UNIVERSIDADE ESTADUAL DE CAMPINAS

INSTITUTO DE BIOLOGIA

RAFAEL CAVALCANTI LEMBI

ESTADO E TENDÊNCIAS DOS SERVIÇOS ECOSSISTÊMICOS NA ÁREA DE PROTEÇÃO AMBIENTAL DE CAMPINAS

STATUS AND TRENDS OF ECOSYSTEM SERVICES AT THE ENVIRONMENTAL PROTECTED AREA OF CAMPINAS

CAMPINAS

2021

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Dissertação apresentada ao Instituto de Biologia da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do Título de Mestre em Ecologia.

Dissertation presented to the Institute of Biology of the University of Campinas in partial fulfillment of the requirements for the degree of Master in Ecology.

Orientador: Dra. Cristiana Simão Seixas

ESTE ARQUIVO DIGITAL CORRESPONDE À VERSÃO FINAL DA DISSERTAÇÃO DEFENDIDA PELO ALUNO RAFAEL CAVALCANTI LEMBI E ORIENTADA PELA DRA. CRISTIANA SIMÃO SEIXAS

CAMPINAS

2021

Ficha catalográfica
Universidade Estadual de Campinas
Biblioteca do Instituto de Biologia
Mara Janaina de Oliveira - CRB 8/6972

Lembi, Rafael Cavalcanti, 1994-
L542e Estado e tendências dos serviços ecossistêmicos na área de proteção ambiental de Campinas / Rafael Cavalcanti Lembi. – Campinas, SP : [s.n.], 2021.

Orientador: Cristiana Simão Seixas.
Dissertação (mestrado) – Universidade Estadual de Campinas, Instituto de Biologia.

1. Serviços ambientais. 2. Ecossistema - Conservação. 3. Áreas de conservação de recursos naturais - Campinas (SP). 4. Gestão ambiental. 5. Desenvolvimento sustentável. I. Seixas, Cristiana Simão, 1970-. II. Universidade Estadual de Campinas. Instituto de Biologia. III. Título.

Informações para Biblioteca Digital

Título em outro idioma: Status and trends of ecosystem services at the environmental protected area of Campinas
Palavras-chave em inglês:
Ecosystem services
Biotic communities - Conservation
Natural resources conservation areas - Campinas (SP)
Environmental management
Sustainable development
Área de concentração: Ecologia
Titulação: Mestre em Ecologia
Banca examinadora:
Cristiana Simão Seixas [Orientador]
Ramon Felipe Bicudo da Silva
Ângela Cruz Guirao
Data de defesa: 11-08-2021
Programa de Pós-Graduação: Ecologia

Identificação e informações acadêmicas do(a) aluno(a)
- ORCID do autor: https://orcid.org/ 0000-0003-2310-295
- Currículo Lattes do autor: http://lattes.cnpq.br/2549378970906577

Campinas, 11 de agosto de 2021.

COMISSÃO EXAMINADORA

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Os membros da Comissão Examinadora acima assinaram a Ata de Defesa, que se encontra no processo de vida acadêmica do aluno.

A Ata da defesa com as respectivas assinaturas dos membros encontra-se no SIGA/Sistema de Fluxo de Dissertação/Tese e na Secretaria do Programa de Pós-graduação em Ecologia da Unidade Instituto de Biologia.

DEDICATÓRIA

A todos e todas que se engajam, trabalham, pesquisam e lutam para que a APA de Campinas seja uma unidade de conservação próspera, justa e sustentável.

AGRADECIMENTOS

Esta dissertação de mestrado é fruto de um trabalho coletivo e colaborativo que não seria possível sem a ajuda e apoio de diversas pessoas. Nesta seção, destaco alguns nomes de toda minha trajetória na Unicamp, com a intenção de visibilizar e reconhecer a importância desta rede de pessoas que foram e são fundamentais. Portanto, agradeço:

Aos meus pais, Patrícia Lembi e Chico Cavalcanti, pelo apoio incondicional em todas minhas escolhas e por me inspirarem através do exemplo a ser a melhor versão de mim.

Às minhas mentoras e orientadoras neste processo de pesquisa, Cristiana Seixas e Alice de Moraes, por serem exemplos de rigor e ética na conduta profissional, sem perder a ternura e o espírito de amizade. Vocês me inspiram.

Às minhas orientadoras de fases acadêmicas anteriores que possibilitaram meu crescimento profissional que culminou na realização deste mestrado: Simone Vieira, Leandra Gonçalves, Andréa Guimarães. Em especial, minha gratidão à Andréa por ter despertado em mim a vontade de fazer ciência quando ainda era adolescente.

Aos membros do meu comitê de acompanhamento, Carlos Joly e Paulo Sinisgalli, pelas contribuições em todas as fases de construção desta pesquisa. Agradeço também ao Joly pela oportunidade única de participar e contribuir na organização da Escola de Modelos e Cenários (SPSAS Scenarios).

Aos membros da banca, Ramon Bicudo e Ângela Guirao, por terem propiciado um rico debate em torno da pesquisa desenvolvida que resultaram em um enriquecimento da dissertação e de futuros manuscritos. Aos membros suplentes pela disponibilidade, Aliny Pires e Carlos Joly. Aos membros da pré-banca Ramon Bicudo, Carlos Joly e Paulo Sinisgalli, pela disponibilidade e valiosas contribuições.

Às funcionárias da Secretaria do Verde, Meio Ambiente e Desenvolvimento Sustentável da Prefeitura de Campinas por terem recebido a proposta desta pesquisa de portas abertas e por todo apoio no compartilhamento de dados e informações geoespaciais sobre a APA: Ângela Guirao, Sueli Thomaziello, Alethea Peraro, Ana Paula Pellegrino.

Aos conselheiros e conselheiras do Conselho Gestor da APA de Campinas (CONGEAPA) por disponibilizarem seu tempo para conversas e trocas que construíram este trabalho. Em especial, agradeço à Cláudia Esmeriz, presidente do Conselho, que me recebeu no CONGEAPA, possibilitou contatos com outros conselheiros, e inseriu minhas apresentações nas pautas de reunião.

Aos professores do PPG Ecologia e funcionários do Instituto de Biologia, em especial Mathias Pires (também membro suplente do comitê de acompanhamento) e Martin Pareja pelos aprendizados durante atividades de monitoria em disciplinas, Peter Groenendijk pelas aventuras em campo em Itirapina, e Raquel Gomes Hatamoto pelo apoio e competência em responder às minhas diversas dúvidas e solicitações.

Aos amigos e amigas dos grupos de pesquisa que faço parte: Laboratório de Ecologia e Manejo de Ecossistemas (LEME) e Conservação e Gestão de Recursos Naturais de Uso Comum (CGCommons). Agradeço pelos cafés, conversas, almoços, projetos de extensão e reformas, interações presenciais e virtuais, carinho e disposição: Camila Islas, Deborah Prado, Ana Carolina Dias, Gabi Berro, Lu Araújo, Rafa Flora, Yvonne Bakker, Luis Quimbayo, Melina Sampaio, Marta Simbine, Cinthia Silva, Ju Farinaci, Maíra Padgurschi, Paula Drummond, Alice de Moraes, Simone Vieira, Cris Seixas. Tenho muito orgulho de ser um lêmure!

Aos companheiros do projeto de diagnóstico da biodiversidade e serviços ecossistêmicos da APA de Campinas, também lêmures, mas que merecem uma linha especial pelo esforço e colaboração em gerar conhecimento útil para a conservação e desenvolvimento focado na APA: Laura Barbon, Victoria Dallari, Amanda de Godoy, Henrique Simões, Alice e Cris.

À equipe de facilitação nas duas oficinas que organizamos e que culminou na elaboração do capítulo sobre cenários desta dissertação: Ana Carolina Dias, João Lagazzi, Alice e Cris.

Aos pesquisadores da EMBRAPA Informática Agropecuária, Alexandre Coutinho e Talita Terra, que disponibilizaram seu tempo e expertise para concretizarmos uma parceria que deu origem ao capítulo sobre mudanças no uso e cobertura da terra.

Às amigas Mirna Gigante e Patricia Campiol pelos aprendizados, e por terem participado de um momento especial nesta jornada do mestrado.

Às minhas queridas amigas e amigos pelo companheirismo, amizade, carinho, amor, cumplicidade e parceria durante todos os anos em Barão Geraldo. As experiências, viagens, frustrações, desabafos, confraternizações e comemorações que compartilhamos foram fundamentais em tantos níveis que me faltam palavras pra expressar minha gratidão por ter vocês em minha vida: Jules, Petra, Villa, Sheldon, Giovana, Thales, Kissuco, Breno, Lepo, Sandrine, Lívia (tia Lili), Narrasha, Lari, Fifo, Holandesa, Julinha Videl, Mixê, Afonso, Gilmar, André Soave, Lui, Pedro Sena, Satã, Ganso, Ana Luiza Saade, Flávia, Marischka, Xico, Padá, Thami, Thais Oceanos, Mateus, Maiona, Leo Napolitano, Gabi Vaz, Shaina, Natalia, Oscar, Anna, Maria Pia, Leo e Kim, Melina Michelaki, Roman Garcia. Em especial, agradeço ao Felipe Vital. Tenho sorte de ter pessoas tão incríveis na minha vida.

Finalmente, agradeço às agências de fomento. Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pela concessão de bolsa nos meses iniciais de mestrado (Processo 131695/2019-3) e à Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) pela subsequente concessão de bolsa (Código de Financiamento 001, Processo 88887.388304/2019-00). Ao PPG Ecologia através do Edital 03 e 04/2019 que possibilitou participação em cursos e realização de trabalho de campo. À Unicamp, pelas condições físicas e institucionais que propiciaram a realização deste projeto, mas também por ser este lugar tão importante em minha história.

RESUMO

Palavras-chave: sistemas socioecológicos, unidades de conservação, conservação e desenvolvimento integrados, gestão ambiental, contribuições da natureza para as pessoas.

A Área de Proteção Ambiental (APA) de Campinas, estado de São Paulo, é um sistema socioecológico provedor de serviços ecossistêmicos para o bem-estar humano em nível local e regional. Ali coexistem centros urbanos, produção agropecuária, silvicultura, recursos hídricos e fragmentos de formação florestal. O objetivo geral desta dissertação foi avaliar o estado e tendências passadas e futuras dos serviços ecossistêmicos na APA de Campinas, visando gerar informações relevantes para gestores e tomadores de decisão locais. Especificamente, busquei (i) identificar os serviços ecossistêmicos que são percebidos na APA, e aqueles considerados mais relevantes para o bem-estar de sua população local; (ii) avaliar as tendências passadas dos serviços ecossistêmicos mais relevantes e identificar os fatores socioecológicos e mecanismos de retroalimentação (*feedbacks*) que os têm influenciado; (iii) identificar respostas da sociedade às mudanças nos serviços ecossistêmicos mais relevantes; (iv) avaliar as mudanças no uso e cobertura da terra na APA como um todo e nas zonas estabelecidas em seu plano de manejo; (v) elaborar cenários futuros para os serviços ecossistêmicos; e (vi) elencar ações para evitar um futuro indesejável. Entre setembro de 2019 e maio de 2021, coletei dados através de 18 entrevistas semiestruturadas com membros do conselho gestor, observei 14 reuniões deste conselho, da Prefeitura e de ONGs, analisei dados de mapas temáticos produzidos a partir de dados e imagens disponíveis na plataforma MapBiomas, conduzi dois grupos focais com gestores e conselheiros da APA para elaboração de cenários. Através da percepção e conhecimento dos conselheiros, identifiquei 15 serviços ecossistêmicos, sendo a regulação da quantidade de água, experiências físicas e psicológicas na natureza e produção de alimento considerados os mais relevantes, respectivamente como contribuições da natureza de regulação, imaterial e material. Os fatores que afetam a disponibilidade e qualidade destes serviços são influenciados principalmente pela urbanização, e alguns destes fatores interagem na forma de mecanismos de retroalimentação (*feedbacks*) amplificadores, induzindo a APA a um estado cada vez mais urbanizado. Alguns atores sociais locais percebem e reagem às mudanças ambientais, realizando ações que visam a conservação dos serviços ecossistêmicos. Em relação às mudanças no uso da terra, as áreas de pasto são predominantes na APA, embora venham se reduzindo desde 1993. Em contraponto, houve um aumento na área de florestas naturais, infraestrutura urbana e plantações de eucalipto. O aumento das florestas naturais está ocorrendo sobre áreas de pasto, e uma reversão histórica entre níveis de desmatamento e aumento de florestas naturais indica o fenômeno de transição florestal. A construção participativa de um cenário provável e outro desejável, e a comparação entre eles, permitiu elencar desafios e possíveis ações para superar o futuro provável. De modo geral, a gestão colaborativa entre múltiplos atores emergiu como necessária para se obter o futuro desejado. O caráter participativo e interdisciplinar desta pesquisa possibilitou um entendimento detalhado das dinâmicas socioecológicas que afetam os serviços ecossistêmicos na APA de Campinas, indicando pontos de ação para um planejamento que vise a integração entre conservação e desenvolvimento.

ABSTRACT

Keywords: social-ecological systems, protected areas, integrated conservation and development, environmental management, nature's contributions to people.

The Environmental Protected Area (APA) of Campinas, state of São Paulo, is a social-ecological system that provides multiple ecosystem services for human well-being at local and regional level. There, urban centers, agricultural production, forestry, water resources and fragments of native forests coexist. The general objective of this dissertation was to evaluate the status and past and future trends of ecosystem services at APA Campinas, aiming to generate relevant information for local managers and decision makers. Specifically, I sought to (i) identify the ecosystem services that are perceived at APA Campinas, and those considered most relevant to the well-being of its local population; (ii) assess past trends of the most relevant ecosystem services and identify the social-ecological factors and feedback mechanisms that have been influencing them; (iii) identify society's responses to changes in the most relevant ecosystem services; (iv) assess changes in land use and land cover at APA Campinas as a whole and in the zones established in its management plan; (v) develop future scenarios for ecosystem services; and (vi) list actions to avoid an undesirable future. Between September 2019 and May 2021, I collected data through 18 semi-structured interviews with members of the management council, observed 14 meetings of this council, the City Hall and NGOs, analyzed data from thematic maps produced from data and images available on the MapBiomas platform, and conducted two focus groups with councilors and managers to develop scenarios. Through the perception and knowledge of the councilors, I identified 15 ecosystem services, being regulation of water quantity, physical and psychological experiences in nature and food production considered the most relevant, respectively as regulating, non-material, and material contributions to people. The factors that affect the availability and quality of these services are mainly influenced by urbanization, and some of these factors interact in the form of amplifying feedback mechanisms, inducing APA Campinas to an increasingly urbanized state. Some of the local social actors perceive and react to environmental changes, carrying out actions aimed at the conservation of ecosystem services. Regarding changes in land use and cover, pasture areas are predominant, although they have been decreasing since 1993. In contrast, there was an increase in area of natural forests, urban infrastructure and eucalyptus plantations. The increase in natural forests is taking place over pasture areas, and a historical reversal between levels of deforestation and increase in natural forests indicates the phenomenon of forest transition. The participatory construction of a likely and a desirable scenario, and the comparison between them, allowed us to list challenges and possible actions to overcome the likely future. In general, collaborative management between multiple actors emerged as necessary to obtain the desired future. The participatory and interdisciplinary nature of this research allowed a detailed understanding of the social-ecological dynamics that affect ecosystem services at APA Campinas, indicating points for action and planning aimed at the integration between conservation and development.

SUMÁRIO

INTRODUÇÃO GERAL

APRESENTAÇÃO E OBJETIVOS

As interações entre pessoas e natureza são extensivamente estudadas no campo de diversas ciências. Na ecologia, especificamente, um dos enfoques para se analisar as relações entre seres humanos e o ambiente se pauta no conceito de serviços ecossistêmicos. Os serviços ecossistêmicos são definidos como os benefícios que os ecossistemas provêm ao bem-estar humano (MA, 2005), e explicitam a dependência que as sociedades humanas possuem em relação à natureza. Os serviços ecossistêmicos são diversos, como, por exemplo, a provisão de água, capacidade de regulação climática, polinização de culturas agrícolas, produção de alimentos, bem-estar derivado de experiências físicas e psicológicas na natureza, entre outros (MA, 2005). Embora a nossa qualidade de vida dependa diretamente da capacidade da natureza de prover tais benefícios, diagnósticos globais claramente indicam que ainda estamos longe de um uso sustentável da biodiversidade, e certas modificações planetárias estão produzindo resultados irreversíveis (Rockström et al., 2009; IPBES, 2019). Sob o pretexto de um desenvolvimento econômico, os recursos naturais têm sido apropriados de maneira depredatória, e tal desenvolvimento não necessariamente reflete na diminuição de desigualdades e aumento da qualidade de vida (Raworth, 2017).

Em nível local, entretanto, estudos elencam possíveis formas que os recursos naturais podem ser gerenciados de maneira sustentável, gerando valiosas lições potencialmente aplicáveis em outros contextos (Seixas & Davy, 2008; Ostrom, 2009). Aliar a capacidade da natureza de nos prover benefícios a longo prazo, o bem-estar de populações humanas, e desenvolvimento econômico, são, portanto, objetivos que não devem ser percebidos como antagônicos (Costanza et al., 2017). Apesar da indicação de que as trajetórias globais caminham para um futuro que irá gerar consequências indesejáveis para pessoas e natureza, o conhecimento científico pode ser uma importante ferramenta para elucidar os mecanismos que impactam o ambiente, investigar como ele tem sido modificado, e identificar possíveis alternativas para trajetórias futuras. Deste modo, a pesquisa acadêmica pode ser útil em gerar conhecimento

que contribui para o embasamento da gestão e tomada de decisão sobre o uso dos serviços ecossistêmicos.

Partindo da premissa de que conservação e desenvolvimento são objetivos compatíveis, e utilizando uma lógica de "pensar global, agir local", a presente dissertação de mestrado discorre sobre os serviços ecossistêmicos na Área de Proteção Ambiental de Campinas (APA de Campinas [1]). Sob a perspectiva dos serviços ecossistêmicos, o presente projeto pretende contribuir para a compreensão de como a APA de Campinas se modificou ao longo do tempo, como está atualmente, e como poderá estar no futuro. Portanto, o objetivo geral dessa dissertação é **avaliar o estado e tendências passadas e futuras dos serviços ecossistêmicos na APA de Campinas.**

Deste modo, para responder a este objetivo geral, a dissertação foi estruturada em três capítulos no formato de artigos científicos cuja leitura pode ser efetuada de maneira independente. A intenção é de que cada um dos capítulos possa eventualmente se tornar uma publicação científica em periódicos da área de ciências ambientais e ecologia, sendo uma contribuição interdisciplinar de caráter científico para a compreensão da dinâmica do sistema socioecológico delimitado pela APA de Campinas. Embora a dissertação seja de autoria de um único autor, os capítulos estão redigidos na primeira pessoa do plural devido ao caráter coletivo de construção deste trabalho. A opção de redigi-los em inglês surge da motivação de que os resultados aqui obtidos tenham um possível alcance internacional, potencialmente difundindo os achados para uma audiência científica mais ampla. Os títulos dos capítulos e seus objetivos específicos são apresentados a seguir:

(i) **Avaliação dos serviços ecossistêmicos em uma unidade de conservação periurbana no sudeste do Brasil: percepções e conhecimento de membros do conselho gestor**.

Objetivos: (a) identificar os serviços ecossistêmicos que são percebidos na APA de Campinas, e aqueles considerados mais relevantes para o bem-estar de sua população local; (b) avaliar

[1] A sigla APA de Campinas será utilizada nos textos em português conforme a maioria dos documentos oficiais, e a sigla APA Campinas nos textos em inglês desta dissertação para fluência de leitura.

tendências passadas dos serviços ecossistêmicos mais relevantes, identificar e analisar os fatores socioecológicos e *feedbacks* que os têm influenciado; (c) identificar e analisar respostas às mudanças nos serviços ecossistêmicos mais relevantes.

(ii) Mudanças no uso e cobertura da terra em uma unidade de conservação de uso sustentável no sudeste do Brasil

Objetivo: avaliar as mudanças no uso e cobertura da terra na APA de Campinas e no zoneamento estabelecido em seu plano de manejo para os períodos de 1993-2001, 2001-2019 e 1993-2019.

(iii) Desenvolvimento participativo de cenários para os serviços ecossistêmicos de uma unidade de conservação periurbana no sudeste do Brasil

Objetivo: (a) elaborar cenários futuros para os serviços ecossistêmicos; (b) listar e discutir ações para evitar o cenário provável e atingir um futuro desejado.

De modo a embasar as discussões propostas nos capítulos, a presente introdução geral irá detalhar nas próximas seções o arcabouço teórico que fundamenta esta dissertação, considerações sobre a área de estudo, aspectos metodológicos utilizados na coleta e análise de dados, e desafios e mudanças impostos pela pandemia no andamento da pesquisa. Além disso, objetiva-se também apresentar um breve histórico da motivação e surgimento da pesquisa, e outros projetos em andamento que surgiram durante seu desenvolvimento.

FUNDAMENTAÇÃO TEÓRICA

Serviços ecossistêmicos são os benefícios que as pessoas obtêm dos ecossistemas (MA, 2005). De acordo com Gómez-Bagghetun et al. (2010), o termo foi cunhado pela primeira vez por Ehrlich & Ehrlich (1981), mas somente na década de 1990 foi posteriormente disseminado e debatido no âmbito da literatura científica com os trabalhos de Daily (1997) e Costanza et al. (1997). Tais trabalhos foram fundamentais para estabelecer explicitamente como as sociedades humanas dependem dos ecossistemas, incluindo uma primeira estimativa global de valoração econômica dos serviços ecossistêmicos (Costanza et al., 1997). Existem diversas maneiras de se classificar os serviços ecossistêmicos, sendo a categorização proposta pela Avaliação Ecossistêmica

do Milênio (2005) a mais comum. Neste contexto, os serviços são diferenciados em quatro categorias: (i) provisão: são os bens obtidos da natureza para o consumo ou uso direto (p. ex., água, alimentos, madeira, combustíveis não fósseis); (ii) regulação: se refere à capacidade da natureza de regular fatores bióticos e abióticos, gerando benefícios para os seres humanos (p. ex., regulação do clima, regulação de eventos extremos como enchentes, regulação da qualidade da água, polinização, controle de pragas e doenças); (iii) culturais: benefícios imateriais obtidos através da interação com a natureza (p. ex., conexões espirituais e religiosas, turismo, recreação e lazer, beleza estética); (iv) suporte: são os processos que garantem a vida no planeta (p. ex., ciclagem de nutrientes, formação de solo, produção primária).

Bem-estar humano é um conceito que relaciona cinco grandes componentes relacionados à qualidade de vida: materiais básicos para uma boa vida, saúde, boas relações sociais, segurança, e liberdade de escolha e ação (MA, 2005). Tal conceito multidimensional engloba fatores como renda, saúde física e mental, segurança contra desastres, identidade cultural, valores, satisfação com a própria vida, dentre outros. Deste modo, é um conceito dinâmico que reconhece a variedade daquilo que caracteriza a qualidade de vida. As contribuições dos serviços ecossistêmicos para o bem-estar humano foram conceituadas pela Avaliação Ecossistêmica do Milênio (MA, 2005) através de um arcabouço teórico que descreve como as categorias de serviços se relacionam com os diferentes componentes do bem-estar humano (Fig. 1). A elaboração deste arcabouço possibilitou a disseminação do conceito de serviços ecossistêmicos para além da academia nos anos 2000, sendo adotado e reconhecido por arenas na interface entre ciência e política.

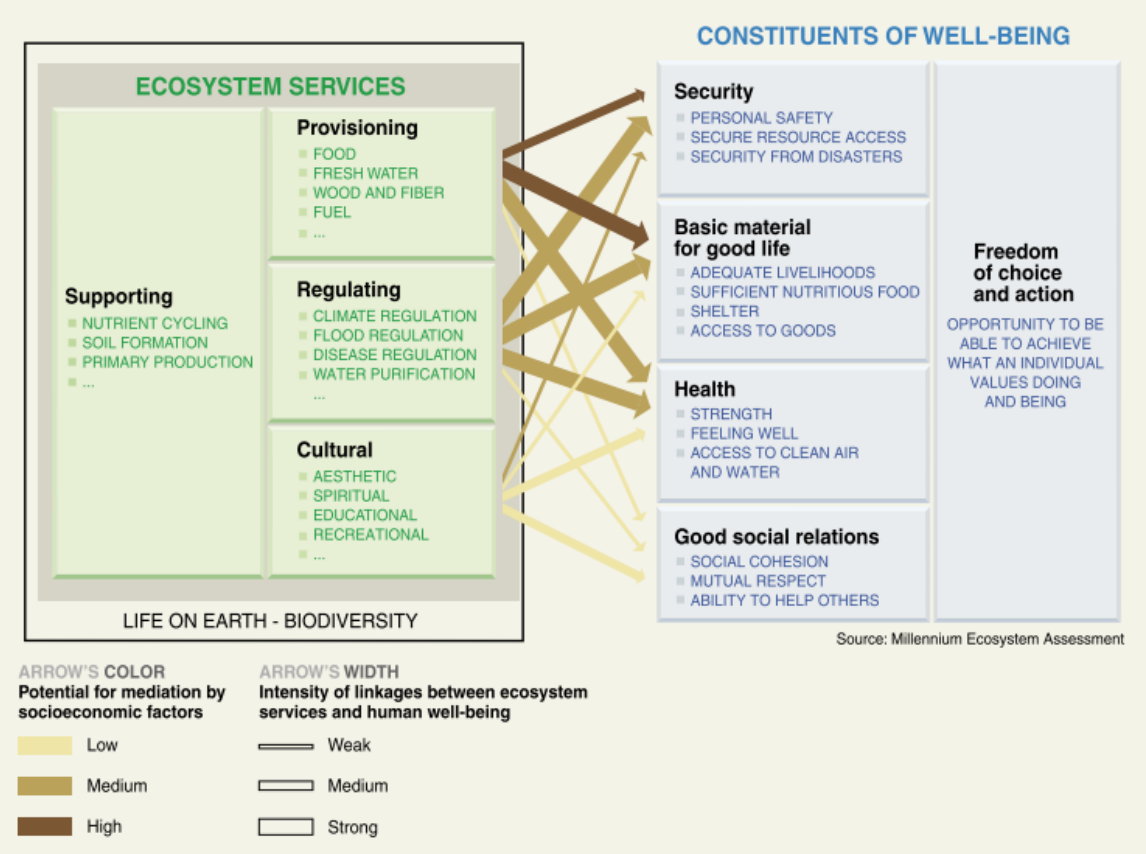

Figura 1 – Arcabouço conceitual proposto pela Avaliação Ecossistêmica do Milênio estabelecendo as ligações entre as categorias de serviços ecossistêmicos (esquerda) e os componentes do bem-estar humano (direita). As diferenças de cores e espessura das setas estão relacionadas à intensidade das ligações entre serviços e bem-estar, assim como o potencial de serem influenciadas por fatores socioeconômicos. Fonte: MA, 2005

Ao reconhecermos a interdependência das populações humanas e a natureza, podemos entender as pessoas como parte integrante dos sistemas naturais, influenciando e sendo influenciadas por estes sistemas, e não apenas como agentes externos que provocam mudanças. Tal paradigma de posicionamento das pessoas como parte central e fundamental da natureza caracteriza os sistemas conhecidos como sistemas socioecológicos. Tal termo cunhado por Berkes & Folke (1998) foi inovador ao reconhecer de maneira abrangente o caráter imbricado e indissociável dos sistemas ecológicos e sociais, abrindo novas possibilidades de estudos interdisciplinares na área socioambiental. Nesse conceito, os limites entre os sistemas sociais (economia, tecnologia, política e cultura) e o ecológico (biodiversidade) são artificiais e

arbitrários (Berkes & Folke, 1998). O principal avanço teórico possibilitado por essa nova abordagem foi seu caráter holístico, evidenciando sistemas socioecológicos como sistemas complexos. A partir dessa perspectiva, compreende-se tais sistemas como dotados de características como propriedades emergentes, componentes adaptativos, dinamismo, ligações entre escalas, alças de retroalimentação (*feedback loops*), não linearidade, limiares críticos, pontos de inflexão e mudanças de regime (Preiser et al., 2018). Deste modo, explicita-se que tais sistemas não podem ser compreendidos apenas pelo estudo de suas partes, e uma abordagem sistêmica no estudo das relações entre humanos e natureza se faz necessária. Moraes (2019) ilustra as ligações entre os domínios dos sistemas socioecológicos de maneira simplificada e didática (Fig. 2). No contexto da presente pesquisa, podemos interpretar a seta que conecta o domínio ecológico ao social como representativa dos serviços ecossistêmicos, e a seta que liga o domínio social ao ecológico como as ações humanas no ambiente. Deste modo, os serviços ecossistêmicos representam um elemento integrador na compreensão dos sistemas socioecológicos (Moraes, 2019).

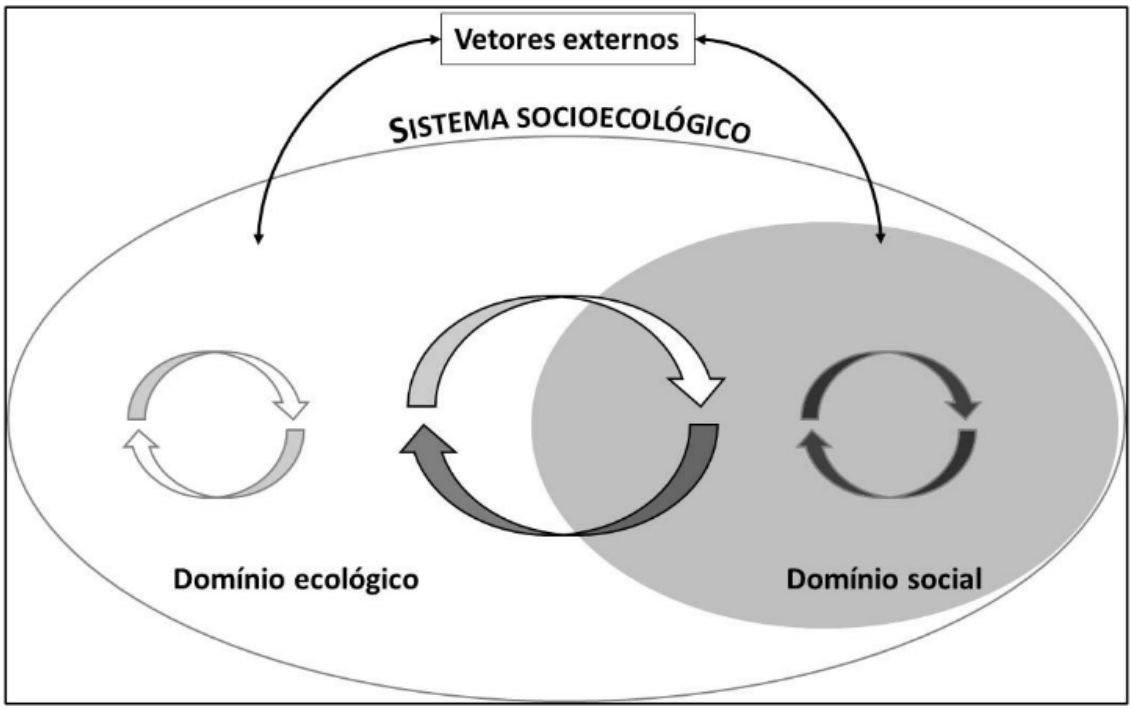

Figura 2 – Representação esquemática de um sistema socioecológico e dos seus domínios, e dos vetores externos que o afeta. As interações entre domínios, dentro dos domínios, e com os vetores se influenciam mutuamente através de um sistema de interações mediados por *feedbacks*. Fonte: Moraes, 2019

Durante a década de 2010, os conceitos de serviços ecossistêmicos e bem-estar humano foram ainda mais consolidados na literatura científica. No entanto, também foram alvo de críticas e debates devido à sua abordagem antropocêntrica, à possível interpretação da natureza como uma mercadoria, e ao foco em valores e visões da natureza oriundos do mundo ocidental (Pascual et al., 2017). No final da década, a Plataforma Intergovernamental sobre Biodiversidade e Serviços Ecossistêmicos (IPBES) propôs um novo arcabouço conceitual para compreender as ligações entre as pessoas e a natureza através da introdução do conceito de "contribuições da natureza para as pessoas" (Díaz et al., 2015; Díaz et al., 2018) (Fig. 3), assim endereçando algumas das críticas ao conceito de serviços ecossistêmicos.

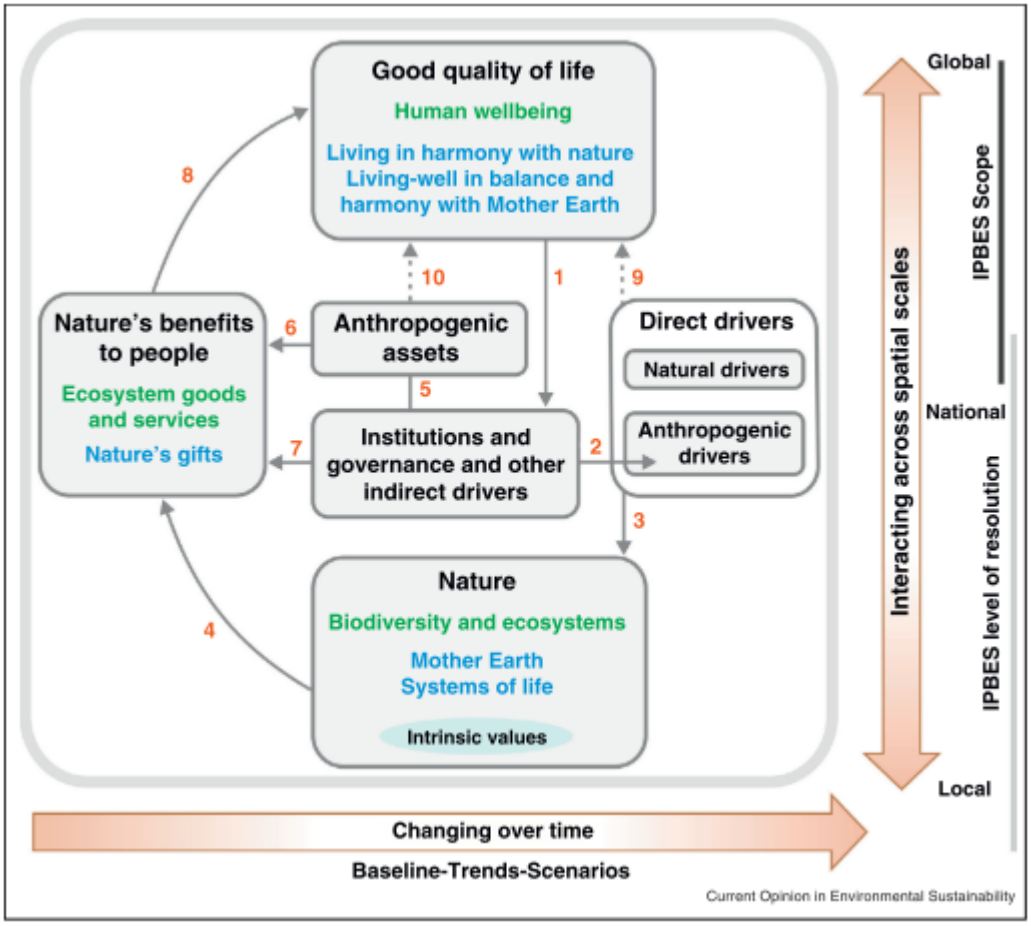

Figura 3 – Arcabouço conceitual utilizado pela Plataforma Intergovernamental sobre Biodiversidade e Serviços Ecossistêmicos (IPBES) para compreensão das relações entre pessoas e natureza. As caixas em cinza e as nomenclaturas em preto são aquelas adotadas pela IPBES, em verde estão as nomenclaturas científicas utilizadas para definir cada um dos conceitos, e em azul as denominações por outros sistemas de conhecimento. Os diversos componentes interagem através do tempo e espaço, se influenciando através de ligações diretas (setas) e indiretas (setas tracejadas). Desde o seu desenvolvimento em 2015, a nomenclatura "*nature's benefits to people*" foi alterada para "*nature's contributions to people*". Fonte: Díaz et al., 2015

A IPBES visa atuar na interface entre ciência e política em assuntos sobre biodiversidade e serviços ecossistêmicos. A sua abordagem de contribuições da natureza possibilitou avanços teóricos na compreensão das ligações entre ecossistemas e qualidade de vida. Especificamente, o conceito de contribuições da natureza para as pessoas reconhece o contexto cultural na interpretação e avaliação dos serviços ecossistêmicos, enfatiza e inclui diferentes sistemas de

conhecimento derivados de povos indígenas e comunidades tradicionais, incorpora diversas noções de uma boa qualidade de vida, e considera os serviços ecossistêmicos como uma coprodução entre pessoas e a natureza (Díaz et al., 2018). As contribuições da natureza são sumarizadas em 18 possíveis categorias, e classificadas em materiais, imateriais e de regulação (Fig. 4). Neste contexto, os serviços de suporte são considerados funções ecossistêmicas, pois não se conectam diretamente ao bem-estar humano (como também pode ser observado no arcabouço da Avaliação Ecossistêmica do Milênio). Ademais, argumenta-se que as categorias de contribuições da natureza não são discretas, e sim contínuas, uma vez que um mesmo serviço pode ser classificado de múltiplas maneiras. Por exemplo, a produção de alimento é um serviço de provisão, mas a comida também possui papel central na cultura e relações entre pessoas nas sociedades humanas. Deste modo, pode ser considerada tanto como contribuição material (serviço de provisão), como também imaterial (serviço cultural) (Díaz et al., 2018). Embora ainda existam debates e disputas sobre a extensão das contribuições teóricas e práticas do conceito de contribuições da natureza para as pessoas (Schröter et al., 2014; Díaz et al., 2018; Kenter, 2018; Kadykalo et al., 2019; Pires et al., 2020), vale ressaltar que os serviços ecossistêmicos são mais amplamente utilizados na formulação de políticas em todo o mundo, incluindo na cidade de Campinas, Brasil.

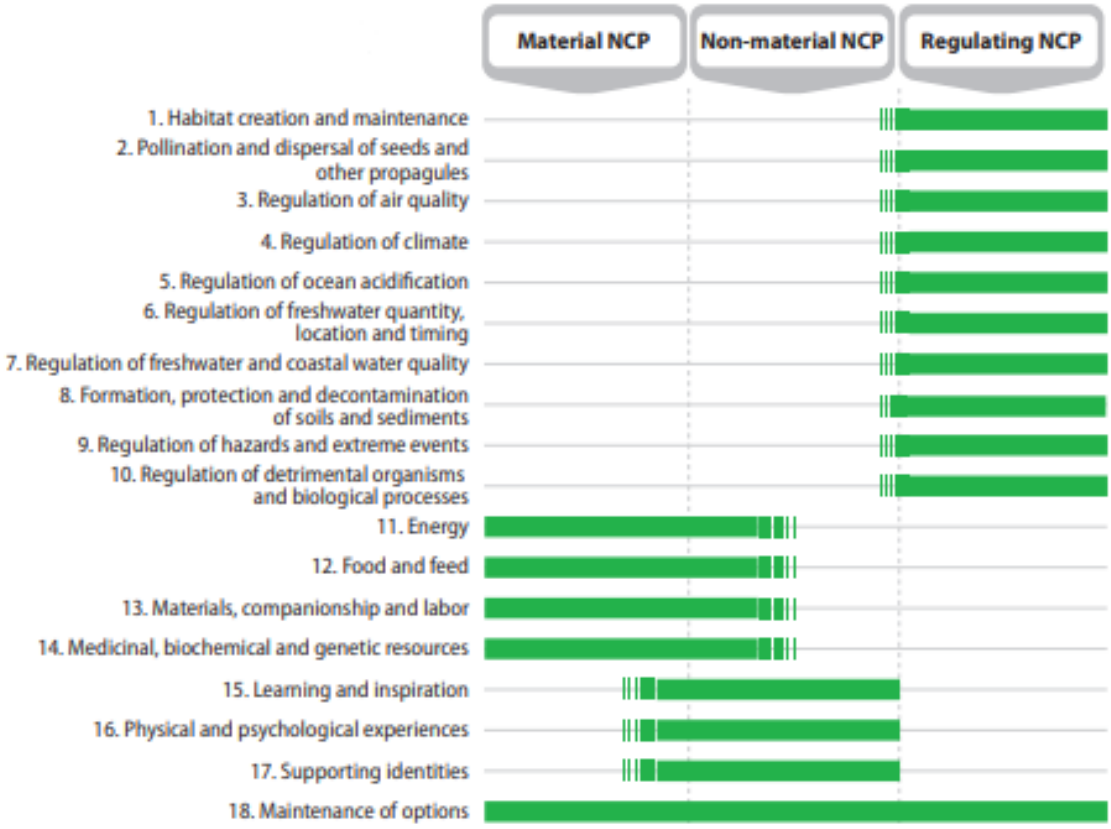

Figura 4 – Contribuições da natureza para as pessoas identificadas por Díaz et al. (2018) e suas categorias (materiais, imateriais e de regulação). Note que todas as contribuições abrangem pelo menos duas categorias, denotando o caráter contínuo da classificação proposta

Os avanços na teoria e governança global sobre serviços ecossistêmicos são perceptíveis, como demonstrado pela evolução teórica deste campo, assim como também pelos diversos acordos multilaterais em vigência na atualidade (p. ex., Agenda 2030 com os Objetivos do Desenvolvimento Sustentável). Entretanto, a última avaliação global sobre biodiversidade e serviços ecossistêmicos publicada pela IPBES mostra claramente que ainda estamos longe da sustentabilidade (IPBES, 2019). A biodiversidade, as funções e os serviços ecossistêmicos estão se deteriorando em todo o mundo, e algumas dessas perdas são insubstituíveis. A biosfera está sendo modificada em uma escala sem precedentes, e diversos pesquisadores argumentam que entramos em uma nova época geológica dominada pelo ser humano: o Antropoceno (Lewis & Maslin, 2015). Cerca de 1 milhão de espécies estão ameaçadas de

extinção, e a mudança no uso da terra é o vetor direto que possui o maior impacto negativo (IPBES, 2019). A mudança climática provavelmente aumentará a temperatura do planeta em 1,5 ° C entre 2030 e 2055 (IPCC, 2018), e as metas globais para alcançar a sustentabilidade não serão cumpridas em nossa trajetória atual (IPBES, 2019). Apesar do cenário pessimista, o atual conhecimento existente também permite identificar quais mudanças são necessárias para se alterar a atual realidade, e consequentemente o futuro. Díaz et al. (2019) indicam que é necessária uma mudança transformativa no jeito com o qual nos relacionamos com a natureza, radicalmente modificando as fundações políticas, econômicas, socioculturais, tecnológicas e institucionais que sustentam o modelo predatório de desenvolvimento global. Elementos-chave para este processo incluem o trabalho colaborativo e intersetorial de múltiplos atores para reduzir consumo e desperdício, praticar uma conservação justa e inclusiva, modificar valores, reconhecer e incluir diversas visões de uma boa qualidade de vida, reduzir desigualdades, promover e compartilhar a geração de conhecimento e educação (Díaz et al., 2019).

No caso do Brasil, embora seja um país megadiverso, os serviços ecossistêmicos encontram-se ameaçados por fatores relacionados principalmente às mudanças no uso da terra, produzindo impactos em termos de segurança hídrica, alimentar, energética e climática (BPBES, 2018). Ainda que o uso dos recursos naturais em escala nacional não seja superior à capacidade da natureza de os repor (BPBES, 2018), essa relação não se dá de forma homogênea no território. Impactos ambientais possuem efeito desproporcional para a população em situação de pobreza, acentuando efeitos de desigualdade social (Kosmus et al., 2012). Municípios brasileiros com maior quantidade de cobertura vegetal nativa remanescente são também os mais pobres (BPBES, 2018), indicando que apesar da existência de um panorama pessimista, existem janelas de oportunidade para compatibilizar o desenvolvimento com a conservação.

Neste recorte, ressalta-se a importância de unidades de conservação, espaços geográficos provedores de serviços ecossistêmicos delimitados através de mecanismos institucionais, e que atualmente ocupam 15% do território nacional (Palomo et al., 2014; BPBES, 2018). Utilizar uma abordagem embasada

nos conceitos de serviços ecossistêmicos e sistemas socioecológicos no estudo, planejamento e gestão de unidades de conservação possibilita diversos avanços, uma vez que proporciona uma linguagem comum entre diferentes atores, demonstra os benefícios para as pessoas que estas áreas provêm, e facilita a integração de diferentes ciências e sistemas de conhecimento (Palomo et al., 2014).

Ainda que o conhecimento seja um dos pontos-chave no âmbito da conciliação entre conservação e desenvolvimento, a pesquisa em biodiversidade ainda carece da capacidade de criar vínculos com o bem-estar humano no Brasil (Pires et al., 2018). Embora haja um número considerável de publicações científicas em nível mundial sobre serviços ecossistêmicos, o Brasil concentrou apenas 3% desta produção intelectual entre 2005-2016 (McDonough et al., 2017). Ao examinarmos mais minuciosamente os estudos que vêm sendo feitos na área, Pires et al. (2018) demonstram como as pesquisas vêm se concentrando em identificar relações entre biodiversidade e serviços ecossistêmicos, porém não abordam componentes da relação entre serviços ecossistêmicos e bem-estar humano. No Brasil, apesar do número de publicações sobre o assunto ter aumentado exponencialmente a partir de 2012, apenas 2,59% dos estudos sobre SE citam a palavra “bem-estar humano” (Pires et al., 2018).

A partir da fundamentação conceitual aqui exposta, justifica-se, portanto, a elaboração da presente pesquisa sobre serviços ecossistêmicos e bem-estar humano em uma unidade de conservação brasileira utilizando uma abordagem embasada no conceito de sistemas socioecológicos. A gestão e tomada de decisão neste contexto se beneficia ao ser informada pela melhor ciência disponível, e a presente dissertação pode ser útil para sintetizar e divulgar o conhecimento criado durante este processo de pesquisa focado na Área de Proteção Ambiental de Campinas.

ÁREA DE ESTUDO

A Área de Proteção Ambiental de Campinas (APA de Campinas) é uma unidade de conservação municipal de uso sustentável, cuja responsabilidade de gestão é da Secretaria do Verde, Meio Ambiente e Desenvolvimento Sustentável do município de Campinas (conhecida por Secretaria do Verde). Antes de ser a APA de Campinas nos moldes em que é conhecida, existiam as Áreas de Proteção Ambiental de Sousas e Joaquim Egídio, criadas em 1993 através do decreto municipal 11.172/93, abrangendo as áreas dos distritos que a nomeavam. A criação da APA em seu atual formato data de 2001 através da Lei 10.850/01, que também estabelece um Conselho Gestor (CONGEAPA) de caráter deliberativo com diversas entidades que possuem atuação comprovada na área. Dentre tais entidades, que são eleitas para mandatos de 2 anos, participam representantes do poder executivo e órgãos públicos municipais, organizações representativas da população residente e proprietários de terras e imóveis, organizações da sociedade civil de interesse público e organizações não-governamentais, representantes de associações de produtores rurais e sindicatos, universidades e institutos de pesquisa. Membros do conselho gestor relatam que a sociedade civil organizada em um movimento de caráter ambientalista foi fundamental na promulgação da lei de 2001 e na conquista de um conselho deliberativo. Ademais, relata-se também que a criação da unidade foi essencial para impedir a construção de uma estrada na região.

Com cerca de 22.300 ha, a APA de Campinas abrange a totalidade dos distritos de Sousas e Joaquim Egídio, localizados na porção nordeste da cidade, além dos bairros Carlos Gomes, Chácaras Gargantilha e Jardim Monte Belo que integram a Administração Regional (AR) 14, ocupando cerca de 27% do território do município (Campinas, 2019) (Fig. 5). Na localidade, coexistem simultaneamente propriedades rurais, áreas urbanas, condomínios residenciais, fragmentos de floresta estacional semidecídua e floresta paludosa, patrimônios arquitetônicos, cursos d'água que abastecem o Rio Atibaia e Rio Jaguari, trilhas e passeios típicos do ecoturismo e turismo rural (Fig. 6, 7 e 8). Além disso, conta com vários potenciais vetores de mudança, como especulação imobiliária e outras pressões urbanizadoras, degradação ambiental, e a construção em andamento de uma barragem nos limites com município vizinho de Pedreira,

caracterizando um complexo sistema socioecológico (Trevisan e Paes, 2009; Campinas, 2018). Em maio de 2019, foi aprovado o Plano de Manejo da APA Campinas, em que um modelo misto de governança institucional e de governança compartilhada e adaptativa da APA é proposto para alcançar os objetivos de conservação do patrimônio natural, cultural e arquitetônico, proteção dos mananciais hídricos, e controle das pressões urbanizadoras e atividades industriais e agrícolas (Campinas, 2019).

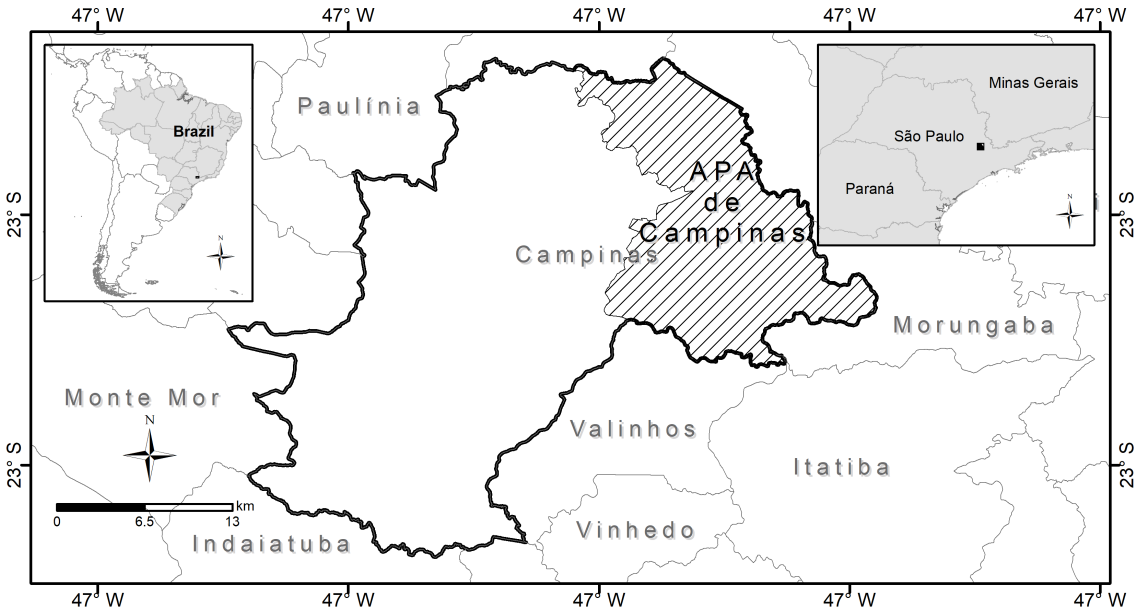

Figura 5 – Localização geográfica da APA Campinas em relação ao município de Campinas e cidades da região metropolitana

Figura 6 – Aspectos da paisagem na Área de Proteção Ambiental de Campinas. (A) Vista do Pico das Cabras na qual é possível observar o mar de morros com plantações de eucalipto e pastos; (B) Rio Jaguari no ponto de acesso à “prainha”; (C) “Prainha” do Rio Jaguari, local que costumava ser frequentado por banhistas até a interdição em vista da construção da barragem de Pedreira-Campinas; (D) Rio Atibaia na entrada do condomínio Colinas do Atibaia; (E) Vista de fragmento de mata no condomínio Colinas do Atibaia. Fotos: Rafael Flora (A, B, C) e Rafael Lembi (D, E)

Figura 7 – Aspectos da paisagem na Área de Proteção Ambiental de Campinas. (A) Vista do Sítio Vale das Cabras em que é possível observar o contraste entre pasto na propriedade vizinha com plantação de eucalipto ao fundo (à esquerda) e sistema produtivo de base agroecológica (à direita); (B) Trilha do bonde que segue paralela ao ribeirão das Cabras próxima ao centro urbano de Joaquim Egídio; (C) Centro de educação ambiental “Estação Ambiental de Joaquim Egídio” no centro urbano de Joaquim Egídio; (D) Pasto com plantação de eucalipto ao fundo. Fotos: Rafael Lembi

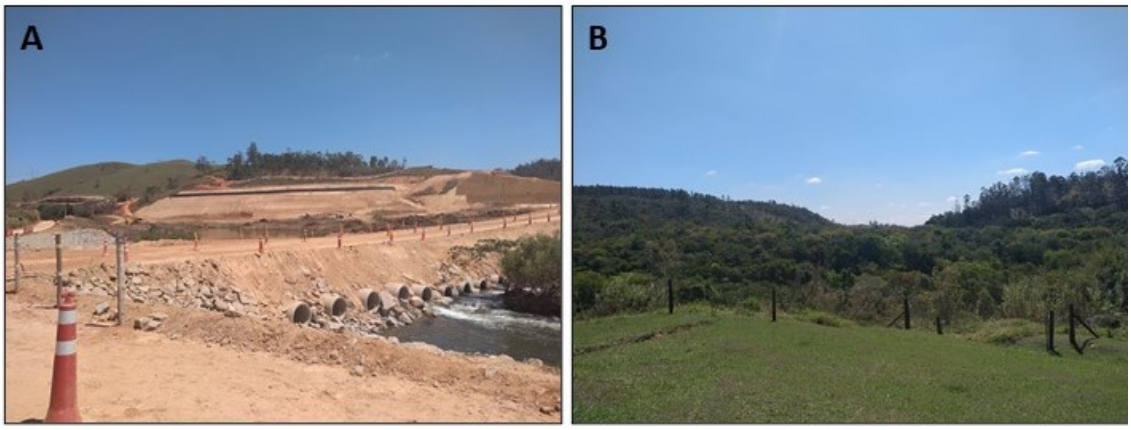

Figura 8 – Aspectos da paisagem na Área de Proteção Ambiental de Campinas. (A) Obra em andamento de construção de barragem na fronteira entre a APA e Pedreira; (B) Fragmento florestal próximo à obra da barragem que será desmatado para inundação. Fotos: Rafael Lembi

A motivação para a escolha desta área de estudo surge a partir de uma série de fatores. Um dos motivos foi o reconhecimento da importância da APA de Campinas como área provedora de serviços ecossistêmicos em nível local e regional. Ademais, desconhecemos pesquisas acadêmicas que detalhem as dinâmicas da região com um enfoque socioecológico ou pesquisas sobre serviços ecossistêmicos dentro da APA de Campinas. Encontramos, entretanto, pesquisas com um enfoque explícito para a gestão da área datadas da década de 1990 (Mattos, 1996; Hammes, 1998), e pesquisas mais recentes direcionadas para estudos de fauna e flora, educação ambiental e processos de urbanização do território (p. ex., Mattosinho, 2000; Santos, 2003; Fernandes, 2009; Trevisan e Paes, 2009; Castilho, 2010). Embora a ausência de pesquisas científicas seja perceptível, muitas informações e dados sobre a área foram compilados e divulgados através da publicação dos tomos que compõem o plano de manejo da área. Deste modo, compreendemos a APA como uma área rica em informações, porém ainda carente de uma pesquisa científica de base socioecológica.

Outro fator tão relevante quanto a lacuna de conhecimento identificada foi a recepção de diferentes atores à proposta da pesquisa. Nos primeiros contatos com funcionárias da Secretaria Municipal do Verde, Meio Ambiente e Desenvolvimento Sustentável de Campinas, a proposta de pesquisa foi bem

recebida e houve interesse de que fosse desenvolvida, facilitando o estabelecimento de contato com diversos outros atores que foram fundamentais para o processo. O subsequente contato com membros do CONGEAPA foi também significativo neste âmbito, uma vez que a proposta também foi bem recebida pelo Conselho. Notou-se durante estes contatos que muitos atores relatavam uma carência de pesquisas acadêmicas tanto na APA, como também em Campinas de maneira geral. Sendo esta pesquisa parte de um vínculo institucional com a Universidade Estadual de Campinas, consideramos relevante a integração da universidade ao contexto local em que se insere.

É válido ressaltar que a APA de Campinas é uma unidade de conservação de uso sustentável e seu conselho possui caráter deliberativo. Assim, diversas decisões e regulações sobre as atividades que ocorrem na região passam pelo âmbito do CONGEAPA e da Secretaria do Verde. Existem diversos projetos e propostas em andamento no território, e, portanto, entendemos que existem oportunidades para que os achados desta pesquisa possam contribuir com informações para a tomada de decisão que influenciam a APA. Deste modo, acreditamos que a pesquisa na região possa colaborar para a construção de conhecimento científico, como também pode ser potencialmente útil para a gestão e tomada de decisão. Ademais, a proximidade geográfica da região com a universidade significou baixos custos orçamentários relativos à locomoção para o desenvolvimento da pesquisa.

Finalmente, este trabalho também possibilitou que outros projetos pudessem ser desenvolvidos. Desde o início da realização desta dissertação, um grupo de pesquisa foi formado envolvendo três professores da Unicamp, uma pesquisadora de pós-doutorado, um pesquisador de doutorado, e três pesquisadoras de iniciação científica. Assim, esperamos que nossos achados possam fomentar e estimular outras pessoas a estudarem a APA de Campinas.

ABORDAGEM METODOLÓGICA

O caráter complexo dos sistemas socioecológicos demanda que diversos tipos de conhecimento sejam integrados para lidar com os problemas ambientais e sociais que emergem da realidade. Deste modo, a abordagem metodológica adotada por esta pesquisa se caracteriza como sendo interdisciplinar e de caráter participativo. No campo das ciências ambientais, compreendemos a interdisciplinaridade como sendo a integração de conhecimento de diversas fontes motivada por um problema do mundo real (Bursztyn & Drummond, 2014), e a inclusão do conhecimento e percepção das pessoas envolvidas com o problema como delimitando seu caráter participativo (Baldauf, 2020). No contexto de sistemas socioecológicos, Seixas (2005) aponta que abordagens convencionais de estudos que levam em conta apenas o ambiente físico e ecológico são insuficientes para uma compreensão sistêmica. Portanto, este enfoque de pesquisa deve levar também em conta o conhecimento e percepção dos atores diretamente envolvidos com um determinado recurso ou área. Berkes (2005) também aponta que a incorporação de conhecimento ecológico local ou tradicional é relevante para o manejo dos recursos naturais e a conservação de áreas protegidas.

Na presente pesquisa, optou-se por trabalhar especificamente com os conselheiros do CONGEAPA por possuírem amplo conhecimento em diversos assuntos referente à APA de Campinas, como também pelo fato de terem demonstrado interesse na elaboração do projeto. Além disso, por serem atores diretamente envolvidos com a tomada de decisão de diversos processos que ocorrem na APA, poderiam potencialmente ser os maiores beneficiários do conhecimento gerado no trabalho. Ressalta-se, entretanto, que a inclusão do conhecimento e percepção das pessoas diretamente envolvidas com uma determinada temática pode ocorrer em diversos graus de participação social (Arnstein, 1969).

O uso de metodologias que envolvem seres humanos em pesquisas científicas exige considerações éticas. Participantes devem estar cientes sobre a justificativa e objetivos que embasam a pesquisa, procedimentos práticos que envolvem a participação, eventuais desconfortos, riscos e benefícios que a pesquisa poderá acarretar, garantia de sigilo e privacidade, além de contatos

externos na universidade à qual a pesquisa está atrelada que possam ser contactados em situações de necessidade. Caso o participante voluntariamente opte por participar e declare seu consentimento, a coleta de dados pode ser efetuada. Na presente pesquisa, os métodos empregados que envolvem a interação com pessoas foram a realização de entrevistas e organização de oficinas. A resolução nº 510/16 do Ministério da Saúde e o Comitê de Ética em Pesquisa nas Ciências Humanas e Sociais (CEP-CHS) da Unicamp preconizam os mecanismos institucionais necessários para garantir uma condução ética de pesquisas que envolvem os métodos aqui utilizados. Deste modo, seguindo os procedimentos exigidos, a presente pesquisa foi avaliada pelo comitê de ética da Universidade e obteve aprovação para sua condução sob a autorização CAAE 20467619.4.0000.8142 (Anexo 1). Anteriormente à condução da coleta de dados, os participantes eram devidamente informados sobre o projeto e recebiam um termo de consentimento livre e esclarecido que detalhava as condições que a participação voluntária exigia (Apêndice I.1). Deste modo, foi possível garantir que considerações éticas fossem empregadas com efetividades na coleta de dados.

O estudo dos sistemas socioecológicos pode ser abordado com inúmeras ferramentas diferentes. Métodos científicos tradicionais, como ferramentas de pesquisa qualitativa (p. ex., entrevistas e grupos focais) e ferramentas quantitativas (p. ex., sistemas de informação geográfica) têm sido comumente usados. Entre abordagens participativas que têm potencial de contribuir para questões relacionadas aos serviços ecossistêmicos, a construção de modelos e cenários de forma participativa é uma possibilidade que tem sido disseminada entre cientistas e tomadores de decisão (IPBES, 2016). Conceituando modelos como descrições qualitativas ou quantitativas dos componentes-chave de um sistema e das relações entre tais componentes, e cenários como representações de futuros possíveis para os componentes de um sistema (IPBES, 2016), tais ferramentas se demonstram úteis tanto na compreensão da realidade como para a predição do futuro. Embora existam diversos métodos para modelagem e construção de cenários, os métodos participativos que se embasam na percepção e conhecimento dos atores locais possuem a ênfase de unir cientistas

e não-cientistas no seu desenvolvimento, valorizando outros tipos e sistemas de conhecimento e valores (Hubacek et al., 2017).

Entre os desafios da sustentabilidade, mudanças no uso e ocupação dos sistemas terrestres se destacam. O entendimento de onde, quando, como e porque o uso e ocupação da terra se altera é fundamental para a gestão. Monitorar e descrever padrões de mudanças e sua relação com vetores de mudança é a base das ciências do sistema terrestre, e utilizar a lente dos sistemas socioecológicos neste âmbito constitui-se como base para uma compreensão sistêmica destas mudanças (Meyfroidt et al., 2018).

Nesta dissertação, uma gama de técnicas foi empregada para alcançar os objetivos propostos. No capítulo 1, entrevistas semiestruturadas (Bailey, 1987) foram conduzidas com conselheiros do CONGEAPA para identificar quais serviços ecossistêmicos ocorrem na APA de Campinas e quais fatores têm influenciado sua disponibilidade e qualidade (Apêndice I.2). As entrevistas foram transcritas e analisadas a partir de preceitos de análise qualitativa baseada na codificação e categorização de dados utilizando o software QDA Data Miner Lite (Saldaña, 2013; Provalis, 2021). Para representar e analisar os fatores e *feedbacks* identificados que influenciam os serviços ecossistêmicos, modelos do tipo "*causal-loop diagrams*" (Meadows, 2008) foram construídos utilizando o software Vensim (PLE 8.2.1 x64 version, Ventana Systems, Inc.).

Uma análise de mudanças no uso e cobertura da terra na APA de Campinas foi conduzida para avaliar as mudanças biofísicas no ambiente ao longo do tempo (Capítulo 2). Dados do MapBiomas para o município de Campinas foram obtidos para os anos de 1993, 2001 e 2019 e sobrepostos com a área delimitada pela APA e seu zoneamento (MapBiomas, 2021 – versão 5). Utilizando o software ArcGIS para condução desta análise, mapas de uso e cobertura da terra foram produzidos, assim como matrizes de transição que explicitavam quantitativamente as mudanças e transições observadas (Pontius Jr et al., 2004). Os dados foram analisados utilizando Excel e figuras foram produzidas utilizando os softwares RStudio (versão 1.4.1106) e Displayr (Displayr, 2021).

A condução de discussão em grupos focais, isto é, uma discussão facilitada e interativa entre um grupo pré-determinado de pessoas sobre uma questão específica (Hennink, 2014), foi utilizada para elaboração dos cenários e identificação de ações de gestão e planejamento para se alcançar um futuro desejável para a APA de Campinas (Capítulo 3). Os cenários foram desenvolvidos na forma de painéis, elaborados por um facilitador gráfico. As duas discussões no formato de grupo focal foram transcritas e analisadas a partir de preceitos de análise qualitativa baseada na codificação e categorização de dados utilizando o software QDA Data Miner Lite (Saldaña, 2013; Provalis, 2021). Transversalmente a todos esses métodos, a observação direta e participação em reuniões diversas foi utilizada para construir relações de confiança com os diferentes grupos de atores que atuam na área, assim como para possibilitar um entendimento das dinâmicas específicas que regem a APA de Campinas.

O uso dos métodos citados possui grande potencial para a compreensão de problemas complexos de natureza socioecológica, oferecendo ferramentas para pesquisadores e tomadores de decisão administrarem a incerteza presentes nestes sistemas. A partir da combinação de diferentes métodos, espera-se uma integração de abordagens para compreender como a APA de Campinas se alterou com o passar do tempo, como está atualmente, e como poderá estar no futuro.

DESAFIOS E ADAPTAÇÕES METODOLÓGICAS NO CONTEXTO DE PANDEMIA

O ingresso no programa de pós-graduação que deu início a presente pesquisa se deu em fevereiro de 2019. No primeiro semestre, o principal foco foi cursar disciplinas, participar de cursos, escrever o projeto de pesquisa, e estabelecer os primeiros contatos com os atores envolvidos na gestão da APA de Campinas, incluindo a Secretaria do Verde e CONGEAPA. No segundo semestre, idas a campo e participação em reuniões se deram de maneira presencial, e foi possível conhecer e estabelecer relações com atores de outras esferas, além do projeto ter sido formalmente submetido para o Comitê de Ética e apresentado para o Conselho Gestor e Prefeitura. A coleta de dados estava prevista para ser realizada no terceiro semestre. Entretanto, com a suspensão de atividades presenciais na Unicamp em março de 2020 e resolução do programa de pós-graduação que indicava suspensão das atividades de campo,

diversas adaptações tiverem que ser realizadas. As entrevistas com os conselheiros que deram origem ao capítulo 1 ocorreram integralmente de forma remota por videoconferência (*Google Meets*) ou por telefone e o roteiro de perguntas teve que ser adaptado, com diversas questões anteriormente previstas que não puderam ser incluídas. A participação em atividades se resumiu apenas às reuniões online do CONGEAPA, e a observação se deu de maneira passiva através da transmissão via YouTube, em contraponto às interações ativas com conselheiros em reuniões presenciais. Uma parceria foi estabelecida com uma pesquisadora da EMBRAPA Informática Agropecuária para a realização do capítulo 2 que não estava previsto anteriormente, mas se tornou uma interessante alternativa devido ao fato de não precisar de idas ao campo. A metodologia de discussão em grupo focal foi utilizada pela primeira vez em formato online pelo nosso grupo de pesquisa, e com tempo reduzido, devido à “fadiga de telas” que as interações virtuais estão provocando. Na Tabela 1, as principais atividades que contribuíram para a realização do projeto são resumidas com a indicação se ocorreram em caráter presencial ou virtual.

Tabela 1 – Relação e descrição das principais atividades que contribuíram para a construção da pesquisa, datas e caráter presencial ou virtual

Datas	**Atividades de formação (cursos e disciplinas)**	**Presencial (P) ou virtual (V)**
03-06/2019, 02-08/2020, 09/2020-01/2021	Atividades de monitoria de disciplinas de graduação (PED)	P e V
01-09/2019	Curso: programa de formação de líderes facilitadores	P
24-28/05/2021	Curso: Resilience Foundations: From theory to practice	V
07/2019	Curso: *São Paulo School of Advanced Science on Scenarios and Modelling on Biodiversity and Ecosystem Services to Support Human Well-Being*	P
01-02/2020	Disciplina de ecologia de campo (IB Unicamp)	P
11/2019	Disciplina em valoração e mapeamento de serviços ecossistêmicos (UFRN)	P
03-06/2019	Disciplinas da pós-graduação (IB Unicamp)	P
Datas	**Atividades de pesquisa**	**Presencial (P) ou virtual (V)**
10/2019, 10/2020, 04/2021	Apresentações em reuniões do CONGEAPA	P e V
05/2020	Entrevistas com conselheiros do CONGEAPA	V
11/2020, 05/2021	Oficinas participativas/Grupos focais	V
09,10,11,12/2019, 09, 10, 11/2020 03,04/2021	Participação em reuniões CONGEAPA	P e V
10/2019	Reunião do coletivo de ONGs da APA de Campinas	P
09/2019	Reunião do programa de Pagamento por Serviços Ambientais	P
09/2019, 03/2020	Reuniões com a Secretaria do Verde	P
08/2019, 10/2020, 06/2021	Reuniões de comitê de acompanhamento	V
09/2019	Visita técnica à obra da barragem de Pedreira-Campinas	P

Os desafios impostos foram diversos, pois também alteraram a rotina e dinâmica de trabalho e interação com os outros membros do grupo de pesquisa, que em diversas vezes possibilitavam discussões e reflexões valiosas. Entretanto, de maneira análoga aos sistemas socioecológicos, o uso da capacidade adaptativa para moldar às condições impostas foi necessário. Os contatos estabelecidos previamente foram fundamentais para que as etapas

virtuais pudessem ocorrer com o rigor necessário, ainda que simplificadas. Até a defesa desta dissertação, uma devolutiva será realizada com os membros do conselho e outros atores interessados para apresentar as principais conclusões. Deste modo, ainda que com os desafios do contexto de pandemia, espera-se que os achados desta dissertação possam ser uma contribuição científica e também para gestão e tomada de decisão.

CHAPTER 1 - ASSESSING ECOSYSTEM SERVICES AT A PERI-URBAN PROTECTED AREA IN SOUTHEAST BRAZIL: PERCEPTIONS AND KNOWLEDGE OF MANAGEMENT COUNCILORS

Keywords: nature's contributions to people; social-ecological systems; causal-loop diagrams; feedbacks; stakeholders.

ABSTRACT

The Environmental Protected Area of Campinas (APA Campinas) is a peri-urban protected area located in Campinas, Brazil. We interviewed management councilors to identify key ecosystem services for local people's quality of life and how these services have changed from 2000 to 2020. Causal-loop diagrams were designed to display factors and identify feedback mechanisms that have been changing availability and quality of ecosystem services. Regulation of water quantity, food production, and physical and psychological experiences in nature stood out as most relevant ecosystem services for each of the following categories: regulating, material and non-material contributions to people. The latter is perceived as increasing over the years while the others as decreasing. Urbanization has been affecting these services through different mechanisms and with specific dynamics that vary between rural and urban areas. Six amplifying feedback mechanisms were described, suggesting that a change of the APA Campinas social-ecological system towards an urban-dominated state is being fostered. Responses to change in ecosystem services were identified, indicating that local stakeholders perceive and act towards improving environmental conditions. These responses, though, are still incipient in integrating actions that target multiple ecosystem services simultaneously. Using perceptions and knowledge of stakeholders in assessing ecosystem services has been a useful tool to understand the status and trends of these services in a protected area. Our findings show the importance of using a system dynamics perspective for data analysis in order to elucidate feedback mechanisms affecting trends in ecosystem services. Finally, we argue for the complementarity of using ecosystem services (a concept already understood by policy makers) and nature's contributions to people (a better concept to acknowledge multiple values and knowledge system in data analysis) on place-based research.

INTRODUCTION

Ecosystem services are the benefits human societies obtain from nature (MA, 2005). The ecosystem services nomenclature emerged in the early 1980s, aiming to describe the importance of biodiversity to human well-being (Gómez-Bagghetun et al., 2010). The growing number of published works that dealt with the theme of ecosystem services over the last three decades point out to the usefulness of the concept (Pires et al., 2018). However, it has also been criticized for an excessive focus on monetary and utilitarian aspects of nature, while disregarding worldviews not derived from Western science (Schröter et al., 2014; Pascual et al., 2017). In this context, the concept of nature's contributions to people has been proposed by Díaz et al. (2018) within the scope of the Intergovernmental Platform of Biodiversity and Ecosystem Services (IPBES), aiming to recognize diverse worldviews, the co-production of benefits between people and nature, and to further stimulate dialogues between science and policy. This concept has also been a target of critiques (Braat, 2018; Kenter, 2018), and recent literature in the area has been evaluating theoretical advancements of the nature's contributions approach and how researchers have been utilizing the concept (Kadykalo et al., 2019; Pires et al., 2020). More recently, it has been deployed to perform place-based assessments of ecosystem's benefits (Brito et al., 2020; Topp et al., 2021).

Assessing ecosystem services is a task that can be approached through several manners, such as geospatial analysis (Laterra et al., 2012), comprehensive literature surveys such as the MA and IPBES reports, and monetary valuation (de Groot et al., 2012). This wide scope of methodologies and techniques confirms the various applications and pluralism of the concept. Nonetheless, it is reasonable to affirm that there is a necessity to ground the study of ecosystem services within a social-ecological systems perspective, in which integrated systems of humans and nature are considered to be complex systems (Berkes & Folke, 1998; Palomo et al., 2016). This perspective is useful for a refined understanding of dynamics that shape a social-ecological system and recognizes features such as cross-scale linkages and feedback loops (Preiser et al., 2018).

Participatory assessments that are based on stakeholder's perceptions, values and knowledge have been increasingly relevant in ecosystem services research, since they can provide valuable insights to the understanding of social and cultural dimensions of a given social-ecological system that are otherwise difficult to attain (Cebrián-Piqueras et al., 2017). Here, we define perception as the way an individual observes, understands, interprets, and evaluates ecosystem services at APA Campinas (based on the definition by Bennett, 2016). Perceptions can be based on knowledge, and we define local knowledge as the cumulative knowledge system that stems from shared and individual experiences of the environment (Díaz et al., 2015; Williams et al., 2020). When we consider stakeholders that participate and engage in decision-making arenas, such as management councils of protected areas, the importance of investigating perceptions increases, since they potentially guide and influence decision-making within environmental management (Bennett, 2016; Prado et al., 2020). Additionally, stakeholder-based methods can have great explanatory power to the current status and past trends of ecosystem services, especially if stakeholders possess local knowledge of the dynamics of the social-ecological system (Davis & Wagner, 2003; Williams et al., 2020).

Protected areas can be understood as social-ecological systems that provide multiple contributions to people's quality of life (Palomo et al., 2014). Institutional arrangements that regulate the governance of these areas influence their conservation status and the supply of ecosystem services, since they offer mechanisms that regulate human activities and impacts (Bennett & Satterfield, 2018). Decision-making arenas within protected areas, such as management councils, are therefore relevant study objects due to their potential ability to influence the status and trends of ecosystem services.

The Environmental Protected Area of Campinas (APA Campinas, for its Portuguese acronym) is a peri-urban sustainable-use protected area located in the city of Campinas, state of São Paulo, southeast Brazil. Its management council has a deliberative character and councilors are usually people with vast experience in the area. Thus, investigating the perceptions and knowledge of management councilors of APA Campinas is of special interest, since they have

a formal role within decision-making and can also provide insights into the social-ecological dynamics that influence ecosystem services.

In this study, we aim to assess past trends of ecosystem services at APA Campinas over a 20-year period (2000 – 2020). We utilize a qualitative stakeholder-based approach, drawing from the set of knowledge and perceptions of its management councilors. More specifically, we aim to

(i) Identify ecosystem services that are perceived at APA Campinas, and those which are considered to be the most relevant to the local population well-being;
(ii) Assess past trends of the most relevant ecosystem services, identify the social-ecological factors and feedbacks that have been influencing them;
(iii) Identify responses to change of the most relevant ecosystem services.

METHODS

Study area

APA Campinas is a sustainable-use protected area located at the municipality of Campinas, state of São Paulo, southeast Brazil (Fig. 1.1). The area was legally established in its current format through the Municipal Law 10.850 in 2001, which aimed to protect relevant cultural heritage sites and water resources, including the Atibaia river that supplies water for 94% of the 1.2 million inhabitants of Campinas (Campinas, 2018). Covering 27% of the municipality (22.300 ha), APA Campinas is characterized by a mosaic of land uses that encompasses agriculture, silviculture, pasture, forest fragments, and urban uses, and is often described as a peri-urban area due to the presence of both rural and urban features (Iaquinta & Drescher, 2000; Campinas, 2018).

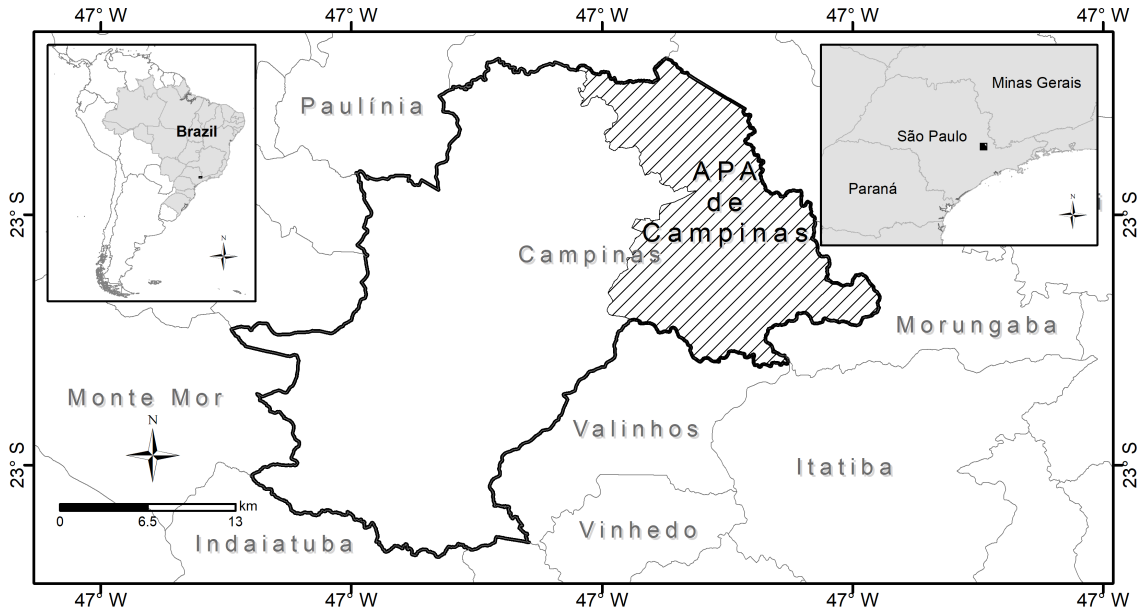

Figure 1.1 – Location of APA Campinas within the municipality of Campinas and neighboring municipalities, state of São Paulo, southeast Brazil

Population has increased 219% at APA Campinas, from 11.500 inhabitants in 1980 to 25.195 in 2010. Urbanized areas concentrate the majority of the local population (80%), and 45% of the urban area is composed by 23 residential condominiums targeting the upper middle-class population (Campinas, 2018). Such residential condominiums are built as gated communities, which are defined as housing developments with controlled access through the use of walls, gates, and fences (Atkinson & Blandy, 2005). Gated communities have been frequently associated with a search for safety and security (Low, 2001), and research at APA Campinas suggest they play a role in spatial socioeconomic segregation (Trevisan & Paes, 2009). Urban areas are located at the center of APA Campinas, and the official urban perimeter has been increasing throughout the decades by the implementation and modification of laws. Historical buildings are located at the urban part of APA Campinas (Fig. 1.2) and in the rural area, including 19th century houses from coffee farms. Touristic attractions such as a trekking circuit, bars and restaurants are also present and highly visited (Fig. 1.2) (Campinas, 2018).

Figure 1.2 – Historical building (former train station) that currently hosts an environmental education center at the urban center of the Joaquim Egídio neighborhood (April 2019) (left); an intensively visited trail that composes a 6 km trekking circuit near the urban center of Joaquim Egídio (April 2019) (right). Photos: Rafael Lembi.

At the rural areas, the predominant land uses are pastures, followed by forest fragments, degraded pastures seldom used by cattle, and silviculture (Fig. 1.3) (Campinas, 2018). Agriculture covers less than 2% of the area and is scattered within the rural areas (Fig. 1.3) (Campinas, 2018). Land tenure is mostly private and 61% of the area of officially registered properties are large farms with over 150 ha in size. Urban areas are more visited in comparison to rural, but there are agrotourism activities and visitation to a museum and an observatory. There has been an increase in second houses at rural areas, especially at the north of APA Campinas, where urban residents buy property to spend weekends and holidays for leisure (Campinas, 2018).

Figure 1.3 – Jaguari river in an area that used to be visited for bathing and recreation, but is currently interdicted due to the construction of a water dam - notice the riparian forest along the river and the pasture at the hilltops (November 2018) (left); Organic agriculture production at "Sítio Vale das Cabras", a 3 ha property at the rural area of APA Campinas that is highlighted as a model for integrated conservation and development (September 2019) (right). Photos: Rafael Lembi

The management of APA Campinas lies within the scope of the municipal Secretariat of the Environment, and the principal arena regarding environmental decision-making at the area is the management council. Organizations must have at least two years of experience in the area in order to be eligible for the council, and elections happen every two years. The council is locally known for actively influencing the conservation status of the area and regulating impactful activities, and it is formed by representatives from organizations that have verified activities at APA Campinas, including residents' associations, non-governmental organizations, public government agencies and farmers and landowners' organizations. During the development of this research, councilors were elected members that composed the 2018-2020 election term.

Data collection

The research proposal[2] was presented in September 2019 to municipal government employees and management councilors of APA Campinas during official meetings prior to data collection. Subsequent personal contact with stakeholders and participant observation of four council meetings and two NGO

[2] Research approved by ethics committee under permit CAAE 20467619.4.0000.8142

meetings from September to December 2019 enabled the development of rapport. Due to social distancing measures imposed by COVID19 pandemics, the contact with management councilors since March 2020 occurred solely through virtual platforms. Observation of meetings changed from participant to direct in five virtual council meetings attended between September 2020 and April 2021. Thus, we collected data from observation of meetings (n = 11) and semi-structured interviews with management councilors (n = 18) (Bailey, 1987). Interviews were conducted in May 2020 using Google Meets online videoconferencing platform and telephone calls, being simultaneously recorded and subsequently transcribed using oTranscribe web platform. Prior to interviews, an informed consent document was sent to interviewees clarifying aspects of the research and inviting them to participate.

During the interviews, which usually lasted 60 minutes, councilors were presented to the concept of ecosystem services adopted by this research (i.e., nature's benefits that contribute to quality of life of the local population) and were then asked to freely speak about which benefits from nature they perceived to occur at APA Campinas. This approach was based on a freelisting technique, in which interviewees freely speak and list items within a given category (Quinlan, 2005), and has the potential to offer insights and identify ecosystem services that might not be cited when using a closed survey. After listing ecosystem services, interviewees were asked to rank which were the three services they considered to be the most relevant to support well-being of the local population. Focusing on these three most relevant ecosystem services, we asked the councilors how they had changed over the last 20 years (2000-2020) and what factors have influenced their availability and quality. On the last section of the interview, councilors were asked about whether they knew or were aware of projects, initiatives, or organizations that worked towards conservation of the three most relevant ecosystem services they appointed. The combination of freelisting and ranking of ecosystem services has been reported to be a successful manner to elicit assigned perceptions and values to nature by stakeholders (Carrilho & Sinisgalli, 2018).

Data analysis

Interview transcripts were analyzed following principles of qualitative data analysis based on coding and grouping within themes that emerged from consulted literature and the dataset itself (Saldaña, 2013). We utilized software QDA Data Miner Lite (Provalis Research) to assist in the process of analyzing qualitative data. The coding process happened in an iterative manner, with frequent consultation to transcripts and field notes, coupled with the utilization of reflexive memo writing technique (Bailey, 1976; Saldaña, 2013).

We ground our data analysis and discussion on an approach that utilizes theoretical contributions from both concepts of ecosystem services and nature's contributions to people. We opted to explicitly utilize the ecosystem services nomenclature to converse with stakeholders, since it is officially adopted by the municipal government through institutional mechanisms, including in the law that creates a payment for environmental services program (Municipal Law 15.046/15). In parallel, we utilize proposed categories (regulating, material and non-material) and list of 18 nature's contributions by Díaz et al. (2018) to classify the benefits from nature cited by interviewees, since it considers cultural context and considers fluid categories of services. Thus, we also aim to argue on the complementarity and application of the two concepts on place-based research.

Based on the ecosystem services that interviewees ranked as most relevant to support well-being for the local population, we selected the most frequently mentioned regulating, non-material and material service to develop causal-loop diagrams to depict the factors that were cited as influencing them. Causal-loop diagrams are graphic representations of system dynamics, describing connections between variables through a relationship of cause and effect (Richardson, 1986; Harraldson, 2004). Variables can be connected through a positive sign, meaning that they change in the same direction, whereas a negative sign means that they change in opposite directions (Harraldson, 2004). For example, an increase in the construction of urban infrastructure leads to an increase in deforestation, meaning that they both vary in the same direction and are connected through a positive sign. Whereas an increase in deforestation leads to a decrease in the regulation of water quantity, with those variables being related to one another in opposite directions and connected through a negative sign. Sometimes a relation between two variables does not occur in the present

and a time lag is expected to observe an effect (Harraldson, 2004). In order to ensure that the diagrams represented a shared understanding of the system among councilors, we only represented the factors and relations between components of the diagrams that were cited by at least three different interviewees.

Causal-loop diagrams enable the detection of feedback loops, which are forces of change or stability within a given system (Harraldson, 2004; Meadows, 2008). We use the letter “A” in the diagrams to describe an amplifying feedback, whereas “S” stands for stabilizing feedback. An amplifying or reinforcing feedback enhances the direction of change within the system through a reaction of self-enhancement, potentially conducting the system to a new state (Meadows, 2008). A stabilizing feedback, also referred to as balancing feedback, promotes equilibrium and opposes change, being a force of stability within the system (Meadows, 2008). We utilized the software Vensim (PLE 8.2.1 x64 version, Ventana Systems Inc.) to design the causal-loop diagrams, since it provides a graphical interface that enables modeling. Within the context of social-ecological systems and ecosystem services research, causal-loop diagrams have been previously utilized to conceptualize a given system and are especially useful to identify possible targets for management interventions (Enfors, 2013; Moraes, 2019; Hossain et al., 2020). Preliminary versions of the causal-loop diagrams were presented to stakeholders during an official council meeting in October 2020, and councilors had the opportunity to assess and validate them.

RESULTS

(i) Ecosystem services at APA Campinas

A profile of the interviewed management councilors from APA Campinas was identified (Table 1.1). We interviewed a representative sample of 16 out of the 19 organizations that compose the council. One member of each organization was interviewed, with two exceptions: NGO Jaguatibaia and the municipal Secretariat of the Environment had two interviewees, because we were unable to complete the interviews with the first contacts. Thus, we had data from 18 interviews.

Table 1.1 – Profile of the interviewed councilors (n = 18) from the management council of APA Campinas, southeast Brazil (2018-2020 term)

		Number of respondents (percentage)
Gender	Men	9 (50%)
	Women	9 (50%)
Organization	NGOs	6 (33%)
	Public sector	6 (33%)
	Residents' associations	3 (17%)
	Farmers and landowners' associations	2 (11%)
	University	1 (6%)
Time at APA Campinas	More than 20 years	13 (72%)
	Less than 20 years	5 (28%)
Council experience	Two or more council terms	10 (56%)
	One council term	8 (44%)
Residents of APA	Reside at APA	12 (67%)
	Reside outside APA	6 (33%)
Properties at APA	Own property	13 (72%)
	Do not own property	5 (28%)
Types of property	Urban	11 (61%)
	Rural	2 (11%)
Management plan	Contributed to elaboration	15 (83%)
	Did not contribute	3 (17%)

A gender balance could be observed among interviewees, alongside a prevalence of council members from NGOs and from the municipal administration. The majority of respondents (72%) have lived in and/or visited APA Campinas since before it was formally established as a protected area in 2001, and 67% currently reside in the area. More than half (56%) had been elected as representatives of the management council in past terms and were familiar with its structure, and 83% participated in the elaboration process of the management plan. Prevalence of residents and property owners from the urban area could also be observed (61%), suggesting a gap in representation from rural inhabitants and farmers (11%).

Twelve interviewees (67%) stated that they previously knew the term ecosystem services, and nine of them shared the same understanding as the one adopted in this research (i.e., the benefits people obtain from nature). Interviewees indicate that 15 ecosystem services occur at APA Campinas (Table 1.2).

Table 1.2 – Ecosystem services identified by management councilors (n = 18) occurring at APA Campinas, southeast Brazil (2018 – 2020 term). Number of respondents refers to the number of interviewees that cited each ecosystem service; number of citations in the parenthesis indicates how many times the ecosystem service was cited considering all of the interviews

		Number of respondents (Number of citations)	Examples
Regulation	Regulation of water quantity	17 (19)	Atibaia river, water production, water springs
	Regulation of climate	9 (10)	Mild temperature and climate, carbon retention
	Regulation of air quality	9 (9)	Clean air without pollution
	Habitat creation and maintenance	8 (8)	Biodiversity, vegetation, forest, fauna and flora
	Formation and protection of soils	4 (5)	Restored soil, living soil, soil retention
	Pollination and dispersal of seeds	4 (4)	Pollination, animals that bury seeds
	Regulation of water quality	3 (3)	Pure water
	Regulation of detrimental organisms and biological processes	1 (1)	Plants that repel pests in agriculture
Material	Food production	8 (8)	Agriculture, agricultural production
	Raw material	2 (2)	Wood production
	Medicinal resources	1 (1)	Phytotherapy
	Energy production	1 (1)	Hydroelectric plant at Jaguari river
Non-material	Physical and psychological experiences	16 (34)	Tourism, leisure, scenic beauty, contact with nature, tranquility
	Supporting identities	2 (2)	Sense of place
	Learning and inspiration	1 (1)	School visits to farms, observatory

The most relevant ecosystem services that are perceived by councilors to support human well-being of the local population are listed in Table 1.3. Past trends for the analyzed period are also shown by arrows, indicating whether the availability of ecosystem services increased, decreased, remained stable or if there was no consensus among interviewees. For instance, air quality is perceived as stable over the analyzed period. While interviewees recognize that car traffic at urban centers and unpaved roads at the rural areas negatively influence air quality, the air is still described as pleasant and pure. This is associated with forest fragments, but also to the absence of industries that have

air pollutant emissions. For habitat creation and maintenance, regulation of water quality, and regulation of climate, there was no consensus regarding past trends among interviewees who listed those as most relevant ecosystem services.

Table 1.3 – Ecosystem services that are identified by management councilors (n = 18) as most relevant to support human well-being at APA Campinas, southeast Brazil (2018 – 2020 term). Arrows represent past trends in the availability of ecosystem services: an upwards arrow indicates increase; downwards indicates decrease; right arrow indicates stability; a question mark represents lack of consensus regarding past trends among interviewees. Number of respondents refers to the number of interviewees that cited each ecosystem service; number of citations in the parenthesis indicates how many times the ecosystem service was cited considering all of the interviews

		Number of respondents (Number of citations)	Trend
Regulation	Regulation of water quantity	13 (13)	↓
	Regulation of air quality	6 (6)	→
	Habitat creation and maintenance	5 (5)	?
	Regulation of water quality	4 (4)	?
	Regulation of climate	3 (3)	?
Material	Food production	4 (4)	↓
Non-material	Physical and psychological experiences	14(10)	↑

In accordance with Table 2, regulation of water quantity and physical and psychological experiences in nature stood out as being the most cited for regulating and no-material ecosystem services. Food production was the most cited material ecosystem service. All three were examined through causal-loop diagrams to assess the changes in their quality and availability in the past 20 years and will be further explored in the next section.

(ii) Social-ecological factors affecting ecosystem services at APA Campinas

- **Regulation of water quantity**

A causal-loop diagram to describe and analyze the status and changes of the regulation of water quantity is presented in Figure 1.4. Councilors share an understanding that water availability (i.e., quantity) at APA Campinas has been decreasing over the last 20 years. This is due to deforestation, erosion and impermeabilization of the soil, siltation of watercourses (including springs), that are caused by factors related to urbanization of the area. The process of urbanization is characterized by the construction of urban infrastructure (e.g., paving of roads, construction of sanitation systems) and the expansion of residential condominiums. Urbanization is fostered by real estate pressure and the arrival of new residents. These factors interact in the form of an amplifying feedback loop (A1) that reinforce each other, leading to increased urban growth as a result. Two other amplifying mechanisms (A2, A3) are represented in the same figure. Deforestation and impermeabilization of the soil and burial of water springs lead to a decrease in regulation of water quantity, which negatively affects water security, an important component of human well-being.

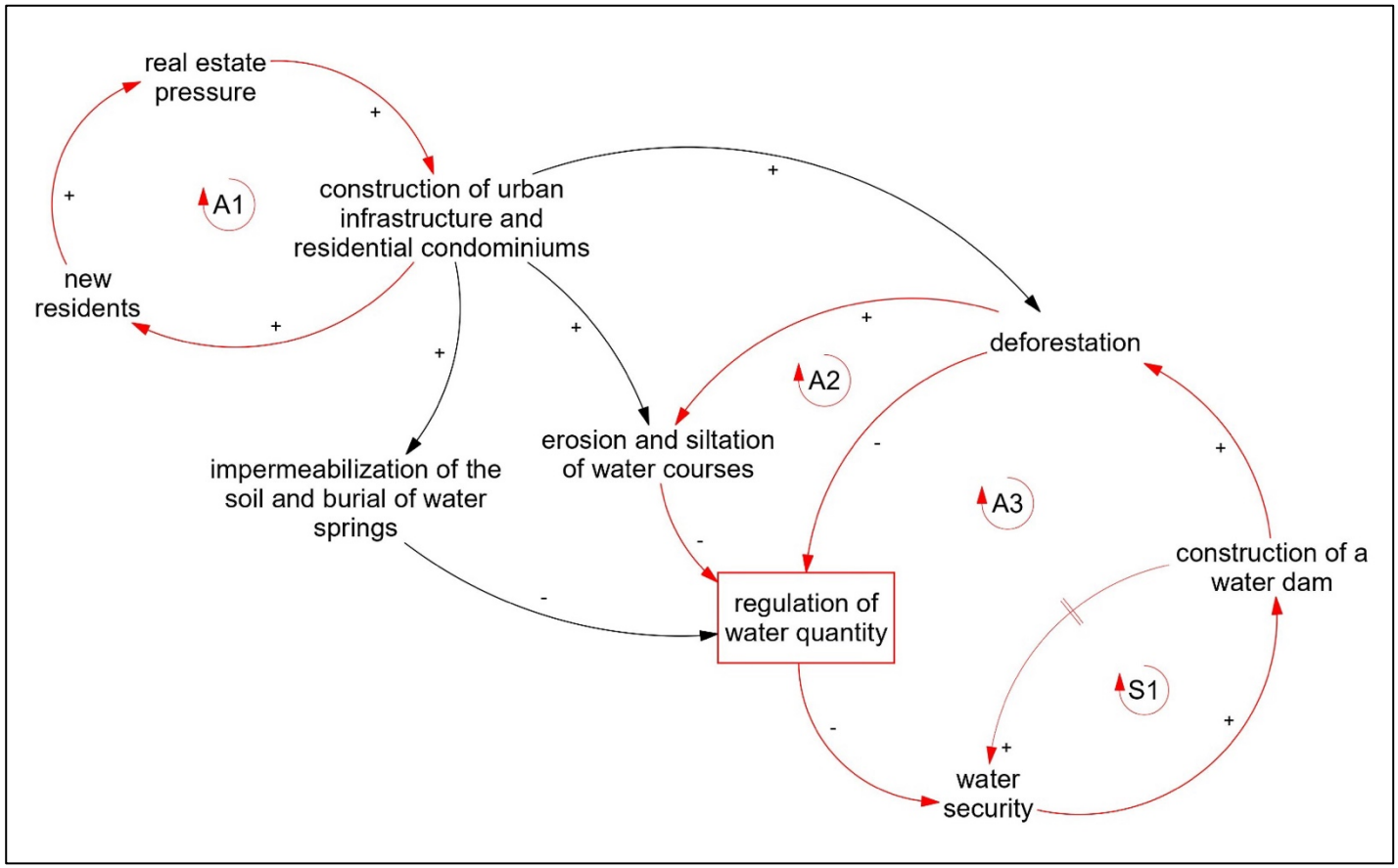

Figure 1.4 – Causal-loop diagram describing factors that have been influencing the regulation of water quantity at APA Campinas, southeast Brazil, from 2000 to 2020, based on data obtained from interviews (n = 18) with management councilors (2018 – 2020 term). The red box delimiting “regulation of quantity” indicates a trend of decrease in the ecosystem service; a red arrow represents a part of a feedback mechanism; the dashed arrow represents a time lag; “A” stands for amplifying and “S” for stabilizing; a “+” indicates change in the same direction and “-” indicates change in opposite directions

Water security has been the motto behind the construction of a water dam at the Jaguari river, the second largest river in the region following the Atibaia river. This construction is currently under way, sponsored by the state government, with expected benefits of increasing regional water availability (DAEE, 2021a). However, several of the interviewees dispute this claim, and the management council issued a motion against this construction. A local newspaper has also reported protests against the construction of this water dam since it is located 2 km away from the city center of Pedreira, a neighboring city of APA Campinas, posing a flooding risk to the population in the event of a rupture (G1 Campinas, 2019). Moreover, councilors have also questioned the intentions behind this construction, with speculations regarding the use of the water. Some interviewees claim that the water dam will increase the availability of water not for purposes of securing water for the city population, but to provide water for a petrochemical industry in another city. Thus, while it is expected that the construction of this dam might contribute to water security in the future, represented by a dashed arrow between construction of a water dam and water security, the current impact is a negative effect on water quantity since a forest fragment is being cut down.

When a preliminary version of this causal-loop diagram was presented to councilors, the only matter of dispute regarding the factors influencing water quantity was deforestation. Councilors agree that deforestation occurs at APA Campinas and affects water quantity but some of them perceive forest fragments as increasing. This is also in accordance with Table 1.3, in which the past trend of habitat creation and maintenance is inconclusive among interviewees. There are not any multi-temporal studies that have assessed changes in forest cover, but punctual surveys of specific years corroborate the perception of fragments as increasing (Santin, 1999; Fasina Neto & Matias, 2010; Campinas, 2018). This difference in perceptions among councilors will be further explored in the discussion section.

- **Physical and psychological experiences in nature**

Physical and psychological experiences in nature are described by interviewees as increasing over the last 20 years (Fig. 1.5). Local vegetation and

watercourses promote a sensation of being close to nature contributing to well-being of both local inhabitants and tourists. These experiences are directly connected to three main factors described in Figure 1.6 as scenic beauty, inhabitant's well-being derived from contact with nature, and nature tourism.

Nature tourism has been increasing in the region, due to scenic beauty, diversity of leisure options in contact with nature, road access to tourism attractions, and search for leisure in contact with nature. Tourism activities are concentrated in the areas of APA Campinas with facilitated access and a certain degree of urbanization. Even though there is some agrotourism (visitation of certain farms), the main nature tourism activities occur in the proximities of the urban centers at APA Campinas, especially at small distance trails that constitute a trekking circuit at the region. This is represented in Figure 1.6 by the construction of urban infrastructure that leads to road access to tourism attractions with consequent increase of nature tourism.

The other component of the experiences in nature is the one related to the local population and newcomers who move to the area. At Figure 6, increased urbanization in Campinas and surrounding areas leads to an increase in urban problems and in the search for housing in contact with nature, which in turn has the effect of more people moving to APA Campinas. New residents move in search of well-being derived from contact with nature, which is influenced by the scenic beauty that attracts people and contributes to quality of life. However, the trend of more people moving to the area in search for nature contributes to enhancing the amplifying feedback loop (A1) that is also present in the regulation of water quantity model (Fig. 1.4), resulting in an increase of deforestation, erosion, and siltation. As one of the management councilors stated: *"we know that the reasons that attract tourism to this region also highlight the region too much. This exposure potentializes real estate pressure*".

Interviewees describe newcomers as being unaware that they are moving to a protected area, and state that there is a difference in how they relate to nature in comparison with councilors. From the perspective of councilors, many of whom reside at APA Campinas, local nature is associated with elements of biodiversity, as one interviewee describes: *"the importance of living here and being able to*

*open my window and see a forest fragment, see a 'jacu' bird [*Penelope obscura*], is priceless"*. In contrast, interviewees indicate that new residents move to APA Campinas not exclusively in search for nature, but also as an escape from urban problems such as violence. Moreover, newcomers also wish to still have the comforts of living in a city while living at the area. This is summarized in the following quote:

> *"The biggest problem here is the lack of awareness. It is people who want to live in a natural place, but do not want to take off their high heels, their air conditioning. (…) They come with standards from the metropolis, and do not want or know how to experience the place."*

Finally, there is also another feedback mechanism (A4) presented in the causal-loop diagram of Figure 1.5. Experiences in nature positively impact mental and physical health, which increases nature tourism. The observed logic is that the good feeling of practicing tourism and being in contact with nature at APA Campinas leads to people coming back to the area to visit it more often. Scenic beauty is perceived by interviewees as stable throughout the last 20 years, due to the absence of large infrastructure interventions that modify the landscape. However, locally at the site of the construction of the water dam, scenic beauty has been negatively impacted.

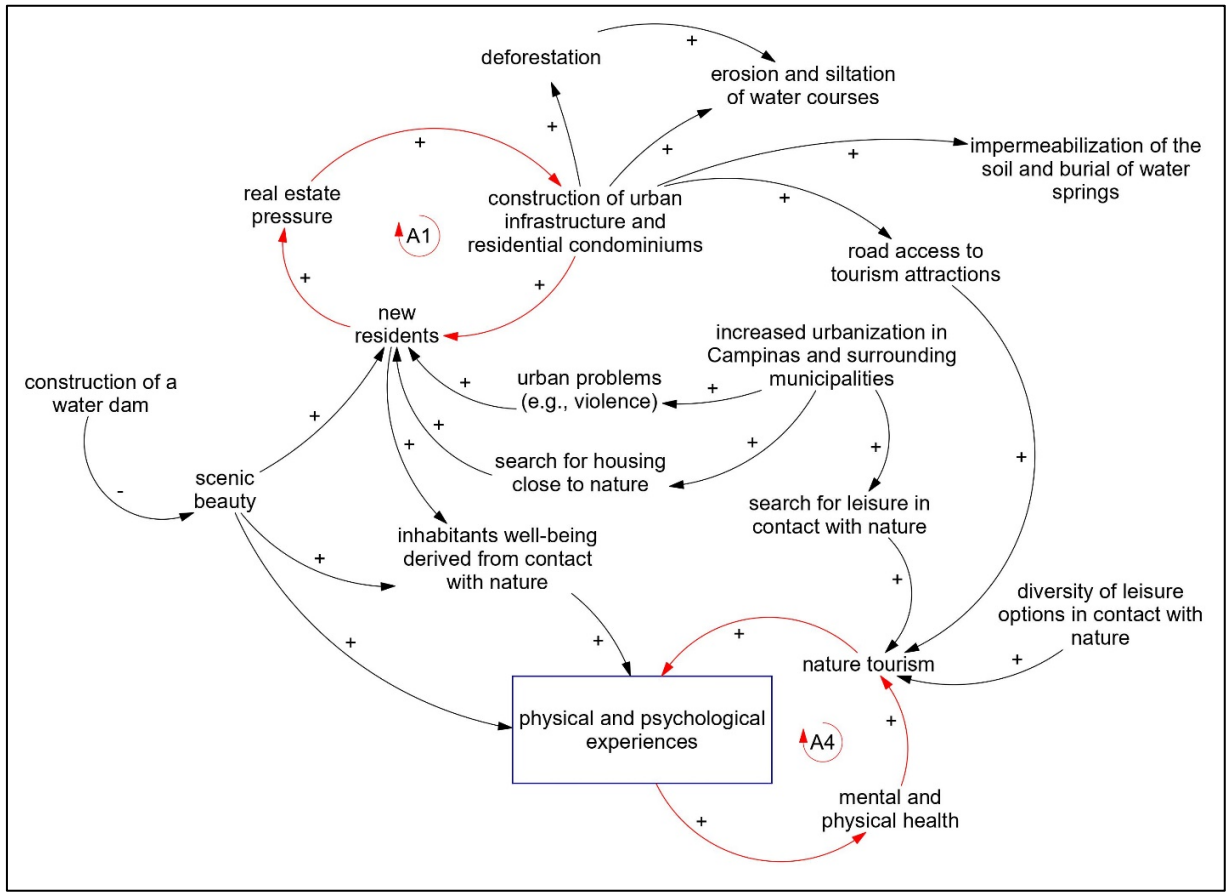

Figure 1.5 – Causal-loop diagram describing factors that have been influencing physical and psychological experiences in nature at APA Campinas, southeast Brazil, from 2000 to 2020, based on data obtained from interviews (n = 18) with management councilors (2018 – 2020 term). The blue box delimiting "physical and psychological experiences" indicates a trend of increase in the ecosystem service; a red arrow represents a part of a feedback mechanism; "A" stands for amplifying and "S" for stabilizing; a "+" indicates change in the same direction and "-" indicates change in opposite directions

- **Food production**

The third causal-loop diagram details the factors that have been influencing food production at APA Campinas from 2000 to 2020 (Fig. 1.6). Interviewees share the perception that food production has been decreasing over the last 20 years due to increased costs of rural production, land conversion to urban uses, and lack of support and recognition of farmers from municipal government. Increased production costs are associated with natural conditions of the local hilly landscape that hinders the adoption of machinery for cultivation. In parallel, lack of infrastructure is also an impeditive, with poor phone and internet connection hampering the adoption of technologies, and poor conditions of rural roads that affect transportation. Moreover, this also influences the ability of people to reach and work at the region, represented by a lack of public transportation to rural areas that leads to a lack of rural workforce, which in turn is also incremented by rural outmigration.

The overall result from this combination of factors is a shared perception among farmers of feeling neglected and not supported by the municipal government, since the lack of infrastructure and municipal policies fostering agriculture hampers production and distribution. This is explicitly highlighted during one of the interviews with an active farmer, in which is stated: "*how many councilors (…) that you talked to are farmers? (…) The farmer must be heard, because (…) we can help to develop and improve the quality of water, the air, and life at APA*". Furthermore, they also perceive the public sector as a bureaucratic instance with excessive regulation.

While this perception may be shared by active farmers, it is important to notice that there are extensive areas of land among rural properties who are degraded and have low prevalence of rural activities. According to the management plan, 12.6% of the land cover in APA Campinas is characterized by degraded pasture in which cattle raising activities were not identified (Campinas, 2018), indicating an important category of land cover that does not contribute to the supply of the most relevant ecosystem services. Additionally, there is also a feedback mechanism that influences food production (A5) (Fig. 1.6). As demand for housing increases, some property owners benefit from this market trend

through real estate speculation. This leads to increased land price that can eventually lead to selling rural land for construction of residential condominiums, with consequent land conversion to urban uses. Furthermore, the lack of ties to inherited land by non-farmers also contributes on this behalf. One of the management councilors summarizes this phenomenon as:

> *"A lot of land here is still in the hands of heirs, who do not see this territory as a place for food production and environmental conservation. They see it as a real estate reserve (…) and the best way to profit from this patrimony is to sell it per square meter".*

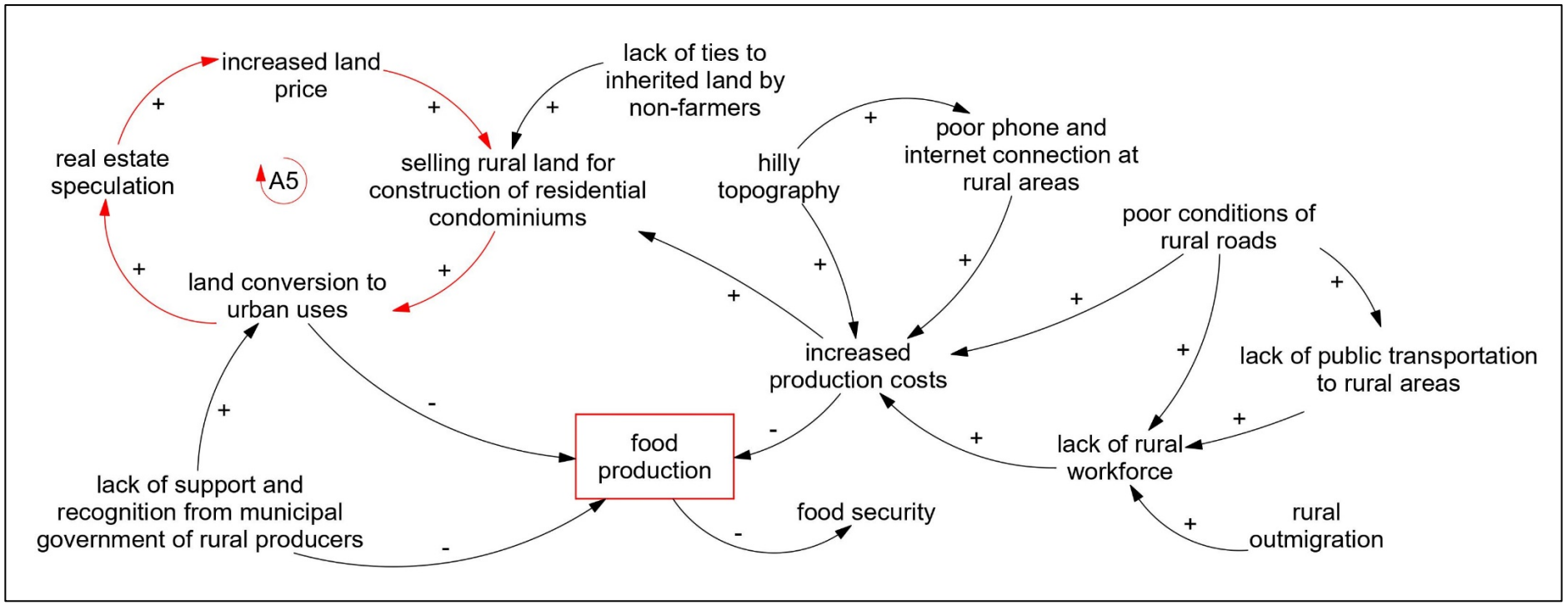

Figure 1.6 - Causal-loop diagram describing factors that have been influencing food production at APA Campinas, southeast Brazil, from 2000 to 2020, based on data obtained from interviews (n = 18) with management councilors (2018 – 2020 term). The red box delimiting “food production” indicates a trend of decrease in the ecosystem service; a red arrow represents a part of a feedback mechanism; “A” stands for amplifying and “S” for stabilizing; a “+” indicates change in the same direction and “-” indicates change in opposite directions

- **Feedbacks**

The identified feedback mechanisms within the three causal-loop diagrams and the causal relations between social-ecological factors that compose feedback loops were detailed in Table 1.4. Five out of six feedback loops were amplifying (A1 – A6).

Table 1.4 – Feedback mechanisms and causal relations that have been affecting ecosystem services at APA Campinas from 2000 to 2020 identified through interviews (n = 18) with management councilors (2018 – 2020 term); "A" stands for amplifying and "S" for stabilizing

Feedback mechanism	Ecosystem services	Causal chain
A1	Regulation of water quantity Physical and psychological experiences	Real estate pressure -> Construction of urban infrastructure and residential condominiums -> New residents
A2	Regulation of water quantity	Deforestation -> Erosion and siltation of water courses -> Regulation of water quantity -> Water security -> Construction of a water dam
A3	Regulation of water quantity	Deforestation -> Regulation of water quantity -> Water security -> Construction of a water dam
A4	Physical and psychological experiences	Nature tourism -> Physical and psychological experiences -> Mental and physical health
A5	Food production	Real estate speculation -> Increased land price -> Selling rural land for construction of residential condominiums -> Land conversion to urban uses
S1*	Regulation of water quantity	Water security -> Construction of a water dam

*Feedback with time lag

(iii) Responses to change in ecosystem services at APA Campinas

A total of 21 projects and/or initiatives were identified from the municipal government, non-governmental organizations and associations, private initiative, and a university as targeting conservation of one or more ecosystem services. In Figure 8, cited responses by interviewees were grouped according to the three most relevant ecosystem services (Fig. 1.7). Responses either aimed to conserve or sustainably increase the provision of ecosystem services through the implementation of actions such as environmental education events, a payment

for environmental services program, and scientific research. Physical and psychological experiences was the most targeted ecosystem service for the implementation of projects and initiatives, especially by the municipal government. In contrast, food production was the least targeted, with interventions from private landowners and rural associations.

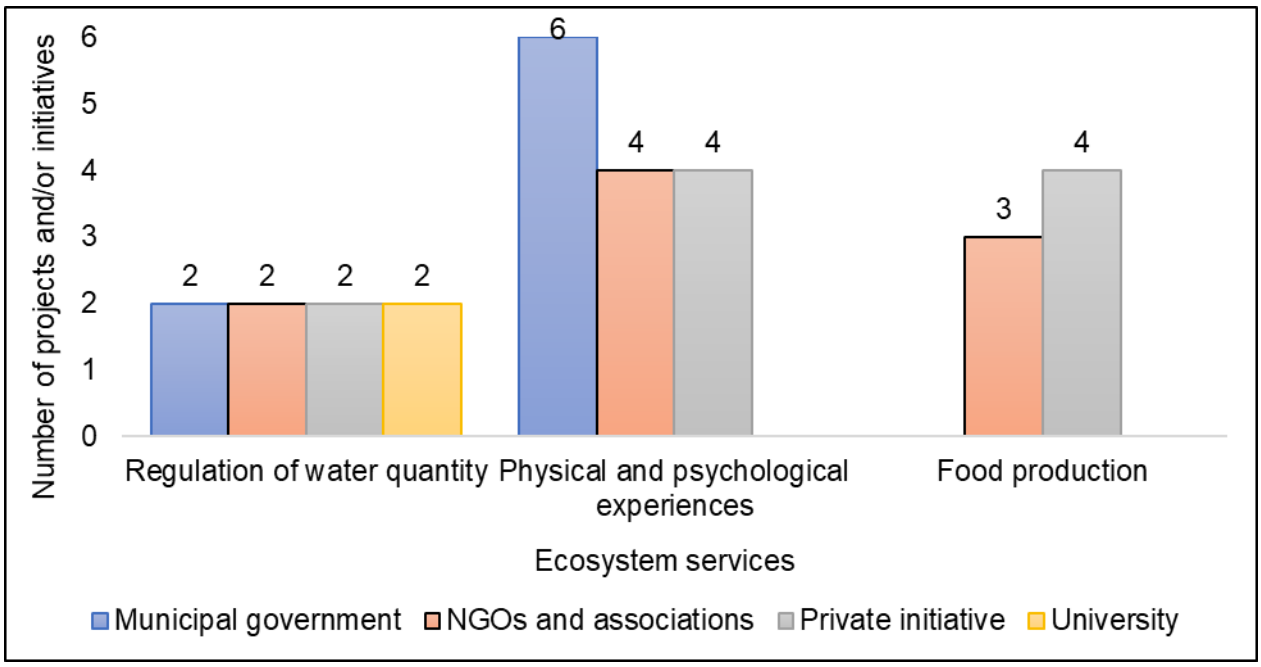

Figure 1.7 – Number of projects, initiatives, and organizations that develop work towards conservation of the most relevant ecosystem services at APA Campinas from 2000 to 2020, identified through interviews (n = 18) with management councilors (2018 – 2020 term)

A brief description of the cited responses is represented in Table 5. It is possible to notice that only one of the initiatives simultaneously targets all three ecosystem services, thus suggesting a gap in the implementation of integrated actions that target multiple services.

Table 1.5 – Brief description of projects, initiatives and organizations that develop work towards conservation of the most relevant ecosystem services at APA Campinas from 2000 to 2020, identified through interviews (n = 18) with management councilors (2018 – 2020 term) (cont.)

	Regulation of water quantity	Physical and psychological experiences	Food production
Municipal government			
Secretariat of green, environment and sustainable development			
Payment for environmental services program	✓	✓	
Bank of green areas	✓	✓	
Secretariat for economic and social Development and tourism			
Guides and signposting of touristic routes		✓	
Environmental station of Joaquim Egídio and events		✓	
Training in rural tourism		✓	
Municipal observatory			
Leisure and environmental education		✓	
NGOs and associations			
Jaguatibaia			
Environmental education and events		✓	
Revegetation	✓		
ASSUMA			
Environmental education		✓	
APAVIVA and NGO collective			
Monitoring and whistleblowing	✓	✓	
Rural union			
Legal, tax and accounting assistance to rural producers			✓
Training in diversification of rural activities		✓	✓
Association of rural landowners			
Mobilization of rural landowners			✓

Table 1.5 – Brief description of projects, initiatives and organizations that develop work towards conservation of the most relevant ecosystem services at APA Campinas from 2000 to 2020, identified through interviews (n = 18) with management councilors (2018 – 2020 term) (cont.)

	Regulation of water quantity	Physical and psychological experiences	Food production
Private initiative			
Farms			
Santa Maria: "pay and harvest" scheme of jaboticaba fruit		✓	✓
Belmonte/Floresta Park: leisure, environmental education		✓	
São Joaquim: production of organics, revegetation	✓		✓
Sítio Vale das Cabras: production of organics, revegetation, environmental education	✓	✓	✓
Horta Seu Cabral: production of leafy vegetables			✓
Open museum of astronomy			
Leisure and environmental education		✓	
University			
University of Campinas			
Research on vegetation cover and floods	✓		
Research on water availability in sub-basins	✓		

DISCUSSION

(i) Perceptions and knowledge of management councilors to assess ecosystem services

The inclusion of stakeholders' perceptions and local knowledge as a source of evidence to assess ecosystem services can improve social and ecological outcomes of conservation measures (Bennett, 2016). Perception studies on ecosystem services used to be scarce in the beginning of the 2010s (Martín-López et al., 2012), but have been increasing over the years. An array of studies has utilized this approach to assess and value ecosystem services, with varying results. For instance, there are publications in which regulating services such as air quality are perceived as most relevant (Martín-López et al., 2012), while there are others that point out to material services such as food (Brito et al., 2020), and others that highlight non-material services such as well-being by being

in contact with nature (Coelho Junior et al., 2020). At APA Campinas, our results indicate the relevance of the area in providing various ecosystem services, thus contributing to multiple dimensions of human well-being (Table 1.2). Water and experiences in nature were highlighted by councilors as the two most cited categories in both the freelisting and ranking questions (Table 1.2, 1.3). Hence, our findings corroborate that place-based research is relevant to inform specific contexts and ecosystem services that arise from different social-ecological systems (Quintas-Soriano et al., 2018).

Using perceptions and knowledge to investigate ecosystem services has the potential to build understanding of the scales and levels in which processes occur. For instance, biophysical data of water flow rate in the Jaguari and Atibaia rivers indicate that water availability has been fluctuating around a yearly average over the last 20 years (28.6 m^3/s for Jaguari and and 21 m^3/s for Atibaia); the year of 2014 is an exception, because of a drought which occurred in the state of São Paulo (DAEE, 2021b). The steadiness of water flow in these two rivers might be counter intuitive in comparison to perceptions of councilors indicating a decrease of water quantity, but our results may be describing a phenomenon occurring at a smaller scale – hence, not aligned with official data but representing local environmental dynamics. APA Campinas is the region of the municipality with the highest number of water springs, brooks, streams and production of water (Campinas, 2016), and these seem to be decreasing in number and water flow according to interviewees. Such small watercourses are difficult to monitor from a biophysical perspective, and to our knowledge, there is a single report by the municipal government that assessed the status of water springs at a subbasin within APA Campinas. Results from this report indicate that from 182 identified water springs, 79 (43%) were in poor conditions of conservation (Campinas, 2012). Thus, perception studies such as ours may identify conditions of ecosystem services at a finer scale, which would be more difficult and costly to attain from conventional biophysical monitoring.

As a perception-based study, we opted to utilize Díaz et al. (2018) nature's contributions to people conceptual framework to classify benefits because it explicitly recognizes the role of culture in mediating interactions between people and the environment. Furthermore, nature's contributions approach argues for

categories of ecosystem services that are not discrete, which was also observed in our case. For instance, the Atibaia river was referred by some councilors as a water supplier, and by others as a place of leisure and recreation, and we classified it as a different ecosystem service depending on the context. Ecosystem services are not only benefits merely obtained from nature (Palomo et al., 2016): wood production, agriculture and cattle raising require active labor from farmers. Oliveira & Berkes (2014) also argue on this behalf, indicating that the ecosystem services concept does not fully capture the dimensions of the co-production of benefits between people and the environment. The context-specific perspectives and fluid categories are novel conceptual claims that the concept of nature's contributions to people advances in the existing theory of ecosystem services science (Kadykalo et al., 2019), and our study contributes to this knowledge frontier that remains underexplored. In parallel, we utilized the nomenclature of ecosystem services to conduct interviews, since stakeholders were familiar with it. Thus, during our study, we were able to combine perspectives that stem from both concepts: ecosystem services and nature's contribution to people.

Subjective and individual experiences shape the way in which people experience the environment (Bennett, 2016), influencing the perceptions and knowledge councilors have. Hence, it is expected that interviewees do not always share the same understanding regarding the processes that have been affecting ecosystem services. For constructing the causal-loop diagrams (Fig. 1.4, 1.5, 1.6) we used information that was commonly agreed among councilors. As previously stated in the results section, the specific point of disagreement that emerged during the processes of data collection and validation was regarding deforestation. APA Campinas suffered a drastic reduction in its original vegetation since the 18th Century, and remaining forest fragments are composed by secondary vegetation that vary in size and conservation status (Santin, 1999; Fasina Neto & Matias, 2010). Although not directly comparable due to the use of different methodologies, three studies calculated forest cover at APA Campinas[3] in different years, and it is possible to infer an increase in area of forest fragments (Santin, 1999; Fasina Neto & Matias, 2010; Campinas, 2018). Considering the

[3] Santin (1999) calculated forest cover only for the districts of Sousas and Joaquim Egídio at APA Campinas

fact that the majority of degraded land at APA Campinas lies within the proximities of urban centers (Campinas, 2018), coupled with the fact that 61% of our interviewees were inhabitants of the urban areas, we hypothesize that councilors perceive deforestation at APA Campinas locally where they reside, but do not perceive forest fragments as increasing. Since forest fragments are mostly small, isolated, and heterogeneously distributed at APA Campinas, councilors do not have a shared perception of their growth. However, in order to investigate this hypothesis of vegetation decreasing near and in urban centers and increasing at forest fragments, a multi-temporal study using remote sensing techniques that allow for direct comparisons is necessary (see Chapter 2 for further details on the test of this hypothesis).

(ii) Ecosystem services change at the urban areas of APA Campinas

The particularities of urban areas of APA Campinas were evaluated through the analysis of changes in the ecosystem services. For instance, visitors and newcomers are attracted to the area due to its natural features and scenic beauty. Simultaneously, the presence of urban infrastructure and other anthropogenic assets have increased and diversified means of access and local leisure options (restaurants, parking facilities, museums), also attracting more tourists and newcomers. This contribution of non-natural assets is important to be recognized to the delivery of ecosystem services (Palomo et al., 2016), especially because it produces a paradox: urban infrastructure facilitates access to places where people feel in contact with nature, and in parallel, it endangers the same nature which people wish to access. As shown in the causal-loop diagrams, real estate pressure and construction of urban infrastructure lead to deforestation, erosion, and siltation.

The differences in perceptions between management councilors, tourists and newcomers are highlighted when experiences in nature are discussed. From the perspective of councilors, the search for nature by tourists and newcomers is not exclusively attached to a search for contact with biodiversity. Rather, it is especially linked to a desire to escape from the city centers while still maintaining the comforts from an urban life. This is corroborated by the way that local real estate is advertised as a green refuge with the facilities of living in a city, and at

the same time as an area that is distant from urban issues such as violence (Trevisan & Paes, 2009; Cocharski, 2016). Therefore, we hypothesize that there is a difference in the notion of what constitutes nature to management councilors, in comparison to visitors and new residents. This is relevant to be recognized because the way in which people relate to the environment is influential in the conservation status of a given area and whether they might care (or not) about changes in their surroundings (Jax et al., 2018). Urbanization has the potential to modify relationships between people and the environment (Lapointe et al., 2021), and is likely to influence the perceptions newcomers have of APA Campinas. Thus, further investigations that target the perceptions tourists and new residents have of nature could be beneficial in clarifying this type of human-nature relationship and how this potentially influences the provision of ecosystem services.

(iii) Ecosystem services change at the rural areas of APA Campinas

Rural areas at APA Campinas have gained environmental relevance over the last 20 years since they contain remaining native vegetation, places for leisure and recreation, and supply water. In parallel, food production decreases and urbanization acts as an important driver of change in ecosystem services. There is a lack of infrastructure to support rural inhabitants and farmers (roads, phone access, internet), whereas new residential condominiums at urban areas are associated with the expansion of this infrastructure. These differences also reverberate within the management council, where only two out of 19 organizations represent the local farmers. The Secretariat of Environment is responsible for the management of APA Campinas and is perceived by interviewees to have a strong presence in the area, with ongoing programs to support vegetation restoration initiatives and protection of watercourses. In parallel, the economic importance of rural areas in Campinas has been historically decreasing (Pinto, 2006), and farmers argue that there is a lack of municipal policies to support agricultural production. A Secretariat of Agriculture does not exist within the organizational structure of the municipality: it is limited to a coordination within a department at the Secretariat of Social and Economic Development and Tourism (Campinas, 2021). With the promulgation of Complementary Municipal Law 207 in 2018, the urban perimeter of the city has

increased at the expense of area previously considered to be rural. This combination of factors may influence an overall perception by farmers of the public sector being concerned with environmental aspects at APA Campinas but neglecting rural production.

Land tenure in APA Campinas is mostly private, meaning that forest fragments, watercourses, springs, and some of the tourism attractions occur within the domain of privately owned properties. This poses a great challenge for the management of natural resources, given that the supply of ecosystem services that benefit urban users and inhabitants stem from these areas. Thus, understanding management actions and underlying values and perceptions from landowners could aid in the formulation of interventions to foster stewardship and the provision of ecosystem services (Raymond et al., 2016). In this sense, we argue to the relevance of further investigation on the perceptions and values landowners have that may underpin decision-making regarding how land is used, especially considering that there are active farmers at APA Campinas but also landowners who have extensive areas of degraded land.

One of the interviewees describes the complexity of the urban and rural relations at APA Campinas as a “metropolitan rural”. Travassos & Portes (2018) have also used this concept to characterize contemporary peri-urban areas at the state of São Paulo and define it as a complex mosaic of land uses with disputes between urban policies, rural activities, and environmental conservation. Even though urban and rural areas have their specificities, there is a need for management interventions that treat both as coupled systems in order to reconcile conservation and development (Silva et al., 2017). Moreover, the application of the ecosystem services concept within the studies of the urban-rural gradient at the state of São Paulo has been deficient (Portes, 2021), stressing the necessity of studies that focus on these areas. Hence, we call attention to the relevance of ecosystem services research within peri-urban contexts.

(iv) A systems perspective for understanding change in ecosystem services at APA Campinas

The construction of causal-loop diagrams enabled a careful description and analysis of the factors and feedbacks that have been affecting the most relevant ecosystem services at APA Campinas (Fig. 1.4, 1.5, 1.6). Feedback mechanisms have the potential to promote or inhibit change, and a dominance of amplifying feedbacks within a system indicates that the current direction of change is being enhanced (Meadows, 2008). These feedbacks act as drivers of increment change, potentially triggering a transition of the system to a different state in the future (Milkoreit et al., 2018). At APA Campinas, we identified amplifying feedback mechanisms that are linked to processes of urbanization, suggesting that the social-ecological system is being induced to a change towards an urban-dominated state. As represented in the causal-loop diagrams, this has consequences for key ecosystem services that support human well-being.

An undesirable future for APA Campinas in terms of ecosystem services provision is expected if business as usual persevere, in which urbanization acts as the main driver influencing the quantity of water, food production and experiences in nature. However, local stakeholders are not merely bystanders to the processes affecting APA Campinas: they perceive and act to prevent more change in nature. Individual and collective responses exist and are represented by a variety of initiatives led by a university, the municipal government, NGOs and associations, and private landowners and enterprises (Fig. 1.5, Table 1.5). Although having different objectives and stakeholders involved, all the responses are embedded within the same context of aiming to contribute to conservation and maintenance of a given ecosystem service. Some of them point out to a new perspective on possible pathways towards integrated conservation and development at APA Campinas, through collaboration between different stakeholders and actions that simultaneously target multiple ecosystem services. For instance, a local agroecological farm (“Sítio Vale das Cabras”) is the only mentioned property that successfully managed to articulate actions around the three most relevant ecosystem services. The owners of “Sítio Vale das Cabras” develop actions (i) retaining rainwater in their land through the use of small water

reservoirs, and implementing a sustainable system for the depuration of domestic effluents (regulation of water quantity and quality); (ii) growing and coordinating the logistics of selling and distributing organic food (including artisanal products from other local farms) through a community supported agriculture scheme (food production); and (iii) hosting courses and guided visits to schools, universities and other interested parties at the location (physical and psychological experiences in nature). Additionally, the property was constructed using sustainable techniques and materials (bioconstruction) and has a system for the generation of solar energy that shares the produced energy with other properties through a cooperative scheme.

Organizations such as “Sítio Vale das Cabras” that improve the social, ecological, and economic conditions of APA Campinas have been conceptualized by Bennett et al. (2016) as a “seed of a good Anthropocene”. Such seeds have a transformative potential and can change the trajectory of a given system towards a desirable future, since they provide the basis in the present for what we wish to achieve in the future for people and nature (Bennett et al., 2016). Furthermore, they have the potential of changing existing values and influencing other initiatives. Current dynamics of the APA Campinas social-ecological system indicates a predominance of urbanization processes with consequences for ecosystem services, but properties such as “Sítio Vale das Cabras” can act as a model for the future of conservation and development in the region. Identifying barriers and opportunities for scaling-up and mainstreaming responses to changes is a topic worth investigating on this behalf. As one interviewee described: “*everyone who owns rural properties must reinvent a format of development for the rural area*”.

CONCLUDING REMARKS

This chapter provided an assessment of ecosystem services at APA Campinas based on perceptions and knowledge of its management councilors and was innovative in the sense of targeting stakeholders that are vastly experienced and also decision-makers. Our findings highlight the region as a supplier of multiple benefits to people’s quality of life, with an emphasis on the regulation of water quantity, physical and psychological experiences in nature,

and food production. Using both concepts of ecosystem services and nature's contribution to people, we were able to identify, analyze and converse with stakeholders about how nature contributes to local quality of life. Thus, we argue to the relevance of research that goes beyond the understanding of the theoretical differences between these concepts and emphasize the combination of them simultaneously on place-based studies.

Overall, APA Campinas is distancing itself from its historic importance as an agricultural area and gaining importance in terms of being a place for feeling in contact with nature and as a water supplier. Proposed solutions by municipal and state government to address water availability at the region are based on engineering infrastructure (dam construction), with a lesser emphasis on nature-based solutions (e.g., the restoration of local springs and brooks). The expansion of urban infrastructure and residential condominiums is likely to continue to increase and represents an important driver affecting ecosystem services. Some of the processes regarding urbanization are interacting in the form of amplifying feedback mechanisms, potentially inducing change of APA Campinas towards an urban-dominated state. In this regard, the use of causal-loop diagrams was an informative methodology to identify such feedbacks. Specific planning is required if conservation and development are to be integrated, because while urban infrastructure facilitates access to APA Campinas where people feel in contact with nature, it also leads to deforestation and erosion. Responses to change in nature exist and some of them were identified, meaning that stakeholders are actively reacting and providing possible alternatives for the use and management of ecosystem services. Nevertheless, such actions still lack targeting multiple ecosystem services simultaneously.

Further studies could benefit from targeting other stakeholder groups that were not the focus of this research, such as residents from urban and rural areas, tourists, and landowners. Researching perceptions from these different stakeholder groups could aid identifying and untangling other factors influencing status and changes of ecosystem services, thus providing useful information for management.

CHAPTER 2 - LAND USE AND LAND COVER CHANGE IN A SUSTAINABLE-USE PROTECTED AREA IN SOUTHEAST BRAZIL

Key words: Peri-urban; Urban expansion; Forest transition; Campinas; cross-tabulation matrix.

ABSTRACT

The assessment of land use and land cover change is a useful tool for understanding the dynamics of change in protected areas throughout time. When zoning is considered, it can provide a more refined understanding of local dynamics. Here, we conducted the first multi-temporal assessment of changes in land use and cover at the Environmental Protected Area of Campinas (APA Campinas), a peri-urban protected area in the city of Campinas, southeast Brazil. We utilized the years of the institutional landmarks of the creation of the protected area (1993), enforcement in protection and expansion of the area (2001), and publication of the management plan (2019), as the basis for our analysis. We utilized data and thematic maps from MapBiomas to develop maps and cross-tabulation matrices to obtain data for area, percentage, changes in area, annual rates of change, and transitions from one land class to another. This analysis was conducted for APA Campinas as a whole and for its five different zones established in the management plan. Results highlight pasture as the most representative land use at APA Campinas, but it has decreased from covering 53% of area in 1993 to 40.5% in 2019. Natural forests have been increasing in area (15.9% in 1993, 20.5% in 2019) and have expanded over the area of pastures. Considering the historical trends of forest cover, we identify a local process of forest transition. Urban areas have expanded (1.6% in 1993, 3.5% in 2019) but are restricted to the specific urbanized zone. Eucalyptus plantations have increased from 1.6% in 1993 to 4% in 2019. Agriculture and water surface cover small areas. The specific dynamics of land use and land cover change was also detailed for each of the five zones within APA Campinas. Our findings can be useful for local planning of integrated conservation and development strategies.

INTRODUCTION

Land change science refers to the interdisciplinary study of land systems as coupled systems of people and nature (Turner et al., 2007). The multi-temporal analysis of land use (i.e., how people are using the land) and land cover (i.e., the physical characteristics of land) is one of the most common approaches within this field, offering valuable insights into the dynamics of change at a given region (Martinez & Mollicone, 2012). Changes in land use and cover through the conversion of natural ecosystems to areas of agriculture, industrial forestry and cities is the most relevant driver of change for terrestrial ecosystems worldwide (Foley et al., 2005; Lambin & Meyfroidt, 2011; Díaz et al., 2019). Consequently, biodiversity and ecosystem services that sustain human well-being are globally declining, thus affecting multiple dimensions of people's quality of life (Foley et al., 2005; Díaz et al., 2019).

In Brazil, trends also indicate an increase in human-modified landscapes at the expense of natural ecosystems (Souza Jr. et al., 2020), but regional and local studies could point out to different trajectories. For instance, in São Paulo state, rainforest cover has been increasing since the 1990s, while savanna vegetation has been decreasing (São Paulo, 2020). For some regions within the state, such as the Paraíba Valley, a temporal shift from deforestation to reforestation leading to net vegetation gain has been detected since 1985, a phenomenon conceptualized as forest transition (Farinaci, 2012; Silva et al., 2017a). Hence, studies at smaller scales can inform how drivers of change manifest at regional and local level, revealing specificities and providing more accurate information for management and decision-making.

The assessment of land use and land cover change in protected areas can be used as an indicator to monitor their effectiveness in protecting natural habitats (Andam et al., 2008; Hockings et al., 2015). In the municipality of Campinas, São Paulo state, southeast Brazil, the Environmental Protected Area of Campinas ("APA Campinas", for its Portuguese acronym) concentrates the highest number of forest fragments and water courses in the municipality (Campinas, 2018). APA Campinas is a sustainable-use protected area initially established in 1993 under a different name and smaller area (Municipal Decree 11.172/93), having expanded and received further protection in 2001, alongside its current name

(Municipal Law 10.850/01). It covers 27% of the municipality's territory (22267 ha) and comprises urban centers, rural areas, degraded pastures, forest fragments, water courses, eucalyptus plantations, among other land uses (Campinas, 2018).

The management plan of APA Campinas was fully completed in 2019, establishing an updated zoning of the area based on environmental fragility, landscape connectivity, and local drivers of change, aiming at conciliating conservation and development through the regulation of the use of land (Campinas, 2019). Zoning is referred by Hull et al. (2011) as a useful conservation tool for planning and management of protected areas, but it is rarely monitored and enforced on the ground. Despite being the largest protected area of the municipality, multi-temporal analysis of change in land use and cover at APA Campinas still lack. Available studies have focused only on the analysis of forest cover (Santin, 1999; Fasina Neto & Matias, 2010), or on multiple land uses for one specific year (Campinas, 2019). Given the recent publication of the management plan, current zoning contributions for conservation and regulation of land uses have not been implemented yet. However, the zones are areas of special interest to be investigated because they can inform how these specific parts of the territory have changed over the years, thus informing trends that could be useful for current and future management.

Obtaining time series information for land use and land cover analysis can occur through multiple manners such as aerial photographs and satellite images, often requiring image classification, accuracy assessments, and field work validation. Differences in methodologies employed by different studies and monitoring agencies potentially lead to non-comparable data, impairing an appropriate assessment of changes in land systems (Farinaci & Batistella, 2012; São Paulo, 2020). Coordinated efforts to map and disclose data of multiple land categories is a challenging task that has only recently been undertaken on a national scale. Such efforts involve experts and different organizations and the MapBiomas platform is highlighted as the main one within this regard (Souza Jr. et al., 2020). MapBiomas is a collaborative network founded in 2015 that provides high-quality open-access spatial information for Brazil at a 30 m pixel size scale from 1975 to 2019 using Landsat Data (Souza Jr. et al., 2020). This platform

provides a comprehensive database that can be utilized for different research purposes, with more user-friendly information than the traditional methodological pathways of remote sensing.

Using data from MapBiomas, the aim of this work is to assess changes in land use and cover at APA Campinas in relation to two institutional landmarks that created (1993) and reinforced protection of the area (2001), and to its current zoning established in 2019. More specifically, we aimed to assess land use and land cover change at APA Campinas and the zoning established in its management plan, covering the period of 1993-2001, 2001-2019 and 1993-2019.

METHODS

(i) Study area

The Environmental Protected Area of Campinas is a peri-urban protected area in the city of Campinas, southeast Brazil (Fig. 2.1). Campinas is a one million inhabitants' metropolis in the interior of São Paulo state (IBGE, 2010). About 25.000 people live at APA Campinas (2.3 % of the total population), even though its size covers about a third of the municipal area (Campinas, 2018). Historically, the region has suffered from extensive deforestation since the 18th century for agriculture purposes, especially for coffee plantations in the 19th and early 20th century.

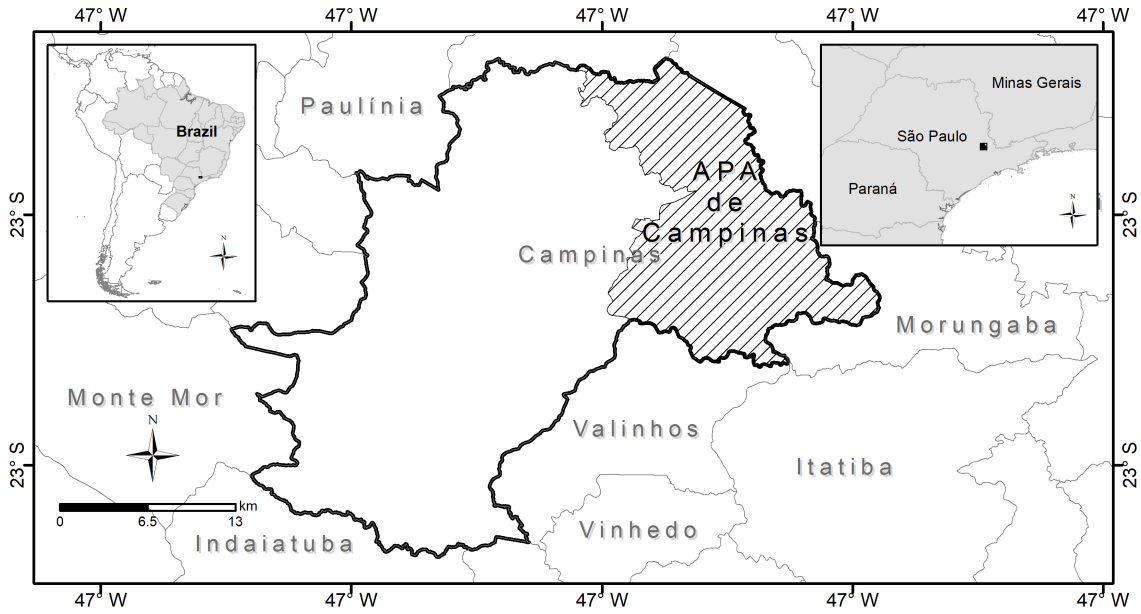

Figure 2.1 – Location of APA Campinas within the municipality of Campinas and its metropolitan region, state of São Paulo, southeast Brazil

In 1993, a sustainable use protected area was established at the region that covered 15475 ha of two municipal districts (Sousas and Joaquim Egídio) with the aim to preserve the local remnants of Atlantic Forest (Municipal Decree 11172/93). According to Young (2000), a management plan was elaborated in 1994 but was not institutionalized, and therefore it had no legal effects on regulating activities. In 2001, the Municipal Law 10850/21 renamed the area as APA Campinas (as it is currently known) expanding it to 22267 ha by incorporating other rural neighborhoods (a 43% increase). With broader objectives and stronger legal support, the protected area expanded its aims to include the conservation of public interest water resources for water supply, protection of local architectural heritage, and conciliation of conservation and development through the regulation of impactful human activities. In contrast with the 1993 decree, the law from 2001 also provided extensive guidelines for management.

In 2019, almost 20 years after the creation of APA Campinas, a management plan was elaborated in a participatory process and approved by the municipal government and management council. An update zoning was established, redefining the guidelines for local activities. The previous law from

2001 was updated so the management plan would be the most relevant institution in effect. The area was divided in five zones, based on criteria of land use and land cover, restrictions by existing legislation and other municipal plans, inputs from the population and experts, biophysical and socioeconomic characteristics, and a landscape fragility index (Campinas, 2019) (Fig. 2.2).

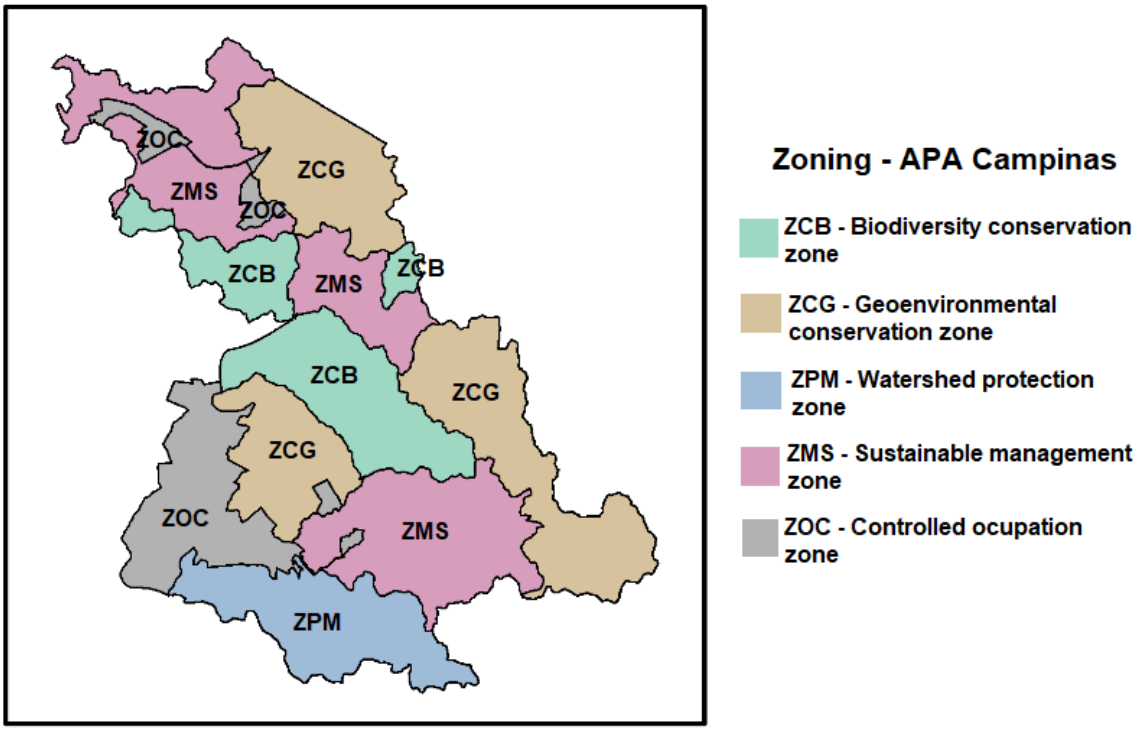

Figure 2.2 – Current zoning as established by the management plan of APA Campinas, southeast Brazil; abbreviations stand for the Portuguese acronyms

The five zones differ in relation to multiple aspects, such as area, social and biophysical characteristics, and aims (Table 2.1). Zones were defined by the management plan as a mechanism to specify place-based regulations for land use according to their local particularities (Campinas, 2019).

Table 2.1 – Description of the five zones as established by the management plan and their respective areas of APA Campinas, southeast Brazil (Campinas, 2019)

	Description	Area in ha (%)
Biodiversity conservation zone	Contains the biggest and most conserved forest fragments of native vegetation	3625 (16%)
Geoenvironmental conservation zone	Contains the land with highest environmental fragility and with characteristics that limit human occupation	6879 (31%)
Watershed protection zone	Contains the water extraction point that supplies water for 94% of the city	2432 (11%)
Sustainable management zone	Contains the majority of rural activities and historical farms	6562.5 (29.5%)
Controlled ocupation zone	Contains the urban perimeter	2769 (12.5%)
APA Campinas (total)		22267 (100%)

(ii) Data collection and analysis

Land use and land cover data was obtained for the whole city of Campinas from MapBiomas platform for years 1993, 2001 and 2019 (version 5) (MapBiomas, 2021). For the Atlantic Forest biome, in which APA Campinas is located, images have an accuracy of over 80% (Souza Jr. et al., 2020). Utilizing ArcGIS software, spatial data was specifically overlapped against the limits of APA Campinas and its specific zones[4]. Shapefiles containing the limits of APA Campinas were obtained from the municipal government website (Campinas, 2021), but spatial data for zoning had to be requested through an official protocol to the municipal Secretariat of Environment.

We opted to consider the present physical boundaries of APA Campinas to conduct our study, even though there is a difference in area from 1993 to 2001. This was done to enable comparisons and to understand how the area we nowadays legally considered as protected has changed throughout the years. Thus, we obtained land use and land cover maps for 1993, 2001 and 2019 for the whole area of APA Campinas and for each zone. Land use and cover classes

[4] The geospatial analysis was conducted by researcher Talita Terra from EMBRAPA Agricultural Informatics

(hereafter, land classes) were categorized according to available options and nomenclature utilized by MapBiomas. Given the small representation for some of the classes that MapBiomas could detect at APA Campinas, we opted to cluster categories that had a representation of under 1.5% if a higher hierarchy were available, resulting in the land classes described in Table 2.2 (Souza Jr. et al., 2020).

Table 2.2 – Land use and cover classes that were utilized for the assessment of changes in land use and land cover at APA Campinas, based on available classes and hierarchy at MapBiomas platform (Souza Jr. et al., 2020)

	Description
Pasture	Pasture areas related with farming activity
Agriculture	Areas predominantly occupied by annual crops, sugarcane plantation, other temporary crops
Mosaic of agriculture and pasture	Farming areas where it was not possible to distinguish between pasture and agriculture
Forest formation	Vegetation types with a predominance of tree species with high-density continuous canopy; forest resulting from natural regrowth
Forest plantation	Planted tree species for commercial use (*Eucalyptus* sp.)
Urban infrastructure	Urban areas with a predominance of non-vegetated surfaces, including roads, highways and constructions
Water	Rivers, lakes, dams, reservoirs, and other water bodies

In order to quantitively analyze changes in land use and cover at APA Campinas, cross-tabulation matrices (or transition matrices) were obtained. Such matrices allow for a careful analysis of change, enabling the identification of net gain, loss and persistence of a given category, and also of transitions between one category to another (Pontius Jr. et al., 2004). Based on this data, we calculated changes in area and percentage for each category of land use for APA Campinas and each of its zones. We calculated annual rates of change (Puyrayaud, 2003) to allow for comparisons between land categories and years. Net change was represented in figures using the ggplot2 package (Wickham, 2016) in Rstudio software (version 1.4.1106) (Rstudio Team, 2020), and further edited in Inkscape software (version 1.0) (Inkscape Project, 2020). We represented transitions of land use and cover from one category to another through Sankey diagrams that were plotted in the web-based application Displayr (Displayr, 2021) and further edited in Inkscape. Sankey diagrams depict flows

between two nodes through a network, emphasizing the size and directions of flows (Cuba, 2015). This type of diagram was originally designed for energy efficiency analysis but has also been used as a graphical method to easily visualize and interpret land dynamics, complementary to available information in cross-tabulation matrices (Cuba, 2015; Esquerdo et al., 2019).

RESULTS

(i) Changes in land use and cover at APA Campinas

The obtained data enables a description of how APA Campinas has changed throughout the years. The maps in Figure 2.3 depict this change, and Table 2.3 quantitatively indicates how area has changed at APA Campinas as a whole and its respective zones. Further details on the quantitative data are detailed in Appendix 2.1 (area, percentage, percentual change, annual rate of change) and Appendix 2.2 (cross-tabulation matrices), and a better resolution image for each year is available in Appendix 2.3.

The observed patterns denote a decrease in pasture and increase in forest formation, forest plantation, urban infrastructure, agriculture, and water, which is also shown in detail Table 2.3. Even though changes are possible to observe, the estimated proportions of each land class in relation to the entire area continue to be similar. For instance, pasture is the only land class with a negative annual rate of change but remains as the most representative land class at APA Campinas in 2019 (53% of the area in 1993, 50.3% in 2001, and 40.5% in 2019). Mosaic of agriculture and pasture, which indicates observed points that could not be undistinguished between agriculture or pasture, declined from 27% in 1993 to 25.3% in 2001, then increased to 29% in 2019, resulting in an annual rate of change of zero between 1993 and 2019. Forest formation is the third most representative land class at APA Campinas, increasing from 15.9% in 1993, to 18.4% in 2001 and 20.5% in 2019. The combination of forest plantation, urban infrastructure, agriculture, and water results in an area inferior to 10% of the total at any given year - but all these classes have been increasing since 1993.

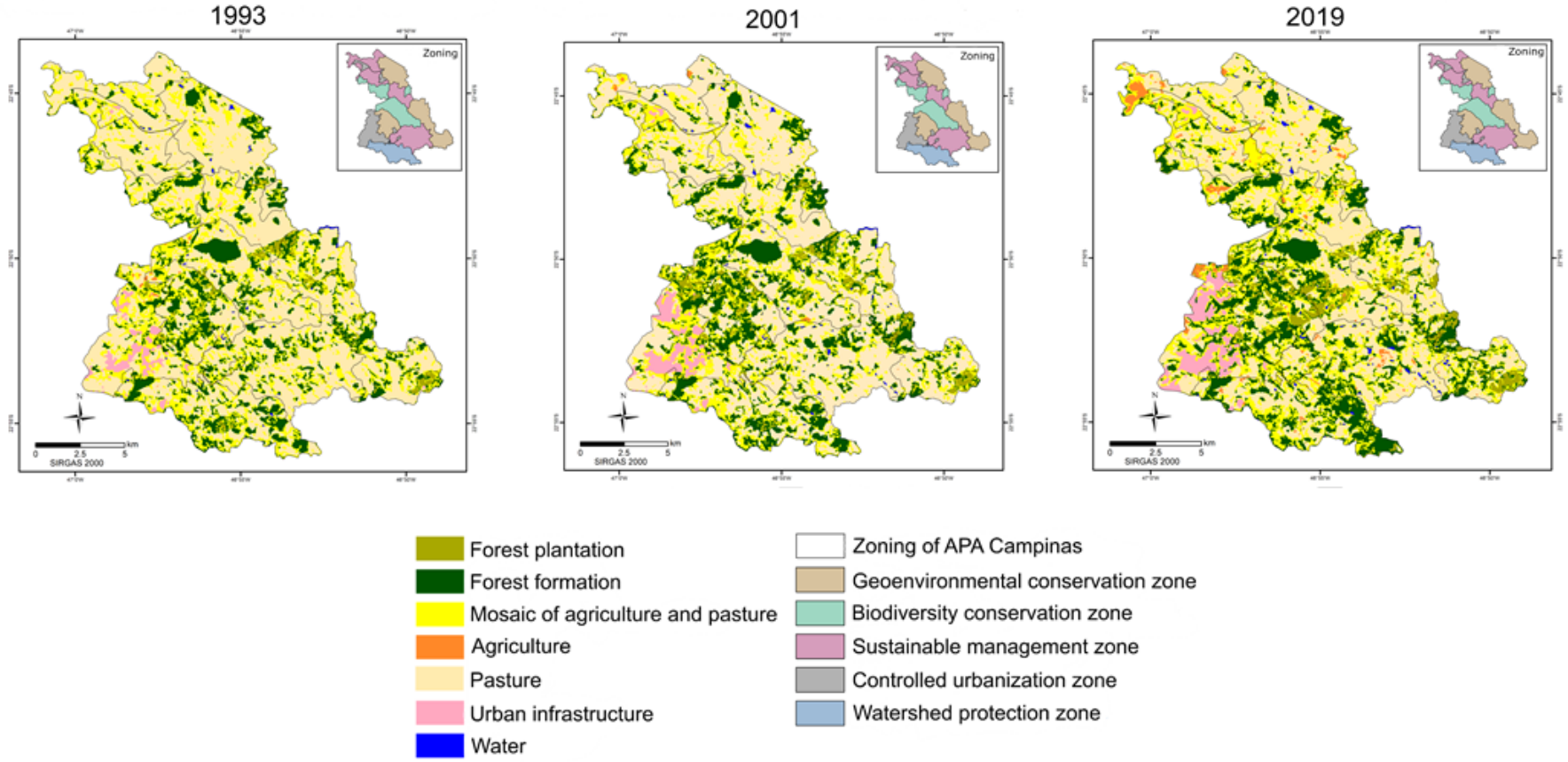

Figure 2.3 – Land use and land cover map of APA Campinas, southeast Brazil, and its respective zones for year 1993, 2001 and 2019 using data and land use and cover classes obtained from MapBiomas (version 5; MapBiomas, 2021). Prepared by Talita N. Terra

Table 2.3 – Area in hectares for each land class for APA Campinas (22267 ha) and its respective zones for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021); Acronyms: ZCB = Biodiversity conservation zone (3625ha, 16%); ZCG = Geoenvironmental conservation zone (6879 ha, 31%); ZMS = Sustainable management zone (6562.5, 29.5%); ZOC = Controlled urbanization zone (2769 ha, 12.5%); ZPM = Watershed protection zone (2432 ha, 11%)

	1993					
	APA Campinas	**ZCB**	**ZCG**	**ZMS**	**ZOC**	**ZPM**
Pasture	11862	1754.4	3616.9	4238.4	1278.7	973.5
Mosaic of agriculture and pasture	6014	1038.1	1720.1	1580.3	884.9	790.7
Forest formation	3546	770.6	1248.5	684.5	227.4	614.7
Forest plantation	374	46.5	243.7	39.5	25.0	19.4
Urban infrastructure	366	0.6	4.7	5.7	330.1	18.5
Agriculture	32	5.1	9.9	1.3	15.1	0.4
Water	75.5	9.3	38.6	14.9	4.9	7.5

	2001					
	APA Campinas	**ZCB**	**ZCG**	**ZMS**	**ZOC**	**ZPM**
Pasture	11210	1610.5	3527.0	4292.8	862.5	916.8
Mosaic of agriculture and pasture	5647	957.4	1526.6	1444.9	956.0	761.5
Forest formation	4115	974.1	1403.2	722.1	313.1	702.2
Forest plantation	579	66.8	373.9	46.5	78.0	14.0
Urban infrastructure	583	0.0	0.0	3.5	550.4	25.4
Agriculture	34	6.5	1.9	23.9	1.2	0.0
Water	103	9.5	49.7	30.8	4.9	7.7

	2019					
	APA Campinas	**ZCB**	**ZCG**	**ZMS**	**ZOC**	**ZPM**
Pasture	9027	1304.2	3075.0	3484.6	464.0	699.1
Mosaic of agriculture and pasture	6460.5	1008.1	1708.9	1943.3	1052.6	747.4
Forest formation	4573.5	1043.7	1403.2	826.8	399.1	900.5
Forest plantation	892	214.2	587.6	45.4	14.8	29.5
Urban infrastructure	780	0.0	2.5	1.7	748.9	25.5
Agriculture	397	41.7	45.9	210.4	82.1	16.7
Water	140	12.8	59.2	52.4	4.6	11.3

Figure 2.4 graphically displays net change for each land use and cover class. Forest formation is the class that presented the largest overall increase in area at APA Campinas, followed by forest plantation, mosaic of agriculture and pasture, urban infrastructure, and agriculture. Areas detected as water (rivers, lakes, dams, reservoirs, and other water bodies) have increased, but remain as less than 1% of the total.

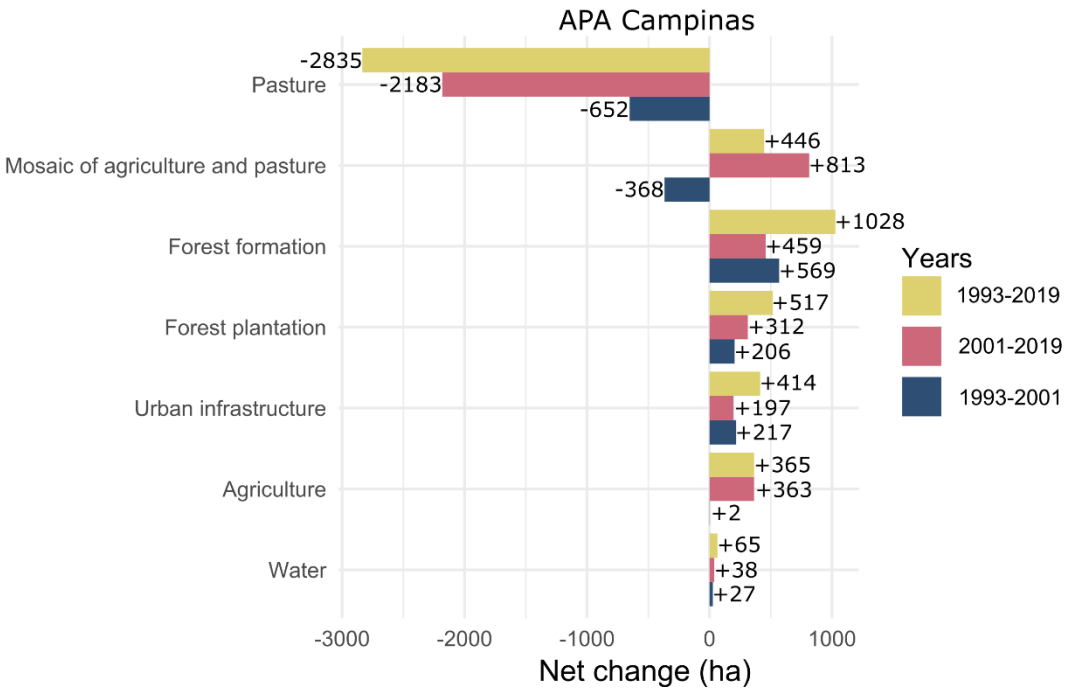

Figure 2.4 – Net change in hectares for each land class at APA Campinas (22267 ha) for three time periods (1993-2001, 2001-2019, 1993-2019), based on MapBiomas data (version 5; MapBiomas, 2021)

(ii) Biodiversity conservation zone

The analysis of each zone within APA Campinas reveals how change has occurred at a finer scale. At the biodiversity conservation zone (3625 ha, 16% of APA Campinas), the area which contains the majority of forest fragments, pasture is the dominant land class (36% of the area in 2019), followed by forest formation (29%) and mosaic of agriculture and pasture (28%). It is also possible to notice that there is currently no urban infrastructure at this zone. Forest formation and forest plantation were the land classes with highest gain in area and percentage, at the expense of a decrease in pasture (Fig. 2.5). While the increase of

vegetation in forests occurred mainly between 1993 and 2001, forest plantations increased mostly from 2001 to 2019.

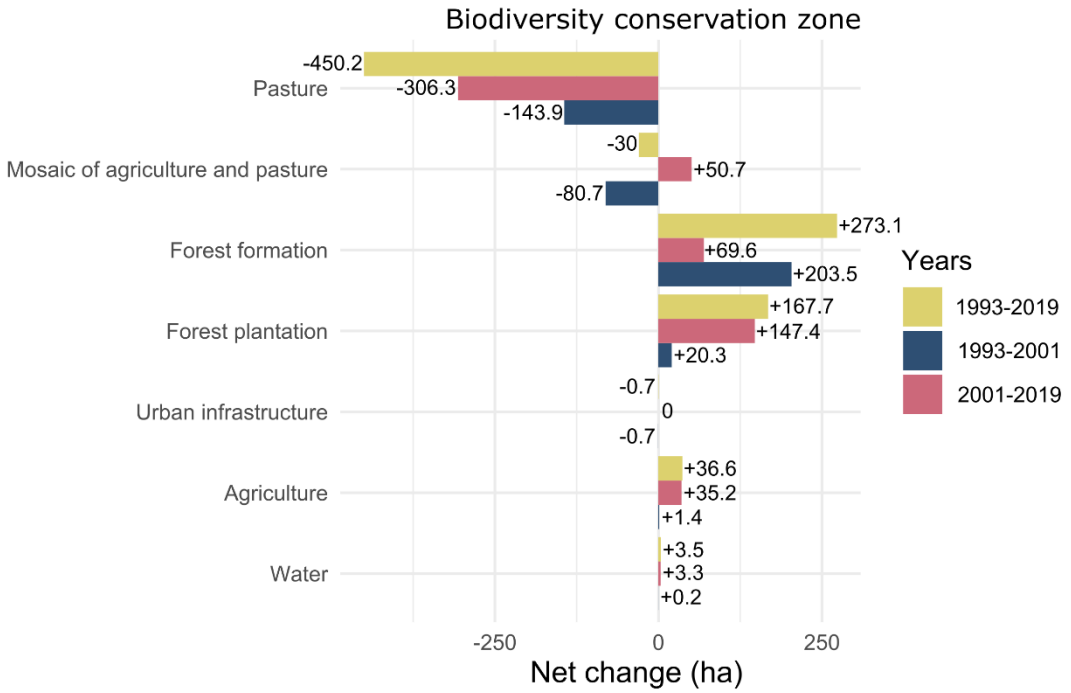

Figure 2.5 – Net change in hectares for each land class at the biodiversity conservation zone (3625 ha, 16%) of APA Campinas for three time periods (1993-2001, 2001-2019, 1993-2019), based on MapBiomas data (version 5; MapBiomas, 2021)

(iii) Geoenvironmental conservation zone

The geoenvironmental conservation zone is the largest zone within APA Campinas (6879 ha, 31% of total area), encompassing fragile terrains with physical features that limit human occupation and potentialize erosive processes. Pasture is the predominant land class, currently covering 46% of the total in 2019, even though it is has declined since 1993. Mosaic of agriculture and pasture (25%), forest formation (20%) and forest plantation (9%) follow as the currently most representative land classes. Agriculture and water had a small increase, and urban infrastructure is practically absent within this zone. Combined at any given time, urban infrastructure, agriculture, and water represent less than 2% of the area. Forest plantation had the largest increase, followed by forest formation, which only expanded between 1993 and 2001 (Fig. 2.6). Mosaic of agriculture

and pasture decreased between 1993 and 2001, and increased between 2001 and 2019, resulting in a small net gain considering 1993 to 2019.

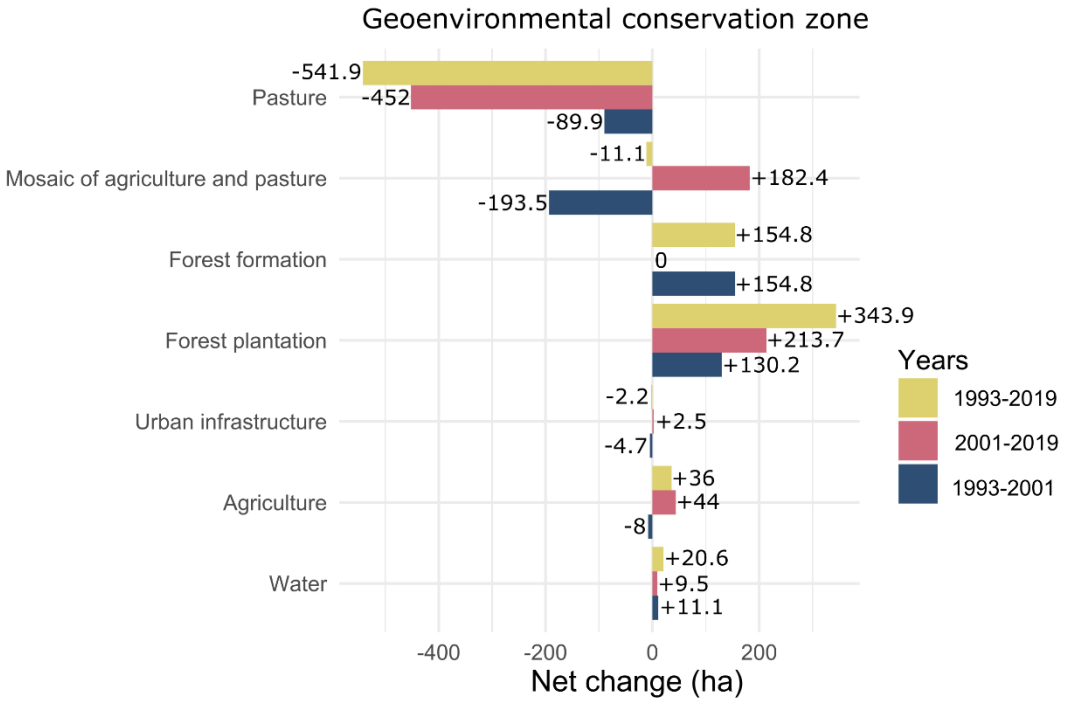

Figure 2.6 – Net change in hectares for each land class at the geoenvironmental conservation zone (6879 ha, 31%) of APA Campinas for the three time periods (1993-2001, 2001-2019, 1993-2019), based on MapBiomas data (version 5; MapBiomas, 2021)

(iv) Sustainable management zone

The sustainable management zone (6562.5 ha, 29.5%) concentrates the majority of rural activities of APA Campinas. Pasture is the most representative land class covering 53% of the area in 2019, followed by mosaic of agriculture and pasture (30%), forest formation (12.6%) and agriculture (3%). Forest plantation, urban infrastructure and water cover less than 1% of the zone each. From the 365 ha of agricultural growth at entire APA Campinas between 1993 and 2019, 209 ha (57%) occurred within the sustainable management zone (Fig. 2.7). However, even within this zone, it covers only 3.2% of the area. Forests have been slightly expanding at this region as well. Mosaic of agriculture and pasture had the largest increase in hectares, exclusively concentrated between 2001 and 2019.

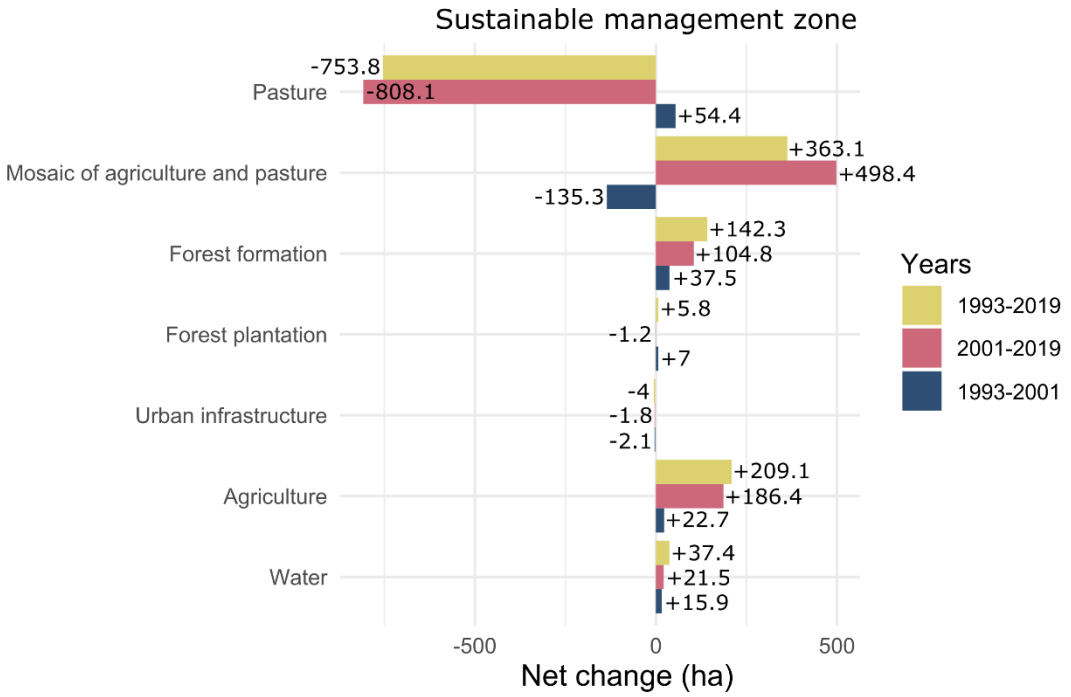

Figure 2.7 – Net change in hectares for each land class at the sustainable management zone (6562.5 ha, 29.5%) of APA Campinas for three time periods (1993-2001, 2001-2019, 1993-2019), based on MapBiomas data (version 5; MapBiomas, 2021)

(v) Controlled urbanization zone

The controlled urbanization zone (2769 ha, 12.5%) delimitates the urban perimeter of APA Campinas, although it is not completely urbanized. Mosaic of agriculture and pasture is the land class with the largest representation (38% in 2019), followed by urbanized areas (27% in 2019). Considering that in 2019 there was 780 ha of urban infrastructure in the entire APA Campinas, it is possible to notice that 95.5% (745 ha) is concentrated within the controlled urbanization zone. Pasture had a noteworthy decrease of 46% in 1993 to 17% in 2019. Forest formation has expanded 171 ha at the zone from 1993 to 2019 (Fig. 2.8). Agriculture, forest plantation and water combined occupy less than 4% of the zone.

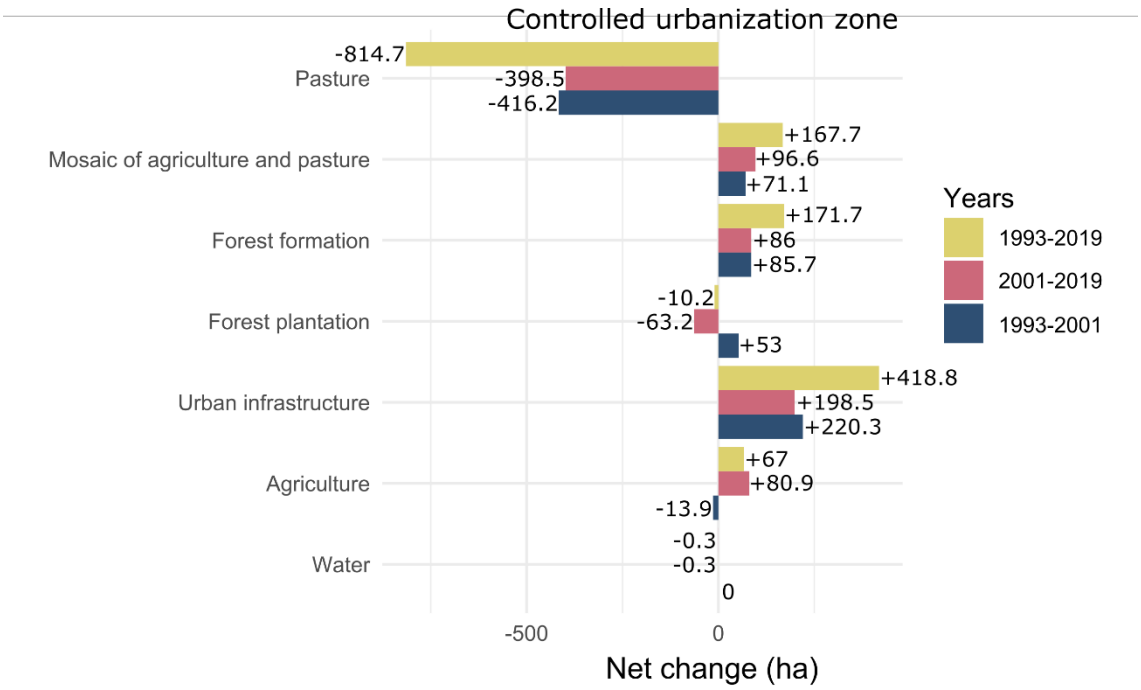

Figure 2.8 – Net change in hectares for each land class at the controlled urbanization zone (2769 ha, 12.5%) of APA Campinas for three time periods (1993-2001, 2001-2019, 1993-2019), based on MapBiomas data (version 5; MapBiomas, 2021)

(vi) Watershed protection zone

The watershed protection zone (2432 ha, 11%) is the smallest zone within APA Campinas, and contains important forest fragments and the location of the water withdrawal point from the Atibaia river (which supplies water for 94% of the population of Campinas). It is the only zone where forest formation was the predominant land class in 2019 (37%), with substantial increase since 1993. Mosaic of agriculture and pasture follows as the second most prevalent land class in 2019. Forest plantation, urban infrastructure, agriculture, and water had little changes throughout the years. On the other hand, pasture has decreased from the dominant land class in 1993 to the third one in 2019, with a 274.4 ha decrease (Fig. 2.9).

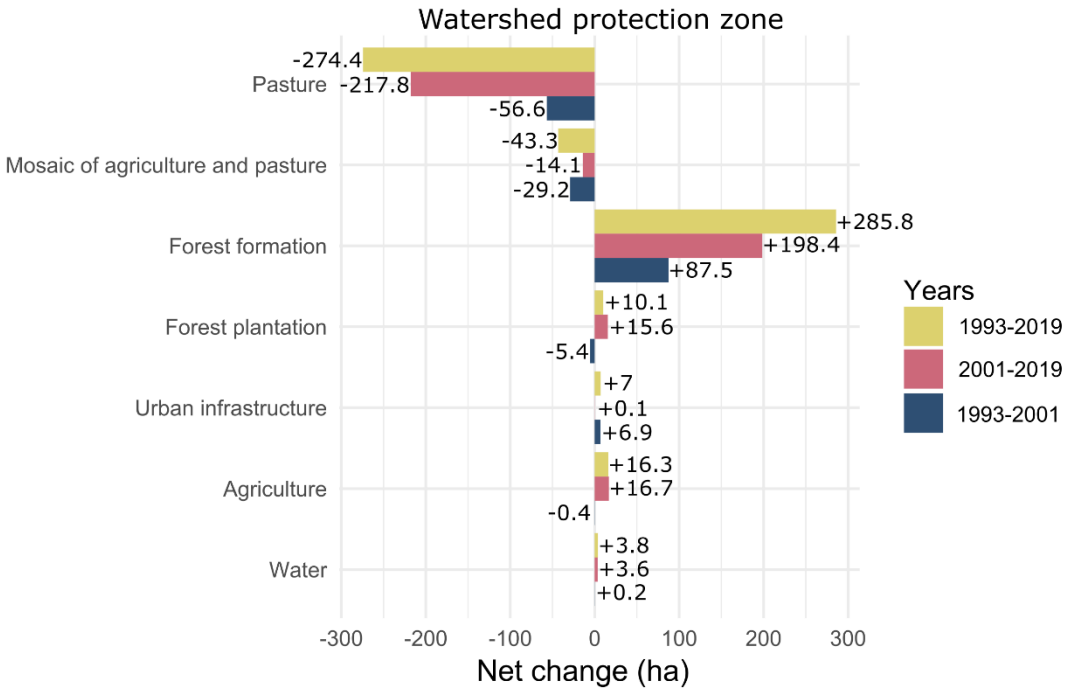

Figure 2.9 – Net change in hectares for each land class at the watershed protection zone (2432 ha, 11%) of APA Campinas for three time periods (1993-2001, 2001-2019, 1993-2019), based on MapBiomas data (version 5; MapBiomas, 2021)

(vii) Land use and cover transitions

In order to effectively evaluate how classes of land use and land cover transitioned to one another, we utilized the cross-tabulation matrices to develop Sankey diagrams for the two analyzed periods (Fig. 2.10, Fig. 2.11). While patterns of change may vary between zones, the overall composition of land use and cover of APA Campinas remains similar since 1993. For instance, pasture percentual decrease translates into contributions to the increase of other land classes (specially to mosaic of agriculture and pasture), but the majority of pasture remains as pasture.

Forest formation has increased, and it has expanded over areas of mosaic of agriculture and pasture (431.5 ha from 1993 to 2001, 439.4 ha from 2001 to 2019) and pasture (163.4 ha from 2001 to 2019). The 217 ha expansion of urban areas occurred exclusively at the expense of pasture and mosaic of agriculture and pasture from 1993 to 2001. From the period of 2001 to 2019, urban infrastructure had an increase of 197 hectares over areas of pasture and mosaic

of agriculture and pasture (122.4 ha), of forest plantations (44.8 ha) and forest formation (29.6 ha). Regarding forest plantation, the 205 hectares increase from 1993 to 2001 occurred over areas of pasture and mosaic of agriculture and pasture (200 ha), and the 313 hectares increase from 2001 to 2019 happened at the expense of areas of pasture and mosaic of agriculture and pasture (277.2 ha), but also at the expense of forest formation (88.9 ha)[5].

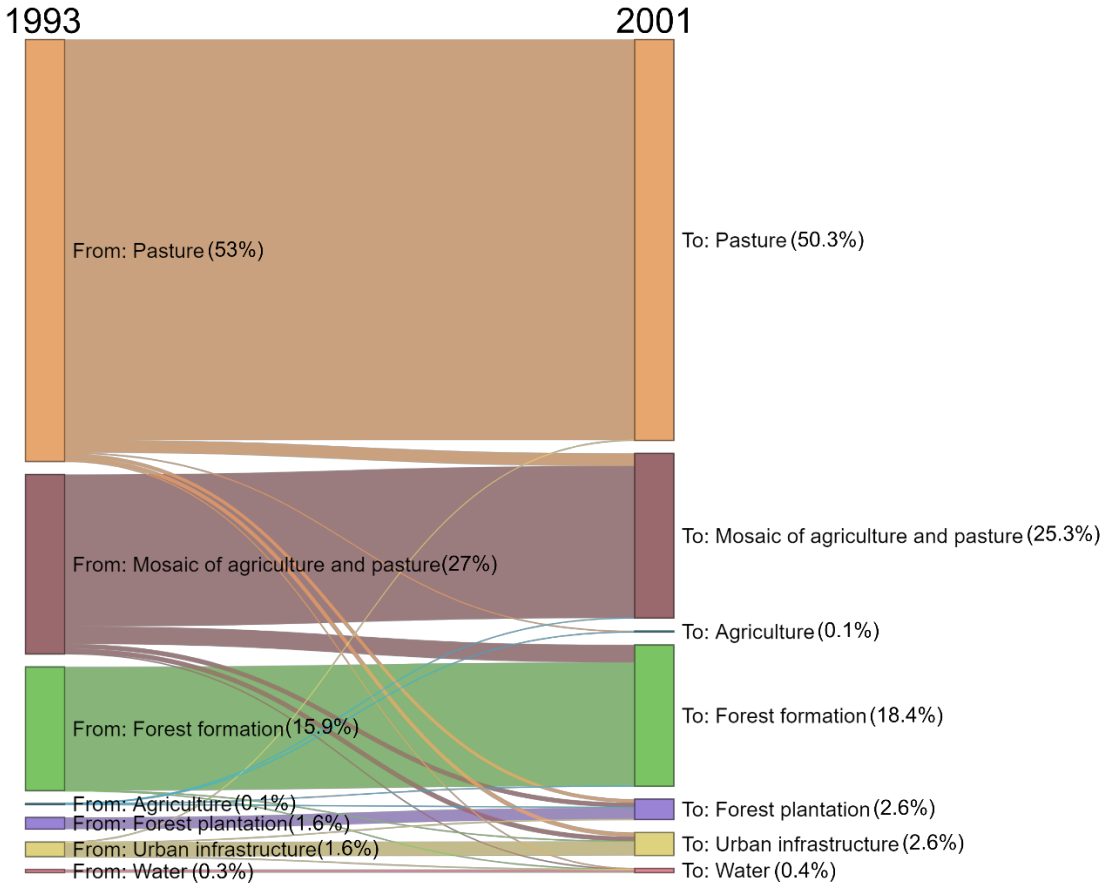

Figure 2.10 – Transitions of land use and land cover classes in APA Campinas from 1993 (left) to 2001 (right), based on MapBiomas data (version 5; MapBiomas, 2021)

[5] Note that these numbers do not add up to the total of 313 hectares increase in forest plantations because there was 44.8 hectares of urban infrastructure and 8.9 ha of agriculture that expanded over areas of forest plantations.

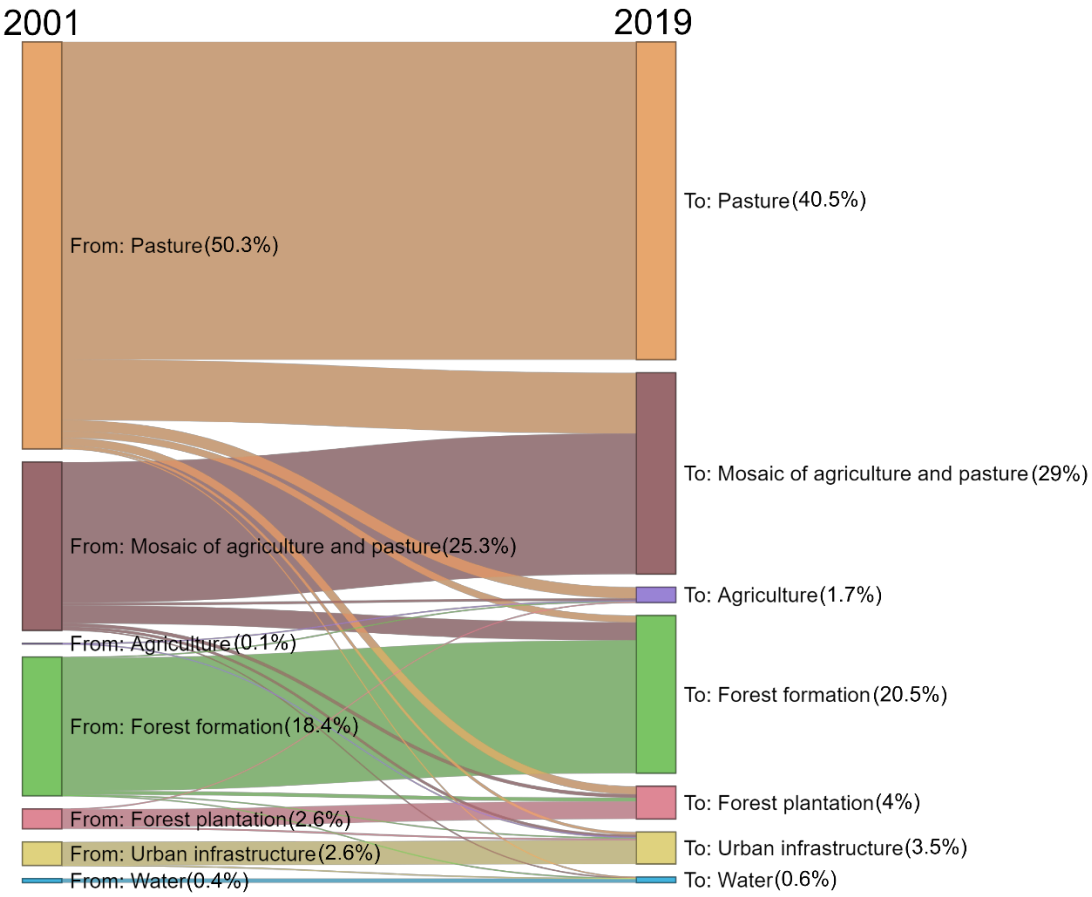

Figure 2.11 – Transitions of land use and land cover classes in APA Campinas from 2001 (left) to 2019 (right), based on MapBiomas data (version 5; MapBiomas, 2021)

DISCUSSION

Trends in land use and land cover change in APA Campinas

- **Pasture**

At the end of 19th century, the economy of Campinas revolved around coffee plantations, and coffee remained as the most important commodity for international exportation until the 1930s (Bianconi, 2002). After the decline of coffee, industrialization followed as an important economic activity and urbanization increased. Urban areas and industries settled elsewhere in the municipality (or even in other municipalities of the region), with consequent rural outmigration of what is now APA Campinas and redirecting rural activities to ones that required less labor, such as cattle raising. The observed predominance of pasture as the most representative class at APA Campinas is a heritage from this

historical period after the 1930s. Nowadays some properties keep some livestock so that the land is classified as productive, thus enabling deduction of rural taxes (Campinas, 2018).

Pasture used to cover 53% of APA Campinas in 1993, declining to 50.3% in 2001, and to 40.5% in 2019. Although declining, it still is the most representative land class, and the relative proportions of each of the other land classes remains similar throughout the years. This pattern suggests an overall steady landscape, even though changes in area among land classes could also be observed. Chambers et al. (2013) conceptualizes such landscapes as a shifting steady-state mosaic, and this phenomenon has also been observed at other areas within the Atlantic Forest in Brazil (Silva et al., 2020). For landscapes in which such pattern is possible to observe, Pelorosso et al. (2011) argues for the necessity of management strategies that simultaneously considers and stimulates an equilibrium between actions focused on restoration and conservation, anthropic activities, and the provision of ecosystem services.

The presence of pasture cannot be directly correlated with cattle raising activities, because there is a difference between pasture with active production and degraded pasture that is abandoned. The management plan of APA Campinas offers valuable insight in this regard, given the fact that its land use and land cover analysis utilized a finer spatial resolution scale of 0.5 m (Campinas, 2018). Using data from World View satellite for year 2012, the management plan distinguishes pasture with and without cattle raising activities. According to this document, 35.7% of APA Campinas was covered by pasture with effective cattle raising in 2012, while 12.6% was abandoned (unproductive) pasture. Considering this proportion, it is possible that approximately one fourth of the pasture area identified at our study could be degraded pasture without livestock.

Degraded pasture is considered a form of land abandonment and it has been frequently observed in other regions of the state of São Paulo (Silva et al., 2017a). Underlying factors for land abandonment include social components (e.g., decline of agricultural activities and rural outmigration) and biophysical ones (e.g., steep terrain and soils with low fertility) (Silva et al., 2017a). The lack of data

related to the number of existing herds at APA Campinas (Campinas, 2018) contributes to a knowledge gap concerning the specific dynamics of change in pasture that could be further detailed in future studies.

Mosaic of agriculture and pasture represents the land class in which pasture and agriculture could not be distinguished. However, the management plan identifies 1.7% of APA Campinas as being covered by agriculture in 2012 (Campinas, 2018), whereas this study identifies 1.4% in 2019. Thus, we argue that mosaic of agriculture and pasture is likely to represent pasture. Nonetheless, given the uncertainty, we still distinguish these two land classes at our study.

In relation to zoning, pasture is the most representative land class at the biodiversity conservation zone, geoenvironmental conservation zone and sustainable management zone at any given year. At the watershed protection zone in year 2019, pasture decreases to the extent that it becomes the third most representative zone. At the controlled urbanization zone, it was second largest land class in 2001, and the third in 2019. Therefore, the watershed protection and controlled urbanizations zones contributed the most to the observed overall decrease of pasture at APA Campinas.

- **Forest formation**

Estimations of forest cover (i.e., vegetation types with continuous canopy of tree species or forest resulting from regrowth) have been undertaken by different studies for the city of Campinas throughout the years. The use of different methodologies deployed within these studies does not allow for a direct comparison but results still indicate an increase in forests. For instance, it has been reported for Campinas that forests cover 2.5% (Santin, 1999), 11.9% (Campinas, 2015) and 14.4% (São Paulo, 2020) of the municipal area. For APA Campinas, more specifically, increases in forest have also been observed: Santin (1999) calculated forests as covering 879 ha (3.9%) of the districts of Sousas and Joaquim Egídio; Fasina Neto & Matias (2010) calculated 3299 ha (14.8%) for the whole area of APA Campinas; and the management plan calculated 6177 ha (27.7%) (Campinas, 2018). Our study corroborates this trend, utilizing a methodology that allows for a direct multi-temporal analysis: 3546 ha (15.9%) in

1993, 4115 ha (18.4%) in 2001, 4573.5 ha (20.5%) in 2019. Thus, it is possible to conclude that forest areas are growing at APA Campinas.

Forest transitions refers to a long-term phenomenon in which forest cover ceases to decline and begins to recover (Rudel et al., 2005). On a global scale, forest transitions have been associated with rural outmigration and the abandonment of unproductive and unprofitable fields and pastures (Rudel et al., 2005). Studies conducted in a regional scale detail how this process has been occurring in Brazil, suggesting an interplay between social and biophysical aspects driving this phenomenon (Molin et al., 2017). For instance, Calaboni et al. (2018) indicate that forest transition in municipalities of São Paulo state is associated with land abandonment, steep terrain, and primary vegetation cover. Additionally, state regulation, economic incentives, and public policies to modernize agriculture also play a role in this regard. At the Paraíba Valley of São Paulo state, Silva et al. (2017a) confirms that 74% of forest expansion occurred over areas of degraded pasture, especially due to the industrialization of some municipalities in the region. APA Campinas has a similar historical trajectory in comparison with municipalities in the Paraíba Valley, and therefore we argue that drivers of gains in forest are similar. Our results suggest that forests have been growing over areas of degraded pasture, which was also observed by Silva et al. (2017a).

Our study did not detect the shift from deforestation to reforestation that characterizes forest transitions, since we only observed net forest gains since 1993. Nonetheless, it is possible to infer that this phenomenon has occurred at APA Campinas, given the fact that the region has been extensively deforested to the point that almost all forest remnants are composed by secondary vegetation (Santin, 1999). Calaboni et al. (2018) corroborates this affirmation by detecting a shift in the forests of Campinas from decreasing in the 1960s to increasing in the 1970s.

Forest remnants are a key element in safeguarding biodiversity and providing ecosystem services. Old-growth forests are indisputably relevant for the conservation of biodiversity, but in the context of extensively altered landscapes such as the ones at APA Campinas, forest fragments of secondary vegetation

present themselves as valuable opportunities for conservation of biodiversity (Tabarelli et al., 2010). Considering the zoning, the watershed protection zone had the largest relative and absolute gains in forest formation from 1993 to 2019, totalizing a 11.79% increase (285.8 ha), even though it is the smallest zone in size. According to the management plan, the biodiversity conservation zone hosts the largest and most well-conserved fragments (Campinas, 2018), but it had the second largest gain in forest formation from 1993 to 2019 (7.53%, 273.1 ha). Thus, we highlight the importance of the watershed protection zone in contributing to the increase in the area of natural forests.

Governance instruments such as policies, plans, laws, and law enforcement influence changes in forest cover (Silva et al., 2017b). Municipal policy instruments such as the greening plan of the city (Campinas, 2015), management plan of APA Campinas (Campinas, 2018, 2019) and other legislations may contribute to the increase in forest cover, if properly applied and enforced. Recently, a connectivity plan for green areas within the metropolitan region of Campinas has been proposed, indicating a possible institutional mechanism to implement ecological corridors on the ground and further contribute to the increase of forests at APA Campinas (ICLEI, 2021). Nonetheless, it is also worth stressing that natural forest regeneration is key to forest growth, and the combination of policies that foster active and passive ecological restoration could further benefit conservation of biodiversity (Crouzeilles et al., 2017). Considering that there are also state and federal legislation directing land use, we argue to the need of considering the multiple dimensions of governance into the analysis of forest transition at APA Campinas.

- **Urban infrastructure**

The 21st century is considered the “urban century” and current trends of urbanization indicate that the growth of cities will extensively affect protected areas and the biodiversity and ecosystem services they provide (McDonald et al., 2018). Campinas is a highly urbanized city, and APA Campinas harbors the most important remnants of forests and rural landscapes within the city. Even though the most representative land uses at the area remain as pasture and forests, there has been a significant increase in urban infrastructure. The approval of

municipal laws that allowed for the urbanization of rural areas at APA Campinas was first observed in the 1970s (Campinas, 2018). In 1993, 1.6% of the territory of APA Campinas was covered by urban infrastructure, increasing to 2.6% in 2001 and 3.5% in 2019. Although urban areas only cover a small portion of the protected area, they have more than doubled within a 26-year period and host 80% of the local population (Campinas, 2018).

Urban expansion has been occurring through the construction and expansion of urban infrastructure and horizontal residential condominiums targeting the upper-middle class. At APA Campinas, this has contributed to shape local land change dynamics: real estate agencies advertise the area as a natural refuge from urban issues (especially violence), influencing people to move to the area, and therefore contributing to urban expansion (Trevisan & Paes, 2009; Cocharski, 2016). This search for well-being at APA Campinas creates a paradox: the same people who move to the region to be closer to nature actively contribute to local urbanization and its impacts to local ecosystems. Moreover, the condominiums have been associated with a social and spatial segregation within the city of Campinas due to the elevated prices of land at the region, influenced by real estate speculation (Trevisan & Paes, 2009). Biophysical impacts of urban expansion have been less studied at the area, and our study provides insight to the fact that it has affected 29.6 ha of forest remnants from the period of 2001 to 2019. Elsewhere in Campinas, a study by Damame et al. (2019) has identified that urban expansion has increased the vulnerability of the soil to erosive processes.

In relation to the zones within APA Campinas, 96% of areas classified as urban infrastructure are located within the limits of the controlled urbanization zone. Even though urbanization is restricted to this area, it is important to highlight that legislation has been modified three times throughout the years to expand the limits of the urban perimeter at APA Campinas (Campinas, 2018). Currently, the urban perimeter can only be expanded to attend demands for housing of social interest, but given the historical context, it is relevant to consider the possibility of future modifications of institutional mechanisms that regulate expansion of urban infrastructure in the protected area.

- **Forest plantation**

Forest plantations at APA Campinas refer to eucalyptus trees that are grown for commercial purposes. Eucalyptus is an exotic species, grown for wood, charcoal, cellulose, and paper. At APA Campinas, the social and ecological impacts of forest plantations have not been extensively studied, but there are reports of areas being deforested for the planting of eucalyptus (Campinas, 2018). Following a similar pattern for the expansion of urban infrastructure, forest plantations increased from 1.6% in 1993, to 2.6% in 2001 and 4% in 2019, mainly at the biodiversity conservation zone and the geoenvironmental conservation zone.

Impacts of eucalyptus plantations are documented in the literature, with studies that indicate negative impacts for biodiversity due to the homogenization of the landscape (Valduga et al., 2016). In parallel, positive contributions to biodiversity have also been identified, with research that highlights the potential of eucalyptus plantations to act as corridors between patches of native vegetation for carnivore mammals (Lyra-Jorge et al., 2008) and to contribute to ecological restoration via seedlings that germinate in the understory (Viani et al., 2010) - which has also been observed at APA Campinas (Campinas, 2018). At the Paraíba Valley, eucalyptus plantations are required to have environmental certifications (e.g, Forest Stewardship Council – FSC) to be sold to international markets. As an effect, an increase in native forest cover has been associated with the proximity to eucalyptus plantations (Farinaci et al., 2013; Silva et al., 2017b; Silva et al., 2020). Given the possibility of different outcomes of eucalyptus plantations for biodiversity conservation and ecosystem services, we suggest further studies at APA Campinas to evaluate their dynamics locally. Considering that this activity has increased 2.5 times in a 26-year period, approaches that focus on how management of eucalyptus can generate desirable outcomes for people and nature could potentially inform decision-making for integrated conservation and development.

- **Agriculture**

Agriculture used to be most important economic activity at Campinas up until to the 1930s, covering extensive areas of APA Campinas (Bianconi, 2002). Currently it is one of the least representative land use classes at APA Campinas (alongside water), covering 0,14% of the area in 1993, 0.15% in 2001, and 1.78% in 2019, mainly restricted to the sustainable management zone. There could be some hectares of agriculture that were not identified through our analysis and were classified as mosaic of agriculture and pasture, but our study aligns with measurements from the management plan that identified 1.7% of the protected area covered by agriculture (Campinas, 2018). Cultures that have been identified include both temporary such as lettuce, corn, sugarcane, manioc, and perennial cultures such as coffee and citriculture (Vendrametto, 2004; Campinas, 2018). One of the objectives of the zoning at APA Campinas is to provide opportunities for integrating conservation and development, and one of the appointed pathways in this regard is the use of agroecological practices (Campinas 2018, 2019). There are reports of local rural properties developing such practices and selling organic products, potentially explaining the observed increase from 0.15% to 1.4%. While still underrepresented at the territory, we highlight the relevance of these properties that have multiple organic cultures in contributing to biodiversity conservation and enhancing the provision of ecosystem services (Chazdon et al., 2009).

- **Water**

Our analysis shows that water surface has been increasing: 75.5 ha (0.3%) in 1993, 103 ha (0.4%) in 2001, and 140 ha (0.6%) in 2019. However, it still remains as the least representative land class at the protected area. APA Campinas has the largest numbers of brooks, water springs and watercourses of the municipality (Campinas, 2016), but they are often narrow and small. Thus, it was not possible to identify them from the spatial scale of MapBiomas data. The exceptions are some parts of the two main local rivers, and possibly some reservoirs. Currently, a dam is being constructed at the limits of APA Campinas and the neighboring city of Pedreira at the geoenvironmental conservation zone. Moreover, there are plans to construct a second dam at the Atibaia river at the biodiversity

conservation zone (Campinas, 2018). These factors could contribute to an increase in the land class of water surface at APA Campinas in the future, since they will require flooding of areas that are currently occupied by forest formation.

CONCLUDING REMARKS

The use of data obtained from MapBiomas was a useful tool for the assessment of changes in land use and cover at APA Campinas. We were able to identify and analyze trends of change, offering valuable insight into the local dynamics from 1993 to 2019. Our findings highlight that pasture has been decreasing at all zones but remains as the most representative land class for the whole area of APA Campinas. Forests have been increasing in area, especially at the watershed protection zone, indicating a forest transition from a historical perspective. Urban areas have been expanding but are restricted to the controlled urbanization zone. Eucalyptus plantations have more than doubled between 1993 and 2019. Agriculture has expanded at the sustainable management zone but cover a small area. Water surface is the least representative land class.

The observation of patterns of change in land use and cover provides valuable insight into the understanding of local dynamics, but it is still insufficient to fully understand the underlying processes that drive them (Rounsevell et al., 2012). Further studies that integrate geographical data to other methodologies could be useful in this regard, and inspiration for this can be found in Farinaci (2012), Silva et al. (2017a) and Silva et al. (2017b). Nonetheless, our investigation of APA Campinas and its zones enabled us to have an overall panorama of how the area has changed in relation to institutional landmarks in the years of 1993, 2001 and 2019. This is the first multi temporal analysis of land use and cover at APA Campinas, and we expect that information can be useful for management and decision-making at the area, especially for the municipal government and the management council.

CHAPTER 3 - PARTICIPATORY SCENARIO DEVELOPMENT FOR ECOSYSTEM SERVICES OF A PERI-URBAN PROTECTED AREA, SOUTHEAST BRAZIL

Key words: social-ecological systems; scenario planning; collaborative management; adaptive co-management.

ABSTRACT

The participatory development of scenarios is a useful methodology to create shared visions of the future among different stakeholders. Scenarios for ecosystem services, specifically, focus on components of the social-ecological systems that explicitly link nature and human well-being. The Environmental Protected Area of Campinas (APA Campinas) is a sustainable use protected area in southeast Brazil that provides multiples ecosystem services and has several drivers of change affecting their availability and quality. Through two focus groups with management councilors and employees from the municipal Secretariat of the Environment, we aimed at developing a business-as-usual and a desired scenario for ecosystem services at APA Campinas, and list actions to achieve the desired scenario. Focus group methodology was successful in fostering discussions and reflections within stakeholders and enabled the design of two illustrations that graphically depict how the two scenarios could look like. This graphical visualization enabled the identification of differences between scenarios, and actions to overcome the business-as-usual future revolved around four different categories: (i) collaborative management; (ii) communication and education, (iii) infrastructure, land regularization and law enforcement, and (iv) integrated conservation and development. We discuss how the concept of adaptive co-management could potentially contribute to the design and implementation of actions around the four listed categories, but challenges are still numerous, such as lack of funding and personnel. We expect that our findings can contribute to integrating conservation and development at APA Campinas now and in the future while highlighting that adaptive co-management is an ongoing iterative process, and the mere implementation of listed actions will likely not be sufficient to achieve the desired future for ecosystem services.

INTRODUCTION

Current sustainability challenges demand coordinated actions to secure nature's capacity to provide ecosystem services for human well-being presently and in the future (Díaz et al., 2019). On this behalf, scenario development (or scenario planning) has been appointed as a useful methodology to anticipate how the future may look like, facilitating the identification of actions to be implemented in the present (Reed et al., 2013). Scenarios are representations of possible futures for one or more components of a system (IPBES, 2016) and have been commonly used within the context of natural resource management in social-ecological systems (Oteros-Rozas et al., 2015). Scenarios can be categorized in different ways, and we call attention to two of them: explorative scenarios, which represent plausible futures of a given system; and target-seeking (or normative) scenarios, which represent futures that are agreed upon by a given group of stakeholders and that could be achieved through multiple manners (IPBES, 2016).

The future is constantly being reshaped by the actions we take in the present, and forecasting it is therefore an inherently fallible task (Bai et al., 2016). However, according to Costanza (2003), in order to change how the world currently is and achieve a future that is desired, we must first envision how the world we want looks like. Establishing a shared vision about a desired future is argued to be one of the first steps towards concretely achieving it (Meadows, 1996; Costanza, 2003). In this regard, integrating plausible and desirable futures to scenario development could potentially aid in identifying differences between scenarios, enabling the identification of actions to achieve a shared vision of what is desired (Bai et al., 2016; Iwaniec et al., 2020). Hence, scenarios can be a useful tool for anticipating and preparing for the future, as well as for actively shaping and building it.

Participatory scenario development that integrates multiple stakeholders has the potential to improve dialogue, collaboration, and legitimacy within environmental decision-making processes (Oteros-Rozas et al., 2015; Rosa et al., 2017). Participation is relevant for scenario development because it fosters response capacity to changes in the environment (Biggs et al., 2012). Thus, considering multiple values, perceptions, and opinions of stakeholders in

scenario building is relevant to the identification of actions that could lead to different pathways (Iwaniec et al., 2020; Lembi et al., 2020; Harmáčková et al., 2021; Pereira et al., 2021).

Scenarios that focus on ecosystem services are relevant to be considered, since they simultaneously address changes in biodiversity and the potential implications this has for human well-being, enabling the identification of synergies and trade-offs (Carpenter et al., 2006). Moreover, participatory scenarios for ecosystem services have been appointed as being useful and informative for decision-making (Rosenthal et al., 2015). Thus, linking the development of participatory scenarios to the ecosystem services concept is relevant to the understanding of how changes in the environment might impact both people and nature.

The Environmental Protected Area of Campinas (APA Campinas, for its Portuguese acronym) is a sustainable-use protected area in southeast Brazil that provides multiple ecosystem services to human well-being locally and regionally (Chapter 1). Several drivers of change simultaneously affect the area, such as urbanization, construction of water dams, and population increase, to name a few (Campinas, 2018, Chapter 1). The availability and quality of ecosystem services have been rapidly changing over the years, generating consequences for human well-being. Thus, the development of scenarios for ecosystem services in the area could be of aid for decision-making that integrates conservation and development now and in the future. Within this context, we aimed at

(i) developing future scenarios for ecosystem services at APA Campinas;
(ii) listing and discussing actions to avoid a business-as-usual scenario and achieve a desirable future.

METHODS

(i) Study area

The Environmental Protected Area of Campinas (APA Campinas) is a sustainable-use protected area located in the city of Campinas, São Paulo state, southeast Brazil (Fig. 3.1). Historically, the area that is currently known as APA Campinas was extensively deforested, especially to make room for extensive

coffee plantations in the late 19th century and early 20th century (Santin, 1999). In 2001, municipal law 10850 officially instituted the current legal status and area of APA Campinas. The area is nowadays described as peri-urban due to its rural and urban features, and land is predominantly covered by pastures, forest fragments, urban settlements, eucalyptus plantations, agriculture, rivers and small water reservoirs (Campinas, 2018). The area is managed by the municipal Secretariat of the Environment. In practice, decision-making is often shared with the deliberative management council which includes local stakeholders such as non-governmental organizations, residents' associations, farmers and landowners' associations and other agencies of the municipal government.

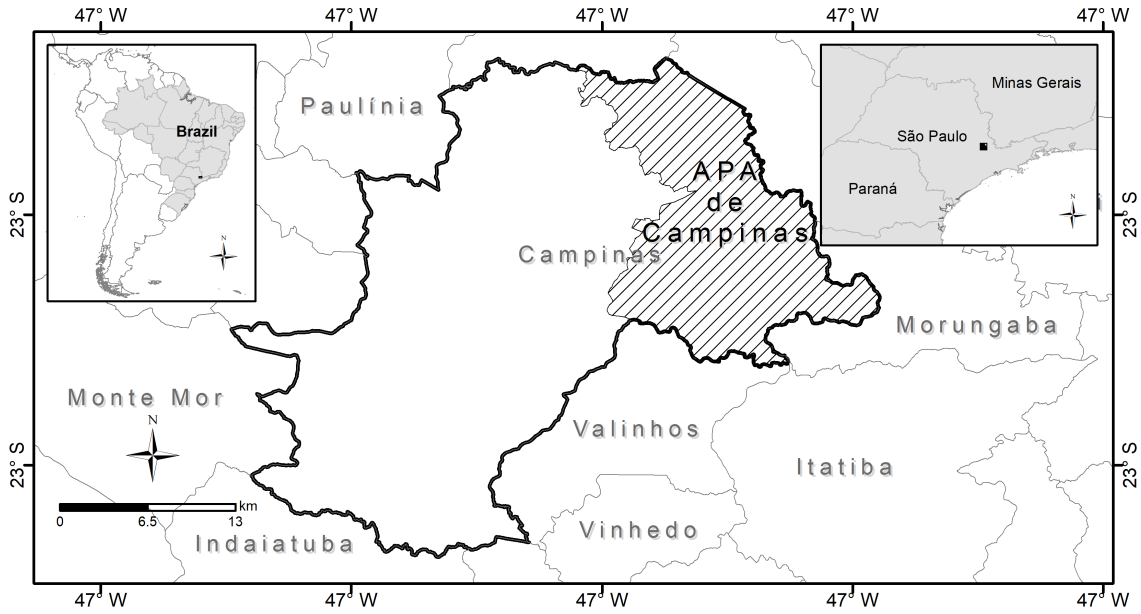

Figure 3.1 – Geographic location and delimitation of APA Campinas within the municipality of Campinas and its metropolitan region, São Paulo state, southeast Brazil

(ii) Data collection and analysis

Data were collected through focus groups, a technique defined as an interactive discussion between a predetermined group of people focused on a specific issue (Hennink, 2014). Focus group discussions are led and facilitated by trained moderators who aim to create an environment in which participants are comfortable to share their views, opinions, and perceptions on the topic of interest (Hennink, 2014). In the context of social-ecological systems, the use of focus group has been commonly deployed as a technique for gathering and

engaging stakeholders to envision and explore scenarios, potentially fostering reflections, building a shared understanding of the system, and informing decision-making (Oteros-Rozas et al. 2015; Rosenthal et al., 2015; Hichert et al., 2021; Shackelton et al., 2021). Hence, we targeted management councilors of APA Campinas and employees from the municipal Secretariat of the Environment to participate in our focus group discussions, since these stakeholders participate in official institutionalized arenas regarding environmental decision-making and have extensive knowledge and experience of the area. Moreover, rapport had been previously established with these stakeholders from participation in meetings and interviews that were conducted for other research purposes (see Chapter 1).

Data collection occurred in two moments through Google Meets videoconferencing platform due to social distancing measures imposed by COVID19 pandemics. In October 2020, management councilors were invited to discuss the future of three ecosystem services, previously identified in Chapter 1: regulation of water quantity, physical and psychological experiences in nature (i.e., nature tourism and scenic beauty) and food production[6] (Appendix 1). The first set of focus group occurred in November 2020. Participants were divided in two small groups and each group was invited to discuss either a likely (i.e., business-as-usual) or a desirable future for these ecosystem services at APA Campinas, considering a 20-year horizon (i.e., 2040). Each small group was tasked with either one of the following questions: “What is the likely future for ecosystem services at APA Campinas, considering the changes that have been taking place over the last 20 years?” and “What is the future you want for ecosystem services at APA Campinas?”. Each of the two small groups had their discussion led by two trained facilitators. A graphic facilitator observed one of the small groups and watched the video recording of the other one to illustrate the likely and the desired future.

In April 2021, we presented the main results from the first set of focus groups in a meeting of the management council where we then invited councilors

[6] We had previously identified on Chapter 1 that these ecosystem services were the most relevant regulating, non-material and material ecosystem service, respectively, to support well-being of the local population at APA Campinas.

to a second workshop (Appendix 3.1). During the second set of focus group, participants were divided in two small groups and discussed the following questions: “What needs to be done to achieve the desired future and avoid the likely future of ecosystem services at APA Campinas? What organizations or who should be responsible for carrying out these measures? What is the urgency of each measure, considering a 20-year horizon?” Differently from the first set of focus group, both small groups discussed the same questions. The same set of facilitators guided the discussions, but there was no graphical facilitation involved at this second round. A summary of the methodological steps is presented in Figure 3.2.

The two set of focus groups occurred within a two-hour timeframe each, since this is usually how long a council meeting lasts, but also because of the online fatigue people in general are experiencing during the pandemics. The discussions were recorded with the consent of participants[7] and were later transcribed with the assistance of oTranscribe web-based application. The analysis of transcripts followed principles of qualitative data analysis based on coding and grouping within themes that emerged from the dataset itself (Saldaña, 2013) and was carried out with the assistance of software QDA Data Miner Lite (Provalis Research). It is worth stressing that while we refer to the utilized technique as focus group, the adopted nomenclature to invite and converse with stakeholders was “participatory workshop”. This is because stakeholders were more familiar with the term, and we do not aim to differentiate them at this work since the nature of our focus group discussions was also participatory (i.e., involved the stakeholders directly connected with the matter of interest). Hence, we utilize the terminologies of focus group discussion and workshop as interchangeable.

[7] Research conducted with approval from ethics committee under permit 20467619.4.0000.8142

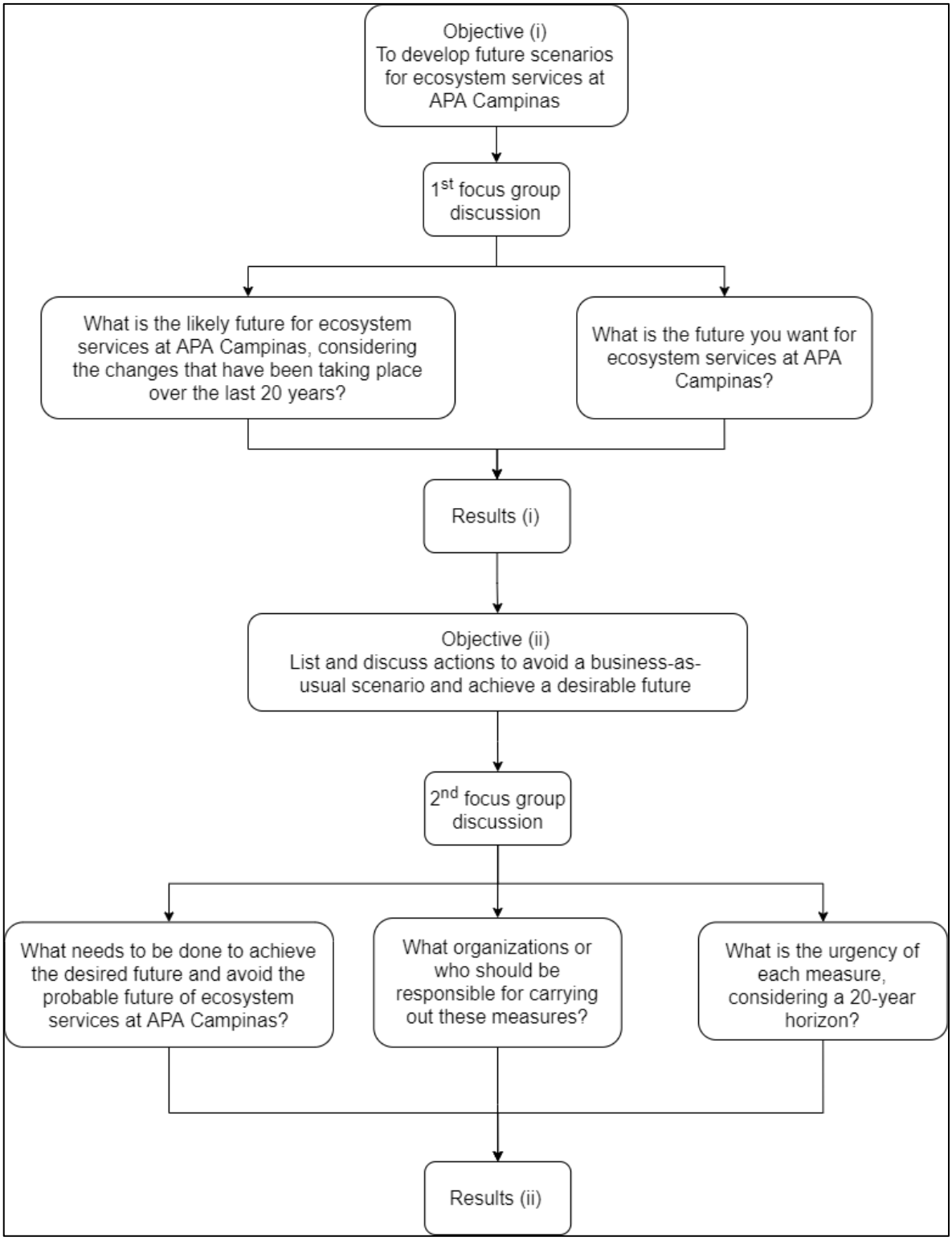

Figure 3.2 – Summary of the methodological steps that were adopted to answer the research objectives and the guiding questions for each of the focus group discussions, presented in chronological order from top to bottom

RESULTS

(i) Business-as-usual and desirable futures for ecosystem services at APA Campinas

- **Profile of the participants in the focus group discussions**

The number of participants and organizations they represent is summarized in Table 3.1. For the first set of focus group, seven people joined the discussion (four women and three men) from municipal government, landowners and farmers' associations, and residents' associations, in equal proportions. At the second set of focus group discussion, thirteen people participated (twelve women and one man), and representatives from NGOs and the municipal government stood out as the most representative. Half of the people that joined the first focus group discussion also participated in the second. The results from the first group discussion had been previously validated in a management council meeting.

Table 1 – Participants and organizations represented in the two sets of focus group discussions in November 2020 and May 2021 on scenarios for ecosystem services of APA Campinas, southeast Brazil

	1st Focus groups discussion (n = 7)	2nd Focus groups discussion (n = 13)
Municipal government		
Secretariat of environment	2	3
Secretariat of planning and urbanism		1*
Non-governamental organizations		
Association for sustainability and environment (ASSUMA)		2*
Association of friends of the protected area of Campinas (APAVIVA)		1
Institute for the study of man-nature relationship		1
Institute for cooperation and development of the total environment		1
Landowners and farmers' associations		
Association of rural landowners (APROAPA)	2	1*
Rural union	1	
Residents' associations		
Association of residents from Botanical Garden neighborhood	1*	1*
Association of residents from Carlos Gomes neighborhood and surroundings	1	2

*On the 1st and 2nd sets of focus groups, respectively 1 and 4 participants did not stay until the end of the workshop. For ASSUMA, one of the participants stayed until the end.

- **Business-as-usual future scenario**

The illustration designed by the graphic facilitator depicts how stakeholders visualize the likely future for ecosystem services at APA Campinas (Fig. 3.3). In different colors, it is possible to see representations of how this scenario will look like for each ecosystem service. There is a transversal axis in gray in the bottom part of the panel that represents aspects that permeate all three ecosystem services.

The business-as-usual scenario highlights that the patterns of change observed from 2000 to 2020 are likely to continue and intensify until 2040, representing an extension of the current reality. This is summarized by one of the participants as "*the likely future, that undesirable future, it is set in the future. But I see many of these situations in the present (…) There are a series of problems that are reported for the future that are already occurring*". For instance, water is perceived as decreasing at APA Campinas over the last 20 years due to erosion of the soil and siltation of watercourses. Participants indicate that this past trend is likely to continue and add that deficient waste management is also impacting the quality of water resources. Consequently, this will lead to water scarcity and water of poor quality in the future.

Nature tourism is perceived as increasing and scenic beauty is perceived as remaining stable from 2000 to 2020. However, when discussing the future scenario for these ecosystem services, participants indicate that negative impacts of visitation itself (e.g., accidental fires caused by tourists, environmental degradation caused by off-road motorcycles) might lead to a decrease in tourism because it will negatively impact the scenic beauty sought by visitors at APA Campinas. Moreover, some impactful activities will intensify the sensation of insecurity among landowners, for instance because visitors often trespass private properties to practice off-road motorcycling. Finally, the lack of other tourism options and the absence of local hotels and inns will restrict tourism to daily activities, which is less profitable for local entrepreneurs. One of the participants summarizes the current tourism and its likely future as "*a tourism that does not bring benefits (..) it is a tourism where people only spend a few hours here and do not consume anything locally*".

Food production is envisioned as continuing to decrease due to rural outmigration, increased costs of production and lack of investment, and increased urbanization. Consequently, this will lead to agriculture that is scarce and less diverse, or to an abandonment of agricultural activities. A farmer describes this future trend and provides some insights into what might happen, considering the current conditions of agriculture at APA Campinas:

> "*If nothing changes in the next 20 years, I won't be complaining about agriculture in 20 years, because I'll have stopped producing in 15 years. If in 5 years the situation worsens, it will be impractical for me to continue working, investing*".

The lack of dialogue among the various local stakeholders and lack of support and public policies from the municipal government affects the three ecosystem services simultaneously. Most participants indicate that because of this APA Campinas is likely to become "abandoned and degraded". Nevertheless, they acknowledge that communication between local stakeholders and the municipal government has improved over the last 20 years. They also perceive that some of the actions from the management plan that contribute to conservation of ecosystem services are likely to be implemented within the next 20 years. However, this is still seen as insufficient to prevent the business-as-usual scenario from occurring. This is summarized in the following quote: "*I try to be optimistic. Because I believe that things will change and develop more than they do today. But, as it is, the tendency is to remain as they are*".

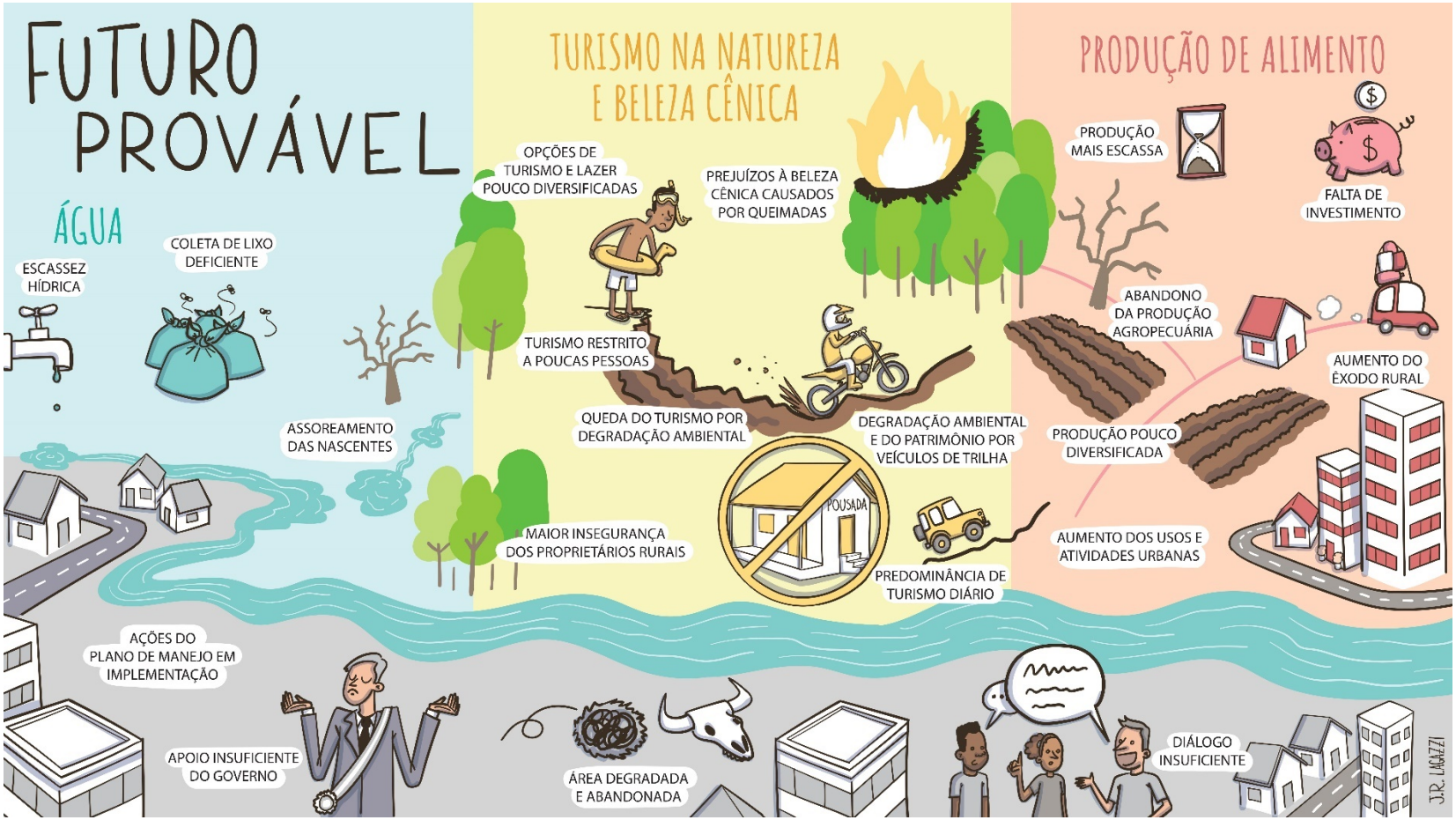

Figure 3.3 – Graphical representation of the scenario that represents the business-as-usual future in 20 years for three selected ecosystem services at APA Campinas obtained through a focus group discussion with management councilors and employees from the municipal Secretariat of the Environment in November 2020. Author: J. R. Lagazzi

- **Desired future scenario**

The graphical representation of the desired future scenario (Fig. 3.4) follows the same pattern of colors for ecosystem services as the probable future scenario (Fig. 3.3). Regarding water, participants highlighted that they wish good quality and quantity (availability) of water in the future. Springs and riparian forest are envisioned as recovered, allowing for groundwater to be recharged. Local actions to retain rainwater (e.g., construction of small reservoirs) are mentioned as implemented on the ground. In parallel, participants also considered that the future conditions of water depend on actions that occur at the regional level of the watershed and on the availability of data to guide decision-making. Thus, coordination among different municipalities regarding the necessary interventions and monitoring of the water cycle is envisioned as desired for the future. A vision of the desired scenario for water is described by one the participants as:

> *"I would like in 20 years from now, but, if possible, in 5 years, that the Atibaia river returns to its normal level. I used to paddle in the Atibaia River in my teens, and today it is impossible to paddle in the river, either because it is silted up, with low water levels, or because the water is practically concentrated sewage".*

This quote also relates to nature tourism (paddling in the river). Specifically for tourism and scenic beauty, participants desire a future with information, infrastructure (e.g., better road access and informative signs, options for overnight stay), safety and law enforcement, and educated and sensibilized visitors. Tourism is highlighted as a bridge to integrate conservation and development, as expressed in the quote: "*tourism is one of the main attractions that can bring sustainability linked to environmental protection*". Furthermore, attention is also called to the importance of involving private landowners in tourism planning, considering that the majority of APA Campinas comprises private rural properties (Campinas, 2018). This is described by one of the participants: "*we have to work to create conditions for the rural landowner to be interested in promoting some type of tourism activity in his area*".

The desired scenario for food production includes the diversification of agriculture, and its integration with local eucalyptus forestry. The creation of a

brand for food grown and produced at APA Campinas (i.e., a certification scheme) is envisioned in the desired future, with high aggregated monetary value and an integrated purchase and distribution logistics with local markets. As one of the participants describes: “*we need a product that is different, and we have to run away from the production of commodities*.”

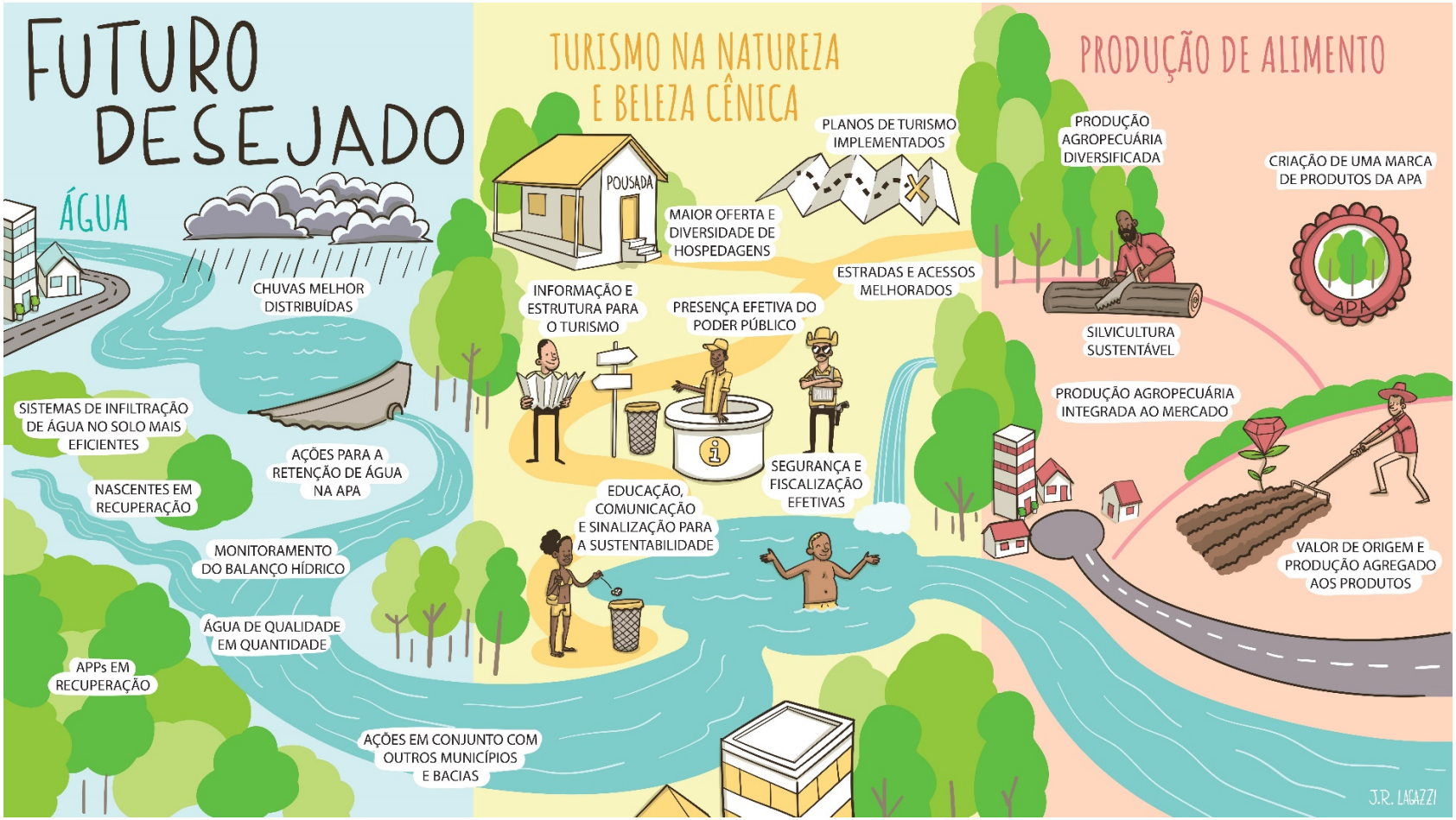

Figure 3.4 – Graphical representation of the scenario that represents the desired future in 20 years for three selected ecosystem services at APA Campinas obtained through a focus group discussion with management councilors and employees from the municipal Secretariat of the Environment in November 2020. Author: J. R. Lagazzi

(ii) Actions and challenges to avoid a business-as-usual scenario and achieve a desired future

In order to avoid the business-as-usual future and achieve the desired future for ecosystem services, participants of the 2nd workshop identified issues and challenges that should be considered, alongside possible management actions that could contribute to overcoming them. Findings were coded within four major categories: collaborative management; communication and education; infrastructure, regularization of land and law enforcement; integrated conservation and development. These categories are not discrete, and some degree of overlap between what is described within each category is expected.

A list of challenges that hamper collaboration or inhibit stakeholder participation is identified within the collaborative management category (Table 3.2). For instance, the lack of social empowerment, political mobilization, and participation in decision-making arenas by the local population is indicated as a challenge for achieving the desired scenario. Participants perceived that this lack of participation makes the population unaware of the processes that occur at APA Campinas, consequently facilitating the implementation of top-down decisions by decision-makers that do not necessarily safeguard biodiversity and ecosystem services. Rather, as the likely future suggests, it enables the implementation of actions that benefit the expansion of urban areas. Thus, in order to achieve the desired scenario, actions that foster collaboration between stakeholders that share a similar vision of a desired future is perceived as necessary.

Table 3.2 – Challenges, issues and management actions regarding collaborative management that were identified to achieve a desired scenario and avoid a business-as-usual scenario for ecosystem services at APA Campinas, southeast Brazil, obtained through a focus group discussion with management councilors and employees from the municipal Secretariat of Environment in May 2021 (n = 13)

	Challenges and issues	**Management actions**
Collaborative management	• Lack of social empowerment and participation of the local population in local projects, initiatives, and decision-making arenas • Lack of political mobilization of the local population • Lack of coordination and communication within the different secretariats and departments of the municipal government • Lack of communication between municipal government and local stakeholders, and within local stakeholders • Top-down decisions taken by the mayor and city councilors • Lack of personnel and funding at the Secretariat of the Environment to implement the outlined actions at management plan	• Foster community engagement in local projects and participatory processes • Foster alliances and partnerships outside the management council • Implement projects that require collaborative work • Monitoring of political decisions and debates of city council and mayor • Learn from examples of collaborative management present at other municipalities and protected areas • Collaborative projects between Secretariat of Environment and other stakeholders to apply and obtain funding from other national and international agencies and implement the outlined actions from the management plan • Diversify communication channels between stakeholders

Actions such as fostering alliances and partnerships through the implementation of collaborative projects that aggregate multiple stakeholders is appointed as potentially contributing on this behalf. Transparent communication is also perceived as a key element, with the necessity of diversifying communication channels between local stakeholders. An emphasis is given to communication with the municipal government. This dialogue is also referred to as relevant to improving and fostering trust building, which may mitigate potential conflicts. This is summarized in the following quote:

> "*If we were really together, if we had unity in decision-making, and (if we) envisioned the environmental area as a collective good that has immeasurable long-term impacts for health, for well-being, for biodiversity, I think management would be much easier*".

Another important aspect is the implementation of the management plan. The plan was elaborated over a two-year period by a private consultancy under the supervision of the Secretariat of the Environment and appoints multiple actions divided among nine programs to concretely achieve its goals (e.g., program for sustainable tourism, program for conservation and restoration of biodiversity) (Campinas, 2019). However, the management of all six protected areas in the municipality (including APA Campinas) is conducted by only four people within the Secretariat. Such situation emphasizes the necessity of collaboration. Moreover, limited financial resources allocated to protected area management within the municipality indicate a need for other sources of funding outside the municipal scope.

The communication and education category refers to the challenge that the lack of knowledge and sensibilization of stakeholders poses to achieve the desired future (Table 3.3). For instance, participants cited that most of the local population and visitors are not even aware that they are inside a protected area with specific laws and regulations. Furthermore, because of the great number of institutions currently in effect at APA Campinas, management councilors themselves are sometimes unsure about which activities are allowed or forbidden. The population and tourists are often insensitive to local environmental conditions, and practices such as littering and trespassing of private properties take place. This is summarized in the following quote:

> "*Environmental education is fundamental so that any new residents of APA Campinas may know where they are and their rights and duties. Everyone who comes here thinks that because they bought a little piece of land, they can do what they want with it, and things don't work like that*".

Hence, informational and educational campaigns are seen as necessary to address such challenges and to avoid the business-as-usual future for ecosystem services. The implementation of actions that stimulate care towards the territory among tourists and residents, based on the dissemination of information and knowledge, is seen as a pathway to achieve the desired future scenario. Participants perceive that such campaigns may be more effective if targeting children in schools and fostering a sense of place and stewardship.

Table 3.3 – Challenges, issues and management actions regarding communication and education that were identified to achieve a desired scenario and avoid a business-as-usual scenario for ecosystem services at APA Campinas, southeast Brazil, obtained through a focus group discussion with management councilors and employees from the municipal Secretariat of Environment in May 2021

	Challenges and issues	**Management actions**
Communication and education	• Lack of awareness by local population and visitors that APA Campinas is a protected area with specific regulations, laws and institutions • Lack of awareness by local population and visitors about allowed and forbidden local activities • Lack of sensibilization of the population to local socioenvironmental issues	• Information points and available informative material in accessible language detailing current regulations, laws and institutions • Local educational campaigns to foster sense of place and stewardship among residents, tourists, farmers, and landowners • Development of environmental education programs at local schools

Infrastructure, land regularization and law enforcement are also perceived as essential for avoiding the probable future (Table 3.4). Participants stressed the existence of long-established rural neighborhoods (e.g., over 40 years) which are not yet officially regularized by the municipal government. Land regularization is seen as fundamental to achieve a desired scenario, so that these areas are incorporated to official management and planning. Some rural neighborhoods lack proper sanitation systems, and suffer from deficient waste collection systems, poor internet and phone service, and unpaved roads that hamper vehicle access. More efficient waste collection systems and overall infrastructure improvement are seen as necessary to improve environmental conditions and well-being. Moreover, there is an overall sensation of a decrease in safety, as petty crimes and burglaries have become more common over the years. Hence, management actions to increase overall policing and law enforcement are appointed as necessary to achieve the desired scenario. Participants claim that they often report irregular activities to authorities, but seldom see any response and indicate that communication with the police should be improved.

Table 4 – Challenges, issues and management actions regarding infrastructure, land regularization and law enforcement that were identified to achieve a desired scenario and avoid a business-as-usual scenario for ecosystem services at APA Campinas, southeast Brazil, obtained through a focus group discussion with management councilors and employees from the municipal Secretariat of Environment in May 2021

	Challenges and issues	**Management actions**
Infrastructure, land regularization and law enforcement	• Deficient waste collection and disposal • Absent sanitation system in some areas • Poor maintenance of unpaved roads in rural areas • Poor internet service in rural areas • Increased criminality and burglaries • Irregular rural neighborhoods (i.e., not regularized by municipal government)	• Improve waste management and recycling systems and educational campaigns to inform population about correct waste disposal • Construction of sanitation systems • Increase maintenance frequency of unpaved roads • Increase policing, law enforcement and other community-based security measures • Improve communication channels to report crimes and irregular activities • Regularization of irregular neighborhoods by the municipal government

Integrated conservation and development theme refers to the challenges and measures that involve both economic development and biodiversity conservation (Table 3.5). Firstly, the perceived dichotomy between conservation and development itself is reported as a challenge for achieving the desired scenario. In order to overcome this, inclusive models of development that consider the reality of people from different socioeconomic backgrounds at APA Campinas is seen as necessary. Educational campaigns are cited as a way to raise awareness about opportunities for integrating conservation and development. The development of rural areas through management actions such as integration of local rural products with local markets and the creation of a specialized Secretariat of Agriculture in the municipal government is also mentioned. In parallel, widening the scope and increasing funding of the municipal payment for environmental services program are manners to integrate rural development with conservation of biodiversity.

Table 3.5 – Challenges, issues and management actions regarding integrated conservation and development that were identified to achieve a desired scenario and avoid a business-as-usual scenario for ecosystem services at APA Campinas, southeast Brazil, obtained through a focus group discussion with management councilors and employees from the municipal Secretariat of Environment in May 2021

	Challenges and issues	**Management actions**
Integrated conservation and development	• Increased agricultural production costs • Lack of a Secretariat of Agriculture to support the development of rural areas • Deforested riparian forests • Perceived dichotomy between conservation and development among stakeholders	• Integration between local rural production to local markets • Implementation of a specialized Secretariat of Agriculture to sustainably develop rural areas • Increase available resources for farmers and landowners to reforest land • Widen the scope and funding for the payment for environmental services program • Education and communication campaigns to raise awareness and sensibilize stakeholders about means to integrate conservation and development • Adoption of inclusive models of development

The implementation of the identified management actions is overall perceived as heavily relying on the leadership and work of the municipal government. Participants agree that the Secretariat of the Environment, which is the official manager of the protected area, should be present and involved with all the actions. Collaborative work with NGOs, residents' associations, farmers and landowners' associations, other municipal secretariats and departments is also considered important, however secondary. For some of the specific actions, a few other organizations are cited. For instance, the possible involvement of the State Coordination of Sustainable Rural Development in rural development planning and actions; the State Road Department in infrastructure issues; and the management council acting as a bridging organization facilitating collaborative management and networking among stakeholders.

All the actions listed by participants were perceived as urgent, especially those within collaborative management and infrastructure. There was no consensus regarding what should be prioritized. The 20-year horizon proposed for the discussion (i.e., 2040) was considered too long to implement the actions and achieve the desired scenario. Thus, according to the stakeholders, all of the

issues and challenges should be tackled as soon as possible, or otherwise the business-as-usual future will be unlikely to avoid.

DISCUSSION

Participatory scenario development enables collective reflections, facilitates the mobilization of stakeholders, and enriches both scientific research and management processes (Oteros-Rozas et al., 2015). Furthermore, the representation of the scenarios using artistic illustrations has the potential to increase the possibility of stakeholders using them as a tool to initiate and foster dialogues (Bennett et al., 2017; Vos et al., 2021). Considering that collaboration and communication were identified as key elements in achieving the desired future, the utilized method and obtained results of this research could contribute to this regard.

The explicit consideration of a desirable and a plausible future is relevant within scenario development to foster action in the present (Costanza & Kubiszewski, 2014; Bai et al., 2016). This occurs through anticipatory planning: by thinking about the future, we can better plan to it and change actions and decisions in the present (Iwaniec et al., 2020). The development of an explorative scenario (business-as-usual future) and a target-seeking scenario (desirable future) enabled the identification of differences between them, thus facilitating the identification of actions that can potentially contribute to avoiding an undesirable trajectory. The identified actions were aligned with several of the outlined propositions by the programs of the management plan (Campinas, 2019), indicating synergy between our findings and the plans for APA Campinas.

An emergent theme identified in the process of data collection and analysis is the necessity of improved collaboration among stakeholders for the desired scenario to be achieved. Collaborative management or co-management refers to an approach of management that focuses on the development of connections between stakeholders through collaboration, thus enabling joint decision-making with shared responsibilities (Berkes, 2009; Plummer et al., 2012). While the results of the focus group discussion highlight collaboration, Berkes (2009) observes that this type of approach evolves over time to include components related to learning and adapting. Adding a layer of experimental and experiential

“learning by doing” to collaborative management defines adaptive co-management (Armitage et al., 2009). Adaptive co-management calls attention to the importance of relations within management, with a focus on the importance of institutional settings where trust can be built and lessons can be learned and applied (Armitage et al., 2009; Plummer et al., 2012).

According to Olsson et al. (2004), there are a set of essential features for the implementation of adaptive co-management, such as funding to enable responses to change, diverse sources of information and monitoring of the environment, and arenas for collaborative learning and management. Empirical experiences in Brazil also list conditions that foster adaptive co-management, such as trust building, the resolution of conflicts between governmental agencies and stakeholders, and integration of conservation to local development (Silva et al. 2013; Schröter et al. 2014; Trimble & Berkes 2015; Freitas & Seixas, 2020). Further, collaboration is appointed as also being possibly enhanced by factors such as implementation of participatory projects, sharing of information, development of training courses (Kalikoski et al., 2009; Seixas et al. 2019). Our research corroborates these previous findings, with stakeholders listing actions to foster collaboration such as implementation of projects that require collaborative work, fostering alliances and partnership outside the management council, diversifying and increasing participation of stakeholders.

The management plan recognizes the relevance of adaptive co-management and proposes a model of collaborative and adaptive governance for APA Campinas based on Armitage et al. (2008) and Borrini-Feyerabend et al. (2013). However, one of the main challenges is how to concretely implement what is predicted at the management plan and the other listed actions to achieve a desired future. Distinctions between what is institutionally established (“de jure”) and what happens in reality (“de facto”) is common in protected area management (Borrini-Feyerabend et al., 2013). Mismatches between the perceived relevance of protected areas and allotted budgets by government agencies is also a challenge (Adams et al., 2008), and funding and personnel issues appears to be a key in this regard at APA Campinas. Hence, considering the management actions highlighted by the participants of the focus group discussion, achieving the means to establish a desired scenario suggests two

complementary possibilities: a political mobilization to pressure municipal politicians to direct more personnel and budget to APA Campinas; or the fostering of local initiatives and partnerships to access funding from regional, national or international agencies. Through these two possibilities, the four major categories of issues and challenges could be transversally approached. Further research on possible financial mechanisms for the management of APA Campinas could be beneficial in this regard.

The management plan of APA Campinas was elaborated in a participatory process and describes its vision for the future as “to be recognized as a sustainable-use protected area within a metropolitan context, where human beings and nature are mutually benefited, creating prosperity” (Campinas, 2018). The mission (i.e., the reason for existence) is “to improve the quality of life through the valorization, protection and strengthening of the natural and sociocultural heritage, guaranteeing ecological functions, the conservation of biodiversity and water production”. Considering the obtained results at this research, we expect to contribute to achieving the vision and mission of APA Campinas.

CONCLUDING REMARKS

In our study, we developed a business-as-usual and a desirable scenario for ecosystem services and combined them with an arts-based technique (graphical facilitation) to clearly depict the difference between two distinct futures. The utilization of the ecosystem services concept was useful to focus scenario development on key elements of the social-ecological system that link nature to human well-being. Our methodological approach enabled a clear visualization of differences between pathways, graphically showing how they could look like. Hence, it was also possible to identify and describe management actions that can potentially aid in reducing the distance between a future that is likely and a future that is desired. Overall, a management approach that is collaborative and adaptive was stressed as needed to overcome the business-as-usual scenario. Likewise, numerous challenges were also stressed, especially regarding funding and implementation of actions on the ground. In this regard, the concept of adaptive co-management offers a working framework for reflection on how decision-making is being carried out at APA Campinas. While findings of this

research might contribute to achieving a desired future for people and nature, it is important to stress that proposed management approaches such as adaptive co-management are on-going processes in space and time. The punctual implementation of actions listed in this research is likely to be insufficient to concretely achieve the desired scenario. It is necessary to go beyond and foster adaptive co-management as a way of thinking and dealing with decision-making, while aiming to achieve the depicted desired scenario.

CONSIDERAÇÕES FINAIS

Nesta dissertação, investigamos as mudanças no sistema socioecológico da Área de Proteção Ambiental de Campinas sob a perspectiva do estado e tendências passadas dos serviços ecossistêmicos (Capítulo 1), das mudanças no uso e cobertura da terra (Capítulo 2) e do desenvolvimento de cenários futuros para os serviços ecossistêmicos (Capítulo 3). A integração de métodos qualitativos com métodos geoespaciais se revelou uma útil ferramenta para uma compreensão sistêmica das mudanças socioecológicas na APA de Campinas, corroborando outros estudos que também se valeram da utilização de métodos mistos (Hodbod et al., 2019).

No capítulo 1, utilizamos a percepção e conhecimento dos membros do conselho gestor da APA de Campinas (gestão 2018-2020) para identificar 15 serviços ecossistêmicos que ocorrem na localidade e que contribuem para o bem-estar da população local, sendo a produção de alimento, a regulação da quantidade de água e as experiências físicas e psicológicas na natureza os mais relevantes, respectivamente, para as categorias de contribuições material, de regulação e imaterial para as pessoas. Identificamos e avaliamos também como estes serviços ecossistêmicos se modificaram no período de 2000 a 2020, os principais fatores socioecológicos que influenciaram as mudanças em sua disponibilidade e qualidade, e como estes fatores se manifestam nas áreas urbanas e rurais. De modo geral, a urbanização tem afetado os serviços ecossistêmicos, e alguns dos processos interagem na forma de mecanismos de retroalimentação amplificadores (f*eedbacks*). Em nosso estudo, os *feedbacks* foram modelados e representados graficamente através de *causal-loop diagrams*, possibilitando uma compreensão sistêmica de como estes fatores operam na APA de Campinas. Os *feedbacks* amplificadores agem como forças de mudanças incrementais no sistema socioecológico e estão possivelmente induzindo a APA a um estado cada vez mais urbanizado. Diversos atores locais percebem e reagem às mudanças na APA de Campinas, implementando ações que visam a conservação dos serviços ecossistêmicos locais, embora seja necessária a implementação de ações que conservem múltiplos serviços simultaneamente. Apesar da sua importância no estudo da dinâmica de sistemas, exemplos empíricos de identificação e gestão de *feedbacks* ainda são

incipientes na literatura científica (Biggs et al., 2012), sendo este capítulo inovador neste âmbito.

No capítulo 2, utilizamos dados secundários do MapBiomas para avaliar as mudanças no uso e cobertura da terra na APA de Campinas. Utilizamos dois marcos institucionais para embasar a escolha de anos em nossa análise. Em 1993, criou-se as Áreas de Proteção Ambiental de Sousas e Joaquim Egídio, abrangendo estes dois distritos de Campinas (Decreto Municipal 11.172/93). Em 2001, a Lei 10.850/01 criou a Área de Proteção Ambiental de Campinas, aumentando a área da antiga APA em 43% ao incluir os bairros Carlos Gomes, Chácaras Gargantilha e Jardim Monte Belo. Por fim, utilizamos os dados disponíveis para o ano de 2019 como representativo da realidade atual da APA de Campinas. Consideramos a área atual da APA como parâmetro para análise de mudanças, haja vista que objetivamos compreender como o que hoje conhecemos como sendo a APA de Campinas se alterou ao longo do tempo. Entre os principais achados sobre as mudanças no uso e cobertura do solo de 1993 a 2019, ressalta-se a diminuição de áreas dedicadas a pastagem, em contraponto ao aumento de florestas, plantações de eucalipto e áreas urbanas. Os processos que vêm ocorrendo na APA de Campinas são semelhantes a outras áreas do estado de São Paulo, indicando a possibilidade de aprendizados a partir do que já se sabe sobre gestão e conservação em outros contextos (p. ex., Silva et al., 2016). Uma das motivações para realização deste capítulo foi a diferença de percepção entre stakeholders em relação ao desmatamento na APA de Campinas que foi detectada no capítulo 1. Alguns conselheiros, principalmente os habitantes dos centros urbanos, relatam uma diminuição nas formações florestais, enquanto os moradores de áreas rurais relatam aumento em área dos fragmentos florestais. De modo geral na APA, detectamos um aumento na cobertura florestal, incluindo um ganho líquido de 171.7 ha na zona de ocupação controlada (*controlled urbanization zone*). Simultaneamente, também detectamos que 29.6 ha de infraestrutura urbana se expandiram em detrimento de áreas de formação florestal entre 2001 e 2019. Considerando que as áreas urbanas são restritas à zona de ocupação controlada, é possível inferir que a percepção sobre cobertura florestal de habitantes de centros urbanos esteja embasada nos hectares que foram desmatados para expansão urbana.

No caso da percepção dos habitantes de áreas rurais, estão de acordo com a tendência geral de aumento de florestas geral para toda a APA.

No capítulo 3, desenvolvemos de forma participativa um cenário provável e um cenário desejado para os serviços ecossistêmicos mais relevantes que haviam sido identificados no capítulo 1. Utilizando a técnica de grupo focal, foi possível obter painéis que graficamente ilustravam os dois diferentes futuros. Deste modo, identificamos possíveis ações para a gestão e planejamento da APA de Campinas que possam ajudar a evitar o futuro provável e alcançar o futuro desejado. A necessidade de uma gestão colaborativa entre múltiplos atores locais emergiu em nossa análise como um dos principais fatores a serem levados em consideração na implementação das ações identificadas, e o conceito de cogestão adaptativa se revela como um útil arcabouço para concretizar a adoção de tais medidas. Este capítulo surge a partir da indagação de quais seriam os possíveis futuros para os serviços ecossistêmicos na APA de Campinas, haja vista que os capítulos anteriores delimitaram um panorama do estado e tendências passadas. Deste modo, como um todo, buscamos olhar para o passado, presente e possíveis futuros da APA de Campinas, utilizando o conceito de serviços ecossistêmicos como as lentes de nossa análise.

Apesar da estrutura da dissertação estar separada em capítulos cuja leitura pode ser realizada de maneira separada, consideramos que existem mensagens-chave gerais que podem ser extraídas da pesquisa como um todo. Nestas considerações finais, a partir dos resultados empíricos de nossa pesquisa, concluímos e ressaltamos os seguintes pontos:

- A APA de Campinas é uma importante área provedora de serviços ecossistêmicos que contribuem para a qualidade de vida de sua população local, ao mesmo tempo que possui relevância para o bem-estar humano em nível municipal e regional;
- Cada vez mais, a APA se afasta de sua importância histórica como polo de agricultura (século XIX e início do século XX), e se torna uma área de relevância ambiental devido aos seus fragmentos florestais, rios, nascentes e riachos, e de relevância turística, devido às paisagens rurais e seus ativos naturais;

- As áreas de pasto vêm diminuindo, mas ainda são as mais representativas no uso do solo. Em contraponto, florestas, plantações de eucalipto e áreas urbanas tem aumentado;
- A APA de Campinas se destaca como área para visitação com fins de recreação e lazer para os habitantes de áreas urbanas que buscam contato com a natureza, e vêm atraindo cada vez mais moradores em busca de qualidade de vida;
- A urbanização afeta a dinâmica socioecológica local, potencialmente induzindo a APA a um estado cada vez mais urbanizado, através de mecanismos de retroalimentação amplificadores (*feedbacks*);
- Existem iniciativas, projetos e organizações que atuam localmente visando a conservação de serviços ecossistêmicos, e que podem ser fontes de inspiração para integração entre conservação e desenvolvimento local em uma escala mais ampla;
- Um futuro desejado para os serviços ecossistêmicos inclui água de qualidade em quantidade, produção agrícola diversificada e com valor agregado, turismo na natureza consciente e sustentável que sensibiliza os visitantes;
- Um futuro provável para os serviços ecossistêmicos inclui escassez hídrica, produção agrícola pouco diversificada e não-rentável, turismo depredatório na natureza e que não gera desenvolvimento socioeconômico;
- Ações para se alcançar um futuro desejado necessitam de uma gestão colaborativa entre os múltiplos atores locais, mas desafios como falta de financiamento e recursos humanos afetam a potencial implementação de tais ações.

Considerando o objetivo geral proposto de avaliar o estado e tendências dos serviços ecossistêmicos na APA de Campinas, é possível concluir que a pesquisa responde a esta pergunta ao traçar um panorama das principais mudanças na APA de Campinas, e como isto se reflete nas dimensões socioecológicas do seu estado atual. Entretanto, existem lacunas de conhecimento que foram identificadas e que potencialmente contribuem para uma resposta ainda mais abrangente deste objetivo geral. Entre elas, destaca-

se (i) a necessidade de estudos que tenham como alvo os proprietários rurais da APA de Campinas, de modo a compreender as percepções e valores que estes possuem, e como isso se relaciona às decisões que tomam em relação ao uso da terra; (ii) a investigação e monitoramento de iniciativas, projetos e organizações que integram a conservação dos serviços ecossistêmicos e desenvolvimento local, e quais oportunidades e desafios existem para o seu fomento e expansão; (iii) o estudo de alternativas para o modelo de urbanização atual que é pautado na especulação imobiliária e expansão urbana através da construção de condomínios; (iv) pesquisas sobre esferas de governança da APA para além do Conselho Gestor, e como esta governança ampliada afeta a provisão de serviços ecossistêmicos e o bem-estar humano. Assim, reitera-se aqui os aportes da pesquisa acadêmica em responder perguntas, mas também sua capacidade de gerar novos questionamentos.

Finalmente, a presente dissertação é uma contribuição científica ao estudo dos serviços ecossistêmicos e de suas dinâmicas em sistemas socioecológicos, enquanto também se revela como importante fonte de informações que potencialmente pode embasar a tomada de decisão local. Assim, esperamos contribuir para que a APA de Campinas seja uma unidade de conservação de referência, onde conservação e desenvolvimento sejam integrados de modo a garantir a provisão de serviços ecossistêmicos para a qualidade de vida de seus habitantes e frequentadores.

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APÊNDICES

APÊNDICE I.1 – TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO UTILIZADO NA PESQUISA

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Serviços ecossistêmicos e suas contribuições para o bem-estar humano na Área de Proteção Ambiental de Campinas (APA Campinas)
Pesquisador: Rafael Cavalcanti Lembi
Orientadora: Dra. Cristiana Simão Seixas
Número do CAAE: 20467619.4.0000.8142

Você está sendo convidado a participar de uma pesquisa. Este documento, chamado Termo de Consentimento Livre e Esclarecido, visa assegurar seus direitos como participante da pesquisa e é elaborado em duas vias, assinadas e rubricadas pelo pesquisador e pelo participante/responsável legal, sendo que uma via deverá ficar com você e outra com o pesquisador. Por favor, leia com atenção e calma, aproveitando para esclarecer suas dúvidas. Se houver perguntas antes ou mesmo depois de assiná-lo, você poderá esclarecê-las com o pesquisador. Se preferir, pode levar este Termo para casa e consultar seus familiares ou outras pessoas antes de decidir participar. Não haverá nenhum tipo de penalização ou prejuízo se você não aceitar participar ou retirar sua autorização em qualquer momento.

Justificativa e objetivos:

Estudar como a natureza influencia na qualidade de vida das pessoas é fundamental para entender as dimensões em que os sistemas ecológicos se relacionam com os sistemas sociais. Serviços ecossistêmicos (SE) são os benefícios que obtemos da natureza, e bem-estar humano é uma abordagem para se avaliar diferentes dimensões daquilo que caracteriza a qualidade de vida. Neste contexto, a Área de Proteção Ambiental de Campinas (APA Campinas) é uma área de interesse para conduzir pesquisas entendendo relações entre SE e bem-estar humano, haja vista possuir simultaneamente população residente, produção rural, e fragmentos de matas. A presente pesquisa pode subsidiar intervenções com vista à conservação e desenvolvimento integrados neste ambiente. O objetivo principal deste estudo é entender o estado e as tendências dos serviços ecossistêmicos e suas contribuições para o bem-estar humano na APA Campinas, e para isso serão realizadas as seguintes etapas: (i) identificar os serviços ecossistêmicos considerados prioritários para o bem-estar da população da APA; os vetores de mudança destes SE; e as respostas a estas mudanças nos SE, (ii) avaliar o estado dos serviços ecossistêmicos prioritários, (iii) valorar os serviços ecossistêmicos prioritários.

Procedimentos:

Participando do estudo você está sendo convidado a responder a uma entrevista, com duração máxima de 40 minutos. Os dados coletados serão guardados por no mínimo 5 (cinco) anos e estarão sob a responsabilidade do pesquisador responsável.

Desconfortos e riscos:

A pesquisa não apresenta riscos previsíveis, e a qualquer momento você poderá interrompê-la caso não deseje mais participar.

Benefícios:

Não há benefícios diretos. Ao participar da pesquisa, você estará contribuindo para o meu projeto de pesquisa, e diretamente auxiliando na compreensão dos serviços ecossistêmicos presentes na APA Campinas, suas relações com o bem-estar humano, e como isso pode subsidiar a gestão da unidade de conservação.

Acompanhamento e assistência:

O pesquisador responsabiliza-se pela assistência integral aos participantes da pesquisa no que se refere às complicações e danos decorrentes da pesquisa.

Sigilo e privacidade:

Você tem a garantia de que sua identidade será mantida em sigilo e nenhuma informação será dada a outras pessoas que não façam parte da equipe de pesquisadores. Na divulgação dos resultados desse estudo, seu nome não será citado.

Ressarcimento e Indenização:

O participante de pesquisa e seu(s) acompanhante(s) têm direito a ressarcimento dos gastos decorrentes da pesquisa. Você terá a garantia ao direito à indenização diante de eventuais danos decorrentes da pesquisa.

Contato:

Em caso de dúvidas sobre a pesquisa, você poderá entrar em contato com o pesquisador Rafael Cavalcanti Lembi, que pode ser contatado através do e-mail rclembi@gmail.com ou pelo telefone (31) 99916-8798, e também através do endereço profissional do Núcleo de Estudos e Pesquisas Ambientais (NEPAM) da UNICAMP, na Rua dos Flamboyants, nº 155, Cidade Universitária, Campinas-SP, CEP 13083-867, e telefone (19) 3521-7690. Caso não seja possível, a orientadora do estudo Cristiana Simão Seixas também poderá ser contatada através do e-mail cristiana.seixas@gmail.com, e mesmo telefone e endereço profissional do NEPAM.

Em caso de denúncias ou reclamações sobre sua participação e sobre questões éticas do estudo, você poderá entrar em contato com a secretaria do Comitê de Ética em Pesquisa em Ciências Humanas e Sociais (CEP/CHS) da UNICAMP das 08:00hs às 11:30hs e das 13:00hs as 17:30hs na Rua: Av. Bertrand Russell, 801, 2º Piso, Bloco C, Sala 5, CEP 13.083-865, Campinas-SP, Brasil; telefone (19) 3521-6836; e-mail: cepchs@unicamp.br.

O Comitê de Ética em Pesquisa (CEP).

O papel do CEP é avaliar e acompanhar os aspectos éticos de todas as pesquisas envolvendo seres humanos. A Comissão Nacional de Ética em Pesquisa (CONEP), tem por objetivo desenvolver a regulamentação sobre proteção dos seres humanos envolvidos nas pesquisas. Desempenha um papel coordenador da rede de Comitês de Ética em Pesquisa (CEPs) das instituições, além de assumir a função de órgão consultor na área de ética em pesquisas

Consentimento livre e esclarecido:

Após ter recebido esclarecimentos sobre a natureza da pesquisa, seus objetivos, métodos, benefícios previstos, potenciais riscos e o incômodo que esta possa acarretar, aceito participar:
Nome do (a) participante: _____
Contato telefônico: _____
e-mail (opcional): _____
(Assinatura do participante ou nome)
Data: ____/_____/_____

Responsabilidade do Pesquisador:

Asseguro ter cumprido as exigências da resolução 466/2012 CNS/MS e complementares na elaboração do protocolo e na obtenção deste Termo de Consentimento Livre e Esclarecido. Asseguro, também, ter explicado e fornecido uma via deste documento ao participante. Comprometo-me a utilizar o material e os dados obtidos nesta pesquisa exclusivamente para as finalidades previstas neste documento ou conforme o consentimento dado pelo participante.

(Assinatura do pesquisador)
Data: ____/_____/_____.

APÊNDICE I.2 – ROTEIRO DE ENTREVISTA UTILIZADO PARA COLETA DE DADOS

Entrevista no.:

Data:

Horário de início da entrevista:

Apresentação pessoal e justificativa da pesquisa; esclarecer que estou acompanhando o CONGEAPA.

Esclarecer TCLE, confidencialidade dos dados e que deve responder livremente (não há respostas certas ou erradas).

Organização que representa no CONGEAPA:

Etapas iniciais

1) Há quanto tempo você conhece e frequenta a APA? Quais áreas você mais conhece? Quais bairros você nunca foi?

2) Qual instituição representa no CONGEAPA?

3) Qual o cargo nesta instituição?

4) Há quanto tempo representa esta instituição no CONGEAPA?

5) Qual o papel do CONGEAPA para a APA?

6) Há limitações para a realização deste papel? Se sim, quais?

7) Participou do processo de elaboração do plano de manejo?

a) ( ) Não ( ) Sim

b) Se sim, de que maneira?

Serviços ecossistêmicos e bem-estar humano

8) Você conhece o termo serviços ecossistêmicos? ( ) Sim ( ) Não

9) O que você entende pelo termo serviços ecossistêmicos?

Esclarecimento da definição: uma forma de se pensar nos serviços ecossistêmicos, são os benefícios que nós obtemos da natureza. Os benefícios podem ser materiais (algo que retiramos da natureza), imateriais (que tem a ver com a nossa relação com a natureza) e benefícios de regulação (que são os processos da própria natureza). Estas três categorias de benefício nos trazem qualidade de vida.

10) Com base nesta explicação, quais benefícios da natureza que podemos encontrar na APA que contribuem para a qualidade de vida das pessoas?

11) Destes benefícios da natureza que você listou, quais são os 3 mais importantes para a qualidade de vida da população da APA?

Tendências no tempo

12) Sobre estes 3 benefícios da natureza que você citou, vamos conversar sobre cada um separadamente para eu entender se eles tem aumentado, diminuído ou se mantido estável nos últimos 5 e 20 anos, e o porquê.

a) Benefício 1 – últimos 20 anos: ( ) Aumentou ( ) Diminuiu ( ) Estável

Por quê?

b) Benefício 1 – últimos 5 anos: ( ) Aumentou ( ) Diminuiu ( ) Estável

Por quê?

c) Benefício 2 – últimos 20 anos: ( ) Aumentou ( ) Diminuiu ( ) Estável

Por quê?

d) Benefício 2 – últimos 5 anos: ( ) Aumentou ( ) Diminuiu ( ) Estável

Por quê?

e) Benefício 3 – últimos 20 anos: ( ) Aumentou ( ) Diminuiu ( ) Estável

Por quê?

f) Benefício 3 – últimos 5 anos: ( ) Aumentou ( ) Diminuiu ( ) Estável

Por quê?

13) Você tem conhecimento de iniciativas, projetos ou organizações que atuem na APA para conservar estes benefícios da natureza? Se sim, quais?

a) Relativos ao benefício 1:

( ) Não ( ) Sim

b) Relativos ao benefício 2:

( ) Não ( ) Sim:

c) Relativos ao benefício 3:

( ) Não ( ) Sim:

14) Existe algum outro assunto que você sente que deveríamos ter conversado, e não foi abordado?

15) Você tem alguma outra observação, sugestão, comentário? Gostaria de acrescentar mais alguma coisa?

Informações do entrevistado

Nome: Gênero: ( ) M ( ) F

É morador da APA ? ( ) Não ( ) Sim:

Tem propriedade(s) na APA? ( ) Não ( ) Sim:

Desenvolve atividade econômica na APA? Qual? ( ) Não ( ) Sim:

Você possui outra atividade profissional na APA? Qual? ( ) Não ( ) Sim:

E-mail:

Telefone:

Caso eu precise de mais alguma informação, eu posso entrar em contato novamente através do seu telefone e/ou e-mail?

( ) Telefone ( ) E-mail

Horário de término da entrevista:

APPENDIX 2.1 - AREA, PERCENTAGE, CHANGES IN PERCENTAGE, AND ANNUAL RATE OF CHANGE FOR EACH LAND CLASS FOR APA CAMPINAS AND ITS RESPECTIVE ZONES FOR YEARS 1993, 2001 AND 2019, BASED ON MAPBIOMAS DATA (VERSION 5; MAPBIOMAS, 2021)

Area, percentage, changes in percentage, and annual rate of change for each land class for APA Campinas (22267 ha) for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021)

APA Campinas (22267 ha)	**1993**		**2001**		**2019**		**Change in land class (%)**	**Annual rate of change (%)**		
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**1993-2019**	**1993 - 2019**	**2001-2019**	**1993-2019**
Pasture	11862	53	11210	50.3	9027	40.5	-12.73	-0.01	-0.01	-0.01
Mosaic of agriculture and pasture	6014	27	5647	25.3	6460.5	29	2.00	-0.01	0.01	0.00
Forest formation	3546	15.9	4115	18.4	4573.5	20.5	4.61	0.02	0.01	0.01
Forest plantation	374	1.6	579	2.6	892	4	2.32	0.05	0.02	0.03
Urban infrastructure	366	1.6	583	2.6	780	3.5	1.86	0.06	0.02	0.03
Agriculture	32	0.1	34	0.1	397	1.7	1.64	0.01	0.14	0.10
Water	75.5	0.3	103	0.4	140	0.6	0.29	0.04	0.02	0.02

Area, percentage, changes in percentage, and annual rate of change for each land class at the biodiversity conservation zone (3625ha, 16%) of APA Campinas for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021)

Biodiversity conservation zone (3625ha)	**1993**		**2001**		**2019**		**Change in land class (%)**	**Annual rate of change (%)**		
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**1993-2019**	**1993 - 2019**	**2001-2019**	**1993-2019**
Pasture	1754.49	48.40	1610.57	44.43	1304.27	35.98	-12.42	-0.01	-0.01	-0.01
Mosaic of agriculture and pasture	1038.16	28.64	957.43	26.41	1008.14	27.81	-0.83	-0.01	0	0
Forest formation	770.62	21.26	974.10	26.87	1043.74	28.79	7.53	0.03	0	0.01
Forest plantation	46.56	1.28	66.86	1.84	214.26	5.91	4.63	0.05	0.06	0.06
Urban infrastructure	0.66	0.02	0.00	0.00	0.00	0.00	-0.02	-	-	-
Agriculture	5.17	0.14	6.54	0.18	41.79	1.15	1.01	0.03	0.1	0.08
Water	9.33	0.26	9.50	0.26	12.80	0.35	0.10	0	0.02	0.01

Area, percentage, changes in percentage, and annual rate of change for each land class at the geoenvironmental conservation zone (6879 ha, 31%) of APA Campinas for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021)

Geoenvironmental conservation zone (6879 ha)	**1993**		**2001**		**2019**		**Change in land class (%)**	**Annual rate of change (%)**		
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**1993-2019**	**1993 - 2019**	**2001-2019**	**1993-2019**
Pasture	3616.94	52.55	3527.03	51.25	3075.04	44.68	-7.87	0.00	-0.01	-0.01
Mosaic of agriculture and pasture	1720.10	24.99	1526.60	22.18	1708.96	24.83	-0.16	-0.01	0.01	0.00
Forest formation	1248.50	18.14	1403.26	20.39	1403.21	20.39	2.25	0.01	0.00	0.00
Forest plantation	243.71	3.54	373.93	5.43	587.64	8.54	5.00	0.05	0.03	0.03
Urban infrastructure	4.73	0.07	0.01	0.00	2.56	0.04	-0.03	-0.75	0.30	-0.02
Agriculture	9.95	0.14	1.98	0.03	45.94	0.67	0.52	-0.20	0.17	0.06
Water	38.66	0.56	49.78	0.72	59.24	0.86	0.30	0.03	0.01	0.02

Area, percentage, changes in percentage, and annual rate of change for each land class at the sustainable management zone (6562.5, 29.5%) of APA Campinas for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021)

Sustainable management zone (6562.5 ha)	**1993**		**2001**		**2019**		**Change in land cover (%)**	**Annual rate of change (%)**		
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**1993-2019**	**1993 - 2019**	**2001-2019**	**1993-2019**
Pasture	4238.44	64.56	4292.81	65.39	3484.67	53.08	-11.48	0.00	-0.01	-0.01
Mosaic of agriculture and pasture	1580.30	24.07	1444.97	22.01	1943.35	29.60	5.53	-0.01	0.02	0.01
Forest formation	684.56	10.43	722.10	11.00	826.86	12.60	2.17	0.01	0.01	0.01
Forest plantation	39.57	0.60	46.58	0.71	45.41	0.69	0.09	0.02	0.00	0.01
Urban infrastructure	5.70	0.09	3.55	0.05	1.73	0.03	-0.06	-0.06	-0.04	-0.05
Agriculture	1.32	0.02	23.98	0.37	210.41	3.21	3.19	0.36	0.12	0.20
Water	14.97	0.23	30.87	0.47	52.42	0.80	0.57	0.09	0.03	0.05

Area, percentage, changes in percentage, and annual rate of change for each land class at the controlled urbanization zone (2769 ha, 12.5%) of APA Campinas for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021)

Controlled urbanization zone (2769 ha)	**1993**		**2001**		**2019**		**Change in land cover (%)**	**Annual rate of change (%)**		
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**1993-2019**	**1993 - 2019**	**2001-2019**	**1993-2019**
Pasture	1278.73	46.22	862.51	31.18	464.01	16.77	-29.45	-0.05	-0.03	-0.04
Mosaic of agriculture and pasture	884.97	31.99	956.09	34.56	1052.65	38.05	6.06	0.01	0.01	0.01
Forest formation	227.45	8.22	313.11	11.32	399.14	14.43	6.21	0.04	0.01	0.02
Forest plantation	25.02	0.90	78.03	2.82	14.85	0.54	-0.37	0.14	-0.09	-0.02
Urban infrastructure	330.12	11.93	550.45	19.90	748.97	27.07	15.14	0.06	0.02	0.03
Agriculture	15.15	0.55	1.27	0.05	82.16	2.97	2.42	-0.31	0.23	0.07
Water	4.95	0.18	4.95	0.18	4.62	0.17	-0.01	0.00	0.00	0.00

Area, percentage, changes in percentage, and annual rate of change for each land class at the watershed protection zone (2432 ha, 11%) of APA Campinas for years 1993, 2001 and 2019, based on MapBiomas data (version 5; MapBiomas, 2021)

Watershed protection zone (2432 ha)	1993		2001		2019		Change in land cover (%)	Annual rate of change (%)		
	Area (ha)	%	Area (ha)	%	Area (ha)	%	1993-2019	1993 - 2019	2001-2019	1993-2019
Pasture	973.53	40.14	916.89	37.81	699.14	28.83	-11.31	-0.01	-0.02	-0.01
Mosaic of agriculture and pasture	790.78	32.61	761.58	31.40	747.48	30.82	-1.79	0.00	0.00	0.00
Forest formation	614.72	25.35	702.20	28.96	900.56	37.14	11.79	0.02	0.01	0.01
Forest plantation	19.48	0.80	14.03	0.58	29.58	1.22	0.42	-0.04	0.04	0.02
Urban infrastructure	18.57	0.77	25.42	1.05	25.59	1.06	0.29	0.04	0.00	0.01
Agriculture	0.41	0.02	0.00	0.00	16.73	0.69	0.67	0.00	0.00	0.14
Water	7.59	0.31	7.75	0.32	11.36	0.47	0.16	0.00	0.02	0.02

APPENDIX 2.2 – CROSS TABULATION MATRICES (TRANSITION MATRICES) FOR LAND USE AND LAND COVER CHANGE (IN HA) AT APA CAMPINAS AND ITS ZONES FROM 1993-2001 AND 2001-2019.

The numbers in blue represent the area who did not change between the two analyzed periods; numbers in the rows represent the gains in area between years; the numbers in the columns represent the losses in area between years. For instance, consider agriculture at APA Campinas between 1993-2001: 0.7 ha of agriculture did not change to other land classes; agriculture increased 15.3 ha over areas of forest plantation, 3.7 ha over areas of forest formation, and so on; agriculture decreased in 10.1 ha and 22.9 due to increases in mosaic of agriculture and pasture and pasture. Thus, agriculture had a net increase from 32.0 ha in 1993 to 33.8 ha in 2001

APA Campinas – 1993-2001

APA Campinas		**2001**							**Total (ha)**
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
1993	Agriculture	0.7	15.3	3.7		10.6	1.7		**32.0**
	Forest plantation		285.7	61.3		22.7	4.6		**374.3**
	Forest formation		50.9	3051.2	1.4	331.0	109.6	1.6	**3545.9**
	Urban infrastructure		0.1	0.4	349.0	15.5	1.2	0.1	**366.3**
	Mosaic of agriculture and pasture	10.1	136.0	762.6	131.0	3755.1	1202.1	17.4	**6014.3**
	Pasture	22.9	91.4	234.8	101.7	1511.0	9890.4	9.8	**11862.1**
	Water			0.7		0.7	0.1	73.9	**75.5**
Total (ha)		**33.8**	**579.4**	**4114.8**	**583.1**	**5646.7**	**11209.8**	**102.8**	**22270.4**

APA Campinas 2001-2019

APA Campinas		2019							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
2001	Agriculture	8.0			0.4	4.1	21.2		**33.8**
	Forest plantation	8.9	430.0	23.0	44.8	51.2	21.6		**579.4**
	Forest formation	23.9	111.8	3249.7	29.6	477.6	220.0	2.2	**4114.8**
	Urban infrastructure	0.2		0.1	574.6	7.5	0.7	0.1	**583.1**
	Mosaic of agriculture and pasture	64.4	135.0	917.0	65.0	3441.7	995.7	27.9	**5646.7**
	Pasture	291.5	215.0	383.4	65.5	2475.1	7767.4	11.9	**11209.8**
	Water			0.4		3.3	0.7	98.5	**102.8**
Total (ha)		**397.0**	**891.7**	**4573.5**	**780.0**	**6460.6**	**9027.1**	**140.4**	**22270.4**

Biodiversity conservation zone – 1993-2001

Biodiversity conservation zone		2001							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
1993	Agriculture		0.5			3.8	0.8		**5,2**
	Forest plantation		32.1	5.5		8.2	0.8		**46,6**
	Forest formation		4.6	712.1		36.0	17.9		**770,6**
	Urban infrastructure					0.5	0.2		**0,7**
	Mosaic of agriculture and pasture		12.5	201.5		642.8	181.1	0.2	**1038,2**
	Pasture	6.5	17.2	55.0		266.1	1409.7		**1754,5**
	Water							9.3	**9,3**
Total (ha)		**6,5**	**66.9**	**974.1**	**0.0**	**957.4**	**1610.6**	**9.5**	**3625.0**

Biodiversity conservation zone –2001-2019

Biodiversity conservation zone		2019							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
2001	Agriculture						6.5		**6.5**
	Forest plantation	0.6	60.8	1.4		3.0	1.1		**66.9**
	Forest formation	2.0	40.6	821.4		74.3	35.6	0.2	**974.1**
	Urban infrastructure								
	Mosaic of agriculture and pasture	0.6	37.4	166.9		538.1	211.4	3.1	**957.4**
	Pasture	38.7	75.4	53.9		392.8	1049.6	0.2	**1610.6**
	Water			0.2				9.3	**9.5**
Total (ha)		**41.8**	**214.3**	**1043.7**	**0.0**	**1008.1**	**1304.3**	**12.8**	**3625.0**

Geoenvironmental conservation zone – 1993-2001

Geoenvironmental conservation zone		2001							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
1993	Agriculture		3.8	0.9		5.2			**9.9**
	Forest plantation		207.6	26.0		9.6	0.6		**243.7**
	Forest formation		38.8	1059.5		110.6	38.8	0.9	**1248.5**
	Urban infrastructure		0.1	0.4	0.0	3.9	0.4		**4.7**
	Mosaic of agriculture and pasture	0.4	80.9	229.9	0.0	1037.5	363.1	8.3	**1720.1**
	Pasture	1.6	42.8	85.8	0.0	359.6	3124.1	3.1	**3616.9**
	Water			0.7		0.3	0.1	37.5	**38.7**
Total (ha)		**2.0**	**373.9**	**1403.3**	**0.0**	**1526.6**	**3527.0**	**49.8**	**6882.6**

Geoenvironmental conservation zone –2001-2019

Geoenvironmental conservation zone		2019							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
2001	Agriculture	0.2				0.1	1.7		**2.0**
	Forest plantation	0.1	318.9	19.1	0.8	27.6	7.5		**373.9**
	Forest formation	1.1	63.7	1104.9	0.1	175.3	57.2	0.9	**1403.3**
	Urban infrastructure				0.0				**0.0**
	Mosaic of agriculture and pasture	5.4	89.2	190.4	1.1	942.3	291.5	6.7	**1526.6**
	Pasture	39.1	115.9	88.8	0.6	561.7	2716.8	4.2	**3527.0**
	Water			0.1		2.0	0.3	47.4	**49.8**
Total (ha)		**45.9**	**587.6**	**1403.2**	**2.6**	**1709.0**	**3075.0**	**59.2**	**6882.6**

Sustainable management zone – 1993-2001

Sustainable management zone		2001							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
1993	Agriculture	0.7				0.2	0.4		**1.3**
	Forest plantation		19.5	15.4		1.5	3.1		**39.6**
	Forest formation		6.3	544.4		93.8	39.5	0.5	**684.6**
	Urban infrastructure				2.7	2.9	0.1		**5.7**
	Mosaic of agriculture and pasture	8.6	13.9	125.1	0.8	955.8	467.4	8.6	**1580.3**
	Pasture	14.6	6.8	37.2		390.8	3782.3	6.8	**4238.4**
	Water							15.0	**15.0**
Total (ha)		**46.6**	**46.6**	**722.1**	**3.6**	**1445.0**	**4292.8**	**30.9**	**6564.9**

Sustainable management zone – 2001-2019

Sustainable management zone		2019							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
2001	Agriculture	7.8				3.3	13.0		**24.0**
	Forest plantation		30.2	2.3		8.3	5.8		**46.6**
	Forest formation	6.8	5.5	534.3		104.9	69.6	1.0	**722.1**
	Urban infrastructure	0.2			0.7	2.5	0.2		**3.6**
	Mosaic of agriculture and pasture	22.5	2.5	188.6	0.7	910.2	304.5	15.9	**1445.0**
	Pasture	173.2	7.2	101.5	0.3	913.4	3091.5	5.7	**4292.8**
	Water			0.2		0.7	0.2	29.8	**30.9**
Total (ha)		**210.4**	**45.4**	**826.9**	**1.7**	**1943.4**	**3484.7**	**52.4**	**6564.9**

Controlled urbanization zone – 1993-2001

Controlled urbanization zone		2001							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
1993	Agriculture		11.0	2.8		1.4			**15.2**
	Forest plantation		18.5	3.7		2.8			**25.0**
	Forest formation		0.4	180.2	1.2	41.0	4.6		**227.4**
	Urban infrastructure				325.8	3.7	0.5	0.1	**330.1**
	Mosaic of agriculture and pasture	1.0	24.4	93.2	127.9	565.9	72.5	0.1	**885.0**
	Pasture	0.2	23.7	33.2	95.6	341.1	784.8		**1278.7**
	Water					0.2		4.8	**5.0**
Total (ha)		**1.3**	**78.0**	**313.1**	**550.4**	**956.1**	**862.5**	**5.0**	**2766.4**

Controlled urbanization zone – 2001-2019

Controlled urbanization zone		2019							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
2001	Agriculture				0.4	0.8	0.1		**1.3**
	Forest plantation	8.2	13.3	0.2	44.1	9.4	2.9		**78.0**
	Forest formation	12.2	0.5	211.7	29.5	51.2	8.0		**313.1**
	Urban infrastructure				548.0	2.1	0.2	0.1	**550.4**
	Mosaic of agriculture and pasture	31.4	1.0	159.4	62.8	637.1	64.1	0.3	**956.1**
	Pasture	30.4		27.9	64.1	351.5	388.6		**862.5**
	Water					0.6	0.2	4.2	**5.0**
Total (ha)		**82.2**	**14.9**	**399.1**	**749.0**	**1052.6**	**464.0**	**4.6**	**2766.4**

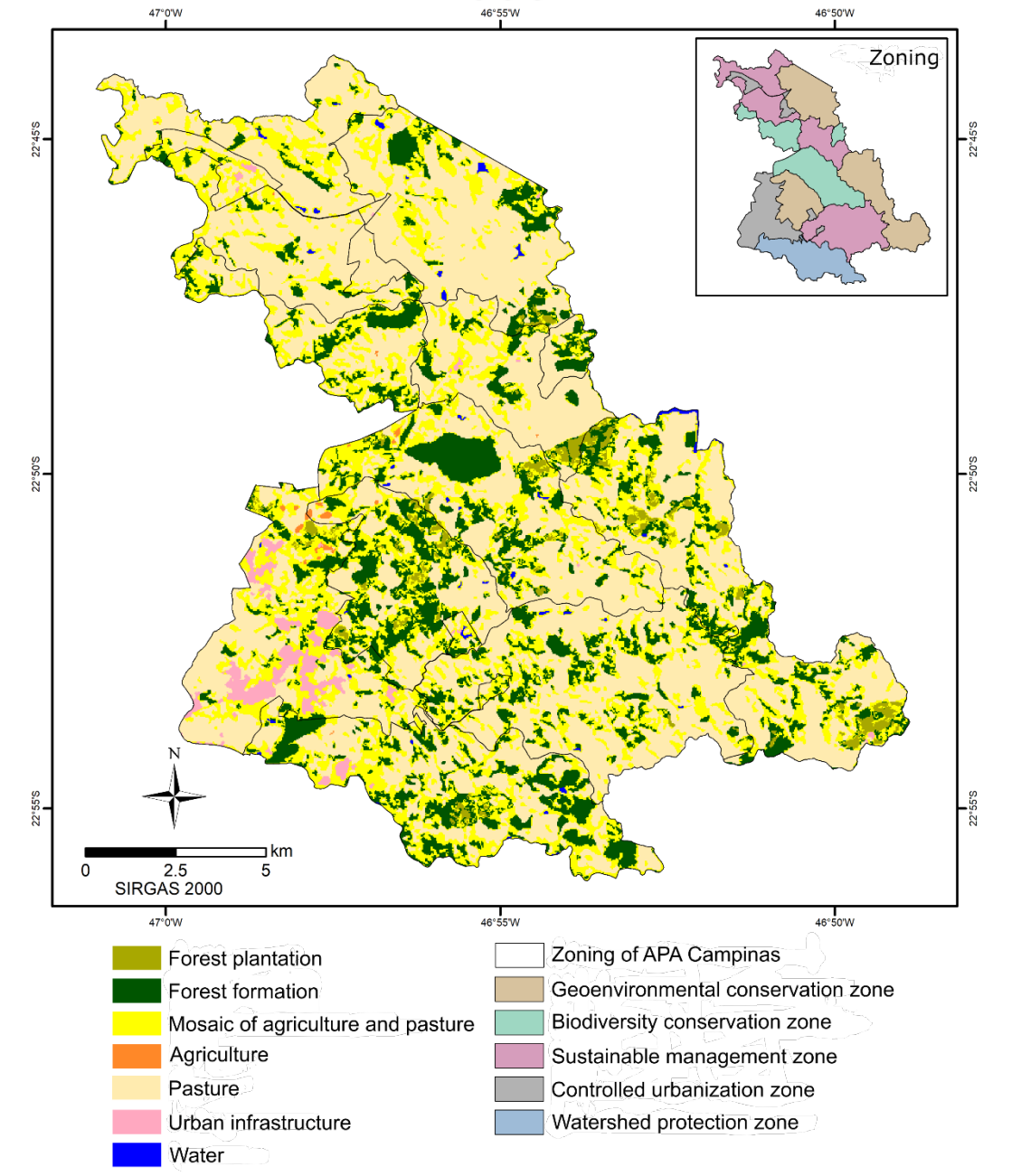
Watershed protection zone – 1993-2001

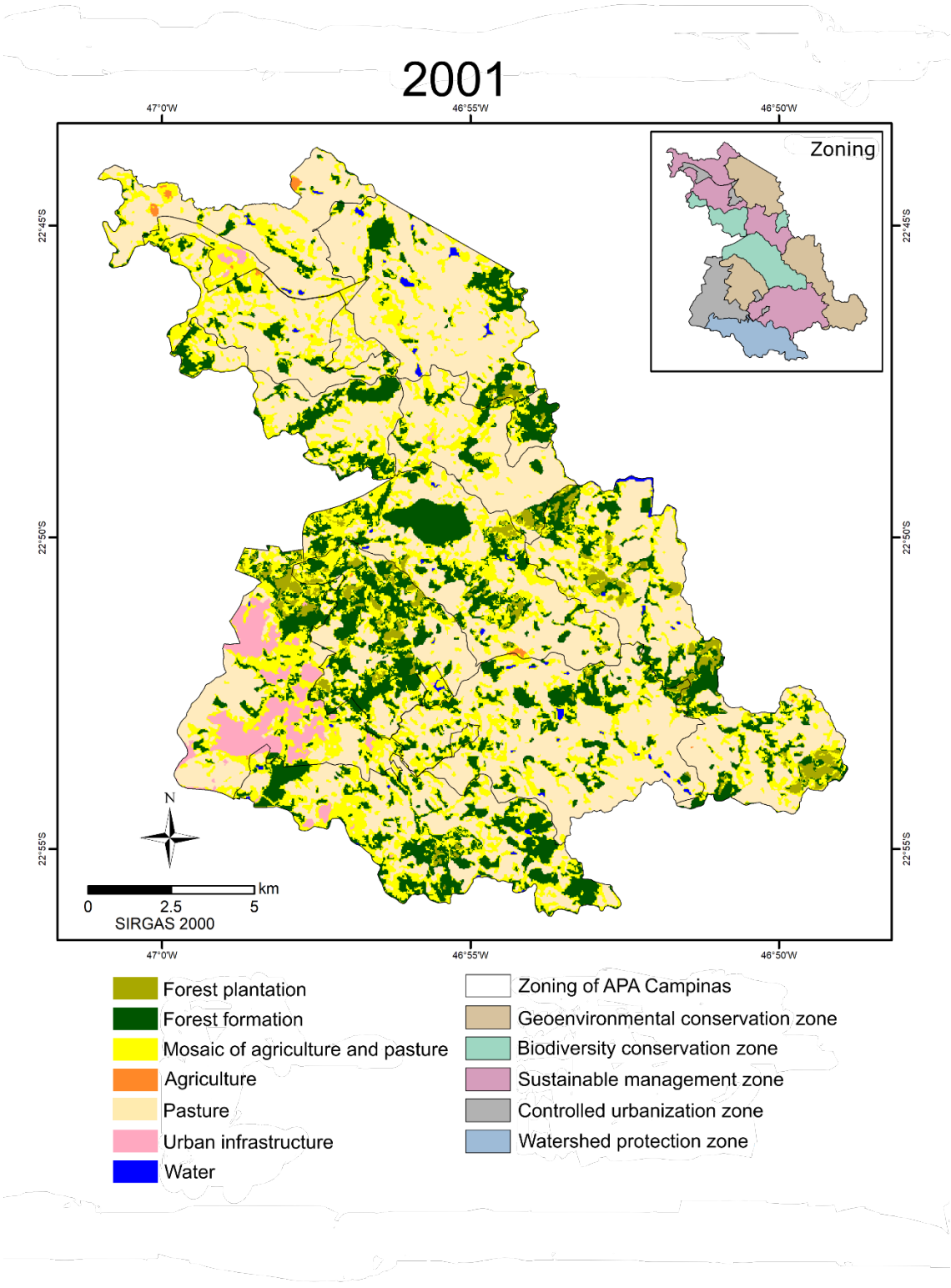
Watershed protection zone		2001							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
1993	Agriculture						0.4		**0.4**
	Forest plantation		8.1	10.7		0.6	0.1		**19.5**
	Forest formation		0.8	555.0	0.2	49.6	8.8	0.2	**614.7**
	Urban infrastructure				20.5	4.5	0.1		**18.6**
	Mosaic of agriculture and pasture		4.2	112.9	2.3	553.1	118.0	0.2	**790.8**
	Pasture		0.9	23.5	6.1	153.5	789.5		**973.5**
	Water					0.2		7.3	**7.6**
Total (ha)		**0.0**	**14.0**	**702.2**	**25.4**	**761.6**	**916.9**	**7.8**	**2431.6**

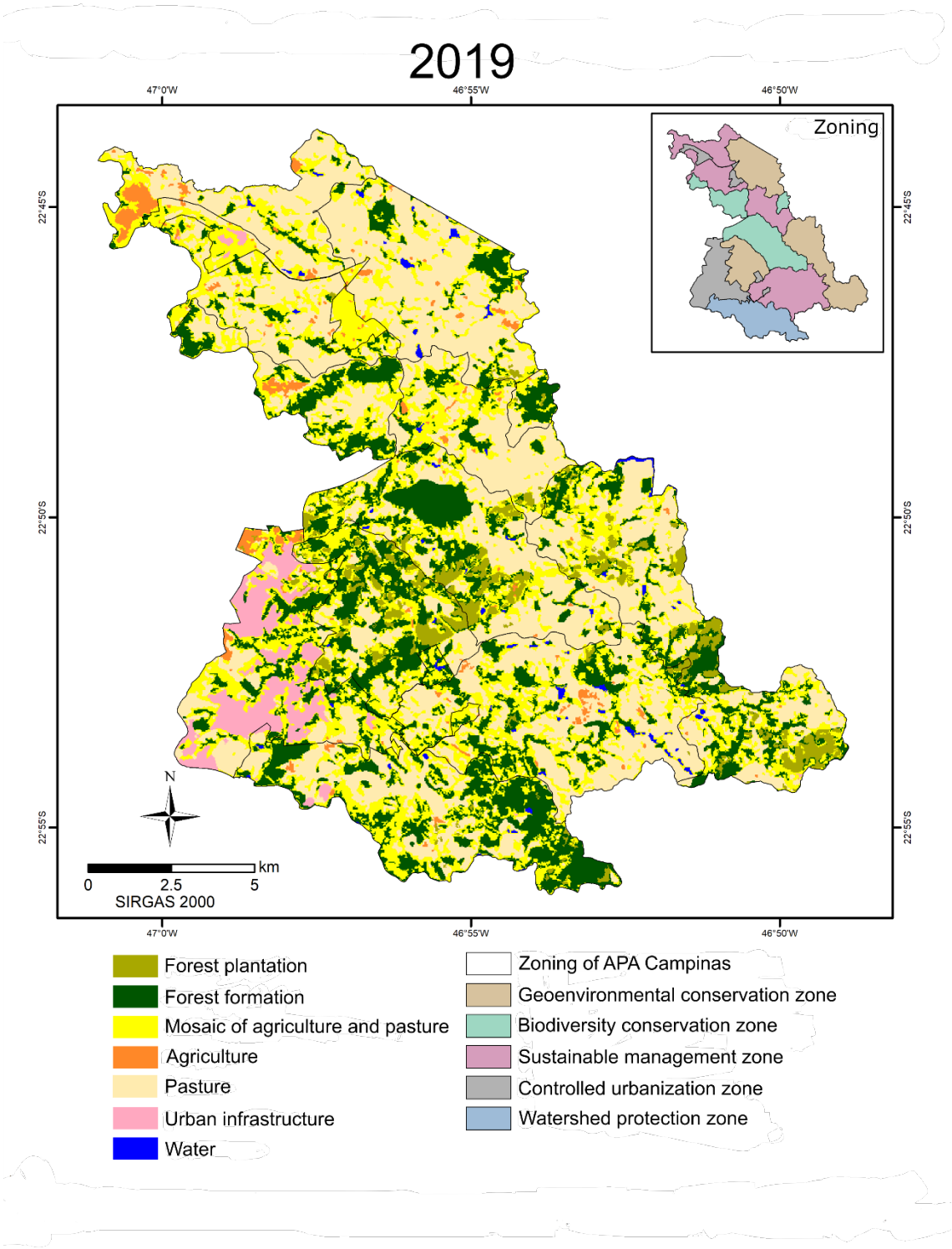
Watershed protection zone – 2001-2019

Watershed protection zone		2019							Total (ha)
		Agriculture	Forest plantation	Forest formation	Urban infrastructure	Mosaic of agriculture and pasture	Pasture	Water	
2001	Agriculture								**0.0**
	Forest plantation	0.1	6.7			3.0	4.3		**14.0**
	Forest formation	1.9	1.5	577.5		71.9	49.5		**702.2**
	Urban infrastructure			0.1	25.8	3.0	0.2		**25.4**
	Mosaic of agriculture and pasture	4.6	4.9	211.7	0.4	414.0	124.3	1.8	**761.6**
	Pasture	10.1	16.5	111.4	0.5	255.7	520.8	1.8	**916.9**
	Water							7.8	**7.8**
Total (ha)		**16.7**	**29.6**	**900.6**	**25.6**	**747.5**	**699.1**	**11.4**	**2431.6**

APPENDIX 2.3 – LAND USE AND LAND COVER MAPS OF APA CAMPINAS AND ITS RESPECTIVE ZONES FOR YEARS 1993, 2001 AND 2019, BASED ON MAPBIOMAS DATA ((VERSION 5; MAPBIOMAS, 2021)




2001
47°0'W
46°55'W
46°50'W
22°45'S
22°50'S
22°55'S
Zoning
N
0
2.5
5
km
SIRGAS 2000
Forest plantation
Forest formation
Mosaic of agriculture and pasture
Agriculture
Pasture
Urban infrastructure
Water
Zoning of APA Campinas
Geoenvironmental conservation zone
Biodiversity conservation zone
Sustainable management zone
Controlled urbanization zone
Watershed protection zone


2019
47°0'W
46°55'W
46°50'W
22°45'S
22°50'S
22°55'S
Zoning
N
0
2.5
5
km
SIRGAS 2000
Forest plantation
Forest formation
Mosaic of agriculture and pasture
Agriculture
Pasture
Urban infrastructure
Water
Zoning of APA Campinas
Geoenvironmental conservation zone
Biodiversity conservation zone
Sustainable management zone
Controlled urbanization zone
Watershed protection zone

APPENDIX 3.1 – WORKSHOP INVITATION SENT THROUGH E-MAIL AND SOCIAL MEDIA TO THE MANAGEMENT COUNCILORS AND PERSONNEL OF THE SECRETARIAT OF THE ENVIRONMENT to participate in the 1st focus group discussion, November 2020

Workshop Invitation sent through e-mail and social media to the management councilors and personnel of the Secretariat of the Environment to participate in the 2nd focus group discussion, May 2021

ANEXOS

ANEXO 1 – PARECER CONSUBSTANCIADO DO COMITÊ DE ÉTICA EM PESQUISA

UNICAMP - PRÓ-REITORIA DE PESQUISA DA UNIVERSIDADE ESTADUAL DE CAMPINAS - CHS/UNICAMP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Serviços ecossistêmicos e suas contribuições para o bem-estar humano na Área de Proteção Ambiental de Campinas (APA Campinas)

Pesquisador: RAFAEL CAVALCANTI LEMBI

Área Temática:

Versão: 1

CAAE: 20467619.4.0000.8142

Instituição Proponente: Núcleo de Estudos e Pesquisas Ambientais

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.598.777

Apresentação do Projeto:

Serviços ecossistêmicos (SE) são os benefícios que as pessoas obtém da natureza, e estão relacionados com diversas dimensões do bem-estar humano. A pesquisa nesta área ainda é deficiente em apontar as relações dos SE com a qualidade de vida das pessoas, e também em analisar os SE sob uma perspectiva integrada que inclua serviços materiais, imateriais e de regulação. Utilizando uma abordagem socioecológica e métodos de pesquisa participativa, o presente projeto objetiva analisar os SE e suas contribuições para o bem-estar humano, utilizando uma unidade de conservação de uso sustentável como estudo de caso, a Área de Proteção Ambiental de Campinas (APA Campinas). Especificamente, será analisada qual a percepção dos conselheiros da APA acerca de quais SE são mais prioritários para o bem-estar dos habitantes da APA, os vetores de mudanças destes SE, e as respostas a estas mudanças, através do uso de entrevistas semiestruturadas. Sob a perspectiva da população residente, será avaliado o estado destes SE prioritários, e também serão valorados através de uma abordagem sociocultural, utilizando questionários como método de coleta de dados. A pesquisa irá contribuir para compreender o

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tema dos SE dentro da APA Campinas, o que poderá
subsidiar estratégias de manejo e uso sustentável dos mesmos, sob uma perspectiva de conservação e desenvolvimento integrados.

Objetivo da Pesquisa:

Objetivo Primário:

Entender o estado e as tendências dos serviços ecossistêmicos e suas contribuições para o bem-estar humano na APA Campinas.

Objetivo Secundário:

(i) Identificar os serviços ecossistêmicos considerados prioritários para o bem-estar da população da APA; os vetores de mudança destes SE; e as
respostas a estas mudanças nos SE

(ii) Avaliar o estado dos serviços ecossistêmicos prioritários

(iii) Valorar os serviços ecossistêmicos prioritários

Avaliação dos Riscos e Benefícios:

Segundo o autor:

"Riscos:

A pesquisa não apresenta riscos previsíveis, e a qualquer momento o entrevistado poderá interrompê-la caso não deseje mais participar.

Benefícios:

Não há benefícios diretos. Ao participar da pesquisa, o entrevistado estará contribuindo para o meu projeto de pesquisa, e diretamente auxiliando na
compreensão de como os serviços ecossistêmicos contribuem para o bem-estar humano na APA Campinas.".

Comentários e Considerações sobre a Pesquisa:

Este protocolo se refere ao Projeto de Pesquisa intitulado Serviços ecossistêmicos e suas contribuições para o bem-estar humano na Área de Proteção Ambiental de Campinas (APA Campinas). A pesquisa foi enquadrada na seguinte Área Temática: 7. Ciências Humanas e A Instituição Proponente é o Instituto de Biologia (IB) e Núcleo de Estudos e Pesquisas Ambientais (NEPAM) da Unicamp. Segundo as Informações Básicas do Projeto, a pesquisa tem orçamento estimado em R$ R$4.850,00 . O cronograma apresentado contempla a coleta de dados Março de 2020. O público pesquisado são os conselheiros do Conselho Gestor da APA Campinas (TABELA 1 do projeto) e população residente da APA Campinas.

Continuação do Parecer: 3.598.777

Considerações sobre os Termos de apresentação obrigatória:
Foram analisados os seguintes documentos de apresentação obrigatória:

- Folha de Rosto Para Pesquisa Envolvendo Seres Humanos:
Devidamente preenchida e assinada
- Projeto de Pesquisa:
Adequado
- Orçamento financeiro e fontes de financiamento:
Adequado
- Termo de Consentimento Livre e Esclarecido:
Endereço do CEP
Desatualizado, favor atualizar para o atual endereço junto à FE.

Recomendações:
Recomenda-se:
- Atualização do endereço do CEP
- Melhor clareza na faixa etária dos participantes do projeto. Uma vez que há apenas um TCLE, pressupõem-se que sejam maiores de 18 anos, mas isso deveria estar expresso nos critérios de inclusão. Caso os participantes sejam menores, submeter emenda ao CEP explicando isso e inserindo um TALE.

Conclusões ou Pendências e Lista de Inadequações:
* Uma vez que há apenas um TCLE, pressupõem-se que sejam maiores de 18 anos, mas isso deveria estar expresso nos critérios de inclusão. Caso os participantes sejam menores, submeter emenda ao CEP explicando isso e inserindo um TALE.

** Esse protocolo tramita no CEP-CHS localizado na Faculdade de Educação, não no CEP localizado no FCM. Adequar todos os contatos do CEP antes de apresentar o TCLE aos participantes.

*** Inserir o CAAE no TCLE

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O Protocolo foi considerado aprovado em 25/09/2019 e o pesquisador deve se comprometer a realizar as adequações acima antes de iniciar contato com os participantes de pesquisa.

Considerações Finais a critério do CEP:

- Vale lembrar que a interação com os participantes de pesquisa só pode ser iniciada a partir da aprovação desse protocolo no CEP. Os cronogramas de geração/coleta de dados deve acompanhar os relatórios parcial e final de pesquisa

- Cabe enfatizar que, segundo a Resolução CNS 510/16, Art.28 Inciso IV, o pesquisador é responsável por "(…) manter os dados da pesquisa em arquivo, físico ou digital, sob sua guarda e responsabilidade, por um período mínimo de 5 (cinco) anos após o término da pesquisa.

- O participante da pesquisa tem a liberdade de recusar-se a participar ou de retirar seu consentimento em qualquer fase da pesquisa, sem penalização alguma e sem prejuízo ao seu cuidado (quando aplicável).

- Eventuais modificações ou emendas ao protocolo devem ser apresentadas ao CEP de forma clara e sucinta, identificando a parte do protocolo a ser modificada e suas justificativas e aguardando a aprovação do CEP para continuidade da pesquisa.

- Relatórios parciais e final devem ser apresentados ao CEP, inicialmente seis meses após a data deste parecer de aprovação e ao término do estudo.

- Caso a pesquisa seja realizada ou dependa de dados a serem observados/coletados em uma instituição (ex. empresas, escolas, ONGs, entre outros), essa aprovação não dispensa a autorização dos responsáveis. Caso não conste no protocolo no momento desta aprovação, estas autorizações devem ser submetidas ao CEP em forma de notificação antes do início da pesquisa.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1414983.pdf	28/08/2019 15:38:59		Aceito
Declaração de	RACrisSeixas.jpeg	28/08/2019	RAFAEL	Aceito

Continuação do Parecer: 3.598.777

Pesquisadores	RACrisSeixas.jpeg	15:36:46	CAVALCANTI LEMBI	Aceito
Declaração de Pesquisadores	AtestadoMatricula_Ecologia.pdf	28/08/2019 15:35:11	RAFAEL CAVALCANTI LEMBI	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	28/08/2019 15:14:12	RAFAEL CAVALCANTI LEMBI	Aceito
Projeto Detalhado / Brochura Investigador	ProjetoCEP.pdf	28/08/2019 15:13:34	RAFAEL CAVALCANTI LEMBI	Aceito
Folha de Rosto	FolhaDeRostoAssinada.pdf	28/08/2019 15:11:18	RAFAEL CAVALCANTI LEMBI	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

CAMPINAS, 25 de Setembro de 2019

Assinado por:
Thiago Motta Sampaio
(Coordenador(a))

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ANEXO 2 – DECLARAÇÃO DE DIREITOS AUTORAIS

Declaração

As cópias de artigos de minha autoria ou de minha co-autoria, já publicados ou submetidos para publicação em revistas científicas ou anais de congressos sujeitos a arbitragem, que constam da minha Dissertação/Tese de Mestrado/Doutorado, intitulada **Estado e tendências dos serviços ecossistêmicos na Área de Proteção Ambiental de Campinas**, não infringem os dispositivos da Lei n.° 9.610/98, nem o direito autoral de qualquer editora.

Campinas, 04 de setembro de 2021

Assinatura : _____
Nome do(a) autor(a): **Rafael Cavalcanti Lembi**
RG n.° MG13981172

Assinatura : _____
Nome do(a) orientador(a): **Cristiana Simão Seixas**
RG n.° 19220414