Non-Market Values in Complex Coupled Systems:
Theoretical Considerations and Pilot Study Results

Presentation for the Glen Canyon Adaptive Management Work Group

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Center for Energy, Security & Society
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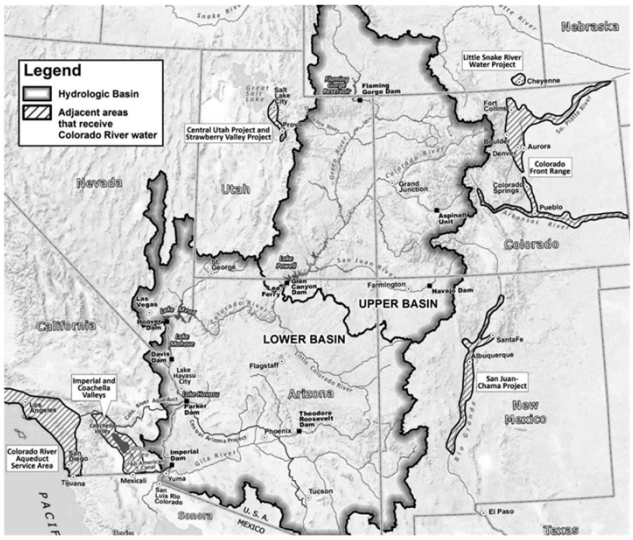
Overview

1. Non-Market Values in Coupled Human/Natural Systems
2. Expanded set of potential dimensions of non-market value
3. Importance of accounting for diversity in stakeholders' value orientations
4. Research design implications for estimation of non-market values in CHANS
5. Applications to alternative operations of the GCD
6. Overview of 2014 pilot study
7. Replication base case and randomization
8. Alternative dimensions of value: Native American and rural ranching/farming communities
9. Implications

Coupled Human/Natural Systems

- Broad recognition that natural (hydrological, biological, atmospheric) subsystems and human communities can be tightly interlinked
  - Both natural and human subsystems are components of coupled systems
- Large river systems in the Western US and elsewhere are prime examples
- Results in a large "working landscape" over which changes in operational conditions can have implications across multiple components of the system



Credit: BOR, 2012

Stakeholder Value Orientations

- Within CHANS, communities tend to optimize to the opportunities and constraints afforded by the system
- Changes in the system can lead to tradeoffs and potential disruptions for affected communities
  - Disruptions can result from changes in current system operations, or expectations about patterns of change in future operations
- Valuation for changes can range from positive to negative
  - Traditional efforts to estimate NMVs via WTP set the lower bound at $0

Implications for Conventional NMV Estimates within CHANS

Disposability (Capacity to Opt Out)	Low	High
Cannot Opt Out	**Little Bias:** Few stakeholders have negative value, but those who do cannot opt out	**Bias:** Some stakeholders hold negative value, and cannot opt out
Can Opt Out	**No Bias:** Few stakeholders hold negative value, and those who do can opt out	**No Bias:** Some stakeholders hold negative value, but those who do can opt out

Level of Disagreement Over Value Change

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Social Disruptions and NMVs

- If there is social disruption (e.g., to rural ways of life) from changing a particular pattern of production, and composition of consumption bundles, then there may be associated changes in non-use values
- Economics recognizes "paternalistic altruism" motivation to non-use value (for inclusion in, say, BCA)
- Individuals may also hold a self-identity motivation with protecting particular ways of life
- These are distinct from transfers and equity concerns

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2014 OU Study

- Our broader goal is to better understand NMVs in the context of changes within CHANS
- Our 2014 report focused on valuation of nonmarket effects of changing Glen Canyon Dam operations
  - Assessed sensitivity of previous estimates of WTP for effects of changing operations to
    - Approach used to structure choices
    - Allowance for differences in value orientations
    - Inclusion of omitted dimensions of value

Research Approach

- Replication of 1995 Welsh et al. study
- Implemented experiments that compare alternative treatments to replication baseline:
  - Randomized presentation of information
  - Structuring of choices
    - Allow for "negative valuation" of changing dam operations
      - Can also be thought of as positive valuation for maintaining dam operations
  - Introduction of omitted dimensions of value

Experimental Treatments

Treatment	Concept	Sample Size
1. Replication	Used Welsh et al (1995) language and format, in Internet survey mode	341
2. Adds randomized presentation of info. to #1	Replication with the exception of randomizing the order of information	345
3. Adds referendum choice options to #2	Permits respondent to vote for one of two options, rather than one "proposal"	352
4. Adds Native American effects to #3	Adds information and potential effects of changed operations on Tribes	343
5. Adds rural Western community effects to #3	Adds information and potential effects of changed operations on rural communities	397
6. Combines #4 and #5	Combines information and potential effects on Tribes and rural communities	345
7. Adds hypothetical air emission effects to #3	Includes hypothetical effects of increased air emissions (*not* combined with 4-6)	342

Experimental Data

- National survey of 2,465 individuals
  - Internet-based and weighted to Census

Collected:	April 22-24, 2014
Average time:	26 minutes
Participant Source:	SSI "Dynamix" Panel
Respondent Mix:	Close to Census
Weights:	2013 Census Estimates

Treatment #1: Replication

- Replication of Welsh et al (1995) approach
  - Introduce purpose of survey
  - Background information
    - Provided a map of the study area
  - Overview of natural resources in the study area
  - Concerns about the resources
  - Projected effects of changing operations
  - Solicit views on changing operations
    - Value preference more than $25?
- Online survey images (desktop, tablets, smart phones)

This survey is part of a national study of issues concerning the operation of the Glen Canyon Dam. The Glen Canyon Dam controls the water level in the Colorado River in the bottom of the Grand Canyon and affects the resources and communities in and along the river. Government officials will soon be making decisions about how the dam is to be operated. They will consider many factors when deciding whether or not to change dam operations. One factor they would like to consider is whether or not changes to dam operations are personally worthwhile to people like you. Therefore, even if you have never heard of the Glen Canyon Dam, your answers are important to this study.

The next several pages provide some background information about the Glen Canyon Dam and the resources downstream from the dam in what is called the Study Area. This information will help you decide whether or not changes to dam operations are personally worthwhile to people like you.

Glen Canyon Dam

- Glen Canyon Dam is located on the Colorado River in Arizona.
  - It is just upstream from the Grand Canyon.
  - It was built to provide water supplies and hydroelectricity.
  - It was completed in 1963.
  - It controls the water flow through the Grand Canyon.
  - Revenues from the sale of hydroelectricity are used to repay costs.

The Glen Canyon Study Area

- The Study Area consists only of the area in and along the Colorado River at the bottom of the Grand Canyon.
- The Study Area begins at Glen Canyon.
- The Study Area continues for nearly 300 miles.
- The Study Area ends at Lake Mead near Las Vegas.
- Part of the Study Area is within the Grand Canyon National Park.
- Part of the Study Area is bordered by American Indian reservations.

How Glen Canyon Dam affects the Colorado River in the Study Area

- The amount of electricity produced by the Glen Canyon Dam depends on the amount of water released from the dam: the more water released, the more electricity produced.
- More water is released during periods of high demand for electricity and less water is released during periods of low demand for electricity.
  - On a seasonal basis, more water is released during the hottest summer months and the coldest winter months.
  - On a daily basis, more water is released during the day than at night.
  - The amount of water released can vary from hour to hour throughout the day.

Natural Resources in the Study Area

The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam.

- Archeological sites are located along the river.
  - These sites are associated with American Indian cultures that have inhabited or used the Grand Canyon for thousands of years.
  - These sites contain evidence of ancient human activity along the river, including pots and tools.
- Present-day American Indians have sacred sites and traditional-use areas along the river.
  - American Indians gather materials from these sites for use in their everyday life.
- Deposits of sand, mud, and gravel, sometimes called beaches, are scattered along the river. The rest of the river bank consists of cliffs and steep slopes covered with rocks, boulders, and desert vegetation.
  - Beaches vary greatly in size. Some are as large as several acres, and others consist of a little sand at the river's edge.
- Some beaches are covered with vegetation.
  - Beaches with vegetation provide habitat for birds and other small animals.
- Only a small percentage of visitors to the Grand Canyon National Park actually see or use the resources in the Study Area.
  - The only people who see the resources in the Study Area are American Indians using resources in the Study Area, river rafters, backpackers, and people who fish there.
- Native fish species live in the Study Area.
  - Only one of these native species is found outside the Colorado River and its tributaries.
- Trout also live in the river.
  - Trout are not native to this section of the Colorado River.
  - People fish for these trout in the first 15 miles of river downstream from Glen Canyon Dam.
- Several other non—native fish species, including carp, catfish, and fathead minnows, also live in the Study Area.

Some People are Concerned About These Resources

- Because of erosion, the number and size of beaches along the river are decreasing.
  - Over an 18-year period, the *number* of beaches decreased from 276 to 258; many of the remaining beaches are *smaller*.
  - The loss is most severe along the narrow sections of river.
- 27 known archeological sites have been affected by erosion. An unknown number of other sites may be affected.
- Resources important to American Indians are also affected by erosion.
  - Loss of archeological sites destroys important links to the past.
  - Sacred sites exist in places that may be damaged by erosion.
  - Plants, animals, and minerals used by American Indians are affected by erosion.
- Populations of native fish in the Study Area have declined.
  - Eight species of native fish evolved in the Colorado River when the water was warmer than it is today.
  - Three of the eight native fish species are no longer found in the Study Area.
  - Two of five remaining native species, the humpback chub and razorback sucker, are in danger of becoming extinct.
  - Cold water released from Glen Canyon Dam may be the most important factor in the decline of native fish populations.
  - Competition from non-native fish (trout, carp, catfish, minnow species) may have contributed to the decline of native species.
- Conditions for trout are affected by daily fluctuations in water level.
  - Maintenance of recreational trout fishing requires annual stocking.
  - Trout eggs dry out and die during low-water periods.
  - Food for trout is reduced because of exposure during low-water periods.

Scientists have learned that by changing the way water is released from the dam, primarily by reducing the size of daily fluctuations, some of the concerns about the natural resources in the Study Area could be addressed.

- Some households receiving power from Glen Canyon Dam could see their monthly electric bill increase.
  - About 4.5 million households live in states surrounding Glen Canyon Dam.
  - About 1.5 million of these households receive some, or all, of their electricity from Glen Canyon Dam.
  - Most of the 1.5 million households receiving power from Glen Canyon Dam are located in rural areas and smaller towns.
  - The amount of increase in a household's electric bill depends on how much of their electricity comes from Glen Canyon Dam.
- Some farmers using electricity to pump irrigation water will also be affected.
  - Higher costs for pumping irrigation water will reduce some farmers' incomes.
- Changing the way water is released from the dam will not reduce the total amount of electricity produced at Glen Canyon Dam.
- However, there will be changes in when and where electricity is produced.
  - During the day:
    - Less electricity will be produced at Glen Canyon Dam.
    - More electricity will be produced from power plants burning gas or oil.
  - During the night:
    - More electricity will be produced at Glen Canyon Dam.
    - Less electricity will be produced from power plants burning coal.
  - Since oil and gas are more expensive fuel sources than coal, the overall cost of meeting electrical demand will increase.
- Reducing fluctuations in water released from the dam could affect the following resources in the Study Area:
  - The number and size of beaches.
  - Conditions of native fish.
  - Conditions for trout.
  - The amount of vegetation available for bird and wildlife habitat.
  - Archeological sites along the river.

Government Officials are Deciding How to Operate Glen Canyon Dam in Future Years.

- Their decision on how the dam should be operated could cost you money. For example:
  - One option for dam operations could be more expensive than another—as a result, taxpayers would have to make up the difference.
  - If you live in an area receiving power from Glen Canyon Dam, your utility bill would increase.

Government officials will consider many factors when deciding whether or not to change dam operations. One factor they would like to consider is whether various proposals are personally worthwhile to people like you. In the next question, we will describe the effects of a specific proposal to change dam operations. We would like you to tell us if you would vote "YES" or "NO" for this proposal.

Some people might vote "NO" because:

- The cost of the proposal is too high.
- The effects of the proposal are not worth anything (not even 10 cents) to them.
- They just can't afford the cost.

Some people might vote "YES" because:

- The cost of the proposal is low enough.
- The effects of the proposal are worth what it would cost them.

At this point in time, it is not certain what the cost would be to any specific individual, so we are asking different people about different amounts. Even if the amount we ask you about seems very low or very high, please answer carefully. This will allow us to determine whether people think the proposal is worthwhile at whatever level the final cost is determined to be. For this study, it is important that you tell us how you would vote, based only on **your personal evaluation** of whether changes in dam operations and their effects, are worth the additional cost **to you**.

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A PROPOSAL

Under this proposal, there would be a moderate reduction in the daily fluctuations in the river level. If this proposal is selected, it will result in the following conditions along the Colorado River in the Grand Canyon:

- The area available for vegetation would increase by about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
- On average, farm incomes would not change significantly. However, about 300 farmers in southern Utah would see their incomes drop by 3%.
- The average electric bill would increase by $5 per month for 1.5 million households receiving power from Glen Canyon Dam. This average reflects a maximum increase of $15 per month for 3,600 households and a minimum of no increase for 800,000 households.
- There would be a small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
- In the long-term, the number and size of beaches would remain at present levels.
- The risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites would decrease substantially.
- There would be a small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.

Think about a situation in which you had the opportunity to vote on this proposal. If passage of this proposal would not cost you anything would you support this proposal?

- ○ No
- ○ Yes
- ○ I would choose not to vote on this proposal

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Replication Results

	Welsh et al. (1995) Study	Our Study
Vote for proposal to change operations	71%	70.6%
Not vote for proposal to change operations	17%	17.3%
Would not vote	12%	12.2%

- Nearly identical results
  - Provides a baseline for exploring effects of:
    - Presentation of information
    - Structuring of alternatives
    - Additional value dimensions

Treatment #2: Randomized Information Ordering

- Original study provided a uniform ordering of information
  - Randomization is required to introduce treatments
  - Ordering effects are common in survey design
  - Giving prominence of place to particular features may privilege those dimensions
- We randomized the ordering of conceptually connected blocks of text
  - No statistically significant effect on replication

Treatment #3: Structuring Alternatives

- Original study structured choice as referendum on a proposal for a change in dam operations
  - Focuses valuation on the proposed *change*
- We structured choice as referendum allowing for selection between one of two options
  - Conceptually more appropriate
  - Necessary for estimation of *positive* values placed on maintaining dam operations

A PROPOSAL

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- On average, farm incomes would not change significantly. However, about 300 farmers in southern Utah would see their incomes drop by 3%.
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- In the long-term, the number and size of beaches would remain at present levels.
- The risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites would decrease substantially.
- There would be a small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.

Think about a situation in which you had the opportunity to vote on this proposal. If passage of this proposal would not cost you anything would you support this proposal?

- No
- Yes
- I would choose not to vote on this proposal

Option 1	Option 2
The dam would continue to be operated as it has in the past. This option will result in the following conditions along the Colorado River in the Grand Canyon and in affected communities:	**Dam operations would be changed to achieve a moderate reduction in the daily fluctuations in the river level.** This option will result in the following conditions along the Colorado River in the Grand Canyon, and in affected communities:
A continued decline in the number and size of beaches.	A continued modest decline in the number and size of beaches.
Lower electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 lower per month.	Higher electricity bills for the 1.5 million households receiving power from Glen Canyon Dam. On average, the electricity bills will be $5 higher per month.
A small deterioration in conditions for native fish. These populations, including those in danger of extinction, would probably continue to decline in numbers.	A small improvement in conditions for native fish, but these populations, including those in danger of extinction, would probably continue to decline in numbers.
No average change in farm income, but about 300 farmers in southern Utah would see their incomes increase by 3%.	No average change in farm income, but about 300 farmers in southern Utah would see their incomes drop by 3%.
A decrease in the area available for vegetation in the Study Area of about 10%, so that the area available for birds and other forms of wildlife would decrease by about 10%.	Increase in the area available for vegetation of about 10%, so that the area available for birds and other forms of wildlife would increase by about 10%.
Higher risk of continued erosion to some of the Native American traditional-use areas, sacred sites, and archeological sites.	Lower risk of erosion to Native American traditional-use areas, sacred sites, and archeological sites.
A small deterioration in conditions for trout. Stocking of trout would still be required to maintain the population.	A small improvement in conditions for trout, but stocking of trout would still be required to maintain the population.
Option 1	Option 2

Think about a situation in which you had an opportunity to vote for Option 1 or Option 2. Keeping in mind all of the potential effects described for each option above, and if adoption of either option would not cost you anything, would you vote for Option 1 or Option 2?

- Option 1
- Option 2
- I would choose not to vote for either option

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Results

	Welsh et al. (1995) Study	Our Replication	Two Options Treatment
Vote for to change operations	71%	70.6%	67.8%
Vote to maintain operations	17%	17.3%	21.3%
Would not vote	12%	12.2%	11.0%

- Results indicate that one respondent in five will vote to maintain current dam operations
- This approach permits assessment of the value placed on *not changing* dam operations

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The option you chose will be more expensive to operate, and will thus increase the cost to taxpayers. The following question asks whether you, as a taxpayer, would vote for this option. As you think about your answer, please remember that if this option is adopted, you would have less money for household expenses or to spend on other environmental issues.

Would you vote for this option if adoption of this option would cost your household $25 in increased taxes **every year** for the foreseeable future?

Definitely No	I would definitely vote against this option.
Probably No	I would probably vote against this option.
Not Sure	I am not sure if I would vote for this option.
Probably Yes	I would probably vote for this option.
Definitely Yes	I would definitely vote for this option.

Next

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Results

	Baseline-Replication of Welsh et al.	Two Options Treatment
Vote to change operations	**70.6%**	**67.8%**
Would you pay $25?	NA	46.9
Vote against proposal (i.e. to maintain operations)	**17.3%**	**21.3%**
Would you pay $25?	NA	6.9
Would not vote	**12.2%**	**11.0%**

- Nominally larger number of respondents chose to leave dam operations unchanged when offered two options
  - 6.9% would pay $25 to leave operations unchanged
- Appears to be a subtle but important effect:
  - A single “proposal” appears to privilege the proposed change

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Treatments #4-5: Omitted Value Dimensions

- Welsh et al. study focused on valuation for selected effects of changing dam operations
- Raises questions of how we choose to define the choice, and characterize the potential dimensions of value associated with the decision
- Additional categories of nonmarket values may affect respondents' choices (Loomis 2014):
  - *"Paternalistic altruism"*
    - Effects on Native American tribes
    - Effects on rural Western communities

Omitted Value Dimensions

- Experimental treatments (random assignment):
  - #4: Native American tribes
  - #5: Rural Western communities
  - #6: Native American tribes + rural Western communities
- Information on these topics was provided in background material and presentation of alternatives for operating the dam
  - Introduced in random order
  - Example: Native American treatment

Background Information

Natural Resources of the Study Area and Rural Western Communities in the Region

The natural resources in the Study Area are located in and along the Colorado River below Glen Canyon Dam. Many of the small communities that have relied on hydropower from the Glen Canyon Dam are in rural parts of Arizona, Colorado, New Mexico and Utah.

- Over 50 American Indian Tribes receive allocations of electricity from the hydropower produced by the Glen Canyon Dam.
  - Included are the Navaho, Utes, Apache, Pueblo Indian communities, and many other tribes.
- These allocations provide low cost and stable electric power to the tribes, or are used to offset more costly electricity purchased from area utilities.
- The benefits to the tribes help tribal residential users and businesses, and are an important part of sustaining tribal communities and improving their economies.

Concerns

Some People are Concerned About These Resources and Communities

- Many Native American Tribes rely on the low and stable prices of the electricity produced at the Glen Canyon Dam.
  - Over 50 American Indian Tribes receive economic benefits from hydropower produced at the Dam.
  - Tribal businesses have relied on the low and stable electricity prices in creating and maintaining area employment.
  - For many Tribal residences, electricity produced at the Glen Canyon Dam is more affordable than electricity produced at power plants that rely on fossil fuels.
  - The low and stable price of electricity produced at the Glen Canyon Dam has contributed to the stability and growth of communities in Tribal areas.

Effects

Scientists have learned that by changing the way water is released from the dam, natural resources in the Study Area and residents of the surrounding rural communities could both be affected in a variety of ways.

- Changing the way water is released through the dam will reduce the benefits of low cost electricity from the Glen Canyon Dam to over 50 American Indian Tribes.
- Some Tribes would need to replace the low-cost electricity from the Glen Canyon Dam with power from local utilities.
  - The cost of electricity from local utilities would be higher and more variable.
  - Higher and more uncertain prices for electricity would make it difficult for businesses to compete, thereby reducing jobs.
  - Some communities in Tribal areas may decline as a result, as jobs and incomes are reduced and residents migrate to other areas.

Alternatives

For effects on Native American tribes…

Option 1	Option 2
Reduced benefits from hydropower for over 50 Native American Tribes. These reduced benefits could pose a threat to the communities in Tribal areas as jobs are reduced and residents seek employment elsewhere	Continued benefits from hydropower production for over 50 Native American Tribes. These continued benefits would sustain jobs and support communities in Tribal areas.

And for rural Western Communities…

Option 1	Option 2
Higher and more variable electricity costs for some farmers, ranchers, and individuals living in small western communities. In some of these communities, increased costs could result in lost jobs and increased migration of residents to other areas.	Continued low and stable electricity prices for farmers, ranchers, and individuals living in small western communities. These continued low and stable electricity prices would sustain jobs, supporting populations in small farming and ranching communities.

Results

	Replication With Two Options	Native American	Rural Western Communities	Native American + Rural Western Communities
Vote to *change* operations	**67.8%**	**49.5%**	**49.1%**	**32.4%**
Would pay $25	46.9	33.0	33.9	21.8
Vote to *maintain* operations	**21.3%**	**39.2%**	**37.1%**	**57.1%**
Would pay $25	6.9	16.5	16.4	30.3
Would not vote	**11.0%**	**11.4%**	**13.8%**	**10.5%**

Results

- *Inclusion of implications for the viability of traditional communities* can have a significant effect on level of support for changing dam operations, and on WTP
- Effect is *cumulative* when Native American and Western community treatments combined into single treatment
  - Nearly 60% of respondents support maintaining operations
  - Over 30% willing to pay at least $25 to maintain operations
    - Suggests that some will be WTP to *retain* current operations
    - Would be treated as $0 valuation in most CV studies

Summary of Findings

- Structuring alternatives as a referendum choice between two options allows respondents to consider *bundles* of distinct value attributes
  - In contrast to Welsh et al (1995) on single proposal for changing operations
    - A single proposal appears to privilege that proposal
  - More appropriate conceptually in that options may require *tradeoffs* across different attributes
  - Allows for expression WTP to retain current operations
    - Meaningful proportion of respondents place positive value on maintaining current dam operations

Implications

- Suggests that some respondents would be WTP to maintain operations when additional relevant nonmarket effects are included
- Note that these experiments do not permit estimation of population WTP
  - Will require full CV research design
  - Appropriate treatment of "negative" values in calculation of WTP will require validation of estimation techniques
  - Protocol for identification of relevant value considerations needs to be developed

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