriate and objective manner, and that they provide reliable comparisons across FPUs, program components, and agencies.
- Fifth, FPA analyses at national and FPU levels should explicitly recognize the role of regional level managers in fire program decisions (e.g., formal regions in USDA Forest Service, National Park Service, and U.S. Fish and Wildlife Service, State offices in Bureau of Land Management).
- Sixth, we recommend using information and data generated in FPA Phase I, and building on partnerships established in Phase I, in Phase II activities.

Inherent in the IST recommendation is recognition of two key concepts. First, we recognize that, in the time allotted for our deliberations, we have not been able to resolve all important issues that will influence ongoing FPA development. In our final report, we will identify specific issues facing the Development Team. Resolving these issues effectively can have a large positive influence on the final structure of the FPA system. This is why IST views prototyping as a significant component of FPA development, and why continued interactions between IST and the Development Team are critical. Second, given the levels of uncertainty that exist in aspects of federal fire programs, the IST designed an analytical structure that arrays decision options along with the consequences of fire program decisions for fire and resource conditions. Our intent is to inform the decision making process through a structured analytical framework, not to search for *the* best answer.

The IST further recognizes that successful implementation of FPA faces challenges that go beyond purely scientific and technical issues.

- First, successful FPA development and implementation requires that appropriate specialized skills are within, or readily accessible to, the FPA Development Team.
- The second is focused on analytical capability and capacity available within the agencies to build requisite data layers, run FPA system models, and interpret results

appropriately. In particular, agencies might consider building analytical capacity into regional teams to help support FPU-level analyses.

- Third, effective training programs are needed to ensure that model users, at FPU and national levels, are capable of running FPA models properly and interpreting results appropriately.
- Fourth, recognizing that some components within the recommended FPA system architecture may have significant computing requirements, successful implementation will require that adequate computing capability is available to run models or analytical tools in reasonable time frames.
- Fifth, benefits from application of proposed FPA analyses will be enhanced if applied across all ownerships, including federal and non-federal. Challenges remain in terms of application on many non-federal lands; such challenges are not inherently technical. The design proposed by the IST can be applied across all ownerships.

References

J.E. Hubbard and others. 2001. Developing an Interagency, Landscape-Scale Fire Planning Analysis and Budget Tool. Report to the National Fire Plan Coordinators: USDA Forest Service and U.S. Department of the Interior.

Appendix
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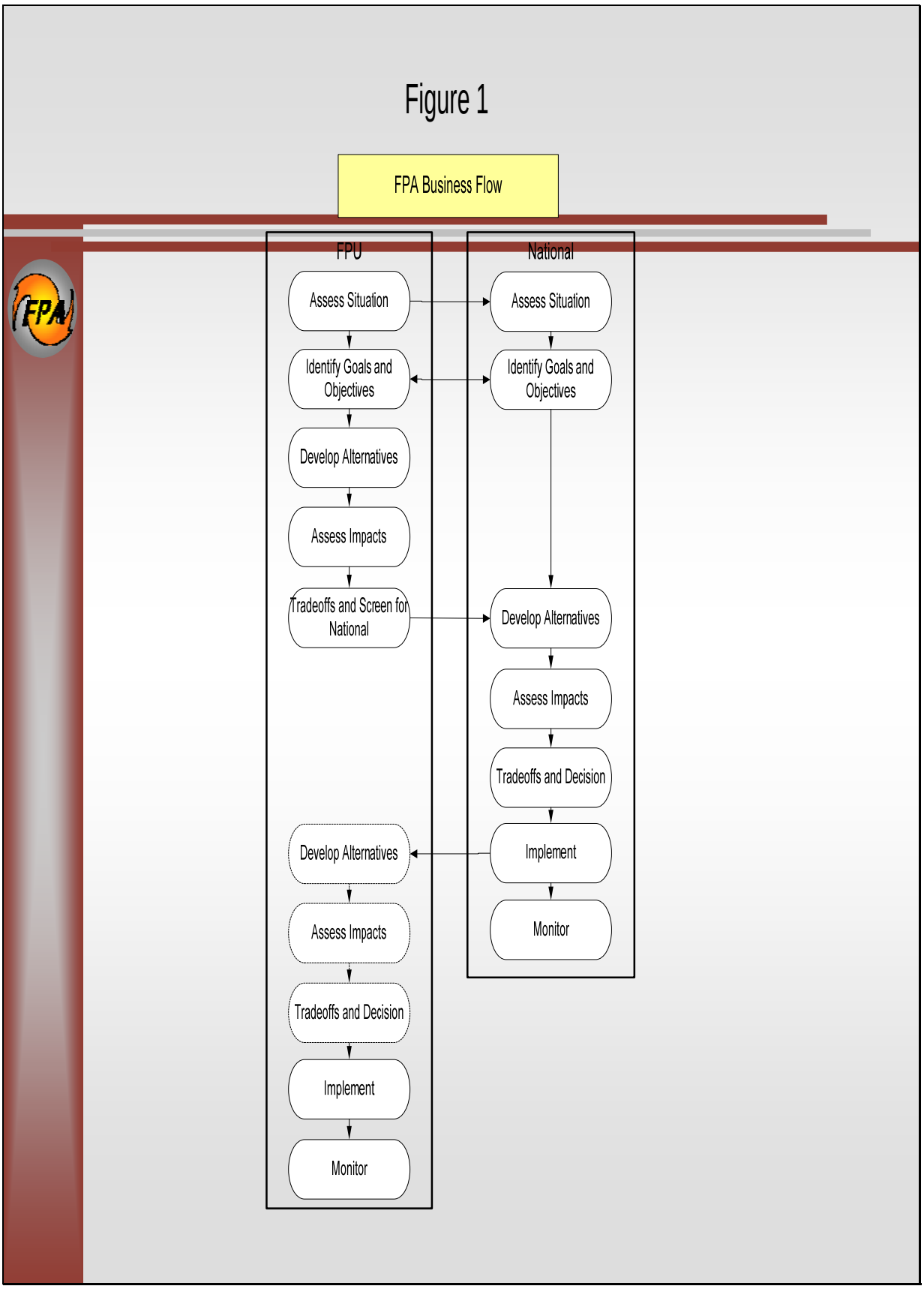


Figure 1
FPA Business Flow
FPU
National
Assess Situation
Identify Goals and Objectives
Develop Alternatives
Assess Impacts
Tradeoffs and Screen for National
Develop Alternatives
Assess Impacts
Tradeoffs and Decision
Implement
Monitor
Assess Situation
Identify Goals and Objectives
Develop Alternatives
Assess Impacts
Tradeoffs and Decision
Implement
Monitor

Figure 2

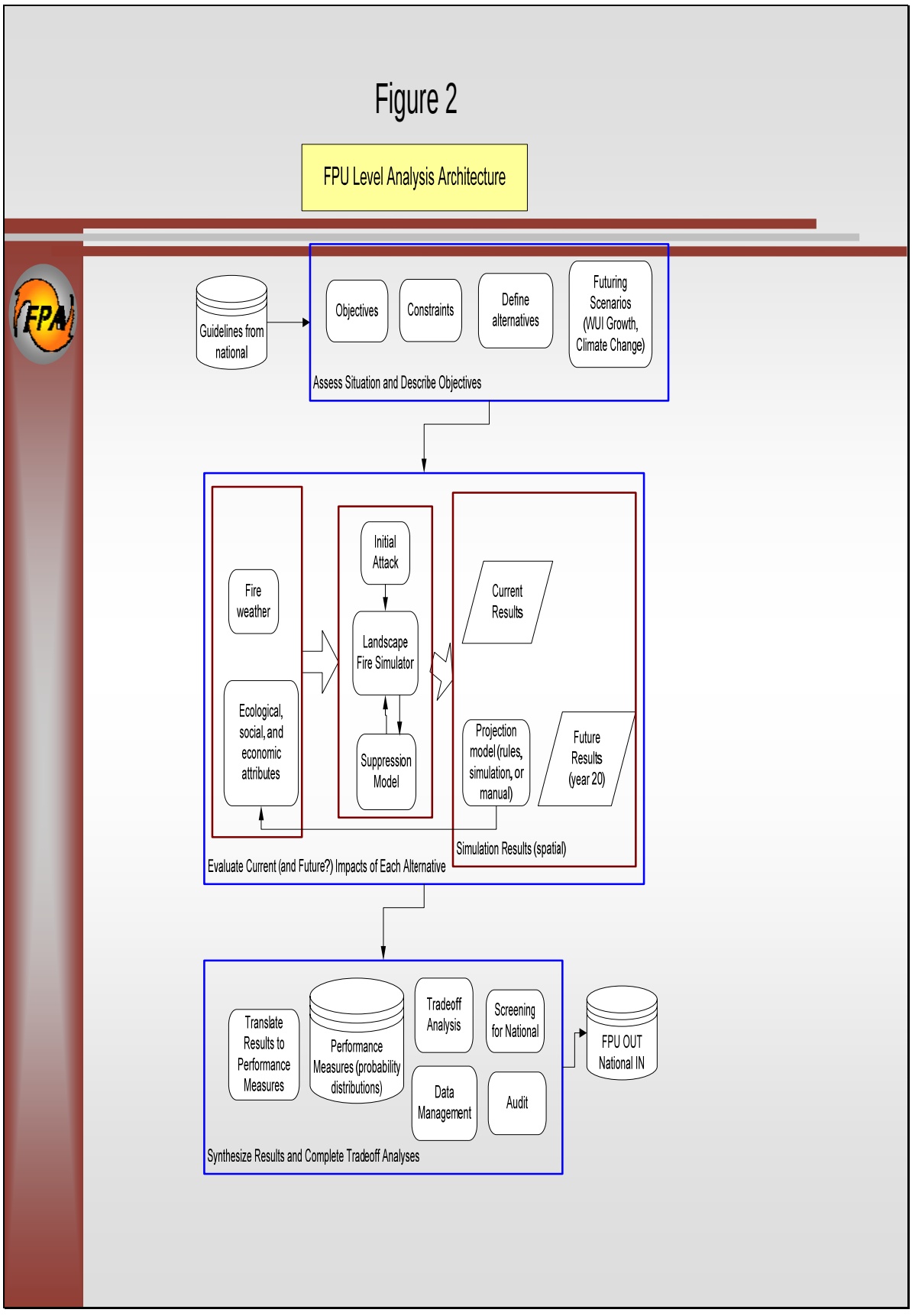
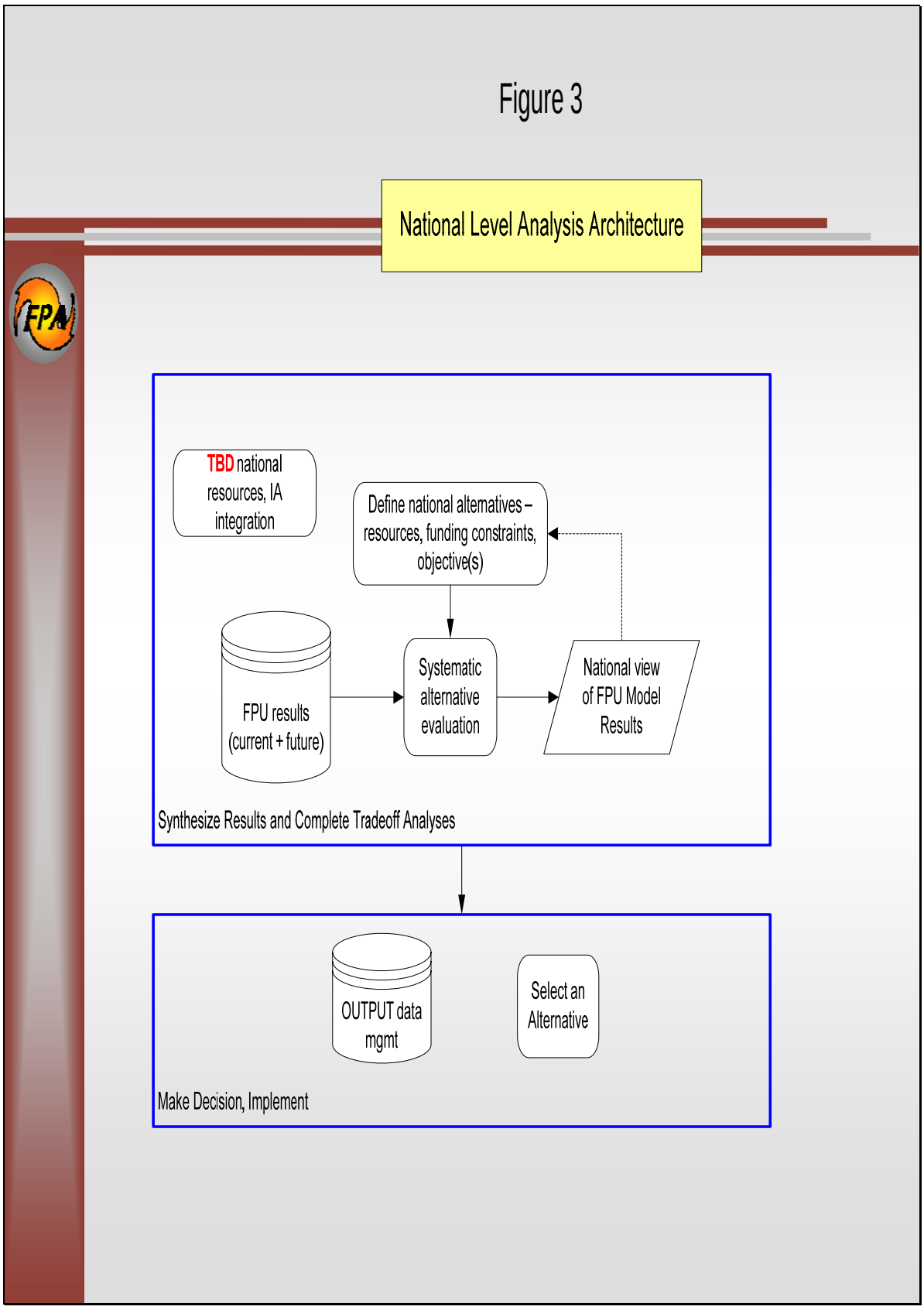

FPU Level Analysis Architecture
Guidelines from national
Objectives
Constraints
Define alternatives
Futuring Scenarios (WUI Growth, Climate Change)
Assess Situation and Describe Objectives
Fire weather
Ecological, social, and economic attributes
Initial Attack
Landscape Fire Simulator
Suppression Model
Current Results
Projection model (rules, simulation, or manual)
Future Results (year 20)
Simulation Results (spatial)
Evaluate Current (and Future?) Impacts of Each Alternative
Translate Results to Performance Measures
Performance Measures (probability distributions)
Tradeoff Analysis
Screening for National
Data Management
Audit
FPU OUT National IN
Synthesize Results and Complete Tradeoff Analyses

Figure 3


National Level Analysis Architecture
TBD national resources, IA integration
Define national alternatives – resources, funding constraints, objective(s)
FPU results (current + future)
Systematic alternative evaluation
National view of FPU Model Results
Synthesize Results and Complete Tradeoff Analyses
OUTPUT data mgmt
Select an Alternative
Make Decision, Implement