Population and Habitat Viability Assessment for

The Kihansi Spray Toad

14-17 May 2007

Bagamoyo, Tanzania

CONSERVATION BREEDING SPECIALIST GROUP

WILDLIFE CONSERVATION SOCIETY

TOLEDO ZOO

Cover and interior photos courtesy of Tim Herman, Toledo Zoo.

A contribution of the IUCN/SSC Conservation Breeding Specialist Group

CBSG. 2008. *Population and Habitat Viability Assessment for the Kihansi Spray Toad.* IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN.

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Population & Habitat Viability Assessment (PHVA) for the Kihansi Spray Toad

14-17 May 2007
Bagamoyo, Tanzania

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Bagamoyo, Tanzania
14-17 May 2007

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Executive Summary and Timeline

With a precipitous decline in detectability of the Kihansi Spray Toad and other amphibians in the Kihansi Gorge, and wild and captive populations having a history of health problems, the prospects for the survival of the species looked in serious doubt. A Population & Habitat Viability Assessment (PHVA) workshop was held in Bagamoyo Tanzania from 14-17 May 2007 in order to promote a structured dialogue among key stakeholders that will result in (a) an extinction risk assessment model based upon in-depth analysis of information on the life history, population dynamics, ecology, and history of the population; (b) detailed management and research recommendations (c) inputs to the preparations of a KST recovery plan. The workshop was designed to capture the best expert opinion and guidance on how the existing and emerging KST management challenges could be handled by way of developing a KST recovery plan to ensure long-term survival of this critically endangered species.

A total of 60 participants (7 journalists and 53 experts) from academia, government, NGOs, industry, and the private sector convened from 5 countries, bringing with them valuable expertise specific to amphibians (husbandry, management, health, biosecurity, conservation), the gorge (ecology, hydrology, land use, hydroelectric), reintroduction, population modeling, and other key disciplines with aspects specific to Tanzania, such as resource management, regulatory agencies, policy and permitting. The group collectively identified the outstanding issues to be addressed, and then arranged them into 5 working groups:

1. Determining the cause of decline
2. Habitat issues
3. Project management, organization, and resource conflicts
4. Captivity, disease, and reintroduction
5. Population modeling

Cause of Decline

The cause of the June 2003 wild population crash is unknown. Currently three prominent hypotheses exist, but other unknown factors need to be considered. The main possibilities proposed are that 1) release of toxic substances during flushing of the dam resulted in the decline, 2) that an outbreak of chytridiomycosis, caused either (a) by endemic infection exacerbated by cofactors, possibly including toxins, or (b) by a locally exotic pathogen recently introduced to a naïve KST population, caused the decline. In addition factors such as habitat alteration and human impacts causing or contributing to the decline have been proposed as alternative hypotheses, but have been excluded by inspection of the evidence provided in the timeline constructed during the course of the PHVA workshop. Resources must be invested into determining the cause(s) of decline if effective mitigation and successful reintroduction are to take place.

Habitat Issues

Construction and operation of the dam continue to modify the KST habitat. This group proposes such counter-measures as initiating long-term studies to better understand the ecology of this unique ecosystem, improving management of the upper catchment to increase the natural flow of water to the Kihansi River, and increasing the area covered by the misters in a manner that simulates the natural gradient decreasing away from the river/falls.

Project Management, Organization, and Resource Conflicts

This group addressed inappropriate land and water use in the catchment area, insufficient sectoral coordination for investment plan, and inadequate coordination among implementing agencies. Solutions included operationalizing the Landscape Wide Conservation Plan, cooperating with Eastern Arc Mountains Conservation Project, developing land use plans, law enforcement, monitoring and controlling activities in the gorge, enforcing the Environmental Management Act, improving agricultural practices, ensuring active participation of local communities in investment planning and implementation, and developing a multi-sectoral implementing team.

Captivity, Disease, and Reintroduction

The greatest challenge for this group was that the captive population has suffered several crashes and is currently the same size as when it was founded, and these animals have not been maintained under adequate biosecurity to ensure that they can be returned to Tanzania without foreign pathogens. Improved husbandry/management and increased space were proposed to help grow the captive population while increased biosecurity and screening/diagnostics can help ensure that any animals returned are as 'clean' as possible. Genome resource banking was also discussed. A reintroduction program (if possible) would require a comprehensive plan, feasibility studies, returning 'clean' surplus animals from the US to a biosecure facility in Tanzania with trained staff, controlled exposure tests in captivity between these animals and naïve natives, monitored soft releases, protection, and long-term monitoring. Independent of a reintroduction program, it is possible to send a small number of animals back to Tanzania as soon as February 2008 for publicity purposes.

Population Modeling

A population model was designed to assess the viability of the KST both in captivity and in the wild following a reintroduction program. The baseline model indicated that both the Toledo and Bronx populations increase significantly in the first 3 years and then stabilise at what appears to be a relatively sustainable population ($r = 0.43 \pm 0.98$) given the estimates of carrying capacity available. The average probability of extinction is 0.149 (for Toledo and Bronx combined), which implies only a 75% chance of survival in captivity under current conditions. Genetic Heterozygosity (H) after 50 years was calculated at 0.83, which indicates a somewhat undesirable loss of genetic diversity (relative to the target H of 0.90 ideally in captivity). The model indicated that the KST has a strong capacity for increase and recovers quickly after catastrophic events. The modelling also showed that the best case scenario overall was for the captive populations to be maintained in the USA and excess KST relocated to the Kihansi Research Center and from there, excess KST reintroduced into the Gorge.

Finally, the timelines for implementation from each group were merged to create a collective plan (below).

Timeline
Captivity, disease, reintroduction - blue
Cause of decline - red
Habitat - green
Project management - black

Date	Activity	Primary responsibility	Comment
14-17 May 2007	PHVA	NA	
May 2007	Improve the management of the upper catchment to increase flow of water to Kihansi River	Kilolo, Mufindi District Executive Directors (DED) (Kirungo and Magoma)	
	Continue monitoring environmental flow	RBWO, TANESCO	
	Continue collecting meteorological data, repair defective equipment	RBWO, TANESCO, NEMC/LKEMP	ongoing
June 2007	Determine designs and commissioning of biosecure facility @UDSM	Sarunday	
	Start approvals at UDSM and Wildlife Division		
	Zoos begin "toad cleaning" process	Bronx and Toledo zoo staff	
	Apply for US, TZ, CITES export/import permits, approvals		
	Begin creating a database of available tissues from 2003 and earlier KST specimens and other species	Peter Hawkes (Africa) Dee (USA)	
July 2007	ID husbandry trainees	Sarunday	
1	Begin increasing awareness and sensitization about the LWCP plan, up scaling community grant schemes to cover the entire catchment area, preparing action plans for other components of LWCP	National Environment Management Council (NEMC), Prime Minister Office Regional Administration Local Government (PMO – RALG), Rufiji Basin Water Office (RBWO) and Ministry of Agriculture.	
1	Begin Eastern Arc Mountains Conservation Project MOU	PMO – RALG (District)	
August 2007	Complete KST husbandry manual	Borek, Herman	
	Initiation of proposal for reintroduction plan	Ministry of Natural Resources & Tourism (Wildlife Division)	
15	Compilation of KST timeline finished	Bill Newmark	
	Check for sediment flushing high flow releases prior to June 2003	Bill Newmark	
September 2007	Develop processes and tools to create biosecure population	Odum, Pramuk	
	Completed comprehensive disease survey of in situ and ex situ amphibian populations	Hawkes, McAloose, Shellabarger	
	Improved and expanded disease diagnostics and treatment options	Pessier, McAloose, Shellabarger	
	Finish database of available tissues from 2003 and earlier KST specimens and other species	Hawkes and McAloose	
October 2007	TZ trainees attend Amphibian Biology and Management school in Toledo and stay for extended training at Bronx and Toledo with KST	Sarunday, Odum, Pramuk	
	Possible approval for facility at UDSM	Sarunday	
	Complete diet analysis	Hawkes, Shellabarger	
November 2007	Begin testing sediment in dam for toxins and heavy metals; replicate high flow release and monitor chemicals released in spray/deposited in wetlands; possibly monitor insects, check literature and possibly test on frogs.	Bill Newmark, Peter Hawkes	

Date	Activity	Primary responsibility	Comment
	Begin conducting pathologic examination of available tissues from 2003 and earlier specimens (pesticides, heavy metals and check for lesions consistent with exposure).	Pessier	
	Begin surveys of preserved materials to test whether chytrid was previously in the area	Ché Weldon	
December 2007	"Clean" frogs in USA	Pessier, McAloose, Shellabarger	
	Permits cleared in US and TZ		
2008			
January 2008	Facility ready at UDSM	Sarunday	
	Testing of "clean" toads in US	Pessier, McAloose, Shellabarger	
	Finish increasing awareness and sensitization about the LWCP plan	National Environment Management Council (NEMC), Prime Minister Office Regional Administration Local Government (PMO – RALG), Rufiji Basin Water Office (RBWO) and Ministry of Agriculture.	
	Finish Eastern Arc Mountains Conservation Project MOU	PMO – RALG (District)	
February 2008	10-30 KST arrive in TZ for testing and practical care at UDSM	Sarunday, Odum, Pramuk	
	Feasibility study complete, proceed with, or modify reintroduction plans	Ministry of Natural Resources & Tourism (Wildlife Division)	
April 2008	Finish pathologic examination of available tissues from 2003 and earlier specimens (pesticides, heavy metals and check for lesions consistent with exposure).	Pessier	
May 2008	Testing of TZ KST		
	More frogs from USA *as available*	Odum, Pramuk	
	Begin increasing the area receiving flow from the sprinklers in a gradient	Sarunday	
July 2008	Finish testing sediment in dam for toxins and heavy metals; replicating high flow release and monitoring of chemicals released in spray/deposited in wetlands; possibly monitor insects, check literature and possibly test on frogs.	Bill Newmark, Peter Hawkes	
	Finish up scaling community grant schemes to cover the entire catchment area, preparing action plans for other components of LWCP	National Environment Management Council (NEMC), Prime Minister Office Regional Administration Local Government (PMO – RALG), Rufiji Basin Water Office (RBWO) and Ministry of Agriculture.	
September 2008	KST transfer from UDSM to Kihansi	Sarunday	
October 2008	Long term studies: Hydrology including spray, Botany, Zoology, Land Use, Soil, Impact of community resource use on the gorge, Water quality, and conservation introduction conditions	NEMC (Lilian Lukambuzi)	
December 2008	End surveys of preserved materials to test whether chytrid was previously in the area	Ché Weldon	
2009			
September 2009	Release of first KST to Kihansi gorge	Sarunday	
Activities dependent on other factors	captive experiment with e.g. high spray and low spray to watch development of disease	Toledo/Bronx Zoos	dependant on availability of experimental subjects
	Prepare and implement participatory land use plan	District Councils, Village Government	1.5 years from start
	Embank on serious tree planting	District Councils, Village Government, and Private sector	1 year from start
	Strengthen law enforcement	Forest and Beekeeping and Local Government, Village Government	1 year from start
	Identify and promote alternative income generating activities	Local District Council	1 year from start

Date	Activity	Primary responsibility	Comment
	Enforce existing entry regulation, upgrade the Kihansi gorge to high conservation status like nature reserve	TANESCO, NEMC, Forestry and Beekeeping Division	1 year from start
	Strengthen law enforcement unit for EMA	District Councils, Village Level	1 year from start
	Conduct Inventory of agrochemicals used in the area, training people in use and handling of agrochemicals	District Councils, Ministry of Agriculture	1 year from start
	Strengthen agriculture extension services	District Council, Ministry of Agriculture,	1 year from start
	Intensify soil and water conservation practices in the area	District Councils, Ministry of Agriculture, Village Government	6 months from start
	Initiate organic farming demonstration plots, create awareness on importance of organic farming	Ministry of Agriculture, District Council	1 year from start
	Conducting inventory of water user and abstractions	RBWO	1 year from start
	Conduct water quality monitoring	RBWO, UDSM	1 year from start
	Install new meteorological station	RBWO, TANESCO, NEMC/LKEMP	1 year from start
	Acquire and install atmospheric deposition network facility	RBWO, TANESCO, NEMC/LKEMP	1 year from start
	Putting in place a functional framework to clear investment	NEMC, District Council, Private Sector	1 year from start
	Capacity building of communities to be able to participate in investment planning and implementation	NEMC, District Council, Private Sector	1 year from start
	Strengthen law enforcement units for EMA	VPO, NEMC	1 year from start
	Train local authority personnel in EIA and Monitoring	VPO, NEMC	1 year from start
	Create a functional multisectoral project implementing team	VPO, NEMC	3 months from start
	Involve all the necessary stakeholders in project formulation	Investors, NEMC, TIC	3 months from start

Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Section 2
Invitation & Agenda

NATIONAL ENVIRONMENT MANAGEMENT COUNCIL (NEMC)

LOWER KIHANSI ENVIRONMENTAL MANAGEMENT PROJECT (LKEMP)
NATIONAL WORKSHOP
POPULATION AND HABITAT VIABILITY ASSESSMENT (PHVA)
FOR THE KIHANSI SPRAY TOAD

PARADISE HOTEL, BAGAMOYO
MAY 14-17, 2007

Dear Colleague,

You are invited to attend the Kihansi spray toad Population and Habitat Viability Assessment (PHVA) to be held in Bagamoyo, Tanzania from 14-17 May 2007. As you know, we are in the midst of an amphibian extinction crisis. A third of the world's 6,000 amphibian species are threatened with extinction. The status of many more is unknown but believed to be imperiled, bringing the percentage of threatened species potentially as high as 50%. This is significantly more than any other group of organisms: by comparison, 12% of bird species and 23% of mammal species are threatened. Recent amphibian extinctions exceed 120 species and one entire family is already lost. The IUCN has urged that "All Critically Endangered and Extinct in the Wild taxa should be subject to *ex situ* management to ensure recovery of wild populations." (IUCN, 2002). Comparable calls to action are included in the Global Amphibian Assessment and other IUCN documents. Without immediate captive management as a stopgap component of an integrated conservation effort, hundreds of species will become extinct.

The Kihansi spray toad (*Nectophrynoides asperginis*) appears to be one such species on the brink of extinction. Endemic to 2.0 hectares of spray zone in the Kihansi Gorge in south-central Tanzania, its habitat was decimated by dam construction from 1996-2000 and amphibian chytrid fungus in ~2003. Wild populations plummeted from tens of thousands to a few per year in a couple months. Although an *ex situ* assurance population of 500 animals was established in 2000, numbers fell steadily for 4 years reaching ~15% of the original size. The population size has been rising since 2005 and is now approaching initial levels.

With *in situ* and *ex situ* programs facing continued challenges, a recovery strategy is urgently needed. This PHVA workshop is designed to generate extinction risk assessments based upon in-depth analysis of information on the life history, population dynamics, ecology, and history of the populations, and to develop detailed management and research recommendations. We hope you will participate in this important effort. You are also invited to join us for a field trip to the Kihansi Gorge 10 -12 May.

As space is limited, we ask that you let us know immediately if you plan to attend the workshop and/or gorge trip. **Please register by contacting Kevin Zippel at KevinZ@AmphibianArk.org.** We have a limited budget for this workshop, and we hope that support will be available from your institution. However, if you require financial assistance from the organizers please contact us immediately. Please forward to us the contact information of anyone else you think needs to be invited to this meeting. We are particularly interested in experts on this species, but also experts in amphibian biology and reintroductions in general.

In preparation for this workshop, we also ask that you send us all data, papers (published or not), and any other information on this species. This information will be assembled into a Briefing Book, which will be provided to all participants prior to their arrival, and pertinent life history data will be extracted for use in computer modeling of population dynamics. Please send this information to the organizers by 15 April 2007. Please, do not let your valuable data (or other data about which you are aware) be omitted from the important analyses and deliberations to occur at the meeting. Thank you for your prompt reply, WilfrSarunday and Kevin Zippel

KC Zippel

LOWER KIHANSI ENVIRONMENTAL MANAGEMENT PROJECT (LKEMP)

NATIONAL WORKSHOP

POPULATION AND HABITAT VIABILITY ASSESSMENT (PHVA) FOR THE KIHANSI SPRAY TOAD (KST)

AGENDA
PARADISE HOTEL, BAGAMOYO
May 14-17, 2007

WORKSHOP OBJECTIVES: generate extinction risk assessments based upon in-depth analysis of information on the life history, population dynamics, ecology, and history of the populations; prepare detailed management and research recommendations and develop a KST Population Recovery Plan.

Foreign guests travelling to Kihansi Gorge should be arriving on May 9[1]. Transportation from the airport to a suitable hotel in Dar es Salaam and later to Kihansi (May 10-13) will be arranged by the LKEMP. Local and Foreign participants who will not travel to Kihansi Gorge are expected to arrive at the venue (travelling from Dar es Salaam to Bagamoyo) on the 13th.

DAY ONE, MONDAY 14TH MAY 2007 **SESSESION 1: Chairperson: Permanent Secretary - VPO**		
TIME	**ACTIVITY**	**RESPONSIBLE PERSON/PARTY**
7:00-8:00am	**BREAKFAST**	ALL
8:00– 8:30 am	Arrival of participants, registration and announcements	Secretariat (VPO & MNRT)
8.30 – 9.00 am	Briefing Remarks	Mr. B. Baya, Ag DG NEMC
9:00 – 9:20 am	Introduction and Welcome Remarks	Permanent Secretary (PS) – Vice President's Office
9:20 – 9:30am	Statement by the World Bank speaking on behalf of the Donor Community	Country Director, World Bank
9:30 – 9:40am	**OFFICIAL OPENING SPEECH**	Hon.Prof. Mwandosya (MP) Minister of State (Environment) - VPO
9:40 – 9:45am	Vote of Thanks	Mr. Salahe Pamba - PS – Ministry of Natural Resources and Tourism
	participant introductions	
9:45am – 10:15am	Keynote Address: Conservation Breeding Specialist Group and the Kihansi Spray Toad (KST) PHVA workshop process	Ms. Yolan Friedmann, CBSG

[1] We are planning to organize an optional field trip to Kihansi Gorge via the Mikumi National Park in Morogoro probably from May 10-12, 2007 This is intended to give key participants first hand knowledge of the Kihansi Gorge Spray wetlands

10:15am – 10:45am	Keynote Address: Using Simulation Models for PVA and PHVA	Ms. Kerryn Morrison, CBSG
10:45am – 11:00am	KST natural History and the LKEMP interventions in-situ	Prof. Kim Howell & Dr. W. Sarunday
	Population trend and Status of Captive populations at the Bronx and Toledo zoos	Mr. Andy Odum, Toledo Zoo
11:00 – 11:30	GROUP PHOTO and TEA/Coffee Break	ALL
11:30am – 12:00pm	Chytrid Fungus and the and the Kihansi Gorge	Dr. Che Weldon, North-West University
12:00pm – 01:00pm	Reintroduction science	Dr. Pritpal Soorae, Reintroduction Specialist Group
01:00– 1:30pm	**LUNCH**	ALL
SESSION 2	**Chairperson: Director of Wildlife**	
01:30– 02:00pm	Biosecurity, hygiene, ex-situ facilities for the Kihansi captive breeding center	Mr. Gerry Marantelli, Amphibian Research Centre
OPEN	Preliminary development of the KST baseline model, Discussion of goals, and Identification of outstanding issues in baseline model	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
OPEN	Identify and theme key issues	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
OPEN	Working group instructions and formation	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
-6:00pm		
6:00-7:00pm	**DINNER**	ALL
evening	open	

Tasks to be completed over the following 2.5 days

Task 1a: Amplify the issues within your group's topic to ensure they are clear and understandable. This is not the time to develop solutions or actions or research projects for the problems. This will be done in later steps in the process.

Task 1b: Consolidate, where appropriate, the ideas generated in the first step. Write a one or two sentence 'problem statement' for each issue. Retain a list of the individual issues under the problem statement.

Task 1c: Prioritize problem statements.

Task 2: Data assembly and analysis. Begin an exhaustive process to determine the facts and assumptions that are pertinent to your group's issues. What do we *know*? What do we *assume* we know? How do we justify our assumptions? What do we *need* to know?

Task 3: Brainstorm, and then prioritize, potential solutions for each high priority problem.
Task 4: Translate potential solutions into population model input data.

Task 5: Develop and prioritize recommendations for implementation of preferred solutions
Task 6: Prepare detailed action steps for each top priority recommendation and Develop a KST Recovery Plan.

DAY TWO, TUESDAY 15TH MAY 2007 SESSESION 3: Chairperson: CBSG		
TIME	**ACTIVITY**	**RESPONSIBLE PERSON/PARTY**
7:00-8:00am	**BREAKFAST**	ALL
8:00-10:00am	Working Group Session: **Task 1**: Amplification of issues and problem statement development	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
10:00-10:30am	Plenary Session: Working group reports	
10:30-10:45am	**COFFEE/TEA BREAK**	ALL
10:45-12:30pm	Working Group Session: **Task 2**: Data assembly and analysis	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
12:30-1:00pm	Plenary Session: Working group reports	
1:00– 1:30pm	**LUNCH**	ALL
1:30-3:00pm	Working Group Session: **Task 3**: Brainstorming of potential solutions	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
3:00-3:30pm	Plenary Session: Working group reports	
3:30-3:45pm	**COFFEE/TEA BREAK**	ALL
3:45-5:30pm	Working Group Session: **Task 4**: Translation of potential solutions into population model input data	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
5:30-6:00pm	Plenary Session: Working group reports	Group Chairpersons
6:00-7:00pm	**DINNER**	ALL
evening	open	
DAY THREE, WEDNESDAY MAY 16TH MAY 2007 **SESSESION 4: Chairperson: CBSG**		
TIME	**ACTIVITY**	**RESPONSIBLE PERSON/PARTY**
7:00-8:00am	**BREAKFAST**	ALL
8:00-10:30am	Working Group Session: **Task 5**:	Facilitators

	Revision of solutions based on model results, and development of recommendations for implementation of preferred solutions	Ms. Yolan Friedmann and the IUCN/CBSG team
10:30-10:45am	**COFFEE/TEA BREAK**	ALL
10:45-12:30pm	continue **Task 5**	
12:30-1:00pm	Plenary Session: Working group reports on recommendations and presentation of revised population models	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
01:00– 1:30pm	**LUNCH**	ALL
1:30-3:30pm	Working Group Session: **Task 6**: Revision of priority recommendations, begin development of KST recovery plan	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
3:30-3:45pm	**COFFEE/TEA BREAK**	ALL
3:45-5:30pm	continue **Task 6**	
5:30-6:00pm	Plenary Session: Workshop recommendation prioritization	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
6:00-7:00pm	**DINNER**	ALL
evening	open	
DAY FOUR, THURSDAY 17TH MAY 2007 **SESSESION 5: Chairperson: CBSG**		
TIME	**ACTIVITY**	**RESPONSIBLE PERSON/PARTY**
7:00-8:00am	**BREAKFAST**	ALL
8:00-10:30am	continue **Task 6:** Continued KST recovery plan development, finalization of working group reports	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
10:30-10:45am	**COFFEE/TEA BREAK**	ALL
10:45-12:30pm	continue **Task 6**	
12:30-1:00pm	Plenary Session: Plans and strategies for further work by PHVA participants and partners	Facilitators Ms. Yolan Friedmann and the IUCN/CBSG team
01:00– 1:30pm	**LUNCH**	ALL
	OFFICIAL WORKSHOP CLOSING	
1:30 – 1:40pm	Welcoming Minister, Minister of Natural Resources and Tourism(MNRT)	Chairperson
1.40 – 2.00pm	Closing Statement	Minister - MNRT
DAY FIVE, FRIDAY 18TH MAY 2007		
DEPARTURE TO DAR ES SALAAM AND OVERSEAS		

Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Section 3
Issues Paper

THE UNITED REPUBLIC OF TANZANIA

VICE PRESIDENT'S OFFICE

LOWER KIHANSI ENVIRONMENTAL MANAGEMENT PROJECT (LKEMP)
IDA CREDIT No. 3546 – TA

ISSUES PAPER FOR THE PROPOSED POPULATION AND HABITAT VIABILITY ASSESSMENT (PHVA) WORKSHOP FOR THE PREPARATION OF RECOVERY PLAN FOR THE KIHANSI SPRAY TOAD (*NECTOPHRYNOIDES ASPERGINIS*)

LKEMP
April, 2007

LOWER KIHANSI ENVIRONMENTAL MANAGEMENT PROJECT (LKEMP): THE FUTURE OF *NECTOPHRYNOIDES ASPERGINIS,* THE KIHANSI SPRAY TOAD (ANURA: BUFONIDAE)

Original KST habitat at Kihansi Gorge, Tanzania

KST in captivity at the Toledo zoo, USA

ISSUES PAPER

Discussion topics planned for the LKEMP PHVA workshop for the Kihansi spray toad, 13–18 May 2007

Included Acronyms: CBSG (Conservation Breeding Specialist Group); IUCN (World Conservation Union); KST (Kihansi spray toads); LKEMP (Lower Kihansi Environmental Management Project); PHVA (Population and Habitat Viability Assessment); SVL (snout–vent length); VPO (Vice-President's Office).

INTRODUCTION:

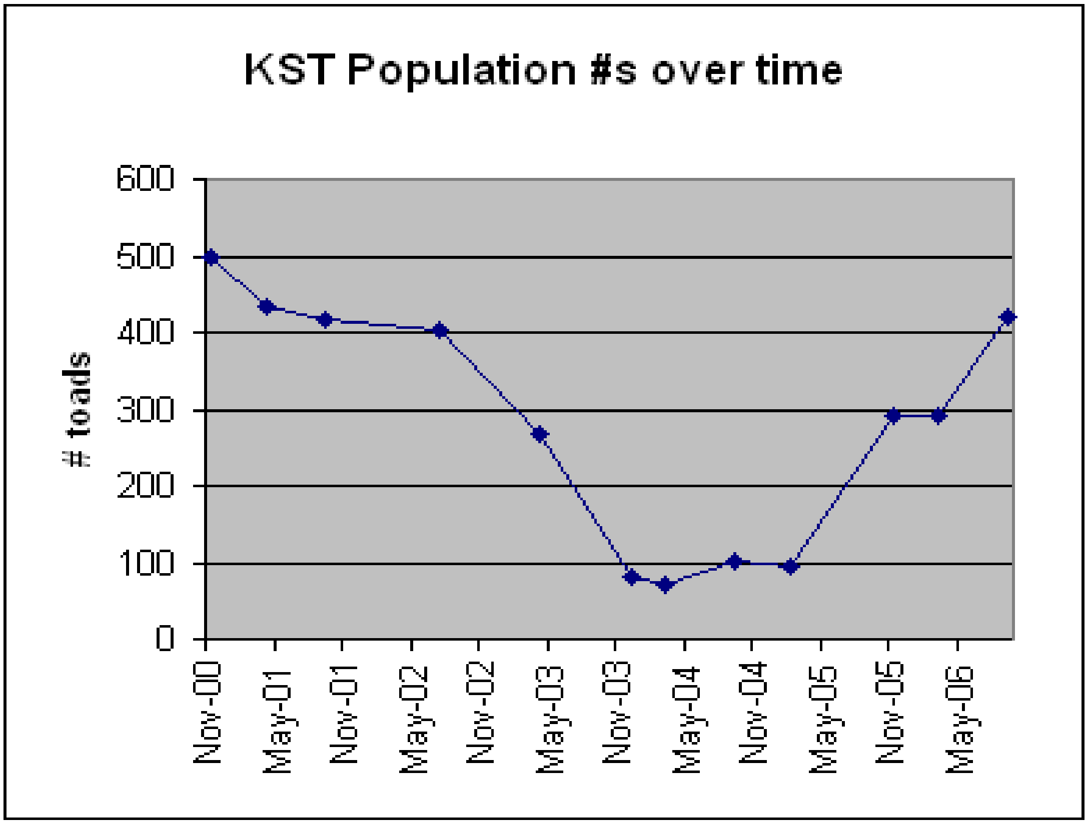
The purpose of this paper is to provide a brief background on the KST and identify issues that will be raised at the PHVA workshop in Tanzania in May 2007. The workshop will consist of approximately 45-55 individuals who will assemble in Bagamoyo for four days to discuss crucial issues relating to future in-situ and ex-situ propagation success of this species as well as understanding the requirements for potential future reintroduction of KSTs to their native habitat. Invitees hail from the World Bank, South Africa and other international institutions; however, most (36) participants are from Tanzania and represent several in-country governmental agencies, universities, and wildlife groups. All participants have expertise on one or more key aspects of KST management, population genetics, in and ex situ conservation, natural history, epidemiology, and/or other relevant conservation areas. Participation of both in-country and international scientists and other individuals and their continued collaboration will be crucial for ensuring the perpetual survival of the KST.

BACKGROUND:

The World is in the midst of an amphibian extinction crisis. A third of the world's 6,000 amphibian species are threatened with extinction. The status of many more is unknown but believed to be imperiled, bringing the percentage of threatened species potentially as high as 50%. This is significantly more than any other group of organisms: by comparison, 12% of bird species and 23% of mammal species are threatened. Recent amphibian extinctions exceed 120 species and one entire family is already lost. The IUCN has urged that "All Critically Endangered and Extinct in the Wild taxa should be subject to *ex situ* management to ensure recovery of wild populations." (IUCN, 2002). Comparable calls to action are included in the Global Amphibian Assessment and other IUCN documents. Without immediate captive management as a stopgap component of an integrated conservation effort, hundreds of species will become extinct.

The Kihansi spray toad (*Nectophrynoides asperginis*) appears to be one such species on the brink of extinction. Endemic to 2.0 hectares of spray zone in the Kihansi Gorge in south-central Tanzania, its habitat was decimated by dam construction from 1996-2000 and amphibian chytrid fungus in ~2003. Wild populations plummeted from tens of thousands to a few per year in a couple months. Although an *ex situ* assurance population of 500 animals was established in 2000, numbers fell steadily for 4 years reaching ~15% of the original size. The population size has been rising since 2005, and today, populations of this toad are thought to be limited to the two remaining captive zoo populations, currently totaling 460 individuals (see the population dynamic graph below).

As of 12 February 2007, the current census at the Bronx zoo (the WCS) is comprised of a sex distribution of 43.51.185 (**n = 279**) and that of Toledo Zoo is comprised of 62.62.57 (**n = 181**). It is important to note that animals mixed between generations, individual identities and generation no longer identifiable for discrete census calculations.



Despite the fact that the KST was first taxonomically described only nine years ago (Poynton et al., 1998), it is listed as Critically Endangered (CR) by the IUCN and may be extinct in the wild (Krajick, 2006). This bufonid is notable as it bears live young—a highly unusual reproductive strategy among anurans. The females retain their fertilized eggs and larvae in their oviducts until the toadlets are born as miniature, grey versions of the adults (Channing et al., 2006). Historically, this species was abundant, with a population of approximately 17,000 individuals (Lee et al., 2006). In 1999 the population began to decline as the result of several causes, including the disappearance of their waterfall spray zone habitat resulting from the construction of a hydroelectric dam and confirmed presence of chytridiomycosis (chytrid), a newly discovered fungal pathogen that quickly can kill entire populations of frogs. The limited distribution and low fecundity of this species, coupled with chytrid infection and extreme habitat alteration, have culminated in its precipitous decline.

In 2000, 499 adult KST were transported from Tanzania to the United States with the hope of propagating stable captive assurance colonies. These founders formed an ex situ population that was divided among several zoos in the U.S., among them being the two institutions where they remain today, the Toledo Zoo and Bronx Zoo.

The last two sightings of the Kihansi spray toad in the wild were in May of 2005 when a biologist claimed to see one individual (Krajick, 2006). Despite several surveys since that time there have been no confirmed sightings. As a result, several scientists suspect that the KST may be hibernating or extinct in the wild. However, habitat studies conducted so far indicates that with the functioning of the primary and secondary sprinkling system the original vegetation, other amphibian species and insect communities are slowly returning to pre-diversion state.

With *in situ* and *ex situ* programs in such a precarious state, a KST recovery plan and management strategy is urgently needed. This PHVA workshop is designed to generate extinction risk assessments based upon in-depth analysis of information on the life history, population dynamics, ecology, and history of the populations, and to develop a KST Recovery Plan.

LKEMP PHVA WORKSHOP ISSUES:

The government of Tanzania through the VPO and the LKEMP intends to apply a portion of the World Bank/IDA credit/ grant to organize a Population and Habitat Viability Assessment (PHVA) workshop at Bagamoyo Tanzania from 13-18 May 2007 with a view to developing a comprehensive KST recovery plan. The PHVA is a collaborative effort that will involve a wide range of stakeholders including the World Bank, the CBSG/AArk, and the AZA, researchers, scientists, and animal keepers and others with expertise on the conservation and management of the KST. While convened, participants will discuss measures necessary for continued ex situ propagation success as well as the potential future reintroduction of this species into its native habitat. For example, discussions are urgently needed to determine whether or not any individuals survive in the wild, and if they are whether or not chytridiomycosis is still present in any remaining individuals. If no remaining KST are found, the presence of chytrid in other sympatric anuran species must be determined.

Issues to be discussed at the workshop will include:

1. **Ex - situ management**

- the science of ex situ propagation
- translating ex situ science from the US into developing an in-country ex situ facility
- AArk recommended biosecurity measures
- unique challenges of an in-country ex situ propagation program
- guidelines for training in-country propagation teams
- population genetics as it pertains to ensuring heterozygosity

2. **Re-introductions**

- obstacles of reintroduction and its long term viability
- IUCN guidelines for reintroduction
- socio-economic and legal requirements for reintroduction
- habitat assessment in the Kihansi Gorge
- implications of the artificial spray zone
- potential vs. real threats of chytridiomycosis in the Kihansi Gorge
- scientific advancements in the effective treatment of chytrid
- availability of suitable release stock
- steps necessary for potential reintroduction
- developing a timeline and budget to reach ultimate goal of reintroduction

3. **Capacity Building for maintaining captive populations of critically endangered species in Tanzania**

    - ❖ Skills, competencies and training requirements for effective captive husbandry in Tanzania
    - ❖ Availability of training opportunities abroad
    - ❖ guidelines for training in-country propagation teams
    - ❖ Mechanisms for linking in-situ and ex-situ processes (both in Tanzania and the US)

4. **Recovery Plan for the KST**

    - ❖ KST information: description, distribution, habitat, current conservation status, life history and Ecology
    - ❖ Previous recovery actions – pre diversion and post commissioning autecological surveys, research and monitoring, captive breeding, genetic studies at the zoos, etc.
    - ❖ Ability of KST to recover and other species management issues, e.g. the presence of Chytrid fungus ***Batrachochytrium***, invasion by weed plant species in the spray wetlands, availability of food items at the Gorge, water quality and quantity;
    - ❖ Conservation requirements of the KST across its known range in Tanzania
    - ❖ Actions to be taken to ensure long-term viability of the KST in Tanzania
    - ❖ Institutional arrangements to implement actions included in the recovery plan
    - ❖ Budgetary and other inputs necessary for the attainments of the recovery plan's objectives

The government of Tanzania, the World Bank, and AZA institutions are working closely to ensure the survival of the KST in the wild. The greatest threat to the survival of the KST is unsuitable habitat resulting from irreversible habitat alteration and introduction of chytrid fungus. The primary goal of this workshop will be to devise a Recovery Plan for this species via collaborative effort and sharing current knowledge of husbandry techniques, bio-security, reintroduction science, and population genetics. The ultimate goals will be to prioritize objectives for continued captive propagation, to study and understand the probability of future reintroductions, and to devise a realistic timeline and budget for meeting these goals.

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Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Section 4
Working Group Report: Cause of Decline

Cause of Decline Working Group

Abbreviations / acronyms

Bd	=	*Batrachochytrium dendrobatidis*
UDSM	=	University of Dar es Salaam
TANESCO	=	Tanzania Electric Supply Company
RBWO	=	Rufiji Basin Water Office
WB	=	World Bank

Group Members:
Peter Hawkes, Gerry Marantelli, Devolent Mtui, Bill Newmark, Allan Pessier, Daniel Shilla, Ché Weldon

Introduction:
The cause of the 2003 KST decline is currently unknown: there are three prominent hypotheses, but other unknown factors need to be considered. The main possibilities proposed are that 1) release of toxic substances during flushing of the dam resulted in the decline, 2) that an outbreak of chytridiomycosis, caused either (a) by endemic infection exacerbated by cofactors, possibly including toxins, or (b) by a locally exotic pathogen recently introduced to a naïve KST population. In addition factors such as habitat alteration and human impacts causing or contributing to the decline have been proposed as alternative hypotheses, but have been excluded by inspection of the evidence provided in the timeline constructed during the course of the PHVA workshop.

Problem Statements:

1. **A complete timeline does not exist: a complete and accurate timeline is essential to understanding potential contribution of different factors to the Kihansi Spray Toad population decline in mid-2003.**

Solution: 1. Construct as complete a timeline as possible

Minimum goal: record in correct sequence all significant events/data available at PHVA.

Maximum goal: record in correct sequence **all** significant events/data.

Action step 1: Compilation of timeline
Responsibility: Bill Newmark
Resources needed: documents and data
Timeline: Start - 14-05-2007, End - initial 15-05-2007, final 15-08-2007
Obstacles: data may not be made available in time.
Collaborators: Peter Hawkes, Kim Howell, John Gerstle, Devolent Mtui, Bill Newmark, Ché Weldon, Gerry Marantelli, Allan Pessier, Daniel Shilla, NEMC/LKEMP, NORPLAN, WB, TANESCO.
Measurable outcomes: all available information is incorporated into a concise but comprehensive timeline.

2. **The relative importance of toxic substances and chytrid in decline of KST is not known. The toxicity to the KST of the compounds potentially accumulating in the dam sediments and the dispersal of these toxins under different flow regimes is unknown. There is conflicting anecdotal evidence regarding impacts on insects. The pattern of chytrid-associated decline of the KST does not fit the global pattern. Investigation for other infectious diseases has not been carried out.**

Solution 1: Evaluate likelihood of toxic substances in sediments causing the decline.

Action step 1: Check for sediment flushing high flow releases prior to June 2003.
Responsibility: Bill Newmark
Resources needed: Data and records from TANESCO & RBWO
Timeline: Start - June 2007, End - August 2007
Obstacles: data may not be made available in time.
Collaborators: TANESCO, Rafik Hirji (WB), RBWO
Measurable outcomes: Re-evaluation of the timeline and influence on Action step 2.

Action step 2: Test sediment in dam for toxins and heavy metals; replicate high flow release and monitor chemicals released in spray/deposited in wetlands; possibly monitor insects, check literature and possibly test on frogs.
Responsibility: Bill Newmark, Peter Hawkes
Resources needed: Expertise, funding, field equipment, laboratory testing
Timeline: Start - November 2007, End - June 2008
Obstacles: Difficulties in organising high-flow releases.
Collaborators: NEMC/LKEMP, TANESCO, RBWO, UDSM, Sokoine University of Agriculture/Tanzania Pesticides Research Institute (Tanzania), CSIR /ARC (South Africa)
Measurable outcomes: Sediment analysis and experimental release will indicate whether or not toxic substances could have been responsible for the decline.

Action step 3: Create a database of available tissues from 2003 and earlier KST specimens and other species.
Responsibility: Peter Hawkes (Africa) Dee (USA)
Resources needed: N/A
Timeline: Start - June 2007, End - September 2007
Obstacles: Collectors may be slow in providing information.
Collaborators: UDSM (Kim Howell), Alan Channing, Ché Weldon.
Measurable outcomes: Database that assists in locating material for Solution 1, Action Step 4, Solution 2, Action Step 1 and captive breeding/reintroduction programs.

Action step 4: Conduct pathologic examination of available tissues from 2003 and earlier specimens (pesticides, heavy metals and check for lesions consistent with exposure).
Responsibility: Alan Pessier
Resources needed: Funding
Timeline: Start - November 2007, End - April 2008
Obstacles: Specimens may not be suitable depending on fixative and post-mortem degradation. Obtaining permits may be complex and time-consuming.
Collaborators: UDSM (Kim Howell), Wildlife Division (CITES) Alan Channing, Ché Weldon, Peter Hawkes.
Measurable outcomes: An indication of whether any toxic substances were involved in the decline.

Solution 2: Evaluate likelihood of amphibian chytrid causing the decline.
Action step 1: demonstrate whether or not chytrid was previously in the area - historic preserved material surveys.
Responsibility: Ché Weldon
Resources needed: Funding, expertise
Timeline: Start - November 2007, End - December 2008
Obstacles: Obtaining permits may be complex and time-consuming, some specimens may not be suitable depending on fixative used.
Collaborators: Wildlife Division (CITES), UDSM (Kim Howell), Alan Channing, Ché Weldon, Peter Hawkes, British Natural History Museum, Natural History Museum of Belgium, Natural History Museum (Paris)
Measurable outcomes: An indication of the history of chytrid fungus in Africa.

Action step 2: captive experiment with e.g. high spray and low spray to watch development of disease.
Responsibility: Toledo/Bronx Zoos
Resources needed: Surplus KST, funding, Bd strain
Timeline: Start - dependant on availability of experimental subjects, End - dependant on availability of experimental subjects
Obstacles: Excess KST may not be available for several years
Collaborators: Ché Weldon
Measurable outcomes: Determination of influence of spray on transmission/autoinfection rates.

Action step 3: evaluate whether changes in spray and spray flow, population density or other environmental factors could have lead to increased autoinfection and hence the 2003 decline.
Responsibility: N/A
Resources needed: N/A
Timeline: N/A
Obstacles: N/A
Collaborators: N/A
Measurable outcomes: N/A

Note: Historic density changes and differing histories of spray/sprinkler irrigation in various wetlands, all of which experienced a similar decline in KST, largely preclude this possibility, which was thus removed from consideration

Action step 4: evaluate possibility that a different chytrid strain arrived to which KST are less resistant
Responsibility: N/A
Resources needed: N/A
Timeline: N/A
Obstacles: can't be tested with present molecular information & material
Collaborators: N/A
Measurable outcomes: N/A

Note: Cannot presently be tested, but if suitable genetic markers are identified the techniques are available to carry out this research.

3. **Recurrence is possible even if factors responsible for the decline are identified, the same factor could recur and lead to a catastrophic decline in a reintroduced population.**

Solution 1: Plans for reintroduction must include alternatives to take into account the possibility that the Kihansi gorge wetlands may never be suitable for KST due to unmanageable continuing or recurring threats.

Action step 1: Inform other working groups of need to take into account different outcomes of cause of decline research.
Responsibility: Cause of Decline working group
Resources needed: None
Timeline: Done
Obstacles: None
Collaborators: N/A
Measurable outcomes: PHVA report includes alternative approaches to captive breeding / reintroduction that accommodate the possible outcomes of research into Problem statement 2.

Solution 2: If chytrid proves to be a permanent problem, produce resistant KST or select alternative (conservation introduction) site - *captive breeding / reintroduction group's* responsibility.

Solution: 3: If toxins in sediments prove to be a permanent problem, manage sediment release by regular or continuous low-level discharge to prevent build-up and the need for large-scale release

Action step 1: Design flow regime and / or modifications to bypass flow intake that will prevent substantial sediment buildup.
Responsibility: TANESCO
Resources needed: Expertise, funding
Timeline: Start: unknown, End: unknown
Obstacles: Unsure of technical feasibility
Collaborators: RBWO, NORPLAN
Measurable outcomes: System designed and implemented that prevents silt from building up to excessive levels.

4. **Potential for emerging threats, including stochastic events, is unknown.**

No solution…such threats remain unknown. All we can do is to acknowledge the possibility of future catastrophes resulting from presently unpredictable causes.

Chytrid Locally Endemic

Arguments For	Arguments Against	Possible Explanations	Method to Validate Explanations	Priority
Out of Africa Hypothesis	KST seems too susceptible for a species adapted to exposure to chytrid	*another factor has modified the frogs resistance*	**demonstrate chytrid was previously in the area - historic preserved material surveys.**	1
		different strain arrived to which KST less resistant	can't be tested with present technology & material	
		changes in spray and spray flow leading to increased autoinfection	**captive experiment high spray and low spray to watch development of disease.**	
		changes in population density leading to increased transmission	likely historic density changes largely preclude this	
		other changes leading to either increased autoinfection or transmission	we don't know what they would be.	
something else caused the decline		*refer to other suggestions in this table.*		

Toxic agent introduced				
Arguments For	**Arguments Against**	**Possible Explanations**	**Method to Validate Explanations**	**Priority**
decline followed water/sediment release		rapid loss due to exposure (e.g. insecticides in mist)	**test sediment and replicate high flow release and monitor chemicals released in spray - check literature and possibly test on frogs**	
		slow loss after assimilation (e.g. heavy metals through food)	**test sediment and replicate high flow release and monitor chemicals released in spray**	
			pathologic examination of remaining tissues from 2003 specimens (heavy metals or lesions consistent with exposure)	
	frogs declined in all areas - probably variable spray/exposure is more reasonable to suggest		**Check for sediment flushing high flow releases prior to June 2003.**	

Chytrid Locally Exotic				
Arguments For	**Arguments Against**	**Possible Explanations**	**Method to Validate Explanations**	**Priority**
apparent susceptibility of the species	does not support the strongly supported "out of Africa" hypothesis	chytrid has been more isolated in Africa than we previously thought	**survey historic preserved materials in Africa - especially very old materials - to establish former distribution.**	1
		chytrid is not as old as we thought	Very difficult to test	
		chytrid is not from Africa	don't waste your time testing - its not possible	

Timeline

DATE	Event	
Dec-96	KST Discovery	
Oct-97	0/1 chytrid positive	
Oct-98	Population estimate = 21000 USW	21000
Oct-99	0/17 chytrid positive	
Dec-99	Water abstraction started	
Jan-00	Dam commissioned	
May-00	2nd & 3rd turbines commissioned	
May-00	0/1 chytrid positive	
Jun-00	Mid-gorge sprinkler installed	
Jul-00	Population estimate = 10 850 USW	10850
Sep-00	Lower Spray Wetland sprinkler installed	
Oct-00	Population estimate 12 193 (combined wetlands) 88.9% USW, 6.3% LSW, 3.9% MFSW, 0.8% MSW, 0.1% MGSW	12193
	0/5 chytrid positive	
	98% reduction in areas receiving spray	
Nov-00	0/1 chytrid positive	
Dec-00	499 KST collected for captive breeding	
	0/54 chytrid positive	
Feb-01	0/2 chytrid positive	
Mar-01	Upper Spray Wetland sprinkler installed	
May-01	Population estimate = 1 258 USW?	1258
Jun-01	High Flow tests	
Jul-01	Insect & Vegetaion sampling	
Aug-01	High Flow tests	
	0/1 chytrid positive	
Oct-01	0/1 chytrid positive	
Dec-01	Upper Spray Wetland hollow jets installed	
Sep-02	High Flow tests	

	0/3 chytrid positive						
Jun-03	Density estimate = 17 745 USW			17745			
	High Flow tests **12** & **16** cumecs	Some dead frogs noted & collected - need to locate					
	1/2 chytrid positive						
	Decline noticed by 11 June 2003, major decline by end June						
Jul-03	2/3 chytrid positive						
	124 KST (**31**/hr) USW	18 KST (9/hr) + 4 dead midgorge	3 KST Main falls		31	37833	1
Aug-03	2/2 chytrid positive (1 x PCR)				18	37864	32
	442 KST (**18**/hr) USW	5 KST (2.5/hr) midgorge			9.6	37894	62
Sep-03	77KST (**9.6**/hr) USW	4 KST (4/hr) midgorge			5	37925	93
Oct-03	11KST (**5**/hr) USW				3.2	37955	123
Nov-03	1/32 various frogs chytrid positive (Kihansi gorge)				2	37986	154
	3/11 various frogs chytrid positive (Udagaje gorge)				2.5	38017	185
	16 KST (**3.2**/hr) USW				2	38045	213
Dec-03	4 KST (**2**/hr) USW				1.3	38077	245
Jan-04	38 KST (**2.5**/hr) USW				0	38107	275
Feb-04	2 KST (**2**/hr) USW						
Mar-04	2 KST (**1.3**/hr) USW						
	0 KST - IREM method			0			

Apr-04	0 KST USW	
May-04	0 KST (0/hr) USW (4.5 hours)	
May-05	0 KST (0/hr) USW (7 hours)	
	1 KST observed in USW (ph incidental)	
	pesticides detected in sediment	
Nov-05	Bypass increased 1.2/1.3 to 1.4/1.9	
Dec-05	0 KST (0/hr) USW (28 hours USW, 12 midgorge, 16 LSW) IREM method	
Apr-06	4/21 various frogs chytrid positive (Kihansi gorge)	
	2/7 various frogs chytrid positive (Udagaje gorge)	
	0 KST (0/hr) USW (24 hours USW, 4 midgorge, 6 LSW) IREM method	0
May-06	1 KST observed in USW (il & pk incidental)	
May-06	0 KST (0/hr) USW (11 hours USW, 4 midgorge, 6 LSW)	
Sep-06	Backup sprinkler systems installed	
Dec-06	0 KST - IREM method	0
Apr-07	0 KST (0/hr) USW (36 hours USW, 4.5 midgorge, 6 LSW)	
	Bronx chytrid outbreak 49/49 dead	
Unknown	Decommissioning / rehabilitation	

Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

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Section 5
Working Group Report: Habitat Issues

Habitat Issues Working Group

Group Members
Madaraka Amani, Alan Channing, Kim Howell, John Chikomo, Gita Kasthala, Yob M. Kiungo, Lilian Lukambuzi, Maynard Lugenja, Alphaxed, Magoma Edward, Msyani, Henry Ndangalasi, Wilkirk Ngalasoni, Vida Ngomuo, Sylvester Sengerema, E.K. Shishira

Problem Statements

1. **Diversion of water has changed the habitat**

Solution: Increase the bypass flow to 7 cu mecs. NOT USED, OUTSIDE THE FILTER, SEE PLENARY DISCUSSION

Action step 1: Increase the area receiving flow from the sprinklers in a gradient
Responsibility LKEMP (Sarunday)
Resources Needed Water, sprinkler system, technicians, supervisor
Timeline begin May 2008, see measurable outcomes by May 2009
Obstacles Institutional arrangementsManagement under different institutions) availability of sprinklers; expertise on installation in a gradient; difficulty of access of site within the gorge
Collaborators Ministry of Natural Resources & Tourism (Wildlife Division); TANESCO; Min. of Water
Measurable Outcomes Increased area receiving flow from the sprinklers in a gradient as pre dam.

Action Step 2 Improve the management of the upper catchment to increase flow of water to Kihansi River
Responsibility Kilolo, Mufindi District Executive Directors (DED) (Kirungo and Magoma)
Resources Needed Training programme for community on soil and water conservation; tree seeds for enrichment planting; wildlings; polythene tubes for seedlings, working gear
Timeline begin: May 2007, measurable outcomes seen by 2012.
Obstacles Availability of seeds and wildlings; unwillingness of community to participate; traditional practice of cultivation along the river (*vinyugu**)
Collaborators Eastern Arc Mountain Conservation Endowment Fund (EAMCEF), LKEMP, Participatory Forestry Management (PFM), Catchment Forestry, Communities around the gorge
Measurable Outcomes Improved catchment, number and areas of trees planted and that traditional riverine agriculture is reduced.

2. Ecology of the ecosystem is not sufficiently understood

Action Step 1: Long term studies: Hydrology including spray, Botany, Zoology, Land Use, Soil, Impact of community resource use on the gorge, Water quality and conservation introduction conditions
Responsibility NEMC (Lilian Lukambuzi)
Resources Needed Expertise, funding and equipment
Timeline Begin: (due to need to budget from govt for next financial year, 2008-2009): begin Oct 2008, measurable outcomes in form of report Oct 2009.
Obstacles Availability of experts and timing
Collaborators UDSM, Mweka Wildlife College, Rufiji Basin Water Office, Local Communities
Measurable Outcomes Study Reports, Publications, information from studies is made available to impact on management of the gorge

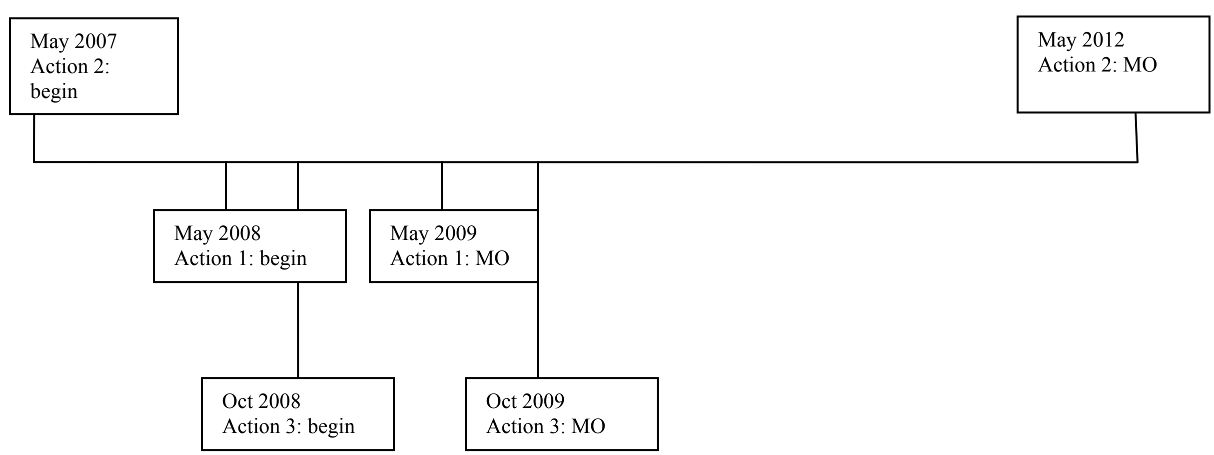
3. Drying of the habitat has allowed predators access

Action Steps are the same as for Action step 1
Problem Statement Number 1

4. Insufficient knowledge for conservation introduction.

Action Step: Initiate studies that would establish suitable conditions for the conservation of KST (these may involve captive studies) covered in Action Plan 3.

Timeline



Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
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Section 6
Working Group Report: Project Management, Organization, & Resource Conflicts

Project Management/Organization/Resource Conflicts

Group Members

Ladisy Chengula, John Gerstle, Japhet J Kashaigili, George Kazimoto, Jane Kibbassa, Anna Maembe, Mganga C. W. Majula, Hamdun R Mansur, Said `Mbwana, Eng. E. Mkini,Cathbert Nahonyo

Issues Identification

1. Investment
2. Land Use plan
3. Water resources management
4. Management (Project)

Problem Statements

1. Land use practices are inappropriate in catchment.

Action Step: Make the Landscape Wide Conservation Plan (LWCP) operational, raise awareness and sensitization about the LWCP plan, scale up community grant schemes to cover the entire catchment area, and prepare action plans for other components of LWCP

Responsibility National Environment Management Council (NEMC), Prime Minister Office Regional Administration Local Government (PMO – RALG), Rufiji Basin Water Office (RBWO) and Ministry of Agriculture.

Resources Needed Funds

Timeline within one year - Starting 1st July

Obstacles budgetary limitations and political will/unwillingness

Collaborators Eastern Arc Mountain Conservation Endowment Fund (EAMCEF), Rufiji Basin Water Office (RBWO), University of Dar es Salaam (UDSM), Tanzania Wildlife Research Institute (TAWIRI), Tanzania Forest Research Institute (TAFORI), Environmental NGO

Measurable Outcomes change of altitude and reduction in number of fields close to streams, improved income, existing of action plan (implementable), reduce siltation, pollution in the catchment.

Solution 2: Collaborate with on going Eastern Arc Mountains Conservation Project, and other initiatives

Action Step: Memorandum of Understanding in place for the institutions involved.

Responsibility PMO – RALG (District)

Resources Needed Funding

Timeline Within 6 months – Starting 1st July

Obstacles Reluctance of some institutions to cooperate

Collaborators (EAMCEF), Local Communities

Measurable outcomes MoU in place and operational**,** Joint plans and evaluation

2. Lack of land use management plan in catchment

Solution 1: We need to have a land use plan in place -1

Action Step 1: Prepare and implement participatory land use plan
Responsibility District Councils, Village Government
Resources Needed Funding
Timeline 1.5 Years
Obstacles Budget Limitation**,** Resistance from communities
Collaborators Ministry of Land, Housing Land and Human Resources**,** RBWO**,** Director of Environment (DoE) – Vice President Office (VPO)
Measurable Outcomes Reduced Land use conflicts**,** existence of implementable land use plans

3. Destructive deforestation in catchment

Solution 1: Deforestation and enrichment planting programmes
Action Step 1: Embank on serious tree planting
Responsibility District Councils, Village Government, and Private sector
Resources Needed Funding
Timeline One year
Obstacles Delayed funding
Collaborators NGOs, National Tree Seed Agency, SUA, TAFORI, Forest and Beekeeping
Measurable outcomes Improved vegetative cover, improved supply of timber, fuel wood, improved microclimate, improved income

Solution 2: To enforce laws and regulations
Action Step 1: strengthen law enforcement
Responsibility Forest, beekeeping, local government, village government
Resources Needed Funding, transport, committed personnel
Timeline One year
Obstacles human capacity, delayed funding
Collaborator NEMC, NGOs
Measurable outcome Reduction in forest related offences, improve forest cover, improve revenue collection

Solution 3: Promote alternative sources of income
Action Step 1 : Identify and promote alternative income generating activities
Responsibility Local District Council
Resources Needed Funds Micro Project Experts
Timeline 1 year
Obstacles Lack of experts in micro project, reluctance of communities to comply, market
Collaborator NGOs, UDSM, SUA and Tanzania Social Action Fund (TASAF), Savings and Credit Cooperative Society (SACCOS)

Measurable outcomes Diversified income generating activities, increase in income, improved people livelihood (housing, bicycles, radios etc)

4. Degradation of environment in Kihansi Gorge

Solution 1: Monitoring and controlling human activities in the gorge

Action Steps: Enforce existing entry regulation, and upgrade the Kihansi gorge to high conservation status like nature reserve

Responsibility TANESCO, NEMC, Forestry and Beekeeping Division

Resources Needed Funding

Timeline 1 Year

Obstacles None

Collaborator Wildlife Division, Ministry of Land and District Councils

Measurable outcomes Reduce illegal activities in the gorge, improve vegetation cover

Solution 2 Intensify monitoring of environmental flow

Action Step: Continue monitoring environmental flow

Responsibility RBWO, TANESCO

Resources Needed Funding

Timeline Immediately

Obstacles Nil

Collaborator NEMC

Measurable outcome Increase Water Flow in the gorge

5. Inappropriate agriculture activities

Solution 1: Enforce Environmental Management Act (EMA) on river bank cultivation

Action Step Strengthen law enforcement unit

Responsibility District Councils, Village Level

Resources Needed Funding

Timeline 1 Year to initiation

Obstacles Lack of awareness of existence of EMA

Collaborators NEMC, DoE VPO

Measurable Outcomes less cultivation along river bank, reduction of siltation

Solution 2: Control and monitor the use of agrochemicals

Action Steps: Conduct Inventory of agrochemicals used in the area**,** training people in use and handling of agrochemicals

Responsibility District Councils, Ministry of Agriculture

Resources Needed Funding

Timeline 1 Year**Obstacles** Inadequate trained personnel**,** dealers and farmers reluctance to provide information on agrochemicals

Collaborators Chemical traders, Villagers

Measurable outcomes Reduce water pollution**,** reduce number of accidents associated with agrochemicals

Solution 3: Improve agriculture extension services in the areas

Action Step Strengthen agriculture extension services
Responsibility District Council, Ministry of Agriculture
Resources Needed Funding, Transport
Timeline 1 Year
Obstacles Delayed funding
Collaborators Village Government
Measurable outcomes Improved agricultural practices**, i**mproved productivity

Solution 4: Improve water and soil conservation practices

Action Step Intensify soil and water conservation practices in the area
Responsibility District Councils, Ministry of Agriculture, Village Government
Resources Needed Funding
Timeline 6 Months
Obstacles Delayed funding**,** resistance by some farmers to adopt soil and water conservation techniques
Collaborators NGOs, Sokoine University of Agriculture, UDSM
Measurable outcomes Increase infiltration, reduce Sediment Load, improved water quality**,** improved water conservation

Solution 5: Encourage organic farming in the areas

Action Steps: Initiate organic farming demonstration plots, and create awareness on importance of organic farming
Responsibility Ministry of Agriculture, District Council
Resources Needed Trained Personnel, Fund
Timeline 1 Year
Obstacles Resistance of farmers in adopting new techniques
Collaborators Villagers, NGOs, SUA, Private Sector
Measurable outcomes Reduction of toxin in soil and water**, i**mproved price on products

Water Resources Problem Statements

1. Lack of inventories of water users abstractions

Solution 1: Update water user register
Action Step Conducting inventory of water user and abstractions
Responsibility RBWO
Timeline 1 year
Obstacles Delaying funding**,** Poor cooperation from water user
Collaborator District Council, Villages, Private Sector, TANESCO
Measurable outcomes Reduction of illegal water users**,** increased water flow

2. Insufficient environmental flow

Solution 1: enforcement water right and monitor the release from the dam
Action Step Refers 1.4.2 Intensify the monitoring of Environmental Flow

3. Lack of watershed management plan

Solution 1: Will be covered under Land use plan
Action Steps Will be covered under Land use plan**, l**imited water quality information and monitoring

Solution 2: Develop systematic water quality monitoring program
Action Step Conduct water quality monitoring
Responsibility RBWO, UDSM
Time line 1 Year
Obstacles Inadequate funding
Collaborator District Council and Village Government
Measurable outcomes Adequate information on water quality used for management

4. Insufficient information on impact of climate change on water quality and quantity

Solution 1: Establish / Rehabilitate meteorological network in the gorge and catchment
Action Step Install new meteorological station
Responsibility RBWO, TANESCO, NEMC/LKEMP
Resources needed Funding
Time line 1 year
Obstacles Insufficient funding
Collaborators UDSM, Tanzania Meteorological Agency
Measurable outcomes Increased numbers of functioning station

Solution 2: Analyze the available meteorological data to ascertain whether there has been a significant climate change in the catchment

Action Steps Continue with the ongoing activities**,** repair defective meteorological equipments
Responsibility RBWO, TANESCO, NEMC/LKEMP
Resources needed Fund
Time line Ongoing
Obstacles Insufficient funding
Collaborators UDSM, TMA,
Measurable outcomes Continuation of meteorological records**,** increased number of functioning stations

Solution 3 Introduce additional meteorological facility to cater for atmospheric deposition monitoring (Atmospheric deposition network)

Action Step Acquire and install atmospheric deposition network facility
Responsibility RBWO, TANESCO, NEMC/LKEMP
Resources needed Funding
Time line 1 year
Obstacles Insufficient fund
Collaborator UDSM, TMA,
Measurable outcomes Atmospheric deposition data will be made available, collection of meteorological data

Investment Problem Statements

1. Insufficient sectoral coordination for investment plan

Solution 1 To have institutional framework in place to clear investments
Action Step Put in place a functional framework to clear investment
Responsibility NEMC, District Council, Private Sector
Resources needed Funding
Time line 1 year
Obstacles Political unwillingness
Collaborator Villagers, Tanzania Investment Centre (TIC), Relevant Ministries
Measurable outcomes Increased number of project approved through established framework

2. Insufficient of local communities involvement in investment plans

Solution 1: Ensure active participation of local communities in investment planning and implementation
Action Step Capacity building of communities to be able to participate in investment planning and implementation
Responsibility NEMC, District Councils, Private Sector
Resources needed Funding
Time line 1 year

Obstacles Inadequate expertise in community participation in investment, inadequate funding
Collaborators Villages, NGOs
Measurable outcomes Increase number of community based investment

3. Insufficient consideration of environmental issues in investment

Solution 1 Enforcement of EMA (EIA / Monitoring)
Action Step Strengthen law enforcement units
Responsibility VPO and NEMC
Resources needed Funding**, e**xpertise
Time line 1 year
Obstacles Expertise, inadequate funding
Collaborators Districts Councils, Villages, NGOs, TIC,
Measurable outcomes Percentage of projects going through EIA process increased**,** defaulters of EMA will be minimized

Solution 2: Capacity building for local authorities
Action Step Train local authority personnel in EIA and Monitoring
Responsibility VPO, NEMC
Resources needed Funding**, e**xperts
Time line 1 year
Obstacles Sufficient expertise, inadequate funding
Collaborators Districts Councils, UDSM, SUA
Measurable outcomes Increased number of local authority personnel capable handling EIA and Monitoring

Management Problem Statements

1. Inadequate coordination among implementing agencies

Solution 1 Have multi-sectoral implementing team
Action Step Create a functional multisectoral project implementing team
Responsibility VPO, NEMC
Resources needed Funding**, e**xperts
Time line 3 months
Obstacles NIL
Collaborators Districts Councils, UDSM, SUA, TANESCO, RBWO and relevant Ministries
Measurable outcomes Number of project activities implemented on time increased

2. Inappropriate project formulation

Solution 1: Adopt participatory project formulation approach

Action Step Involve all the necessary stakeholders in project formulation
Responsibility Investors, NEMC, TIC
Resources needed Funding**, e**xperts
Time line 3 Months
Obstacles Insufficient expertise, inadequate funding
Collaborators Districts Councils, Villages
Measurable outcomes Reduced number of conflicts in investment

Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Section 7
Captivity, Disease, & Reintroduction Working Group Report

Kihansi Spray Toad PHVA: Captivity, Disease, and Reintroduction Working Group (a.k.a., Group "Chura")

Group Members
Benjamin Andulege, Alyssa Borek (AB), Timothy Herman (TH), D McAloose (DM), Charles Msuya, Chrispine Njau, Jennifer Pramuk (JP), Wynona Shellabarger (WS), Pripal Soorae, and Kevin Zippel.

Captivity Problem Statements

1. We do not know if we have a viable, healthy, increasing, and biosecure, captive KST population,

I. The captive KST populations have been housed in cosmopolitan collections in zoos in the US for seven years. Several issues regarding the health, genetics, and potential disease may affect long term survivability of this species.

Solution 1: Develop a biosecure, captive KST population:

Action Step 1a: Prevent transmission of disease from US to TZ (Tanzanian representatives: "some risk is acceptable").

- Improve current biosecurity (i.e., quarantine conditions) of current propagation rooms.
- Transfer clean animals to a high secure facility.
- Transfer to similar, highly biosecure facility in Tanzania.
- Conduct tests with sentinel animals.
- Transfer to breeding facility to generate animals for release.

Responsible: R.A. Odum, J. Pramuk.
Time frame: Ongoing
Obstacles: Funding
Collaborators:
Measurable outcomes: Reduction of pathogens and increase captive KST population.

Solution 2: Put no limit on carrying capacity (tied with number 3, below).

Action Step 2a: Increase propagation space at Toledo, Bronx (to house 2000?) [plan for surplus-discuss in plenary *Hawkes-provide for toxicology and other studies, Pessier, for cell lines, experimental AI, experimental caesarian*].

Responsible: RAO, JP.
Time frame: Finish by Aug 2007.
Obstacles: Lack of space and funding.

Solution 3: To maximally increase captive KST populations (to review and optimize husbandry practices) – A maximally increasing KST population (abiotic, nutrition, biosecurity, management) [what are limits before toads are sent back?].

Action Step 3a: Finish KST Husbandry Manual.

Responsible: A. Borek, T. Herman.

Time frame: Finish by Aug 2007.

Obstacles: None.

Action step 3b: Quantified experimental tracking of changes in variables.

Responsible: AB, TH.

Time frame: Continuous.

Solution 4: A captive population managed to minimize loss of genetic diversity (e.g., continue to outbreed as much as possible; cross distantly related colonies).

Action Step 4a: Plan for exchange of animals between zoos and investigate cryopreservation of sperm—low priority.

Responsible: RAO, JP.

Time frame: Ongoing

Obstacles: Funding

Collaborators: Andy Kouba

Health Problem Statements

1. Incomplete understanding of factors that impact *ex-situ* KST health and survival.

Solution 1: Develop a biosecure population (defined as a population managed to minimize the presence of infectious disease.) We all agree that the goal of disease free animals is unachievable. This process aims to decrease the presence and/or transmission of infectious disease.

Action Step 1 Development of quarantine protocols: See Quarantine Standards (particularly Quarantine situation 1) from CBSG/WAZA Amphibian Ex-Situ Conservation Planning Workshop Final Report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN 55124, USA. Pg 33–35.

Time frame, etc.: quarantine protocols already exist.

Action Step 2 Identification and/or development of test methods to screen for pathogens

Responsible A. Pessier

Time frame 9/07

Funding World Bank, Tanzanian Government, NGOs, other granting organizations, host-zoos, some contribution from non-zoo based organizations will be necessary.

Responsible: JP, RAO.

Obstacles: Funds need to be identified.

Action Step 3: Monitor and treat infectious disease as it occurs in the population.

a) Necropsy protocol tailored to specific needs of species, including list of samples for diagnostic tests.

Responsible: All facilities housing captive animals.

Time frame: Present and ongoing.
Collaborators: A. Pessier.
Obstacles: Availability of screening tests for known and novel pathogens, lack of funding for tests, test development and treatment. Lack of available or ineffective disease treatment(s).

Action Step 4: serial passage of animals to decrease disease transmission. Method (still in development):

- Select animals with history of least disease occurrence.
- Remove to new enclosure.
- Remove newborn toadlets to new enclosure.
- Repeat process with each successive generation.
- Test and treat all identified and treatable disease.

Responsible: all captive facilities: Initially Toledo Zoo (WS, RAO, TH) and Bronx Zoo (JP, AB, DM) then to include Tanzanian facilities.
Time frame: present and ongoing.
Obstacles: goal of disease free animals is unachievable but process minimizes presence. Need to establish guidelines for "clean environment" to minimize exposure to infectious disease.

Action Step 5: Caesarian-derived animals. To reduce disease transfer between female toads and their offspring, we can develop caesarian techniques on animals earmarked for reintroduction.

- Monitor gravid females and estimate, as closely as possible, oviductal development of eggs, tadpoles and toadlets.
- Perform caesarian delivery of toadlets as close to time of parturition as possible,
- Remove toadlets and rear in new "clean" enclosure.
- Repeat process with each successive generation.
- Test and treat all identified and treatable disease.

Responsible: all captive facilities (see above).
Time frame: beginning 8/2007; no identified endpoint.
Obstacles: goal of disease free animals is unachievable but process minimizes presence, need to establish guidelines for "clean" environment" to minimize exposure to infectious disease. Process has never been attempted in amphibians and feasibility of procedure unknown. Will require sacrifice of gravid female toad (removing her from the reproductive pool). May not be possible due to lack of support (e.g. ethical, social, political, practical, other reasons) for procedure from zoos, governments, etc. Lack of funding for staff training and development of techniques.

Action Step 6: Semen collection and freezing (banking) for potential future artificial insemination.
Responsible: WS, DM.
Time frame: To be determined.

Obstacles: No known amphibian procedures exist. Lack of funding for development of techniques and staff training. Also, may not be possible due to lack of support (e.g. ethical, social, political, practical, other reasons) for procedure from zoos, governments.

Action Step 7: Upon return of KST to Kihansi, preparing toads for pre-release into native environment:

- Recommend introduction of native amphibian species as sentinel animals to test groups of captive KST in order to assess possible disease transmission and significance of disease presence in all species (KST to other native species and other native species to KST).
- Results will be used to determine feasibility of KST release into Kihansi gorge.
- Specific plans will need to be developed including diagnostic tests performed upon animal death/s and before animal release into Gorge.

Responsible: zoos, LKEMP, Tanzanian Ministry of Livestock, others as yet to be determined.
Time frame: To be determined.
Measurable outcomes: Animal death; disease presence based on test results.

Action Step 8: A comprehensive disease survey of *in-situ* and *ex-situ* amphibian populations according to time-line of KST events including a retrospective investigation of KST and other amphibian populations in the Kihansi and other local gorges.

- Catalog existing samples (e.g. animal, environmental) housed in Tanzanian organizations and North American facilities.

Responsible: PH (African). DM, WS (North American).
Timeline: (For N. American samples): 7/07.

Action Step 9: Create a prioritized list of diagnostic tests to be performed on available animal samples.

a) Necropsy Examination: Gross, histological.
b) Infectious Disease testing:

- *Batrachochytrium dendrobatidis:* Development of real time (TaqMan) PCR.
- Parasites.
- Ranavirus (Conventional PCR).
- Rickettsia.
- Intravascular ciliated protozoa.

c) Develop list of pre-shipment tests (pre-Tanzania return or between zoos) to screen for infectious disease.
Responsible: A. Pessier, DM, WS.
Time frame: ongoing.
d) Cell line banking (potentially).
Responsible: CRES (A. Pessier).

Obstacle: will need approval for procedure from Tanzanian Government official/s responsible for KST/LKMEP programs.

Action Step 10: Improve and expand disease diagnostics and treatment options.

- Diagnostics.
- Retrospective review and disease summary of all captive animal necropsy reports.

Responsible: DM, WS.
Time frame: 9/07.

- Compile lists of disease-related treatments and preventative medicine programs.

Responsible: WS.
Time frame: 9/07.

Action Step 11: Continue ongoing and develop new diagnostics for identified KST pathogens.

a) Intravascular ciliated protozoa. Characterization is ongoing.
Responsible: DM to check w/NW ZooPath.
- Treatment regime established and being refined.

Responsible: WS.

b) Rickettsia.
- Ongoing investigation at Toledo Zoo to speciate organism and determine significance.

Responsible: WS.
- Explore method of treatment.

Responsible: WS.

c) Fungal pathogen *Batrachochytrium dendrobatidis*
- Ongoing investigation at WCS/Bronx Zoo.

Responsible: AP, DM.
Time frame: ongoing, endpoint unclear.

d) Treatment with antifungals (Need to create standardized protocol).
Responsible: WS.

Action Step 12: Parasites: Ongoing fecal examination and histology at Toledo and Bronx Zoos for identification in living and dead animals.

- Consultation with specialist parasitologist as appropriate samples become available.

Responsible: DM.

- Continued attempts to achieve positive organism identification in recent cases (genus, species) as samples are available.

Responsible: DM, WS, AB, TH.

- Treatments are on going as needed using standard protocols.
- Create standardized treatment protocol.

Responsible: WS.
Obstacle: lack of funding.
Time frame: Ongoing.

Action Step 13: Improve networking between US institutions and between US and Tanzanian institutions related to veterinary and animal movement issues.

a) US Institutions:
- Toledo Zoo, Wildlife Conservation Society/Bronx Zoo, San Diego Zoo.
- Veterinary and other Medical or non-Medical Universities and Colleges (to be determined as opportunity is identified or needed).
- US Fish and Wildlife Agency, IUCN, CBSG, OIE.

b) Tanzanian institutions:
- Organizations: LKEMP, WCS, Toledo Zoo, Sokoine University (SUA), University of Dar Es Salaam, Ministry of Livestock Development Veterinary Services, World Bank.

c) Contacts to be developed as needed and as processes develop:
- All workshop participants, in particular those working with Health related issues.

Responsible: ?
Time frame: Ongoing.

Action Step 14: Develop a healthy diet (optimization and quantification) for captive KSTs.

a) Review of Peter Hawkes Kihansi Gorge insect and gastrointestinal samples to identify KST prey items.
- Generate summary information to be used to create most appropriate recommendations for in-country diet (e.g., types and volumes (min and max number) of prey items).

Responsible: PH, WS.
Time frame: 11/07.

b) Captive Diet: Generate summary information of existing diet and supplements.
- Supplements will be required for any cultured food items both in US and Tanzania.
- Create recommended general captive diet plan.

Responsible: WS, TH, AB, JP.
Time frame: 9/07.

3. We lack infrastructure and expertise in TZ to maintain a captive, biosecure KST population.

Solution 1: Develop a trained, dedicated, local animal care staff for KST (pilot species test project?).

Action Step 1a: Recruitment/assignment and training of several detail-oriented, Kihansi-based husbandry staff with a background in ecology and biology (4-year degree and experience with amphibians preferred). Training will include the following:

- Review of husbandry document.
- Send candidates to Amphibian Biology and Management School 10/07 and two weeks minimum at Toledo and Bronx.
- Keeper exchange with Toledo and Bronx zoos.
- Potential for future amphibian course in Tanzania.

Responsible: Wilfred Sarunday
Time frame: Selection made by 7/07 for visa purposes.
Obstacles:?
Funding: World Bank?
Collaborators: Toledo and Bronx Zoos.
Measurable outcomes: A fully-trained TZ staff for maintaining KSTs in captivity.

Solution 2: A fully equipped, biosecure facility for KST in TZ [building near visitor center should serve the purpose, alternative is a retrofitted shipping container].

Action Step 2a: Develop biosecure facility in TZ. Facility location up for discussion in plenary (Dar and/or Kihansi).

- Institute Panama guidelines for multiple levels of biosecurity; water filtration/sterilization/storage; backup electrical generation; wastewater sterilization with UV or 1% bleach.
- Collaboration on facility design and construction.
- Proposal for facility design.

Responsible: Wilfred Sarunday
Collaborators: Gerry Marantelli, Toledo and Bronx zoos.
Funding: World Bank?
Measurable outcomes: A fully equipped biosecure facility or facilities in TZ.
Timeline: ?

Solution 3: Animal healthcare and diagnostics lab access [communication/training of TZ experts and maintain open lines of communication with US experts]
*simultaneous implementation with facility

Action Step 3a: Obtain in country veterinary consultants and services:

- Sokoine University of Agriculture in Morogoro.
- Ministry of Livestock.
- University of Dar es Salaam.

Action Step 3b: Develop in country pathology:

- Networking with US experts.
- Training internship at US facility.
- Distance learning technology for collaboration (Euthanasia and preservation as cost effective alternative to treatment).

Responsible: ?
Collaborators: Toledo and Bronx zoos.
Funding: World Bank?
Timeline: ?

Solution 4: Develop media, educational, and public outreach materials and programmes [television, school, t-shirts, etc.].

Action Step 4a: Defer to LKEMP/NEMC/Wildlife Division.
Responsible: to be determined.

Solution 5: Research opportunities focused on Kihansi [current students have not necessarily focused on the Kihansi system, although funding has been provided by LKEMP].

Action Step 5a: Continue to develop Kihansi ecosystem studies with Tanzanian universities.
Responsible: to be determined.

Reintroduction Problem Statements

1. We lack a reintroduction plan consistent with IUCN guidelines.

I. A comprehensive reintroduction plan including (all in guidelines):
   1. Feasibility study:
      a. Habitat:
         i. **A plan for permanent monitoring and maintenance of the unique environment**
      b. Species.
      c. Sociopolitical/Economic.
   2. Planning and Implementation.
   3. Post-release Monitoring.

II. Enforcement of National Legislations and CITES Appendix 1 #2.

Solution 1a: A comprehensive Re-introduction Plan consistent with IUCN Guidelines (with modification of the guidelines as necessary – see outcome).

Action step 1a: A feasibility study undertaken by a multidisciplinary team to determine when a re-introduction of Kihansi Spray Toads (KST) is possible in the Kihansi Gorge, Tanzania. As per the three main criteria 1) habitat, 2) species and 3) socio-political and economic issues.
Responsible: Ministry of Natural Resources & Tourism (Wildlife Division)
Resources needed:

- Funding
- Scientific equipment for in situ surveys
- Vehicles

Time frame: Inform the Director, Wildlife Division by August 2007 of the intention to conduct a feasibility study by LKEMP/NEMC.
Obstacles: Funding

Collaborators: Ministry of Energy & Minerals, Ministry of Environment, Division of the Environment, Ministry of Water, NEMC, TANESCO, University of Dar, Local Governments, Rufiji Water Basin Office, TAWIRI, Toledo Zoo, Bronx Zoo, Trade Record Analysis, Press

Measurable outcomes:

1. A report that contains the following:
   - Whether to conduct a Re-introduction into the historic range and/or a Conservation Introduction.
   - Information whether there are any remnant wild populations in the historic range.
   - A plan for permanent monitoring and maintenance of the unique environment ecosystem indefinitely (i.e. spray system).
   - Evaluation of reasons for previous decline in the habitat and elimination or reduction of these threats to a sustainable level.
   - A comprehensive disease baseline data for the release site.
   - Thorough socio-economic studies to assess the attitudes of local communities and harness support for the release.
   - Design of pre- and post- release monitoring program with respect to the original threat so that each re-introduction is a carefully designed experiment.

Action step 1b: When appropriate the planning and implementation of the KST re-introduction project in the Kihansi Gorge, Tanzania.

Responsible: Ministry of Natural Resources & Tourism (Wildlife Division)

Resources needed:

- Funding
- Scientific equipment for in situ surveys
- Vehicles
- Biosecure facility for breeding and preparing toads for release.

Time frame: Dependent on the completion of the feasibility stage.

Obstacles: Funding

Collaborators:

- Ministry of Energy & Minerals, Ministry of Environment, Division of the Environment, Ministry of Water, NEMC, TANESCO, University of Dar, Local Governments, Rufiji Water Basin Office, TAWIRI, Toledo Zoo, Bronx Zoo, Trade Record Analysis, Press

Measurable outcomes:

- Establishing a multidisciplinary team with access to expert technical advice for all phases of the program.
- Establishing a captive-breeding facility at Kihansi Gorge.
- Identification of short- and long-term success indicators including amphibian bioassays – controlled captive interactions between captive-bred KST and sympatric species.

- Development of transport plans for delivery of stock to the country and site of reintroduction (the welfare of animals for release and other species at the release site is of paramount concern through all these stages).
- Determination of release strategy.
- Development of conservation education for long-term support.
- Professional training of individuals involved in the long-term program.
- Public relations through the mass media and in the local community.
- Involvement of local people in the program.

Action step 1c: Post-release monitoring of the KST in the Kihansi Gorge, Tanzania.
Responsible: Ministry of Natural Resources & Tourism (Wildlife Division).
Resources needed: Funding, scientific equipment for in situ surveys, vehicles.
Time frame: Dependent on the completion of the planning and implementation stage.
Obstacles: Funding.
Collaborators: Ministry of Energy & Minerals, Ministry of Environment, Division of the Environment, Ministry of Water, NEMC, TANESCO, University of Dar, Local Governments, Rufiji Water Basin Office, TAWIRI, Trade Record Analysis, Press
Measurable outcomes:

- Scientific monitoring of released individuals.
- Evaluation of success indicators.
- Continued monitoring and maintenance of unique environment at the release site.
- Continued public awareness through the mass media.
- Dissemination of results of post release monitoring through the scientific and popular literature.
- Evaluation of cost-effectiveness and success of re-introduction techniques.

Action step 2: Enforcement of National Legislation and CITES.
Responsible: Wildlife Division.
Resources needed: Wildlife rangers, Funding, Vehicles.
Time frame: Dependent on implementation of KST in Kihansi Gorge.
Obstacles: Funding, Staff.
Collaborators: Police and Courts of Law, Rufiji Water Basin Office, TANESCO, NEMC, Local Governments.
Measurable outcomes:

- Increased presence of wildlife law enforcement officers in release area.
- Increased vigilance at ports of departure i.e. avoid smuggling by training custom officials in recognizing this and other related species.
- This species does not enter the illegal pet trade in-country and internationally through poached individuals re-introduced (or through conservation introduction(s)) in Tanzania.

Plenary Comments

- Allan Pessier: What is definition and how will biosecurity be addressed prior to release? Controversy over potential caesarian extraction of toadlets destined for release.
- Kim Howell: What environmental factors need to be clarified in gorge ecosystem?
- Kevin Zippel: Which is more important…large captive population vs. genetic diversity?
- R. Andrew Odum: Population size and genetic diversity are not mutually exclusive. Mean kinship between groups can be calculated.
- Gerry Marantelli: Bottlenecks are known to exist, possibly in wild. This species such as others with limited range may be adapted to cope with inbreeding. Group swapping techniques. Individual physical identification may be possible for combination into large groups without losing parentage information.
- Tim Herman: Should small groups of animals with known parentage be combined into large groups, potentially increasing reproduction, but losing parentage info?
- Sarunday: Will it be possible to be send animals back to a captive facility in TZ?
- Newmark: Can facilities be feasibly expanded to accommodate a much larger US population?
- Odum: Only limited by funding.
- Marantelli: Populations should be cleaned for pre-release while population is expanded.
- Herman: Facilities must be able to house much larger groups than cutoff limit due to potential for rapid population growth.
- Pramuk: Consider bringing other zoos back into the program which previously were involved?

Final comments

REINTRODUCTION

Add zoos to collaborators

Ministry of Environment is within the Division of the Environment?

Change wording to "when possible" to "if possible"?

Continuous research and attempts will be made to reintroduce toads and overcome **Obstacles**

Tanzanian community would like to see an endpoint

Separate plan to transfer toads back to country

Add to collaborators: vice president's office department of environment, press,

Trade Record Analysis

WORKING TIME FRAME:

2007

May	PHVA
June	Determine designs and commissioning of biosecure facility @UDSM Start approvals at UDSM and Wildlife Division Zoos begin "toad cleaning" process Apply for US, TZ, CITES export/import permits, approvals
July	ID husbandry trainees
August	Complete KST husbandry manual Initiation of proposal for reintroduction plan
September	Develop processes and tools to create biosecure population Completed comprehensive disease survey of in situ and ex situ amphibian populations Improved and expanded disease diagnostics and treatment options
October	TZ trainees attend Amphibian Biology and Management school in Toledo and stay for extended training at Bronx and Toledo with KST Possible approval for facility at UDSM Complete diet analysis
December	"Clean" frogs in USA Permits cleared in US and TZ

2008

January	Facility ready at UDSM Testing of "clean" toads in US
February	10-30 KST arrive in TZ for testing and practical care at UDSM Feasibility study complete, proceed with, or modify reintroduction plans
May	Testing of TZ KST More frogs from USA *as available*
September	KST transfer from UDSM to Kihansi

2009

September	Release of first KST to Kihansi gorge

Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
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Final Report

Section 8
Working Group Report: Modeling

Kihansi Spray Toad PHVA Modelling Report

Working Group Participants

James Gibbs, Kerryn Morrison, R. Andrew Odum

Demographic modeling is a valuable and versatile tool for assessing risk of decline and extinction of wildlife populations. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population or species. Moreover the process of model building can highlight data deficiencies, which can, in turn, help to identify research needs. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis or "PVA."

The simulation software program Vortex (v9.58) was used to examine the viability of the Kihansi Spray Toad ("KST") populations under various scenarios in captivity in the United States of America and Tanzania, and within the species original habitat in the wild in Tanzania. Program Vortex uses Monte Carlo simulation to integrate the effects of deterministic forces and stochastic (demographic, environmental, and genetic) events on wild populations. The program begins by creating individuals to form the starting population and stepping through life cycle events (*e.g.* births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities. Consequently, each run (iteration) of the model produces a different outcome. By running any given model hundreds of times, it is possible to examine the probable outcome and range of possible outcomes. For a more detailed explanation of Vortex and its use in population viability analysis, see Lacy (1993, 2000) and Miller and Lacy (1999).

This population model was designed to assess the viability of the KST both in captivity and in the wild following a reintroduction program. There are currently captive populations of the KST at the Toledo Zoo and the Wildlife Conservation Society's Bronx Zoo in the USA. The KST is thought to be extinct in its natural habitat in the lower Kihansi River Gorge in Tanzania. The current, anticipated plan is to transfer (probably excess) KST from the Toledo and Bronx Zoos to a captive facility (or two) in Tanzania, with at least a captive facility at the Kihansi Gorge close to the release site. From there, a reintroduction program into the gorge is planned. Although the natural habitat in the gorge has been highly altered, an artificial sprinkler system has been installed to mimic optimal natural conditions and restore some of the habitat that remains.

The modelling performed herein was based only on data collected at the Toledo Zoo, which maintained the KSTs in small cohorts in separate containers allowing for relatively easy collection of information of KST demography. The Bronx Zoo maintained its collection in far larger containers with many more toads in each. Besides the population size, the individual reproductive and population parameters for the Bronx Zoo population were therefore not available. No reproductive data were collected from the wild before the KST went extinct and thus assumptions were required to be made for some, key aspects of the modelling ., such as the carrying capacity invoked in various scenarios. Thus, it is important to recognize that the model outputs are most useful in comparisons among scenarios rather than in terms of their specific outputs for any given scenario. Moreover. it must be recognized that the modelling is based on demographic data gathered in captivity at the Toledo Zoo population and is only as accurate as permitted by those estimates. Further modelling should be completed as more information is obtained in the future, so that better understanding and more realistic simulations can be obtained.

Vortex Baseline Model Parameters

The final values used in the baseline model are described below. The baseline model was run for 1000 independent iterations. The population was modelled for 50 years (about 30 generations) so that long term trends could be observed. This allows results to be viewed in shorter time periods, so that short-term and long-term management actions and impacts can be considered. It was also suggested at the workshop that this is an appropriate temporal window because the Kihansi Gorge hydroelectric project life expectancy would probably be around 50 years.

Note that although the baseline model had two captive populations (Toledo and Bronx), the datasets were the same and were based on the Toledo Zoo data. The initial population size was, however, known and specific to both.

Population parameters

Extinction definition: Only 1 sex remains

It was agreed at the workshop that extinction be defined occurring when only one sex remaining

Number of populations: Two

The baseline model was developed on the current situation of two captive populations based at the Toledo Zoo and the Wildlife Conservation Biology's Bronx Zoo.

Initial population size: (see table below)

April 2007 age-class census data from the Bronx and Toledo zoos were used in the model.

	Toledo Zoo		Bronx Zoo	
Age	Females	Males	Females	Males
1	51	51	171	167
2	8	7	7	25
3	30	30	4	2
4	2	1	0	0
5	0	0	0	4
Total	180		380	

Carrying capacity: 1000

It was agreed that both Toledo and Bronx Zoo had the capacity to maintain a maximum of 1000 individual KST.

Catastrophes: Disease only

The one catastrophe included in the baseline model was disease, which the workshop participants agreed was a highly probable scenario. Participants agreed that a disease catastrophe had a frequency of 33% and would probably have little effect on reproduction (0.05) and a moderate effect (0.5) on survival.

Demographic and genetic parameters

Inbreeding depression: No

It was noted at the workshop that there seemed to be no evidence of inbreeding depression in similar species of amphibians and hence it was agreed that it not be included in the model.

Concordance between environmental variation in reproduction and survival: No

Due to the fact that the captive facilities had seen high reproduction and low survival at times, it was agreed that for the purposes of this model that there be no concordance between environmental variation in reproduction and survival.

Mating system: Polygynous

The workshop participants suggested that a polygynous mating system be was the most appropriate situation.

Age of first offspring for males and females: 1 year

Lee, Zippel, Ramos and Searle (2006) noted that KSTs were first seen in amplexus at 7 months of age with males calling by then as well, but that females had visible follicles developing at only 8.5 months. They also noted that the gestation period was 30 – 60 days. Based on the fact that this variable for the model relates to the average age of first offspring, the workshop participants agreed that 1 year was probably a good approximation of age at first breeding.

Maximum age of reproduction: 5 years

Bronx Zoo observed a few individuals of 5 years old, but none older.

Maximum number of progeny per year: 22

Toledo Zoo observed one female giving birth to 22 young.

Sex ratio at birth-in % males: 50%

The workshop participants agreed that due to a lack of knowledge on the sex ratio at birth, that it be assumed that it is around 50%.

Percentage of adult females breeding: 70%

The KST is maintained in group enclosures and individual identification of each animal is not possible in most situations. This makes assigning each birth event to a single female impossible. Using data from the Bronx and Toledo zoos, it was the consensus of the caretakers of the toads that about 70% of the post one-year age-class females will produce offspring. An EV of 10% was used.

Mean number of offspring per female per year: 9 (SD = 5)

The number of offspring produced per birthing event was calculated from Toledo KST data from March 2003 to 1 March 2007. The KST is reasonably secretive and the offspring very small making census problematic. Censuses were performed when neonates were observed in the enclosure during normal cage maintenance. To fully count the newborn neonates, the enclosure must be entirely dismantled. These animals are also maintained in groups where there are multiple adult females in each cage, thus it is possible that more than one female gave birth in each recorded event. Two of the events were considered multiple births with 32 and 42 offspring counted. These were considered two birthing events in each cage with 16 and 21 offspring being produced per female respectively. A total of 27 censuses of newborn toadlets were performed when neonates were observed. This was then considered as a total of 29 individual events.

Mortality rates: Year 1 = 24% ± 9.6%; Adults = 32% ± 12.8%
Although mortality data were outlined in Lee *et. al.* 2006 for the first 31 months of the KST history at the Bronx Zoo, it was agreed that only data from 2005 through 2006 be used to determine mortality rates. The numbers of wild-caught KST captured in the Gorge in 2000 and imported into the U.S. declined precipitously over the first six months of the ex-situ program to ~15% of the original 499. A variety of health issues and a lack of husbandry expertise with *Nectophrynoides* caused this significant mortality rate, which continued through 2004. By May 2004, <100 KST remained in captivity. A great deal of effort was made to resolve these issues and mortality rates decreased past mid 2005 (LKEMP, 2007). For this reason only mortalities in this 2005-2006 have been included in the mortality rates under the assumption that these data are more reflective of the current and future population performance.

Mate monopolisation: 50% of males in breeding pool
The workshop participants agreed that although every male had the potential to breed, some males were more dominant than others and some held better territories and had to attract a female successfully to breed. For this reason, the participants agreed that not all males were in the breeding pool and that 50% was a reasonable approximation.

Baseline Model Results

Deterministic results
The demographic rates (reproduction and mortality) included in the baseline model can be used to calculate deterministic characteristics of the model population. These values reflect the biology of the population in the absence of stochastic fluctuations, inbreeding depression, limitation of males, and immigration / emigration. Deterministic results are useful for examining whether the base model generates realistic for the species and population being modelled.

The deterministic projection from the baseline model describes a population that shows strong growth when resources are abundant (r = 0.661), enabling the population to increase by 94% (λ=1.937) in one year. The workshop participants noted that although probably realistic for captive populations, the wild population could exhibit a much higher lambda, based on census data collected in the Kihansi Gorge.

A generation time of 1.66 years was given for males and females, which the workshop participants contended was realistic.

Baseline model

The baseline model (Figure 1) indicated that both the Toledo and Bronx populations increase significantly in the first 3 years and then stabilise at what appears to be a relatively sustainable population (r = 0.43 ± 0.98) given the estimates of carrying capacity available. This final mean population size was below the estimated carrying capacity of 1000 individuals and was likely caused by the high variability around the mean mortality and reproductive rates used in the model. The probability of extinction for Toledo Zoo was calculated at 0.154 and for Bronx at 0.144, the slight difference being attributed only to the larger initial population size at the Bronx. The average probability of extinction of 0.149 (for Toledo and Bronx combined), which implies only a 75% chance of survival in captivity under current conditions. In both cases, genetic Heterozygosity (H) after 50 years was calculated at 0.83, which indicates a somewhat undesirable loss of genetic diversity (relative to the target H of 0.90 ideally in captivity).

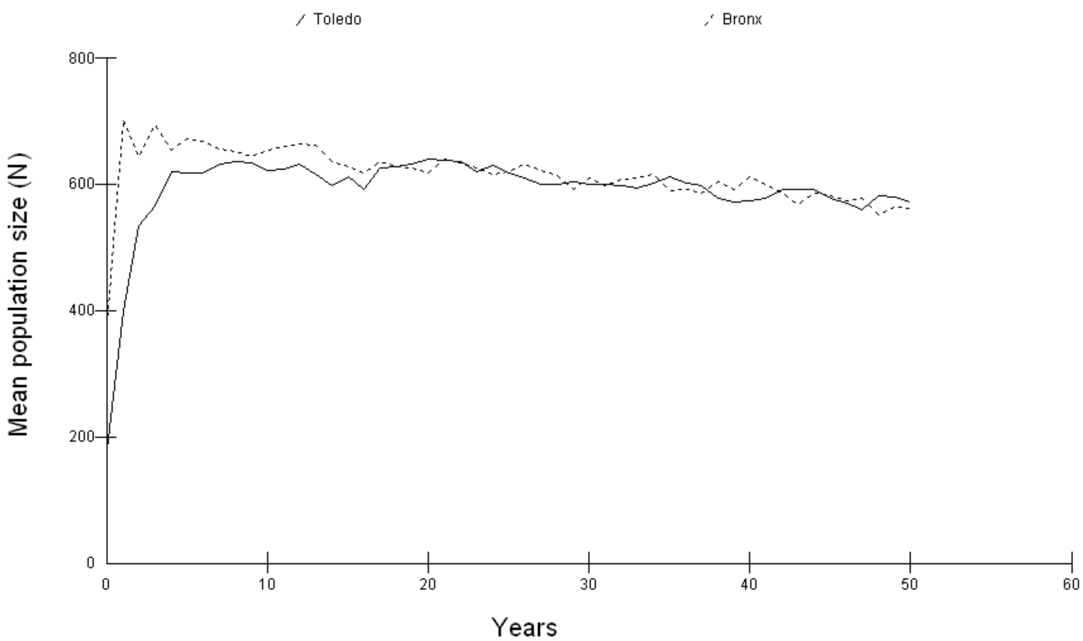

Figure 1: Baseline model showing the results of the Toledo and Bronx Zoo populations over a period of 50 years.

Sensitivity analysis

The baseline model was developed using primarily data collected from the captive population at Toledo Zoo, with some input from the Bronx Zoo history. To investigate areas of where uncertainty in the parameter values could unduly affect model outcomes, sensitivity testing was conducted to explore the sensitivity of the model results to key model parameters. The outcomes from baseline values for each variable in the model were compared with those obtained during sensitivity analyses where the variable was increased and decreased by 10% for all variables where this was possible. In addition, the sensitivity analyses were made with concordance of reproduction and survival, age of first offspring at 2 years, maximum age of reproduction at 4 years, maximum number of progeny per year at 20 and 26 and the exclusion on catastrophes. All sensitivity analyses were run for 1000 iterations with a carrying capacity of 60 000 (Vortex limit) so that this would minimise limits on population growth and so have less of an effect on the results.

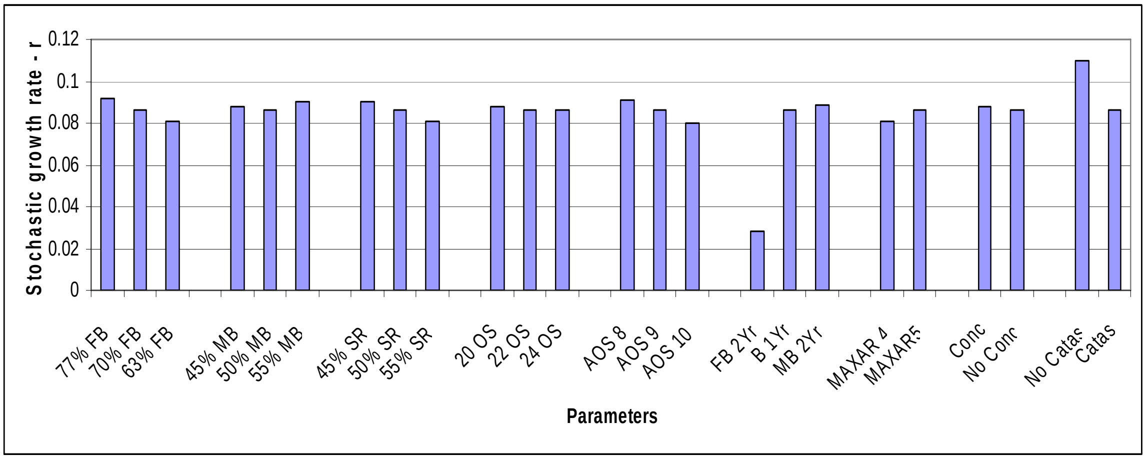

Figure 2: Stochastic growth rate (r) that varied % of females breeding (FB) (baseline 70%); % males in breeding pool (MB) (baseline 50%); sex ratio in % males (SR) (baseline 50%); maximum number of offspring (OS) (baseline 22); average number of offspring (AOS) (baseline 9); average age of first male breeding (MB) and female breeding (FB) (baseline 1 year for male and female); concordance of reproduction and survival (conc) (baseline no concordance) and no catastrophe (No Catas) (baseline with catastrophe).

The sensitivity analysis (Figure 2) indicated that model outputs are most sensitive to two reproductive parameters: catastrophes and age of first reproduction for females. By increasing the age of first reproduction for females from 1 to 2 years, the stochastic growth rate decreases as the number of years available for females to breed decreases. An increase in growth rate follows the removal of a catastrophe which is to be expected as the frequency of catastrophes in the baseline model was high (33% chance in any one year) and when occurred, resulted in a 50% mortality rate.

Sensitivity evaluation in relation to mortality rates indicated that stochastic growth rate (r) of the baseline against a 10% increase and 10% decrease for each of the sex and age class variables in the model showed a limited effect on model outputs, with all *r* remaining at 0.08 (range 0.082 to 0.089). The model is therefore not too sensitive to mean mortality rates.

Catastrophes

Any examination of the role of catastrophes on the future of the KST consider that some catastrophes, e.g., a severe outbreak of a amphibian specific Chytrid fungus, could cause the population to go extinct in an area, regardless of the population size at the time. Herein we consider non-devastating catastrophes, for example associated with less lethal amphibian diseases, and in the baseline model, defined a catastrophe to be a disease which has a 33% chance of occurring in any one year, and at that time, will cause a decline of 50% due to mortality and will reduce breeding by 95%. This was a best guess provided by the workshop participants. For this reason, a range of catastrophe frequencies and a range of its impact on reproduction and survival were run in the model and compared.

Figures 3, 4 and 5 show the probabilities of extinction under a varying range of catastrophe frequencies and severity values for reproduction and survival. As the frequency increased, so too did the probability of extinction. A decrease in productivity though a reduction in reproduction in years of catastrophes, resulted in the clearest increase though in the probability of extinction.

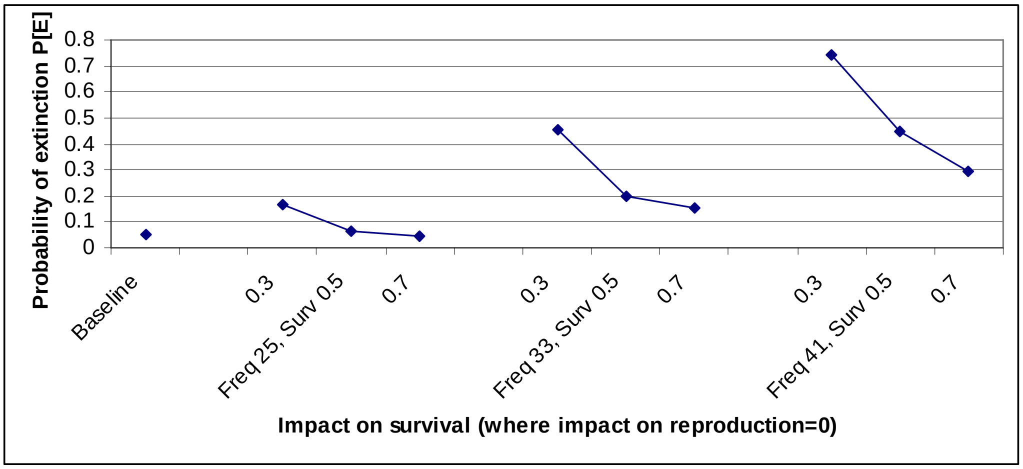

Figure 3: Probability of extinction of the population with different frequencies of catastrophe occurrence and a range of impacts on survival (where 0.3 has the greatest affect and 0.7 the least) when the severity of the catastrophe on reproduction is 0 (i.e. no reproduction)

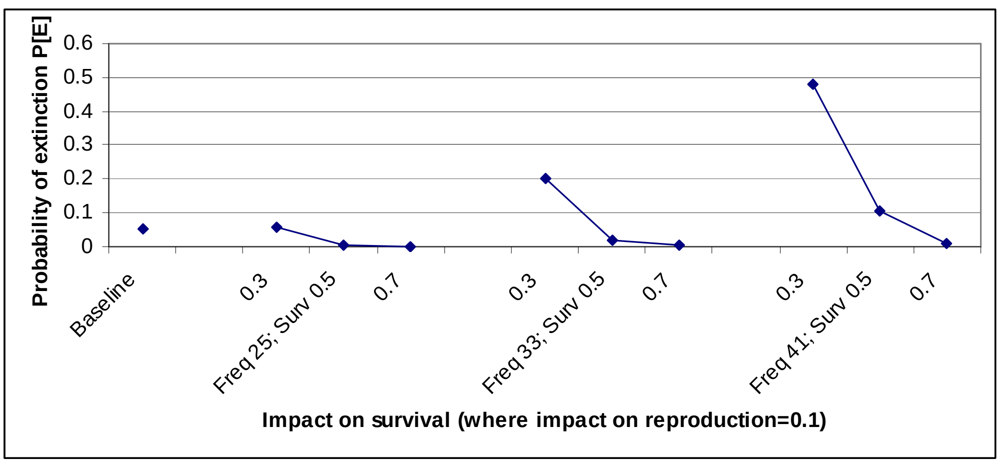

Figure 4: Probability of extinction of the population with different frequencies of catastrophe occurrence and a range of impacts on survival (where 0.3 has the greatest affect and 0.7 the least) when the severity of the catastrophe on reproduction is 0.1 (i.e. a 90% reduction in reproduction)

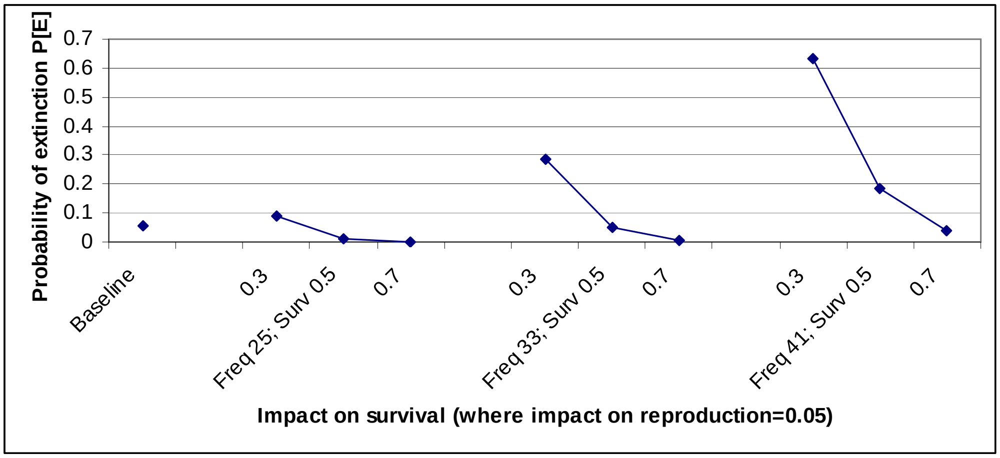

Figure 5: Probability of extinction of the population with different frequencies of catastrophe occurrence and a range of impacts on survival (where 0.3 has the greatest affect and 0.7 the least) when the severity of the catastrophe on reproduction is 0.05 (i.e. a 95% reduction in reproduction when a catastrophe event occurs)

It appears that the species has a strong capacity to recover in numbers following a catastrophic event, even if large numbers of individuals die in any given mortality event. This is as a result of the species' breeding biology and capacity for high population growth rates. However, a loss in reproduction in a year of catastrophe effects on mortality strongly limits a population's ability to recover. For this reason, it is important that any future research during a catastrophic event carefully record the effects on both reproduction and mortality.

Management Scenarios

Two sets of management scenarios were run. The first was based on the suggestion that all KST were returned to Tanzania and then a release programme to the wild organised from there. The second set of scenarios was based on the suggestion that for a period of time excess KST from Toledo and the Bronx were sent to a captive facility in Tanzania and releases then organised from there. Although workshop participants wanted KST to be released into several sites in the Gorge, it was decided that only one wild population be modelled as a result of the uncertainties related to how the KST would fare in the wild. As more information is obtained and a better understanding achieved of this species' biology, the model should be expanded to incorporate populations established at multiple wetlands, each potentially with differing habitat quality.

None of the workshop participants had an understanding on how the wild population would react or how well the Tanzanian captive facility would fare. There seemed to be widely differing opinions on this and hence an average (baseline), worst case and best case scenarios were run for each of the scenarios. 500 iterations were run for each of the scenarios.

All KST sent back to a Tanzanian captive facility and released into the Kihansi Gorge

Within the first year, it was noted that all KST were sent to the captive facility in Tanzania (for the purposes of the model, this was called Kihansi Rearing Facility (KRF)) by allowing for a 100% dispersal from the captive facilities to KRF in Vortex. It was assumed that no releases to the Kihansi Gorge (for the purposes of the model, this was called "Gorge") would occur within the first 3 years in order that captive husbandry was improved and any disease transmission minimised. Thereafter, it was assumed that a release programme would be instituted from KRF into the Gorge annually between years 3 and 8. In order to have all KST harvested from KRF go into the Gorge, Vortex was set to consider translocation so that supplements were obtained from the last population, which was the Gorge and all harvests, for the purposes of the model-KRF. Bearing in mind that the workshop participants felt that KRF would have a carrying capacity of 1000, it was assumed that any KST in excess of this would be released. To facilitate this in the model, an optional criterion for harvest was used : (N>1000). It was then assumed that 50% of the released KST would be female and 50% male, and to achieve this in the model, the number of females and males released (under harvest) were given the following function: (N-1000)*0.5.

Three scenarios for each the KRF and the Gorge were developed – intermediate (based on the baseline data), worst case and best case, using variability in percentage of females breeding, average number of offspring produced and mortality. Table 1 outlines the variables changed. A carrying capacity of 7500 was given to the Gorge.

Table 1: Vortex input variables used for the various scenarios

	% EV in % female breeding	Average number of young produced	Mortality of 0-1 age class	Mortality of adult age class
Worse case scenario	14	6	26	35
Intermediate (baseline)	10	9	24	32
Best case scenario	7	12	22	29

In addition, a set of scenarios for each of the KRF/Gorge scenarios were run to determine the impacts on the population if the sprinkler system were to fail for whatever reason for a short period of time. To do this, it was added as a catastrophe with a frequency of 10% (a probability of 0.1 of it happening in any year), a reproductive severity of 0.5 (i.e. a 50% reduction in reproduction in that year) and a survival impact of 0.75 (i.e. 25% decline in the population). Note that it assumed that the sprinkler systems malfunctioned for a period of one year only at any one time.

Table 2: Outcomes of the scenarios, showing probability of extinction (P[E]) and total population size of all extant populations (N). Note that due to all KST being removed from the USA, they would automatically have a P[E] of 1 and N=0.

	KRF	**Gorge**
Scenario	**P[E]**	**P[E]**
Best case Kihansi; best case Gorge	0.06	0.07
With sprinkler catastrophe	0.05	0.07
Best case Kihansi, intermediate case Gorge	0.06	0.08
With sprinkler catastrophe	0.07	0.09
Best case Kihansi, worst case Gorge	0.05	0.13
With sprinkler catastrophe	0.05	0.19
Intermediate case Kihansi, best case Gorge	0.11	0.09
With sparkler catastrophe	0.13	0.10
Intermediate Kihansi, intermediate case Gorge	0.12	0.12
With sprinkler catastrophe	0.11	0.13
Intermediate Kihansi, worst case Gorge	0.14	0.19
With sprinkler catastrophe	0.14	0.25
Worst case Kihansi, best base Gorge	0.35	0.20
With sprinkler catastrophe	0.34	0.21
Worst case Kihansi, intermediate case Gorge	0.33	0.25
With sprinkler catastrophe	0.37	0.25
Worst case Kihansi, worst case Gorge	0.37	0.36
With sprinkler catastrophe	0.30	0.35

As expected, the probability of extinction generally increases as you move from best to intermediate to worst case scenario (Table 2) (some irregularities in this trend are due to model stochasticity).

Of particular note (Table 2), the Gorge is most affected when the KRC scenario is at its worst. This is due to the fact that the KRC has a relatively higher probability of extinction which would obviously affect the number of KST that could be released in a reintroduction programme. This in turn would mean that the Gorge population was at greater risk of going extinct.

For both the KST population in the Gorge at its best or intermediate, a failure of sprinklers in the Gorge had a limited impact on the population. However, if the KSTs follow the worst case scenario and the sprinkler systems fail, the probability of extinction increases. However, this difference between a sprinkler catastrophe and no catastrophe decreases when the KRF KST are functioning in a worst case scenario.

Clearly, Table 2 shows that the best case scenario would be when the KST in the KRF and in the Gorge followed the best case scenario and the sprinklers never failed.

Excess KST sent from Toledo and Bronx Zoos to KRF and excess from there released into the Gorge

This model took all KST in excess of 1000 from each of Toledo and Bronx Zoos and sent them to the KRF, for a period of 6 years. From the KRF, all KST in excess of 1000 for the same 6 years, were released into the Gorge. The same variables outlined in table 1 and in the management scenarios above were used. Within Vortex, this was accomplished using the translocation under special options. KRF was the fourth population (last) so that any harvests from Toledo and Bronx Zoos automatically went into KRF. The Gorge was made the third population and supplementation was then used to obtain excess KST from KRF.

Table 3: Outcomes of the scenarios, showing probability of extinction (P[E]) and total population size of all extant populations (N) if populations are maintained in captivity in the USA. Note that due to both Toledo and Bronx having the same breeding variables and hence very similar outcomes, only the Toledo Zoo figures are shown.

	Toledo	KRF	Gorge
Scenario	**P[E]**	**P[E]**	**P[E]**
Best case Kihansi; best case Gorge	0.16	0.07	0.03
With sprinkler catastrophe	0.15	0.06	0.04
Best case Kihansi, intermediate case Gorge	0.17	0.07	0.07
With sprinkler catastrophe	0.09	0.07	0.10
Best case Kihansi, worst case Gorge	0.16	0.08	0.15
With sprinkler catastrophe	0.13	0.07	0.21
Intermediate case Kihansi, best case Gorge	0.14	0.10	0.04
With sparkler catastrophe	0.15	0.13	0.06
Intermediate Kihansi, intermediate case Gorge	0.15	0.14	0.05
With sprinkler catastrophe	0.19	0.14	0.08
Intermediate Kihansi, worst case Gorge	0.16	0.13	0.17
With sprinkler catastrophe	0.14	0.14	0.22
Worst case Kihansi, best base Gorge	0.16	0.32	0.05
With sprinkler catastrophe	0.00	0.28	0.01
Worst case Kihansi, intermediate case Gorge	0.14	0.32	0.07
With sprinkler catastrophe	0.15	0.32	0.11
Worst case Kihansi, worst case Gorge	0.17	0.33	0.15
With sprinkler catastrophe	0.17	0.344	0.22

Table 3 differs from Table 2 in that both Toledo and the Bronx Zoos maintain their populations but that KST in excess of 1000 at each institution for a period of 6 years are transferred to KRF. The Toledo population (and in turn the Bronx) maintains a relatively constant probability of extinction and population size irrespective of scenario in the Gorge or KRF. This is expected as they are not linked in any way, except that excess KST are transferred to KRF.

KRF experiences a considerably greater increase in probability of extinction when its KST function at their worst according to the model. Interestingly, the probability of extinction in the KST population in the Gorge never increases above 0.22 when captive populations are maintained in the USA, and never above 0.17 when the sprinkler failure is not included as a catastrophe. The Gorge population size however is relatively smaller (Table 3) when USA captive populations are maintained than when all USA KST are moved to KRF (Table 1). Due to the 6 years of KSTs supplementing KRF, it is fair to assume that more KST are released into the Gorge each year during the 6 years reintroduction years and hence the Gorge is not as dependant on Kihansi as it was in Table 2.

Medical interventions: Caesarean Section
The workshop participants considered the possibilities of removing all young via Caesarean sections to improve the survivorship of young KST. This was done in the model by giving all adult female KST a mortality rate of 100% (i.e. to simulate their death resulting from the operation), increasing the mean number of young to 12 (from 9) and decreasing the mortality rate of 0 – 1 year male and female KST to 20% (from 24%).

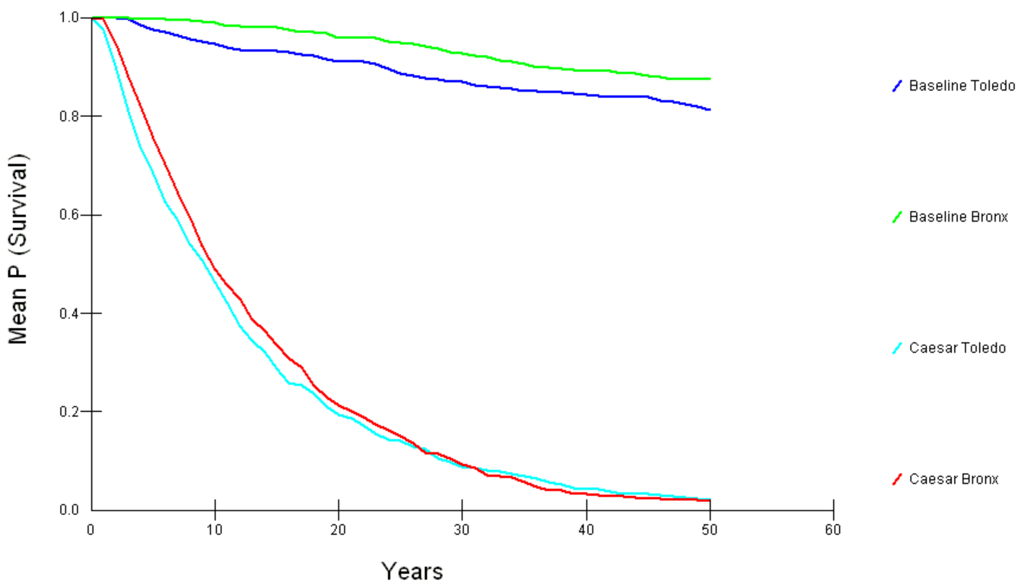

Figure 6: The differences in Probability of survival of both Toledo and Bronx KST populations if Caesarian sections are carried out on 1st year female

Figure 6 shows clearly that the probability of survival of both captive populations would decrease significantly to a probability of extinction of 0.975 at 50 years. If Caesarean sections were to be considered, it is recommended that consideration be given to the percentage of females involved in the procedure and also the number of years such a management option be considered for.

Summary
This model has been built on data collected from one captive population, and extrapolated to a further three populations, all realistically "living" under totally different environments and conditions. General concurrence on estimates of model parameters was obtained from workshop participants and baseline simulations produce patterns of population growth that workshop participants considered consistent with their knowledge of how the KST populations behave in the wild and in captivity. Data limitations nevertheless significantly constrain the outcomes of

the model. However, an attempt has been made to show the outcomes of various scenarios for each case and to look at a limited variation between worst, intermediate and best case scenarios. It is imperative however, that further modelling be conducted as new information on the KST is derived and improved models can be developed.

This said, the model indicated that the KST has a strong capacity for increase and recovers quickly after catastrophic events. Catastrophes had the ability to significantly impact on a population and its future probability of survival and in particular in relation to the severity of the impact of the catastrophe on reproduction. Age of first breeding was the most sensitive variable in the model and is probably not a significant factor as it appears that most females breed at one year of age. However, consideration should be given to the fact that should a large percentage of females only breed at two years of age, the growth rate of the population will be affected.

Conducting Caesarean sections on all pregnant female KST significantly increased the probability of extinction of the captive populations. However, further assessment of this and its impact on the number of young KST born and 0-1 year old mortality rates when compared to the current baseline data should be conducted.

A range of scenarios for both KRC and the Gorge were developed and not surprisingly, the probability of extinction increased as the reproductive situation of the respective population decreased from best to worst case scenarios. The modelling showed, however, that the best case scenario overall was for the captive populations to be maintained in the USA and excess KST relocated to KRC and from there, excess KST reintroduced into the Gorge.

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Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Appendix 1

Habitat Group notes

Bagamoyo PHVA workshop: Habitat Group 1100 hrs Tuesday, 15 May 2007

Henry Ndangalasi, presenter
KMHowell computer

Members:
Vida Ngomuo Min of Water
Kiungo
John
Alan Channing
Henry Ndangalasi
Gita Kasthala
Shishira
Magoma
Ngalason
Amani
Msyani
Lugenja
Lillian

Original cards:

Issues raised in cards on the wall:

Dam leads to loss of habitat
Habitat Destruction
Gorge Habitat no suitable
Water Releases insufficient
Lack of Spray
Change in Habitat
Unstable Habitat
Predation by safari ants
Ecology not understood
Restoration of wetland
Introduction/reintroduction site

Changes: combine 1-3:

Dam lead to loss of habitat

> Dam leads to loss of habitat
> Habitat Destruction
> Gorge Habitat no suitable
> Unstable habitat
> Changes in habitat
> Restoration of wetland habitat

Lack of Spray; Water releases insufficient

Predation

Ecology of ecosystem not understood

Restoration of wetland habitat goes with others at beginning

Introduction, Re-introduction site choice

Magoma wanted to add another statement about upstream activities but this was felt to have been covered by problem statement 1 below

PROBLEM STATEMENTS:

1. Diversion of water has changed the habitat (some discussion here over wording: is it the DAM?) by reducing spray. Habitat needs to be restored.

2. Drying of the habitat has allowed predators access
(some discussion about use of the word "new" predators, this was explained that these predators were formerly not in the wetland, ie, army ants)

3. Ecology of the ecosystem is not understood

4. A suitable site for introduction/re-introduction of KST has to be chosen

Now prioritise:

	Rank			
1	9	3	1	1
2	3	4	7	2
3	3	3	4	4
4	1	4	2	7

Rank: 1 is 48, 2 is 32, 3 is 45 4 is 27

NEW RANKING OF PROBLEM STATEMENTS:
1. Diversion of water has changed the habitat (some discussion here over wording: is it the DAM?) by reducing spray (ranked 48)

2. Ecology of the ecosystem is not understood (ranked 45)

3. Drying of the habitat has allowed predators access

(some discussion about use of the word “new” predators, this was explained that these predators were formerly not in the wetland, ie, army ants) (ranked 32)

4. Choosing a suitable site for introduction/re-introduction of KST has to be chosen (ranked 27)

(Note: 4 reworded slightly as per group suggestion; also 1 reworded by addition of 2nd phrase)

ended: 11:45 hrs

Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Appendix II

Participant List

Participant List

INTERNATIONAL POPULATION AND HABITAT VIABILITY ASSESSMENT (PHVA) WORKSHOP HELD ON 14TH - 17TH MAY, 2007 AT PARADISE HOLIDAY RESORT - BAGAMOYO

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Kihansi Spray Toad PHVA

Bagamoyo, Tanzania
14-17 May 2007

Final Report

Appendix III
Participant Questionnaire Responses

What do you hope will be accomplished in this Workshop?

- General plan which will make sure that spray toads are surviving.
- I hope that the participants will arrive at a decision to ensure the survival of the spray toads while maintaining the best interests of the Tanzanians.
- A viable plan for the reintroduction of the KST back into the gorge if possible
- A plan to search for KST in other parts of Tanzania, and a comprehensive plan for conservation of the gorge and monitoring to ensure the re-surfacing of the KST in the wild.
- Consensus of problems and recommendations for future actions related to the Kihansi Gorge and KST
- Long-term conservation of the KST
- To find a way to ensure the existence of the KST
- A management plan to ensure the survival of KST that can be implemented and sustained in Tanzania.
- To make sure that the West does not send a dangerous pathogen back to Africa, but I don't really care about the Spray Toad. But if we can save it at the same time, I won't complain.
- Develop a plan to determine if the KST can be reintroduced/recover.
- A recovery plan for the KST in place.
- Create a viable action plan for KST reintroduction and survival, identifying all issues that are present and to help outline a strategy for discussing these.
- Development of a comprehensive plan to ensure the long-term survival of the KST and it's natural habitat.
- Develop a plan of action to ensure the long-term survival of the KST, if possible including a strategy to restore the species into the ecosystem in which it evolved.
- A plan to aid in the restoration of the KST in Tanzania.
- KST survival strategies based on the scientific research done and prepared.
- A plan to sustain the future of the KST.
- Develop a means of reintroducing KST at the Kihansi gorge.
- Input for a rigorous species recovery plan, and technical guidelines for the management of a captive KST population.
- A workable recovery plan for the KST
- Decisions on how to move ahead with KST issues; reintroduction, *in-situ*, captive breeding, etc.
- Create an environment conducive to the recovery of the KST.
- A feasible and implementable KST recovery plan.
- Compile information about KST disappearance and come up with a recovery action plan.
- Guidelines for the management of KST and a recovery plan. Environment flow requirement for KST.
- Feasible strategies on the reintroduction of the KST. This workshop will solicit the factors that have affected the KST.
- KST recovery plan will be in place.
- Concrete recovery plan for conserving the critically endangered KST.

- Realistic recovery plan for the KST, timeline for its implementation, and technical guidelines for KST management *in situ* and *ex situ*.
- A recovery plan for the captive KST, a report detailing the KST as a flagship species in relation to the build environment, and a body of knowledge and information exchange and accumulation.
- A strategic KST recovery plan and a plan to combat KST diseases.
- A strategy to protect the KST from extinction.
- The strategy and action plan for the reintroduction and future survival of the KST.
- Strategic plan which will give solutions to the limitations of reintroducing KST back into the wild, and control the pathogen outbreak in the gorge.
- A plan to reintroduce KST in the gorge.
- Have a strategy and action plan to ensure the survival of the KST in place.
- Solutions to restore the toad habitat and reintroduce the toads. Set up a captive breeding facility in Tanzania.
- A solid, working plan to save the KST from extinction.
- Agreement on how to restore/conserve/protect the Kihansi gorge ecosystem considering the needs of the people of Tanzania.
- KST recovery plan including a possibility of reintroducing the KST in Tanzania. A plan to establish a captive facility for KST in Tanzania.
- Clear understanding of the trade-offs among various management alternatives for the persistence of the KST. This information will then be made available to authorities for making decisions on how best to move forward and maintain this species.
- A feasible, viable and realistic recovery plan.

What do you wish to contribute to the workshop?

- TENESCO should set the bypass flow of 2 m^3/sec
- My knowledge of captive amphibian husbandry, natural history and evolution.
- Expertise in extinction modelling, husbandry and biology.
- Contribute the knowledge of the community socio-economic activities in the catchment areas.
- General animal health-related perspective and specific in particular those associated with infectious disease and other pathology.
- Experience in gorge as to conditions under which KST was found.
- Information on the original KST population in the gorge.
- Knowledge of implementing international goals at a local level.
- Knowledge of amphibian biology, monitoring amphibian disease and epidemiology, amphibian breeding/reintroduction, amphibian biosecurity and quarantine.
- Expertise on amphibian diseases, and disease management as well as development/application of disease diagnostic methods.
- Discussion of the complex task of maintenance of the recovery of the KST, and suggestions as to how to go about it.
- Knowledge and expertise in amphibian medicine.
- Understanding of the physical and biological structure of the spray wetland ecosystems to assist both in captive breeding programs and in evaluating KST introduction/reintroduction options.

- Knowledge of the biology and captive husbandry of KST population.
- Management of the ecosystem.
- Restoration of the upper catchment of Kihansi for supporting the downstream life system.
- Conservation of the upper catchment for continuous supply of river flow with water for both the gorge and electricity supplies.
- Knowledge of forestry research and to control the fungus.
- Input to the creation of a species recovery plan based upon experience designing and supervising LKEMP.
- Research coordination to achieve desired objectives, and indentify real problems facing the KST in order to have appropriate mitigation measures.
- Consideration of practical issues associated with KST management alternatives
- Environmental management plan including compliance of water discharge.
- Knowledge on wildlife species conservation in Tanzania.
- All the possible baseline information about KST in the wild, and any other information such as local beliefs on the disappearance of the KST.
- Catchment management and institutions.
- Study of ecotoxins, especially water pollutants and sediments.
- Dissemination of information of issues raised.
- Ideas in various aspects concerning KST. Reintroduction plan as well as habitat restoration.
- As former World Bank Task Team Leader, I would like to contribute LKEMP project implementation experiences. Transforming or putting plans into action by describing financial arrangements.
- Sustainability of the ecosystem through environmental management.
- My experience in operation of Kihansi hydropower plant in connection with KST.
- Role of tropical forests in watershed conservation.
- General ecology, ecosystem management for the survival of KST.
- Habitat viability and water use issues.
- Information on the vegetation of the upper spray wetland (main habitat of KST).
- Knowledge of insects as food for KST in the gorge and experience and probably how best the KST can survive.
- Suggest ways of restoring the habitat at Kihansi gorge wetlands.
- My experience with captive husbandry and breeding.
- Knowledge of pertinent amphibian disease and conservation.
- Amphibian/KST ecology.
- Technical assistance with PVA, general knowledge of amphibian population biology, knowledge of Kihansi ecology.
- Information on reintroduction.