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MERDG
Modelling Environmental Risks and Decisions Group

Assessing Ecosystem Service Benefits from Military Installations

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25 YEARS OF ESTCP
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2019 | Enhancing DoD's Mission Effectiveness

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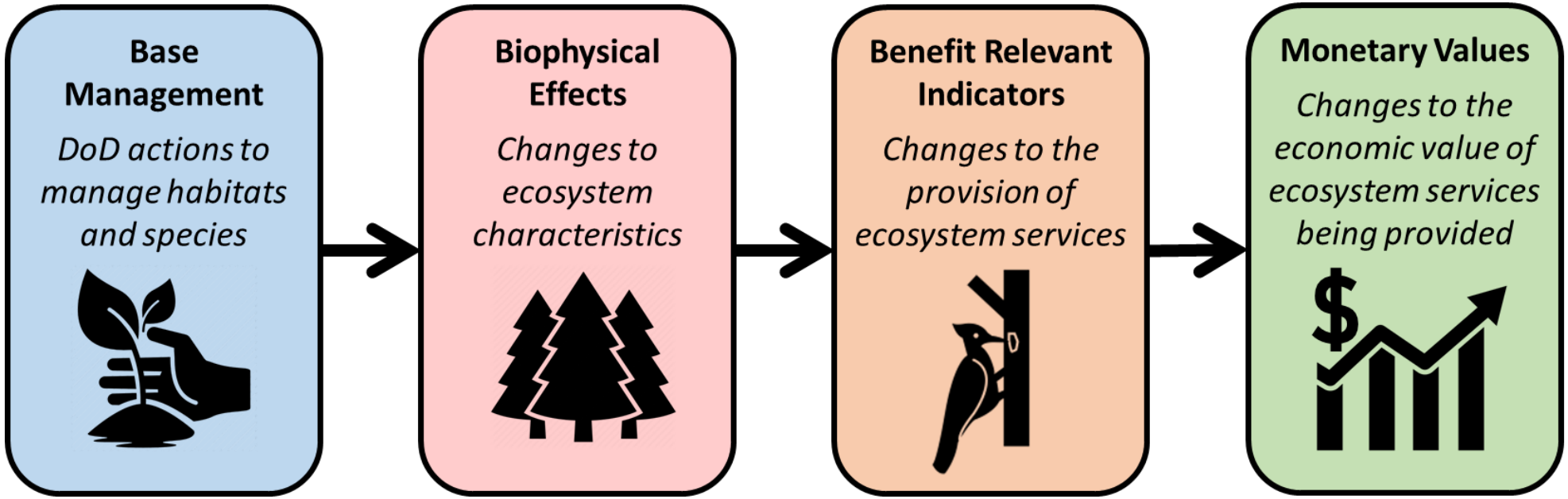
- Most United States military bases feature large areas of sparsely developed land.
- This land serves a range of important non-military functions including flood protection, habitat provision, outdoor recreation, and carbon storage.
- Therefore, military bases provide substantial ecosystem services to the public.

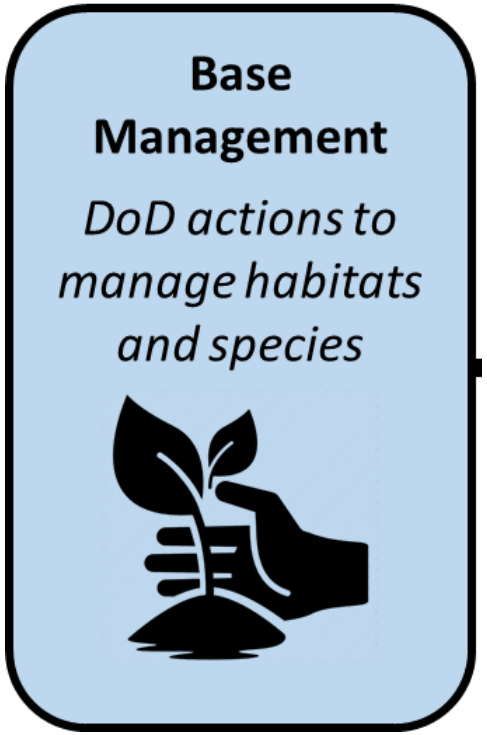
Project Objective

To develop a method for quantifying the ecosystem services being actively provided by U.S. military bases.



Conceptual Models

- Create a suite of **conceptual models** of ecosystems being actively managed at military bases:
  1. Fire- and non-fire maintained forests
  2. Fire- and non-fire maintained grasslands
  3. Deserts and drylands
  4. Rivers, streams, riparian areas
  5. Lakes, ponds, wetlands
  6. Estuaries, saltmarsh, bays, shorelines

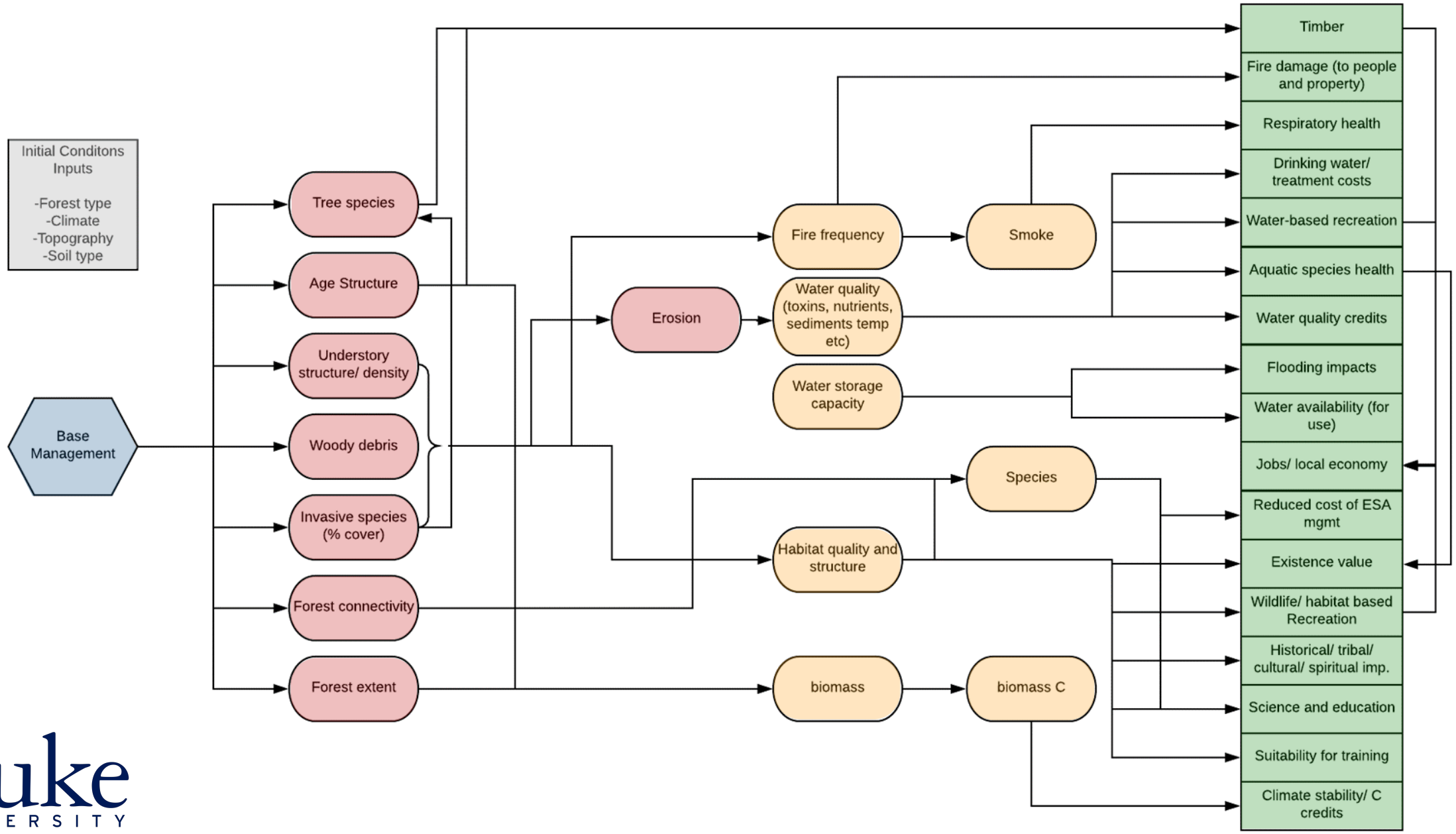


Conceptual Models

Developed with reference to four bases:

1. Eglin Air Force Base, Florida
2. Fort Hood Army Base, Texas
3. Camp Lejeune Marine Base, North Carolina
4. Joint Base Lewis-McChord, Washington

Base Management → Biophysical Effects → Benefit Relevant Indicators (BRIs) → Benefit Relevant Indicators and Monetary Values



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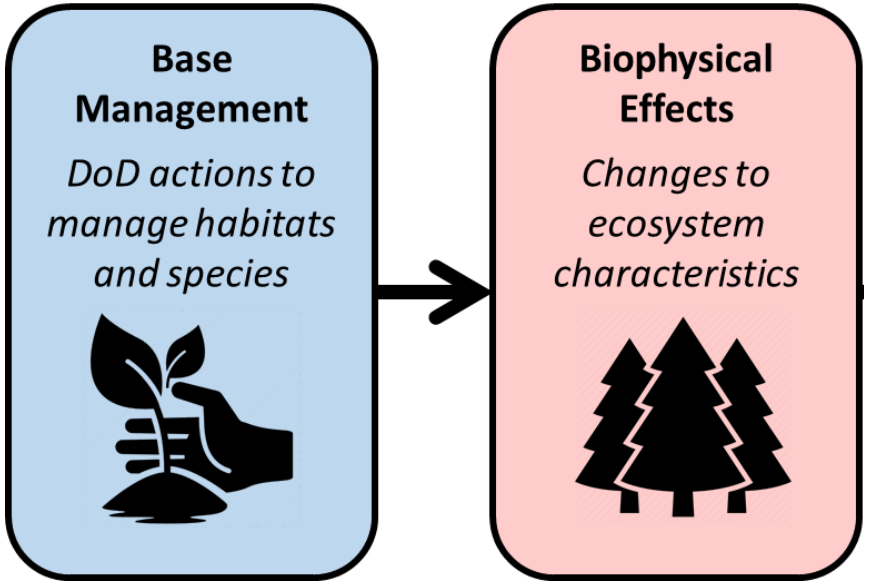
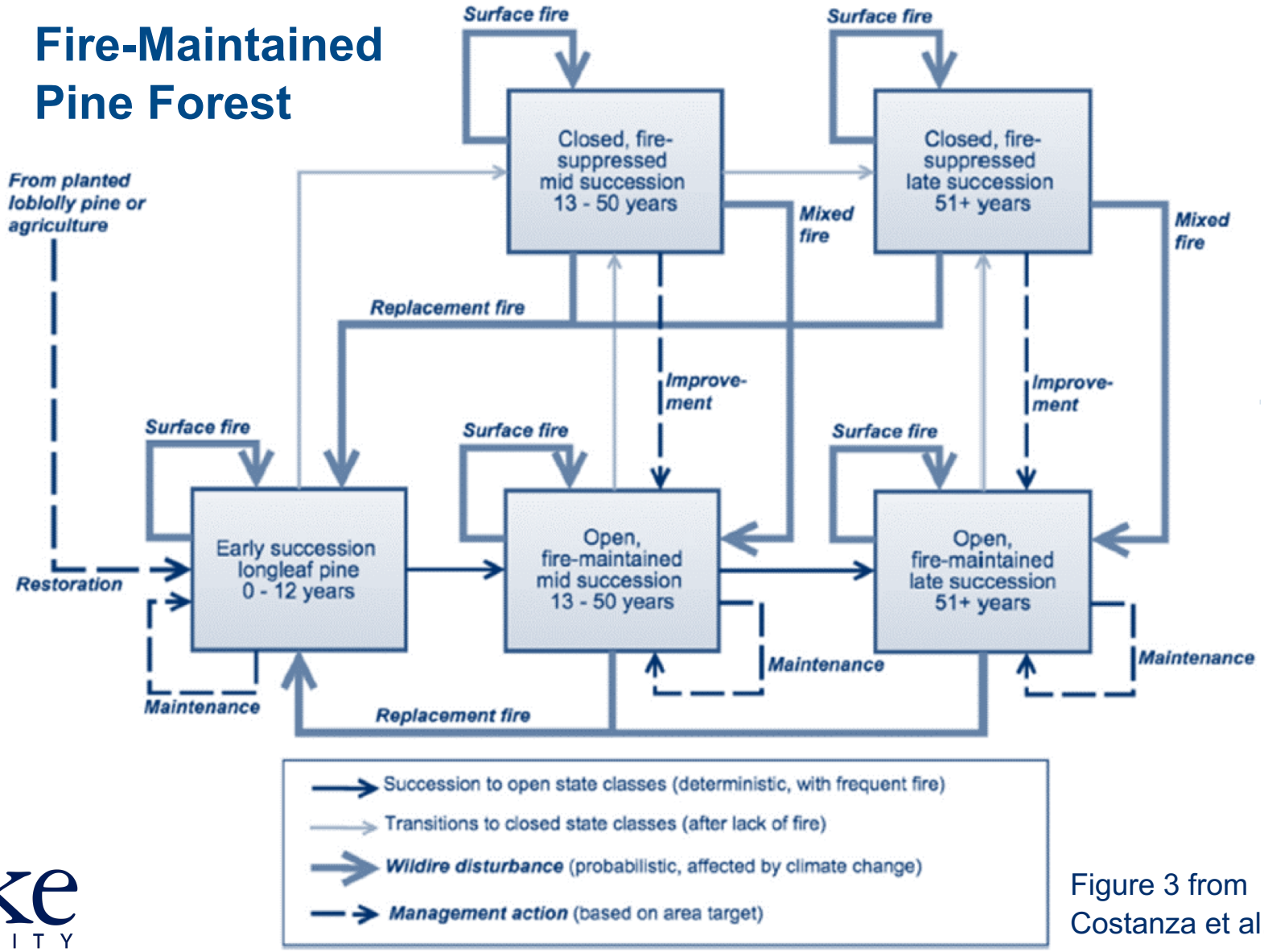
Biophysical Models



- Use **biophysical models** to characterize ecological state, condition, and function under scenarios of interest:
  - e.g., state-and-transition simulation models (STMSs)

Biophysical Models

Fire-Maintained Pine Forest



Closed

Open

Illustrations by Bob Van Pelt

Figure 3 from Costanza et al. 2015

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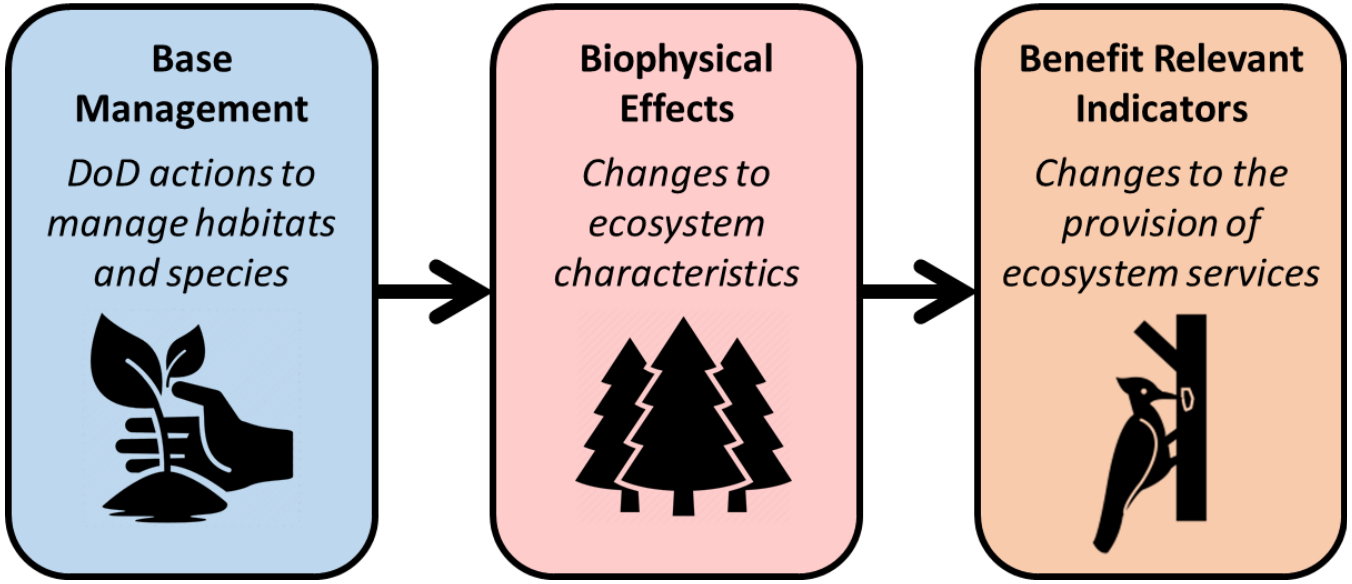
Benefit Relevant Indicators (BRIs)



- Link biophysical effects to **benefit relevant indicators (BRIs)**:

  Water storage capacity

  ↓

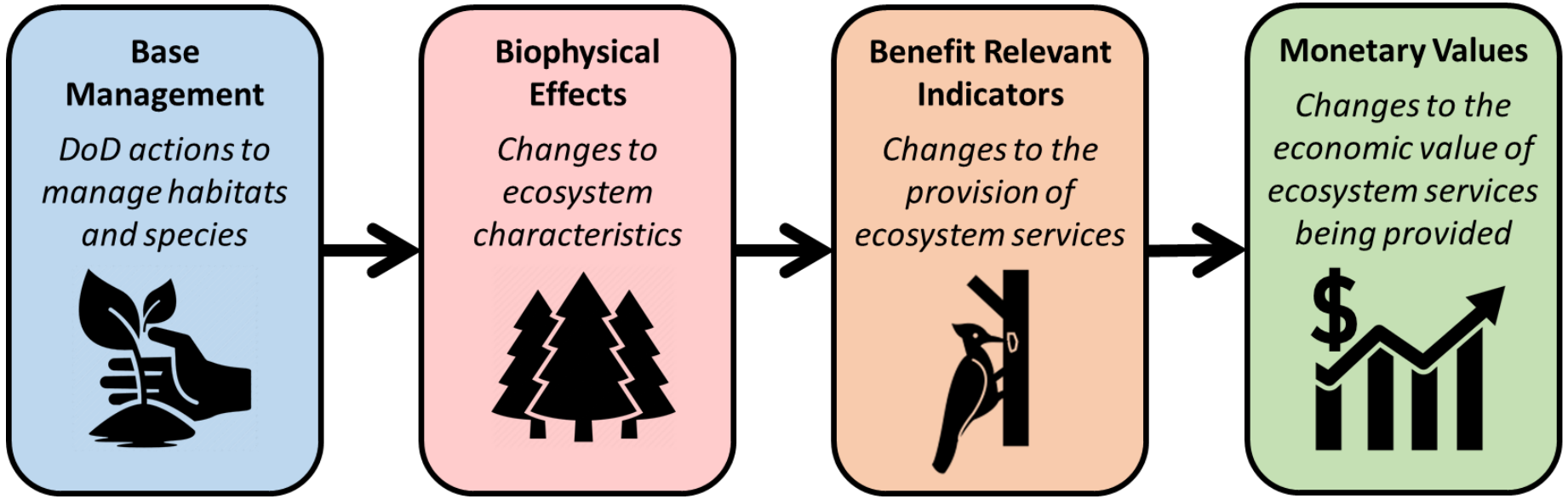
  Reduction in flood risk

- Using, for example:
  - Flood risk model (HAZUS)
  - Smoke exposure model (CMAQ)
  - Storm surge model (SLOSH)
  - Data analysis

Model Endpoint	Benefit Relevant Indicator (BRI)
Wildfire damage	• Increased/decreased severity and/or extent of fire on and around base (per acre)
Respiratory health (smoke)	• Number of people expected to experience increased smoke exposure/day
Timber harvest	• Board-feet of timber harvested per year from the base
Energy production (from biofuels)	• Biomass energy production from the base
Recreation opportunity	• User-days recreating on the base
Carbon storage	• Mg C on the base
Federally-listed threatened and endangered species	• Acres of occupied habitat on the base • Population estimates • Population estimates on base relative to population over full range • Stream miles of occupied habitat • # of occurrences • # of occurrences on base relative to occurrences within species range
Endemic or locally important species	• Acres of occupied habitat on the base • Stream miles of occupied habitat • # of occurrences • # of occurrences on base relative to occurrences within species range
Huntable wildlife species	• Number of hunting permits or tags from the base
Harvestable fish	• Number of fishing licenses from the base
Water quality	• Tons of sediment per year exported from base, relative to proportion of waterways impaired in the catchment. • Sediment retention by land cover per year for catchment, relative proportion of waterways impaired in the catchment.
Flood damage to property (from coastal storm surge)	• Change in the probability of flooding downstream of base, due to base land cover (to estimate number of properties or facilities damaged per year)
Flood damage to property (from inland flooding)	• Water holding capacity of base uplands, wetlands and waterbodies during flood events in areas where downstream flooding impacts people and property
Shoreline erosion	• Area of beach used by people, providing habitat for species, or protecting infrastructure
Water available for agriculture or industrial uses	• Water storage on the base and amount of water needed by farmers or industry downstream from the base or otherwise able to access base water

Economic Valuation

- Assign **monetary values** to BRIs whenever possible:

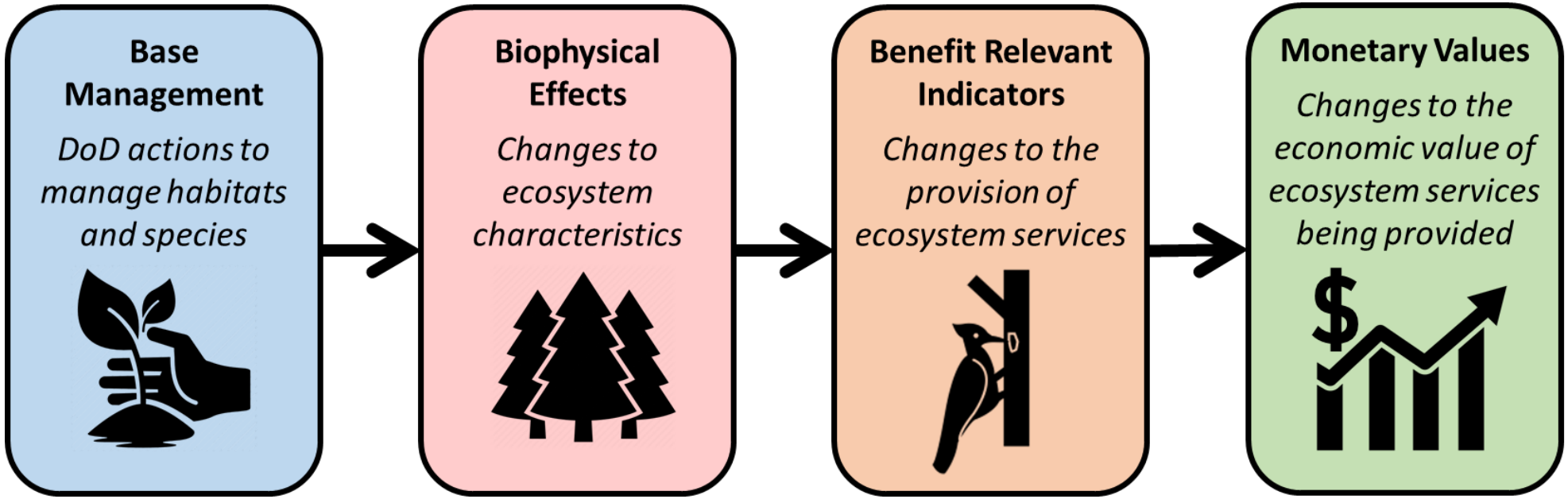


- Market values
- Avoided costs
- Willingness to pay
- Social cost of carbon
- Benefits transfer

Model Endpoint	Benefit Relevant Indicator (BRI)	Economic Value
Wildfire damage	• Increased/decreased severity and/or extent of fire on and around base (per acre)	• Avoided suppression costs • Avoided damage to property
Respiratory health (smoke)	• Number of people expected to experience increased smoke exposure/day	• Willingness to pay for reduced smoke exposure
Timber harvest	• Board-feet of timber harvested per year from the base	• Market value of timber
Energy production (biofuels)	• Biomass energy production from the base	• Electricity cost savings for a base
Recreation opportunity	• User-days recreating on the base	• Willingness to pay for recreation
Carbon storage	• Mg C on the base	• Social cost of carbon
Federally-listed threatened and endangered species	• Acres of occupied habitat on the base • Population estimates • Population estimates on base relative to population over range • Stream miles of occupied habitat • # of occurrences • # of occurrences on base relative to occurrences within range	• Willingness to pay for species preservation
Endemic or locally important species	• Acres of occupied habitat on the base • Stream miles of occupied habitat • # of occurrences • # of occurrences on base relative to occurrences within range	• Willingness to pay for endemic species preservation
Huntable wildlife species	• Number of hunting permits or tags from the base	• Willingness to pay for hunting
Harvestable fish	• Number of fishing licenses from the base	• Willingness to pay for fishing
Water quality	• Tons of sediment per year exported from base • Sediment retention by land cover per year for catchment	• Avoided water treatment and sediment removal costs • Value of improved fisheries
Flood damage to property (from coastal storm surge)	• Change in the probability of flooding downstream of base	• Avoided damage to property
Flood damage to property (from inland flooding)	• Water holding capacity of uplands, wetlands and waterbodies	• Avoided property damage
Shoreline erosion	• Area of beach used by people, providing habitat for species, or protecting infrastructure	• Cost of beach renourishment • Avoided damage to property
Water available for agriculture or industrial uses	• Water storage on the base and amount of water needed by farmers or industry downstream from the base	• Cost of water rights or purchases

Model Integration

Connect all components to holistically account for cumulative effects, co-benefits, and feedbacks.



Model Integration

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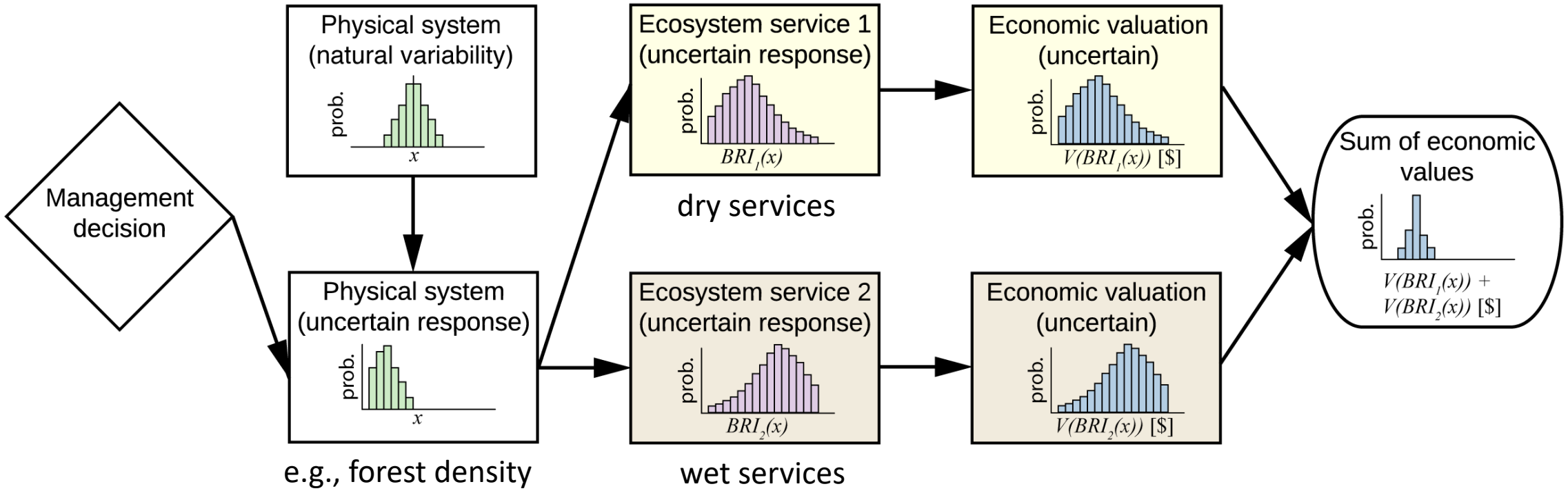

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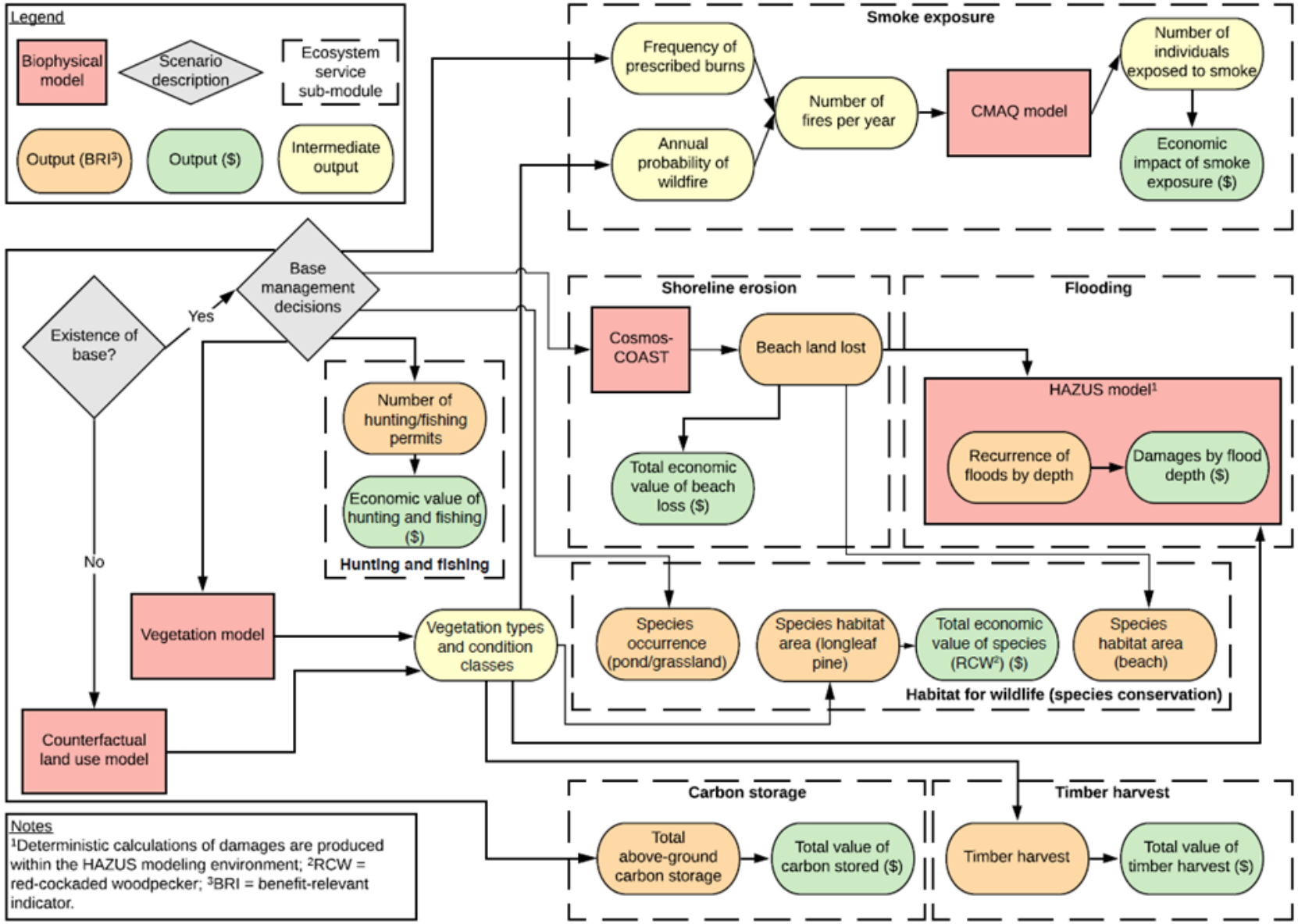
Model-based Tracking and Integrated Valuation of Ecosystem Services (MoTIVES)



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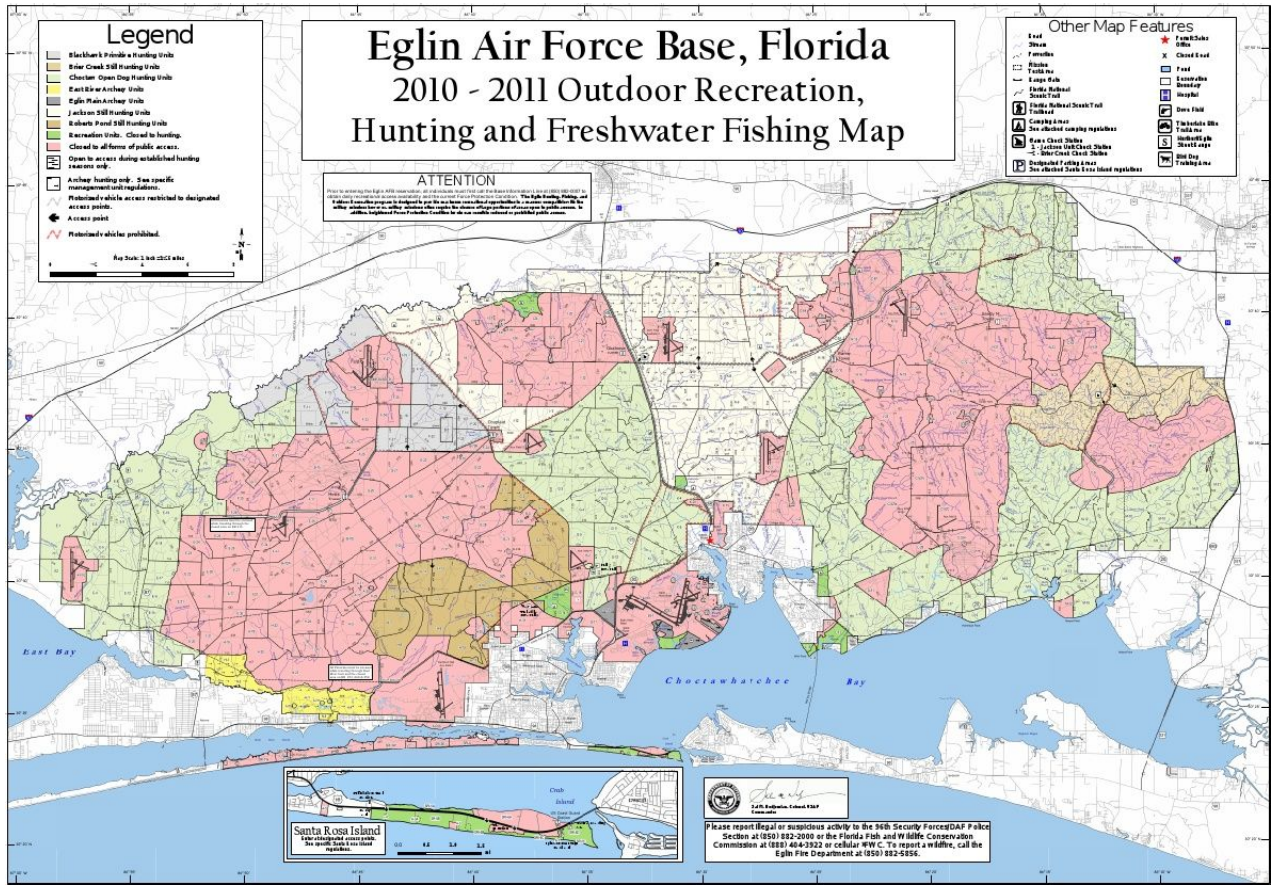
Proof of Concept: Eglin AF Base

- Largest forested military base in the US.
- Largest remaining mature longleaf pine forest in the world.
- Habitat for 24 listed threatened or endangered species, including red-cockaded woodpecker.
- Extensive freshwater and estuarine wetlands, ponds and riparian meadows.
- Supports outdoor recreation, hunting, and fishing.



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Proof of Concept: Eglin AF Base

- Coastal streams and bays support at-risk fish as well as desirable fishing locales.
- Includes much of the eastern portions of Santa Rosa Island, a Gulf of Mexico barrier island.
- Turtle nesting, habitat for endangered shorebirds, threatened lichen.
- Protection from storm surges and coastal flooding for the communities of Fort Walton Beach and Navarre.

Eglin AF Base: Three Scenarios

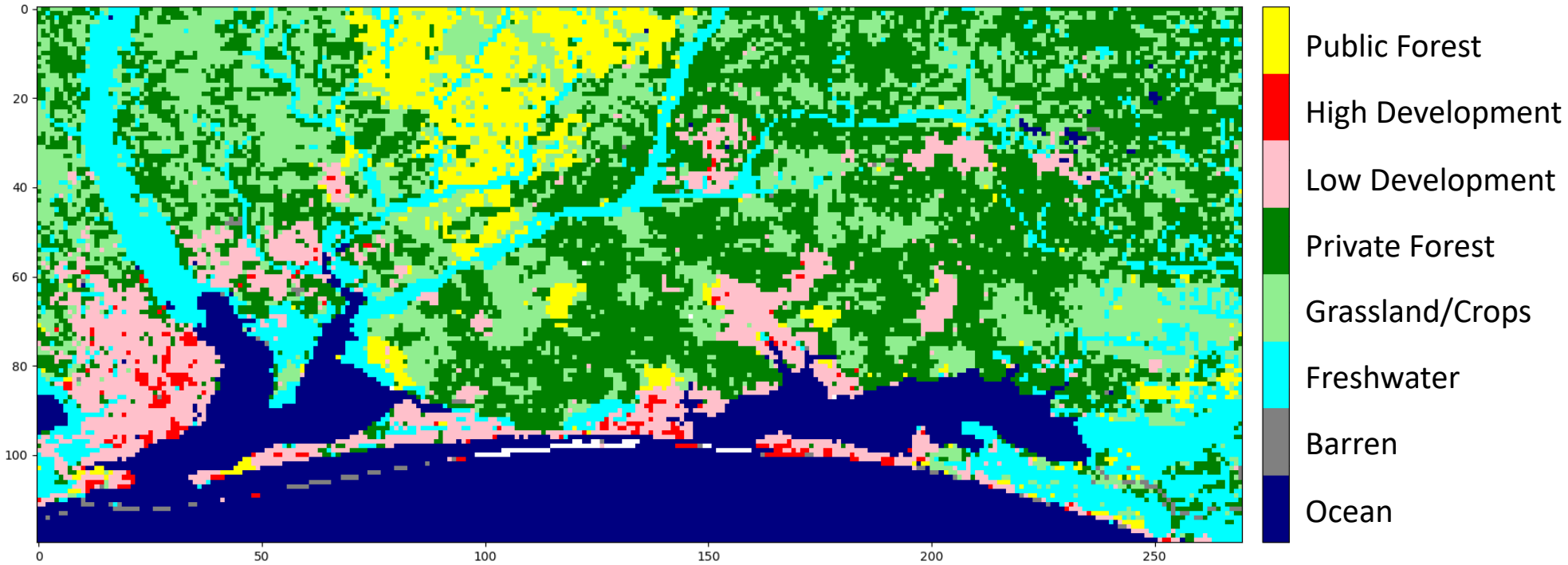
1. **Current Management Scenario**: Prescribed burning to create conditions favorable to longleaf pine and associated wildlife species.
2. **No-Management Scenario**: Continued military operations but no (current or historical) management for natural resources.
3. **No-Base Scenario**: Counterfactual scenario in which the base never existed.

(U.S. Air Force Photo by Staff Sgt. Mike Meares)

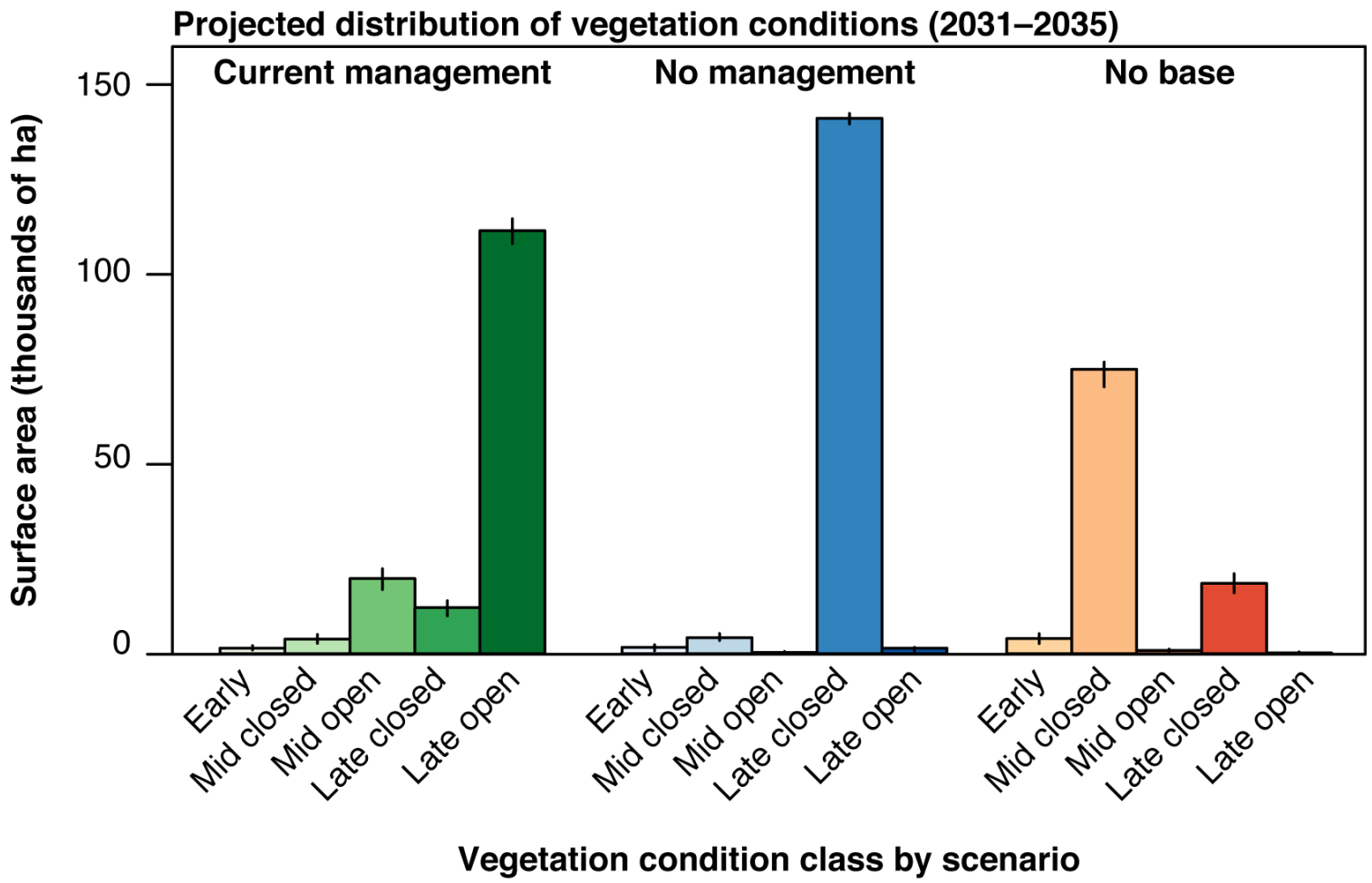
Eglin AF Base: Three Scenarios

3. **No-Base Scenario**:

   The current base footprint replaced by hypothetical land use patterns by sampling logical combinations of adjacent land uses.

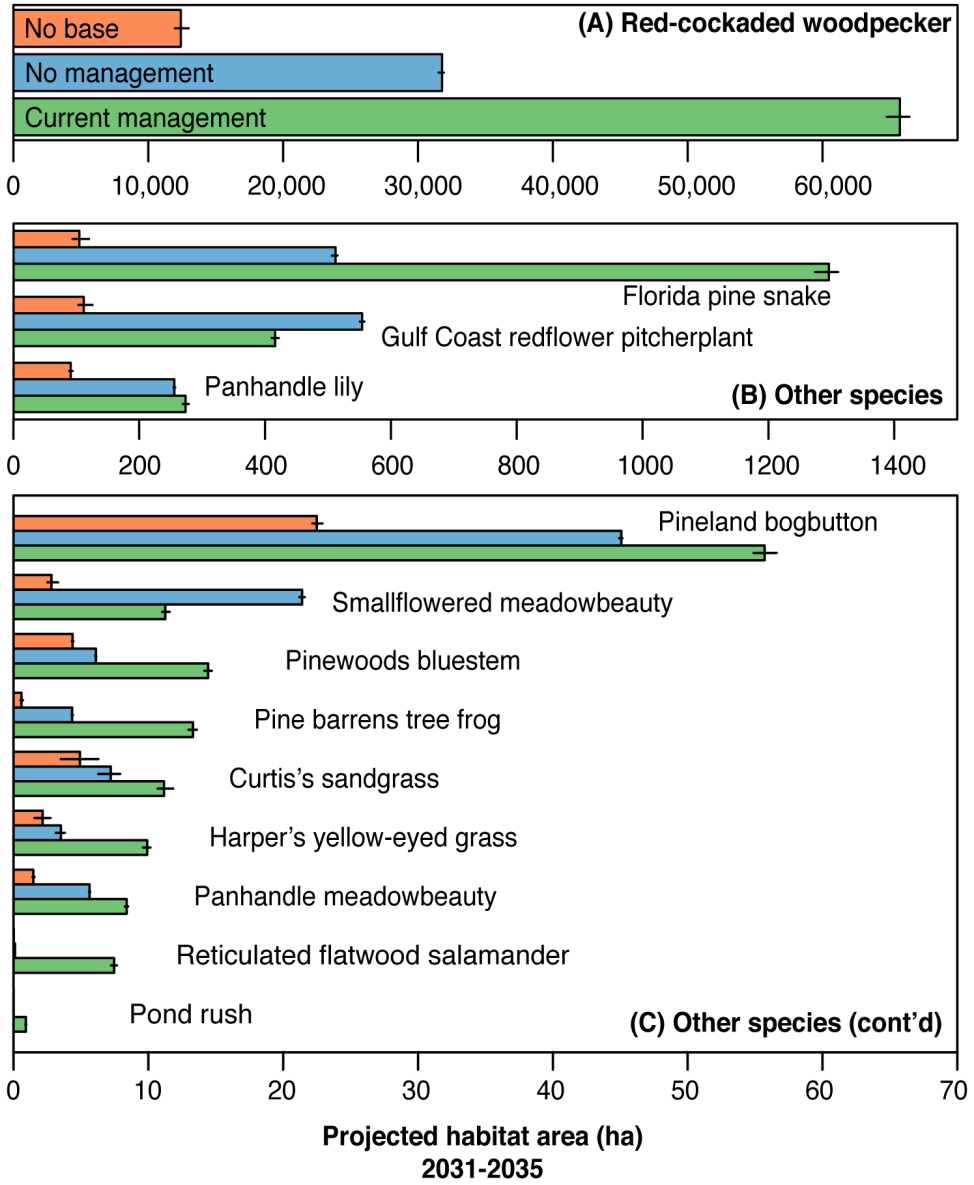


Eglin AF Base: Results



Without active management, longleaf pine condition degrades from open (desirable) to closed (undesirable) forest conditions.

Eglin AF Base: Results



Current management practices greatly enhance habitat area for most threatened species, relative to both the 'no management' and the 'no-base' scenarios.

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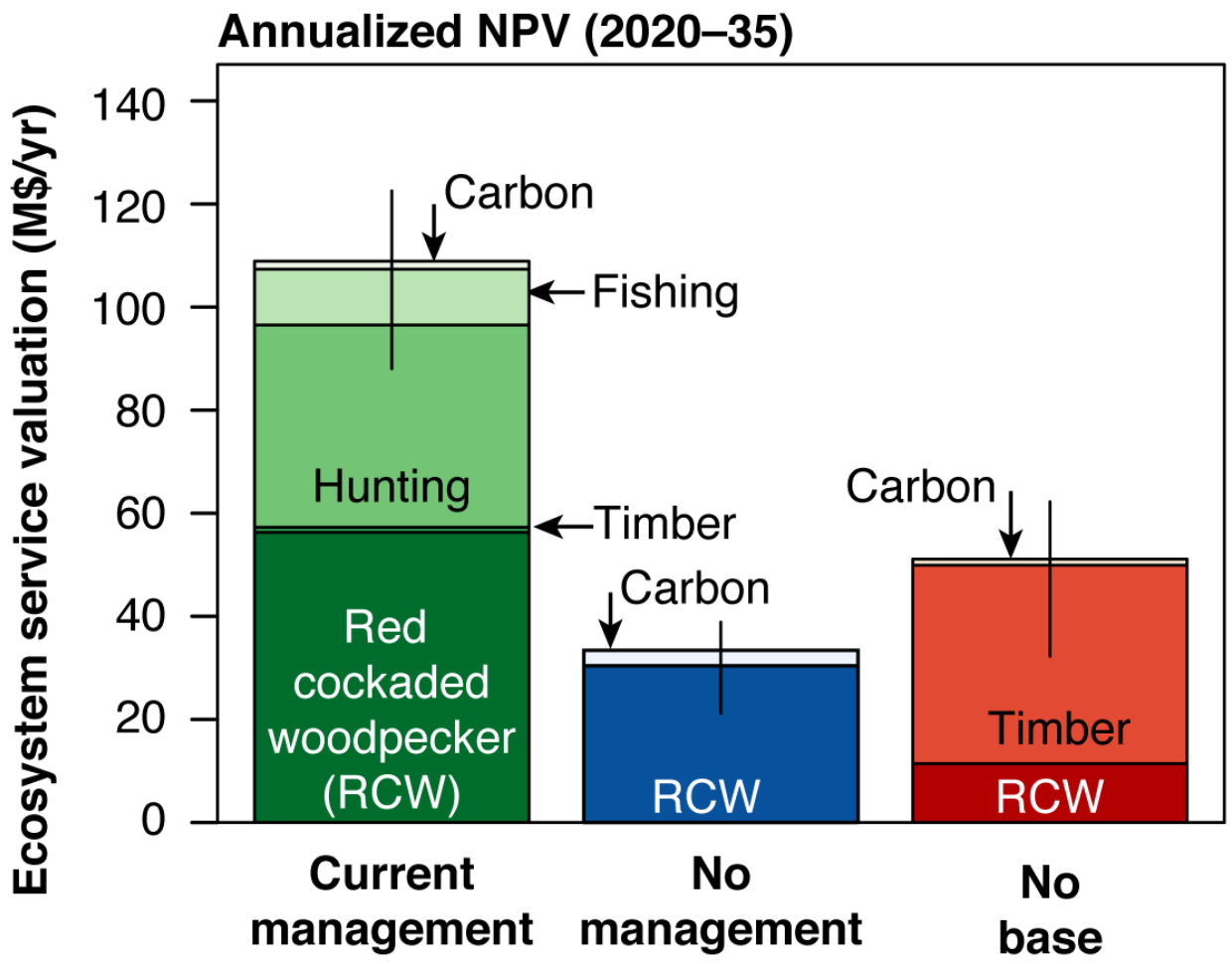
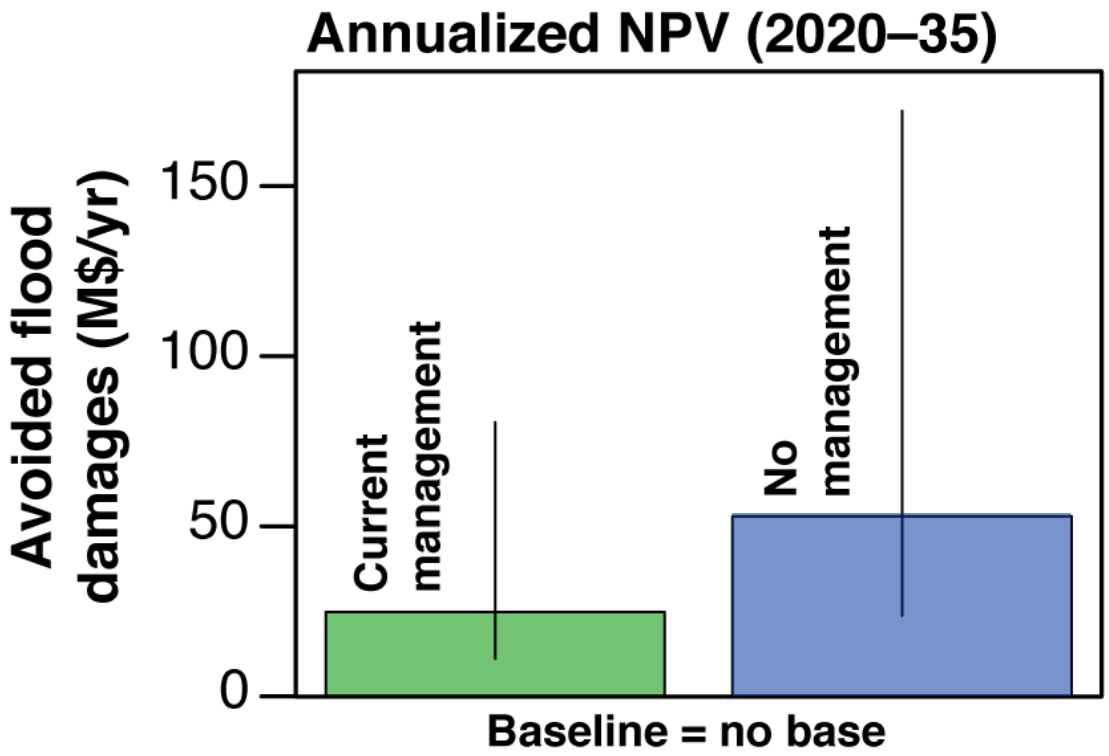
Eglin AF Base: Results



Current management practices are estimated to generate $75.6 million more per year in ecosystem services than the 'no management' scenario and **$57.8 million more per year** than the 'no-base' scenario.

Eglin AF Base: Results



- **Current management practices are estimated to avoid flood damages of $26.4 million** compared to the 'no base' scenario.
- This is **$30.0 million per year less in avoided flood damages** than the 'no management' scenario.
- However, this difference is easily **outweighed by the enhancement of other ecosystem services** provided by current management.

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Project Contributions

Our project provides:

- Generalized conceptual models of ecosystem management relevant to military bases.
- Detailed biophysical models of ecosystem state, condition, and function.
- Production functions linking ecosystem conditions to benefit relevant indicators (BRIs).
- Estimates of the economic value of BRIs.
- An integrated, transferable model (MoTIVES) that accounts for co-benefits and offsets to improve predictive accuracy.

Project Contributions

Our model will help DOD natural resource managers show that:

1. The existence of the base itself provides **substantial ecosystem service benefits** to neighboring communities.
2. Management activities can **further enhance the production of ecosystem services**.

(U.S. Air Force photo/Ilka Cole)

Acknowledgements

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