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House Subcommittee on National Parks, Forests & Public Lands
Committee on Natural Resources
April 7, 2009 Hearing:
"The Impacts of Climate Change on America's National Parks"

I. Background on Dr. Rebecca Shaw

I am Rebecca Shaw, the Director of Conservation for the California Chapter of The Nature Conservancy. It is my job to provide the technical guidance and leadership necessary for the Conservancy to make smart decisions regarding the conservation and management of nature. Prior to taking a position at The Conservancy, I was a researcher at the Carnegie Institution's Department of Global Ecology at Stanford University and pursuing a career in climate change science. At the Conservancy, I have continued research on climate change impacts and adaptation, developing scientific methods and information for use by field managers of natural resources and policy makers that creates an explicit link between climate science information and its users. I have dedicated my scientific career to using rigorous, practical analysis and synthesis of science data for management and use our lands and waters. I am here today to talk explicitly about adapting our natural lands and waters, especially those in our National Parks, to a rapidly changing climate.

II. Background on The Nature Conservancy

For the past 50 years, the Conservancy has integrated science, policy and on-the-ground conservation to protect more than 117 million acres of land and 5,000 miles of river around the world. We work in all 50 states and 32 countries, and are supported by approximately one million individual members. Our work also includes more than 100 marine conservation projects in 21 countries and in 22 US states. The Conservancy owns and manages approximately 1,400 reserves throughout the United States—the largest private system of nature sanctuaries in the world. The Conservancy recognizes that successful conservation is the underpinning of human health and prosperity and uses science and its strategic application to protect biological diversity and meet human needs. To achieve our goals we routinely partner with government agencies, non-profit organizations, academic institutions, and business enterprises. However, climate change impacts on the Earth's lands and waters are real and tangible, and we have found that protecting our natural systems has become increasingly challenging.

III. Context for Ecosystem-based Adaptation to Climate Change

In many parts of the world, including right here in Joshua Tree National Park, impacts are already observable and measureable. Forests from Canada to Brazil are more susceptible to pest outbreaks and catastrophic fires. Species like polar bears in the Arctic are struggling to survive as suitable habitat shrinks. As climate continues to change, water supplies will be threatened as some regions experience more flooding and others more drought. Agricultural productivity will shift. Low-lying coastal communities may be inundated by sea-level rise. In fact, with or without societal interventions, we are committed to continued human-driven climatic change and additional impacts in the future (Kerr 2004, 2005) and it is important to develop concrete approaches for helping communities and ecosystems deal with the climate change that is unavoidable.

Nature can play a powerful role the solutions. Adapting nature to the impacts of climate change will help ensure the health of valuable resources, such as forests and fisheries, upon which people depend for their well-being and livelihoods. However, there is emerging evidence that adaptive responses to climate change are focusing heavily on defensive infrastructure, such as reinforcing seawalls, relocating communities or roads, and building dams, levees, and channels to control flooding. Such infrastructure responses will often be necessary, but they will not be sufficient to address the full scope of climate change impacts. Also needed are strategies to ensure that the ecosystems that support biodiversity and that provide people with water, food, and other natural resources and services continue to function despite the changing conditions. Done right and under the right conditions, we can also harness nature to protect us from climate change threats, such as increased flooding, more cost-effectively than by deploying additional infrastructure.

While the testimony provided today will focus on adaptation in order to lessen climate change impacts, action to address the causes of climate change is essential if adaptation efforts are to be effective. To that end, implementation of policy that explicitly links three concepts is essential to success adaptation success:

1) A strong cost-effective cap on emissions and a market-based program compatible with other international efforts. Meaningful emission reductions are needed to stabilize atmospheric greenhouse gas concentrations at a level that ensures the well-being of human communities and ecosystems worldwide. The Conservancy supports caps that would establish emissions reductions of 20% below 2005 levels by 2020 and an 80% reduction by 2050.
2) Reduction of emissions from forest and land-use practices through a comprehensive framework including incorporation of verified credits from these practices in a cap-and-trade program, and
3) Strong support for ecosystem-based adaptation programs designed to protect human and natural communities from the impacts of climate change.

III. Climate Change Impacts in California and at Joshua Tree National Park

Our terrestrial, freshwater, and marine habitats, including the already dry and hot California desert in which we find ourselves today, face an uncertain climatic future. Climate change projections forecast significant ecological and economic impacts as a result of rising temperatures, changing rainfall patterns and extreme weather events. Although climate has changed repeatedly over past millennia, for a variety of reasons (Houghton et al. 2001), anticipated human-driven changes are likely to be unusually fast and large. Many of the species and ecosystems here are particularly vulnerable to future climatic change because their current ranges are limited and their potential ranges are bounded by the coast, mountains and other geographic features (Snyder et al. 2003). California's unique climate, under which its ecological systems evolved, is projected to change dramatically. Mean annual temperatures in California have already increased by 1 degree Celsius (1.8°F) between 1950 and 2000. The contemporary climatic changes have already had a demonstrable impact on California's natural resources. Droughts have become more severe, especially in the southern part of the state, and this trend is projected to continue over the next 100 years (Christensen et al. 2007; Seager et al. 2007; Trenberth et al. 2007). In addition, movement of species in response to climate warming is already resulting in shifts of species ranges north and upward along elevational gradients (Parmesan, 2006) and have begun to explore the implications of these changes for the provisions of ecosystem services (*sensu* Millennium Ecosystem Assessment 2005). Indeed, an explosion of studies in the last five years document observed climate impacts on species distributions. In one such study in Southern California's Santa Rosa Mountains, researchers documented plants shifting upslope by 65 m over the 30 year period from 1970 to 2007 (Kelly and Goulden, 2008). The altitudinal shift is attributable to increases in surface temperature and in the precipitation due to climate change. In another, researchers discovered that 70% of butterfly species studied advanced the date of first spring flights by an average 24 days over the period from 1972 to 2002 (Forister and Shapiro 2003).

In California this century, the average annual statewide temperature is projected to rise 1.7 – 3.0°C (3.0– 5.4°F) under low emission scenarios and 3.8 – 5.8°C (6.8 – 10.4°F) under higher emissions scenarios; the current trend is the higher than the high emissions scenario (Hayhoe et al. 2004; Cayan et al. 2006, Rapauch 2007). The projections for statewide annual average precipitation change varies in both direction and magnitude from a decrease of 157 mm to an increase of 38 mm (Hayhoe et al. 2004; Cayan et al. 2006), with significant variation in projections among Global Circulation Models (GCMs) and emissions scenarios (Metz et al. 2001; Salathe 2003; Wood et al. 2004).

The projections for the California deserts, including Joshua Tree National Park, are even more severe, with the typical summer maximum temperatures by the end of the century reaching levels that are hotter than the most extreme year we have seen in the last 100 years. The majority of climate models also predict these deserts will become even more arid, losing an average of 1.6 inches of precious rain each year. Additional stresses to species and ecological systems are also likely to come from increased invasions from non-native species, more frequent high-intensity fires, unforeseen interactions between species as the climate shifts, and natural and non-natural barriers to wildlife migration (Suttle et al. 2007). Under pressure from climate change and the full array of stressors, these ecosystems, including the distinctive species associated with these places, will necessarily respond and change.

Indeed, here in the Mojave Desert at Joshua Tree National Park, there will likely be increased rates of plant mortality, including the charismatic Joshua Tree, which will accelerate rates of erosion, create opportunities for exotic plant invasions and promote fire. The increased frequency of fire will further reduce abundance of native plants. The climate-driven dynamics of the fire cycle are likely to become the single most important feature controlling future plant distributions in these deserts. Thus it is likely that California's desert species and ecosystems, and the direct value we derive from them via ecosystem services (e.g., to sustain biodiversity, promote clean water, and sequester carbon), will also be altered dramatically.

As we are now able to measure ecological signals for a temperature increase of just 1.0° C (1.8˚F), the expected impacts on species and ecosystems of the temperature expected by 2099 are sure to be dramatic and we need to develop approaches for securing our past investment in our federal, state and private protected areas through a comprehensive adaptation strategy that takes into account the likely impacts of climate change, analyzes the vulnerability of species and ecosystems to those impacts and develops adaptation strategies for building resilience into natural systems.

IV. Ecosystem-based Adaptation Approach - Strategies and Benefits

While a world of rapidly changing climate is not desirable, it is now inevitable. To alter course of impact of climate change, it is essential to implement meaningful greenhouse gas reduction targets; but it is also important to come to terms with degree of climate change to which we have committed ourselves, both through our past emissions and through emissions that will occur between now and in the future. It is therefore vital to act now to begin to/take steps to fund, plan and implement strategies to protect our important protected areas and the services they provide to our nation's people in the face of anticipated changes in climate. These last strategies are commonly referred to as ecosystem-based adaptation strategies.

In practice, ecosystem-based adaptation includes practices such as ensuring that ecosystems remain intact and interconnected to allow for biodiversity and people to adjust to changing environmental conditions. It can also include restoration of fragmented or degraded ecosystems, or simulation of missing ecosystem processes such as migration or pollination. It can include the use of natural infrastructure such as wetlands or fringing mangrove communities to buffer human settlements from floodwaters or storms. These interventions are not without costs – all will demand adaptation of management, governance and institutional settings – but they are necessary to safeguard ecosystems and the essential services that natural systems provide to people such as clean water, clean air and recreations. Protecting, restoring, and managing key ecosystems yields significant sustained benefits in a world of climate change for both humans and nature. These benefits include cost-effective protection against storms and flooding and reinforcing mitigation efforts.

Ecosystem-based adaptation encompasses a range of strategies whereby ecosystem management, restoration and uses are modified or diversified to confer greater resilience of natural ecosystems, production landscapes, human populations and livelihoods in the face of accelerated climate change. Ecosystem-based strategies include, but are not limited to:

- Integrating climate change into local and regional plans
- Protecting large areas with buffer zone, increase reserve size and increase number of reserves
- Increasing connectivity between reserves through design of corridors, removal of barriers for dispersal, reforestation
- Minimizing and mitigate synergistic threats including invasive species, fragmentation, and fire
- Practicing intensive management to secure populations including relocating species

- Improving interagency regional coordination
- Providing private land stewardship incentives

Early lessons from existing ecosystem-based adaptation projects suggest some principles for developing effective ecosystem-based adaptation strategies:

- Ecosystem-based adaptation should be based on robust predictive modeling of climate, biodiversity and social/economic responses to climate change.
- Ecosystem-based adaptation strategies should include a focus on minimizing other anthropogenic stresses that have degraded the condition of critical ecosystems, as healthy ecosystems will be more resilient to climate change.
- Existing management practices and governance infrastructure should be the basis for adaptation efforts, although these may have to be substantially altered in order to achieve management objectives.
- The development of adaptation strategies and their implementation should involve diverse stakeholders in government, the private sector and civil society.

Ecosystem-based adaptation complements other climate change responses in two ways. First, it helps to make ecosystems more resistant and resilient in the face of climate change so that they can continue to provide the full suite of services that nature provides. Such strategies are especially important for sustaining natural resources like water, timber and fisheries that people depend on for their well-being and livelihoods. Second, ecosystem-based adaptation protects and restores ecosystems that can provide cost-effective protection against some of the threats that result from climate change. For example, wetlands, mangroves, coral reefs, oyster reefs, and beaches all provide shoreline protection from storms and flooding that can reinforce and enhance engineered solutions while sustaining biodiversity at the same time.

Protecting, restoring, and managing key ecosystems yields the following significant sustained benefits in a world of climate change for both humans and biodiversity:

- Cost-effective protection against storms and flooding: protecting and restoring “green infrastructure” like healthy riparian corridors and wetlands could be a more cost-effective means for protecting large coastal areas, and require less maintenance since they are living systems
- Maintenance of connectivity across temperature and moisture gradients will allow plants and wildlife to adapt naturally to some degree of climate change
- Maintenance of essential ecosystem services, such as water purification, will ensure continued availability and access to natural resources so that communities can maintain and adapt livelihoods to the conditions that are projected in a changing climate.
- Reinforcement of mitigation efforts through, for example, “working forest” easements can sequester carbon by improving overall forest health, and simultaneously sustain functioning ecosystems that provide food, fiber and water resources on which people depend.
- Consolidation and expansion of parks and other protected areas in carbon-rich habitats can increase carbon storage, thereby reducing greenhouse gas emissions, and involve a wide range of people in mitigation and adaptation efforts.

V. Effective Adaptation – Information and Tools

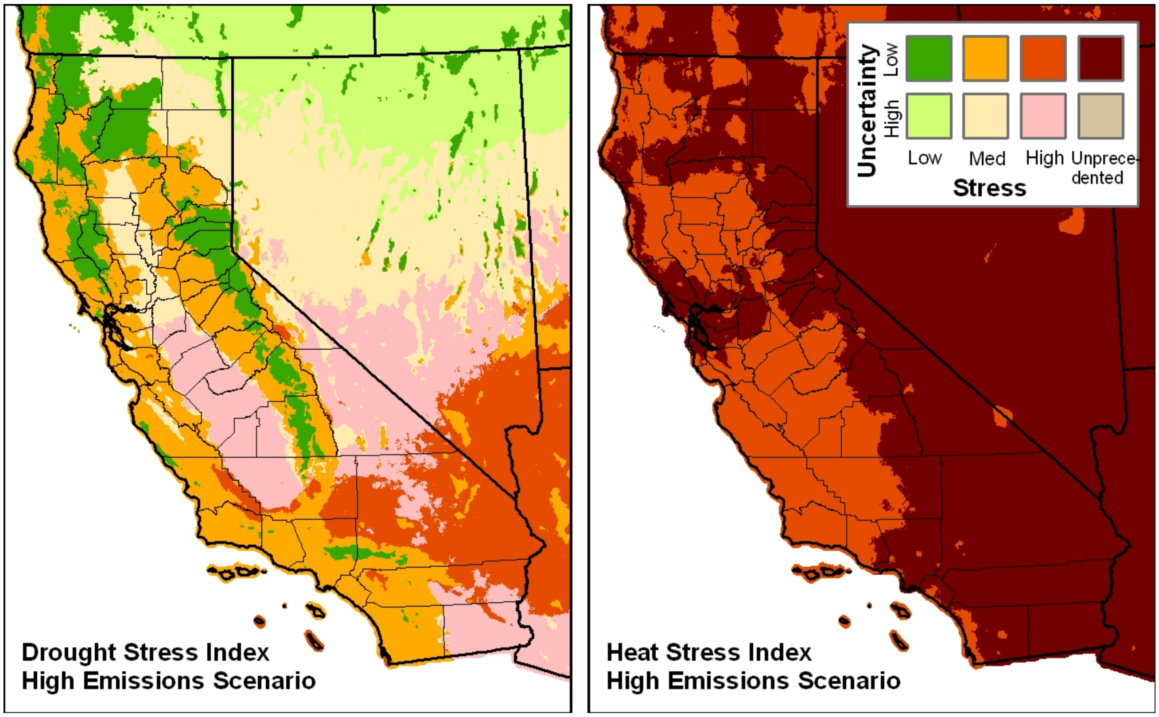
As we work to curb greenhouse gas emissions, it is important that the adaptation go beyond the systematic identification of potential future impacts to produce a much more comprehensive analysis of vulnerability and pathway for modifying that vulnerability through implementable strategies. The goal of adaptation should be increasing the long-term resilience of natural and managed systems by increasing the adaptive capacity of the managing institutions. There are four important features are necessary for such an adaptation approach:

1) Tools that identify the range of potential future climate changes, the uncertainties associated with those ranges, the degree of vulnerability of particular species or systems to the full range of climatic change
2) An assessment the synergistic impacts of other factors that might alter vulnerability to climatic changes (e.g., land use change, fragmentation, pollution, proximity to other protected areas, etc.)
3) An assessment of the adaptive capacity for existing resource management institutions to respond to and reduce vulnerability given current goals and resources constraints; and
4) Development of an adaptive framework for reassessing goals and policies that promotes cross-institutional collaboration for ensuring the persistence of the nation's ecosystem and parks.

This adaptation approach will allow for a systematic analysis of the institutions that manage natural resources, the factors that make species and natural resources vulnerable to impending climate change and the identification of institutional changes to enhance resilience. Proactive measures to address climate change impacts have proven to be more cost-effective and efficient than reactive measures (e.g., Schneider et al. 2000; Easterling et al. 2004). With concerted planning for adaptation, adaptation measures can be implemented in the course of short-term operational and longer-term strategic planning and management decisions (Paavola and Adger 2002; Luers and Moser 2006). I will focus in this testimony on concrete examples of tools and approaches that represent The Conservancy's experience at developing decision support tools for climate adaptation and the development and implementation of action plans for an adaptive approach.

Decision-Support Tools for Climate Change Impacts

There is so much climate change information that managers and decision-makers can easily become overwhelmed. Information on climate change and its uncertainty, past and future, is not readily accessible to managers and decision makers and distilled in an applicable form. It is for this reason that Conservancy scientists have developed decision-support tools such the "Climate Wizard" (see www.climatewiz.org) that allow users choose any place and get records of past temperature and precipitation trends as well as future projections under different scenarios and the "Climate Stress Index" which interprets that climate impacts data relative to the climate under which management now occurs and at scales relevant for decision-making.



Climate Stress Index: Figure shows how different the future climate (precipitation on the left and temperature on the right) will be relative the past climate under which resource managers have come accustom. The Drought Stress Index (left) indicates whether the change in precipitation will be low, medium, high or unprecedented relative to the last 100 years and whether there is low or high uncertainty associated with the change. The Heat Stress Index (right) indicates whether the change in temperature will be low, medium, high or unprecedented relative to the last 100 years and whether there is low or high uncertainty associated with the change.

Cost-Impact Study for Reality Check on What Adaptation Strategies are Cost-Effective

With impacts of climate change, new land protection and species management strategies may needed to maintain and achieve current conservation goals but we will have to be smart about the use of limited resources. In an analysis of a 780,000 acre (320,000 ha) Conservancy project area around San Jose, California, we found 43% of the endemic, highly-restricted species at high risk of local extinction requiring the establishment of corridors and the implementation of assisted migration strategies to new suitable areas; and 41% of the wide-ranging species in need of new climate-adaptive conservation strategies, such as new land use, land acquisition and land management contracts, in order to persist in the future. The total cost of sustaining the biodiversity and ecosystem function of this landscape under a current climate would likely exceed $300M during the next 40 years. Under a changing climate, the total cost could exceed $750 million, or a 2.5 times increase. With considerable emphasis on the adoption of new policies to incentivize implementation of lower-cost climate-adapted strategies in place of traditional, resource-intensive strategies such as land acquisition, the costs can be reduced considerably. Methodologies and tools developed in this study should be made widely-available to all natural lands managers.

Cost-Impact Studies for Reality Check of What Is at Stake to Lose

In a California Energy Commission–funded study on the impacts of climate change on ecosystem service production and value, the Conservancy values the economic impact of climate change on our natural resources in the state of California and the ecosystem services they provide (Shaw et al. 2009). In this study, we show that California's famous grasslands and forests will likely shrink in area and generally become more shrubby and scrubby. Less grassland habitat means mean fewer opportunities for ranchers to graze cows on natural forage. The loss of natural forage not only deprives consumers of naturally fed beef, but results in a loss of profits for ranchers who must raise fewer cows or pay more to feed these cattle using grain and other sources of feed. By 2070, we estimate the annual loss in net income to ranchers could be between $22 million and $312 million annually. Likewise, the economic effects of climate change on forests will be substantial. A change in the ability of California forests to store carbon will affect the state's ability to meet greenhouse gas emission goals and will result in broader impacts on society as a whole. The market cost of changes in carbon storage by estimating how much it would cost to buy carbon offsets in a carbon trading market could be as high as $22 billion annually by 2070. Lost carbon storage also will contribute to global climate change and have an impact on economies around the world. This "social cost" of the lost carbon storage could result in impact that could cost society more than $62 billion annually. However, the sooner we act, the less likely we will be forced to incur this full cost.

VI. Examples of Implementation of Adaptation Implementation: Learning By Doing

The Nature Conservancy does not have all the answer but has developed tools for understanding climate impacts, has begun to develop a series of adaptation strategies - ecosystem by ecosystem - and we have begun to implement these tools and strategies to better understand what will work best. Below are two examples of our adaptation approach:

Example One - Coastlines:

Coastlines have always been dynamic, but are now more so than ever because of changing storm patterns and sea level rise, placing human and natural communities at greater risk. The costs of these hazards to human and natural communities are increasing as coastal development continues and natural buffers, such as coastal wetlands, dunes, and mangroves are lost. Despite a growing awareness of the reality of these hazards, communities and local decision makers still have little access to information on likely changes in storm and flooding risk or tools to visualize the potential impacts and identify alternative scenarios. As a consequence, communities are unable to integrate sea level rise and coastal hazard risk into decision-making regarding natural resource protection and land use management. This information is needed to protect human communities from the dramatic changes that are underway. The Conservancy has contributed to the development of two different examples of tools and approaches that can help address these services and objectives jointly in the Florida panhandle (www.marineebm.org/32.htm) and a more advanced and developing decision support tool for the southern shores of Long Island (http://www.coastalresilience.org).

The salt marshes, sea-grass beds and oyster reefs of Florida's Gulf Coast harbor manatees, sea turtles, piping plovers and many other threatened species, as well as serving as nurseries for economically important shrimp, crab and red snapper. These habitats also provide protection from storm surges that accompany hurricanes. Yet strategies to defend and restore coastal ecosystems—which could simultaneously assist people and expand habitats for threatened and economically valuable species—have largely been ignored in favor of engineering projects (diking, building levees, and hardening the coastline) that accelerate erosion and habitat loss. Working with scientists from the National Oceanic and Atmospheric Administration, the Conservancy recently combined maps of critical habitats and threatened species in the Florida Panhandle with maps of anticipated storm surges and of human communities most physically and socio-economically vulnerable to storm damage. By overlaying these data sets, we were able to identify areas in which restoration should simultaneously protect the most vulnerable human populations as well as many of the area's most important species.

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Example Two - California Grasslands:

In the Mount Hamilton range, south of San Francisco, The Conservancy is implementing a conservation plan called the Mount Hamilton Project. The Conservancy developing a climate-adapted conservation plan using information about temperature and precipitation changes and employing climate adaptation strategies to ensure the persistence of a full array of species and ecosystems important to California's biodiversity. An example of one important species found at the site is the Bay Checkerspot Butterfly (*Euphydryas editha bayensis*). The federally-threatened butterfly relies on a native plant that was once widespread, but now persists only on rare serpentine soil patches. Current conservation plans, identify for protection the areas where the species is currently found but not where the future habitats are. The areas of suitable climate for the butterfly and its host plants are projected to shift upslope, but the distribution of suitable soils is too limited to support their gradual migration to higher elevations. In this case, the butterfly, and other sensitive species, would go locally extinct without climate adaptation strategies including (1) the drafting of a climate-sensitive conservation plan that identifies for protection those areas where the butterfly can persist in the future and (2) the relocation populations to those climate-safe areas. We are currently updating our methodology to create site specific conservation plans to take current and future habitat needs into consideration, in addition

VII. Closing Recommendations

Moving forward, it will be important to carefully explore what will be needed to implement adaptation strategies on a scale that will be meaningful for protecting on natural and human communities. I encourage you to consider the inclusion of the following key elements in a policy context:

1) *Dedicated Funding*: While in the long run ecosystem-based adaptation will be cost effective, there is an immediate and long-term need for a dedicated revenue stream to support the data collection and synthesis, the development of a robust adaptation approach and its implementation.
2) *National Climate Change Adaptation Plan*: Implementation of comprehensive adaptation approach will not be easy. I encourage the development of National Climate Change Adaptation Program with a nationally prioritized list of ecosystem-based adaptation strategies and action to address climate change impacts, guidelines for how that is to be accomplished, and guidance on when infrastructure solutions such as raising roads and building sea-walls are necessary.
3) *Climate Change Adaptation Partnership*: The National Climate Change Adaptation Plan should be designed to facilitate partnerships among all levels of government and the private sector.

4) *Avoiding Impacts Counter to Adaptation Goals*: Federal and State agencies taking action to prevent damage to roads and property from sea level rise or flooding should avoid damage to natural systems to the maximum extent practicable.
5) *Facilitate Land Acquisition for Adaptation.* Federal, state and local agencies will need funding for land, easements and cooperative management agreements to facilitate ecosystem-based adaptation and connectivity.

As this Subcommittee contemplates legislation for the adaptation of our valued National Parks, it is faced with the daunting task of simultaneously configuring our policies and economy to reduce greenhouse gas emissions and support our natural and human communities to adapt to climate change. We do have very practical solutions for advancing both to great success. I would like to extend an offer to work with the Committee as you explore policy options for assisting the nation in adapting to our future climate.

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