The Nature Conservancy

EARTH ECONOMICS

Stress Testing the BCA Toolkit with Nature-based Solutions:

OBSERVATIONS AND RECOMMENDATIONS FOR THE FEDERAL EMERGENCY MANAGEMENT AGENCY

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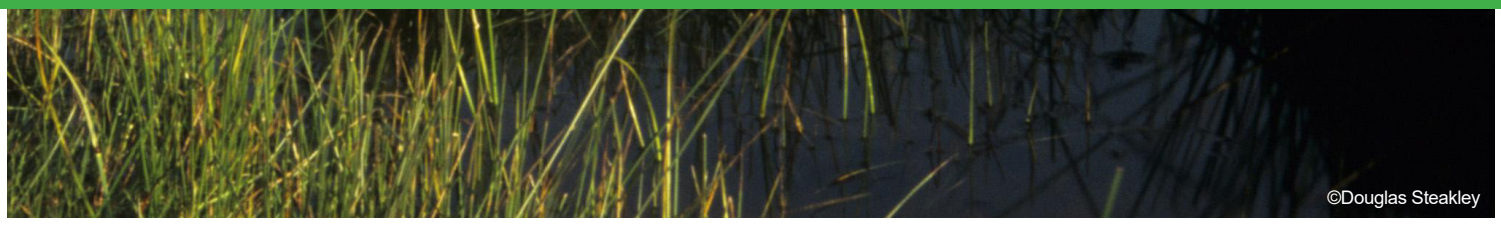

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Purpose of this Report

The Federal Emergency Management Agency (FEMA) provides billions of dollars each year to communities through its Hazard Mitigation Assistance (HMA) programs to reduce or eliminate long-term risk. The 2018 Disaster Recovery Reform Act (DRRA), which passed in Congress with overwhelming bipartisan support, formed the basis for FEMA's Building Resilient Communities and Infrastructure (BRIC) program, and significantly increased the amount of funding available annually for pre-disaster mitigation. In addition, FEMA has increasingly recognized the important role of nature-based solutions (NBS) for building community resilience and mitigating the impacts of floods, wildfires, droughts, and other hazards. NBS utilize nature, open space, and/or ecosystems to provide hazard mitigation and other environmental and social benefits to communities.

FEMA requires that hazard mitigation projects must be cost-effective to the federal government, as demonstrated in a Benefit-Cost Analysis (BCA), which compares the net present value of a project's future benefits and costs. A BCA is required for the vast majority of FEMA-funded hazard mitigation activities, with some exceptions (e.g. 5% Initiative projects). Over the past few years, FEMA has made substantial updates to its policies and supporting BCA Toolkit software to facilitate projects that utilize NBS. Examples of policies include the agency's "ecosystem services"[1] policies in 2013, 2016, and 2020.

FEMA and The Nature Conservancy (TNC) share an interest in maximizing and facilitating the use of expanded mitigation dollars for NBS, and in June of 2019, The Nature Conservancy in California (TNC-CA) formally partnered with FEMA Region IX under a Cooperating Technical Partners (CTP) grant to help communities develop and advance hazard mitigation projects that incorporate NBS. Under the CTP grant, TNC-CA is leading a collection of related efforts. One of these efforts is colloquially referred to as "Break the BCA", the goal of which is to determine whether the benefits of high-quality NBS projects for hazard mitigation can be fully quantified using the newest version of the BCA Toolkit (v6.0) – or whether these projects "break the BCA". Specifically, the goal of this project was to test the usability of FEMA's BCA Toolkit (v6.0) on hazard mitigation project ideas developed by state and local partners in Region IX – especially those with a significant NBS element – and assess the challenges and opportunities for further advancing the tool and associated policies. It was assumed that there would be at least several barriers to NBS within the FEMA BCA depending on the hazard and project type.

The non-profit organization Earth Economics was hired by TNC-CA as the technical consultant for this project. Earth Economics worked with FEMA as a subcontractor to develop the agency's ecosystem service framework and values for the BCA Toolkit updates in 2013 and 2016 and has experience working with subapplicants conducting BCAs for projects that incorporate NBS, and therefore entered the project with some understanding of the challenges that might arise.

Since November 2019, TNC-CA and EE have identified and worked with several partners to provide technical assistance related to FEMA's hazard mitigation programs and develop preliminary (or final) BCAs for hazard mitigation projects that incorporate NBS. The purpose of this report is to summarize the progress and outcomes of the BCAs conducted to date and to share lessons learned and recommendations for potential updates to the BCA Toolkit. At the time of writing, two BCAs have been

[1] Ecosystem services were referred to as "environmental benefits" in the 2013 and 2016 policies.

completed and two are still in progress, so this document will be updated if new lessons emerge from these experiences.

The report is structured as follows:

- **General Findings and Recommendations**: Provides a summary of findings and recommendations based on the BCAs conducted to date.
- **Case Studies**: Provides more context for two of the BCAs conducted, a summary of methods and results, and status of the projects; as well as a summary of BCAs in progress or not pursued.
- **Appendices A and B**: Contains detailed methodologies for the two completed BCAs, conducted for the Paradise Recreation & Parks District (Butte County) and Permit Sonoma (Sonoma County) respectively. The Paradise methodology is written as a sequence of steps, while the Sonoma example is provided in the format of a BCA Justifications report.
- **Addendum A:** A discussion paper on the importance of the discount rate as it relates to FEMA's programs and long-term resilience, including a summary of the Office of Management and Budget's (OMB) approach to the discount rate, reflects on recent academic thinking, and offers recommendations for the consideration of FEMA and OMB leadership.

We are also pleased to note that this effort has already helped to make a real-world impact for two of the communities, as described in Section 2. The BCA conducted in Sonoma County was included in Permit Sonoma's ~$49 million mitigation project subapplication for BRIC 2020 (~$37 million federal cost share), which was listed as "Selected for Further Review" on the BRIC website. The project was specifically highlighted by President Biden in a discussion with Western state governors and members of the Cabinet on June 30, 2021.[2] The preliminary BCA and project definition support provided for Paradise Recreation & Parks District supported the submission of a $315,000 ($218,000 federal cost share) Capability & Capacity Building (C&CB) subapplication for BRIC 2020, which was also listed as "Selected for Further Review" on the BRIC website.

Finally, it should be noted that this report is primarily focused on the BCA Toolkit and associated policies, and there are many interrelated broader issues/policies – not covered here – that could be addressed to reduce barriers to NBS, such as non-federal cost share requirements, technical capacity of subapplicants, project eligibility, EHP/permitting, hazard mitigation planning processes, and/or Stafford Act requirements.

[2] Paraphrasing from: https://www.c-span.org/video/?513095-1/president-biden-holds-meeting-western-governors&live

General Findings and Recommendations

FEMA's new BCA Toolkit (v6.0) and supporting policies make it easier to value both the hazard mitigation benefits and broader environmental/social benefits of projects that incorporate NBS. The BCA Toolkit itself is relatively user friendly, and the widespread use of standard values and pre-calculated benefits do seem to reduce the burden on subapplicants, especially those who are conducting a BCA for the first time and without consultant support.[3] However, based on our experience conducting BCAs for the projects described in the next section, there remain opportunities to advance FEMA's BCA Toolkit and/or policies in a way that would further reduce barriers to NBS. To that end, this section provides several broad recommendations and specific ideas.

Recommendation: Provide additional flexibility and guidance on the use of ecosystem service values in the BCA Toolkit

Ecosystem services (ES) are defined by FEMA as "direct or indirect contributions that ecosystems make to the environment and human populations." FEMA recognizes that the environment is an important component of a community's resilience strategy, and therefore allows the use of ES values in the BCA. Pre-calculated ES values are embedded into FEMA's BCA Toolkit, calculated as a "$/acre/year" value that depends on the land cover type. ES can be important benefit of many hazard mitigation projects that incorporate NBS, and can also be indirectly supported by established hazard mitigation approaches that are not considered NBS per se (e.g. acquisition and relocation).

A previous limitation of the ES values was that projects were required to achieve a Benefit-to-Cost Ratio (BCR) of 0.75 using "traditional" risk reduction benefits, such as reduced damage to structures, before the ES values could be included in a BCA. However, in 2020, FEMA released an important policy update, building directly on its earlier policies. FEMA Policy FP-108-024-02, titled "Ecosystem Service Benefits in Benefit-Cost Analysis for FEMA's Mitigation Programs Policy," recognizes that the natural environment is an important component of a community's resilience strategy, and removes the 0.75 BCR threshold requirement.

On the other hand, many hazard mitigation projects that utilize NBS and generate ES do not necessarily require the use of ES values to show cost-effectiveness; in other words, they can be cost-effective based on their traditional (risk reduction) benefits alone. The Paradise and Sonoma County case studies, described in the next section and appendices, are good examples; each include a significant NBS element, but achieved a BCR of approximately 4:1 based on the reduced risk to structures and people and avoided wildfire suppression costs – before environmental benefits were included. The Sonoma Baylands project on the other hand, though the BCA is still waiting to incorporate hydraulic modeling data, may be an example of a project that will require ES values to be cost effective. Regardless of the project context, and whether or not the ES values are required for a positive BCR, the use of ES values will help NBS become more competitive by demonstrating a higher BCR and by providing a more complete picture of the project's benefits.

Currently, the ES "value sets" are provided for several land cover types within the BCA tool, and each land cover type is assigned a total value in dollars per acre per year. For example, "Forests" have a value

[3] This is an assumption. Earth Economics works with the BCA Toolkit on a regular basis, and our judgement of "user friendly" may be different to that of a subapplicant who is totally new to FEMA's BCA requirements.

of $554 per acre per year. There's no question that FEMA's pre-calculated ES values are convenient and allow for rapid integration of ES into a BCA. However, in certain situations greater flexibility could improve the precision and defensibility of the final ES values. Examples include:

1. A subapplicant may want to calculate – or refer to a study that has estimated – local ES values that are more precise or appropriate than those provided in the FEMA BCA Toolkit. However, currently it is unclear in which context such an approach would be allowable, the criteria that custom ES values would need to meet, and any additional justifications that would be required. It would be helpful to see this information provided in a future BCA Reference Guide.
2. A subapplicant may want to use FEMA's pre-calculated ES value sets, but only a subset of the ES values for that landcover may be applicable for the project. For example, if a project leads to creation of the land cover "green open space", but the green open space is on private property and maintained through an agreement with the landowner, then the specific value for "Recreation and Tourism" may not be applicable because the parcel is not accessible to the public for recreation, and counting that value could result in an overestimate. To avoid this issue, FEMA could allow for selection of specific ES values by the BCA analyst. This would result in the same or more conservative values since ES values could only be removed and not added (unless the subapplicant is permitted to calculate custom ES values per #1 above).
3. Some mitigation actions do not necessarily result in a land cover *change* but may result in an improvement in the *functionality* of the existing land cover (ecosystem). In the case of forests, mitigation action like hazardous fuels reduction will improve the functionality and health of a forest and support increased ES value, but the land cover category will be "forest" before and after the project is completed. In the current ES module of the BCA Toolkit, it is not currently possible to calculate these "marginal" improvements. This uncertainty is one reason that ES values were not (yet) included in the Paradise and Sonoma County BCAs, as it was unclear whether – for example – an acre of forest should be given 100% of the value for "forest" ($554/acre/year) if the functionality of that forest improves from 50% to 80% as a result of hazardous fuels reduction.

It should of course be acknowledged that additional flexibility could lead to a greater diversity of BCA methods and increase the time it takes for states and FEMA to review BCAs, which is not necessarily in the interest of FEMA or subapplicants. Therefore, any improvements in flexibility and precision would need to be weighed against the additional level of effort for FEMA and subapplicants.

Recommendation: Create additional pre-calculated benefits or modules to facilitate inclusion of nature-based solutions in the BCA Toolkit

To reduce the burden placed on subapplicants to conduct complex and time-consuming BCAs, FEMA has developed "pre-calculated benefits" for certain project types. Pre-calculated benefits are unit values calculated and pre-vetted by FEMA for certain kinds of benefits or certain project type/benefit combinations for use anywhere in the nation. Pre-calculated benefits can be an incredibly powerful tool, reducing the effort/cost associated with a BCA considerably. Examples include the ES values (described above), post-wildfire mitigation, and the thresholds for acquisitions and elevations ($276,000 and $175,000 respectively).

As noted above, FEMA's 2020 policy "Ecosystem Service Benefits in Benefit-Cost Analysis for FEMA's Mitigation Programs Policy" recognizes that the natural environment is an important component of a

community's resilience strategy and removes the 0.75 BCR threshold requirement for ecosystem services. While the policy is new and has not been utilized in any subapplications to our knowledge at the time of writing, in theory it means that nature-based hazard mitigation projects can now be considered cost-effective based on the value of their ES benefits alone. In practice, of course, subapplications are typically competing against each other for limited HMA funds, so demonstrating and estimating the hazard mitigation benefits of a project along with ES value is likely to strengthen an application.

However, this step can present a barrier for many NBS projects, because while the hazard mitigation benefits of many NBS projects (and traditional projects) can technically be quantified in a BCA, the associated level of effort and cost can often be a barrier. Examples of approaches FEMA could take to help reduce this barrier could include:

1. **Incorporate hazard mitigation values into the ES value sets.** In the academic literature, hazard mitigation (e.g. flood, fire, drought) is a type of ES, and these benefits have been quantified in many studies. The results of these studies are often presented in – or can be translated into – "$/acre/year" by landcover type (e.g. forest, wetland), consistent with FEMA's ES value sets. Since NBS are often (though not always) associated with a landcover change, once conceptually simple way of quantifying the hazard mitigation benefits of projects with NBS would be to develop $/acre/year values for hazard mitigation benefits of the existing land cover types, where appropriate. For example, a $/acre/year value could be developed for the storm buffering value of wetlands and included in FEMA's ES value set for wetlands, along with the environmental benefits. A subapplicant proposing a wetland restoration project for storm risk reduction could then use the pre-calculated ES value set for wetlands (provided other feasibility and effectiveness criteria are met) and capture both hazard mitigation benefits and ES benefits of their project without requiring costly Hydrologic & Hydraulic modeling.
2. **Develop a programmatic BCA for certain classes of NBS.** An analogous approach to pre-calculated benefits, but at the program level, would be the development of a programmatic BCA for certain classes of mitigation projects, including both established approaches and nature-based solutions. The programmatic BCA itself would be based on detailed analysis of past projects, but once complete, future projects that meet specific criteria (eligibility, design, feasibility, effectiveness etc.) would not require a BCA. This approach would even further reduce barriers for subapplicants, especially those representing underserved communities. Engagement with OMB would likely be required for such an approach.

Recommendation: Provide additional technical resources to support the development of high-quality BCAs by subapplicants

FEMA has developed many helpful resources to support subapplicants in the development of a BCA and other required components of a subapplication, ranging from the BCA Toolkit itself to the Mitigation Action Portfolio and Job Aids. However, in our discussions with FEMA, state hazard mitigation staff, and subapplicants, the BCA is still often cited as a key stumbling block for mitigation projects, especially projects that incorporate NBS. Though many of these hurdles could be overcome by subapplicants by spending more time studying the BCA tool, or by hiring BCA consultants, not all subapplicants have the time to become experts or the means to hire consultants. To help bridge this gap, FEMA could develop

additional user-friendly resources that further reduce subapplicants' time and effort on the BCA. For example, FEMA could consider development of the following resources:

1. **An update to the 2009 BCA Reference Guide** (and 2011 Supplement to the BCA Reference Guide), both in PDF and web format.
2. **BCA factsheets** (in PDF format) could be developed to describe the BCA methods and potential data sources for common project types. The California Office of Emergency Services 404 Hazard Mitigation Grant Program webpage has a few good examples of these factsheets, which could be adapted to the national level.[i]
3. **BCA Toolkit template files** (in Excel format) could be developed for common project types, including NBS. The template files could have pre-loaded data in FEMA's BCA Toolkit that subapplicants would adjust for their own local contexts, including infrastructure and people at risk and return intervals.
4. **BCA justifications report templates** (in Word format) could be developed for common mitigation project types, including NBS. The template files could have pre-written paragraphs describing typical assumptions and methodologies associated with different mitigation project types, and subapplicants could simply fill in their project-specific assumptions from their BCA file.

Though ideas 2-4 above may present challenges given the diversity of mitigation project types, hazard types, and local contextual factors, it may be worth exploring whether such resources could be developed for certain project types, especially emerging project types such as NBS.

Recommendation: Allow future conditions to include future development projections within an area

To the extent possible, FEMA now encourages applicants to consider "future conditions" and their influence on future hazard risk. Future conditions can be reflected in the assumptions for a BCA, and may include changes in population, demographics, land use, sea level, and precipitation patterns. While FEMA appears to be encouraging the consideration of a variety of future conditions, more clarity and examples would be helpful, including guidance on how future conditions could be quantified, justified, and incorporated into a BCA. Also, certain "future conditions" are currently difficult to account for in a BCA. For example, a broad interpretation of "future conditions" could include future development potential on a parcel of open space land, and this could be important from a hazard mitigation perspective, as many open space parcels in hazardous areas (flood, wildfire etc.) are at a high risk of being developed, and if developed would ultimately increase exposure to FEMA and the federal government (since FEMA funding may later be required to acquire/demolish/elevate structures on those same parcels, or the development may include a levee that "pushes" flood risk downstream to other areas). While local jurisdictions should ultimately be responsible for preventing development in risky areas or creating additional risk, there may be instances in which it makes economic sense for FEMA to fund the purchase of development rights on an open space parcel(s) to keep the land in open space, provided the project supports hazard mitigation, meets other criteria and ample justification can be provided in the BCA. In the case of flood, for example, an open space parcel may be providing upstream flood storage capacity, thereby reducing risk to downstream properties. In the case of wildfire, purchase of development rights on an open space or forested parcel, along with ongoing hazardous fuels reduction, could reduce risk to both 1) People and homes/structures adjacent to the parcel; and 2)

People and homes/structures on the open space parcel that would have been developed (assuming those homes/structures are then constructed in a safer location instead).

Recommendation: Allow pre-calculated benefits and standard values to be adjusted for inflation

Inflation refers to the increase in the prices of goods and services over time. The inflation rate in the U.S. has generally hovered between 0 and 5% for the past several decades. The process of inflation is well-understood and can be quantified using the Bureau of Labor Statistics' CPI Inflation Calculator.[4] However, FEMA's precalculated and standard values within the BCA tool are not annually adjusted for inflation, nor is it possible for the analyst to manually adjust these values. Because inflation leads to gradually rising costs associated with hazard mitigation actions, while the pre-calculated benefits remain the same, this could impact the eligibility of certain project types over time. For example, FEMA's 2013 policy "Cost Effectiveness Determinations for Acquisitions and Elevations in Special Flood Hazard Areas" developed pre-calculated benefits for acquisitions and elevations, stating that projects that cost less than or equal to $276,000 and $175,000 (respectively) are considered immediately cost effective provided they meet certain other criteria. The policy does explicitly allow for adjustment of the pre-calculated benefit based on different regional costs of doing acquisition or elevation projects, using "locality multipliers", but does not allow for inflation adjustments warranted by a rise in building costs (which are used to calculate building replacement values, a core element of avoided damage calculations) or home values. Assuming the original values were in 2013 dollars, and the costs associated with acquisitions have since risen at the same rate as inflation, then a project that cost $276,000 August 2013 would cost approximately $322,000 in July 2021. Using another measure, the S&P/Case-Shiller U.S. National Home Price Index, $276,000 in August 2013 has the same buying power as $377,000 in January 2020. While inflation is not an issue specific to NBS, the same issue does apply to pre-calculated ES benefits that are often needed for NBS in a BCA. Potential solutions to this issue could include:

1. FEMA could program the BCA Toolkit to automatically adjust pre-calculated and standard values for inflation on an annual basis, based on CPI data from the Bureau of Labor Statistics and/or other sources.
2. FEMA could allow subapplicants to adjust existing pre-calculated and standard values for inflation (supported by appropriate documentation), in the same way that "locality multipliers" can be used for the pre-calculated benefits related to acquisition or elevation projects.

Recommendation: Provide additional guidance related to the Project Useful Life for NBS and nature-based elements of mitigation actions

The term "Project Useful Life" (PUL) refers to the length of time the project will provide benefits. FEMA's BCA Toolkit provides default PULs for a range of project types, but allows custom values provided documentation is provided. It is recommended that the default values be used whenever possible, due to the additional justification required for custom values. The existing Project Useful Life (PUL) table within the BCA Toolkit provides helpful guidance on the PUL to assign for many project types/elements, including some projects that incorporate NBS. However, it would be helpful to have additional guidance related to the PUL of nature-based elements of eligible project types within the BCA Toolkit, including documentation required to back up a higher PUL in the cases where a range is provided. In many cases,

[4] https://www.bls.gov/data/inflation_calculator.htm

nature-based elements – such as a restored floodplain – can continue providing mitigation value for decades or even in perpetuity, provided they have a baseline level of maintenance.

Recommendation: Advance the discussion with OMB leadership about the need to revisit and update Circular A-94 and/or provide more explicit guidance on the use of "other discount rates" as defined in Circular A-94.

Within a BCA, the discount rate determines how much weight is given to future costs and benefits and can have a significant impact on the types of projects that are prioritized and funded by government agencies.

In 1992, the Office of Management and Budget (OMB) mandated a real discount rate of 7% for BCA of public investments and regulatory programs in *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*.[ii] Based on this guidance, a 7% discount rate is now used by the Federal Emergency Management Agency (FEMA) and other federal agencies in BCA to help prioritize a range of investments.

A relatively high discount rate like 7% rapidly diminishes the present value of future benefits and costs associated with a project, program, or policy. As OMB notes in Circular A-94, "for typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value." All other things being equal, a higher discount rate will often bias federal investments toward projects with more immediate returns, potentially at the expense of alternative projects – including those that incorporate NBS – with long-term benefits and resilience.

Since 1992, and increasingly in recent years, a number of economists, thought leaders, and agencies have used a variety of methods and assumptions to conclude that a lower discount rate (i.e. lower than 7%) is more appropriate for public agencies, especially those like FEMA that make long term, intergenerational investments (or at least for the long-term project types funded by those agencies). Some have also questioned the assumptions behind OMB's formulation of the 7% rate in Circular A-94.

A more detailed discussion paper, *"Revisiting the OMB Discount Rate to Support Federal Agency Goals and Advance Community Resilience*, is included for FEMA's reference in Addendum A of this document. The discussion paper includes more detail on OMB's approach to the discount rate, reflects on recent academic thinking, and offers the following recommendations for the consideration of FEMA and OMB leadership:

1. **Revisit and update Circular A-94.** OMB could convene its staff along with an expert panel of economists to revisit the methods and assumptions that form the basis for the 7% discount rate specified in Circular A-94. In its review, OMB could also consider the use of a "dual" discount rate – a higher rate for short-term projects and a lower rate for projects that generate intergenerational cost/benefits or incorporate NBS – and/or the use of declining discount rates. Transparency, open debate, and collaboration should be encouraged during this review.

2. **Provide more explicit guidance on the use of "other discount rates" as discussed in Circular A-94.** In the short term, given the likely time and effort required to update Circular A-94, OMB could make immediate progress by providing more clarity on the context in which an "other discount rate" (per Section 8(b)(2)) could be used by an agency and when such a rate could be used as the primary basis for a BCA, rather than just for sensitivity analysis. Specifically, OMB

could create a discount rate exemption in Circular A-94, allowing a lower discount rate to be applied to federal investments that meet certain criteria (e.g. intergenerational costs and benefits, use of nature-based solutions), provided ample justification is given. In the case of FEMA, for example, certain kinds of hazard mitigation projects would then be eligible for a lower discount rate, given their long-term resilience benefits, and FEMA could build this function into its BCA tool and policies.

Case Studies

Case Study #1: Resilience Parks for Wildfire Risk Reduction and Hazard Mitigation in Paradise

Location

Butte County, CA

Subapplicant

Paradise Recreation & Park District (PRPD)

Project Description

The most destructive wildfire in California's history, the 2018 Camp Fire, killed 85 people, destroyed over 14,000 homes, and displaced nearly 50,000 people. After the fire, the area was susceptible to an increased risk of floods, landslides, and infrastructure damage. Paradise is located in a fire-prone area – one that has burned repeatedly over the last century, and that will inevitably burn again. In the aftermath of the Camp Fire, residents and public servants have come together to rethink individual and community needs in the context of recovery and redevelopment. Some of the measures include adoption of more rigorous building codes and implementation of defensible space around homes. Other approaches – on the landscape scale – are also being planned in order to enable the community to confidently rebuild in a more resilient way. In doing so, the community can serve as an example to the world and other rural areas in high fire risk areas. Among these landscape approaches are community-scale buffers at the Wildland Urban Interface (WUI) or greenbelts that would provide defensible space for the entire community.

BCA Methodology and Results

Earth Economics conducted a preliminary BCA of several of PRPD's proposed mitigation actions as they were planned at the time. The full BCA narrative is provided in Appendix A. A summary of key steps and results is provided below:

1. **Mitigation Scenarios.** Define a "No Action" and "With Mitigation" scenario for comparison. In this case, the With Mitigation scenario included a combination of: 1) Acquisition of approximately 2,000 acres of land (comprised of 85 parcels) via fee title or purchase of development rights along key areas to the east of Paradise, followed by upfront and ongoing hazardous fuels reduction activities on these lands; and 2) Creation of a 300 foot defensible space buffer along the eastern border of Paradise, adjacent to parcels that are acquired for hazardous fuels reduction activities in (1) above.

2. **Project Benefits.** Quantify a subset of benefits that will result from the mitigation actions. Quantified benefits included: Avoided physical damages (structures and contents); avoided emergency response costs (wildfire suppression); and avoided injuries and casualties.

3. **Project Costs.** Estimate upfront and ongoing costs associated with the mitigation actions, specifically 1) acquisition of parcels; 2) hazardous fuels reduction; and 3) creation of defensible space.

4. **Results.** Compare the net present value of benefits and costs over the Project Useful Life using a 7% discount rate. The preliminary Benefit-Cost Ratio for this BCA was approximately 3.9:1.

Project Status

PRPD submitted a subapplication through the 2020 cycle of the BRIC program, requesting $218,000 federal cost share ($315,000 total project cost) funding for C&CB activities. The purpose of the C&CB project was to conduct further scoping and refinement of several scenarios for community-scale defensible space, site-specific feasibility assessments, landowner outreach, and more detailed modeling/BCA. As of July 2021, when FEMA announced the 2020 BRIC selections, the project was listed as "Selected for Further Review".

Case Study #2: Nature-based Mitigation to Adapt in an Era of Megafire

Location

Sonoma County, CA

Subapplicant

Permit Sonoma[5]

Project Description

Sonoma County is proposing a project to help mitigate wildfire risks to life, property, and the environment in the County. This project is envisioned as the pilot project for further wildfire mitigation projects within the County and is intended to establish the foundational components for these future efforts. The scope of this project is built upon the resilience premise of hardening the "inner core" (i.e. areas where residential and commercial development is concentrated) - while creating an "outer core" (i.e. surrounding wildland-urban interface) that is able to absorb and reduce the impacts from wildfires before they reach the hardened inner core. This approach has been coined, the "Inside-out, outside-in" approach (IO-OI)'. The IO-OI approach applies structural hardening and defensible space techniques to an inner core, while applying hazardous fuels reduction techniques to an outer core to create and overarching wildfire resilience zone.

BCA Methodology and Results

Earth Economics conducted a BCA for Permit Sonoma, which was included in the agency's full subapplication package for the 2020 BRIC cycle. The full BCA justifications report is provided in Appendix B. A summary of key steps and results is provided below:

1. **Mitigation Scenarios.** Define a "No Action" and "With Mitigation" scenario for comparison. In this case, the With Mitigation scenario included a combination of: Hazardous Fuels Reduction, Defensible Space, and Ignition-Resistant Construction.

2. **Project Benefits.** Quantify a subset of benefits that will result from the mitigation actions. Quantified benefits included: Avoided physical damages (structures and contents); and avoided displacement of people during wildfire events.

3. **Project Costs.** Estimate upfront and ongoing costs associated with the mitigation actions described in #2 above.

[5] Permit Sonoma is Sonoma County's consolidated land use planning and development permitting agency.

4. **Results.** Compare the net present value of benefits and costs over the Project Useful Life using a 7% discount rate. The preliminary Benefit-Cost Ratio for this BCA was approximately 4.5:1.

Project Status

Permit Sonoma submitted a subapplication through the 2020 cycle of the BRIC program, requesting approximately $37 million federal cost share ($49 million total project cost) for the Mitigation Project described here, supported by the BCA and Justifications Report provided by Earth Economics. As of July 2021, when FEMA announced the 2020 BRIC selections, the project was listed as "Selected for Further Review". Notably, President Biden, in his meeting with Western Governors just prior to the announcement, highlighted this project specifically as an innovative example of wildfire mitigation.[6]

Other Case Studies

In addition to the case studies above, two other BCAs were in development at the time of producing this paper: 1) A wetland restoration and resilience project in the Sonoma Baylands to support flood risk reduction and ecosystem services; and, 2) A feasibility study for coral reef restoration in Hawaii for coastal hazard mitigation and ecosystem services. This report also drew from experience from other projects that were evaluated and ultimately not pursued due to various factors including BCA-related barriers.

[6] https://www.c-span.org/video/?513095-1/president-biden-holds-meeting-western-governors&live

Appendix A. Paradise BCA Methodology

This section describes the results of a preliminary Benefit-Cost Analysis (BCA) that was conducted for mitigation actions proposed by the Paradise Recreation and Park District (PRPD). These assumptions helped to inform PRPD's C&CB subapplication in the 2020 BRIC cycle and will form the basis for a FEMA BCA Justifications Report when a full subapplication is submitted for the project. Please note that the specific details of the mitigation actions are still preliminary and subject to change.

Summary of Approach

This BCA consisted of the following steps, described in more detail in the sections that follow:

5. **Mitigation Scenarios.** Define a "No Action" and "With Mitigation" scenario for comparison, and specific FEMA-eligible mitigation actions in the latter scenario.
6. **Project Benefits.** Quantify a subset of benefits that will result from the mitigation actions.
7. **Project Costs.** Estimate upfront and ongoing costs associated with the mitigation actions.
8. **Results.** Compare the net present value of benefits and costs over the Project Useful Life using a 7% discount rate.

Mitigation Scenarios

For the purposes of this BCA, two scenarios were defined:

1. **"No Action".** This scenario represents what would happen *without mitigation*. The No Action scenario provides a baseline, and any benefits and costs associated with the proposed mitigation actions are estimated relative to this baseline. In a No Action scenario, it is assumed that wildfire risk for the Town of Paradise will remain the same, and a Camp Fire-scale event will occur every 28 years on average. This frequency is based on FEMA's default Return Interval for wildfire for this location. The outcome of a Camp Fire-like event is visually represented in Figure 1 below.
2. **"With Mitigation".** This represents the outcomes of a scenario in which PRPD is funded to implement its proposed "mitigation actions". Specifically, the following mitigation actions were analyzed in this BCA (see Figure 2 below for a visual representation):
    a. **Hazardous fuels reduction**. PRPD proposes to acquire approximately 2,000 acres of land (comprised of 85 parcels) via fee title or purchase of development rights/easements along key areas to the east of Paradise and conduct upfront and ongoing hazardous fuels reduction activities on these lands. This could include use of prescribed fire, prescribed grazing, timber harvest techniques, invasive plant removal, or mechanical treatment to remove fine fuels, dense stands of fire-prone species, shrubs, and dead and dying vegetation.
    b. **Defensible Space.** PRPD proposes to create a 300-foot defensible space buffer along the eastern border of Paradise, adjacent to parcels that are acquired for hazardous fuels reduction activities (above).

Important caveats related to the With Mitigation Scenario include:

- The With Mitigation scenario does not completely eliminate a Camp Fire-like event, but does significantly mitigate the impacts to people and property, as described further below.

- For this analysis, the With Mitigation scenario focuses on hazardous fuels reduction and defensible space. However, ultimately the Town of Paradise would like to implement a suite of additional mitigation actions to provide additional layers of mitigation, such as ignition resistant construction, and these may be included in a final mitigation project subapplication to FEMA.
- Key inputs and assumptions related to avoided structural damage were based on outputs of a Conservation Biology Institute (CBI) model.

Figure 1. Wildfire Risk in the No Action Scenario

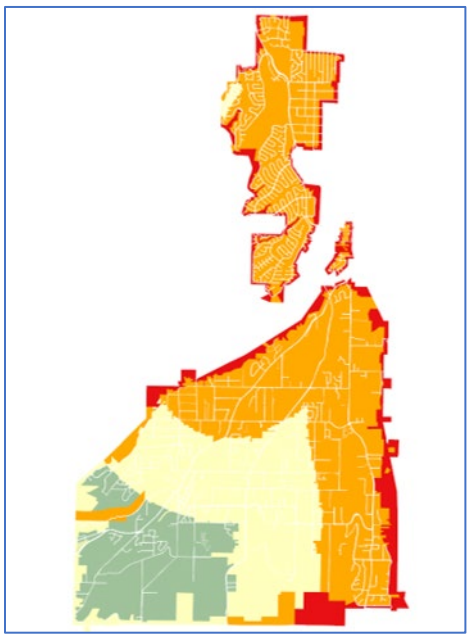
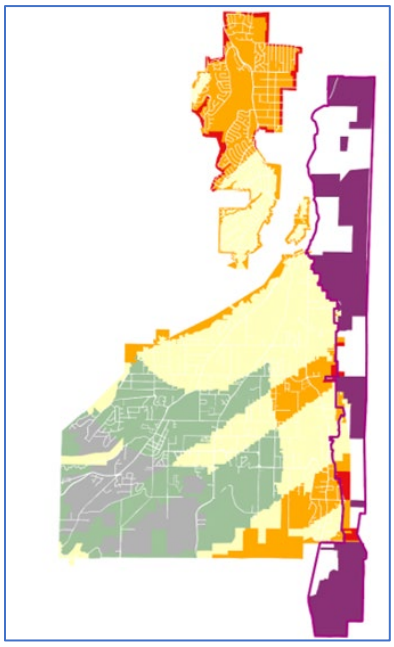


Figure 2. Wildfire Risk in the With Mitigation Scenario



Project benefits

The primary intent of FEMA's mitigation programs is to reduce risk to life and property by minimizing the impact of hazards. The Butte County Local Hazard Mitigation Plan (2019) identifies wildfire as an extremely likely and consequential hazard. The plan goes on to outline a goal of reducing the risk of harm to people, property loss, and damages associated with wildfires. However, FEMA is also increasingly recognizing broader environmental and social benefits of projects, which may be included in future BCA iterations. Examples of project benefits include (but are not limited to):

1. **Avoided physical damages** (structures and contents, roads, bridges, utilities, residences, critical services)
2. **Avoided loss-of-function** (roads, bridges, utilities, residences, critical services)
3. **Avoided emergency response costs** (sandbagging, evacuation, road closure)
4. **Avoided injuries and casualties** (both direct from a hazard and follow-on such as health issues)
5. **Societal and environmental benefits** (water quality, habitat etc.)

In this preliminary BCA, Earth Economics quantified and valued three categories of benefits of PRPD's proposed mitigation actions: Avoided physical damages (structures and contents); avoided emergency response costs (wildfire suppression); and avoided injuries and casualties. One important benefit category that was not included in the preliminary BCA, but which will be quantified in the final BCA, is the value of ecosystem services that will be enhanced by the hazardous fuels reduction and associated forest health improvements.

It should also be noted that all of the benefits are expressed as "annual averages". While it is possible to determine a "recurrence interval" for hazardous events like flooding and even wildfire, it is impossible to predict when that hazard – and by extension, the benefits of mitigating a hazard – will occur in any given future year. Therefore, FEMA's BCA Toolkit allows subapplicants to "annualize" future benefits, which means to average them out over the life of the project.

The following subsections describe the methods used to value each of the benefit categories included in the BCA.

Avoided Physical Damages

An important benefit of PRPD's proposed mitigation actions will be avoided and/or reduced physical damages to residential and non-residential structures (and their contents) within the Town of Paradise.

In a No Action scenario, it is assumed that a Camp Fire-scale event will occur every 28 years on average, and such an event will inflict the same level of damage to structures as the Camp Fire. To estimate the extent and cost of this damage, we used actual damage data from the Camp Fire. Damage to structures was provided geospatially as point data, with each point representing one structure and recorded damage level from the Camp Fire. The damage categories are defined in Table 1 below.

Table 1. Camp Fire Damage Categories

Camp Fire Damage Category	Camp Fire Damage Level
Affected	9%

Minor	25%
Major	50%
Destroyed	100%

This point data was then merged with geospatial data from the Butte County Assessor's office, which provided more complete information about each structure, such as Assessor's Parcel Number (APN), address, structure type (e.g. single family residential), and structure size (in square feet). Using the 2020 National Building Cost Manual, a Building Replacement Value (BRV) in dollars per square foot ($/sq ft) was identified for each structure type; $/sq ft values also vary by building size to reflect the fact that larger buildings generally cost less per square foot than smaller buildings. The total BRV of each unique structure was then calculated by multiplying the structure's area (sq ft) by the appropriate BRV ($/sq ft). Following FEMA guidelines, it was assumed that the value of contents within those structures were 50% of the value of the structures. For example, a residential home with a BRV of $200,000 would have a contents value of $100,000, for a total value of $300,000.

To estimate the total cost of damage due to the Camp Fire event, the total BRV (including contents) for each structure was multiplied by its respective damage level, and the total damages for all structures were summed. Table 2 below shows an example of the different damage levels and costs associated with a typical Single Family Residential structure. Based on this approach and the available data, the total estimated cost of damages across all structures was approximately $3.99 billion. Note that according to a report by Munich Re,[7] the total cost of the Camp Fire exceeded $16 billion, so this may be an underestimate and will be further refined in the final BCA.

Table 2. Example Damage Cost Estimates

Structure Size (sq ft)	Structure BRV ($/sq ft)	Value of Structure ($)	Value of Contents ($)	Damage Category	Damage Level	Total Damage
1600	$142	$227,200	$113,600	Affected	9%	$30,672
1600	$142	$227,200	$113,600	Minor	25%	$85,200
1600	$142	$227,200	$113,600	Major	50%	$170,400
1600	$142	$227,200	$113,600	Destroyed	100%	$340,800

In a With Mitigation scenario, it is assumed that PRPD's proposed mitigation actions will reduce the impact of another Camp Fire event. The reduced risk to each structure was based on the outputs of the CBI model, shown in Figure 2 above. As the figure shows, modeling indicates that hazardous fuels reduction and defensible space along the eastern border of Paradise (purple shaded areas) will reduce fire risk to many – though not all – structures to the west. Depending on the structure's location on the map, the appropriate risk reduction factor was applied to each of the structures valued earlier in the "No Action" scenario. For example, the expected damage in a Camp Fire-like event will be reduced from "Major" (i.e. 50% damage) to "Minor" (i.e. 25% damage) in many cases, and reduced from "Destroyed (i.e. 100% damage) to "Major" (i.e. 50% damage) in some cases. Based on this approach, in a With

[7] https://www.latimes.com/local/lanow/la-me-ln-camp-fire-insured-losses-20190111-story.html

Mitigation scenario, the reduced damage across all structures in Paradise is approximately $1.53 billion, or an average of $54.7 million per year across 28 years.

Avoided Suppression Costs

Wildfire suppression refers to the people and equipment (bulldozers, helicopters etc.) required to fight a wildfire. In a No Action scenario, it is assumed that a Camp Fire-scale event will occur every 28 years on average, and such an event will require the same level of fire suppression as the Camp Fire. Wildfire suppression costs for the Camp Fire were estimated at $150 million.[iii] For lack of a better estimate, it was assumed that PRPD's mitigation actions will reduce suppression costs by an amount proportionate to the reduced damages to structures. As described above, damage to structures in the No Action scenario was estimated at $3.99 billion, and the With Mitigation scenario was estimated to reduce damages by approximately $1.53 billion – a 38% reduction in damages. A 38% reduction in wildfire suppression costs is approximately ($150,000,000 * 0.38 =) $57.6 million every 28 years, or an average of $2.1 million per year.

Avoided Casualties

The Camp Fire resulted in 85 deaths. In a No Action scenario, it is assumed that a Camp Fire-scale event will occur every 28 years on average, and such an event will result in the same number of casualties as the Camp Fire. Applying FEMA's value of a statistical life - $9.63 million in 2020 dollars – to 85 lives is $818 million, or an average annual cost of $29.2 million in the No Action scenario.

In the With Mitigation scenario, like the approach used for avoided suppression costs, it was assumed that PRPD's mitigation actions will reduce casualties by 38% on average, proportionate to the reduced damages to structures. A 38% reduction in casualties is valued at approximately ($818 million * 0.38 =) $314 million every 28 years, or an average of $11.2 million per year.

Project Costs

The With Mitigation scenario included the following cost assumptions:

- **Purchase of development rights** (or fee title) of 2,00 acres (85 parcels) along the eastern border of Paradise – $32 million total across Years 1-3.
- **Hazardous fuels reduction** on the 2,000 acres of land that were acquired – $2.1 million upfront in Year 1, and $8.5 million over the next 19 years.
- **Creation of defensible space buffer** (300' width along the eastern border of Paradise) – $835,000 upfront in Year 1, $3.3 million over 19 years.

Results

The term Project Useful Life (PUL) refers to the length of time the project will provide benefits. FEMA's BCA Toolkit provides default PULs for a range of project types, but allows custom values provided documentation is provided. It is recommended that the default values used whenever possible, due to the additional justification required for custom values. The FEMA default PUL for hazardous fuels reduction projects is 20 years, provided the forest canopy is maintained every 3 years, so this PUL was used for the overall project.

All benefits and costs (upfront and ongoing) described above were allocated across the 20-year PUL, as shown in Table 3 below. As seen in the table, all of the benefit values were calculated as average annual values, while the costs were spread out according to project capital and maintenance estimates. The total value of costs and benefits at each future year was converted to present dollars using a 7% discount rate. Summing all discounted future costs yields a "net present value" (NPV) of $39 million, and summing all discounted future benefits yields an NPV of $770 million.

Table 3. Summary of BCA Results

Year	Costs				Benefits			
	Acquisition	Hazardous Fuels Reduction	Defensible Space	Present Value of Costs (7% discount rate)	Avoided damage to structures & contents	Avoided suppression	Avoided mortality	Present Value of Benefits
1	$10,731,574	$2,129,078	$835,985	$13,696,637	$54,680,678	$2,057,716	$11,224,291	$67,962,685
2	$10,731,574			$10,029,509	$54,680,678	$2,057,716	$11,224,291	$63,516,528
3	$10,731,574			$9,373,373	$54,680,678	$2,057,716	$11,224,291	$59,361,241
4				$0	$54,680,678	$2,057,716	$11,224,291	$55,477,795
5		$2,129,078	$835,985	$2,262,032	$54,680,678	$2,057,716	$11,224,291	$51,848,407
6				$0	$54,680,678	$2,057,716	$11,224,291	$48,456,455
7				$0	$54,680,678	$2,057,716	$11,224,291	$45,286,407
8				$0	$54,680,678	$2,057,716	$11,224,291	$42,323,744
9		$2,129,078	$835,985	$1,725,694	$54,680,678	$2,057,716	$11,224,291	$39,554,901
10				$0	$54,680,678	$2,057,716	$11,224,291	$36,967,198
11				$0	$54,680,678	$2,057,716	$11,224,291	$34,548,783
12				$0	$54,680,678	$2,057,716	$11,224,291	$32,288,582
13		$2,129,078	$835,985	$1,316,523	$54,680,678	$2,057,716	$11,224,291	$30,176,245
14				$0	$54,680,678	$2,057,716	$11,224,291	$28,202,098
15				$0	$54,680,678	$2,057,716	$11,224,291	$26,357,101
16				$0	$54,680,678	$2,057,716	$11,224,291	$24,632,805
17		$2,129,078	$835,985	$1,004,369	$54,680,678	$2,057,716	$11,224,291	$23,021,313
18				$0	$54,680,678	$2,057,716	$11,224,291	$21,515,246
19				$0	$54,680,678	$2,057,716	$11,224,291	$20,107,706
20				$0	$54,680,678	$2,057,716	$11,224,291	$18,792,249
TOTAL				**$39,408,137**				**$770,397,487**

In order to be conservative, FEMA's BCA tool assumes that wildfire mitigation actions are not 100% effective. Specifically, when the mitigation actions "hazardous fuels reduction" and "defensible space" are included in a project, each can be assigned a maximum value of 10% effectiveness. The "effectiveness" of mitigation actions proposed by PRPD were combined, giving the overall project an effectiveness of 20%. In other words, the net present value of all calculated benefits was reduced by 80%

Table 4 below summarizes the net present value of costs, net present value of benefits (after adjusting for effectiveness), and preliminary benefit-cost ratio for the project.

Table 4. Final Results of Preliminary BCA

Discount Rate	7%
Project Useful Life	20 Years
Net Present Value of Benefits	$770,397,487

Project Effectiveness	20%
Effective Net Present Value of Benefits	$154,079,497
Net Present Value of Costs	$39,408,137
Preliminary Benefit-Cost Ratio	**3.91**

Appendix B. Sonoma County BCA Justifications Report

This appendix is a copy of the BCA justifications report that was developed to accompany the BCA for Permit Sonoma's 2020 BRIC application. Please note that there are several references to attachments that were included in the full subapplication package to FEMA, but these attachments are not included in this report.

Sonoma County is proposing a project to help mitigate wildfire risks to life, property, and the environment in the County. This project is envisioned as a pilot project for further wildfire mitigation projects within the County and is intended to establish the foundational components for these future efforts. The scope of this project is built upon the resilience premise of hardening the "inner core" (i.e. areas where residential and commercial development is concentrated) - while creating an "outer core" (i.e. surrounding wildland-urban interface) that is able to absorb and reduce the impacts from wildfires before they reach the hardened inner core. This approach has been coined, the "Inside-out, outside-in" approach (IO-OI)'. The IO-OI approach applies structural hardening and defensible space techniques to an inner core, while applying hazardous fuels reduction techniques to an outer core to create and overarching wildfire resilience zone.

The final resulting BCR of 4.45 should be considered very conservative for at least five reasons:

1. Some of the mitigation activities, like hazardous fuels reduction, will improve forest health and support increased levels ecosystem services (environmental benefits). While FEMA recognizes the value of ecosystem services in its BCA Toolkit, it is not currently possible to calculate these "marginal" improvements, so these were not quantified.
2. As described in the analysis, the average Building Replacement Value used for most of the structures ranged between $144 and $172 per square foot and is likely to be conservative. As discussed in a 2018 analysis from the North Coast Builders Exchange (Attachment A), $425 per square foot may be more realistic in Sonoma County.
3. The mitigation actions described here are likely to benefit many structures outside of the IO-OI area, and these benefits have not been quantified. For example, the areas that receive home hardening and defensible space will act as a line of defense for those homes and other structures deeper in urban areas. Also, homes in the IO area that don't elect to participate in defensible space and/or structural hardening may also benefit from those 80% (targeted) that do opt-in, due to reduced risk in the community overall (analogous to "herd immunity").
4. Avoided suppression is one potential benefit of these mitigation actions, but this benefit was not estimated here.
5. Avoided loss of life and injury would also be a potential benefit of this project but was not valued in the analysis.

Key Project Benefit Assumptions

The BCA is driven primarily by avoided wildfire damage to structures in the project area. For the purposes of this analysis, the project was broken into three "Mitigation Actions", and a separate BCA was conducted for each one. Each Mitigation Action includes one or more Mitigation Activities (hazardous fuels reduction, defensible space, ignition-resistant construction). The table below provides a summary of what structures are included in the BCAs for each Mitigation Action. The BCA assumptions for each of these Mitigation Actions (1, 2, and 3) are described in the sections that follow.

Mitigation Action	Structures Included in BCA Mitigation Scenario
1. Hazardous Fuels Reduction	All structures within the project area – both the outer core and inner core – will benefit from the management of hazardous fuels. **The number of structures to benefit from hazardous fuels reduction is estimated to be 6,498.**
2. Defensible Space	We estimate that 80%* of the structures in the inner core – or 4,103 structures – will opt in to the defensible space program (which provides cost-share to property owners to install defensible space alone or both defensible space and ignition resistant construction). Of those 4,103 structures, **1,641 structures** (40%) **will receive defensible space only.**
3. Defensible Space, Ignition-Resistant Construction	Of the 4,103 structures that will opt in to the defensible space program (described in #2 above), **2,462 structures** (60%*) **will receive both defensible space and ignition resistant construction.** This is a separate and distinct group of structures to those described under Mitigation Action 2 above.

* The strategy for engaging homeowners to participate in this project is described in detail in Permit Sonoma's Scope of Work for its full BRIC application (not included here). It should also be noted that Sonoma County is taking steps to break down barriers to participation.

Key Initial Project Cost Assumptions

Due to the scale of the project, the final costs associated with the mitigation actions may vary depending on landowner engagement, defined further during the Planning, Assessment, and Design phase. Using the best available data, we have estimated the project will have a total cost of $49,061,636.15 (including federal and non-federal cost share and 5% Grant Management). The costs for each mitigation action are summarized in the table below, and are the costs used for the purpose of the BCA. Attachment G (Columns J-N) is a copy of the Cost Estimate Spreadsheet (submitted via FEMA GO) that show how the different Task budgets (e.g. "Task 2D - Vegetation Management Implementation") were allocated across the three different mitigation actions to estimate a total budget for each mitigation action for the purposes of the BCA.

	Mitigation Action		
	1. Hazardous Fuels Reduction	2. Defensible Space	3. Defensible Space, Ignition-Resistant Construction
Subtotal*	$17,373,595	$7,558,271	$24,129,771
Total*	$49,061,636		

*Includes 5% Grant Management

Mitigation Action 1: Hazardous Fuels Reduction

Cost Estimation

Project Useful Life

A 20-year PUL was used for hazardous fuels reduction investments. The FEMA default PUL for hazardous fuels is 20 years, provided the forest canopy is maintained every 3 years. The first component of this project explores the use of recurring landscape-scale fuels treatment to remove fuel ladders, which may include use of prescribed fire, prescribed grazing, timber harvest techniques, invasive plant removal, or mechanical treatment to remove fine fuels, dense stands of fire-prone species, shrubs, and dead and dying vegetation. To ensure these properties are maintained at least every 3 years, private landowners that opt-in to the initial fuel treatment will sign an agreement that requires them to perform hazardous fuels maintenance on their lands every 3 years. A maintenance agreement will be developed as a component of this project.

Initial Project Costs

Initial project costs for this mitigation action were estimated at $17,373,595, as described in the section above "Key Initial Project Cost Assumptions" and as detailed in Attachment G.

Maintenance Costs

We estimate that hazardous fuels can be maintained at $1,500 per acre per year when averaged over 20-year project useful life. Our estimate is based on historical costs to do similar work throughout the County. Annual maintenance is estimated to be $8,106,720 across 5,404.48 acres.

Burn Recurrence

The default burn recurrence interval for Sonoma County in the BCA Toolkit is 28 years. However, we have assumed a burn recurrence interval of 16 years. Please see Attachment B for a letter from the County of Sonoma Fire & Emergency Services Department that provides justification for this burn recurrence interval. This justification was previously accepted by FEMA for HMGP application PP4407-0035 in 2019.

Project Effectiveness

The mitigation action "hazardous fuels reduction" was assigned the FEMA default value of 10% effectiveness.

Standard Benefits

Structure Cost Justification

To estimate numbers and types of structures that would benefit in terms of avoided damages, we first identified all primary structures within the project area using building footprint data (6,498). Assessor data was used to determine information on each structure, including square footage, year built, and number of stories. Where this data was not available, we used default values based on use code descriptions and Hazus data (Attachment F). This information was used to determine the appropriate replacement cost values.

Next, we matched the information gained from the assessors' data with Hazus Occupancy Classes (e.g., multi-family residential or commercial retail trade). Replacement cost is based on industry-standard cost-estimation models published in RS Means Square Foot Costs (RS Means, 2020). It is calculated using the RS Means square foot cost for a structure, which is based on the Hazus occupancy class, multiplied

by the square footage of the structure from the tax assessor data. The construction class and number of stories for single-family residential structures also factor into determining the square foot costs.

A full accounting of structures in the project area and their replacement value is found in Attachment E, but is summarized in the table below, which shows structure type, counts, total square footage, average building replacement value (BRV), and total BRV by structure type.

Structure Type	Structure Count	Total Square Footage	Average BRV ($ per square foot)	Total BRV ($)
Agricultural	418	6,776,420	$144	$1,189,731,542
Commercial	370	6,522,862	$172	$1,376,217,828
Multi-Family	72	402,163	$145	$68,296,454
Residential	5,637	11,501,344	$144	$1,855,936,446
Winery/Vineyard	1	2,500	$144	$436,205
Total	6,498	25,205,289	$145	$4,490,618,476

Contents Cost Justification

Content replacement values are calculated using the methodology used in Hazus. This value is a percentage of the structure replacement cost based on the Hazus occupancy class (Attachment D).

Structure Type	Total BRV	Contents Percent*	Total Contents Value
Agricultural	$1,189,731,542	100%	$1,189,295,437
Commercial	$1,376,217,828	101%	$1,390,062,380
Multi-Family	$68,296,454	50%	$34,148,227
Residential	$1,855,936,446	52%	$966,789,011
Winery/Vineyard	$436,205	100%	$436,205
Total	$4,490,618,476		$3,580,731,259

* While FEMA default contents percent is 50%, the contents precents are direct outputs of Hazus. These values can be found in the Hazus Flood Model Technical Manual, Table 14.6 “Default Hazus Contents Value Percent of Structure Value” or the Hazus Earthquake Model Technical Manual, Table 3.10 “Default Hazus Contents Value Percent of Structure Value”.

Standard Benefits - Displacement

Sonoma County has an average household size of 2.55 according to the 2010 census (Attachment C). To estimate total number of people impacted during wildfire events, we multiplied the average household size by the number of residential and multi-family structures in the project area.

Structure Type	Structure Count	Average HH Size	People in Project Zone
Multi-Family	72	2.55	184
Residential	5,637	2.55	14,374
Total	5,709	2.55	14,558

Mitigation Action 2: Defensible Space

Cost Estimation

Project Useful Life

A 4-year PUL was used for defensible space investments. This is the FEMA default PUL for defensible space. It is worth noting that private property owners that opt-in will sign an agreement that requires them to perform defensible space maintenance on their lands every 3 years. A maintenance agreement will be developed as a component of this project. A 4-year project useful life is conservative; this mitigation action will provide benefits throughout the life of this project.

Initial Project Costs

Initial project costs for this mitigation action were estimated at $7,558,271, as described in the section above "Key Initial Project Cost Assumptions" and as detailed in Attachment G.

Maintenance Costs

We estimate that the defensible space can be maintained at an average of $750 per parcel per year when averaged over 4-year project useful life. Our estimate is based on historical costs to do similar work throughout the County. Assuming 1,641 defensible space only parcels (one structure per parcel), the total annual cost to maintain defensible space is estimated to be $1,230,750.

Burn Recurrence

The default burn recurrence interval for Sonoma County in the BCA Toolkit is 28 years. However, we have assumed a burn recurrence interval of 16 years. Please see Attachment B for a letter from the County of Sonoma Fire & Emergency Services Department that provides justification for this burn recurrence interval. This justification was previously accepted by FEMA for HMGP application PP4407-0035 in 2019.

Project Effectiveness

The mitigation action "Defensible Space" was assigned the FEMA default value of 10% effectiveness.

Standard Benefits

Structure Cost Justification

We estimated that, of the 1,641 structures to receive defensible space, 22 were classed as "multi-family" and 1,619 were classed as "residential", based on County Assessor and building footprint data.

A full accounting of structures in the project area is found in Attachment E, but is summarized in the table below, which shows structure type, counts, total square footage, average building replacement value (BRV), and total BRV by structure type.

Structure Type	Structure Count	Total Square Footage	Average BRV	Total BRV
Multi-Family	22	158,082	$170.81	$27,001,307
Residential	1,619	4,126,491	$158.97	$656,004,220
Total	1,641	4,284,573	$159.41	$683,005,527

Contents Cost Justification

Content replacement values are calculated using the methodology used in Hazus. This value is a percentage of the structure replacement cost based on the Hazus occupancy class (Attachment D).

Structure Type	Total BRV	Contents Percent	Total Contents Value
Multi-Family	$27,001,307	50%	$13,500,654
Residential	$656,004,220	52%	$341,561,936
Total	$683,005,527		$355,062,589

Standard Benefits - Displacement

Sonoma County has an average household size of 2.55 according to the 2010 census (Attachment C). To estimate total number of people impacted, we multiplied the average household size by the number of residential and multi-family parcels in the inner core area that opt-in for defensible space.

Structure Type	Structure Count	Average HH Size	Total
Multi-Family	22	2.55	57
Residential	1,619	2.55	4,128
Total	1,641		4,185

Mitigation Action 3: Defensible Space and Ignition-Resistant Construction

Cost Estimation

Project Useful Life

A 10-year PUL was used for structures that receive both defensible space and ignition resistant construction. The FEMA default PUL for defensible space is 10 years, provided it is maintained every 3 years. Private property owners that opt-in will sign an agreement that requires them to perform defensible space maintenance on their lands every 3 years. A maintenance agreement will be developed as a component of this project

Initial Project Costs

Initial project costs for this mitigation action were estimated at $24,129,771, as described in the section above "Key Initial Project Cost Assumptions" and as detailed in Attachment G.

Maintenance Costs

We estimate that the defensible space and ignition resistant construction can both be maintained at a cost of $1,000 per parcel per year when averaged over the 10-year project useful life. Our estimate is based on historical costs to do similar work throughout the County. Assuming 2,462 parcels receiving both defensible space and ignition-resistant construction, the total annual cost to maintain defensible space and structural hardening is estimated to be $2,462,000.

Burn Recurrence

The default burn recurrence interval for Sonoma County in the BCA Toolkit is 28 years. However, we have assumed a burn recurrence interval of 16 years. Please see Attachment B for a letter from the County of Sonoma Fire & Emergency Services Department that provides justification for this burn recurrence interval. This justification was previously accepted by FEMA for HMGP application PP4407-0035 in 2019.

Project Effectiveness

The mitigation action of both Defensible Space and Ignition-Resistant Construction was assigned the FEMA default value of 20% effectiveness (i.e. 10% for each).

Standard Benefits

Structure Cost Justification

We estimated that, of the 2,462 structures to receive both defensible space and ignition resistant construction, 34 were classed as "multi-family" and 2,428 were classed as "residential", based on County Assessor and building footprint data.

A full accounting of structures in the project area is found in Attachment E, but is summarized in the table below, which shows structure type, counts, total square footage, average building replacement value (BRV), and total BRV by structure type.

Structure Type	Structure Count	Total Square Footage	Average BRV	Total BRV
Multi-Family	34	237,122	$170.81	$40,501,961
Residential	2,428	6,189,737	$158.97	$984,006,330
Total	2,462	6,426,859	$159.41	$1,024,508,291

Contents Cost Justification

Content replacement values are calculated using the methodology used in Hazus. This value is a percentage of the structure replacement cost based on the Hazus occupancy class (Attachment D).

Structure Type	Total BRV	Contents Percent	Total Contents Value
Multi-Family	$40,501,961	50%	$20,250,980
Residential	$984,006,330	52%	$512,342,904
Total	$1,024,508,291		$532,593,884

Standard Benefits - Displacement

Sonoma County has an average household size of 2.55 according to the 2010 census (Attachment C). To estimate total number of people impacted, we multiplied the average household size by the number of residential and multi-family parcels in the inner core area that opt-in for defensible space.

Structure Type	Structure Count	Average HH Size	Total
Multi-Family	34	2.55	86
Residential	2,428	2.55	6,192
Total	2,462		6,278

Addendum A. Discussion Paper: Revisiting the OMB Discount Rate to Support Federal Agency Goals and Advance Community Resilience

Summary

Effective investment of the nation's tax dollars is essential to successful economic prosperity, resilience, and financial accountability. Benefit-Cost Analysis (BCA) is used to inform the allocation of many billions of dollars of federal, state, and local government investment every year. Within a BCA, the discount rate determines how much weight is given to future costs and benefits and can have a significant impact on the types of projects that are prioritized and funded by government agencies.

In 1992, the Office of Management and Budget (OMB) mandated a real discount rate of 7% for BCA of public investments and regulatory programs in *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*.[iv] Based on this guidance, a 7% discount rate is now used by the Federal Emergency Management Agency (FEMA) and other federal agencies in BCA to help prioritize a range of investments.

Since 1992, and increasingly in recent years, a number of economists, thought leaders, and agencies have used a variety of methods and assumptions to conclude that a lower discount rate (i.e. lower than 7%) is more appropriate for public agencies, especially those like FEMA that make long term, intergenerational investments (or at least for the long-term project types funded by those agencies). Some have also questioned the assumptions behind OMB's formulation of the 7% rate in Circular A-94.

The purpose of this memo is to summarize OMB's approach to the discount rate, reflect on recent academic thinking, and offer several recommendations for the consideration of FEMA and OMB leadership. While by no means an exhaustive review of the vast academic and policy literature related to the discount rate, this memo is intended to support a foundation for open discussion.

The recommendations are as follows:

3. **Revisit and update Circular A-94.** OMB could convene its staff along with an expert panel of economists to revisit the methods and assumptions that form the basis for the 7% discount rate specified in Circular A-94. In its review, OMB could also consider the use of a "dual" discount rate – a higher rate for short-term projects and a lower rate for projects that generate intergenerational cost/benefits or incorporate nature-based solutions – and/or the use of declining discount rates (see the discussion below citing Arrow, Boardman, and Weitzman). Transparency, open debate, and collaboration should be encouraged during this review.

4. **Provide more explicit guidance on the use of "other discount rates" as discussed in Circular A-94.** In the short term, given the likely time and effort required to update Circular A-94, OMB could make immediate progress by providing more clarity on the context in which an "other discount rate" (per Section 8(b)(2)) could be used by an agency and when such a rate could be used as the primary basis for a BCA, rather than just for sensitivity analysis. Specifically, OMB could create a discount rate exemption in Circular A-94, allowing a lower discount rate to be applied to federal investments that meet certain criteria (e.g. intergenerational costs and benefits, use of nature-based solutions), provided ample justification is given. In the case of

FEMA, for example, certain kinds of hazard mitigation projects would then be eligible for a lower discount rate, given their long-term resilience benefits, and FEMA could build this function into its BCA tool and policies.

OMB Circular A-94 and what this means for FEMA

OMB oversees federal agency performance, federal procurement, and financial management, and plays a significant role in directing where federal dollars are spent.[v] In 1992, OMB published *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. The purpose of the circular was to "promote efficient resource allocation through well-informed decision-making by the Federal Government" and to provide "…specific guidance on the discount rates to be used in evaluating Federal programs whose benefits and costs are distributed over time." Circular A-94 recommends a real discount rate of 7% for public investments and regulatory programs. By default, this discount rate has become a national benchmark for state and local agencies to follow.[8]

In Circular A-94, OMB begins by noting, "public sector investments and regulations displace both private investment and consumption" and selects a 7% discount rate in order to approximate "the marginal pretax rate of return on an average investment in the private sector in recent years." These statements indicate that OMB is using the Social Opportunity Cost of Capital (SOC) approach to calculate a discount rate for public agencies, one of several methods used by governments worldwide. Other methods used by governments include the Social Rate of Time Preference, the Weighted Average approach, and Shadow Price of Capital approach.[vi] While there is no consensus on the "correct" approach,[vii] a survey by the Asian Development Bank concluded that "most developed countries follow the Social Rate of Time Preference approach and apply much lower discount rates, mostly in the range of 3–7%, with many revising the rates downward in recent years."[viii]

The SOC approach depends on a number of assumptions, including: 1) Resources are scarce; 2) Governments and the private sector compete for the same pool of funds; 3) Public investment displaces private investment dollar for dollar; and 4) Dollars invested by public agencies could be invested in the private sector, so these dollars should yield at least the same return as private investment. While the SOC approach is valid and accepted in general by economists, concerns have been raised with several of the above individual assumptions. For example, this approach considers the opportunity cost (i.e. next best alternative) of public investments to be investment in the private sector. However, it could be argued that opportunity cost should reflect how dollars would be spent, in this case on public programs, rather than how money could have been spent on other types of (e.g. private sector) investments.[ix] In fact, a large proportion of federal BCAs determine the most productive investment within a portfolio of federal projects for which funds have already been allocated. Also, private sector returns are likely inflated due to substantial externalities (environmental, social etc.) that have not been accounted for in market returns over the past several decades. Therefore, these returns may not be a realistic benchmark in the future, as the private sector and government agencies better account for such externalities.[x]

[8] It should be noted that significant variation has been observed in the discount rates actually used by federal agencies in practice. See for example Morrison, 1998. Judicial Review of Discount Rates Used in Regulatory Cost-Benefit Analysis and Zerbe et al. 2002. A History of Discount Rates and Their Use by Government Agencies.

Private sector returns may also be higher due to risks faced in the private sector, which may not apply to the public sector.[xi]

A relatively high discount rate like 7% rapidly diminishes the present value of future benefits and costs associated with a project, program, or policy. As OMB notes in Circular A-94, "for typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value." All other things being equal, a higher discount rate will often bias federal investments toward projects with more immediate returns, potentially at the expense of alternative projects with long-term benefits and resilience. For the same reason, projects with higher long-term economic, social, or environmental costs can look more appealing with a higher discount rate when the costs occur in the heavily discounted future.

The importance of the discount rate is clear for an agency like FEMA. In addition to its emergency support and post-disaster recovery functions, FEMA spends billions of dollars each year on hazard mitigation projects, with a primary goal of promoting community resilience. The benefit-to-cost ratio is one of the key criteria used by FEMA to rank projects and allocate funding. The bipartisan passage of the 2018 Disaster Recovery Reform Act and formation of the Building Resilient Infrastructure and Communities (BRIC) program indicates that hazard mitigation funding is likely to increase over the coming years, and allocation of this funding will be guided – in part – by the discount rate.

Increasingly, within the BRIC program and other hazard mitigation funding programs, FEMA has begun to emphasize the role of nature-based solutions (NBS) for building community resilience and mitigating the impacts of floods, wildfires, and drought. These advances are reflected in recent policy updates that recognize the economic value of these kinds of investments and have reduced barriers to accessing FEMA funding for NBS, including floodplain and stream restoration, post-wildfire restoration of forested lands, aquifer storage and recovery, and green infrastructure. NBS tend to generate benefits in a different way to traditional hazard mitigation projects. To provide a simple example, a levee designed to protect an adjacent community provides its highest level of benefit (i.e. flood protection) immediately after construction, and those benefits gradually decline over several decades as the levee reaches the end of its useful life – after which the levee will fail or need to be decommissioned at a high cost. On the other hand, a floodplain and stream restoration project, designed to add flood storage and reduce flooding to the same community, may provide some immediate flood protection benefits, but those benefits increase over time as the floodplain vegetation matures and increases in functionality. Provided it receives adequate maintenance, the floodplain project can provide flood protection benefits – and many other social and environmental benefits – in perpetuity. While the floodplain project may intuitively make more sense as a long-term resilience solution, the levee project would look more attractive in a BCA that uses a high discount rate because the project's benefits occur upfront while many of the project costs occur in the discounted future.

FEMA also emphases consideration of "future conditions" in hazard mitigation project BCAs, and a high discount rate can diminish the perceived impact of these future conditions – and by extension the benefits of a hazard mitigation project designed to address them. For example, sea level rise is a future condition that is well studied and understood. In some areas, sea level rise can cause a community's flood exposure risk to rise incrementally but significantly over a period of decades. A hazard mitigation designed to address this future condition – whether an established approach such as

acquisition/relocation or NBS such as wetland restoration – may accrue most of its benefits incrementally over several decades, so most of these benefits will be heavily discounted.

Academic Perspectives and Local Agency Precedents

A number of economists, using different methods and assumptions, have come to the conclusion that a lower discount rate (i.e. lower than 7%) is more appropriate for public investments. For example, Kenneth Arrow, a winner of Nobel Memorial Prize in Economics, argues that discount rates for environmental resources should be interpreted as social discount rates due to the public nature of most environmental goods and services.[xii] Using assumptions developed by Arrow related to the social rate of time preference, Boardman et al. (2006) calculate a social discount rate of approximately 3%.[xiii]

Flory (2015)[xiv] reviews the literature and calculates the implied discount rate using a range of different approaches (social marginal rate of time preference, opportunity cost of capital, optimal growth rate approach, and others), and finds that all come out much lower than 7%. Flory finds that even if one uses the SOC concept, like OMB has done in Circular A-94, the estimate of the discount rate should be in the 4% range. Flory also notes that "A much greater concern is that [the OMB approach] may not be the correct concept. Boardman et al, in their textbook on cost benefit analysis[xv] strongly suggest that the best proxy for the *marginal* rate of return on private investment is the real, before-tax rate of return on corporate bonds. They cite four reasons for using the bond rate rather than the average return on equities, the most compelling of which is that using a measure based on *average* returns to equities produces a discount rate that is too high because the return on the marginal investment is lower than the average return."

The Harvard economist Martin Weitzman takes a different approach. Acknowledging the lack of consensus among economists on the discount rate, he surveys 2,160 economists on their "professionally considered gut feeling" as to what the discount rate should be over different time horizons. Weitzman also corroborates responses against those of a "blue ribbon panel" of 50 distinguished economists, including Nobel Prize Winners Paul Krugman, Kenneth Arrow, and Amartya Sen. Based on statistical analysis of responses to the survey, Weitzman concludes that society should be using a declining discount rate, beginning at 4% for the immediate future (1-5 years), declining to 2% for the medium future (26-75 years), and 1% for the distant future (76-300 years).[xvi] This is equivalent to a constant discount rate somewhere between 1.2 and 3.4% depending on the length of the time horizon.[xvii]

Following the lead of these academics and local experience in their communities, several local governments have already lowered their discount rate to emphasize project investments that provide greater service, are more resilient, and provide far more benefit in the long term. They found that a higher discount rate biased decisions toward short-term, fragile projects with reduced public benefits in the long term. Seattle Public Utilities and Tacoma Public Utilities have both lowered their standard discount rate from 5% to 2.5%, for example.

Recommendations

To realign the discount rate with the economic literature, current economic realities, and the current Administration's priorities, OMB could implement one of both of the following steps:

1. **Revisit and update Circular A-94.** OMB could convene its staff along with an expert panel of economists to revisit the methods and assumptions that form the basis for the 7% discount rate specified in Circular A-94. In its review, OMB could also consider introduction of a "dual"

discount rate – a higher rate for short-term projects and a lower rate for projects that generate intergenerational cost/benefits or incorporate nature-based solutions – and/or the use of declining discount rates (see the discussion above citing Arrow, Boardman, and Weitzman). Transparency, open debate, and collaboration should be encouraged during this review.

2. **Provide more explicit guidance on the use of "other discount rates" as discussed in Circular A-94.** In the short term, given the likely time and effort required to update Circular A-94, OMB could make immediate progress by providing more clarity on the context in which an "other discount rate" (per Section 8(b)(2)) could be used by an agency and when such a rate could be used as the primary basis for a BCA, rather than just for sensitivity analysis. Specifically, OMB could create a discount rate exemption in Circular A-94, allowing a lower discount rate to be applied to federal investments that meet certain criteria (e.g. intergenerational costs and benefits, use of nature-based solutions), provided ample justification is given. In the case of FEMA, for example, certain kinds of hazard mitigation projects would then be eligible for a lower discount rate, given their long-term resilience benefits, and FEMA could build this function into its BCA tool and policies.

Conclusion

Clearly, any new guidance related to the discount rate will require careful thought due to the potentially widespread ramifications. It should also be acknowledged that while a discount rate can be calculated in a mathematical and "objective" way, the selection of an appropriate method and assumptions also requires many subjective inputs. As stated by Creedy and Passi (2017), "Essentially the discount rate reflects how the government values the future when making decisions on behalf of society: value judgements and assumptions are necessary."[xviii]

Ultimately, economic tools such as benefit-cost analysis and discount rates are not mathematical laws, but instead reflect social preferences and are intended to help leaders use taxpayer funds wisely. In decades past, with a sense of resource abundance and reliance on "technological fixes", decision makers tended to have a near term planning horizon geared towards higher consumption. Today we know that past decisions often turned out to be shortsighted and have led to resource depletion or high long-term costs to society, whether related to floods, toxics, drought, or climate change. While our economic and financial analysis tools are not solely responsible for the environmental and social problems we face, they have helped to justify many of the poor choices made.[xix]

The nation faces significant long-term infrastructure and environmental challenges that require long-term solutions supported by robust economic analysis. OMB can potentially remove an important barrier to investments in more resilient infrastructure by revisiting the discount rate methods and assumptions in Circular A-94. If it concludes that a lower discount rate is warranted (in at least some cases), this change could lead to improved allocation of taxpayer dollars and to more infrastructure investments that offer long term, resilience benefits to the American public. A lower discount rate would also support the Administration's priorities, including resilience, equity, and the use of NBS.

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