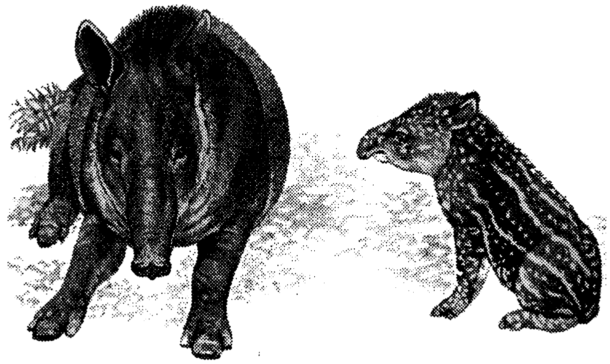
EVALUACIÓN DE VIABILIDAD DE POBLACION Y HABITAT DEL MACHO DE MONTE (*Tapirus bairdi*)

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994



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Un Taller en Colaboración: (*A Collaborative Workshop of:*)
ANCON

IUCN/SSC Grupo Especialista de Tapires
IUCN/SSC *Tapir Specialist Group*

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A contribution of the IUCN/SSC Conservation Breeding Specialist Group and the IUCN/SSC Tapir Specialist Group, in cooperation with ANCON - Asociación Nacional para la Conservación de la Naturaleza.

Cover Photo: San Diego, one of a group of Baird's tapirs (*Tapirus bairdi*) in General Manuel Noriega's former private zoo in Panama. Photo by David G. Spielman

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27 February 1996

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EVALUACIÓN DE VIABILIDAD DE POBLACIÓN Y HABITAT DEL MACHO DE MONTE (*Tapirus bairdi*)

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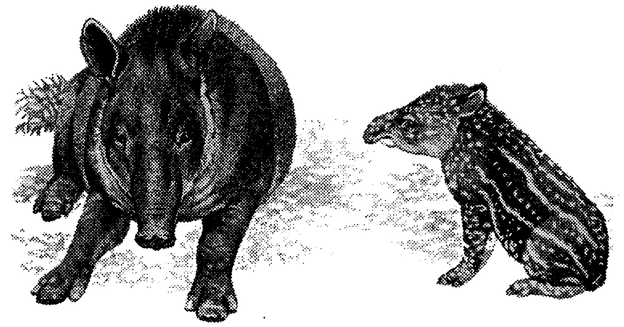

Sección 1
Resumen Ejecutivo

RESUMEN EJECUTIVO

El Macho de Monte (*Tapirus bairdi)* es el mamífero terrestre de mayor talla corporal en los Neotrópicos. Distribuida desde el sur de México hasta el noroeste de Colombia y Venezuela, esta especie se encuentra enlistada en el Apéndice I de CITES y se considera como amenazada de acuerdo al criterio de La Lista Roja de la IUCN. Se ha estimado que aproximadamente 3,000 tapires aún ocupan los bosques tropicales de Panamá. Existen cuatro regiones principales que cuentan con *T. bairdi*: la región norte, comprendiendo 1,200 animales en las áreas Bocas del Toro y Chiriqui; la región Azuero, con aproximadamente 50 animales; la región sur, incluyendo las áreas de San Blas y Darién, con aproximadamente 1,500 animales; y la región de la Serranía de Maje, con aproximadamente 60 animales. Estas cuatro áreas están separadas, por lo que se considera que constituyen poblaciones aisladas donde no hay intercambio.

Un número de serias amenazas influyen sobre la variabilidad futura de las poblaciones del macho de monte en Panamá. La destrucción y fragmentación del hábitat por actividades humanas continúan en el país; de hecho, más de la mitad del rango geográfico de *T. bairdi* ha sido destruido durante los últimos 40 años. La cacería ilegal de tapires por humanos, para alimento y otros propósitos, puede también tener impactos dramáticos sobre las poblaciones del tapir. Los tapires son relativamente fáciles de rastrear, y por lo tanto, fáciles de cazar. Siendo una de las primeras especies del bosque tropical afectadas por disturbios humanos, la continua invasión de la civilización sobre el hábitat del tapir puede tener consecuencias serias para el futuro de la especie.

Como un paso inicial en el desarrollo de una estrategia común para proteger a esta especie de la extinción en Panamá, la Asociación Nacional para la Conservación de la Naturaleza (ANCON) realizó una Taller de Análisis de la Viabilidad de la Población y del Hábitat (PHVA) en el Centro de la Naturaleza Río Chagres, cerca de la Ciudad de Panamá, Panamá, durante los días de diciembre 1 - 3 de 1994. El Grupo Especialista de Conservación y Crianza de la Comisión de Sobrevivencia de Especies/ IUCN fue solicitado para conducir el taller y asistir en la asesoría y planeación subsecuente. Veintitrés biólogos, manejadores de vida silvestre y representantes de organizaciones no gubernamentales de los Estados Unidos, Panamá y Colombia atendieron el taller durante tres días. Uno de los propósitos de esta reunión fue el revisar información de las poblaciones silvestres como base para desarrollar simulaciones de modelos estocásticos de las poblaciones. Estos modelos estiman el riesgo de extinción y las tasas de pérdida genética resultantes de la interacción de los factores demográficos, genéticos y ambientales. Los resultados de estos modelos son utilizados posteriormente como herramientas en las prácticas de manejo para la especie. Otras metas comprendieron la revisión del estado actual del conocimiento concerniente a los requerimientos del hábitat, distribución de la especie y tamaños poblacionales, el papel de las amenazas directas como factores responsables en el declinamiento de la especie, y la función de la reproducción en cautiverio en el manejo de la especie a largo plazo.

El taller fue iniciado con una serie de presentaciones que resumieron información sobre el estado de las poblaciones del macho de monte en vida silvestre y cautiverio. Como una introducción sobre el uso del modelo y sobre los problemas asociados con poblaciones pequeñas y aisladas, se realizó una presentación sobre el proceso PHVA, los principios de la biología de poblaciones y del paquete software para simulaciones de poblaciones VORTEX. Posteriormente los participantes formaron tres grupos de trabajo -biología de población y modelaje, poblaciones silvestres y poblaciones en cautiverio- para revisar en detalle información actual y establecer los parámetros para los modelos de simulación, y para desarrollar escenarios d manejo y recomendaciones. Los modelos estocásticos de simulación de poblaciones fueron iniciados con rangos de valores en las variables principales para estimar la viabilidad de la población utilizando VORTEX.

El modelaje de las poblaciones del tapir utilizando VORTEX demostró una extrema sensibilidad de estas poblaciones a la mortalidad adulta. La eliminación adicional de adultos por cacería furtiva en un 6% por arriba de los valores de mortalidad normal, provocó un cambio en la tendencia poblacional del crecimiento a la declinación (la cacería furtiva se define aquí como cualquier forma de cacería de una especie considerada oficialmente como en peligro de extinción tal como el macho de monte). Esta declinación en la población no ocurre bajo niveles altos de mortalidad juvenil, siempre y cuando la mortalidad adulta sea baja. La inestabilidad poblacional puede incluso observarse al existir tasas tan bajas como del 3% de cacería furtiva en adultos, bajo condiciones ambientales estresantes tales como sequías. Así mismo, el riesgo de extinción de la población se incrementa considerablemente bajo estos escenarios de cacería furtiva. Estos datos sugieren que una tasa anual de cacería furtiva del 3-6% no es sustentable para ninguna de las poblaciones que existen actualmente en Panamá. Como resultado, el manejo planificado del el tapir debe de investigar estrategias que busquen reducir la tasa de cacería furtiva a niveles sustentables.

Las consideraciones sobre el estado de las poblaciones silvestres del tapir condujo a las siguientes recomendaciones:

- Investigar la posibilidad de restauración del hábitat del tapir previamente degradado por actividades humanas.

- Establecer programas de reintroducción con el objeto de abarcar los problemas genéticos asociados con la consanguinidad en poblaciones pequeñas y aisladas.

- Recopilar sistemáticamente información referente a la historia natural del tapir, su distribución y calidad del hábitat, sin desdeñar el conocimiento de los residentes de las comunidades locales.

- Identificar prioridades de conservación en aquellas áreas susceptibles a la fragmentación, tales como la Cordillera Central.

- Esforzarse para lograr que el tapir sea el símbolo de los esfuerzos de conservación en Panamá.

- Crear localmente un Grupo de Trabajo para el Tapir en Panamá, en coordinación con el INRENARE.
- Trabajar con los pobladores nativos (Indios Kuna) para evaluar más rápidamente el estado de la especie en áreas habitadas por estos residentes y desarrollar programas educativos basados en la comunidad para prevenir la cacería local del tapir.

- Evaluar la utilización de la reproducción en cautiverio como una herramienta de manejo en las poblaciones.

Los participantes del taller construyeron una planilla de recolección de datos a ser utilizada por los residentes locales como una herramienta para recolectar información importante de las características de las poblaciones del tapir. Se espera que a través de esta herramienta se logre una conservación más efectiva del tapir y de su hábitat.

Actualmente existen menos de 20 tapires en tres parques zoológicos y colecciones privadas. Las metas primarias del manejo del tapir en cautiverio incluyen:

- Establecer programas educativos que actúen localmente, nacionalmente, gubernamentalmente e internacionalmente.

- Establecer un programa coordinado de reproducción en cautiverio en Panamá.

- Establecer metas y lineamientos para la reintroducción.

Es vital establecer programas de alcance dirigidos a las personas que habitan en aquellas áreas donde existe el tapir en Panamá. Estos programas incrementan la conciencia y la apreciación de la especie. Así mismo, estos programas pueden comunicar efectivamente los efectos devastadores de la cacería furtiva. Para los programas de reproducción en cautiverio en Panamá, será importante el traducir al Español la información científica de la especie y hacerla llegar a los investigadores en Panamá. Además, en relación con el manejo del tapir bajo condiciones de cautiverio, es muy crítico el que se maneje a los tapires en cautiverio como una sola población y que esta se distribuya en diferentes centros que cooperen en el programa. Tal vez, un hecho de mayor importancia fue el que los participantes propusieron establecer un Comité del Tapir en Panamá, que será responsable primariamente de decidir el manejo en cautiverio de los tapires en Panamá y las transferencias de individuos necesarias a realizar.

La meta de la reintroducción es altamente deseable para el manejo efectivo de la población, pero los participantes sintieron que era necesario el retrasar esta meta hasta que las amenazas actuales a las poblaciones silvestres sean identificadas y resueltas. Mientras que esta fase entra en efecto, se realizarán censos de enfermedades en los individuos en cautiverio y en libertad para identificar los problemas de salud que enfrenta el tapir. Posteriormente, deberán de realizarse investigaciones en las áreas de genética, reproducción y comportamiento del tapir, al igual que protocolos veterinarios y de manejo de la especie para los animales en cautiverio.

La conservación efectiva del macho de monte en Panamá será una cuestión complicada que requiere de la participación de biólogos, organizaciones gubernamentales y comunidades locales. Tal vez, la prevención de la extinción del macho de monte sea posible únicamente a través de la integración concertada del manejo de la población existente en vida silvestre y cautiverio.

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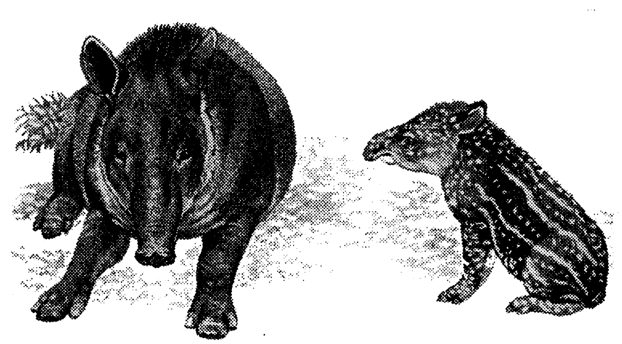

Sección 2
Poblaciones Silvestre

POBLACIONES SILVESTRE DEL MACHO DE MONTE (*Tapirus bairdi*) EN PANAMÁ

Tabla 2.1. Distribución

SECTORES	A.T.[†]	A.O.	Pobl.	A.P.	C.C.
Oeste (Bocas de Toro y Chiriqui)	6000	2400	1200	3600	3000
Azuero (P. N. Cerro Hoya)	250	100	50	150	125
Este (P. N. Chagres, San Blas y Darien)	7290	2916	1458	4374	3645
Serrania de Maje Isla de Maje	300	120	60	180	150
TOTALES	13840	5536	2768	8304	6920

[†] A.T. = area total (km^2); A.O. = area ocupada (km^2); Pobl. = poblacion actual; A.P. = area potencial (km^2); C.C. = capacidad de carga

Para estimar los valores arriba presentados se hicieron una serie de apreciaciones. Eisenberg (1989), señala que los tapires pueden alcanzar una densidad de población de 0.8 por km^2 en un hábitat adecuado. Sin embargo, basados en nuestras experiencias de campo y en los datos de Glanz (1990) consideramos que la densidad de población puede ser estimada en 0.5 individuos /km^2.

Se consideró que existe un área total de 13840 km^2 con condiciones adecuadas para las poblaciones de tapires, de las cuales consideramos que el 40 % (5536 km^2) se encuentra ocupado por la especie, quedando el 60% (8304 km^2) del área total como hábitat disponible. Esto nos indica que la capacidad de carga del hábitat actual es de 6920 individuos en todo el territorio nacional. Cabe destacar que aproximadamente el 45% de esta área corresponde a áreas protegidas por parques nacionales, reservas forestales y territorios indígenas tales como la Comarca de Kuna Yala.

La población de tapires de la Isla Barro Colorado no se ha considerado como una población natural de la isla, ya que la población existente (12 individuos) fue reintroducida (Smythe, 1992). Además, en este ecosistema no existen los grandes depredadores como el Jaguar (*Panthera onca*) y el Puma (*Puma concolor*). Existe también el registro de un tapires liberado en la Reserva Forestal de Sherman, el cual fue criado en cautiverio (Smythe, 1992).

Tabla 2.2. Registros de Población Silvestre del Macho de Monte (*Tapirus bairdi*) en Panamá

AREA DE REGISTRO	TIPO DE REGISTRO
SECTOR OESTE	
Rio Culubre	Huellas: E. Ponce, F. Arosemena
Cotito	Huellas: E. Ponce, F. Arosemena
Rio Teribe-Bonyic	Cazadores/guardaparques: E. Ponce, F. Arosemena
Cabecera del Rio Changuinola	Avistamientos, huellas/cazadores, guardaparques: R. Hinds, E. Ponce, F. Arosemena
Reserva Forestal de Fortuna	Huellas: F. Arosemena
Culebra	Huellas/guardaparques: J. Tovar, E. Ponce, F. Arosemena
Cerro Guabo	Huellas: E. Ponce, F. Aroemena
Bajura de Pando	Huellas/guardaparques y cazadores
Rio Yorkin	Huellas/ guardaparques: E. Ponce, F. Arosemena
El Respingo	Huellas: B. Cuevas
Cerro Pata de Macho	Huellas: B. Cuevas
SECTOR AZUERO	
Cerro Hoya	A. Gonzales, comunidades adyacentes al P.N. Cerro Hoya
Rio Varadero	Cazadores/comunidades de Varadero y Arenas de Quebro

Tabla 2.2 (contd.)

AREA DE REGISTRO	TIPO DE REGISTRO
SECTOR ESTE	
Cabecera del Rio Pequeni	Huellas/indigenas Embera, comunidad de San Juan de Pequeni
Cuenca alta del Rio Chagres	Huellas/guardaparques, J. Tovar
Rio Cascada (terrenos de MELO, S.A.)	Huellas: F. Arosemena, I. Rosales
Sendero Interpretativo El Cantar	Huellas: F. Arosemena
Cerro Guagaral (Cerro Brewster)	Huellas: A. Telesca, F. Arosemena
Cabecera del Rio Mandinga	Huellas: A. Telesca, F. Arosemena
*Cangandi	Huellas y animal cazado: J. Ventocilla
Rio Nergala	Animal cazado: J. Ventocilla
Carretera El Llano Carti	Huellas: J. Ventocilla
*Pucuro	Craneos y mandibulas: I. Candanedo
*Paya	Avistamientos (madre e hijo), craneos y mandibulas: R. Hinds, I. Candanedo
**Manene	Craneos y mandibulas: I. Candanedo
**Altos de Rio Jaque	Craneos y mandibulas: I. Candanedo
**Punusa	Craneos y mandibulas: I. Candanedo
Cerro Pirre (ladera noreste y noroeste)	Avistamientos/guardaparques
Rio Seteganti (hacia Cerro Setetule)	Avistamientos: R. Hinds
Estacion de INRENARE en Pirre	Avistamientos/guardaparques
Estacion de INRENARE en Cruce de Mono	Avistamientos / guardaparques
Camino Cruce de Mono-Cana	Huellas / guardaparques: J. Polanco, F. Arosemena
Serrania de Bernal	Huellas: O. Lastra
Comarca Embera No. 2	Huellas / indigenas de la comunidad de La Chunga
Rio Tacarcuna (antiguo pueblo Kuna)	Avistamientos: R. Hinds

Tabla 2.2 (contd.)

AREA DE REGISTRO	TIPO DE REGISTRO
Cerro Tacarcuna	Avistamientos: R. Hinds
Anachucuna	Avistamientos: R. Hinds
Cerro Mali	Huellas: R. Hinds
Altos de Nique	Huellas: R. Hinds
Rio Mono	Avistamientos: R. Hinds

* Comunidad Indigena Kuna
** Comunidad Indigena Embera

La Comarca de San Blas tiene 42 comunidades insulares, unas 8 sobre la misma costa y 2 en tierra firme. Segun nuestra experiencia en cada comunidad hay , por lo menos, una vivienda con quijadas de Tapir a manera de trofeo / J. Ventocilla. Situación similar se presenta en las comunidades kunas de Pucuro y Paya en el Darien.

AREA DE REGISTRO	TIPO DE REGISTRO
SECTOR DE MAJE	
Isla Maje	Plan de Manejo Isla Maje, Lab. Com. Gorgas.: R. Hinds
Cordillera de Maje	Huellas / cazadores: B. Lavern
Tutecito	Huellas, animales cazados / comunidad indigena Embera de Tutecito

Amenazas

Se ha determinado que las principales amenazas que enfrentan los tapires en Panama son:

- Perdida de habitat por colonizacion en el sector de El Guabo (indigenas Guaymies), ganaderia (Nueva Zelandia, Culubre, Valle Libre).
- Deforestación provocada por el embalse de la hidroelectrica Fortuna y la posible construcción de los proyectos de mediana capacidad de Bonyic y Changuinola I en la provincia de Bocas del Toro.
- Deforestación por colonos en el area fronteriza de Cerro Tacarcuna y cultivo de coca (*Eryctrocilon coca*).
- Caceria de subsistencia, ademas la caceria deportiva (furtiva) principalmente en el area indigena de Darien, San Blas y Bocas del Toro.
- Endogamia especialmente en la Isla Majé en el lago Bayano, donde el aislamiento geografico puede causar este problema.
- Mineria: esta es una amenaza potencial, debido al posible desarrollo minero de Cerro Colorado.

Recomendaciones

- Hacer cumplir las leyes existentes en cuento a la protección del tapir y su habitat natural en Panama.
- Promover la recuperación del habitat natural en las áreas entre las poblaciones identificades de tapir. Esto permitiría el intercambio genetico entre los animales y disminuiría las posibilidades de una fragmentacion total de las poblaciones.
- Se debe establecer un programa de reintroducción, elcual debe contemplar los aspectos geneticos para evitar problemas de consanguinidad.
- Recopilar y sistematizar la informacion existente sobre historia natural, distribucion y calidad de habitat del tapir, tomando en cuenta también el conocimiento que poseen las comunidades locales (indigenas, campesinos, cazadores) que puedan contribuir a mejorar las actividades de conservacion de la especie.
- Considerar como prioridad de conservacion las areas susceptibles a fragmentacion en la Cordillera Central, especialmente en Bocas del Toro y Veraguas. Tambien se debe prestar especial atencion a la poblacion de tapires en el Parque Nacional Cerro Hoya y Maje.

- Sugerir al tapir como animal simbolo de la conservacion en Panama de manera que pueda utilizarse en los programas de educacion ambiental.

- Crear un Grupo de Trabajo sobre el Tapir en Panama.

- Para el caso particular del territorio de los indigenas kunas (Comarca KunaYala), consideramos que esta reune condiciones appropriadas para una evaluación rapida de la situacion de la especie. Los cazadores kunas no son muchos y son conocidos. Las mandibulas de los tapires son colgadas fuera de las viviendas como trofeos y cada cazador kuna guarda asi registro del numero de ejemplares cazados. En un tiempo relativamente corto se podria visitar y entrevistar a los principales cazadores y obtener informacion confiable de la historia natural del Tapir, de la magnitud de la actividad cinegetica y de la situacion en general de la especie. Refiera al Apéndice para la Población Silvestre Forma de Recaudo de Datos.

- Buscar alternativas viables para las comunidades indigenas y campesinas que utilizan el tapir (*Tapirus bairdi*) como fuente de proteinas y/o documentar o mejorar proyectos de cria en cautiverio de la especie.

Un Grupo de Trabajo sobre el Tapir en Panama (GRUTA)

Argumentos:

1. El Tapir es un buen candidato para servir como "especie indicadora" de las condiciones ambientales del pais.

2. Encontramos que las personas que viven en las cercanias (indigenas y campesinos), suelen tener informacion sobre presencia o ausencia y sobre la historia natural de esta especie.

3. A la fecha, salvo el caso del aguila harpia (nombre científico) no se ha llevado ningun registro nacional sistemático para especie alguna de animal (o vegetal) silvestre.

4. Es mas realista pensar en un diagnostico poblacional, realizado en forma digamos "artesanal", que en investigaciones cientificas sofisticadas sobre esta especie.

5. Existe un numero de naturalistas haciendo trabajo de campo en areas propicias para poblaciones de tapires.

Tareas de un Grupo de Trabajo sobre el Tapir:

1. Recopilar informacion sobre el estado poblacional y la historia natural de la especie;
2. Recopilar informacion sobre su presencia historica;
3. Informar sobre animales vivos cautivos;
4. Publicar cada tres meses una hoja informativa y de enlace entre interesados;
5. Tener una reunion general anual.

Necesidades inmediatas para empezar:

1. Elaborar hoja(s) de colecta de datos (Apéndice);
2. Conseguir un lugar dentro de una oficina gubernamental u ONG, para que sirva de Centro donde se reciba, se limpie y se almacene la informacion;
3. Contar con unos 4 o 5 voluntarios, distribuidos en las tres areas geograficas de distribucion del tapir, para comenzar.

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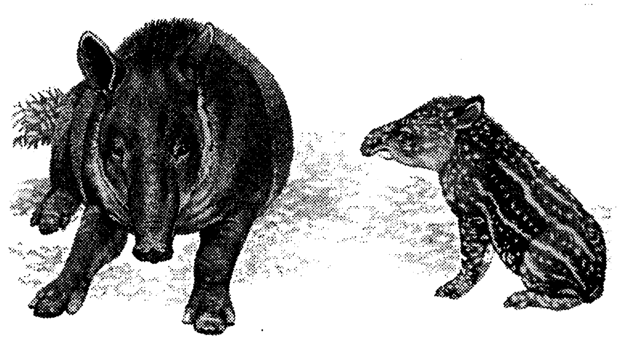
EVALUACIÓN DE VIABILIDAD DE POBLACION Y HABITAT DEL MACHO DE MONTE (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994

Sección 3
Biologia de Poblaciones y Modelaje



BIOLOGIA DE POBLACIONES Y MODELAJE

Introducción

El macho de monte (*Tapirus bairdi*) se encuentra actualmente enlistado en el Apéndice I de CITES. En general, las principales amenazas que afectan la viabilidad de las poblaciones del tapir en el Neotrópico parecen ser la destrucción continua del hábitat y la cacería excesiva. Gran parte del conocimiento en vida silvestre del macho de monte proviene de observaciones directas en campo, rastros y muestras fecales y cráneos recuperados en el hábitat del tapir. Así mismo, varios de los parámetros biológicos relacionados con la reproducción del tapir han sido obtenidos de estudios ampliamente documentados del tapir bajo condiciones de cautiverio (referirse a la sección de bibliografía).

La necesidad de y los efectos de estrategias intensivas de manejo pueden ser modeladas para sugerir que prácticas pueden ser más efectivas para preservar esta población. VORTEX, un paquete de simulación de modelaje escrito por Robert Lacy y Kim Hughes fue utilizado como herramienta para estudiar la interacción de múltiples variables tratadas en una forma estocástica.

El programa VORTEX es una simulación Monte Carlo tanto de los efectos de fuerzas determinísticas, como de los eventos demográficos, ambientales y genéticos estocásticos en poblaciones de animales silvestres. VORTEX modela las dinámicas de poblaciones como eventos discretos, secuenciales (por ejemplo, nacimientos, muertes, catástrofes etc.) que ocurren de acuerdo a probabilidades definidas. Las probabilidades de los eventos son modeladas como variables constantes o al azar que obedecen a distribuciones especificadas. VORTEX simula una población a través de una serie de eventos que describen el ciclo de vida típico de organismos diploídes con reproducción sexual.

VORTEX no pretende proporcionar respuestas absolutas, debido a que proyecta estocásticamente las interacciones de los múltiples parámetros que se introducen al modelo y debido también a los procesos aleatorios que ocurren en la naturaleza. La interpretación de los resultados depende del conocimiento de la biología del tapir, de las condiciones que afectan la población y de los posibles cambios que pueden presentarse en el futuro.

Entrada de Parámetros para Simulaciones

Edad a Primera Reproducción: 3 años para ambos hembras y machos. VORTEX define a la reproducción como el nacimiento; de acuerdo a un período gestacional de 13 meses para el tapir, las hembras pueden aparearse a los 2 años de edad y reproducirse a los 3 años de edad.

Producción de Crías: El intervalo entre nacimientos fue establecido en 2 años para tapires en vida silvestre. Por lo tanto, el 50% de las hembras adultas no se reproducen en un año determinado. De aquellas hembras que se reproducen, todas producen únicamente una cría. Se ha reportando la producción de dos crías en un mismo parto bajo condiciones de cautiverio, aunque estos eventos han sido extremadamente raros y las crías han nacido muertas.

La variación en la reproducción es modelada en VORTEX al incluir una desviación estandard (DE) para la proporción de hembras que no producen crías en una año determinado. Debido a que no contamos con datos empíricos al respecto, asumimos que tal variación (debido a fluctuaciones en la disponibilidad de parejas y a variaciones de la edad en que las hembras alcanzan la madurez sexual) fue del 25% de la media. De esta forma, VORTEX determina el porcentaje de reproductores para cada año de la simulación, muestreando de una distribución binomial con la media (50%) y la DE (12.5%) especificadas.

Debido a que no existe información diferente a la indicación de una relación de sexos al nacimiento de 50:50 para el macho de monte, utilizamos esta misma relación de sexos en todos los escenarios.

Edad a Senectud : VORTEX asume que los individuos de esta especie pueden reproducirse (en la tasa normal) a lo largo de su vida adulta. Bajo condiciones de cautiverio se ha reportado la reproducción de los tapires macho de monte hasta los 25 años de edad; sin embargo estimamos que la edad máxima de reproducción para poblaciones silvestres es de 20 años, debido a la severidad de las condiciones ambientales en vida silvestre.

Mortalidad: Para el "mejor" escenario, en el que la mortalidad del tapir no es afectada por influencias humanas y en la que otros factores bióticos tienen un impacto mínimo, establecimos una mortalidad del 20% para juveniles (edad 0 al año 1) y una mortalidad del 10% para sub-adultos y adultos. Estos valores son similares a aquellos reportados para taxa cercanamente relacionados.

Por supuesto, la mortalidad del tapir puede ser influenciada fuertemente por presiones humanas tales como la cacería, principalmente en adultos (Terwilliger 1978; Fragoso 1991). Así mismo, tanto la incidencia de enfermedades como de altos niveles de depredación por jaguares etc., pueden incrementar la mortalidad, principalmente en juveniles. Por lo tanto, modelamos poblaciones con mortalidad juvenil del 25% y 30%. Para modelar el efecto de la cacería en la mortalidad de adultos, construimos escenarios de simulación con tasas de cacería furtiva del 3%, 6% y 9%. La aplicación equitativa de estas tasas a través de las clases de sexo y edad de sub-adultos y adultos, incrementa las tasas anuales de mortalidad adulta a 13%, 16% y 19% respectivamente. Los datos de poblaciones de tapires en Panamá sugieren que estas tasas de cacería furtiva no son irrazonables (Terwilliger 1978).

Capacidad de Carga: La capacidad de carga (K) define un límite superior para el tamaño de la población, sobre el cual se impone una mortalidad adicional para regresar a la población a K. VORTEX, por lo tanto, utiliza K para imponer una densidad-dependiente en tasas de sobrevivencia.

Las poblaciones del macho de monte en Panamá se agrupan en dos categorías generales con respecto a su tamaño: poblaciones grandes como en el noreste de Panamá (región Bocas del Toro) y al sur de Panamá (regiones de San Blas y Darien); y pequeñas, como en la Península de Azuerro y en la Serranía de Majé. Se ha estimado que la capacidad de carga para ambas poblaciones grandes corresponde a 3,000 individuos, mientras que las poblaciones pequeñas presentan una capacidad de carga estimada para 150 animales. Estas aproximaciones están basadas en estimaciones publicadas de densidades para el tapir correspondientes a 0.5 - 0.8 individuos por km^2.

A partir de estos datos, generamos dos series de modelos de simulación con capacidades de carga de 3,000 y 150 individuos respectivamente. La amplia variación en capacidad de carga para los dos tipos de poblaciones ofrecen un panorama considerable de las dinámicas de extinción que operan en las poblaciones de tapires en Panamá.

VORTEX puede también modelar tendencias determinísticas en la capacidad de carga. Estas tendencias son especificadas como un porcentaje anual de cambio y son modeladas como incrementos o decrementos lineares, y no geométricos. Los datos actuales muestran que una larga proporción del hábitat del tapir en Panamá se encuentra amenazado por una degradación o fragmentación significante. Para investigar las consecuencias de tal amenaza, modelamos reducciones determinísticas en la capacidad de carga en una tasa de 2.5% por año sobre los primeros 20 años de las simulaciones. Este hecho resulta en una reducción del 50% del hábitat disponible para el tapir sobre el período de tiempo considerado.

Tamaño Inicial de la Población: Generamos dos series de modelos de simulación utilizando tamaños poblacionales iniciales correspondientes a las dos clases de tamaño poblacional estimadas en Panamá: $N_0 = 1200$, similar a las poblaciones de Bocas del Toro y San Blas/Darien; y $N_0 = 60$, similar a las poblaciones existentes en la Península de Azuero y Serranía de Majé.

Distribución Inicial de Edades: Iniciamos todas las corridas de los modelos con una distribución estable de edades que distribuye la población total entre cada una de las clases de sexo-edad de acuerdo con los valores especificados de mortalidad y reproducción.

Depresión por Consanguinidad: No existe información específica sobre la prevalencia y efectos de la consanguinidad en las poblaciones silvestres del tapir. Sin embargo, debido a el reducido número de tapires que se piensa existe en las regiones de la Península de Azuero y en la Serranía Majé, parece razonable el inferir que en estas reducidas poblaciones está ocurriendo un grado medible de consanguinidad. Por lo tanto, hemos incluido la variable de depresión por consanguinidad en aquellos escenarios del modelaje que abarcan estas regiones.

Utilizamos el modelo de heterosis de depresión por consanguinidad, en que aquellos individuos que son heterocigotos para un locus genético específico presentan una capacidad de sobrevivencia superior que aquellos que son homocigotos para ese locus. Debido a que la selección natural no remueve de la población los alelos detrimentales a lo largo del tiempo en este modelo, puede ser que el modelo de heterosis proporcione una sobrestimación conservadora de los efectos deletéreos de la consanguinidad sobre las poblaciones de tapir modeladas.

La severidad de la depresión por consanguinidad en poblaciones de mamíferos puede ser medida como el número de "equivalente letales" contenidos en el genoma de la población de interés. Información derivada de varias especies de mamíferos mantenidos bajo condiciones de cautiverio, sugiere que estas especies contienen alrededor de 3 equivalentes letales (Ralls et al.

1988). Consecuentemente, hemos modelado la depresión por consanguinidad utilizando este valor de la mediana del equivalente letal.

Catástrofes: Las catástrofes se consideran como variaciones ambientales extremas, y son tratadas conceptual y operativamente en una forma diferente en VORTEX. El programa modela tanto la frecuencia de ocurrencia de la catástrofe como el impacto de ésta sobre la reproducción y sobrevivencia de la población. Incluimos a una condición de sequía como catástrofe, con una probabilidad de ocurrencia del 10% para un año particular (por ejemplo, el evento ocurre en promedio cada diez años) ocasionando una reducción en la reproducción del 50% y una reducción en la sobrevivencia del 20%, en aquellos años en los que la catástrofe ocurre.

Repeticiones y Años de Proyección:

En aquellos casos en los que no se incluyó depresión por consanguinidad el número de repeticiones para cada escenario correspondió a 500, sin embargo debido a limitaciones computacionales, este número fue reducido a 200 en aquellos escenarios en los que se incorporó depresión por consanguinidad. Para todos los escenarios se realizaron proyecciones para el futuro considerando un período de tiempo de 100 años. Los resultados fueros resumidos en intervalos de tiempo de diez años en las gráficas de series de tiempo. Cada escenario tabulado presenta un número de fila correspondiente para referencia y en caso de ser necesario para una futura obtención de resultados adicionales. Las simulaciones fueron corridas utilizando la versión 7.0 de VORTEX.

Resultados de los Modelos de Simulación

Explicación de Tablas y Figuras

Los resultados numéricos de los modelos de simulación son presentados en las Tablas 3.1 a 3.6. Cada tabla representa una serie de condiciones especificadas, por ejemplo capacidad de carga, inclusión de depresión por consanguinidad, etc. En cada tabla, los resultados están organizados bajo la siguiente estructura: cada nivel de mortalidad juvenil fue corrido con cada grado de mortalidad adulta, y cada uno de éstos fue corrido con o sin la ocurrencia de catástrofes.

Los títulos de las tablas son los siguientes:

r_d: tasa de crecimiento determinístico, calculado por los métodos de la matriz Leslie a partir de información de la tabla de historia de vida.

r_s(SD): media y desviación estandard de la tasa de crecimiento estocástico a través de las repeticiones calculadas de la variación anual en el tamaño poblacional;

P(*E*): probabilidad de extinción sobre el período de 100 años considerado en la simulación, calculado como la proporción de poblaciones repetidas que se extinguieron en un período de 100 años.

N_{100}(SD): tamaño final de esas poblaciones que sobrevivieron después del período considerado de 100 años;

H_{100} : proporción de la heterocigocidad original aún presente en la población después de un período de 100 años;

T(*E*): media del tiempo de extinción de aquellas poblaciones extintas.

Resultados Determinísticos

Tasa de Crecimiento (r_d): Las tasas de crecimiento determinístico calculadas utilizando los métodos de la matriz Leslie se muestran para cada escenario en la columna 5 de las Tablas 3.1 y 3.2. Los valores positivos indican un crecimiento poblacional; los valores negativos indican un declinamiento en la población. Una población con $r_d < 0$ indica un declinamiento determinístico (las muertes sobrepasan los nacimientos) y esta población se extinguirá aún cuando no se presente algún tipo de fluctuación estocástica. La diferencia entre la tasa de crecimiento determinístico de una población y la tasa de crecimiento estocástico resultante de las simulaciones (r_s referirse arriba) puede proporcionar una indicación del impacto de los factores estocásticos en la persistencia de las poblaciones.

Estas tasas de crecimiento determinístico son calculadas a partir de los datos de mortalidad y fecundidad de cada escenario modelado. Como resultado, el cambiar el tamaño inicial de la población y/o la capacidad de carga, o el imponer una reducción anual en la carga del hábitat no altera las tasas de crecimiento para un valor de mortalidad particular. Esto se refleja en las series idénticas de las tasas de crecimiento determinístico mostrado en todas las tablas. Como resultado, la siguiente discusión es aplicable tanto a las poblaciones grandes como a las pequeñas con una capacidad de carga constante o decreciente.

Bajo el escenario más optimista - baja mortalidad juvenil y adulta, sin sequía y sin depresión por consanguinidad - la población muestra un crecimiento anual de casi el 4% (r_d= 0.038). Al incrementar la mortalidad juvenil en un 5% adicional al 25%, se produce una reducción del crecimiento determinístico de la población de alrededor del 20% (r_d = 0.030), y un incremento adicional de la mortalidad a un 30% conduce a una reducción del 45% en el crecimiento determinístico (r_d = 0.022). Esta situación cambia dramáticamente cuando se incrementa la mortalidad adulta bajo un cierto nivel de mortalidad juvenil. Aún en condiciones de baja mortalidad juvenil, un incremento del 10 % al 13% en la mortalidad adulta resulta en un crecimiento anual de la población de menos del 1% (r_d= 0.008). Cuando se incrementa la mortalidad adulta al 16%, la población presenta un declinamiento anual del 2.2%. El efecto de incrementar la mortalidad adulta al 19% es muy severo, ya que puede observarse un declinamiento anual del 5% en la población (r_d = - 0.054). La tasa de declinamiento es mucho más severa conforme se incrementa la mortalidad juvenil; bajo condiciones de un 30% de mortalidad juvenil y sin la ocurrencia de sequía, la tasa de crecimiento determinístico es de -0.071.

Estos resultados determinísticos proveen suficiente evidencia de la considerable sensibilidad de las poblaciones del tapir en Panamá como respuesta a incrementos de la mortalidad adulta. El cambio incremental de r_d es de 0.102 por un incremento del 10% en la mortalidad adulta, mientras que el cambio correspondiente para la mortalidad juvenil es de únicamente 0.016 por un incremento del 10%. En otras palabras, el cambio incremental correspondiente a la mortalidad adulta es más de seis veces mayor con respecto al de la mortalidad juvenil.

El crecimiento determinístico se ve severamente afectado cuando se incluye la ocurrencia de sequía en los diferentes escenarios modelados. Bajo condiciones de baja mortalidad adulta y juvenil, la tasa de crecimiento determinístico se reduce de 0.011 a 0.038. El escenario menos optimista, con alta mortalidad juvenil y adulta, así como con la ocurrencia de sequía, conduce a una tasa de crecimiento determinístico del -0.097.

Resultados de Simulación Estocástica

El escenario base (Fila # 301), con baja mortalidad juvenil y adulta y sin sequía en la categoría de población grande (N_0 = 1200, K = 3000), resulta en un crecimiento anual de casi el 4% sin ningún riesgo de extinción durante el período considerado de 100 años (Tabla 3.1). De hecho, la población se incrementa rápidamente de un tamaño inicial de 1,200 individuos a casi el limite de la capacidad de carga del hábitat de 3,000 individuos, en solo 40 años (Figura 3.1b). El riesgo de extinción permanece en 0 cuando se incrementa la mortalidad juvenil al 25% y aún al 30% bajo una reducida mortalidad adulta, con tamaños poblacionales finales mantenidos cerca de K (2930 y 2876 respectivamente; Figuras 3.2 y 3.3). Si se adiciona la sequía a estos mismos escenarios, el riesgo de extinción permanece en 0 aún bajo una mortalidad juvenil del 40%. Sin embargo, la tasa de crecimiento estocástico de la población (r_s) se reduce significativamente y de hecho se muestra como negativa bajo niveles altos de mortalidad juvenil con una reducción en casi un 40% en el tamaño de la población final (N_{100} = 760). Estos resultados indican que aún cuando eventos catastróficos tales como una sequía tienen una probabilidad de ocurrencia relativamente baja, sus efectos pueden ser severos y conducir a la inestabilidad en la población.

En contraste con los resultados obtenidos al incrementar la mortalidad juvenil bajo condiciones de baja mortalidad adulta, niveles altos de mortalidad adulta casi siempre conducen a una inestabilidad de la población (Tabla 3.1, Figuras 3.1 - 3.3). Aún cuando la mortalidad juvenil es baja, una mortalidad adicional del 6% en los adultos conduce a un declinamiento de la población (r = -0.026) y a una reducción en el tamaño final de las poblaciones (N_{100} = 131), con un pequeño pero aún medible riesgo de extinción en el período de 100 años ($P(E)$ = 0.008). Cuando la mortalidad adulta se incrementa al 19%, la población se muestra como severamente inestable, presentando una probabilidad de extinción del 56% y una media en el tiempo de extinción de 83 años. La inclusión de sequía en estos escenarios produce inestabilidad adicional, particularmente bajo una mortalidad adulta del 16%, pudiéndose observar una probabilidad de extinción del 0.48 y un tamaño de la población final correspondiente a 19 individuos (Figura 3.4). Bajo una mortalidad adulta del 19%, la extinción es virtualmente inevitable con una media en el tiempo de extinción correspondiente a 65 años (Figura 3.4a).

Conforme se incrementa la mortalidad adulta bajo condiciones de una mayor mortalidad juvenil, la población se desestabiliza mayormente (Tabla 3.1). Bajo mortalidades adultas del 13%, 16% o 19%, todas las tasas de crecimiento estocástico son negativas, con o sin la inclusión de la sequía. El riesgo de extinción presenta un rango de cero, cuando la mortalidad juvenil es del 25% y la mortalidad adulta es del 13%, a cerca del 100% cuando la mortalidad adulta es del 19% y la mortalidad juvenil es del 25% o 30% bajo condiciones de sequía. Bajo estas condiciones de máxima severidad, la extinción usualmente ocurre en promedio durante un período de 80 años. Los tamaños poblacionales usualmente se reducen considerablemente de los 1,200 animales iniciales. Bajo condiciones de una mortalidad adulta del 13%, mortalidad juvenil del 25% y sin sequía, la población exhibe un declinamiento estocástico muy lento (r_s = -0.002) y un tamaño final de la población de 1171 animales (Fila #306). Sin embargo, bajo condiciones más severas, el tamaño de la población final consiste en únicamente un número muy reducido de individuos (por ejemplo, Fila # 308, 312 y 324).

Los resultados de estas simulaciones incorporando una reducción determinística anual del 2.5% en la capacidad de carga del hábitat para la categoría de poblaciones grandes se muestra en la Tabla 3.2. En general, los resultados son muy similares a aquellas simulaciones que carecen de dicha tendencia en *K:* r_s, $P(E)$ y $T(E)$, difieren de los valores correspondientes en la Tabla 3.1 por unos pocos porcentages. En general, el impacto de la reducción de K es mayor bajo condiciones de sequía y/o de elevada mortalidad adulta. En otras palabras, una situación en la que el hábitat ocupado es gradualmente destruido conduce a incrementar los problemas estocásticos demográficos y ambientales enfrentados por la población. Tal y como se espera, los tamaños de las poblaciones finales son modulados por la reducción en la capacidad de carga, pero únicamente en aquellos escenarios que muestran un crecimiento positivo. En aquellos escenarios que muestran un declinamiento en la población, los tamaños de la población final son esencialmente equivalentes a aquellos mostrados en los escenarios de la Tabla 3.1.

La Tabla 3.3 y las Figuras 3.7-3.9 presentan los resultados de los escenarios que modelan las categorías de poblaciones pequeñas. Mientras que las tendencias poblacionales para los escenarios de poblaciones pequeñas son cualitativamente muy similares a los modelos de las poblaciones grandes (Figuras 3.7b-3.9b) debido a la similitud en las tasas de crecimiento estocástico, las poblaciones pequeñas se encuentran bajo un riesgo considerablemente mayor de extinción bajo niveles intermedios y elevados de mortalidad adulta. Por ejemplo, con un 20% de mortalidad juvenil y un 16% de mortalidad adulta y sin sequía (Fila # 351), la probabilidad de extinción es de casi el 73%. En contraste, la población mayor, bajo la misma serie de condiciones (Fila # 303, Tabla 3.1), presenta una probabilidad de extinción menor al 1%. Desde luego, ambas poblaciones presentan un declinamiento determinístico (y estocástico), por lo que el destino a largo plazo de ambas poblaciones simuladas es el mismo. Estos resultados, sin embargo, muestran las amenazas inmediatas enfrentadas por las poblaciones pequeñas de tapir en Panamá. De hecho, esta evidencia es más clara por la observación de que bajo severas condiciones de mortalidad, la media en el tiempo de extinción poblacional presenta un rango de 30 años en aquellos casos en los que una sequía se presenta, a aproximadamente 50 años. El riesgo de extinción se incrementa considerablemente conforme se incrementa la mortalidad juvenil (Figuras 3.11 y 3.12).

Las reducciones de la capacidad de carga en escenarios de poblaciones pequeñas conducen a resultados similares a los obtenidos en las poblaciones mayores (Tabla 3.4). Posiblemente la observación más evidente es la reducción adicional en la heterocigocidad poblacional bajo estas condiciones (comparar columna 9 en Tablas 3.3 y 3.4). Esta consecuencia del persistente reducido tamaño poblacional así como de la consanguinidad acompañante puede conducir tanto a una reducción en la sobrevivencia de la población como a una disminución del potencial adaptativo a largo plazo conforme las poblaciones intentan adaptarse a los cambios ambientales.

La inclusión de depresión por consanguinidad en los escenarios de poblaciones pequeñas contribuye a un incremento del riesgo de extinción en todos los escenarios con excepción de los de más baja mortalidad adulta (Tablas 3.5 y 3.6, Figuras 3.13-3.18). Una ilustración adecuada de este efecto puede ser observada en el escenario que considera una mortalidad juvenil del 20% y una mortalidad adulta del 13% sin la ocurrencia de sequía (Fila # 350). Sin los efectos deletéreos de la consanguinidad, la población presenta un crecimiento anual del 0.3% (r_s = 0.003) con un tamaño de la población final de 90 individuos y un riesgo de extinción del 4% en un período de 100 años (Tabla 3.3, Figura 3.7). Si se incluye consanguinidad en el modelo, la tasa de crecimiento estocástico de la población se convierte en negativa (r_s = - 0.016), el tamaño de la población final disminuye a 43 animales, y el riesgo de extinción se incrementa a 31.5% (Tabla 3.5, Figura 3.13). Las Figuras 3.7b y 3.13b ilustran gráficamente este efecto (referirse a la línea con los símbolos cuadrados). Mientras que las poblaciones simuladas sin depresión por consanguinidad muestran un crecimiento consistente a lo largo del período de tiempo (Figura 3.7b), las poblaciones consanguíneas muestran tasas de crecimiento similares únicamente durante los primeros 20 años de simulación, pudiéndose observar posteriormente que el incremento en la mortalidad juvenil a través de consanguinidad genera una declinación casi linear en el tamaño poblacional en la duración del período de tiempo considerado (Figura 3.13b).

Bajo condiciones de consanguinidad, la inclusión de sequías conduce a que todas las poblaciones experimenten un declinamiento estocástico, aún aquellas con baja mortalidad (Figuras 3.16-3.18). Bajo el escenario más pesimista, en la que poblaciones pequeñas y consanguíneas de tapires ocupan hábitats perturbados sujetos a condiciones de sequía, posiblemente el riesgo de extinción es de cerca del 35% aún bajo las condiciones de mortalidad más optimistas (Tabla 3.6, Fila #433). Si la capacidad de carga permanece constante, el riesgo es aún considerable ($P(E) = 0.315$: Tabla 3.5, Fila # 409). Estos resultados demuestran, que aunque carecemos de información específica de los efectos de consanguinidad de las poblaciones silvestres del tapir, las consecuencias de tal proceso no pueden ser ignoradas al considerar la viabilidad de poblaciones pequeñas y fragmentadas.

Conclusiones

Las simulaciones del modelaje VORTEX referentes a las poblaciones del macho de monte en Panamá, sugieren que el principal factor demográfico que afecta la viabilidad de sus poblaciones es la mortalidad en adultos. Asumiendo una mortalidad base en adultos del 10%, una mortalidad adicional del 6% conduce a un declinamiento de la población y a un riesgo substancial de extinción en un período de 100 años. Si la mortalidad adulta se incrementa a un 25%, la extinción de la población virtualmente se asegura en un período de alrededor de 80 años.

La considerable sensibilidad de las poblaciones de tapir a la mortalidad adulta identificada en el modelaje, se presenta gráficamente en la Figura 3.19. Cada barra en la gráfica muestra la probabilidad de extinción promediada sobre todos los escenarios con un valor asignado sobre el parámetro. Por ejemplo, la media en la probabilidad de extinción poblacional para todos los escenarios en los que la mortalidad juvenil fue del 20% (N = 48) es 0.504 (la barra ubicada en el extremo izquierdo). La figura muestra que un incremento en la mortalidad juvenil y la inclusión de sequía y de depresión por consanguinidad condujeron de hecho a un incremento en el riesgo de extinción. Sin embargo, el factor determinante sobre el riesgo de extinción es claramente la mortalidad en ejemplares adultos, al compararlo con otros factores.

Tal y como fue discutido anteriormente, el incremento en la mortalidad adulta fue utilizado para simular la cacería furtiva de ejemplares adultos por habitantes locales. Más especificamente, estos niveles de mortalidad simularon tasas de cacería furtiva correspondientes al 3%, 6% y 9%. Debido a que en el "mejor de los casos", el escenario sin cacería furtiva, resultó en una tasa de crecimiento del 4%, una tasa de cacería furtiva del 6% en tapires adultos, no parece ser sostenible. En otras palabras, la cacería furtiva de aproximadamente 60 tapires de una población de 1,000, bajo las condiciones modeladas aquí, puede conducir a la extinción de una población, aún bajo niveles bajos o modestos de mortalidad juvenil. En caso de que se presenten condiciones de sequía similares a las modeladas en este reporte en las poblaciones silvestres de Tapir en Panamá, aún una tasa de cacería furtiva del 3% conduce a un declinamiento determinístico de la tasa de crecimiento poblacional, incluso cuando la mortalidad en juveniles es baja. **En conjunto, los resultados del modelaje conducen a la conclusión de que la cacería furtiva de tapires adultos—aún a bajos niveles—pueden tener consecuencias detrimentales para la persistencia de estas poblaciones.**

El desarrollo de un plan de manejo coherente para el tapir seguramente incluirá la elección entre estrategias alternativas. De acuerdo a estos prospectos, es claro que un componente vital del manejo del tapir en vida silvestre debe de enfocarse a reducir las tasas de cacería furtiva a niveles sostenibles.

Sample VORTEX Input File

```
TAPIR425.OUT     ***Output Filename***
Y     ***Graphing Files?***
N     ***Each Iteration?***
Y      ***Screen display of graphs?***
200     ***Simulations***
100     ***Years***
10     ***Reporting Interval***
1     ***Populations***
Y     ***Inbreeding Depression?***
H
3.140000
N     ***EV correlation?***
1     ***Types Of Catastrophes***
P     ***Monogamous, Polygynous, or Hermaphroditic***
3     ***Female Breeding Age***
3     ***Male Breeding Age***
20     ***Maximum Age***
0.500000     ***Sex Ratio***
1     ***Maximum Litter Size***
N     ***Density Dependent Breeding?***
50.000000     ***Population 1: Percent Litter Size 0***
50.000000     ***Population 1: Percent Litter Size 1***
12.500000     ***EV--Reproduction***
25.000000     ***Female Mortality At Age 0***
7.500000     ***EV--FemaleMortality***
10.000000     ***Female Mortality At Age 1***
3.000000     ***EV--FemaleMortality***
10.000000     ***Female Mortality At Age 2***
3.000000     ***EV--FemaleMortality***
10.000000     ***Adult Female Mortality***
3.000000     ***EV--AdultFemaleMortality***
25.000000     ***Male Mortality At Age 0***
7.500000     ***EV--MaleMortality***
10.000000     ***Male Mortality At Age 1***
3.000000     ***EV--MaleMortality***
10.000000     ***Male Mortality At Age 2***
3.000000     ***EV--MaleMortality***
10.000000     ***Adult Male Mortality***
3.000000     ***EV--AdultMaleMortality***
20.000000     ***Probability Of Catastrophe 1***
1.000000     ***Severity--Reproduction***
1.000000     ***Severity--Survival***
Y     ***All Males Breeders?***
Y     ***Start At Stable Age Distribution?***
60     ***Initial Population Size***
150     ***K***
0.000000     ***EV--K***
Y     ***Trend In K?***
20
-2.500000
N     ***Harvest?***
N     ***Supplement?***
Y     ***AnotherSimulation?***
```

Sample VORTEX Output File

```
VORTEX -- simulation of genetic and demographic stochasticity

TAPIR425.OUT
Thu Apr 13 10:17:28 1995


  1 population(s) simulated for 100 years, 200 iterations

  HETEROSIS model of inbreeding depression
    with 3.14000 lethal equivalents per diploid genome

  First age of reproduction for females: 3   for males: 3
  Age of senescence (death): 20
  Sex ratio at birth (proportion males): 0.50000


Population 1:

  Polygynous mating; all adult males in the breeding pool.

  Reproduction is assumed to be density independent.

  50.00 (EV = 12.50 SD) percent of adult females produce litters of size 0
  50.00 percent of adult females produce litters of size 1

   25.00 (EV = 7.50 SD) percent mortality of females between ages 0 and 1
   10.00 (EV = 3.00 SD) percent mortality of females between ages 1 and 2
   10.00 (EV = 3.00 SD) percent mortality of females between ages 2 and 3
   10.00 (EV = 3.00 SD) percent annual mortality of adult females
(3<=age<=20)
   25.00 (EV = 7.50 SD) percent mortality of males between ages 0 and 1
   10.00 (EV = 3.00 SD) percent mortality of males between ages 1 and 2
   10.00 (EV = 3.00 SD) percent mortality of males between ages 2 and 3
   10.00 (EV = 3.00 SD) percent annual mortality of adult males
(3<=age<=20)
    EVs may have been adjusted to closest values
        possible for binomial distribution.
    EV in mortality will be correlated among age-sex classes
       but independent from EV in reproduction.

  Frequency of type 1 catastrophes: 10.000 percent
    with 1.000 multiplicative effect on reproduction
     and 1.000 multiplicative effect on survival

  Initial size of Population 1:
    (set to reflect stable age distribution)
 Age 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 Total
     4  4  3  2  3  2  2  1  2  1  1  1  1  0  1  0  1  0  1  0   30  Males
     4  4  3  2  3  2  2  1  2  1  1  1  1  0  1  0  1  0  1  0   30
Females

  Carrying capacity = 150 (EV = 0.00 SD)
    with a 2.500 percent decrease for 20 years.
```

Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression):

r = 0.030 lambda = 1.031 R0 = 1.291
Generation time for: females = 8.49 males = 8.49

Stable age distribution:

Age class	females	males
0	0.079	0.079
1	0.057	0.057
2	0.050	0.050
3	0.044	0.044
4	0.038	0.038
5	0.033	0.033
6	0.029	0.029
7	0.025	0.025
8	0.022	0.022
9	0.019	0.019
10	0.017	0.017
11	0.015	0.015
12	0.013	0.013
13	0.011	0.011
14	0.010	0.010
15	0.009	0.009
16	0.008	0.008
17	0.007	0.007
18	0.006	0.006
19	0.005	0.005
20	0.004	0.004

Ratio of adult (>= 3) males to adult (>= 3) females: 1.000

Population 1

Year 10
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 200, P[S] = 1.000
Population size = 81.37 (1.34 SE, 18.98 SD)
Expected heterozygosity = 0.978 (0.000 SE, 0.003 SD)
Observed heterozygosity = 0.996 (0.000 SE, 0.007 SD)
Number of extant alleles = 65.64 (0.63 SE, 8.92 SD)

Year 20
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 200, P[S] = 1.000
Population size = 73.59 (0.69 SE, 9.80 SD)
Expected heterozygosity = 0.965 (0.000 SE, 0.007 SD)
Observed heterozygosity = 0.986 (0.001 SE, 0.015 SD)
Number of extant alleles = 44.14 (0.46 SE, 6.46 SD)

```
Year 30
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =    200, P[S] = 1.000
     Population size =             68.61 (    0.62 SE,     8.80 SD)
     Expected heterozygosity =     0.950 (   0.001 SE,    0.010 SD)
     Observed heterozygosity =     0.974 (   0.001 SE,    0.020 SD)
     Number of extant alleles =    32.42 (    0.31 SE,     4.43 SD)

Year 40
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =    200, P[S] = 1.000
     Population size =             67.83 (    0.67 SE,     9.48 SD)
     Expected heterozygosity =     0.935 (   0.001 SE,    0.015 SD)
     Observed heterozygosity =     0.961 (   0.002 SE,    0.025 SD)
     Number of extant alleles =    25.67 (    0.25 SE,     3.54 SD)

Year 50
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =    200, P[S] = 1.000
     Population size =             66.74 (    0.78 SE,    11.00 SD)
     Expected heterozygosity =     0.919 (   0.001 SE,    0.020 SD)
     Observed heterozygosity =     0.947 (   0.002 SE,    0.033 SD)
     Number of extant alleles =    21.12 (    0.22 SE,     3.13 SD)

Year 60
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =    200, P[S] = 1.000
     Population size =             64.09 (    0.93 SE,    13.09 SD)
     Expected heterozygosity =     0.906 (   0.002 SE,    0.022 SD)
     Observed heterozygosity =     0.930 (   0.003 SE,    0.039 SD)
     Number of extant alleles =    17.90 (    0.21 SE,     2.97 SD)

Year 70
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =    200, P[S] = 1.000
     Population size =             61.96 (    1.03 SE,    14.54 SD)
     Expected heterozygosity =     0.890 (   0.002 SE,    0.027 SD)
     Observed heterozygosity =     0.917 (   0.003 SE,    0.047 SD)
     Number of extant alleles =    15.55 (    0.20 SE,     2.81 SD)

Year 80
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =    200, P[S] = 1.000
     Population size =             60.32 (    1.14 SE,    16.11 SD)
     Expected heterozygosity =     0.873 (   0.003 SE,    0.038 SD)
     Observed heterozygosity =     0.904 (   0.004 SE,    0.050 SD)
     Number of extant alleles =    13.76 (    0.20 SE,     2.78 SD)

Year 90
     N[Extinct] =        1, P[E] = 0.005
     N[Surviving] =    199, P[S] = 0.995
     Population size =             57.73 (    1.19 SE,    16.85 SD)
     Expected heterozygosity =     0.858 (   0.003 SE,    0.047 SD)
     Observed heterozygosity =     0.887 (   0.004 SE,    0.054 SD)
     Number of extant alleles =    12.21 (    0.19 SE,     2.73 SD)
```

```
Year 100
     N[Extinct] =       3, P[E] = 0.015
     N[Surviving] =   197, P[S] = 0.985
     Population size =            55.06 (   1.28 SE,    17.99 SD)
     Expected heterozygosity =    0.839 (  0.004 SE,    0.059 SD)
     Observed heterozygosity =    0.873 (  0.005 SE,    0.068 SD)
     Number of extant alleles =   10.93 (   0.19 SE,     2.62 SD)


In 200 simulations of Population 1 for 100 years:
  3 went extinct and 197 survived.

This gives a probability of extinction of 0.0150 (0.0086 SE),
  or a probability of success of         0.9850 (0.0086 SE).

3 simulations went extinct at least once.
Of those going extinct,
    mean time to first extinction was 94.67 years (3.18 SE, 5.51 SD).


No recolonizations.

Mean final population for successful cases was 55.06 (1.28 SE, 17.99 SD)

   Age 1       2   Adults    Total
    3.23    2.68   21.16     27.07  Males
    3.32    3.17   21.50     27.99  Females

Without harvest/supplementation, prior to carrying capacity truncation,
  mean growth rate (r) was 0.0134 (0.0006 SE, 0.0781 SD)

Final expected heterozygosity was      0.8394 ( 0.0042 SE,  0.0593 SD)
Final observed heterozygosity was      0.8732 ( 0.0049 SE,  0.0681 SD)
Final number of alleles was             10.93 (   0.19 SE,    2.62 SD)
*************************************************************************
```

Table 3.1. Baird's tapir population analysis: initial population size = 1200, K = 3000.

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
301	20	10	None	.038	.037 (.054)	0.0	2955 (94)	0.996	—
313			Drought	.011	.008 (.104)	0.0	1923 (820)	0.991	—
302		13	None	.008	.006 (.064)	0.0	2080 (713)	0.992	—
314			Drought	-.018	-.024 (.116)	0.014	208 (256)	0.941	93
303		16	None	-.022	-.026 (.081)	0.008	131 (124)	0.943	90
315			Drought	-.049	-.059 (.151)	0.480	19 (21)	0.753	82
304		19	None	-.054	-.062 (.136)	0.556	12 (10)	0.696	83
316			Drought	-.081	-.096 (.184)	0.970	6 (5)	0.434	65
305	25	10	None	.030	.029 (.055)	0.0	2930 (121)	0.995	—
317			Drought	.004	.000 (.104)	0.0	1359 (868)	0.990	—
306		13	None	.000	-.002 (.066)	0.0	1171 (687)	0.988	—
318			Drought	-.026	-.032 (.119)	0.038	99 (138)	0.906	86
307		16	None	-.030	-.035 (.091)	0.038	58 (52)	0.897	91
319			Drought	-.057	-.068 (.161)	0.728	15 (14)	0.713	80
308		19	None	-.062	-.073 (.148)	0.796	10 (9)	0.633	80
320			Drought	-.089	-.105 (.187)	0.996	8 (5)	0.512	61
309	30	10	None	.022	.021 (.057)	0.0	2876 (184)	0.995	—
321			Drought	-.005	-.008 (.105)	0.0	760 (654)	0.979	—
310		13	None	-.008	-.011 (.069)	0.0	510 (362)	0.981	—
322			Drought	-.034	-.043 (.131)	0.170	47 (56)	0.854	87
311		16	None	-.039	-.044 (.103)	0.136	31 (32)	0.841	89
323			Drought	-.065	-.078 (.169)	0.834	9 (6)	0.653	75
312		19	None	-.071	-.083 (.157)	0.916	8 (7)	0.537	73
324			Drought	-.097	-.113 (.190)	0.998	5 (0)	0.480	57

Table 3.2. Baird's tapir population analysis: initial population size = 1200, K = 3000, 2.5% annual reduction in K over the first 20 years of the simulation (50% total reduction in K).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
325	20	10	None	.038	.036 (.055)	0.0	1478 (42)	0.992	—
337			Drought	.011	.008 (.105)	0.0	1036 (382)	0.988	—
326		13	None	.008	.006 (.064)	0.0	1218 (267)	0.990	—
338			Drought	-.018	-.024 (.116)	0.020	191 (214)	0.938	93
327		16	None	-.022	-.026 (.082)	0.006	132 (125)	0.940	89
339			Drought	-.049	-.059 (.153)	0.494	19 (21)	0.767	82
328		19	None	-.054	-.065 (.138)	0.636	13 (10)	0.723	83
340			Drought	-.081	-.095 (.181)	0.972	7 (4)	0.526	66
329	25	10	None	.030	.029 (.056)	0.0	1463 (68)	0.992	—
341			Drought	.004	.000 (.105)	0.0	863 (435)	0.986	—
330		13	None	.000	-.002 (.066)	0.0	882 (345)	0.988	—
342			Drought	-.026	-.032 (.120)	0.050	96 (112)	0.914	89
331		16	None	-.030	-.035 (.090)	0.044	60 (58)	0.900	93
343			Drought	-.057	-.069 (.162)	0.702	12 (14)	0.696	79
332		19	None	-.062	-.073 (.149)	0.814	10 (7)	0.645	80
344			Drought	-.089	-.105 (.187)	0.992	4 (1)	0.458	61
333	30	10	None	.022	.020 (.058)	0.0	1431 (100)	0.992	—
345			Drought	-.005	-.008 (.105)	0.002	571 (395)	0.979	100
334		13	None	-.008	-.010 (.069)	0.0	488 (269)	0.981	—
346			Drought	-.034	-.042 (.128)	0.138	48 (59)	0.862	87
335		16	None	-.039	-.046 (.106)	0.182	29 (28)	0.830	91
347			Drought	-.065	-.079 (.170)	0.862	10 (6)	0.647	75
336		19	None	-.071	-.084 (.156)	0.950	8 (5)	0.617	74
348			Drought	-.097	-.113 (.191)	0.998	3 (0)	0.611	57

Table 3.3. Baird's tapir population analysis: initial population size = 60, K = 150.

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
349	20	10	None	.038	.036 (.066)	0.0	145 (9)	0.910	—
361			Drought	.011	.003 (.126)	0.090	85 (45)	0.812	67
350		13	None	.008	.003 (.091)	0.040	90 (44)	0.822	70
362			Drought	-.018	-.033 (.169)	0.646	26 (25)	0.618	64
351		16	None	-.022	-.038 (.156)	0.726	17 (15)	0.583	64
363			Drought	-.049	-.067 (.203)	0.966	8 (4)	0.435	47
352		19	None	-.054	-.073 (.193)	0.990	7 (4)	0.519	45
364			Drought	-.081	-.103 (.225)	1.0	—	—	30
353	25	10	None	.030	.027 (.069)	0.0	142 (12)	0.908	—
365			Drought	.004	-.005 (.133)	0.174	67 (45)	0.781	69
354		13	None	.000	-.007 (.105)	0.148	62 (42)	0.772	72
366			Drought	-.026	-.040 (.175)	0.762	17 (16)	0.609	61
355		16	None	-.030	-.045 (.162)	0.818	15 (13)	0.537	60
367			Drought	-.057	-.076 (.204)	0.990	10 (7)	0.496	44
356		19	None	-.062	-.083 (.199)	0.996	7 (6)	0.452	40
368			Drought	-.089	-.114 (.233)	1.0	—	—	30
357	30	10	None	.022	.019 (.072)	0.006	134 (24)	0.895	68
369			Drought	-.005	-.015 (.141)	0.282	45 (40)	0.738	68
358		13	None	-.008	-.017 (.122)	0.322	38 (31)	0.716	73
370			Drought	-.034	-.050 (.185)	0.870	12 (10)	0.559	57
359		16	None	-.039	-.055 (.174)	0.916	11 (8)	0.483	54
371			Drought	-.065	-.083 (.210)	0.996	7 (3)	0.572	40
360		19	None	-.071	-.093 (.207)	0.998	4 (0)	0.375	37
372			Drought	-.097	-.123 (.233)	1.0	—	—	28

Table 3.4. Baird's tapir population analysis: initial population size = 60, K = 150, 2.5% annual reduction in K over the first 20 years of the simulation (50% total reduction in K).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
373	20	10	None	.038	.034 (.075)	0.0	71 (6)	0.853	—
385			Drought	.011	.003 (.131)	0.106	47 (22)	0.767	69
374		13	None	.008	.001 (.099)	0.070	47 (21)	0.780	72
386			Drought	-.018	-.033 (.170)	0.646	20 (16)	0.615	65
375		16	None	-.022	-.035 (.154)	0.694	16 (14)	0.539	66
387			Drought	-.049	-.068 (.202)	0.972	8 (5)	0.397	46
376		19	None	-.054	-.075 (.196)	0.990	7 (5)	0.358	44
388			Drought	-.081	-.102 (.227)	1.0	—	—	33
377	25	10	None	.030	.025 (.077)	0.002	69 (9)	0.846	41
389			Drought	.004	-.007 (.139)	0.232	38 (22)	0.736	71
378		13	None	.000	-.007 (.108)	0.176	40 (20)	0.744	72
390			Drought	-.026	-.043 (.179)	0.796	15 (11)	0.533	61
379		16	None	-.030	-.047 (.167)	0.868	12 (11)	0.508	60
391			Drought	-.057	-.081 (.211)	0.994	6 (3)	0.432	41
380		19	None	-.062	-.083 (.199)	0.996	2 (0)	0.313	40
392			Drought	-.089	-.112 (.228)	0.998	8 (0)	0.219	30
381	30	10	None	.022	.017 (.080)	0.008	65 (14)	0.837	80
393			Drought	-.005	-.016 (.147)	0.350	29 (21)	0.694	72
382		13	None	-.008	-.017 (.122)	0.312	28 (18)	0.680	69
394			Drought	-.034	-.049 (.183)	0.868	13 (10)	0.567	56
383		16	None	-.039	-.056 (.172)	0.932	10 (9)	0.462	55
395			Drought	-.065	-.085 (.208)	0.996	13 (16)	0.239	39
384		19	None	-.071	-.091 (.201)	1.0	—	—	33
396			Drought	-.097	-.123 (.231)	1.0	—	—	28

Table 3.5. Baird's tapir population analysis: initial population size = 60, K = 150; inbreeding depression (heterosis, 3.14 lethal equivalents).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
397	20	10	None	.038	.027 (.066)	0.0	140 (13)	0.910	—
409			Drought	.011	-.012 (.132)	0.280	51 (41)	0.800	73
398		13	None	.008	-.016 (.109)	0.315	43 (33)	0.800	78
410			Drought	-.018	-.053 (.178)	0.930	9 (8)	0.683	60
399		16	None	-.022	-.055 (.167)	0.965	10 (5)	0.584	61
411			Drought	-.049	-.082 (.203)	1.0	—	—	42
400		19	None	-.054	-.087 (.196)	1.0	—	—	40
412			Drought	-.081	-.118 (.229)	1.0	—	—	30
401	25	10	None	.030	.017 (.071)	0.005	125 (32)	0.898	71
413			Drought	.004	-.020 (.140)	0.405	38 (34)	0.778	75
402		13	None	.000	-.024 (.123)	0.475	28 (26)	0.738	79
414			Drought	-.026	-.057 (.185)	0.960	11 (8)	0.669	56
403		16	None	-.030	-.065 (.176)	1.0	—	—	53
415			Drought	-.057	-.089 (.203)	1.0	—	—	38
404		19	None	-.062	-.097 (.199)	1.0	—	—	35
416			Drought	-.089	-.121 (.234)	1.0	—	—	29
405	30	10	None	.022	.008 (.075)	0.025	101 (40)	0.879	84
417			Drought	-.005	-.032 (.151)	0.630	25 (30)	0.735	74
406		13	None	-.008	-.037 (.141)	0.755	17 (15)	0.682	71
418			Drought	-.034	-.066 (.188)	0.980	5 (3)	0.554	50
407		16	None	-.039	-.073 (.180)	1.0	—	—	47
419			Drought	-.065	-.097 (.213)	1.0	—	—	35
408		19	None	-.071	-.104 (.200)	1.0	—	—	33
420			Drought	-.097	-.128 (.228)	1.0	—	—	27

Table 3.6. Baird's tapir population analysis: initial population size = 60, K = 150, 2.5% annual reduction in K over the first 20 years of the simulation (50% total reduction in K); inbreeding depression (heterosis, 3.14 lethal equivalents).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
421	20	10	None	.038	.023 (.075)	0.0	64 (13)	0.852	—
433			Drought	.011	-.013 (.139)	0.345	27 (19)	0.743	76
422		13	None	.008	-.019 (.118)	0.380	22 (16)	0.729	78
434			Drought	-.018	-.051 (.180)	0.935	9 (6)	0.567	61
423		16	None	-.022	-.054 (.165)	0.965	5 (3)	0.490	59
435			Drought	-.049	-.078 (.203)	0.995	5 (0)	0.780	43
424		19	None	-.054	-.083 (.190)	1.0	—	—	40
436			Drought	-.081	-.115 (.233)	1.0	—	—	31
425	25	10	None	.030	.013 (.078)	0.015	55 (18)	0.839	95
437			Drought	.004	-.025 (.148)	0.545	19 (15)	0.715	77
426		13	None	.000	-.026 (.128)	0.515	16 (12)	0.682	78
438			Drought	-.026	-.055 (.180)	0.965	7 (3)	0.675	59
427		16	None	-.030	-.063 (.170)	1.0	—	—	53
439			Drought	-.057	-.090 (.209)	1.0	—	—	38
428		19	None	-.062	-.095 (.202)	1.0	—	—	36
440			Drought	-.089	-.121 (.224)	1.0	—	—	29
429	30	10	None	.022	.003 (.087)	0.070	45 (21)	0.819	87
441			Drought	-.005	-.033 (.154)	0.680	15 (15)	0.645	71
430		13	None	-.008	-.037 (.141)	0.745	11 (11)	0.639	72
442			Drought	-.034	-.063 (.184)	0.960	6 (3)	0.629	50
431		16	None	-.039	-.071 (.178)	1.0	—	—	48
443			Drought	-.065	-.094 (.212)	1.0	—	—	36
432		19	None	-.071	-.101 (.202)	1.0	—	—	34
444			Drought	-.097	-.130 (.232)	1.0	—	—	27

Figure Legends

Figure 3.1. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20%. Initial population size is 1200 and the carrying capacity is 3000. The four curves in each plot correspond to the four levels of adult mortality modelled in the simulations: 10%, 13%, 16%, and 19%. These symbols remain constant throughout the figures.

Figure 3.2. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25%. Initial population size is 1200 and the carrying capacity is 3000.

Figure 3.3. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30%. Initial population size is 1200 and the carrying capacity is 3000.

Figure 3.4. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20% and the addition of drought. Initial population size is 1200 and the carrying capacity is 3000.

Figure 3.5. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25% and the addition of drought. Initial population size is 1200 and the carrying capacity is 3000.

Figure 3.6. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30% and the addition of drought. Initial population size is 1200 and the carrying capacity is 3000.

Figure 3.7. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20%. Initial population size is 60 and the carrying capacity is 150.

Figure 3.8. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25%. Initial population size is 60 and the carrying capacity is 150.

Figure 3.9. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30%. Initial population size is 60 and the carrying capacity is 150.

Figure 3.10. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20% and the addition of drought. Initial population size is 60 and the carrying capacity is 150.

Figure 3.11. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25% and the addition of drought. Initial population size is 60 and the carrying capacity is 150.

Figure 3.12. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30% and the addition of drought. Initial population size is 60 and the carrying capacity is 150.

Figure 3.13. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20%. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 3.14. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25%. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 3.15. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30%. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 3.16. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20% and the addition of drought. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 3.17. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25% and the addition of drought. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 3.18. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30% and the addition of drought. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 3.19. Effect of varying different population parameters on probability of extinction in simulated Baird's tapir populations. Each bar in the graph gives the probability of extinction averaged over all scenarios with the given parameter value.

Figure 1. Juvenile Mortality = 20%
$N_0 = 1200, K = 3000$

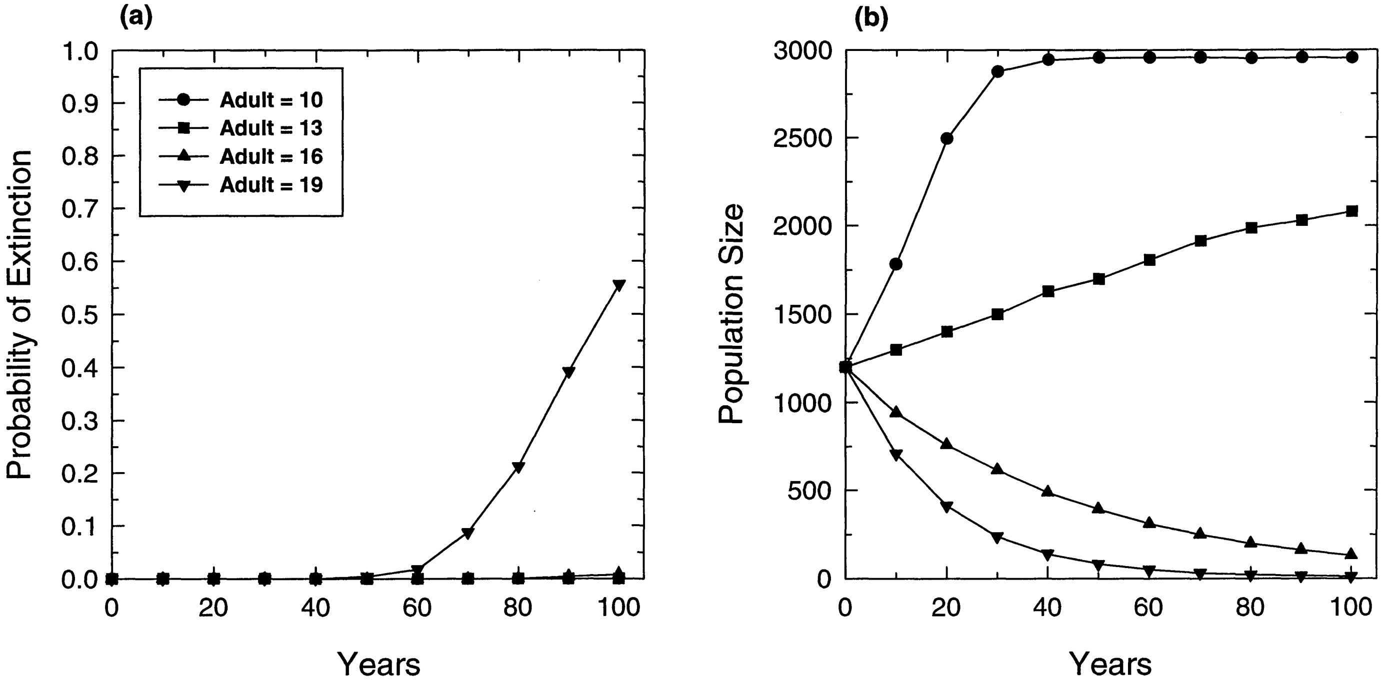


Figure 2. Juvenile Mortality = 25%
$N_0 = 1200, K = 3000$

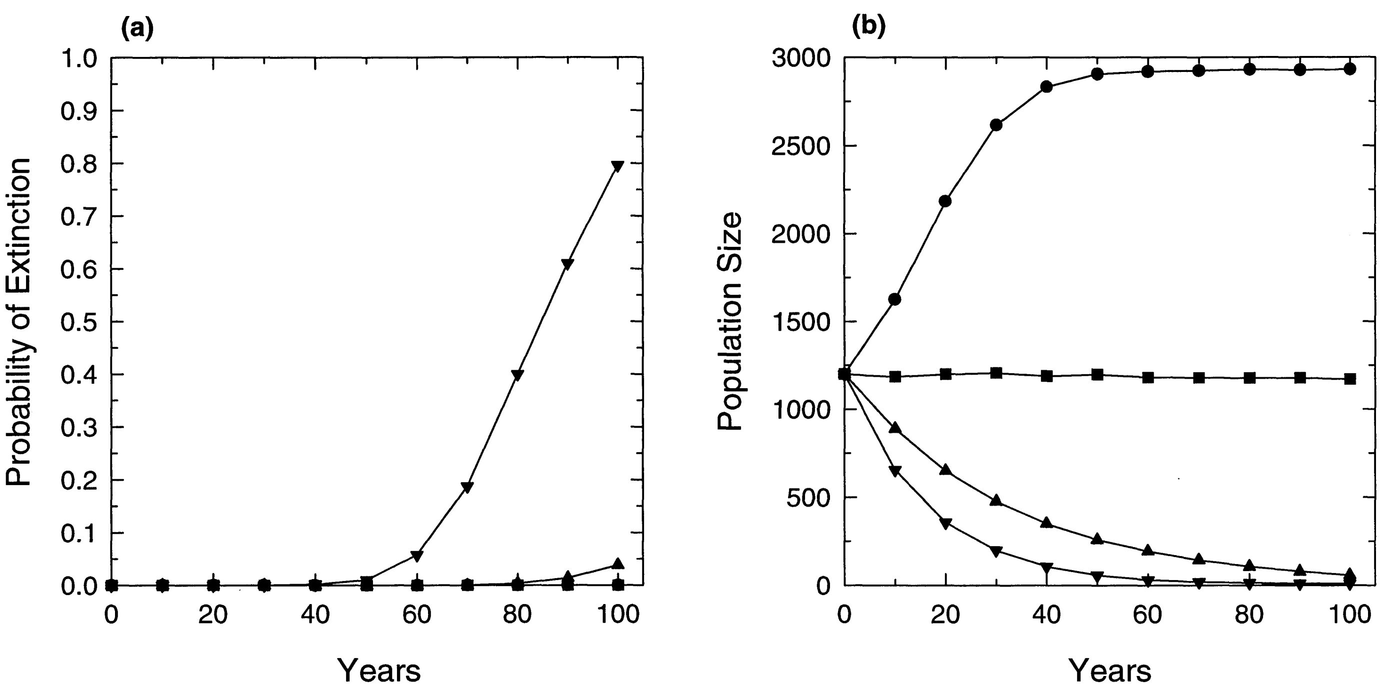


Figure 3. Juvenile Mortality = 30%
N_0 = 1200, K = 3000

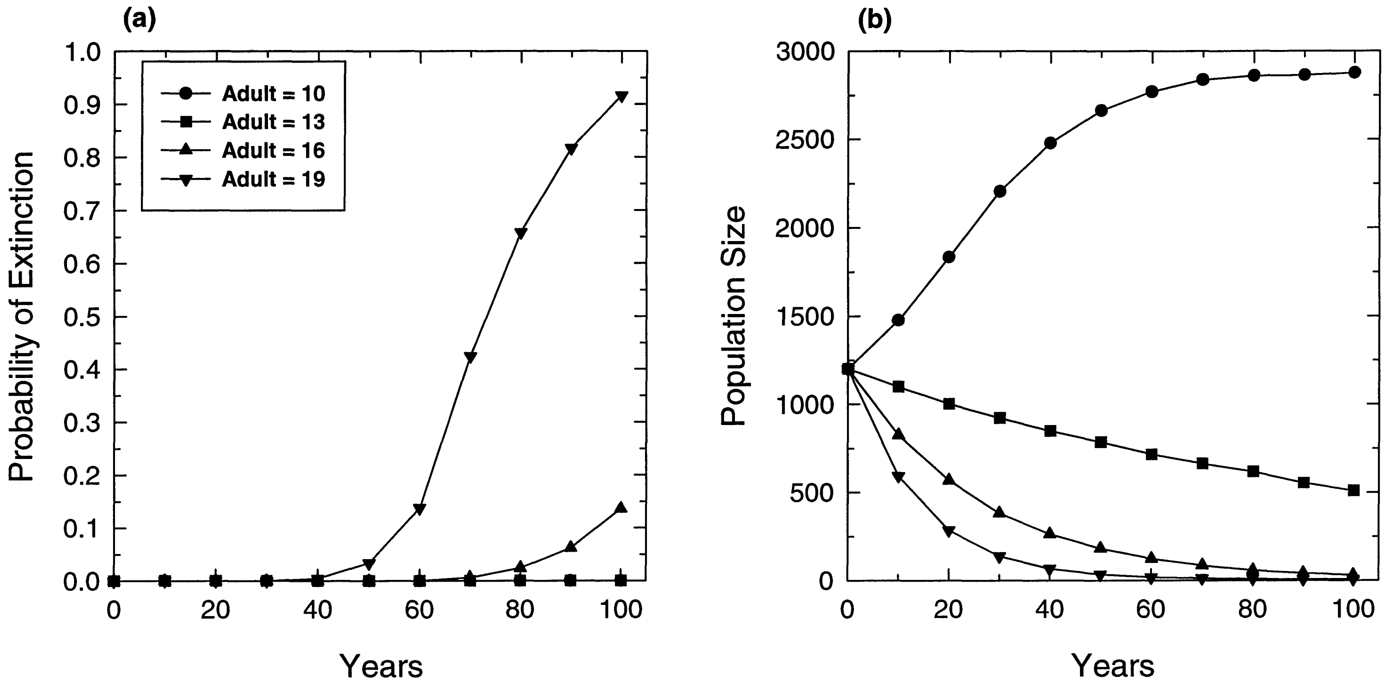


Figure 4. Juvenile Mortality = 20%
N_0 = 1200, K = 3000; Drought

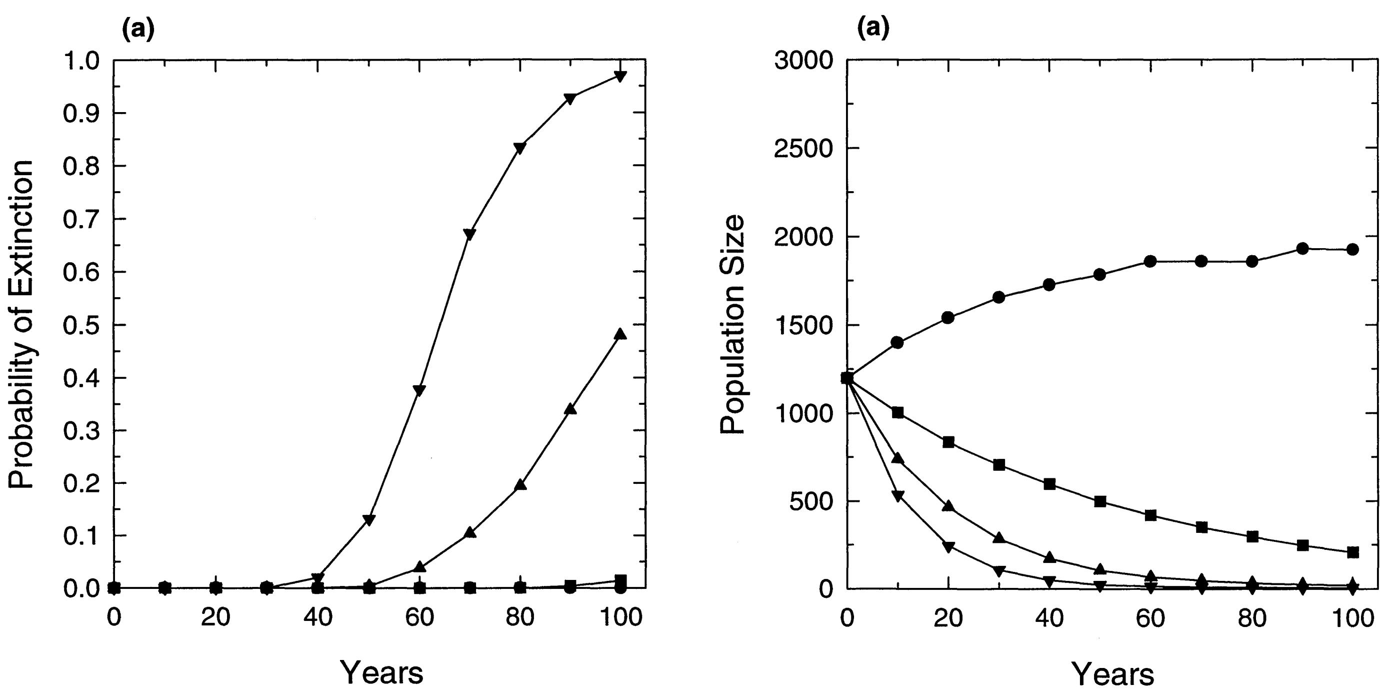


Figure 5. Juvenile Mortality = 25%
N_0 = 1200, K = 3000; Drought

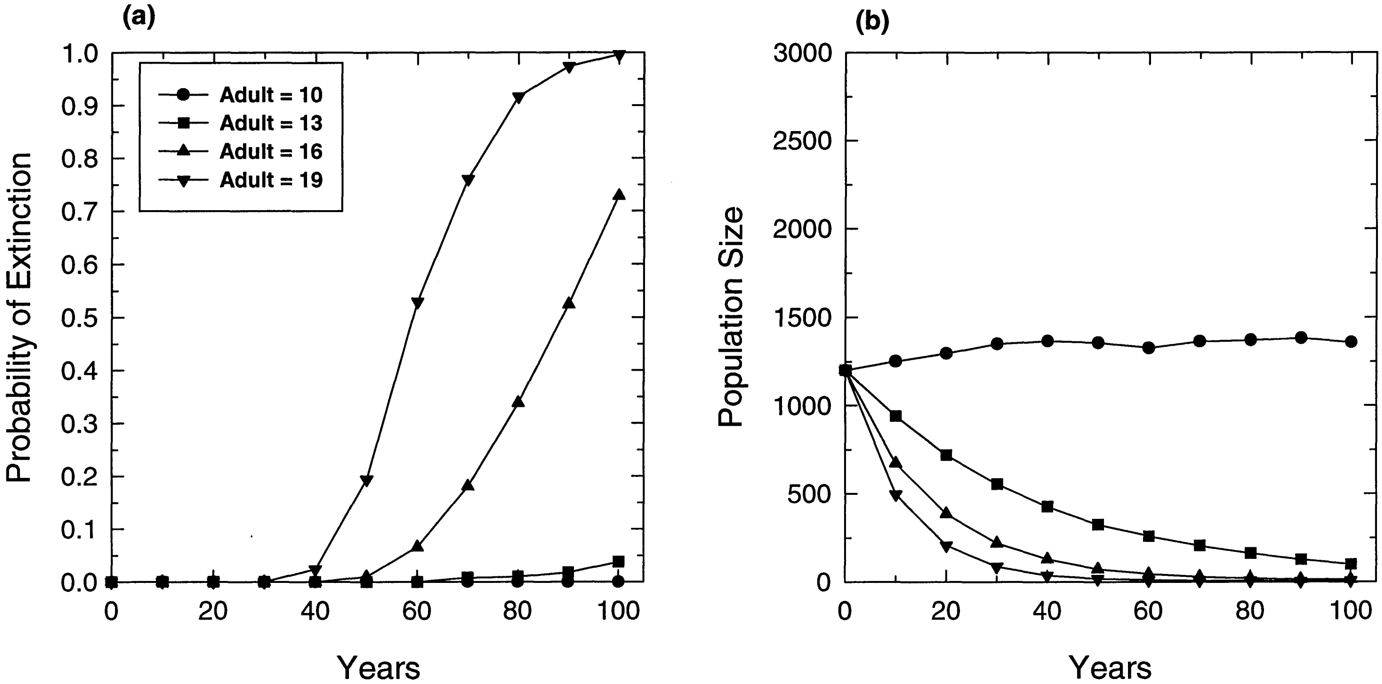


Figure 6. Juvenile Mortality = 30%
N_0 = 1200, K = 3000; Drought

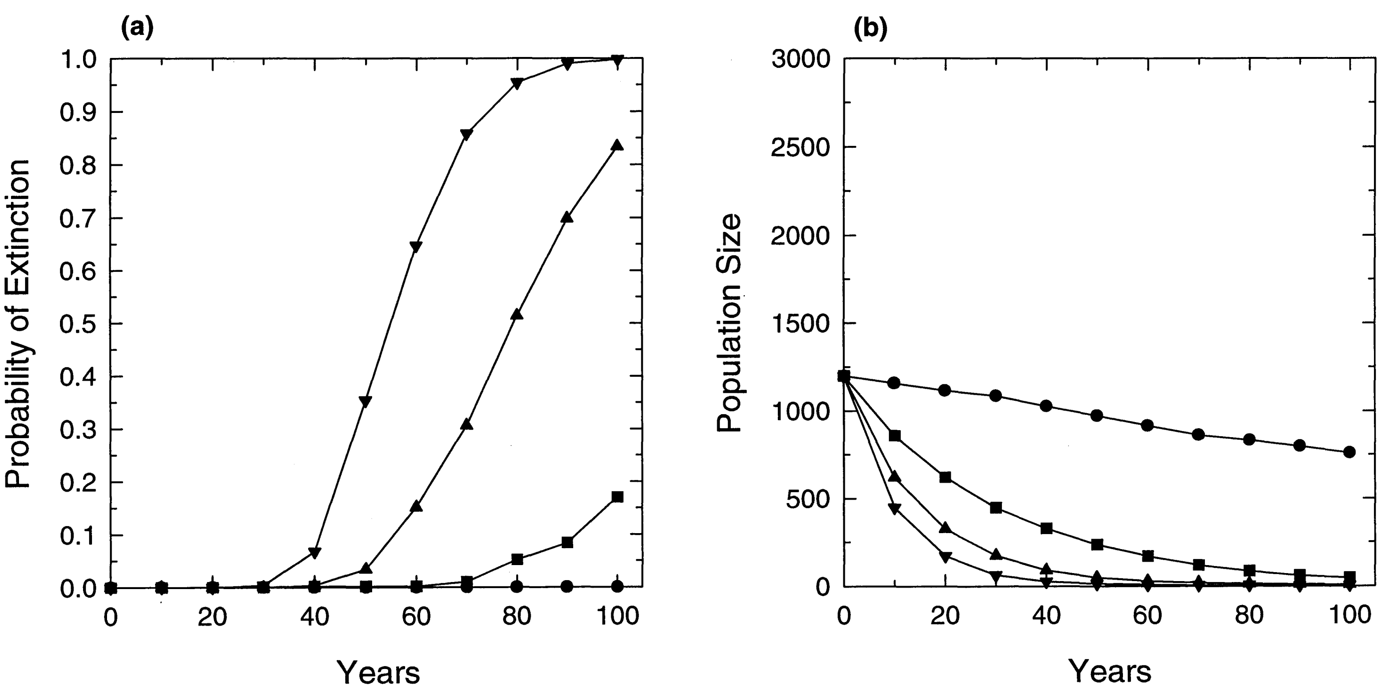


Figure 7. Juvenile Mortality = 20%
$N_0 = 60$, K = 150

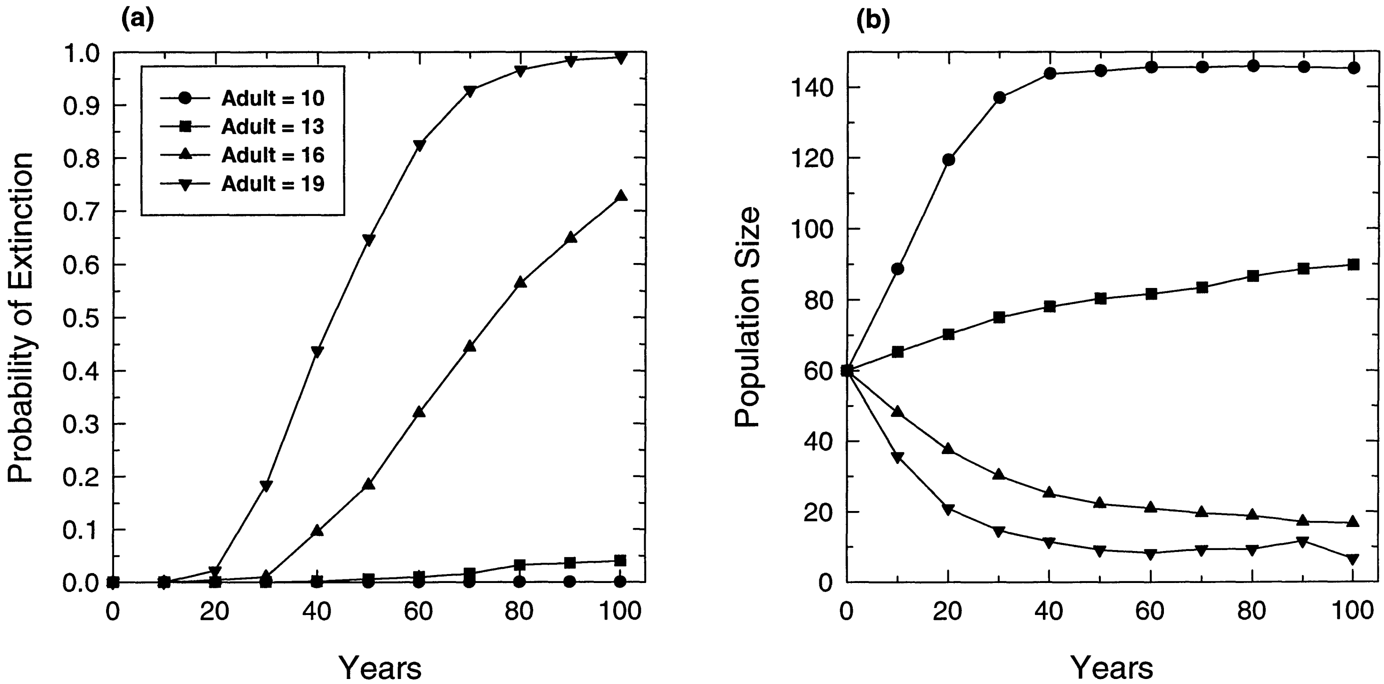


Figure 8. Juvenile Mortality = 25%
$N_0 = 60$, K = 150

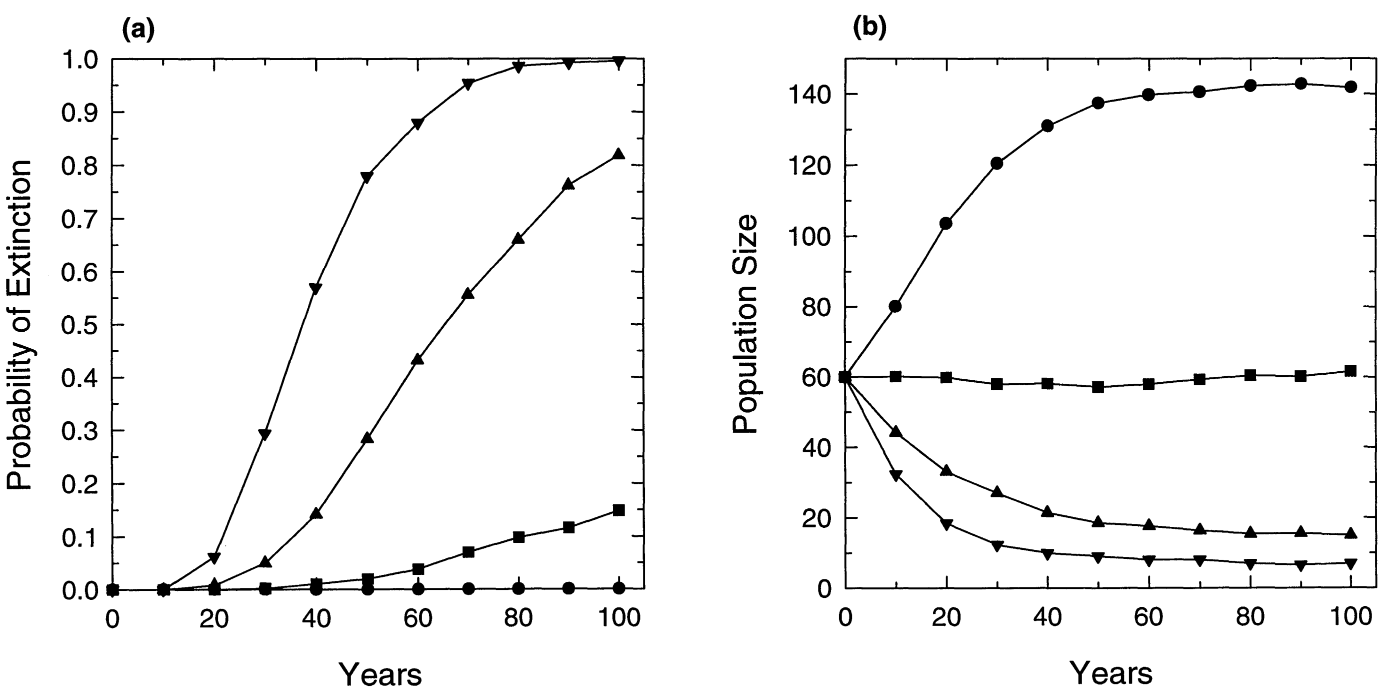


Figure 9. Juvenile Mortality = 30%
N_0 = 60, K = 150

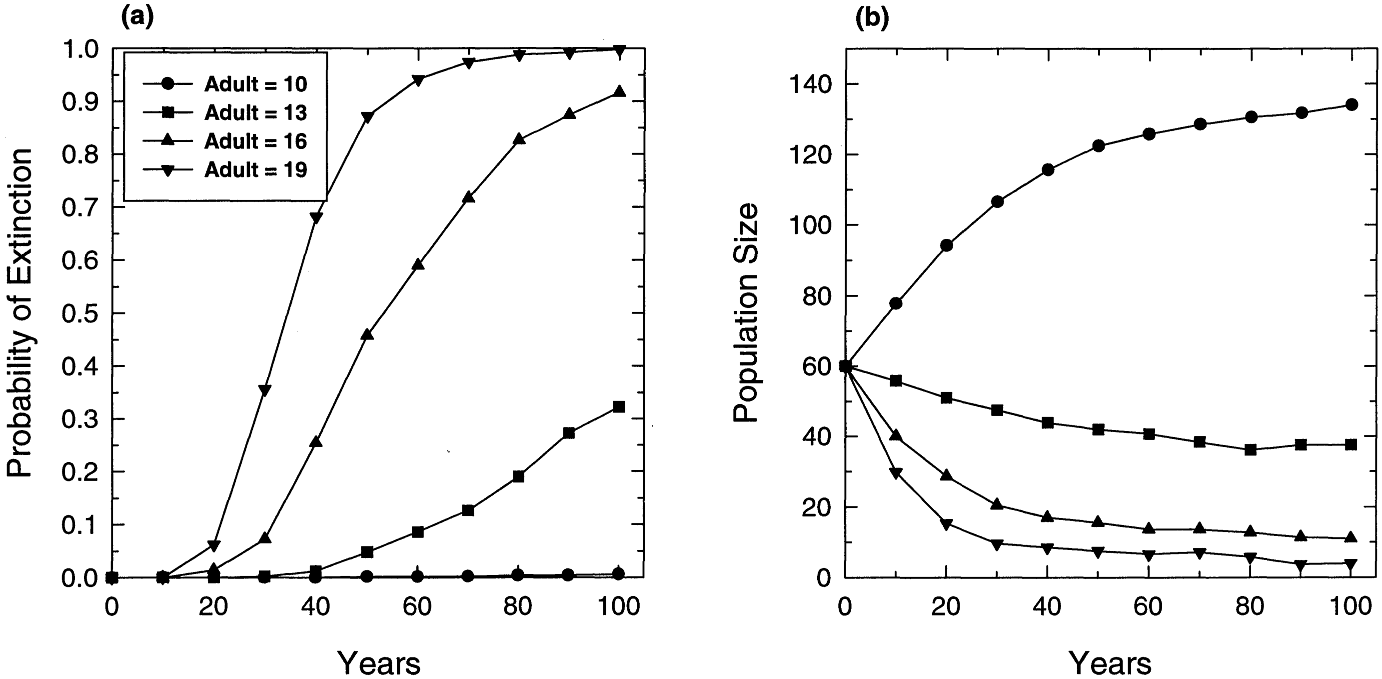


Figure 10. Juvenile Mortality = 20%
N_0 = 60, K = 150; Drought

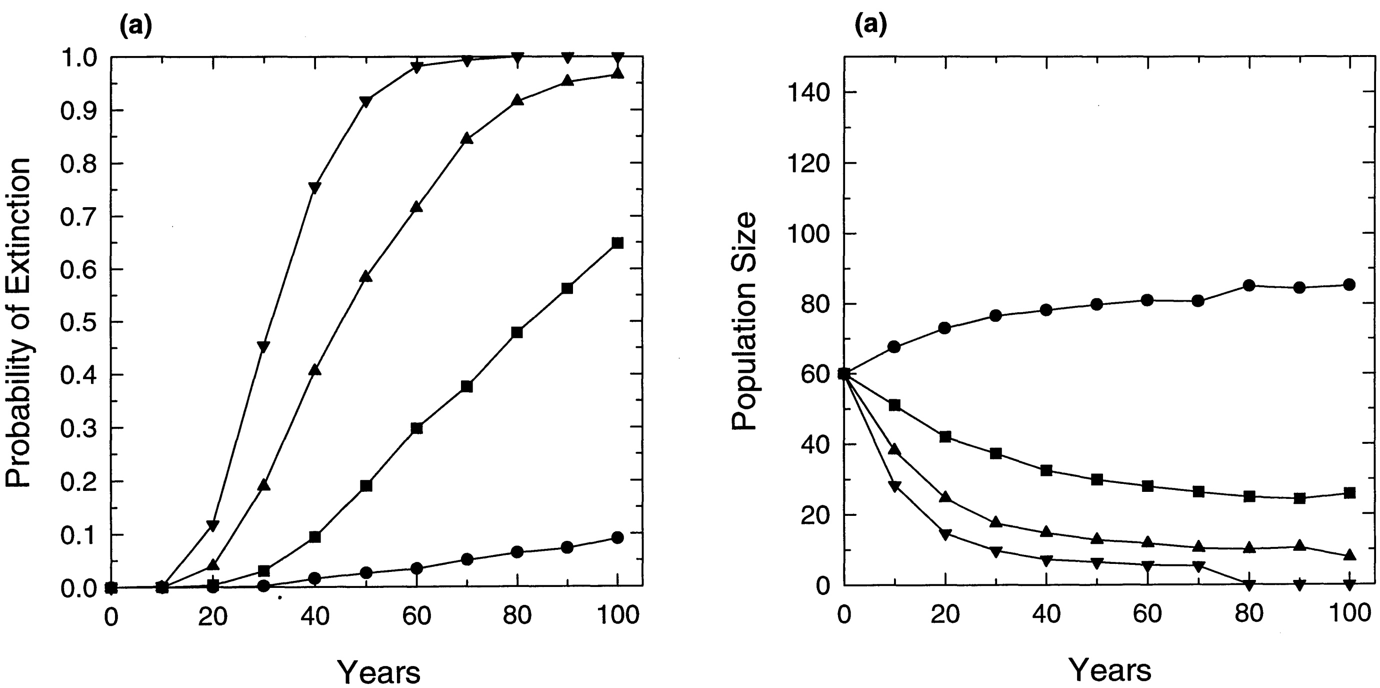


Figure 11. Juvenile Mortality = 25%
N_0 = 60, K = 150; Drought

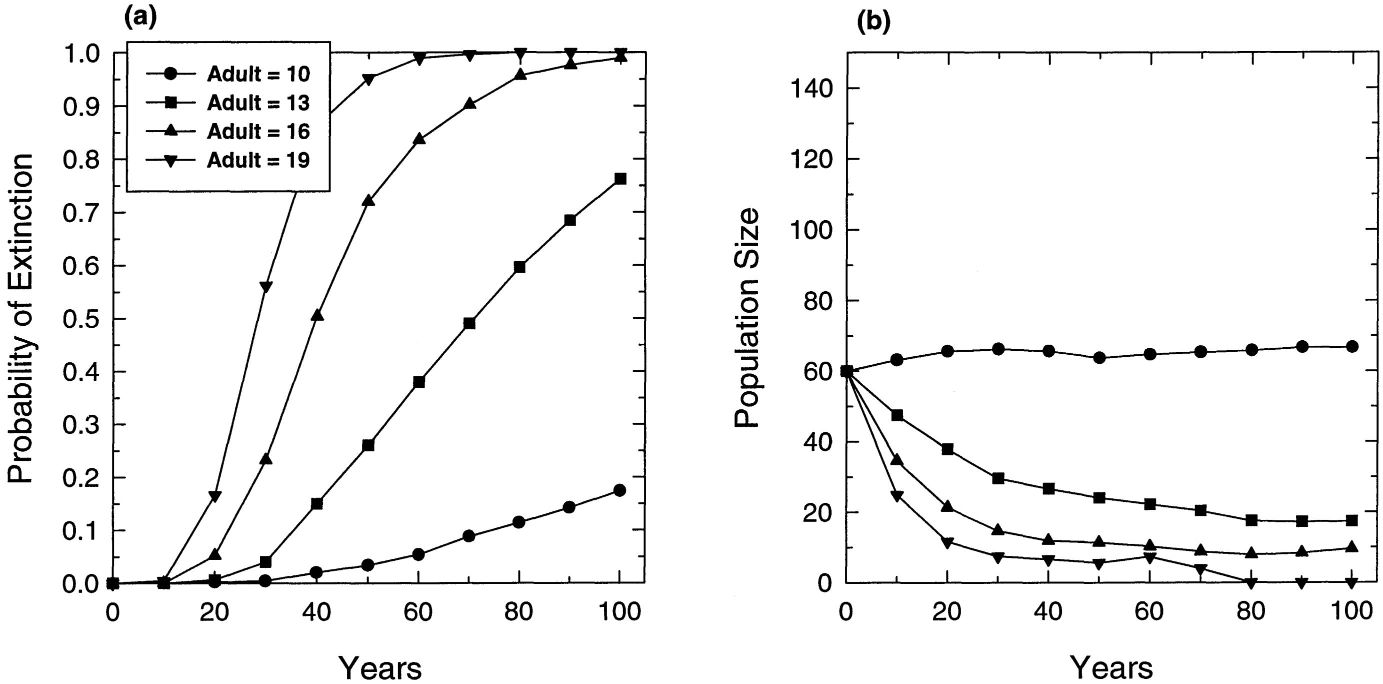


Figure 12. Juvenile Mortality = 30%
N_0 = 60, K = 150; Drought

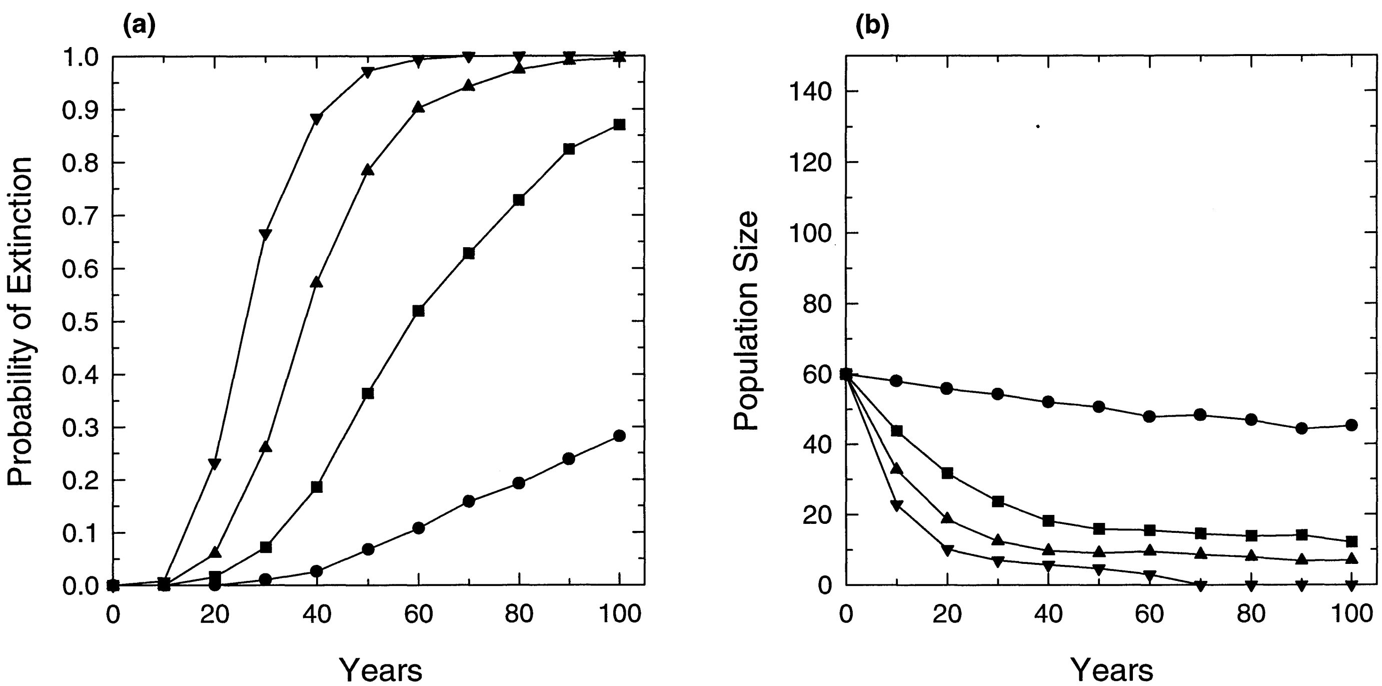


Figure 13. Juvenile Mortality = 20%
N_0 = 60, K = 150; Inbreeding Depression

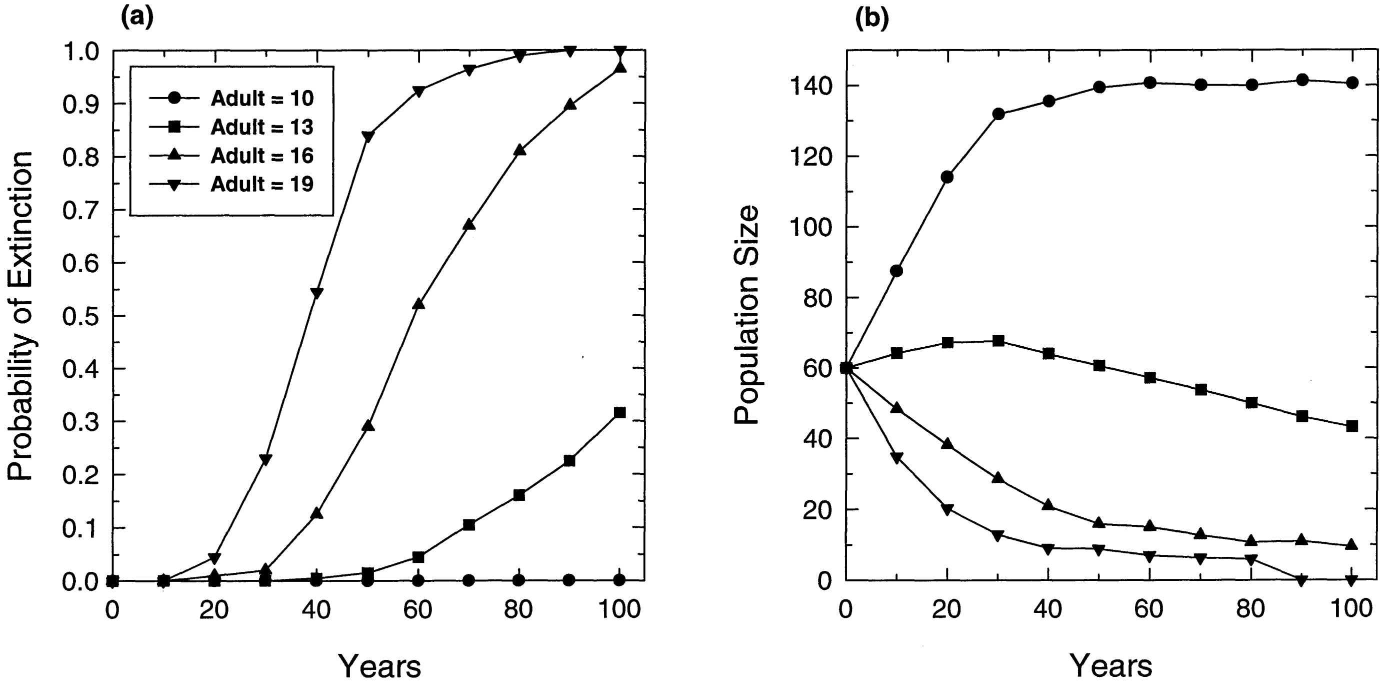


Figure 14. Juvenile Mortality = 25%
N_0 = 60, K = 150; Inbreeding Depression

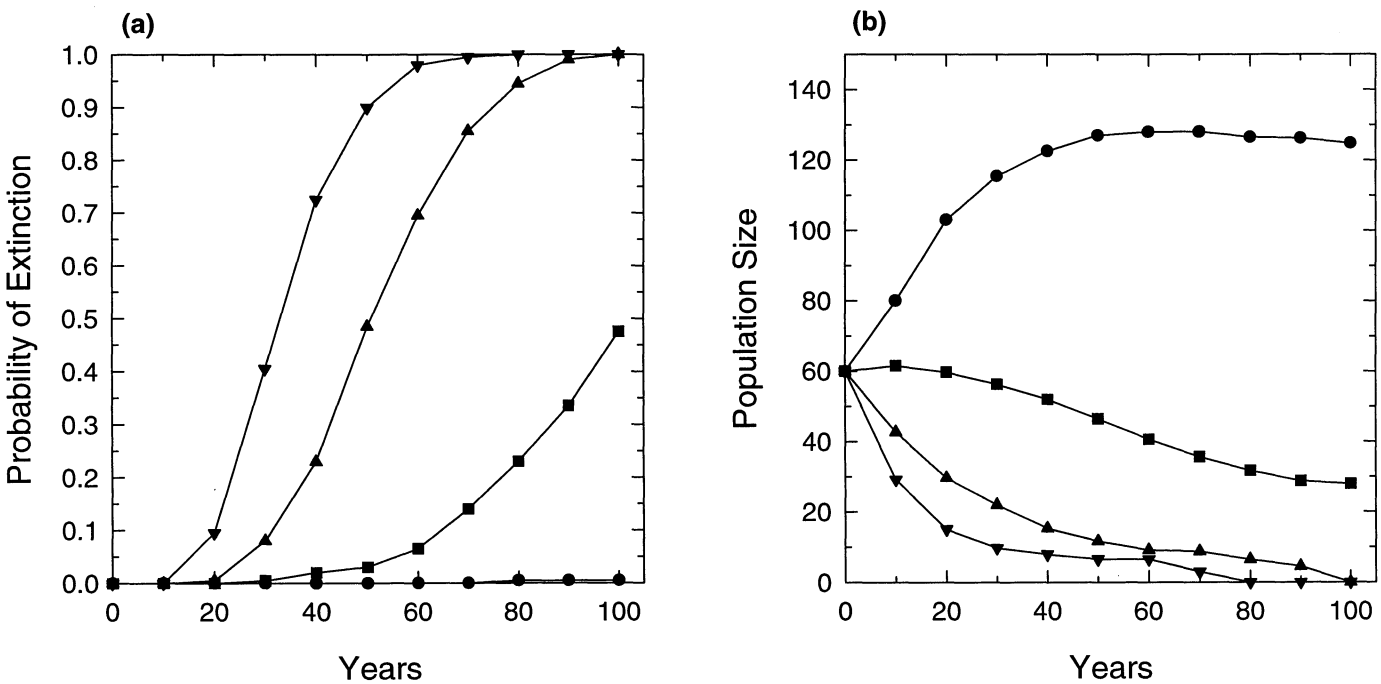


Figure 15. Juvenile Mortality = 30%
N_0 = 60, K = 150; Inbreeding Depression

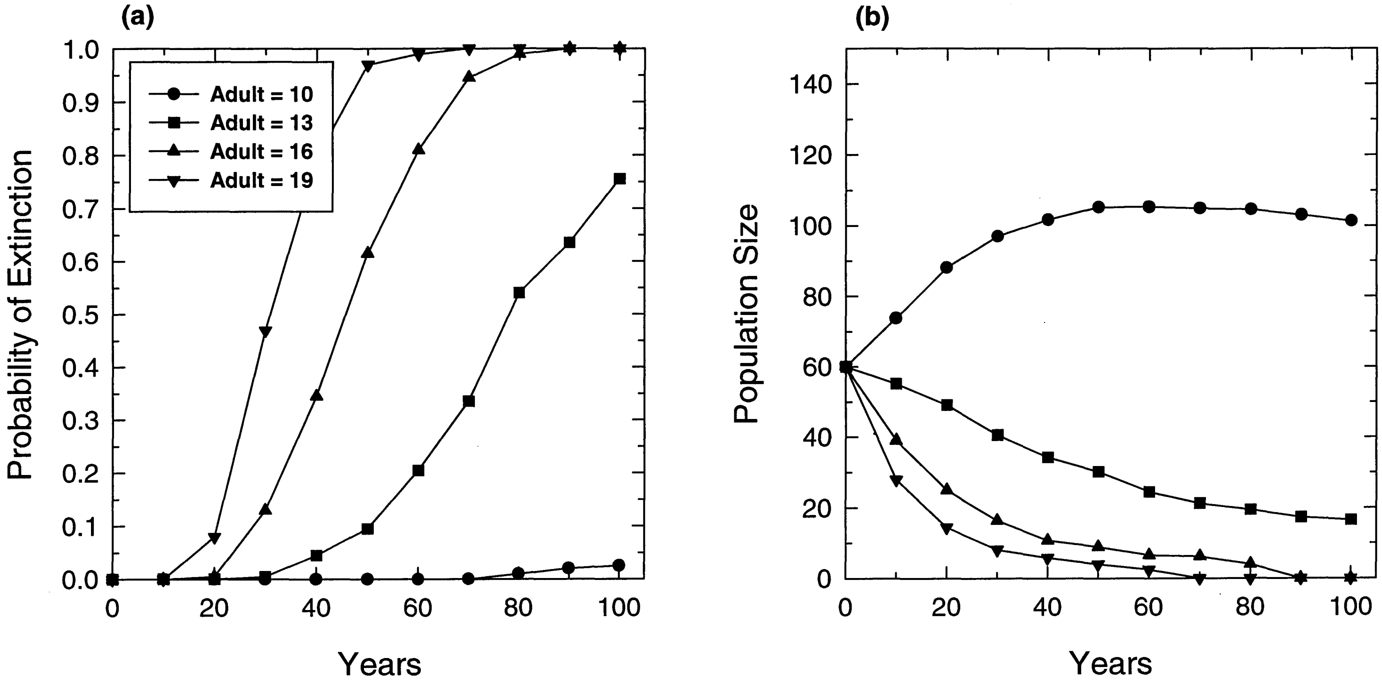


Figure 16. Juvenile Mortality = 20%
N_0 = 60, K = 150; Drought; Inbreeding Depression

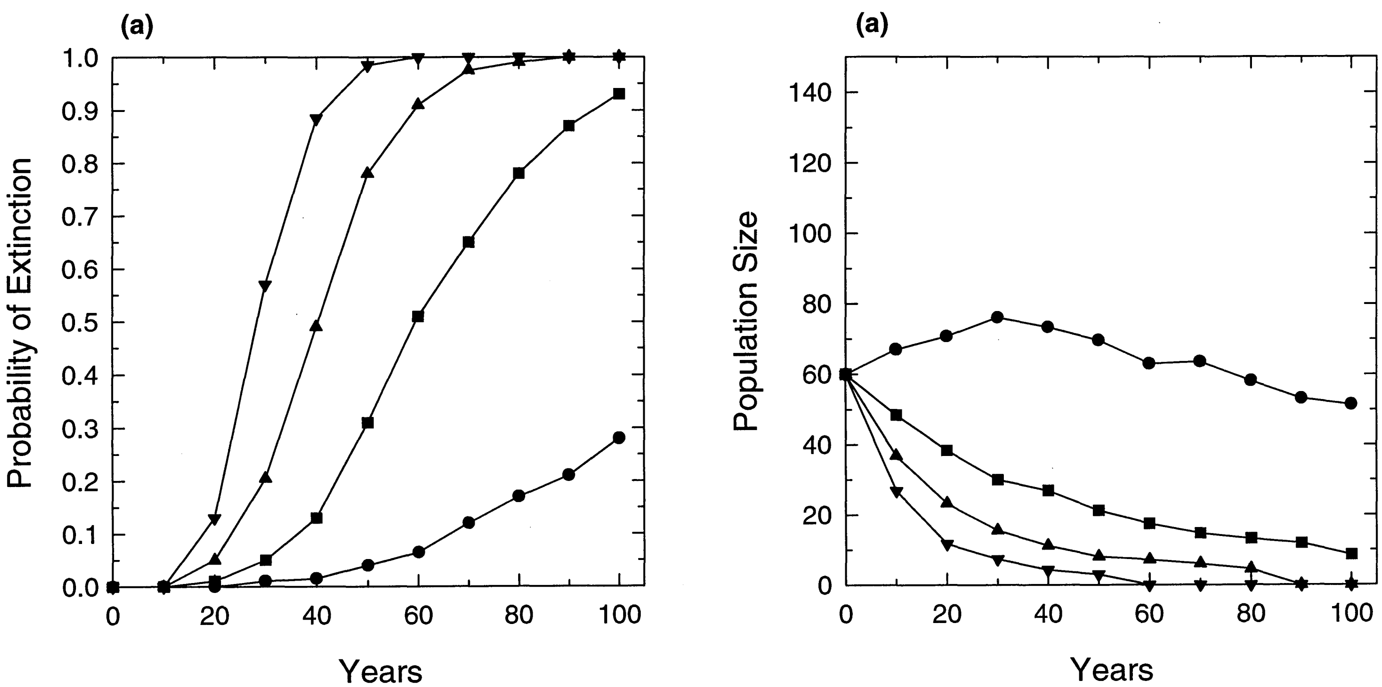


Figure 17. Juvenile Mortality = 25%
N_0 = 60, K = 150; Drought; Inbreeding Depression

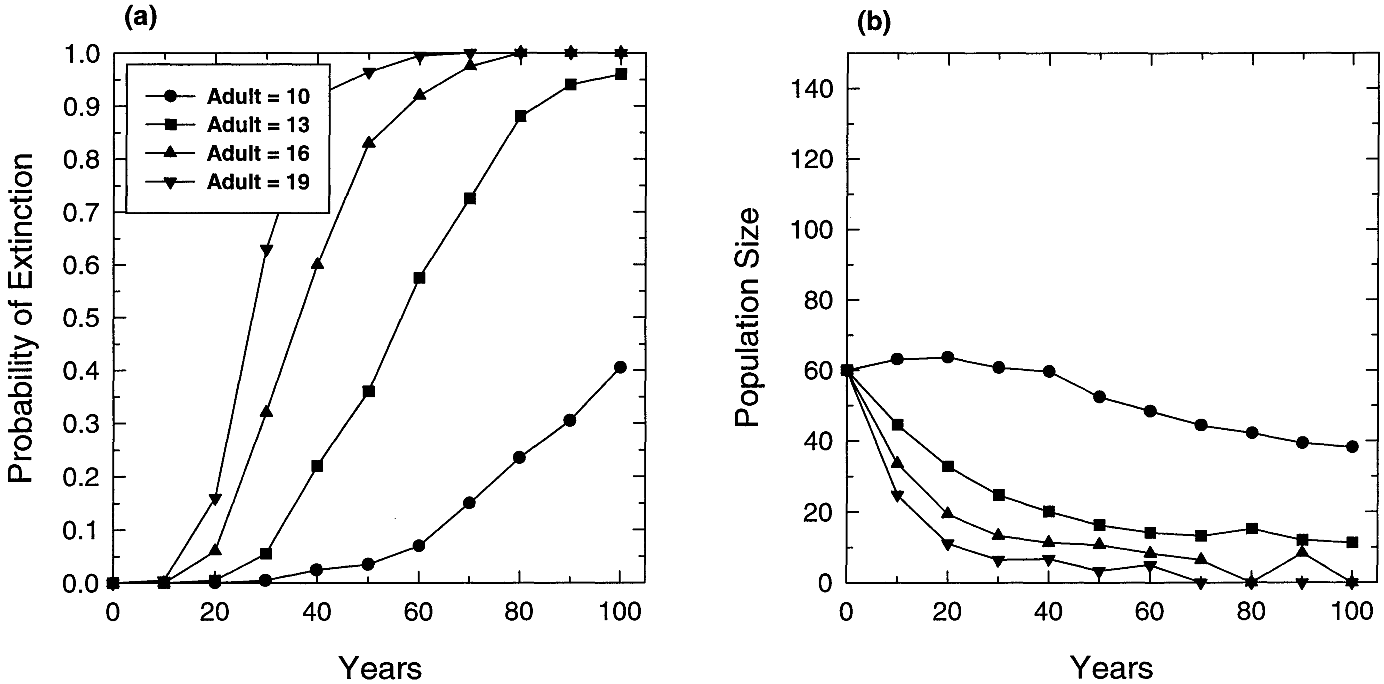


Figure 18. Juvenile Mortality = 30%
N_0 = 60, K = 150; Drought; Inbreeding Depression

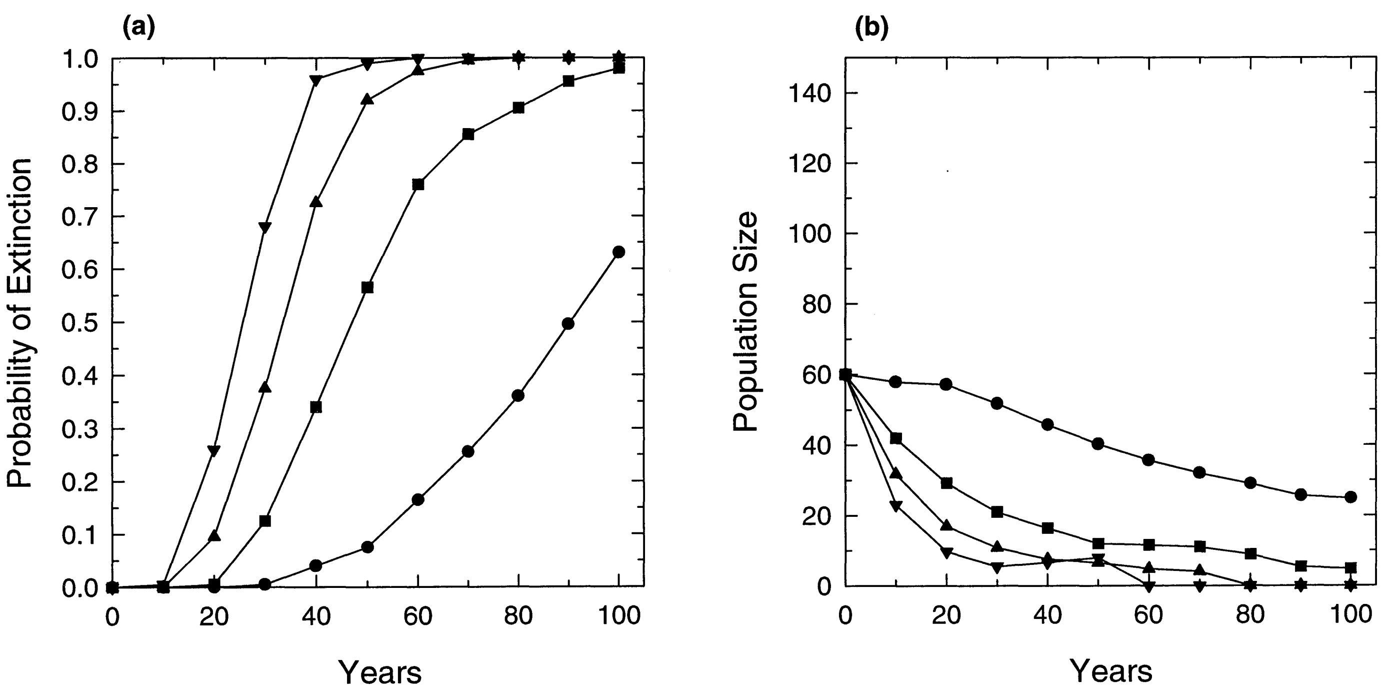
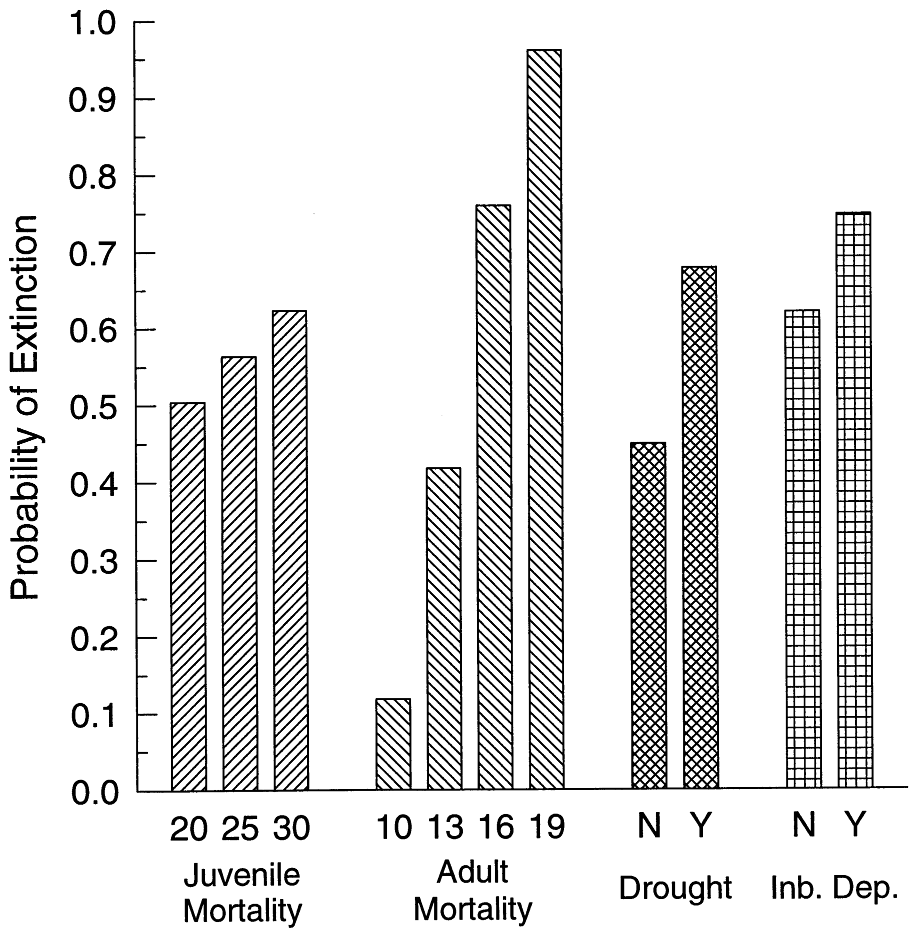
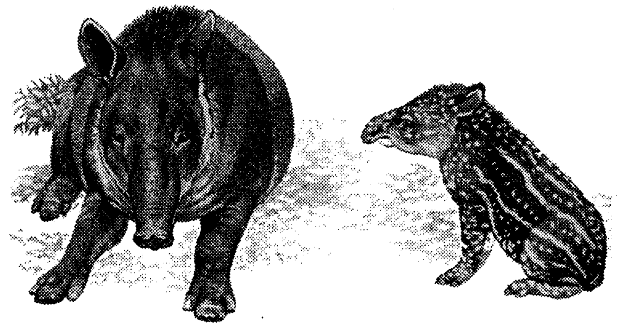


Figure 19.
Sensitivity Analysis:
Probability of Extinction



EVALUACIÓN DE VIABILIDAD DE POBLACION Y HABITAT DEL MACHO DE MONTE (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994



Sección 4
Poblaciones en Cautiverio

POBLACIONES EN CAUTIVERIO DEL MACHO DE MONTE

Metas Primarias del Manejo en Cautiverio del Tapir

I. Establecer programas educativos que actúen localmente, nacionalmente, gubernamentalmente e internacionalmente.
II. Establecer un programa coordinado de reproducción en cautiverio en Panamá.
III. Desarrollar programas de estudio e investigación que beneficien al tapir en Panamá.
IV. Establecer metas para la reintroducción.

I. Educación

A. Local

1. Inicialmente los gastos tendrán que ser reducidos a un mínimo.
2. Desarrollar programas educativos para los tapires en exhibición en Panamá (actualmente en el Níspero y en los Jardines de la Cúspide.
3. Desarrollar programas de "alcance" dirigidos a las personas que habitan en aquellas áreas donde existe el tapir en Panamá. Incrementar la conciencia y apreciación de la especie en estas áreas. Comunicar los efectos devastadores de la cacería furtiva sobre las poblaciones del tapir. Algunos ejemplos de este tipo de programas son los siguientes:
   a. Desarrollar programas en la radio dirigidos a las personas que habitan áreas correspondientes al hábitat del tapir.
   b. Donación por parte de organizaciones internacionales de material educativo a ONG's, personal de instituciones gubernamentales, investigadores extranjeros y voluntarios, quienes puedan distribuir estos materiales a los residentes de estas áreas.
   c. Será necesario desarrollar procesos similares para otros voluntarios que trabajen en el hábitat del tapir.
   d. El Comité Panameño del Tapir será responsable de mantener informados a estos trabajadores para que sean embajadores adecuados del tapir.

B. Nacional.

1. Crear una publicación periódica que resuma las actividades concernientes a los tapires de Panamá, tanto en vida silvestre como en cautiverio.
   a. El Comité deberá decidir como esta publicación será creada, escrita y distribuida.
   b. El Comité deberá de explorar la oferta del Smithsonian de proporcionar material de oficina e instalaciones para las juntas concernientes a las actividades de la publicación periódica y el Comité.
2. Anticipar la necesidad de educar al público Panameño de la necesidad de intercambiar selectivamente tapires a otros países con el propósito de intercambios genéticos. Estar preparado para desarrollar programas para educar tanto al público general como a oficiales clave.
3. Referirse a la Sección de Educación Local para otras ideas aplicables.

C. <u>Gubernamental</u>.

1. Identificar todas las agencias gubernamentales que necesiten ser informadas y actualizadas. Algunos ejemplos son:
   a. Dirección Nacional de Sanidad Animal, Ministerio de Desarrollo Agropecuario.
   b. Departamento de Salud Pública, Ministerio de Salud.
   c. Laboratorio Conmemorativo Gorgas, Ministerio de Salud.
   d. INRENARE, Departamento de Bosques, Departamento de Parques.
   e. Facultad de Agronomía, Departamento de Zootecnia, Universidad de Panamá.
   f. Fuerza Pública.
2. Identificar otras instituciones/organizaciones a las que sea necesario mantener informadas.
   a. Instituto Tropical de Investigación del Smithsonian.
   b. División Veterinaria, Comando Sur, Ejército de los Estados Unidos.
3. Distribuir los Resúmenes Ejecutivos del PHVA y CAMP para Tapires en Español tanto a agencias como a oficiales claves.

D. <u>Internacional.</u>

Comunicarse con operadores de tours, hoteles locales, y otros elementos de la industria turística. Proporcionar materiales que muestren como es que los tapires están en peligro de extinción, por que son animales importantes y que señalen que son nuestra especie "bandera" a nivel nacional. Hacer disponible este material tanto a eco-turistas como a turistas "normales" para que puedan observar estos animales en cautiverio o en condiciones semi-naturales.

E. Establecer programas de entrenamiento para veterinarios de vida silvestre o para manejadores de vida silvestre con el objeto de desarrollar conocimiento experto a nivel nacional.

1. Identificar proyectos de investigación que puedan ser desarrollados por biólogos y candidatos a veterinarios Panameños, utilizando y beneficiando tapires en cautiverio (por ejemplo, nutrición, censos de enfermedades y reproducción).
2. Organizar visitas a otros países e instituciones expertas en el mantenimiento y medicina del tapir para desarrollar programas de entrenamiento avanzados.
3. Hacer disponible en Panamá la información científica existente sobre el tapir y traducirla al Español. Producir versiones en Español de artículos de manejo, la bibliografía para Tapiridae y los documentos CAMP y PHVA. Algunas de las localidades en las que se podría mantener esta información son:
   a. Biblioteca del Laboratorio Conmemorativo Forgas, Fax 225-4366.
   b. Biblioteca del Instituto Smithsonian de Investigaciones Tropicales, Unidad 0948, APO AA 34002-0948.
   c. Biblioteca de la Universidad de Panamá.
   d. Centro de Documentación INRENARE, Paraíso, Areas Revertidas.
   e. Centro de Información ANCON, Calle Alberto Navarro, El Cangrejo.
   f. Centro de Información sobre el Medio Ambiente (CIMA).
   g. Biblioteca, Parque Natural Metropolitano.

II. Reproducción en Cautiverio: Mantenimiento

A. Tapires actualmente en cautiverio en Panamá:

Jardines Cúspide (2 machos, 3 hembras)

Sexo	*Nombre*	*Fecha de Nacimiento*	*Número ID*
Macho	Macho	1986	11A055
Macho	Premier	Junio 29, 1992	1C121D
Hembra	Bell Bell	1986	13A6DA
Hembra	Juanita	1988	2413B8
Hembra	Chiquita	Septiembre, 1990	1DB98E
Parejas actuales:	Macho y Bell Bell; Premier y Chiquita		
Veterinario:	Anabel de Julio, teléfono: 32-4854		

El Níspero, El Valle

Sexo	*Nombre*	*Fecha de Nacimiento*	*Número ID*
Macho	Noriega	1982	14699F
Macho	Galen	1991	11F5F8
Macho	San Diego	Mayo, 1990	240219
Hembra	Mónica	1983	1C0C08
Parejas actuales:	Galen (11F5F8) y Mónica (Octubre 1994).		
Dueño:	Pablo Caballero, teléfono: 507 - 93-6142 o 23-8720		
Responsable:			

Villa Griselda, El Valle

Sexo	*Nombre*	*Fecha de Nacimiento*	*Numero ID.*
Macho		1990	4D9F69
Hembra		Octubre, 1992	1E9969D
Pareja Actual:	Macho ("Shakespere") nacido en Junio 8, 1995 de esta pareja.		
Dueño:	Jaime Padilla Beliz, Fax: 507-269-6954		
Responsable: Andrés.			

B. Los tapires existentes en cautiverio deben de ser manejados como un solo grupo y deben de mantenerse en múltiples centros cooperativos.

C. Establecer el Comité Panameño del Tapir quien tendrá la responsabilidad de decidir el manejo de los tapires en cautiverio en Panamá y las transferencias de animales que sean necesarias.

1. Este Comité deberá ser dirigido por un representante del INRENARE.
2. Los miembros núcleo incluirán representantes de cada una de las instituciones que cuente con tapires (actualmente Villa Griselda, El Níspero y los Jardines Cumbre).
3. Podrán ser invitados a participar en el Comité como miembros adicionales, representantes de las siguientes organizaciones:
   Asociación de Médicos Veterinarios de Panamá
   Instituto Smithsonian de Investigación Tropical
   Colegio de Biólogos de Panamá.

ANCON
Universidad de Panamá
Sociedad Protectora de Animales.

4. La estructura exacta de este Comité será determinada por los miembros núcleo.
5. Sugerimos que las decisiones principales adoptadas por este grupo sean endosadas por el jefe del INRENARE y por la oficina del Mayor.

D. Determinar prioridades para la población en cautiverio.
   1. Desarrollar un plan de manejo de colección para los diversos grupos de tapires en cautiverio en Panamá.
   2. Evaluar los requerimientos de instalaciones y mantenimiento para cada institución.
      a. Determinar la capacidad de carga existente para cada institución.
      b. Identificar la necesidad de construir albergues adicionales, anticipando futuros nacimientos y el recibimiento de huérfanos adicionales del medio silvestre.
   3. Evaluar el intercambio de tapires nacidos en cautiverio para mejorar la genética del tapir en otras colecciones de tapir en cautiverio existentes fuera del país. La calendarización y factibilidad de esta actividad es dependiente del éxito de los programas de reproducción en Panamá. El grupo recomienda que el Comité Panameño del Tapir consulte y mantenga comunicación con el coordinador Estadounidense del TAG para tapir de AZA y con el Grupo Especialista del Tapir de la IUCN/SSC.

E. Desarrollar protocolos de manejo y medicina veterinaria para los tapires en cautiverio en Panamá. A continuación se incluyen algunos ejemplos:
   1. Identificación de animales y registros.
      a. números de microchips.
      b. fechas de nacimientos y decesos.
      c. fechas de acceso y salida.
      d. pesos corporales registrados periódicamente.
      e. registros reproductivos.
      f. registros de procedimientos médicos.
      g. registros de tratamientos veterinarios.
      h. desarrollar un studbook regional para Panamá (utilizando el programa de computadora SPARKS, disponible a través de ISIS)
   2. Procedimientos de transportación/transferencia entre instituciones, revisar lineamientos internacionales.
      a. lineamientos sugeridos para la transportación de tapires
   3. Criterios para el Diseño de Instalaciones y Mantenimiento de Ejemplares.
      a. tamaño del encierro.
      b. diseño de alberca.
      c. sustrato y drenaje.
      d. diseño y materiales de cerca
      e. cobertizos y sombreaderos.
      f. comederos.

4. Procedimientos de medicina preventiva
   a. cuarentena
   b. identificación individual de animales.
   c. vacunaciones.
   d. control de parásitos
5. Protocolos de necropsia
   a. determinar el procedimiento a realizar en caso del fallecimiento de un tapir (por ejemplo, quien realizará la necropsia, donde será realizada).
6. Establecer fuentes de apoyo en para diagnóstico
   a. microbiología.
   b. parasitología.
   c. generales e histopatología.
7. Técnicas de anestesia.
8. Especificaciones de la dieta y distribución de alimentos.

III. Estudios / Investigación

A. Realizar un censo de enfermedades en tapires en cautiverio y vida silvestre para identificar problemas de salud de tapires en Panamá.
   1. Identificar proyectos potenciales de investigación para estudiantes, candidatos a veterinarios etc.
      a. Ejemplo: censos serológicos y parasitológicos de enfermedades que potencialmente afecten a los tapires. Emplear al caballo doméstico como ejemplo para aquellas enfermedades que puedan afectar al tapir.
   2. Hacer disponible para entrenamiento de investigación avanzada tanto a las poblaciones del tapir en cautiverio como a los laboratorios e instalaciones veterinarias.

B. Desarrollar estudios para mejorar el mantenimiento del tapir en cautiverio.
   1. Nutrición y dietas en los trópicos.
   2. Observaciones de la reproducción y cuidado maternal por biólogos calificados.

C. Evaluar el uso de técnicas de criopreservación y técnicas de reproducción asistida que faciliten el intercambio de material genético a nivel internacional.
   1. El grupo en el PHVA consideró ésta como una alternativa importante a realizar para evitar la necesidad de transportar fuera del país tapires nacidos en condiciones silvestres.

D. Validar información obtenida en zoológicos de otros países con propósitos de reproducción.

E. Obtener información que está siendo o ha sido obtenida de tapires en su hábitat natural que pueda se aplicable para el cuidado del tapir en cautiverio.

F. Determinar fuentes de financiamiento para apoyar proyectos de investigación y necesidades de la crianza en cautiverio del tapir.
   Ejemplo: El Instituto Smithsonian ofrece becas de corto plazo.

IV. Reintroducción

A. Esta meta es altamente deseada pero el grupo siente que será necesario retrasar esta meta hasta que se identifiquen y resuelvan las amenazas que actualmente afectan a las poblaciones silvestres.

B. Las reintroducciones semi-naturales podrían ser benéficas por las siguientes razones:
   1. Proporcionarían oportunidades educativas.
   2. Proporcionarían oportunidades para promover el eco-turismo.
   3. Proporcionarían prototipos para la reintroducción de tipos transicionales.

C. Realizar una evaluación de riego antes de la reintroducción.
   1. Identificar enfermedades que representen riesgos tanto a las poblaciones silvestres como a las reintroducidas.
   2. Identificar enfermedades que representen riesgos a las especies domésticas en las áreas de reintroducción.
   3. Identificar enfermedades que representen riesgos a los tapires reintroducidos, transmitidas por especies domésticas presentes en las áreas de reintroducción.
   4. Determinar cuales son los riesgos aceptables para las poblaciones existentes y reintroducidas.

<u>RECOMENDACIONES</u>

1. Lograr acceso a todas las formas de información educativa del tapir y traducirlas al Español. Proporcionar estos materiales a el público local y a las bibliotecas científicas especializadas. Referirse a la Sección 1.

2. Iniciar el diseño de una fase de información sobre los tapires en cautiverio y el programa de reproducción en cautiverio y adaptarlo tanto para las comunidades locales como para otros niveles de audiencia.

3. Establecer el Comité Panameño del Tapir quien tendrá la responsabilidad de decidir como serán manejados los tapires bajo condiciones de cautiverio en Panamá y que transferencias son necesarias a realizar. Referirse a Sección II.

4. Determinar prioridades para la población en cautiverio. Producir un plan de manejo en cautiverio.

5. Desarrollar protocolos de manejo y medicina veterinaria para poblaciones en cautiverio de tapires en Panamá.

6. Realizar un censo de enfermedades en tapires bajo condiciones de cautiverio y en vida silvestre para identificar problemas de enfermedades tropicales de tapires en Panamá.

7. Promover estudios de genética, reproducción, comportamiento, así como de colección y preservación de material genético. Conducir necropsias y hacer un uso más eficiente de las

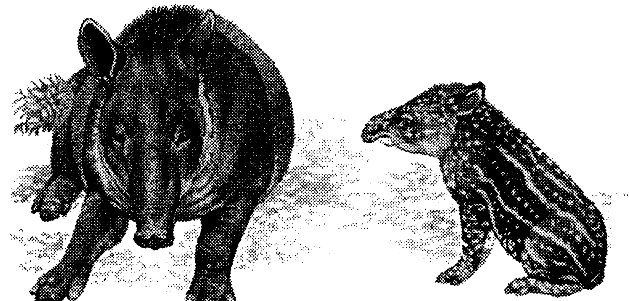
muestras de tejido y de otros materiales de interés científico para instituciones y/o investigadores.

8. Determinar fuentes de financiamiento para apoyar investigaciones y necesidades de la reproducción en cautiverio.

Para lograr la realización de estas actividades es necesario la continuidad de todas las partes interesadas. **El primer paso esencial es el establecimiento del COMITÉ PANAMEÑO DEL TAPIR.**

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

Panama City, Panama
1-3 December 1994



Section 5
Executive Summary

EXECUTIVE SUMMARY

Baird's tapir (*Tapirus bairdi*) is the largest land mammal in the Neotropics. Distributed from southern Mexico to northwest Colombia and Venezuela, the species is listed on Appendix I of CITES and is considered Endangered according to the IUCN Red List criteria. It is estimated that approximately 3,000 tapirs still occupy the tropical forests of Panama. There are four primary regions that support *T. bairdi*: the northern region, including the Bocas del Toro and Chiriqui areas with approximately 1200 animals; the Azuero region, with approximately 50 animals; the southern region, including the San Blas and Darien areas, with approximately 1500 animals; and the Serrania de Maje region, with approximately 60 animals. These four regions are effectively disjunct, resulting in separate populations with no exchange.

A number of serious threats influence the future viability of Baird's tapir populations in Panama. Human-mediated habitat destruction and fragmentation continue in the country; in fact, more than half of the geographical range of *T. bairdi* has been destroyed over the last 40 years. Poaching of tapirs by humans, for food or other purposes, can also have dramatic impacts on the tapir populations. Tapirs are relatively easy to track and, therefore, easy to hunt. One of the first tropical forest species to be adversely affected by human disturbances, the continuous encroachment of civilization upon tapir habitat can have serious consequences for the future of the species.

As a first step in developing a unified approach for protecting this species from extinction in Panama, the Asociación Nacional para la Conservación de la Naturaleza (ANCON) held a Population and Habitat Viability Assessment (PHVA) Workshop at the Rio Chagres Nature Center, near Panama City, Panama, on 1-3 December, 1994. The Conservation Breeding Specialist Group of the IUCN/Species Survival Commission was asked to conduct the workshop to assist in assessment and subsequent planning. Twenty-three biologists, wildlife managers, and non-governmental organization representatives from the United States, Panama, and Colombia attended the three-day workshop. One purpose of the meeting was to review data from wild populations as a basis for developing stochastic population simulation models. These models estimate risk of extinction and rates of genetic loss from the interactions of demographic, genetic, and environmental factors. Results from these models are then used as a tool for ongoing species management. Other goals included review of the current state of knowledge regarding habitat requirements, species distribution and population sizes, the role of direct threats as factors in the decline of the species, and the role to be played by captive breeding in the long-term management of the species.

The workshop opened with a series of presentations summarizing data on the status of both wild and captive popualtions of Baird's tapir. A brief presentation on the PHVA process, the principles of population biology, and the use of the VORTEX population simulation software package was made as an introduction to the use of the models and the problems associated with small, isolated populations. The participants then formed three working groups—population biology and modelling, wild populations, and captive populations—to review in detail current information, to develop input parameters for the simulation models, and to develop management scenarios and recommendations. Stochastic population simulation models were initialized with ranges of values for the key variables to estimate the viability of the populaton using VORTEX.

Modelling tapir populations using VORTEX demonstrated the extreme sensitivity of these populations to adult mortality. Removing an additional 6% of adults from the population through poaching, above and beyond normal mortality, results in a switch from population growth to population decline (poaching is defined here as any form of hunting of an officially endangered species such as Baird's tapir). This decline does not occur under higher levels of juvenile mortality, as long as adult mortality is low. Additionally, under stressful environmental conditions such as drought, an annual adult poaching rate as low as 3% leads to population instability. Moreover, the risk of population extinction is greatly increased under these poaching scenarios. Taken together, these data suggests that a 3-6% annual adult poaching rate is not sustainable for any of the populations currently existing in Panama. As a result, tapir management planning must investigate strategies for reducing the rate of poaching to sustainable levels.

Considerations of wild tapir population status led to the following recommendations:

- Investigate the possibility of restoration of tapir habitat previously degraded through human activity.

- Establish reintroduction programs in order to address the genetic problems associated with inbreeding in small isolated populations.

- Systematically compile information regarding tapir natural history, distribution, and habitat quality without disdain for the knowledge possessed by residents of the local communities.

- Prioritize conservation efforts in those areas deemed susceptible to fragmentation, such as the Central Cordillera.

- Work toward making the tapir a symbol of conservation efforts in Panama.

- Create a local Tapir Working Group in Panama, in coordination with INRENARE.

- Work with native people (Kuna Indians) in order to more rapidly evaluate the species' status in areas these people inhabit and develop community-based educational programs to prevent local hunting of tapirs.

- Evaluate the use of captive breeding as a wild population management tool.

A data collection sheet was constructed by the participants for use with local people as a tool to collect important information on tapir population characteristics. With such a tool, it is hoped that more effective conservation of tapirs and their habitat can be effected.

There are currently less than 20 tapirs in the three recognized zoos and private facilities in Panama. The primary goals of captive tapir management include:

- Establish educational programs acting locally, nationally, governmentally, and internationally.

- Establish a coordinated captive breeding program in Panama.

- Develop programs for investigation and research that will benefit the tapir in Panama.

- Establish goals and guidelines for reintroduction.

It is vital to establish outreach programs for people living in areas of Panama where tapirs exist. Such programs increase awareness and appreciation of the species. Moreover, these programs can be effective in communicating the devastating effects of overhunting. For captive programs to work in Panama, it will be important to make scientific information on tapirs available, translated into Spanish, to researchers in Panama. Furthermore, regarding captive tapir husbandry, it is critical that captive tapirs be managed as a single effective group and held at multiple cooperating facilities. Perhaps most importantly, the participants proposed to form the Panama Tapir Committee, which will be primarily responsible for deciding how captive tapirs are managed in Panama and which inter-zoo transfers are to be made.

The goal of reintroduction is a highly desirable one for effective tapir management, but the participants felt it necessary to delay this goal until current threats to wild populations are identified and resolved. While this phase is in effect, disease surveys on captive and free-ranging tapirs are to be conducted in order to identify disease problems in tapirs. Furthermore, research should be conducted on genetics, reproduction, and behavior of tapirs, and husbandry and veterinary protocols should be developed for captive animals.

Effective conservation of Baird's tapir in Panama will be a complicated issue that will require input from biologists, governmental organizations, and local communities. Perhaps only through concerted integration of wild and captive population management can the extinction of Baird's tapir be prevented.

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

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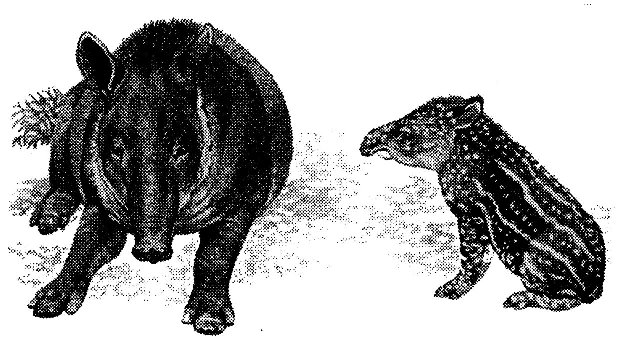

Section 6
Wild Populations

WILD POPULATION OF THE BAIRD'S TAPIR (*Tapirus bairdi*) IN PANAMA

Table 6.1. Distribution

SECTOR	T.A.†	O.A.	N	P.A.	K
West (Bocas de Toro and Chiriqui)	6000	2400	1200	3600	3000
Central (P. N. Cerro Hoya)	250	100	50	150	125
East (P. N. Chagres, San Blas and Darien)	7290	2916	1458	4374	3645
Serrania de Maje Isla de Maje	300	120	60	180	150
TOTALS	13840	5536	2768	8304	6920

†T.A. = total area (km^2); O.A.= occupied area (km^2); N = actual population; A.P. = potential area (km^2); K = carrying capacity

In order to estimate the values presented above, a number of assumptions were made. Eisenberg (1989) states that under adequate habitat conditions tapirs can reach a population density of 0.8 animals per km^2. However, based on our field experiences and in the data reported by Glanz (1990) we consider that population density can be best estimated at 0.5 individuals per km^2.

A total area of 13,840 km^2 of adequate habitat currently exists for the tapir populations. From this total, we consider that 40% (5,536 km^2) is occupied by the species, leaving approximately 60% as available remaining habitat. These estimates indicate that the carrying capacity of the habitat over the entire area is 6,920 individuals. It is important to state that approximately 45% of this area corresponds to protected areas such as national parks, forest reserves and Indian territories such as the Kuna Yala District.

The tapir population on Barra Colorado Island has not been considered as a natural island population, because the current population (12 individuals) was reintroduced (Smythe, 1992). Also, this ecosystem lacks major predators as the jaguar (*Panthera onca*) and the mountain lion (*Felis concolor*). Also, there is a record of a tapir released in the Sherman Forest Reserve, which was captive raised (Smythe, 1992).

Table 6.2. Records of the Wild Population of Baird's Tapir (*Tapirus bairdi*) in Panama

LOCATION	TYPE OF RECORD
WESTERN SECTOR	
Rio Culubre	Footprints: E. Ponce, F. Arosemena
Cotito	Footprints: E. Ponce, F. Arosemena
Rio Teribe-Bonyic	Hunters/Park guards: E. Ponce, F. Arosemena
Cabecera del Rio Changuinola	Sightings, footprints/hunters, Park guards: R. Hinds, E. Ponce, F. Arosemena
Reserva Forestal de Fortuna	Footprints: F. Arosemena
Culebra	Footprints/Park guards: J. Tovar, E. Ponce, F. Arosemena
Cerro Guabo	Footprints: E. Ponce, F. Arosemena
Bajura de Pando	Footprints/Park guards and hunters
Rio Yorkin	Footprints/Park guards: E. Ponce, F. Arosemena
El Respingo	Footprints: B.Cuevas
Cerro Pata de Macho	Footprints: B. Cuevas
CENTRAL SECTOR	
Cerro Hoya	A. Gonzales, communities adjacent to P.N. Cerro Hoya
Rio Varadero	Hunters/communities of Varadero and Arenas de Quebro

Table 6.2 (contd.)

LOCATION	TYPE OF RECORD
EASTERN SECTOR	
Cabecera del Rio Pequeni	Footprints/Embera Indians, community of San Juan de Pequeni
Cuenca alta del Rio Chagres	Footprints/Park guards, J. Tovar
Rio Cascada (terrenos de MELO, S.A.)	Footprints: F. Arosemena, I. Rosales
Sendero Interpretativo El Cantar	Footprints: F. Arosemena
Cerro Guagaral (Cerro Brewster)	Footprints: A. Telesca, F. Arosemena
Cabecera del Rio Mandinga	Footprints: A. Telesca, F. Arosemena
*Cangandi	Footprints and hunted animal: J. Ventocilla
Rio Nergala	Hunted animal: J. Ventocilla
Carretera El Llano Carti	Footprints: J. Ventocilla
*Pucuro	Skulls and jawbones: I. Candanedo
*Paya	Direct sightings (mother and son), skulls and jawbones: R. Hinds, I. Candanedo
**Manene	Skulls and jawbones: I. Candanedo
**Altos de Rio Jaque	Skulls and jawbones: I. Candanedo
**Punusa	Skulls and jawbones: I. Candanedo
Cerro Pirre (ladera noreste y noroeste)	Direct sightings / Park guards
Rio Seteganti (hacia Cerro Setetule)	Direct sightings: R. Hinds
Estacion de INRENARE en Pirre	Direct sightings / Park guards
Estacion de INRENARE en Cruce de Mono	Direct sightings / Park guards
Camino Cruce de Mono-Cana	Footprints / Park guards: J. Polanco, F. Arosemena
Serrania de Bernal	Footprints: O. Lastra
Comarca Embera No. 2	Footprints / Indigenous community of La Chunga
Rio Tacarcuna (antiguo pueblo Kuna)	Direct sightings: R. Hinds

Table 6.2 (contd.)

LOCATION	TYPE OF RECORD
Cerro Tacarcuna	Direct sightings: R. Hinds
Anachucuna	Direct sightings: R. Hinds
Cerro Mali	Footprints: R. Hinds
Altos de Nique	Footprints: R. Hinds
Rio Mono	Direct sightings: R. Hinds

* Kuna Indigenous Community

** Embera Indigenous Community

The San Blas District has 42 insular communities, 8 along the coastline and 2 on the mainland. According to our experience in every community, there is at least one house with a tapir's jawbone as a trophy (J. Ventocilla). A similar situation exists in the Kuna communities of Pucuro and Paya in the Darien.

LOCATION	TYPE OF RECORD
SECTOR DE MAJE	
Isla Maje	Plan de Manejo Isla Maje, Lab. Com. Gorgas.: R. Hinds
Cordillera de Maje	Footprints / hunters: B. Lavern
Tutecito	Footprints, hunted animals / Embera community de Tutecito

Threats

It has been determined that the main threats that affect the wild populations of tapirs in Panama are:

- Habitat loss due to colonization in the El Guabo sector (Guaymies Indians), and to livestock (Nueva Zelandia, Culubre, Valle Libre).

- Deforestation resulting from the Fortuna hydroelectric dam and the possible construction of the medium-capacity projects of Bonyic and Changuinola I in the Bocas del Toro province.

- Deforestation by locals in the Cerro Tacarcuna border and farming of coca (*Eryctrocilon coca*).

- Hunting for food, aside from sport hunting (illegal hunting), mainly in the indigenous areas of Darien, San Blas and Bocas del Toro.

- Inbreeding, especially in the Maje Island population where geographical isolation can lead to reproductive difficulties.

- Mining: this is a potential threat, due to the possible mining development in Cerro Colorado.

RECOMMENDATIONS

- To enforce the existing laws concerning the protection of the tapir and its habitat in Panama.

- To promote recovery of natural habitat in areas where tapir populations have been identified. This will allow genetic interchange between the animals and will decrease the possibilities of the population's total fragmentation.

- A reintroduction program needs to be established, considering genetic aspects to avoid inbreeding problems.

- To systematically compile information regarding tapir natural history, distribution and habitat loss without disdain for the knowledge possessed by residents of the local communities (Indians, farmers and hunters) that may contribute to improve conservation activities for the species.

- To consider as conservation priorities those areas susceptible to fragmentation in the central Cordillera, especially in Bocas del Toro and Veraguas. Special attention should be also directed towards the tapir populations in the Cerro Hoya National Park and in Maje.

- To suggest the tapir as the national symbol for conservation in Panama so it can be used in environmental education programs.

- To establish a Panama Tapir Committee.

- For the specific case of the Kunas Indians territory (Kuna Yala District), we contend that it presents conditions which are appropriate for a fast evaluation of the species' situation. The Kuna hunters are few in numbers and are known. The tapir jawbones are hung on the outside of the houses as trophies and, by this technique, each Kuna hunter keeps a record of the number of tapirs hunted. Within a relatively short period of time, it would be possible to visit and interview those hunters primarily responsible for tapir hunting, and to obtain reliable information regarding the natural history of the tapir, the impact of hunting activities and information regarding the general status of the species.

- To identify viable alternatives for the indigenous and farming communities that use the tapir (*Tapirus bairdi*) as a protein source and/or document or improve captive breeding programs for the species.

Un Grupo de Trabajo sobre el Tapir en Panama (GRUTA)
(The Panama Tapir Working Group)

Arguments

1. The tapir is a good candidate to act as a "indicator species" of the environmental conditions in the country.

2. We found that the persons that live in the surrounding areas usually have information of the natural history and of the presence or absence of this species.

3. Up to the present and with the exception of the Harpy eagle (scientific name), no systematic census at the national level has been conducted for any other animal or vegetal wild species.

4. It is more realistic to think that a "artesian" population diagnostic can be conducted rather that a sophisticated scientific research of the specie.

5. There are a number of naturalists conducting field studies in propitious areas for the tapirs.

Responsibilities of the PanamaTapir Working Group

A. To compile information about the status of the populations and the natural history of the species;
B. To compile information about its historical presence;
C. To inform about living captive animals;
D. To publish every three months a newsletter between those who are interested;
E. To conduct general meeting every year.

Priority needs that should be developed

A. To develop data sheets collection forms.
B. To identify a place within a governmental or non governmental office which may act as a center to receive, process and file information.
C. To start with the cooperation of 4 to 5 volunteers distributed in the three geographical distribution areas of the tapir.

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

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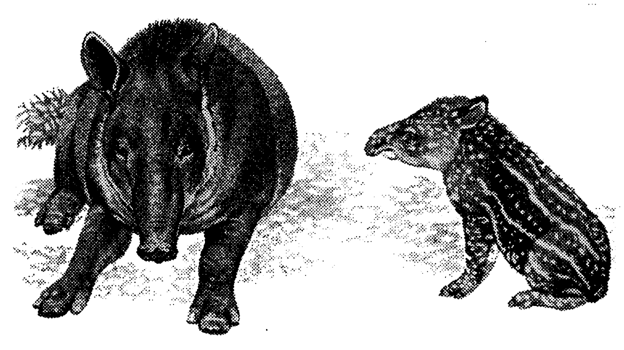
1-3 de Diciembre de 1994



Section 7
Population Biology and Modelling

POPULATION BIOLOGY AND MODELLING

Introduction

Baird's tapir (*Tapirus bairdi*) is currently listed on Appendix I of CITES. In general, the greatest threats to the continued viability of tapir populations in the Neotropics appear to be continued habitat destruction and excessive hunting. Much of what we know about Baird's tapir in the wild comes from direct field observation, tracks, and from fecal and skull samples recovered from tapir habitat. In addition, many of the biological parameters related to tapir reproduction are taken from well-documented studies of tapirs in captivity (see Bibliography).

The need for and effects of intensive management strategies can be modelled to suggest which practices may be the most effective in preserving this population. VORTEX, a simulation modeling package written by Robert Lacy and Kim Hughes was used as a tool to study the interaction of multiple variables treated stochastically.

The VORTEX program is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wildlife populations. VORTEX models population dynamics as discrete, sequential events (e.g., births, deaths, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or as random variables that follow specified distributions. VORTEX simulates a population by stepping through the series of events that describe the typical life cycle of sexually reproducing, diploid organisms.

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters which enter into the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the tapir, the conditions affecting the population, and possible changes in the future.

Input Parameters for Simulations

Age of First Reproduction: 3 years, both females and males. VORTEX defines reproduction as birth; given a gestation period in tapirs of 13 months, females breeding at 2 years of age then reproduce at 3 years of age.

Offspring Production: Interbirth interval was set at 2 years in wild tapirs. Therefore, 50% of adult females do not reproduce in a given year. Of those females that do reproduce, all give birth to only one calf. Twins have been reported in captivity, but are extremely rare, and all have been stillborn.

Variation in reproduction is modelled in VORTEX by entering a standard deviation (SD) for the proportion of females failing to produce offspring in a given year. Lacking empirical data, we assumed that such variation (due to fluctuations in mate availability and variations in the age at which females reach sexual maturity) was 25% of the mean. VORTEX then determines the percent breeding each year of the simulation by sampling from a binomial distribution with the specified mean (50%) and SD (12.5%).

As no data exist indicating other than a 50:50 sex ratio at birth for Baird's tapir, we used an equal sex ratio for all scenarios.

Age of Senescence: VORTEX assumes that animals can breed (at the normal rate) throughout their adult life. Baird's tapirs have bred in captivity up to age 25; because of harsher environmental conditions present in the wild, we set the maximum age of reproduction in wild populations at 20 years.

Mortality: As a "best-case" scenario, in which tapir mortality is not affected by human influences and other biotic factors have minimal impact, we set juvenile (age 0 to 1 year) mortality at 20% and sub-adult and adult mortality at 10%. These values are similar to those from other related taxa.

Of course, tapir mortality can be strongly influenced by human pressures such as hunting, primarily of adults (Terwilliger 1978; Fragoso 1991). Additionally, disease and high levels of predation by jaguars, etc. can increase mortality, primarily of juveniles. We therefore modelled populations having 25% and 30% juvenile mortality. To model the effect of hunting on adult mortality, we constructed scenarios simulating 3%, 6%, and 9% poaching rates. These rates, imposed equally across sexes as well as sub-adult and adult age classes, result in total annual adult mortality rates of 13%, 16%, and 19%, respectively. Data from populations of tapirs in Panama suggest that these rates of poaching are not unreasonable (Terwilliger 1978).

Carrying Capacity: K defines an upper limit for the population size, above which additional mortality is imposed in order to return the population to K. VORTEX, therefore, uses K to impose density-dependence on survival rates.

Baird's tapir populations in Panama fall into two general size categories: large, as in the northeastern Panama (Bocas del Toro region) and southern Panama (San Blas and Darien regions) populations; and small, as in the Azuero peninsula and Serrania de Majé populations. Both large populations have an estimated tapir carrying capacity of about 3000, while the small populations have an estimated carrying capacity of approximately 150. These estimates are based on published tapir density estimates of 0.5 - 0.8 individuals per km^2.

From these date, we generated two sets of simulation models with carrying capacities of 3000 and 150, respectively. This wide variation in carrying capacity for the two population types can give considerable insight into the extinction dynamics operating in tapir populations in Panama.

VORTEX can also model deterministic trends in carrying capacity. These trends are specified as an annual percentage change, and are modelled as linear, rather than geometric, increases or decreases. Current data show that a large proportion of tapir habitat in Panama is threatened with significant degradation or fragmentation. To investigate the consequences of such a threat, we modelled deterministic reductions in carrying capacity at a rate of 2.5% per year over the first 20 years of the simulations. This results in a 50% decrease in available tapir habitat over that time span.

Starting Population Size: We generated two sets of simulation models using initial population sizes corresponding to the two classes of estimated wild population sizes in Panama: N_0=1200, similar to the Bocas del Toro and San Blas/Darien populations; and N_0=60, similar to the Azuero peninsula and Serrania de Majé populations.

Starting Age Distribution: We initialized all of the model runs with a stable age distribution that distributes the total population among each sex-age class in accordance with the existing mortality and reproductive schedules.

Inbreeding Depression: Specific data do not exist on the prevalence and effects of inbreeding in wild tapir populations. However, given the small numbers of tapirs thought to inhabit the Azuero peninsula and the Serrania de Majé regions, it may be reasonable to infer that some measurable degree of inbreeing is occurring in these small populations. Therefore, we have included inbreeding depression in that subset of modelling scenarios specifically dealing with these regions.

We employed the heterosis model of inbreeding depression, in which individuals that are heterozygous at a given genetic locus have superior fitness to those that are homozygous at that locus. Because detrimental alleles are not removed by natural selection from the population over time in this model, the heterosis model may provide a conservative overestimate of the deleterious effects of inbreeding in the tapir populations modelled below.

The severity of inbreeding depression in mammalian populations can be measured as the number of "lethal equivalents" contained in the genome of the population of interest. Data for a number of captive mammal species suggests that these species harbor about 3 lethal equivalents (Ralls et al. 1988). Consequently, we have modelled inbreeding depression using this median lethal equivalent value.

Catastrophes: Catastrophes are thought of as extremes in environmental variation, and are treated differently conceptually and operationally in VORTEX. Both the frequency of occurrence and the impact on reproduction and survival of the catastrophic event is modelled by the program. We included a catastrophe representing drought conditions, with a 10% probability of occurrence in a given year (i.e., the event occurs on average every ten years) with a 50% reduction in reproduction and a 20% reduction in survival in years in which the catastrophe occurs.

Iterations and Years of Projection:

Each scenario in which inbreeding depression was absent was iterated 500 times, while those scenarios incorporating inbreeding depression were interated 200 times due to computational limitations. Projections were made for 100 years into the future for all scenarios. Output results were summarized at 10 year intervals in the time series figures. Each tabulated scenario has a corresponding file number for reference and future retrieval of other results, if necessary. The simulations were run using VORTEX version 7.0.

Results from Simulation Modelling

Explanation of Tables and Figures

The numerical results of the simulation models appear in Tables 7.1 through 7.6. Each table represents a specified set of conditions, for example, carrying capacity, inclusion of inbreeding depression, etc. Within each table, the results are organized in a nested structure: each level of juvenile mortality was run with each degree of adult mortality, with each of those run with and without catastrophes.

The headings for the tables are as follows:

- r_d: deterministic growth rate, calculated by Leslie matrix methods from life table data;
- r_s (SD): mean and standard deviation of stochastic growth rate across iterations, calculated from annual variation in population size;
- *P*(*E*): probability of extinction over the 100-year time span of the simulation, calculated as the proportion of iterated population that become extinct within 100 years;
- N_{100} (SD): final size of those populations remaining extant after 100 years;
- H_{100}: proportion of the original heterozygosity remaining in extant populations after 100 years;
- *T*(*E*): mean time to extinction of those populations becoming extinct.

Note that computer file numbers are given for each scenario for future reference and retrieval, if necessary.

Figures 7.1-7.18 are time series graphs of the probability of extinction and mean size of extant populations for the 100-year duration of each scenario.

Deterministic Results

Growth rate (r_d): The deterministic growth rates calculated using Leslie matrix methods are shown for each scenario in column 5 of Tables 7.1 and 7.2. Positive values indicate population growth, while negative values indicate population decline. A population with $r_d < 0$ is in deterministic decline (deaths outpace births), and will go extinct even in the absence of any stochastic fluctuations. The difference between the deterministic population growth rate and the stochastic growth rate resulting from the simulations (r_s, see below) can give an indication of the impact of stochastic factors on population persistence.

These deterministic growth rates are calculated from the mortality and fecundity schedules for each modelling scenario. As a result, changing the initial population size and/or the carrying capacity, or imposing an annual reduction in habitat carrying does not alter the growth rates calculated for a particular mortality schedule. This is reflected in the identical set of deterministic growth rates shown in all tables. As a result, the following discussion applies to both large and small populations under constant or decreasing habitat carrying capacity.

Under the most optimistic scenario—low juvenile and adult mortality, no drought, and no inbreeding depression—the population shows nearly 4% annual growth ($r_d = 0.038$). Increasing juvenile mortality by an additional 5% to 25% results in a reduction in deterministic population growth by about 20% ($r_d = 0.030$), and a further increase in mortality to 30% results in an almost 45% reduction in deterministic growth ($r_d = 0.022$). This situation changes dramatically, however, when adult mortality is increased under a given level of juvenile mortality. Even under conditions of low juvenile mortality, an increase in adult mortality from 10% to 13% results in the population growing at less than 1% per year ($r_d = 0.008$). When adult mortality is increased further to 16%, the population goes into a 2.2% annual decline. The effect of increasing adult mortality to 19% becomes quite severe, with the population decreasing at over 5% annually ($r_d = -0.054$). The rate of decline becomes more severe as juvenile mortality is increased until, under conditions of 30% juvenile mortality and no drought, the deterministic growth rate is -0.071.

These deterministic results provide strong evidence for the considerable sensitivity of tapir populations in Panama to increases in adult mortality. The incremental change in r_d is 0.102 per 10% increase in adult mortality, while the corresponding change for juvenile mortality is only 0.016 per 10% increase. In other words, the incremental change with respect to adult mortality is over six times greater than that with respect to juvenile mortality.

Deterministic growth is severely affected when drought is added to the modelling scenarios. Under conditions of low juvenile and adult mortality, the deterministic growth rate is reduced to 0.011 from 0.038. The least optimistic scenario, with high juvenile and adult mortality and drought, leads to a deterministic growth rate of -0.097.

Stochastic Simulation Results

The base scenario (File #301), with low juvenile and adult mortality and no drought in the large population class ($N_0 = 1200$, $K = 3000$), results in nearly 4% annual growth with no risk of extinction over the 100-year time frame (Table 7.1). In fact, the population increases rapidly from an initial size of 1200 individuals to just below the habitat carrying capacity of 3000 in just 40 years (Figure 7.1b). The risk of extinction remains zero when juvenile mortality is increased to 25% and even 30% under low adult mortality, with final population sizes maintained near K (2930 and 2876, respectively; Figures 7.2 and 7.3). If drought is added to these same scenarios, the risk of extinction remains zero even under 40% juvenile mortality. However, the stochastic population growth rate (r_s) is reduced significantly and in fact becomes negative under high juvenile mortality with a nearly 40% reduction in final population size ($N_{100} = 760$). These results indicate that even though catastrophic events such as drought have a relatively low probability of occurrence, their effects can be quite severe and can lead to population instability.

In contrast to the results obtained from increasing juvenile mortality under conditions of low adult mortality, higher levels of adult mortality nearly always lead to population instability (Table 7.1, Figures 7.1-7.3). Even when juvenile mortality is low, an additional 6% mortality imposed on adults leads to population decline (r_s = -0.026) and low final population sizes (N_{100} = 131), with a small but measurable risk of extinction within 100 years (*P*(*E*)=0.008). The population is severely unstable when adult mortality is increased to 19%, with a probability of extinction of 56% and a mean extinction time of 83 years. The addition of drought to these scenarios produces further instability, particularly under 16% adult mortality when the probability of extinction is 0.48 and the final population size is just 19 individuals (Figure 7.4). Under 19% adult mortality, extinction is virtually certain with a mean time to extinction of 65 years (Figure 7.4a).

As adult mortality is increased under conditions of higher juvenile mortality, the population becomes further destabilized (Table 7.1). Under 13%, 16% or 19% adult mortality, all stochastic growth rates are negative, with or without the addition of drought. The risk of extinction ranges from zero, when juvenile mortality is 25% and adult mortality is 13%, to near 100% when adult mortality is 19% and juvenile mortality is 25% or 30% under drought conditions. Under these most severe of conditions, extinction usually occurs within about 80 years on average. Population sizes are usually considerably reduced from the initial 1200 animals. Under conditions of 13% adult and 25% juvenile mortality with no drought, the population exhibits a very slow stochastic decline (r_s = -0.002) and a final population size of 1171 animals (File #306). However, under more severe conditions, final population size is just a very small number of individuals (i.e., Files #308, 312, and 324).

The results from those simulations incorporating a 2.5% annual deterministic reduction in habitat carrying capacity for the large population class are shown in Table 7.2. Overall, the results are very similar to those simulations lacking such a trend in *K*: r_s, *P*(*E*), and *T*(*E*) differ from the corresponding values in Table 7.1 by a few percent. In general, the impact of the reduction in K is greatest under conditions of drought and/or higher adult mortality. In other words, a situation in which occupied habitat is gradually eroded away acts to exacerbate the problems of demographic and environmental stochasticities faced by the population As expected, the final population sizes are modulated by the reduced carrying capacity, but only in those scenarios showing positive growth. In those scenarios showing population decline, final population sizes are essentially equivalent to those in the scenarios shown in Table 7.1.

Table 7.3 and Figures 7.7-7.9 present the results from the scenarios modelling the small population size class. While the general population size trends for the small population scenarios are qualitatively very similar to the larger population size models (Figures 7.7b-7.9b) due to the similarity in stochastic growth rates, the smaller populations are under considerably greater risk of extinction under intermediate and high levels of adult mortality. For example, with 20% juvenile mortality and 16% adult mortality with no drought (File #351), the probability of extinction is nearly 73%. In contrast, the larger population, under the same set of conditions (File #303, Table 7.1), has a probability of extinction of less than 1%. Of course, both populations are in deterministic (and stochastic) decline, so the long-term fate of both simulated populations is identical. These results, however, show the immediate threats faced by the smaller tapir populations in Panama. Indeed, this is made clearer by the observation that under severe mortality conditions, mean time to population extinction ranges from just 30 years when drought occurs to approximately 50 years. Extinction risk becomes very high as juvenile mortality is increased (Figures 7.11 and 7.12).

Carrying capacity reductions in the small population scenarios lead to results similar to those for the larger populations (Table 7.4). Perhaps most noteworthy is the additional reduction in population heterozygosity observed under these conditions (compare column 9 in Tables 7.3 and 7.4). This consequence of persistent small population size and accompanying inbreeding can lead to reduced survival as well as long-term adaptive potential as populations attempt to track environmental change.

The inclusion of inbreeding depression in the small population scenarios contributes to an increased extinction risk in all but the lowest adult mortality scenarios (Tables 7.5 and 7.6, Figures 7.13-7.18). A good illustration of this effect can be seen in the scenario with 20% juvenile and 13% adult mortality in the absence of drought (File #350). Without the deleterious effects of inbreeding, the population grows at approximately 0.3% per year ($r_s = 0.003$) with a final population size of 90 and a 4% risk of extinction in 100 years (Table 7.3, Figure 7.7). If inbreeding is included in the model, the stochastic growth rate of the population becomes negative (r_s=-0.016), the final population size drops to 43 animals, and the risk of extinction rises to 31.5% (Table 7.5, Figure 7.13). Figures 7.7b and 7.13b graphically illustrate this effect (see the line with the square symbols). While the simulated population without inbreeding depression shows consistent growth throughout the time period (Figure 7.7b), the inbred population shows growth at about the same rate only for the first 20 years of the simulation, after which increased mortality of juveniles through inbreeding generates an almost linear decline in population size for the duration of the time period (Figure 7.13b).

Under inbreeding, inclusion of drought results in all populations experiencing stochastic decline, even those with low mortality (Figures 7.16-7.18). Under perhaps the most pessimistic of scenarios, in which small, inbred tapir populations occupy shrinking habitat subject to drought conditions, the risk of extinction is nearly 35% even under the most optimistic mortality conditions (Table 7.6, File #433). If carrying capacity remains constant, the risk is still considerable ($P(E) = 0.315$: Table 7.5, File #409). These result demonstrate that, while we lack specific data on the effect of inbreeding in wild tapir populations, the consequences of such a process cannot be ignored when considering the viability of small, fragmented populations.

Conclusions

VORTEX simulation modelling of Baird's tapir populations in Panama suggests that the primary demographic factor influencing population viability is adult mortality. Assuming a baseline adult mortality of 10%, an additional 6% mortality results in population decline and a generally substantial risk of extinction within 100 years. If adult mortality is further increased to 25%, population extinction is virtually assured within about 80 years.

The considerable sensitivity of tapir populations to adult mortality as modelled here is graphically represented in Figure 7.19. Each bar in the graph gives the probability of extinction averaged over all scenarios with a given parameter value. For example, the mean probability of population extinction for all scenarios in which juvenile mortality was 20% (N = 48) is 0.504 (the left-most bar in the figure). The figure shows that increased juvenile mortality and the inclusion of drought and inbreeding depression did in fact lead to increased extinction risk. However, the primary determinant of extinction risk is clearly shown to be adult mortality over all other factors.

As discussed earlier, the increased adult mortality was employed to simulate poaching of adults by local peoples. More specifically, these levels of mortality simulated 3%, 6% and 9% poaching rates. Given that the "best-case", non-poaching scenario resulted in a 4% population growth rate, a 6% rate of poaching of adult tapirs does not appear to be sustainable. Stated another way, poaching about 60 tapirs from a population of 1000, under the conditions simulated herein, can drive a population to extinction, even under low or modest levels of juvenile mortality. If drought conditions similar to those modelled in this report are operating on wild tapir populations in Panama, even a 3% poaching rate leads to a deterministic decline in the population growth rate even when juvenile mortality is low. **Taken together, these modelling results lead to the conclusion that poaching of adult tapirs—even at low levels—can have severe consequences for the persistence of these populations.**

Development of a coherent tapir management plan will likely involve choices between alternative strategies. Given this prospect, it is clear that a vital component of wild tapir management should focus on reducing rates of poaching down to sustainable levels.

Sample VORTEX Input File

```
TAPIR425.OUT     ***Output Filename***
Y     ***Graphing Files?***
N     ***Each Iteration?***
Y      ***Screen display of graphs?***
200      ***Simulations***
100      ***Years***
10     ***Reporting Interval***
1     ***Populations***
Y     ***Inbreeding Depression?***
H
3.140000
N     ***EV correlation?***
1     ***Types Of Catastrophes***
P     ***Monogamous, Polygynous, or Hermaphroditic***
3     ***Female Breeding Age***
3     ***Male Breeding Age***
20     ***Maximum Age***
0.500000     ***Sex Ratio***
1     ***Maximum Litter Size***
N     ***Density Dependent Breeding?***
50.000000     ***Population 1: Percent Litter Size 0***
50.000000     ***Population 1: Percent Litter Size 1***
12.500000     ***EV--Reproduction***
25.000000     ***Female Mortality At Age 0***
7.500000     ***EV--FemaleMortality***
10.000000     ***Female Mortality At Age 1***
3.000000     ***EV--FemaleMortality***
10.000000     ***Female Mortality At Age 2***
3.000000     ***EV--FemaleMortality***
10.000000     ***Adult Female Mortality***
3.000000     ***EV--AdultFemaleMortality***
25.000000     ***Male Mortality At Age 0***
7.500000     ***EV--MaleMortality***
10.000000     ***Male Mortality At Age 1***
3.000000     ***EV--MaleMortality***
10.000000     ***Male Mortality At Age 2***
3.000000     ***EV--MaleMortality***
10.000000     ***Adult Male Mortality***
3.000000     ***EV--AdultMaleMortality***
20.000000     ***Probability Of Catastrophe 1***
1.000000     ***Severity--Reproduction***
1.000000     ***Severity--Survival***
Y     ***All Males Breeders?***
Y     ***Start At Stable Age Distribution?***
60     ***Initial Population Size***
150     ***K***
0.000000     ***EV--K***
Y     ***Trend In K?***
20
-2.500000
N     ***Harvest?***
N     ***Supplement?***
Y     ***AnotherSimulation?***
```

Sample VORTEX Output File

```
VORTEX -- simulation of genetic and demographic stochasticity

TAPIR425.OUT
Thu Apr 13 10:17:28 1995


  1 population(s) simulated for 100 years, 200 iterations

  HETEROSIS model of inbreeding depression
    with 3.14000 lethal equivalents per diploid genome

  First age of reproduction for females: 3   for males: 3
  Age of senescence (death): 20
  Sex ratio at birth (proportion males): 0.50000


Population 1:

  Polygynous mating; all adult males in the breeding pool.

  Reproduction is assumed to be density independent.

   50.00 (EV = 12.50 SD) percent of adult females produce litters of size 0
   50.00 percent of adult females produce litters of size 1

   25.00 (EV = 7.50 SD) percent mortality of females between ages 0 and 1
   10.00 (EV = 3.00 SD) percent mortality of females between ages 1 and 2
   10.00 (EV = 3.00 SD) percent mortality of females between ages 2 and 3
   10.00 (EV = 3.00 SD) percent annual mortality of adult females
(3<=age<=20)
   25.00 (EV = 7.50 SD) percent mortality of males between ages 0 and 1
   10.00 (EV = 3.00 SD) percent mortality of males between ages 1 and 2
   10.00 (EV = 3.00 SD) percent mortality of males between ages 2 and 3
   10.00 (EV = 3.00 SD) percent annual mortality of adult males
(3<=age<=20)
    EVs may have been adjusted to closest values
        possible for binomial distribution.
    EV in mortality will be correlated among age-sex classes
       but independent from EV in reproduction.

  Frequency of type 1 catastrophes: 10.000 percent
    with 1.000 multiplicative effect on reproduction
     and 1.000 multiplicative effect on survival

  Initial size of Population 1:
    (set to reflect stable age distribution)
Age 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 Total
    4  4  3  2  3  2  2  1  2  1  1  1  1  0  1  0  1  0  1  0   30  Males
    4  4  3  2  3  2  2  1  2  1  1  1  1  0  1  0  1  0  1  0   30  Females

  Carrying capacity = 150 (EV = 0.00 SD)
    with a 2.500 percent decrease for 20 years.
```

```
Deterministic population growth rate (based on females, with assumptions of
  no limitation of mates, no density dependence, and no inbreeding
depression):

     r =  0.030      lambda = 1.031      R0 =      1.291
   Generation time for:  females = 8.49    males = 8.49

Stable age distribution:  Age class     females     males
                              0          0.079       0.079
                              1          0.057       0.057
                              2          0.050       0.050
                              3          0.044       0.044
                              4          0.038       0.038
                              5          0.033       0.033
                              6          0.029       0.029
                              7          0.025       0.025
                              8          0.022       0.022
                              9          0.019       0.019
                             10          0.017       0.017
                             11          0.015       0.015
                             12          0.013       0.013
                             13          0.011       0.011
                             14          0.010       0.010
                             15          0.009       0.009
                             16          0.008       0.008
                             17          0.007       0.007
                             18          0.006       0.006
                             19          0.005       0.005
                             20          0.004       0.004

Ratio of adult (>= 3) males to adult (>= 3) females: 1.000


Population 1

Year 10
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =   200, P[S] = 1.000
     Population size =             81.37 (   1.34 SE,    18.98 SD)
     Expected heterozygosity =     0.978 (  0.000 SE,    0.003 SD)
     Observed heterozygosity =     0.996 (  0.000 SE,    0.007 SD)
     Number of extant alleles =    65.64 (   0.63 SE,     8.92 SD)

Year 20
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =   200, P[S] = 1.000
     Population size =             73.59 (   0.69 SE,     9.80 SD)
     Expected heterozygosity =     0.965 (  0.000 SE,    0.007 SD)
     Observed heterozygosity =     0.986 (  0.001 SE,    0.015 SD)
     Number of extant alleles =    44.14 (   0.46 SE,     6.46 SD)
```

```
Year 30
     N[Extinct] =         0, P[E] = 0.000
     N[Surviving] =     200, P[S] = 1.000
     Population size =              68.61 (    0.62 SE,     8.80 SD)
     Expected heterozygosity =      0.950 (   0.001 SE,    0.010 SD)
     Observed heterozygosity =      0.974 (   0.001 SE,    0.020 SD)
     Number of extant alleles =     32.42 (    0.31 SE,     4.43 SD)

Year 40
     N[Extinct] =         0, P[E] = 0.000
     N[Surviving] =     200, P[S] = 1.000
     Population size =              67.83 (    0.67 SE,     9.48 SD)
     Expected heterozygosity =      0.935 (   0.001 SE,    0.015 SD)
     Observed heterozygosity =      0.961 (   0.002 SE,    0.025 SD)
     Number of extant alleles =     25.67 (    0.25 SE,     3.54 SD)

Year 50
     N[Extinct] =         0, P[E] = 0.000
     N[Surviving] =     200, P[S] = 1.000
     Population size =              66.74 (    0.78 SE,    11.00 SD)
     Expected heterozygosity =      0.919 (   0.001 SE,    0.020 SD)
     Observed heterozygosity =      0.947 (   0.002 SE,    0.033 SD)
     Number of extant alleles =     21.12 (    0.22 SE,     3.13 SD)

Year 60
     N[Extinct] =         0, P[E] = 0.000
     N[Surviving] =     200, P[S] = 1.000
     Population size =              64.09 (    0.93 SE,    13.09 SD)
     Expected heterozygosity =      0.906 (   0.002 SE,    0.022 SD)
     Observed heterozygosity =      0.930 (   0.003 SE,    0.039 SD)
     Number of extant alleles =     17.90 (    0.21 SE,     2.97 SD)

Year 70
     N[Extinct] =         0, P[E] = 0.000
     N[Surviving] =     200, P[S] = 1.000
     Population size =              61.96 (    1.03 SE,    14.54 SD)
     Expected heterozygosity =      0.890 (   0.002 SE,    0.027 SD)
     Observed heterozygosity =      0.917 (   0.003 SE,    0.047 SD)
     Number of extant alleles =     15.55 (    0.20 SE,     2.81 SD)

Year 80
     N[Extinct] =         0, P[E] = 0.000
     N[Surviving] =     200, P[S] = 1.000
     Population size =              60.32 (    1.14 SE,    16.11 SD)
     Expected heterozygosity =      0.873 (   0.003 SE,    0.038 SD)
     Observed heterozygosity =      0.904 (   0.004 SE,    0.050 SD)
     Number of extant alleles =     13.76 (    0.20 SE,     2.78 SD)

Year 90
     N[Extinct] =         1, P[E] = 0.005
     N[Surviving] =     199, P[S] = 0.995
     Population size =              57.73 (    1.19 SE,    16.85 SD)
     Expected heterozygosity =      0.858 (   0.003 SE,    0.047 SD)
     Observed heterozygosity =      0.887 (   0.004 SE,    0.054 SD)
     Number of extant alleles =     12.21 (    0.19 SE,     2.73 SD)
```

```
Year 100
     N[Extinct] =       3, P[E] = 0.015
     N[Surviving] =   197, P[S] = 0.985
     Population size =           55.06 (   1.28 SE,   17.99 SD)
     Expected heterozygosity =   0.839 (  0.004 SE,   0.059 SD)
     Observed heterozygosity =   0.873 (  0.005 SE,   0.068 SD)
     Number of extant alleles =  10.93 (   0.19 SE,    2.62 SD)


In 200 simulations of Population 1 for 100 years:
  3 went extinct and 197 survived.

This gives a probability of extinction of 0.0150 (0.0086 SE),
  or a probability of success of          0.9850 (0.0086 SE).

3 simulations went extinct at least once.
Of those going extinct,
    mean time to first extinction was 94.67 years (3.18 SE, 5.51 SD).

No recolonizations.

Mean final population for successful cases was 55.06 (1.28 SE, 17.99 SD)

   Age 1       2   Adults    Total
    3.23    2.68   21.16     27.07  Males
    3.32    3.17   21.50     27.99  Females

Without harvest/supplementation, prior to carrying capacity truncation,
  mean growth rate (r) was 0.0134 (0.0006 SE, 0.0781 SD)

Final expected heterozygosity was      0.8394 ( 0.0042 SE,  0.0593 SD)
Final observed heterozygosity was      0.8732 ( 0.0049 SE,  0.0681 SD)
Final number of alleles was             10.93 (   0.19 SE,    2.62 SD)
*************************************************************************
```

Table 7.1. Baird's tapir population analysis: initial population size = 1200, K = 3000.

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
301	20	10	None	.038	.037 (.054)	0.0	2955 (94)	0.996	—
313			Drought	.011	.008 (.104)	0.0	1923 (820)	0.991	—
302		13	None	.008	.006 (.064)	0.0	2080 (713)	0.992	—
314			Drought	-.018	-.024 (.116)	0.014	208 (256)	0.941	93
303		16	None	-.022	-.026 (.081)	0.008	131 (124)	0.943	90
315			Drought	-.049	-.059 (.151)	0.480	19 (21)	0.753	82
304		19	None	-.054	-.062 (.136)	0.556	12 (10)	0.696	83
316			Drought	-.081	-.096 (.184)	0.970	6 (5)	0.434	65
305	25	10	None	.030	.029 (.055)	0.0	2930 (121)	0.995	—
317			Drought	.004	.000 (.104)	0.0	1359 (868)	0.990	—
306		13	None	.000	-.002 (.066)	0.0	1171 (687)	0.988	—
318			Drought	-.026	-.032 (.119)	0.038	99 (138)	0.906	86
307		16	None	-.030	-.035 (.091)	0.038	58 (52)	0.897	91
319			Drought	-.057	-.068 (.161)	0.728	15 (14)	0.713	80
308		19	None	-.062	-.073 (.148)	0.796	10 (9)	0.633	80
320			Drought	-.089	-.105 (.187)	0.996	8 (5)	0.512	61
309	30	10	None	.022	.021 (.057)	0.0	2876 (184)	0.995	—
321			Drought	-.005	-.008 (.105)	0.0	760 (654)	0.979	—
310		13	None	-.008	-.011 (.069)	0.0	510 (362)	0.981	—
322			Drought	-.034	-.043 (.131)	0.170	47 (56)	0.854	87
311		16	None	-.039	-.044 (.103)	0.136	31 (32)	0.841	89
323			Drought	-.065	-.078 (.169)	0.834	9 (6)	0.653	75
312		19	None	-.071	-.083 (.157)	0.916	8 (7)	0.537	73
324			Drought	-.097	-.113 (.190)	0.998	5 (0)	0.480	57

Table 7.2. Baird's tapir population analysis: initial population size = 1200, K = 3000, 2.5% annual reduction in K over the first 20 years of the simulation (50% total reduction in K).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
325	20	10	None	.038	.036 (.055)	0.0	1478 (42)	0.992	—
337			Drought	.011	.008 (.105)	0.0	1036 (382)	0.988	—
326		13	None	.008	.006 (.064)	0.0	1218 (267)	0.990	—
338			Drought	-.018	-.024 (.116)	0.020	191 (214)	0.938	93
327		16	None	-.022	-.026 (.082)	0.006	132 (125)	0.940	89
339			Drought	-.049	-.059 (.153)	0.494	19 (21)	0.767	82
328		19	None	-.054	-.065 (.138)	0.636	13 (10)	0.723	83
340			Drought	-.081	-.095 (.181)	0.972	7 (4)	0.526	66
329	25	10	None	.030	.029 (.056)	0.0	1463 (68)	0.992	—
341			Drought	.004	.000 (.105)	0.0	863 (435)	0.986	—
330		13	None	.000	-.002 (.066)	0.0	882 (345)	0.988	—
342			Drought	-.026	-.032 (.120)	0.050	96 (112)	0.914	89
331		16	None	-.030	-.035 (.090)	0.044	60 (58)	0.900	93
343			Drought	-.057	-.069 (.162)	0.702	12 (14)	0.696	79
332		19	None	-.062	-.073 (.149)	0.814	10 (7)	0.645	80
344			Drought	-.089	-.105 (.187)	0.992	4 (1)	0.458	61
333	30	10	None	.022	.020 (.058)	0.0	1431 (100)	0.992	—
345			Drought	-.005	-.008 (.105)	0.002	571 (395)	0.979	100
334		13	None	-.008	-.010 (.069)	0.0	488 (269)	0.981	—
346			Drought	-.034	-.042 (.128)	0.138	48 (59)	0.862	87
335		16	None	-.039	-.046 (.106)	0.182	29 (28)	0.830	91
347			Drought	-.065	-.079 (.170)	0.862	10 (6)	0.647	75
336		19	None	-.071	-.084 (.156)	0.950	8 (5)	0.617	74
348			Drought	-.097	-.113 (.191)	0.998	3 (0)	0.611	57

Table 7.3. Baird's tapir population analysis: initial population size = 60, K = 150.

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
349	20	10	None	.038	.036 (.066)	0.0	145 (9)	0.910	—
361			Drought	.011	.003 (.126)	0.090	85 (45)	0.812	67
350		13	None	.008	.003 (.091)	0.040	90 (44)	0.822	70
362			Drought	-.018	-.033 (.169)	0.646	26 (25)	0.618	64
351		16	None	-.022	-.038 (.156)	0.726	17 (15)	0.583	64
363			Drought	-.049	-.067 (.203)	0.966	8 (4)	0.435	47
352		19	None	-.054	-.073 (.193)	0.990	7 (4)	0.519	45
364			Drought	-.081	-.103 (.225)	1.0	—	—	30
353	25	10	None	.030	.027 (.069)	0.0	142 (12)	0.908	—
365			Drought	.004	-.005 (.133)	0.174	67 (45)	0.781	69
354		13	None	.000	-.007 (.105)	0.148	62 (42)	0.772	72
366			Drought	-.026	-.040 (.175)	0.762	17 (16)	0.609	61
355		16	None	-.030	-.045 (.162)	0.818	15 (13)	0.537	60
367			Drought	-.057	-.076 (.204)	0.990	10 (7)	0.496	44
356		19	None	-.062	-.083 (.199)	0.996	7 (6)	0.452	40
368			Drought	-.089	-.114 (.233)	1.0	—	—	30
357	30	10	None	.022	.019 (.072)	0.006	134 (24)	0.895	68
369			Drought	-.005	-.015 (.141)	0.282	45 (40)	0.738	68
358		13	None	-.008	-.017 (.122)	0.322	38 (31)	0.716	73
370			Drought	-.034	-.050 (.185)	0.870	12 (10)	0.559	57
359		16	None	-.039	-.055 (.174)	0.916	11 (8)	0.483	54
371			Drought	-.065	-.083 (.210)	0.996	7 (3)	0.572	40
360		19	None	-.071	-.093 (.207)	0.998	4 (0)	0.375	37
372			Drought	-.097	-.123 (.233)	1.0	—	—	28

Table 7.4. Baird's tapir population analysis: initial population size = 60, K = 150, 2.5% annual reduction in K over the first 20 years of the simulation (50% total reduction in K).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
373	20	10	None	.038	.034 (.075)	0.0	71 (6)	0.853	—
385			Drought	.011	.003 (.131)	0.106	47 (22)	0.767	69
374		13	None	.008	.001 (.099)	0.070	47 (21)	0.780	72
386			Drought	-.018	-.033 (.170)	0.646	20 (16)	0.615	65
375		16	None	-.022	-.035 (.154)	0.694	16 (14)	0.539	66
387			Drought	-.049	-.068 (.202)	0.972	8 (5)	0.397	46
376		19	None	-.054	-.075 (.196)	0.990	7 (5)	0.358	44
388			Drought	-.081	-.102 (.227)	1.0	—	—	33
377	25	10	None	.030	.025 (.077)	0.002	69 (9)	0.846	41
389			Drought	.004	-.007 (.139)	0.232	38 (22)	0.736	71
378		13	None	.000	-.007 (.108)	0.176	40 (20)	0.744	72
390			Drought	-.026	-.043 (.179)	0.796	15 (11)	0.533	61
379		16	None	-.030	-.047 (.167)	0.868	12 (11)	0.508	60
391			Drought	-.057	-.081 (.211)	0.994	6 (3)	0.432	41
380		19	None	-.062	-.083 (.199)	0.996	2 (0)	0.313	40
392			Drought	-.089	-.112 (.228)	0.998	8 (0)	0.219	30
381	30	10	None	.022	.017 (.080)	0.008	65 (14)	0.837	80
393			Drought	-.005	-.016 (.147)	0.350	29 (21)	0.694	72
382		13	None	-.008	-.017 (.122)	0.312	28 (18)	0.680	69
394			Drought	-.034	-.049 (.183)	0.868	13 (10)	0.567	56
383		16	None	-.039	-.056 (.172)	0.932	10 (9)	0.462	55
395			Drought	-.065	-.085 (.208)	0.996	13 (16)	0.239	39
384		19	None	-.071	-.091 (.201)	1.0	—	—	33
396			Drought	-.097	-.123 (.231)	1.0	—	—	28

Table 7.5. Baird's tapir population analysis: initial population size = 60, K = 150; inbreeding depression (heterosis, 3.14 lethal equivalents).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
397	20	10	None	.038	.027 (.066)	0.0	140 (13)	0.910	—
409			Drought	.011	-.012 (.132)	0.280	51 (41)	0.800	73
398		13	None	.008	-.016 (.109)	0.315	43 (33)	0.800	78
410			Drought	-.018	-.053 (.178)	0.930	9 (8)	0.683	60
399		16	None	-.022	-.055 (.167)	0.965	10 (5)	0.584	61
411			Drought	-.049	-.082 (.203)	1.0	—	—	42
400		19	None	-.054	-.087 (.196)	1.0	—	—	40
412			Drought	-.081	-.118 (.229)	1.0	—	—	30
401	25	10	None	.030	.017 (.071)	0.005	125 (32)	0.898	71
413			Drought	.004	-.020 (.140)	0.405	38 (34)	0.778	75
402		13	None	.000	-.024 (.123)	0.475	28 (26)	0.738	79
414			Drought	-.026	-.057 (.185)	0.960	11 (8)	0.669	56
403		16	None	-.030	-.065 (.176)	1.0	—	—	53
415			Drought	-.057	-.089 (.203)	1.0	—	—	38
404		19	None	-.062	-.097 (.199)	1.0	—	—	35
416			Drought	-.089	-.121 (.234)	1.0	—	—	29
405	30	10	None	.022	.008 (.075)	0.025	101 (40)	0.879	84
417			Drought	-.005	-.032 (.151)	0.630	25 (30)	0.735	74
406		13	None	-.008	-.037 (.141)	0.755	17 (15)	0.682	71
418			Drought	-.034	-.066 (.188)	0.980	5 (3)	0.554	50
407		16	None	-.039	-.073 (.180)	1.0	—	—	47
419			Drought	-.065	-.097 (.213)	1.0	—	—	35
408		19	None	-.071	-.104 (.200)	1.0	—	—	33
420			Drought	-.097	-.128 (.228)	1.0	—	—	27

Table 7.6. Baird's tapir population analysis: initial population size = 60, K = 150, 2.5% annual reduction in K over the first 20 years of the simulation (50% total reduction in K); inbreeding depression (heterosis, 3.14 lethal equivalents).

	Mortality (%)								
File #	Juvenile	Adult	Catastrophe	r_d	r_s (SD)	P(E)	N_{100}(SD)	H_{100}	T(E)
421	20	10	None	.038	.023 (.075)	0.0	64 (13)	0.852	—
433			Drought	.011	-.013 (.139)	0.345	27 (19)	0.743	76
422		13	None	.008	-.019 (.118)	0.380	22 (16)	0.729	78
434			Drought	-.018	-.051 (.180)	0.935	9 (6)	0.567	61
423		16	None	-.022	-.054 (.165)	0.965	5 (3)	0.490	59
435			Drought	-.049	-.078 (.203)	0.995	5 (0)	0.780	43
424		19	None	-.054	-.083 (.190)	1.0	—	—	40
436			Drought	-.081	-.115 (.233)	1.0	—	—	31
425	25	10	None	.030	.013 (.078)	0.015	55 (18)	0.839	95
437			Drought	.004	-.025 (.148)	0.545	19 (15)	0.715	77
426		13	None	.000	-.026 (.128)	0.515	16 (12)	0.682	78
438			Drought	-.026	-.055 (.180)	0.965	7 (3)	0.675	59
427		16	None	-.030	-.063 (.170)	1.0	—	—	53
439			Drought	-.057	-.090 (.209)	1.0	—	—	38
428		19	None	-.062	-.095 (.202)	1.0	—	—	36
440			Drought	-.089	-.121 (.224)	1.0	—	—	29
429	30	10	None	.022	.003 (.087)	0.070	45 (21)	0.819	87
441			Drought	-.005	-.033 (.154)	0.680	15 (15)	0.645	71
430		13	None	-.008	-.037 (.141)	0.745	11 (11)	0.639	72
442			Drought	-.034	-.063 (.184)	0.960	6 (3)	0.629	50
431		16	None	-.039	-.071 (.178)	1.0	—	—	48
443			Drought	-.065	-.094 (.212)	1.0	—	—	36
432		19	None	-.071	-.101 (.202)	1.0	—	—	34
444			Drought	-.097	-.130 (.232)	1.0	—	—	27

Figure Legends

Figure 7.1. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20%. Initial population size is 1200 and the carrying capacity is 3000. The four curves in each plot correspond to the four levels of adult mortality modelled in the simulations: 10%, 13%, 16%, and 19%. These symbols remain constant throughout the figures.

Figure 7.2. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25%. Initial population size is 1200 and the carrying capacity is 3000.

Figure 7.3. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30%. Initial population size is 1200 and the carrying capacity is 3000.

Figure 7.4. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20% and the addition of drought. Initial population size is 1200 and the carrying capacity is 3000.

Figure 7.5. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25% and the addition of drought. Initial population size is 1200 and the carrying capacity is 3000.

Figure 7.6. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30% and the addition of drought. Initial population size is 1200 and the carrying capacity is 3000.

Figure 7.7. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20%. Initial population size is 60 and the carrying capacity is 150.

Figure 7.8. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25%. Initial population size is 60 and the carrying capacity is 150.

Figure 7.9. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30%. Initial population size is 60 and the carrying capacity is 150.

Figure 7.10. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20% and the addition of drought. Initial population size is 60 and the carrying capacity is 150.

Figure 7.11. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25% and the addition of drought. Initial population size is 60 and the carrying capacity is 150.

Figure 7.12. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30% and the addition of drought. Initial population size is 60 and the carrying capacity is 150.

Figure 7.13. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20%. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 7.14. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25%. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 7.15. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30%. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 7.16. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 20% and the addition of drought. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 7.17. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 25% and the addition of drought. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 7.18. Probability of extinction (a) and population size (b) for simulated Baird's tapir populations with juvenile mortality = 30% and the addition of drought. Initial population size is 60 and the carrying capacity is 150, with inbreeding depression added to the simulations.

Figure 7.19. Effect of varying different population parameters on probability of extinction in simulated Baird's tapir populations. Each bar in the graph gives the probability of extinction averaged over all scenarios with the given parameter value.

Figure 1. Juvenile Mortality = 20%
$N_0 = 1200, K = 3000$

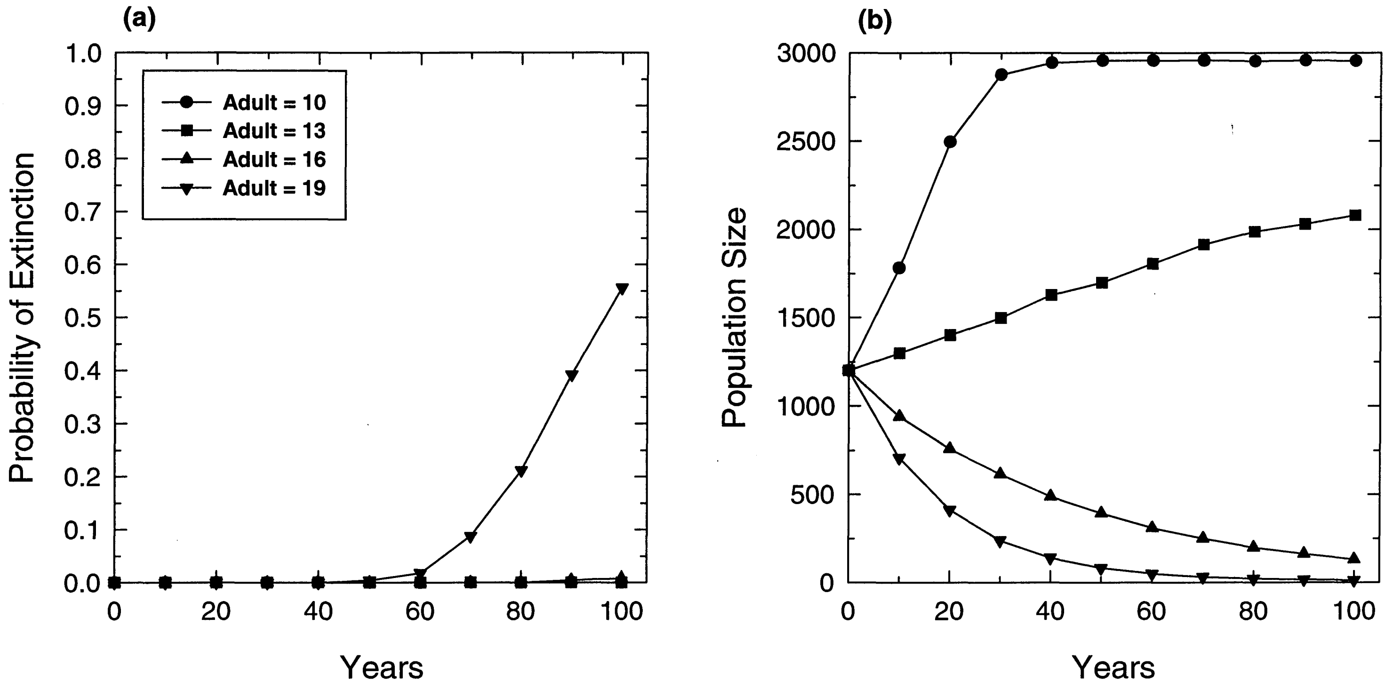


Figure 2. Juvenile Mortality = 25%
$N_0 = 1200, K = 3000$

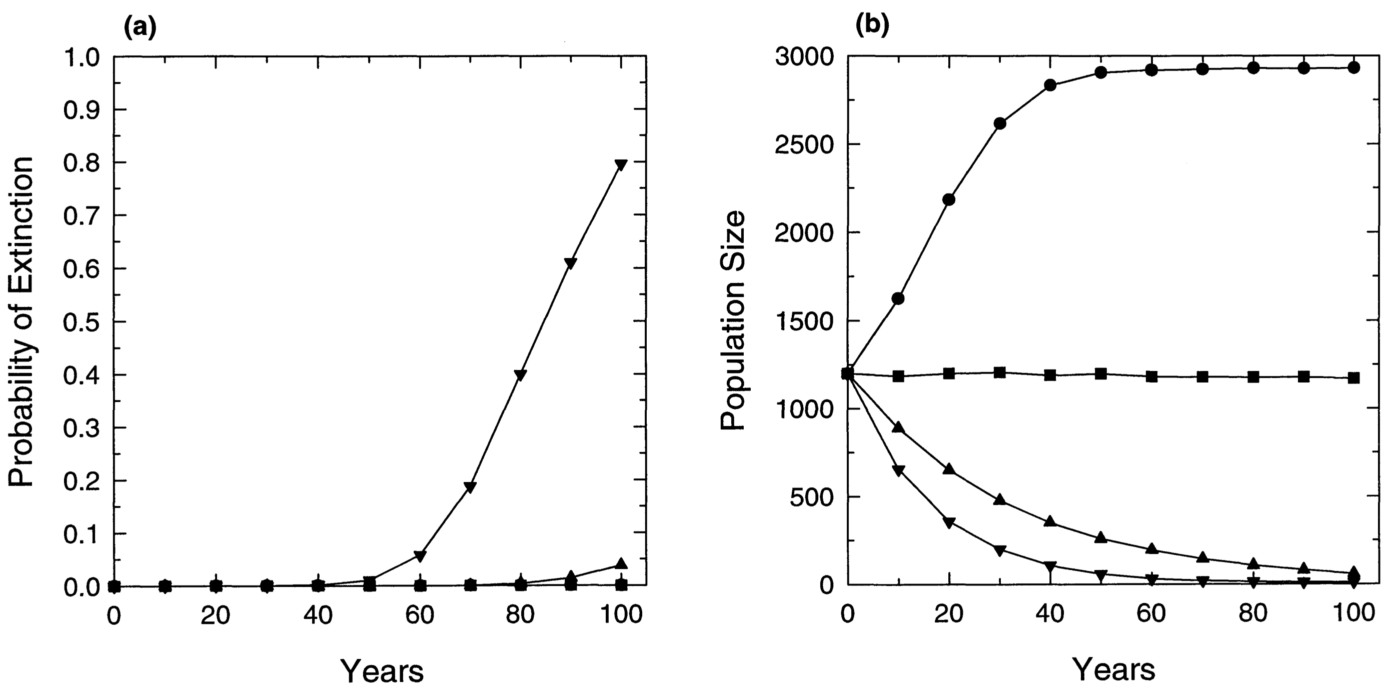


Figure 3. Juvenile Mortality = 30%
N_0 = 1200, K = 3000

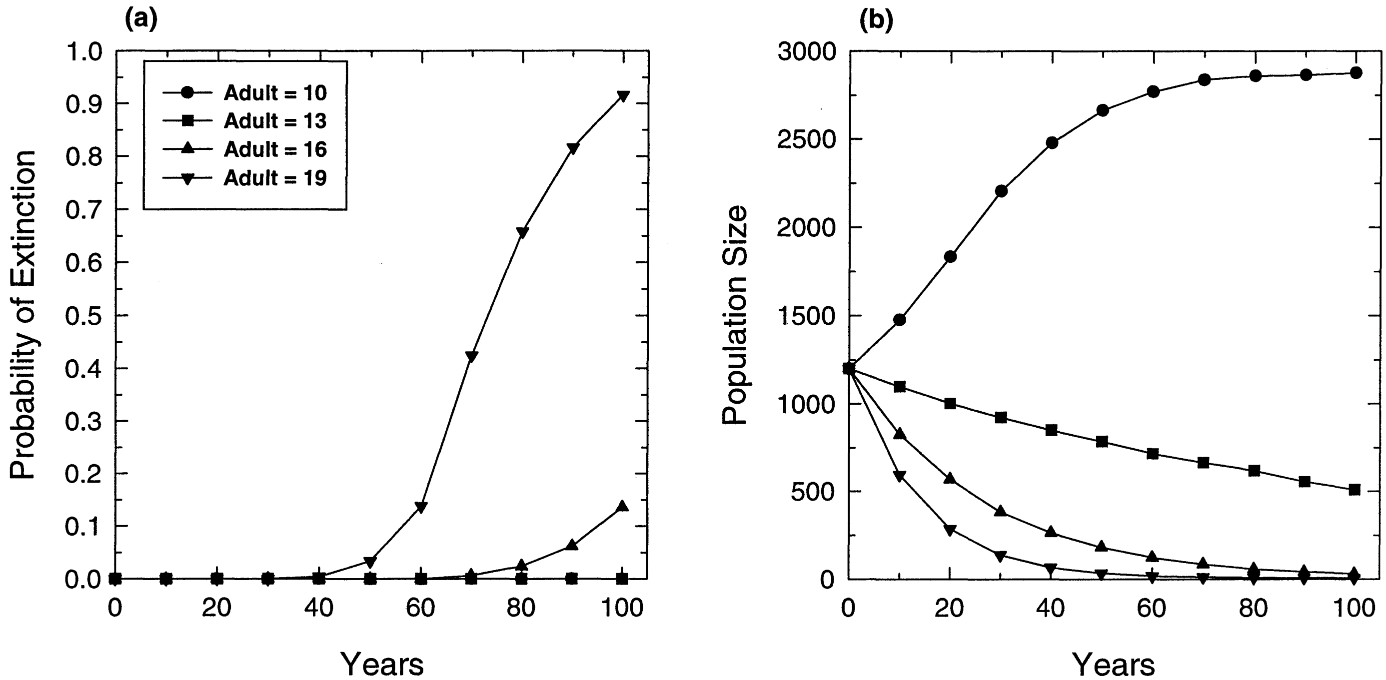


Figure 4. Juvenile Mortality = 20%
N_0 = 1200, K = 3000; Drought

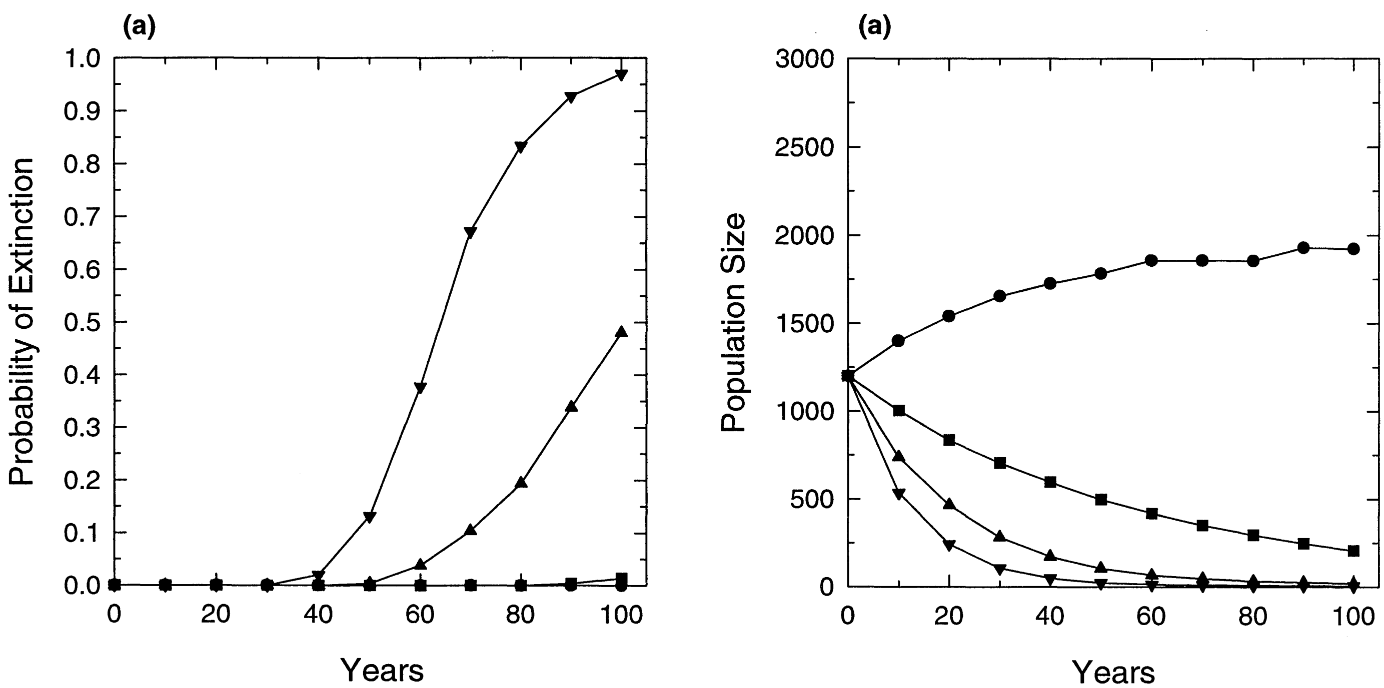


Figure 5. Juvenile Mortality = 25%
N_0 = 1200, K = 3000; Drought

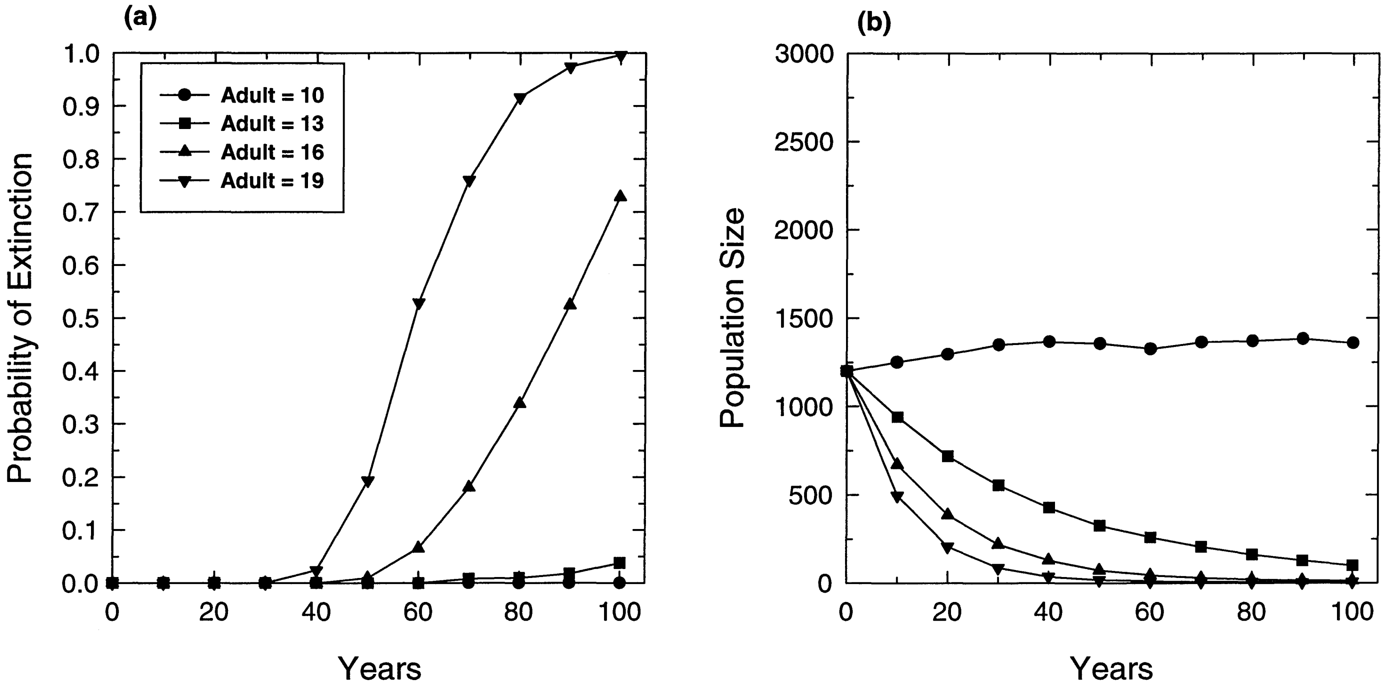


Figure 6. Juvenile Mortality = 30%
N_0 = 1200, K = 3000; Drought

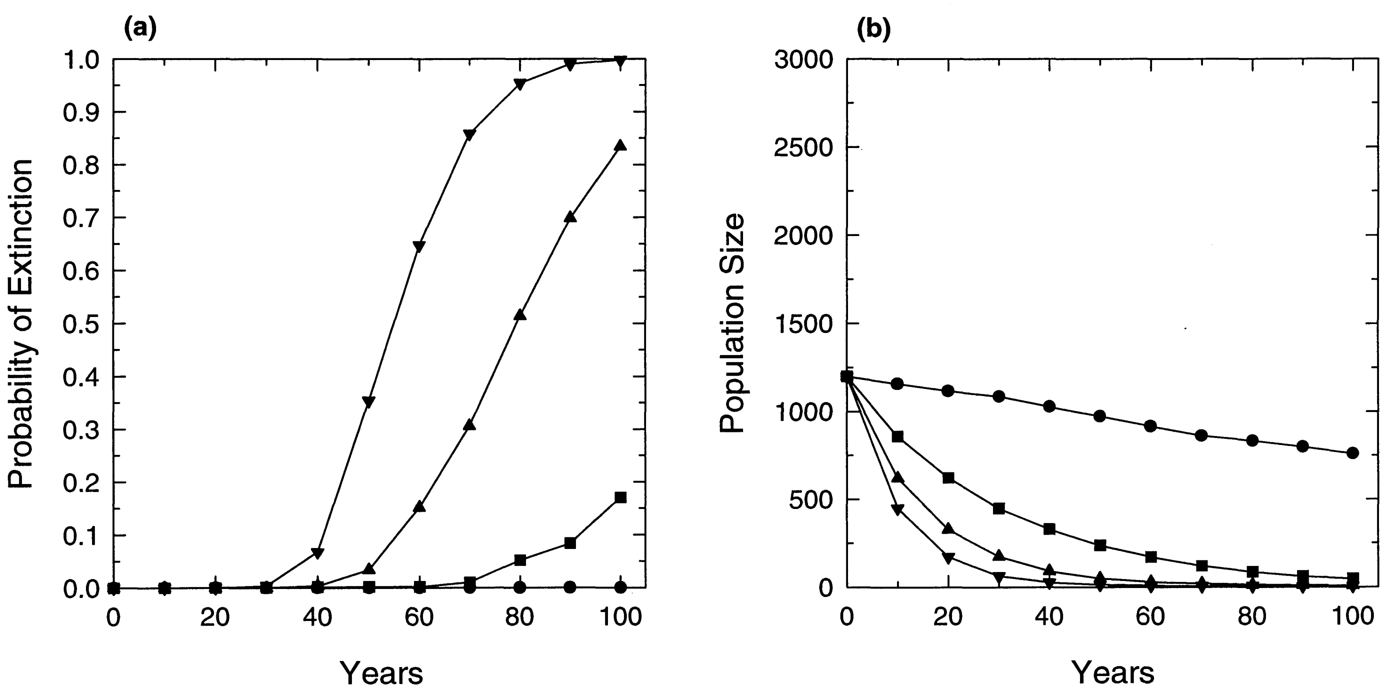
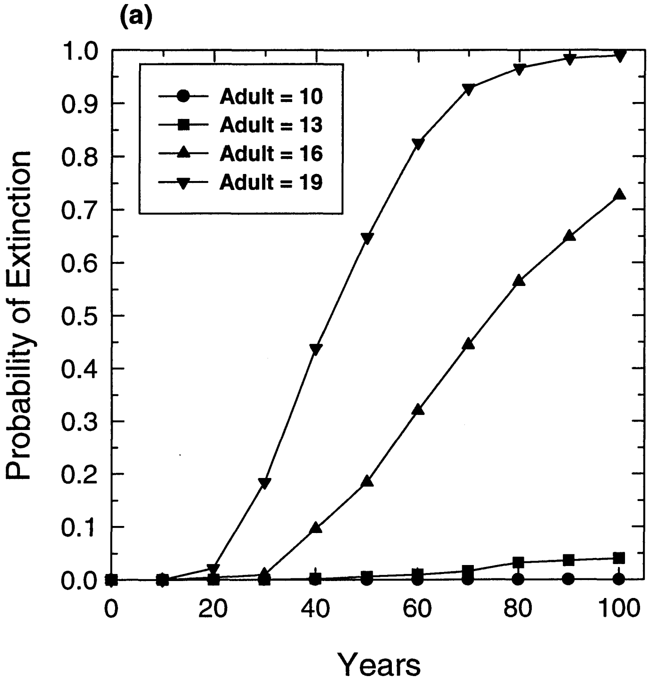


Figure 7. Juvenile Mortality = 20%
N_0 = 60, K = 150



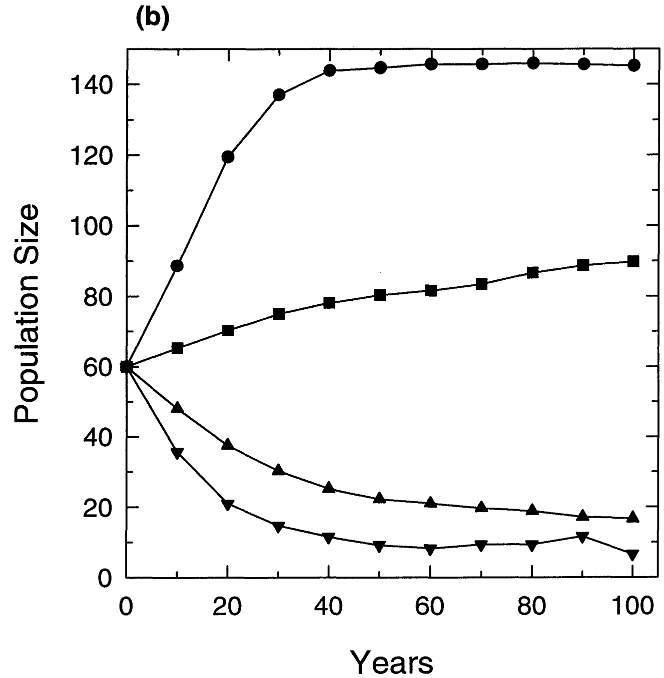
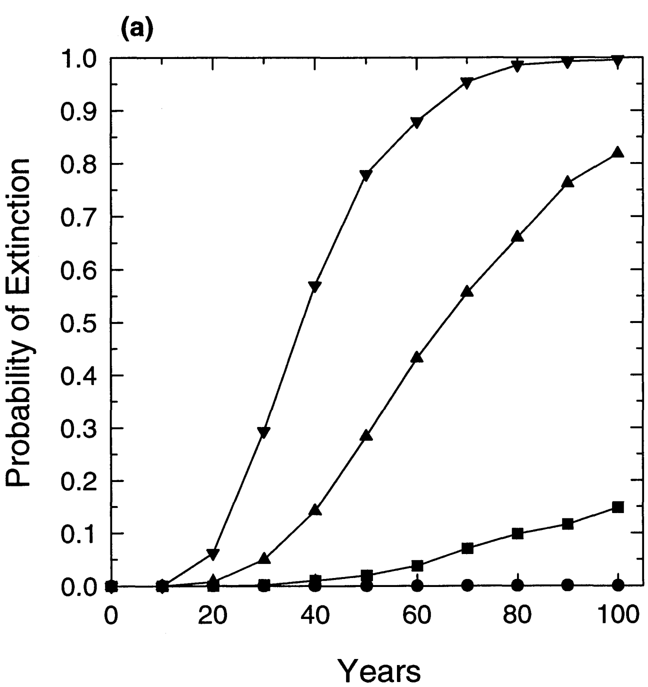


Figure 8. Juvenile Mortality = 25%
N_0 = 60, K = 150



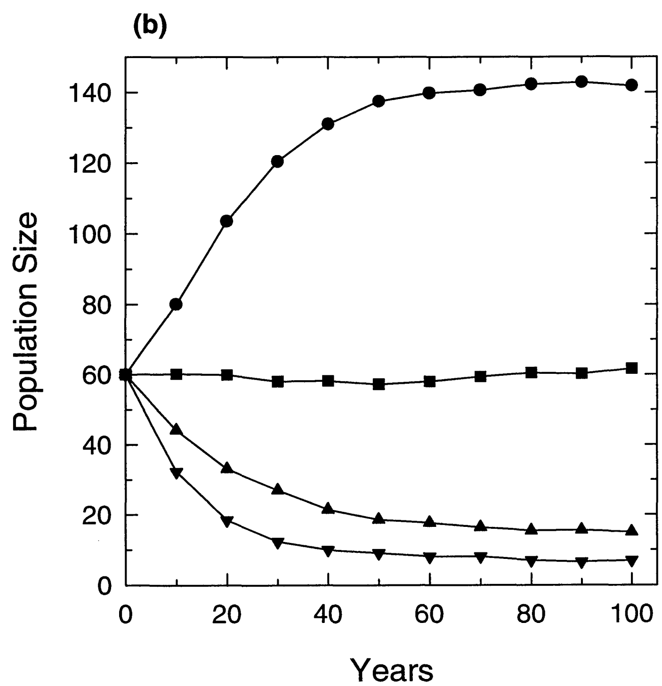


Figure 9. Juvenile Mortality = 30%
$N_0 = 60$, K = 150

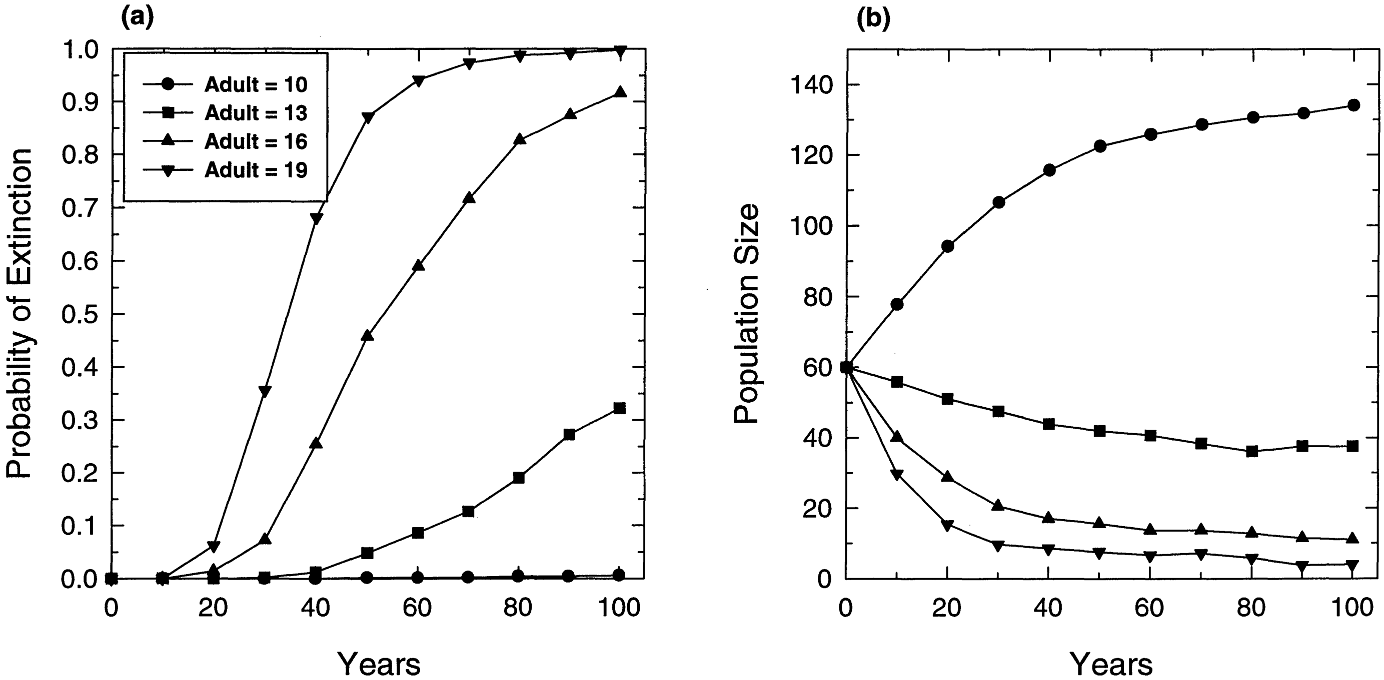


Figure 10. Juvenile Mortality = 20%
$N_0 = 60$, K = 150; Drought

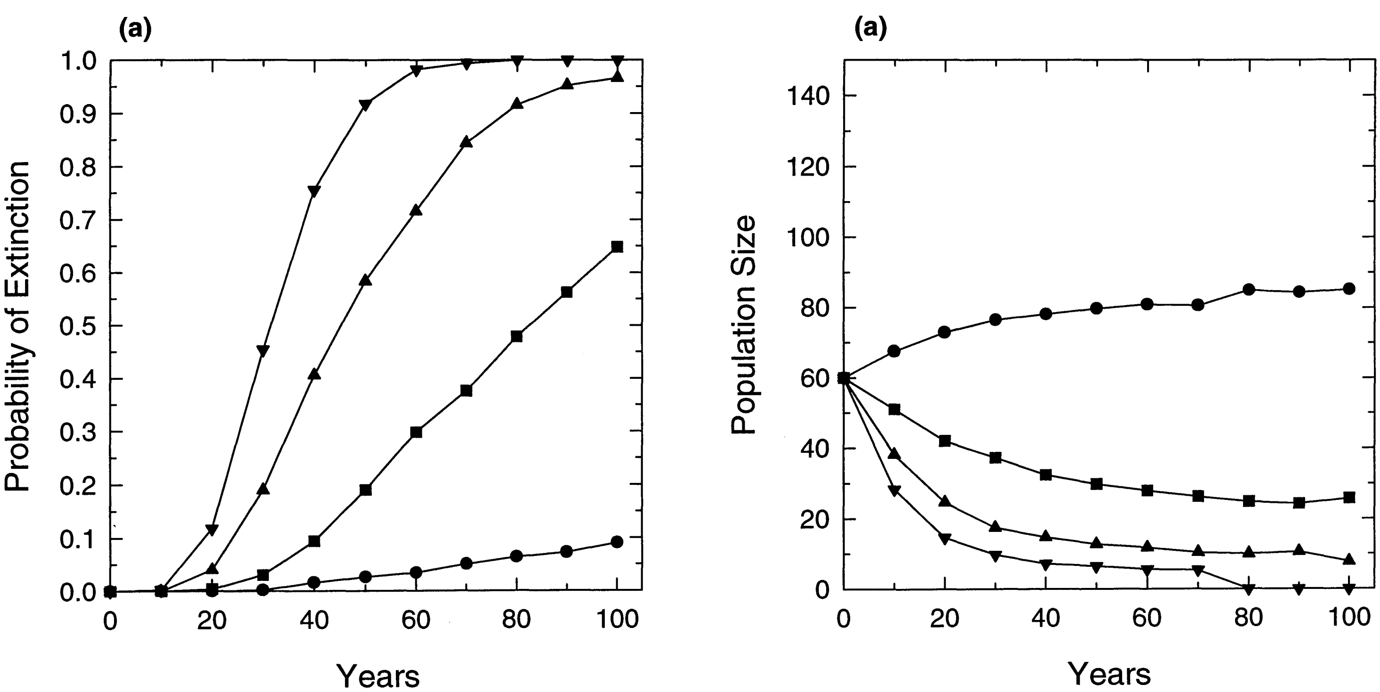


Figure 11. Juvenile Mortality = 25%
N_0 = 60, K = 150; Drought

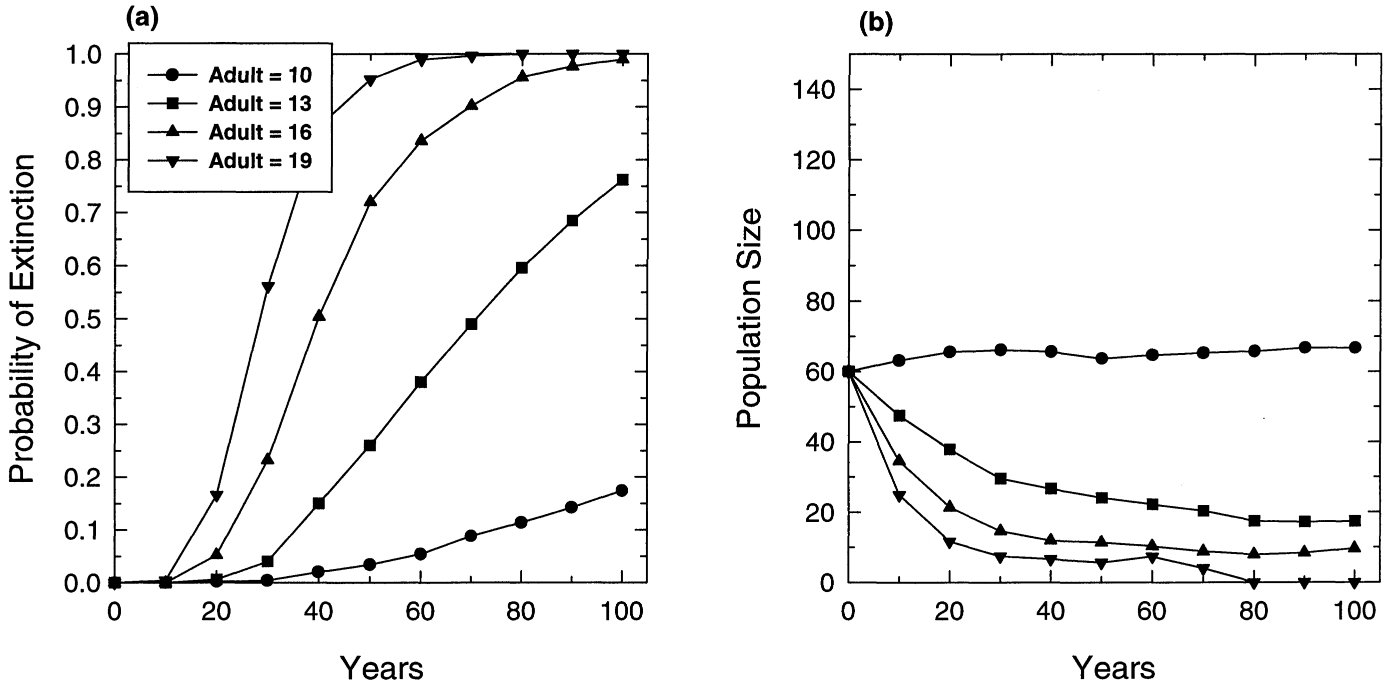


Figure 12. Juvenile Mortality = 30%
N_0 = 60, K = 150; Drought

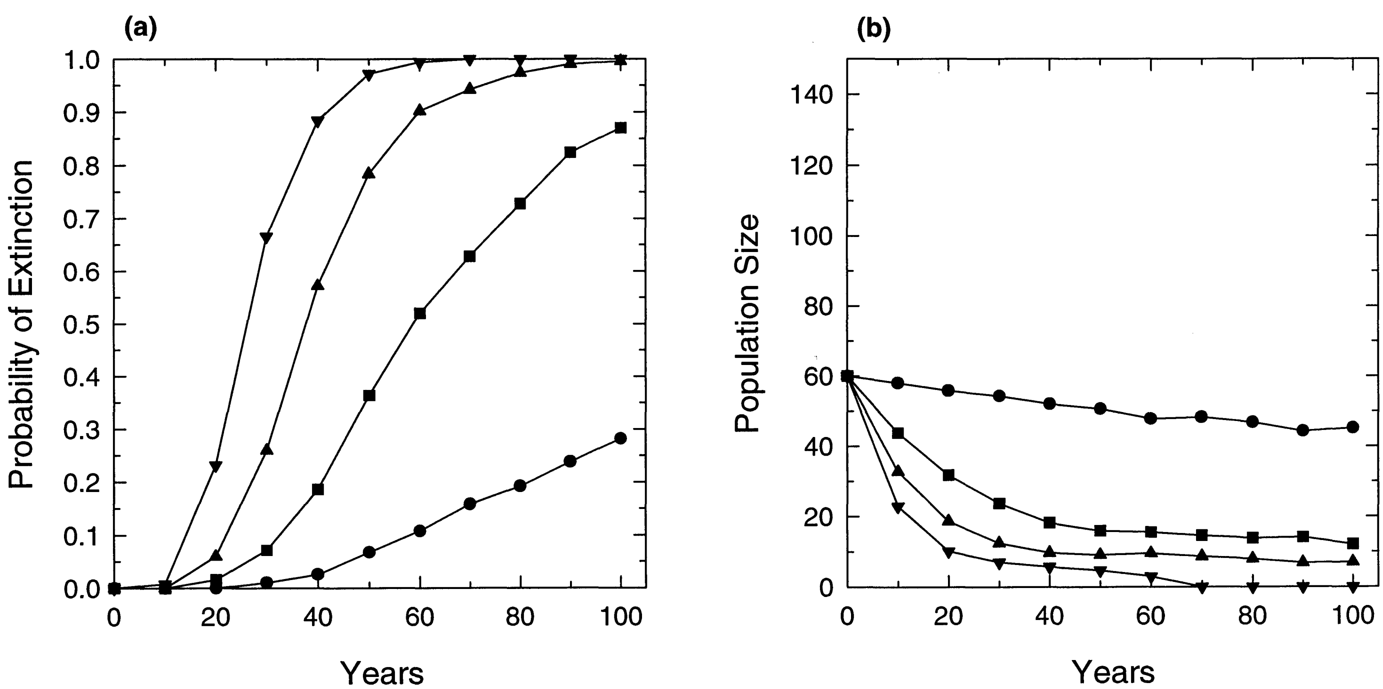


Figure 13. Juvenile Mortality = 20%
N_0 = 60, K = 150; Inbreeding Depression

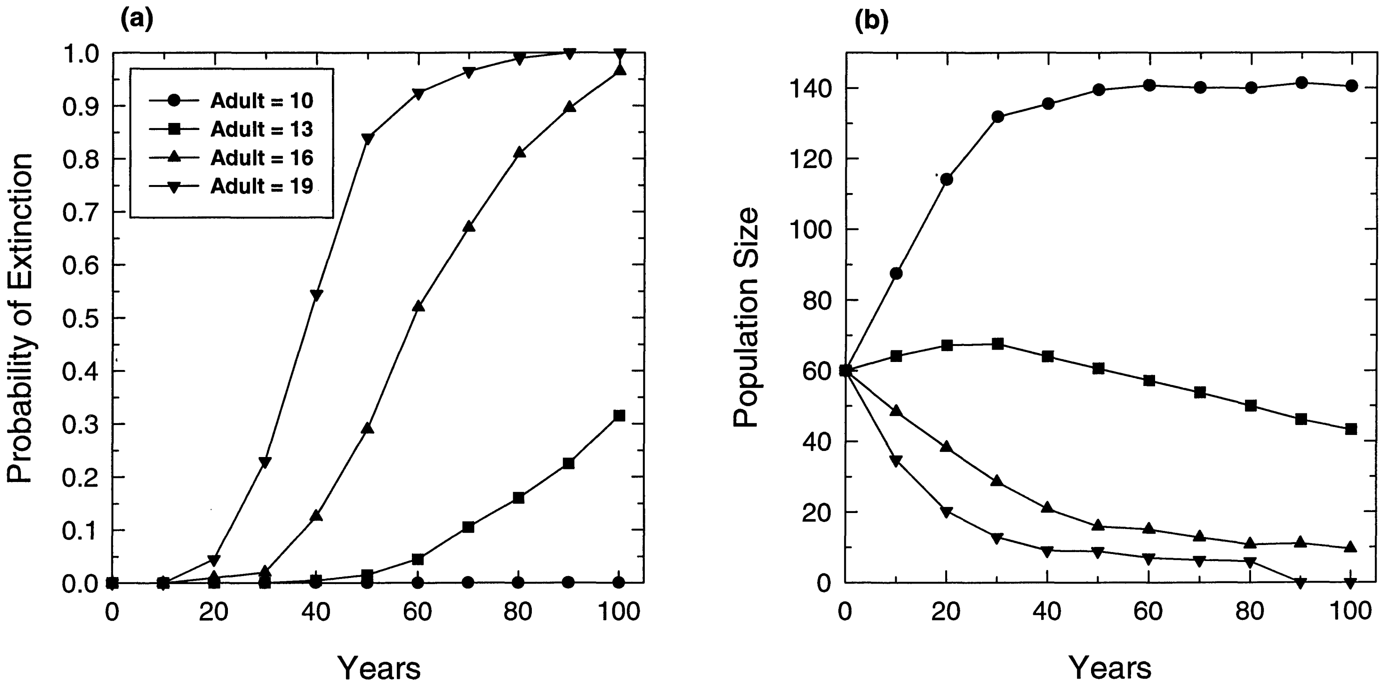


Figure 14. Juvenile Mortality = 25%
N_0 = 60, K = 150; Inbreeding Depression

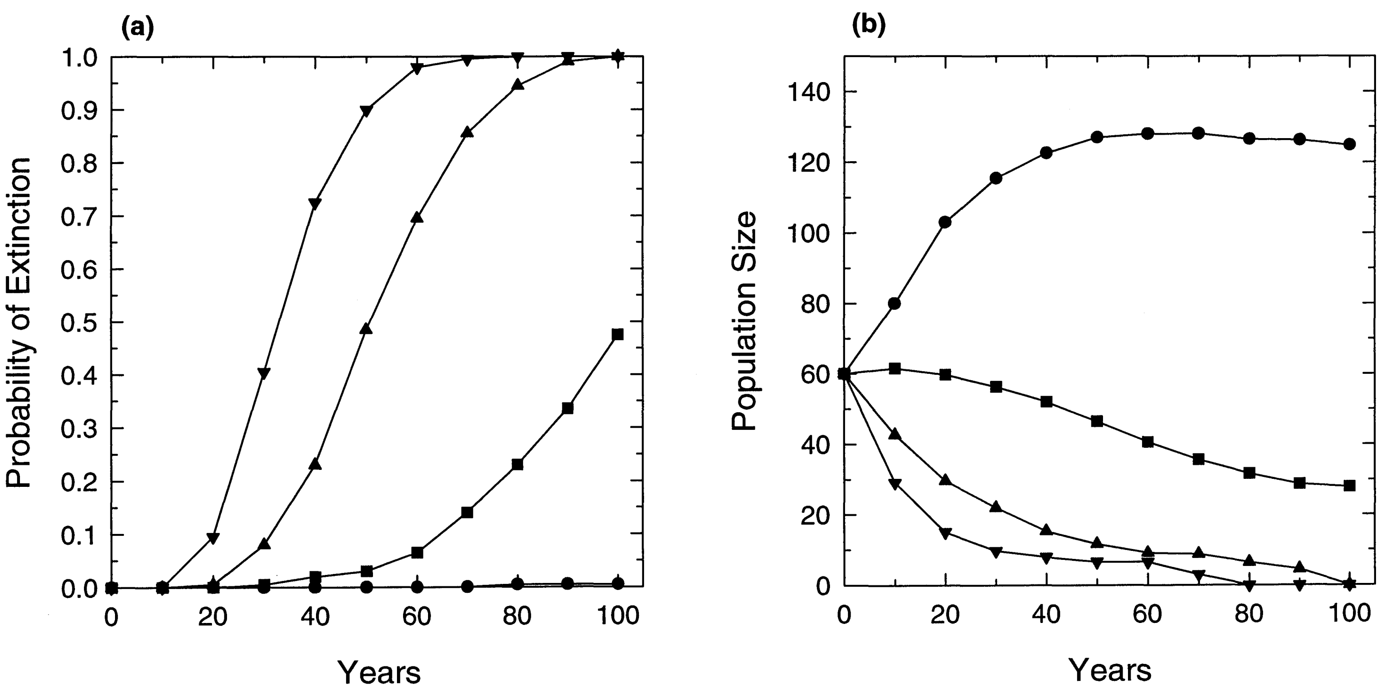


Figure 15. Juvenile Mortality = 30%
N_0 = 60, K = 150; Inbreeding Depression

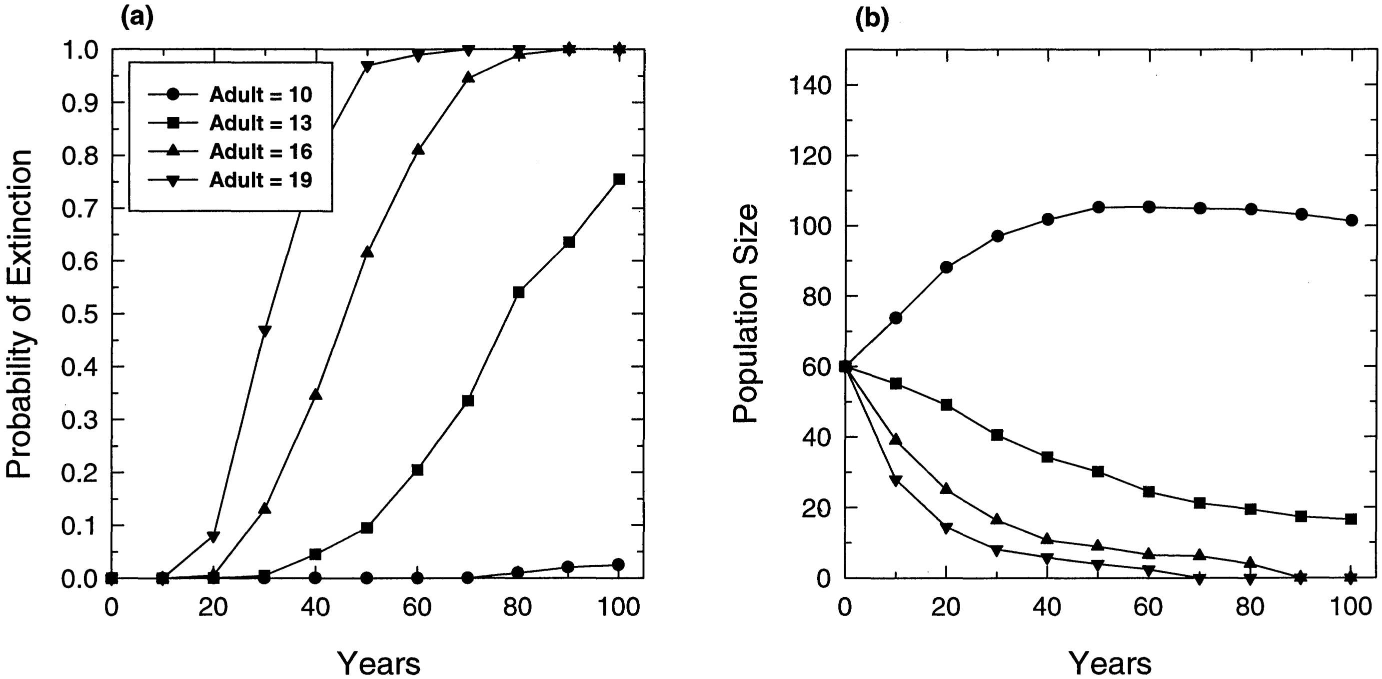


Figure 16. Juvenile Mortality = 20%
N_0 = 60, K = 150; Drought; Inbreeding Depression

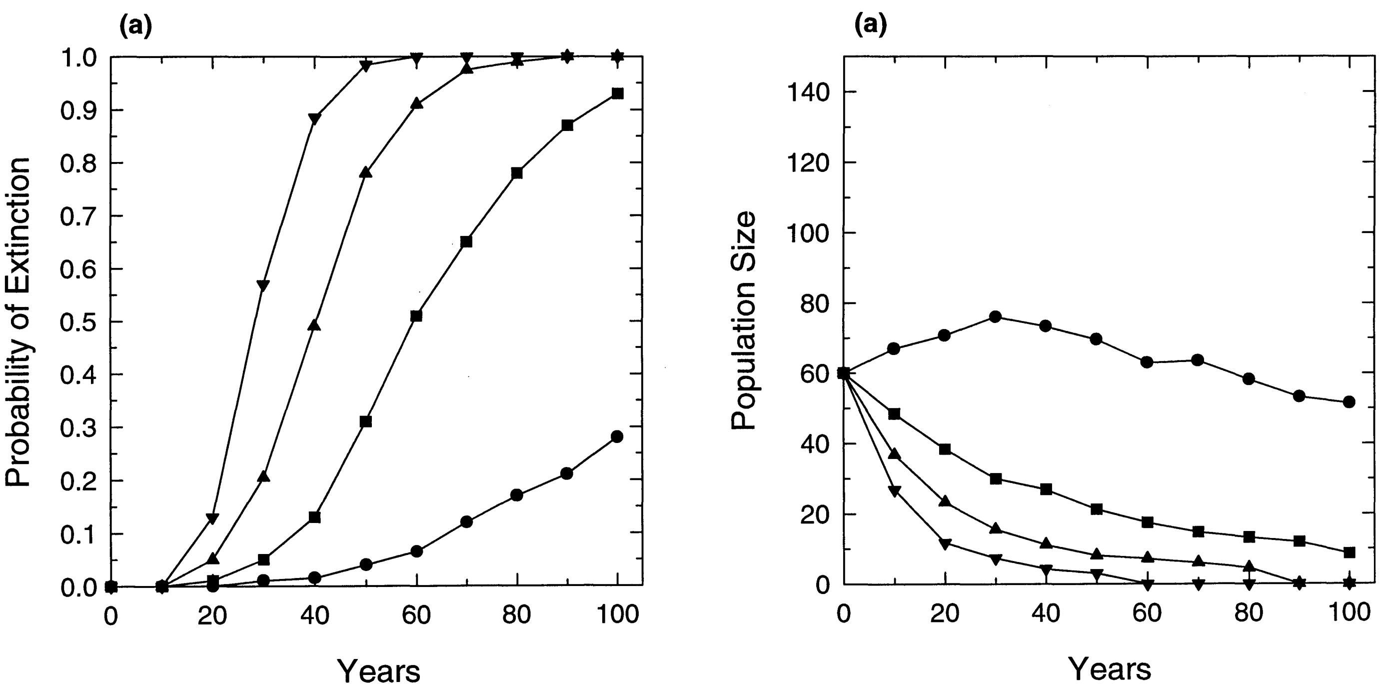


Figure 17. Juvenile Mortality = 25%
N_0 = 60, K = 150; Drought; Inbreeding Depression

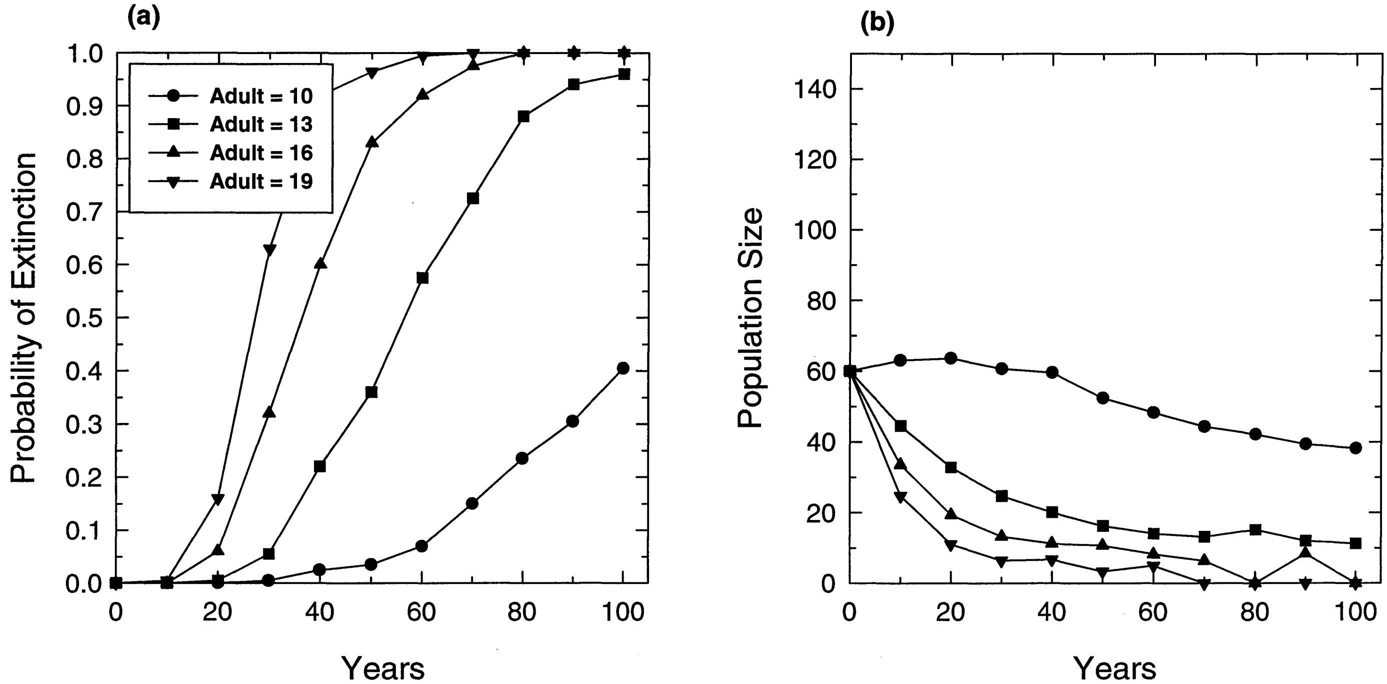


Figure 18. Juvenile Mortality = 30%
N_0 = 60, K = 150; Drought; Inbreeding Depression

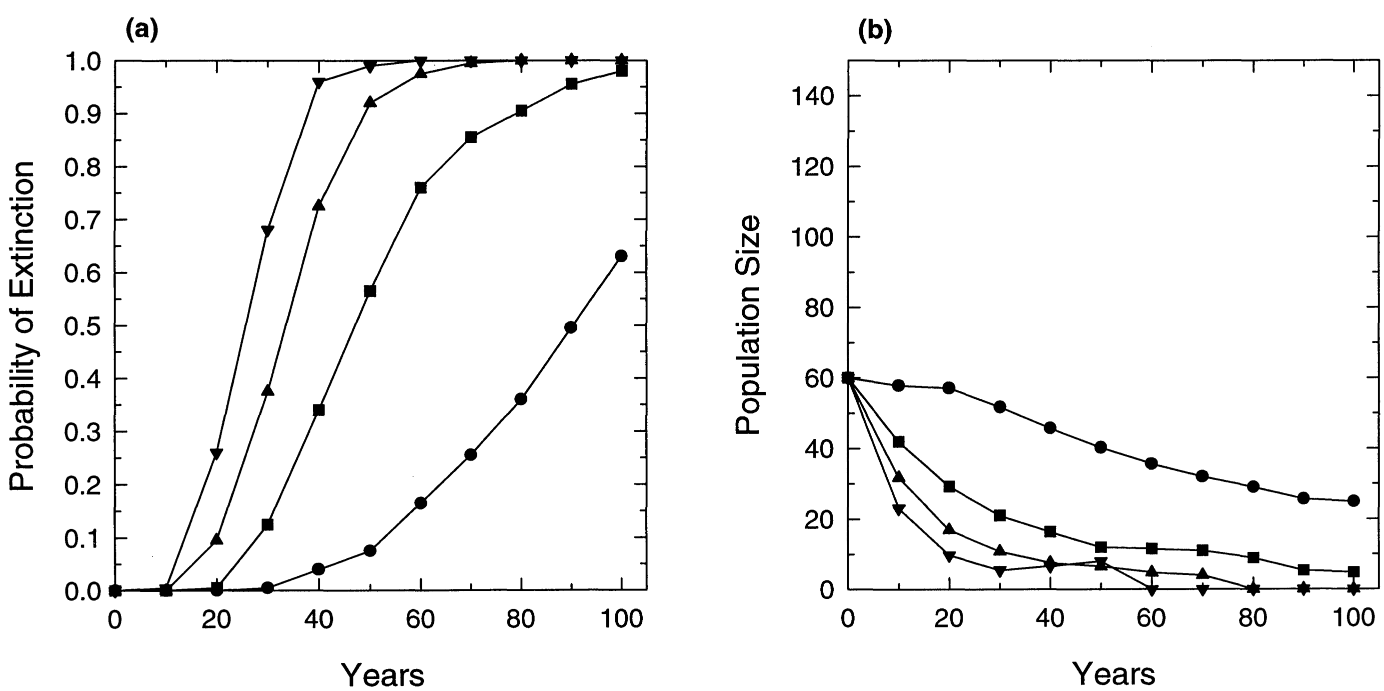
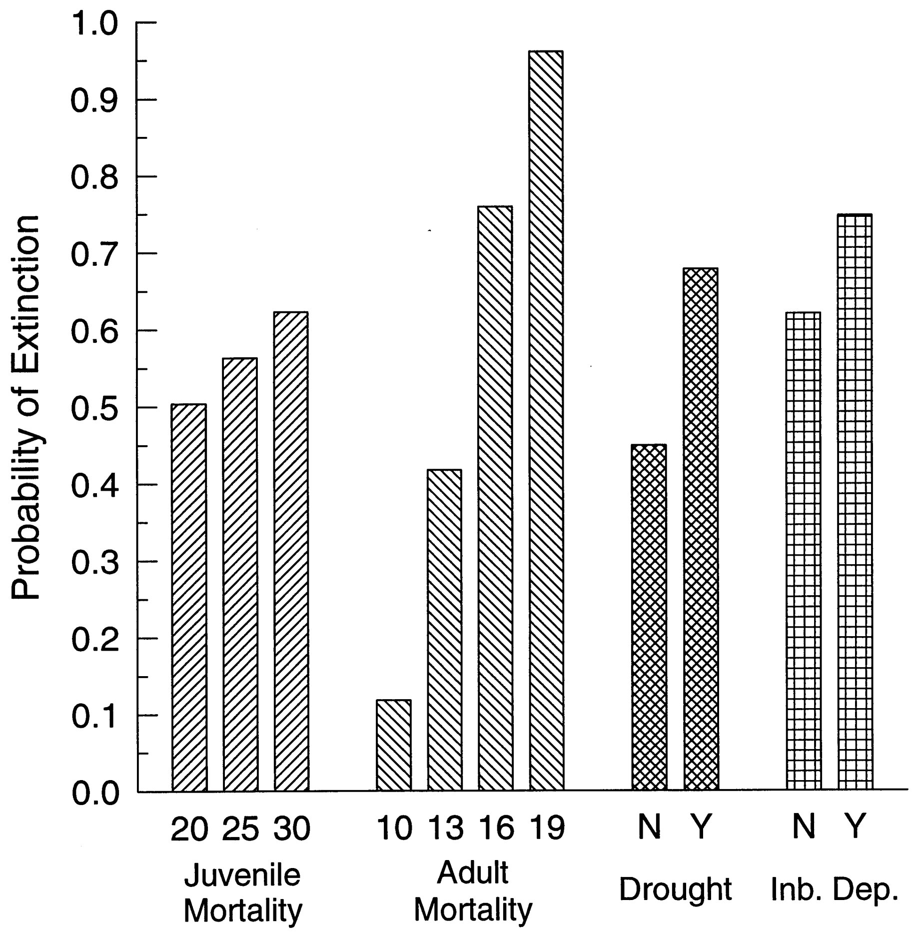
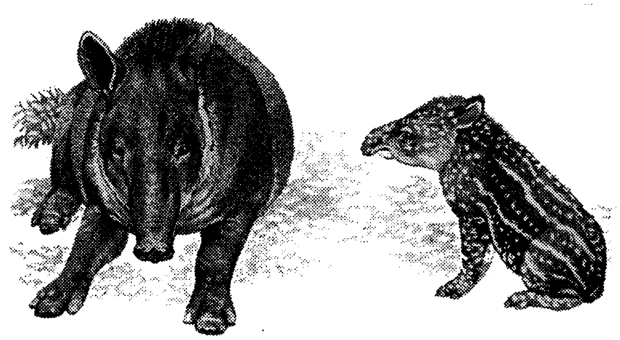


Figure 19.
Sensitivity Analysis:
Probability of Extinction



POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994



Section 8
Captive Populations

BAIRD'S TAPIR CAPTIVE POPULATIONS

Primary Goals of Captive Tapir Management

I. Establish educational programs acting locally, nationally, governmentally, and internationally.
II. Establish a coordinated captive breeding program in Panama
III. Develop programs for investigation and research that will benefit the tapir in Panama.
IV. Establish goals for reintroduction

I. Education

A. Local

1. Initially, expenses will need to be kept to a minimum.
2. Develop educational programs for tapirs on display in Panama (currently at El Nispero and Summit Gardens).
3. Develop "outreach" programs for people living in areas where tapirs exist. Increase awareness and appreciation of the species there. Communicate the devastating effects to the tapir population of overhunting. Examples of "outreach" programs:
    a. Develop radio programs to reach people surrounding tapir habitat.
    b. Provide educational materials to NGO, government personnel, foreign researchers, and volunteers from international organizations who can make these materials available to peoples in these areas.
    c. Similar processes need to be developed for other volunteers working in tapir habitats.
    d. The Panama Tapir Committee will be responsible to keep these workers informed so that they will be good ambassadors for the tapir.

B. National

1. Develop a newsletter that summarizes the activities of tapirs in Panama, both wild and captive.
    a. The Panama Tapir Committee should address how this newsletter would be created, written, and distributed.
    b. The Committee should followup on the offer from the Smithsonian to provide office supplies and meeting facilities for activities for the newsletter and Committee.
2. Anticipate the need for educating the Panamanian public as to the need for selective exchange of tapirs to other countries for the purpose of genetic exchanges. Be prepared to develop programs to educate the general public as well as key officials.
3. See Local Education for other applicable ideas.

C. Governmental
   1. Identify all the governmental agencies that need to be informed and updated. Examples follow:
      a. Direccion Nacional de Sanidad Animal, Ministerio de Desanollo Agropecuario.
      b. Dept de Salud Publica, Ministerio de Salud.
      c. Laboratorio Conmemorativo Gorgas, Ministerio de Salud.
      d. INRENARE, Department of Forestry, Department of Parks.
      e. Facultad de Agronomia, Depto. Zootecnia, Universidad de Panama.
      f. Fuerza Publica
   2. Identify other institutions/organizations that need to be kept informed. Examples follow:
      a. Smithsonian Tropical Research Institute
      b. Division Veterinaria, Comando Sur, US Army
   3. Make available to key governmental agencies and officials the Spanish Executive Summary of this PHVA and the Tapir CAMP.

D. International

   Communicate with tour operators, local hotels, and others of the tourist industry. Provide materials that show how tapirs are endangered and important animals, and are our national "flagship" species. Make accessible to eco-tourists and "normal" tourists so they can see these animals on exhibit or in semi-natural settings.

E. Establish training programs for wildlife veterinarians and wildlife managers in order to develop our in-country expertise.
   1. Identify research projects that can be performed by Panamanian biologists and candidate veterinarians using and benefiting captive tapirs (e.g. nutrition, disease surveys, and reproduction).
   2. Organize visitations to other countries and institutions with expertise in tapir medicine and husbandry for advanced training.
   3. Make scientific information on tapirs available in Panama and translate into Spanish. Produce Spanish versions of husbandry articles, the Bibliography for Tapiridae, CAMP, and PHVA. Suggested locations for maintaining this information include:
      a. Biblioteca del Laboratorio Conmemorativo Gorgas FAX: 225-4366.
      b. Biblioteca del Instituto Smithsonian de Investigaciones Tropicales, Unit 0948, APO AA 34002-0948.
      c. Biblioteca Universidad de Panama.
      d. Centro de Documentacion INRENARE, Paraiso, Area Revertidas.
      e. Centro de Informacion ANCON, Calle Alberto Navarro, El Cangrejo.
      f. Centro de Información sobre el Medio Ambiente (CIMA)
      g. Biblioteca, Parque Natural Metropolitano

II. Captive Breeding: Husbandry

A. Current captive tapirs in Panama:

Summit Gardens (2 males, 3 females)

Sex	*Name*	*Birth Date*	*I.D. Number*
Male	Macho	1986	11A055
Male	Premier	29 Jun 92	1C121D
Female	Bell Bell	1986	13A6DA
Female	Juanita	1988	2413B8
Female	Chiquita	Sep 90	1DB98E

Current pairings: Macho with Bell Bell; Premier with Chiquita
Veterinarian: Anabel de Julio, telephone 32-4854
Caretaker:

El Nispero, El Valle

Sex	*Name*	*Birth Date*	*I. D. Number*
Male	Noriega	1982	14699F
Male	Galen	1991	11F5F8
Male	San Diego	May 90	240219
Female	Monica	1983	1C0C08

Current pairing: Galen (11F5F8) with Monica Oct 1994
Owners: Pablo Caballero, telephone 507-93-6142 or 23-8720
Caretaker:

Villa Griselda, El Valle

Sex	*Name*	*Birth Date*	*I. D. Number*
Male		1990	4D9F69
Female		Oct 92	1E9969D

Current pairing: Male ("Shakespeare") born to this pair 8 June 1995.
Owner: Jaime Padilla Beliz FAX 507-269-6954
Caretaker: Andres

B. Captive tapirs should be managed as a single group and held at multiple cooperating facilities.

C. Establish the Panama Tapir Committee which will have the responsibility to decide how captive tapirs are managed in Panama and what transfers are to be made.

1. Led by a representative from INRENARE.
2. Core members will include representatives from each of the institutions holding tapirs (currently Villa Griselda, El Nispero, Summit Gardens).
3. Additional members representing the following organizations could be invited to participate in the Committee:
   Asociacion de Medicos Veterinarios de Panama
   Smithsonian Tropical Research Institute
   Colegio de Biologos de Panama

ANCON
Universidad de Panama
Sociedad Protectora de Animales

4. The exact structure of the committee will be determined by the core members.
5. We suggest that the major decisions of this group be endorsed by the head of INRENARE and the mayor's office.

D. Determine priorities for the captive population.
   1. Develop a collection management plan for the combined group of captive tapirs in Panama.
   2. Evaluate the facility and husbandry needs of each holding institution.
      a. Determine existing carrying capacity of each facility.
      b. Identify the need to build additional enclosures, anticipating births and the receipt of additional orphans from the wild.
   3. Evaluate exchange of captive-born tapirs to improve genetics of tapirs in other captive collections out of the country. The timing and feasibility of this is dependent on the success of reproduction of the captive tapirs in Panama. The group recommends that the Panama Tapir Committee consults and maintains communication with the AZA Tapir TAG coordinator in the USA and the IUCN/SSC Tapir Specialist Group.

E. Develop husbandry and veterinary medical protocols for captive Panamanian tapirs. Examples include:
   1. Animal identification and records
      a. transponder numbers
      b. birth and death dates
      c. accession and deaccession dates
      d. body weights recorded periodically
      e. breeding records
      f. medical procedure records
      g. veterinary treatment records
      h. develop regional studbook in Panama (SPARKS computer program available through ISIS)
   2. Transportation/transfer procedures between institutions, check international guidelines.
      a. Suggested guidelines for tapir transport.
   3. Facility design/husbandry standards
      a. enclosure size
      b. pool design
      c. substrate and drainage
      d. fencing materials and design
      e. shelter and shade
      f. feeding pad

4. Preventive medicine procedures
    a. quarantine
    b. individual animal identification
    c. vaccinations
    d. parasite control
5. Necropsy protocols
    a. determine how to proceed if a tapir dies (ie who will perform the necropsy, where will it be done).
    b. Tapir TAG necropsy protocol included in this Section.
    c. disposition of skull and carcass
6. Establish sources for diagnostic support
    a. microbiology
    b. parasitology
    c. gross and histopathology
7. Anesthesia techniques
8. Diet specifications and procurement of feeds
    a. List of diet items to feed
    b. Quantities of each item to feed per tapir
    c. Develop reliable sources for procurement of feeds

III. Investigation / Research

A. Perform disease surveys on captive and free-ranging tapirs for identification of tropical/Panamanian disease problems in tapirs.
  1. Identify potential research projects for students, veterinary candidates, etc.
      a. Example: serologic and parasitological surveys of diseases potentially affecting tapirs. Use the horse as an example for diseases potentially affecting tapirs.
  2. Make captive tapir populations and local veterinary facilities and laboratories available for advanced research training.

B Perform research to improve captive husbandry of tapirs (Mantenimiento)
  1. Nutrition and diet in the tropics.
  2. Breeding and maternal behavioral observations by qualified biologists.

C. Evaluate the use of cryopreservation and assisted reproduction techniques to facilitate the international exchange of genetic material.
  1. The PHVA group considered this as an important alternative to pursue to obviate the need to transporting wild-caught tapirs out of the country.

D. Validate information already collected in foreign zoos for reproduction purposes.

E. Obtain information that is or has been collected on tapirs in their natural habitat that could apply to tapir care in captivity.

F. Determine sources of funds to support tapir-related research and captive breeding needs.
Example: Smithsonian offers short-term fellowships.

IV. Reintroduction

A. This goal is highly desirable but the group feels that it will be necessary to delay this goal until the current threats to the populations in the wild are identified and resolved.

B. Semi-natural reintroductions could be beneficial for the following reasons:
   1. Provide educational opportunities.
   2. Provide opportunities to encourage eco-tourism.
   3. Provide prototype for transition-type reintroduction.

C. Perform a risk assessment prior to reintroduction
   1. Identify diseases which are threats to both wild and introduced populations
   2. Identify diseases which are threats to domestic animals in the areas of reintroductions.
   3. Identify diseases which are threats to the reintroduced tapirs from domestic animals which are present in the areas of reintroduction.
   4. Determine what are acceptable risks to existing and introduced populations

RECOMMENDATIONS:

1. Gain access to all forms of educational information on tapirs and translate into Spanish. Provide these materials to the local public and specialized scientific libraries. See section I.

2. Start the design of an information phase regarding tapirs in captivity and breeding program and adapt it for local communities as well as for other levels of audience.

3. Establish the Panama Tapir Committee which will have the responsibility to decide how captive tapirs are managed in Panama and what transfers are to be made. See Section II.

4. Determine priorities for the captive population. Produce a captive management plan.

5. Develop husbandry and veterinary medical protocols for captive Panamanian tapirs.

6. Perform disease surveys on captive and free-ranging tapirs to identify tropical/Panamanian disease problems in tapirs.

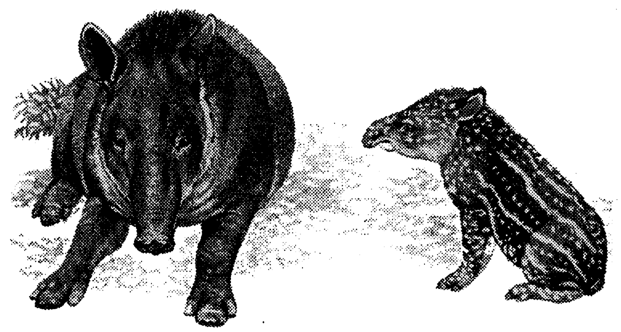
7. Promote research on genetics, reproduction, behavior, as well as the collection and preservation of genetic material. Carry out autopsies and make more efficient use of tissue samples and other materials of scientific interest to institutions and/or researchers.

8. Determine sources of funds to support tapir-related research and captive breeding needs.

Followup by all parties crucial in order for these activities to reach fruition. **The first essential step is to set up the PANAMA TAPIR COMMITTEE.**

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994



Section 9
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EVALUACIÓN DE VIABILIDAD DE POBLACION Y HABITAT DEL MACHO DE MONTE (*Tapirus bairdi*)

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994

Section 10
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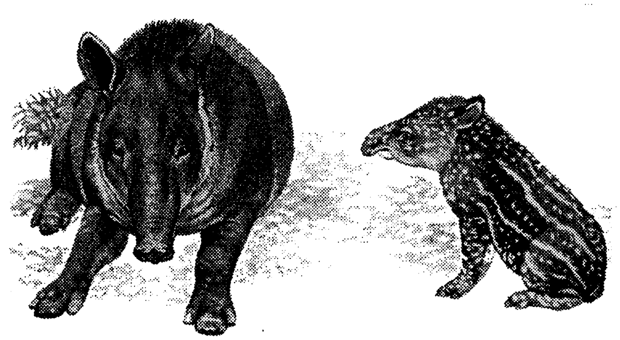

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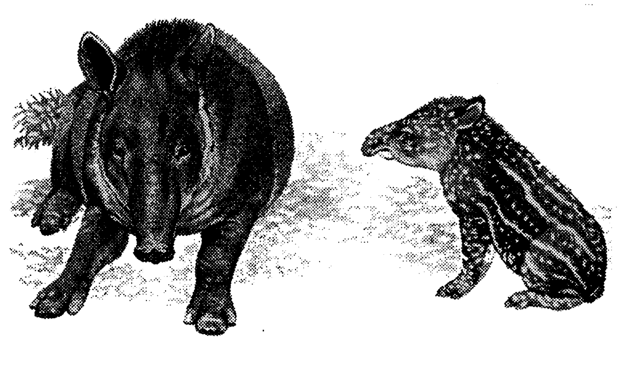

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Squamous lesions were observed on a male tapir (*Tapirus pinchaque*) kept at the zoo for 51/2 yr. Loss of hair was restricted to a large patch on the buttocks and to 4 smaller patches on the head. Cultures of scrapings yielded Microsporum canis. A month later the hair started to grow and similar cultures were negative. Cure was spontaneous and without treatment indicating that the tapir is probably not a normal host for the fungus.
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A three-month old female was noted to have a protruding rectal prolapse 3-4 inches in length. Enemas were administered to remove impacted hay and straw. Liquid petrolatum was administered to remove all roughages. Visitors were feeding her acorns and oak leaves. One half mg of M99 was administered, the prolapse reduced and two purse string sutures were applied which remained for 15 days. She prolapsed again. A median incision

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A fully grown mountain tapir, on arrival in E. Germany by air from Ecuador, was found to have many nearly hairless patches on the skin of the shoulder, breast, flanks, and back from

which Microsporum canis was isolated. The condition was cured by griseofulvin administration in the feed within 50 days.
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A tabulated account is given of relevant literature, before findings are presented which were obtained by the authors, in ten instances, from anesthesia of Malayan tapirs (*Tapirus indicus*). Combinations of tranquilizers with morphine derivatives proved to be highly favourable for their reversibility.
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A newborn male lowland tapir (*Tapirus terrestris*) fell sick with salmonellosis and died ten days after birth, in spite of intensive treatment. Secondary pulmonary mycosis caused by Candida albicans had probably been the cause of death.
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In the rainforest study area within the Taman Negara Park in the north-central part of the Malay Peninsula more than 115 species of 70 genera in 40 plant families were found to have been browsed by the rare Malayan tapir (*Tapirus indicus*). The families Euphorbiacea and Rubiaceae included 42% of species taken. Feeding activities were not concentrated in particular localities although most browsing occurred in mesic or hydric areas. The stems of plants browsed by tapirs were usually less than 2.7 cm in diameter. In addition to woody forage young leaves of some herbaceous plants were also eaten. For 46 species of food plants of tapirs which were studied, over 75% of the available forage from 27 species was eaten and these were considered to be the most highly preferred foods. Analysis of faecal samples indicated that forages were only coarsely chewed and fruit parts and seeds were usually present; fruits of woody plants were taken from the forest floor. It is suggested that

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Hoja Para Colecta de Datos

Fecha :

*Sobre la persona que llena el formulario:

Nombre:
Ocupación y lugar de residencia:

*Sobre el reporte en si:

Tipo de reporte:

- ❑ observación directa del animal
- ❑ huellas (pocos rastros)
- ❑ trillo (hecho con muchos rastros)
- ❑ heces
- ❑ huesos (tipo: _____________)
- ❑ lugar de estancia ("dormidero" o "comedero")
  Que estaba comiendo?: ______________________
- ❑ llamados ("silbidos")
- ❑ marcas en corteza
- ❑ ejemplar cazado

Localidad precisa donde sucedio lo que se reporta:___________________
Corregimiento:________________
Provincia: ___________________

Condiciones de la vegetación en esa localidad particular:

*Sobre el Animal:

Sexo:

Edad aproximada:
- ❑ cria con pintas en el cuerpo
- ❑ juvenil (sin pintas)
- ❑ Adulto

Estado reproductor (si es hembra)
- ❑ mamas "normales" (pequenas)
- ❑ mamas "crecidas"

*Sobre la persona que brinda la informacion:

Nombre:

Ocupacion:
- ❑ campesino
- ❑ Indigena
- ❑ agricultor
- ❑ ganadero
- ❑ Funcionario (Guardaparque, etc)
- ❑ Maderero
- ❑ otro (especifique) ____________________________

Lugar exacto donde reside:

Observaciones:

Tapir Necropsy Protocol

Compiled by Dr. Bruce Rideout
Pathology Department
San Diego Zoo

ANATOMICAL NOTES

The internal anatomy of the tapir is analogous to the domestic horse and other perissodactyla.

1. Guttural Pouches: The guttural pouches of the tapir are similar to those of the horse. They are located in the pharyngeal region, lateral tot he hyoid bones and are best evaluated after the tongue and trachea (pluck) have been removed. Both guttural pouches should be examined for the presence of exudates, concretions, etc. Bacterial cultures of any exudates should be obtained.

2. Testes: The testes are in the inguinal canals, which are located in the subcutaneous tissues on either side of the penis.

3. Gallbladder: Tapirs lack a gallbladder.

4. Stomach: The squamous portion of the stomach is small and is located in the cardia (near the gastroesophageal junction). Samples of the squamous and glandular portions of the stomach should be collected for histopathology.

5. Kidneys: The kidneys are like the horse (not lobulated). The adrenal glands are closely associated with the kidneys.

6. Pleura: The normal parietal and visceral pleura can be thick and prominent, but only the Malayan tapirs should have adhesions between the lung and chest wall (as in the elephant).

RESEARCH REQUESTS

1. Approximately 100g of liver and 10ml of serum (frozen at -20 or -70°C) for copper analysis. Dr. Don Janssen, San Diego Zoo, 1354 Old Globe Way, San Diego, CA 92103 (619) 231-1515, ext 3933.

2. If active skin lesions are present on the dorsum, two skin biopsies should be obtained; one to be placed in formalin and the other in Micheles medium. The samples may then be shipped overnight (at room temperature) to Dr. Bruce Rideout, Pathology Dept., San Diego Zoo, 1354 Old Globe Way, San Diego, CA 92103 (619) 231-1515, ext. 4535.

Conduct a complete necropsy: ANY LESIONS should be cultured (aerobic and anaerobic bacterial cultures and fungal cultures) before they are contaminated, and samples of lesions should be saved frozen (at -20° or -70°C). MAKE SURE SAMPLES FROM ALL LESIONS ARE SAVED FOR HISTOPATHOLOGY.

TISSUE CHECKLIST: All of the following tissues may be placed together in a single container of 10% neutral buffered formalin-THE VOLUME OF FORMALIN SHOULD BE AT LEAST 10 TI MES THE TOTAL VOLUME OF THE TISSUES COLLECTED. Tissues should be no thicker than 0.5cm and need be no larger than 2cm X 2cm.

Skin (from dorsum)
Muscle (medial thigh, with sciatic nerve)
Tongue
Guttural pouches
Trachea
Thyroid/Parathyroid
Thymus
Lung
Heart
Aorta
Salivary gland
Esophagus
Stomach (squamous and glandular)
Duodenum
Jejunum
Cecum
Large colon
Small colon
Lymph node (peripheral and mesenteric)
Liver
Adrenal
Gonad
Uterus
Pancreas
Spleen
Kidney
Urinary Bladder
Pituitary
Cerebrum
Cerebellum
Eye

NEONATES: For neonate animals be sure to:

1. Get a piece of the UMBILICUS with surrounding skin (obtain bacterial cultures of there is evidence of infection).
2. Examine the FEET in new/still-born animals for evidence of wear (indicating whether they were able to stand and walk).
3. Note the size of the thymus (cranial to the heart).
4. Examine the STOMACH and intestinal content for evidence of nursing.
5. Examine the LUNGS carefully and evaluate degree of inflation (NOTE whether sections of lung float in formalin).
6. Note whether there is MECONIUM in the colon/rectum.
7. Check carefully for evidence of congenital deformities.

NECROPSY FINDINGS

Identification Number/Name: Necropsy Number:

ISIS Number: Weight:

Studbook Number: Institution:

Date of Death/Euthenasia: Time of Death/Euthenasia:

Date of Necropsy: Time of Necropsy:

Age/Birth Date: Date of Acquisition:

History (include copy of medical record of possible):

GENERAL:
Degree of Autolysis:
Nutritional Condition:

SKIN AND PELAGE (NOTE amount of subcutaneous adipose):

BODY ORIFICES:

BODY CAVITIES:
Thorax:

Abdomen:

CARDIOVASCULAR SYSTEM (NOTE amount of coronary groove adipose):

RESPIRATORY SYSTEM (Guttural pouches, Trachea, Bronchi, Lungs):

DIGESTIVE SYSTEM (teeth, Gingiva, Tongue, Esophagus, Stomach, Intestines, Liver, Pancreas; NOTE any abnormal content or fecal consistency):

HEMATOPOIETIC SYSTEM (Lymph Nodes, Spleen, Thymus, Bone Marrow):

GENITOURINARY SYSTEM (Kidneys, Ureters, Urinary Bladder, Testes/Ovaries, Uterus, Mammary Gland):

MUSCULOSKELETAL SYSTEM:

NERVOUS SYSTEM:

ENDOCRINE SYSTEM (Thyroids/Parathyroids, Pituitary, Adrenal):

SPECIAL SENSES (Eyes, Ears):

ABORTIONS AND STILLBIRTHS

Abortions and stillbirths are relatively common problems in tapirs. In order to maximize diagnostic success in these cases, the following protocol should be followed whenever possible. Samples should be submitted to the pathology and microbiology laboratories normally utilized by the institution housing the animal(s).

PLACENTA:

1. Carefully examine the placenta and obtain cultures for bacteria (aerobic and anaerobic) and fungi. Note any areas of discoloration, exudation, or necrosis. Tapirs have diffuse placentation. Look for avillous areas (there should be none).

2. Measure the length and diameter of the placenta (tapir placentas reportedly only occupy one horn of the uterus; the shape of the placenta should therefore be a simple tube). These measurements are important for documenting placental insufficiency.

3. Check the placenta for completeness (an incomplete placenta could indicate partial placental retention in the dam, which can be fatal).

4. Measure the length of the umbilical cord and note where the cord attaches to the placenta.

5. Obtain representative sections of the placenta and umbilical cord for histopathology (formalin fixation) and freezing (-20° or -70°C).

FETUS:

1. Estimate stage of gestation (first, second, or third trimester) and degree of autolysis.

2. Obtain weight and crown-rump length.

3. Examine carefully for evidence of congenital deformities and note overall nutritional condition. Describe and obtain samples of any fluid in the body cavities.

4. Collect stomach contents (1-3cc) in a sterile syringe for bacterial culture (aerobic and anaerobic) and cytology (to look for bacteria and inflammatory cells).

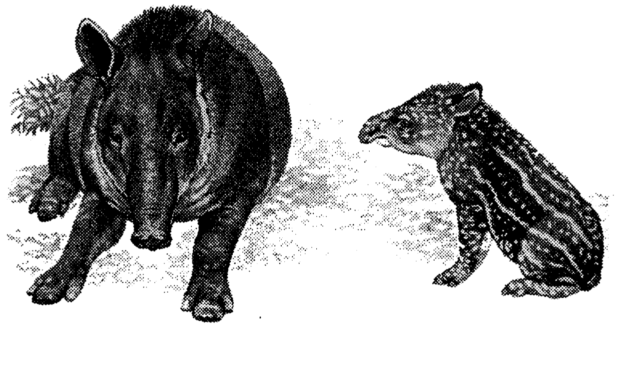
5. Collect a complete set of tissues for histopathology (see adult necropsy protocol). MINIMUM TISSUE REQUIREMENT: lung, liver, kidney, spleen, brain, and lymph node.

6. Collect 25-100g each of lung, live, kidney and spleen for freezing.

EVALUACIÓN DE VIABILIDAD DE POBLACION Y HABITAT DEL MACHO DE MONTE (*Tapirus bairdi*)

POPULATION AND HABITAT VIABILITY ASSESSMENT FOR BAIRD'S TAPIR (*Tapirus bairdi*)

Panama City, Panama
1-3 de Diciembre de 1994



Section 12
Referencia Técnica de VORTEX
VORTEX Technical Reference