



Ecosystem Science Center Annual Report

FY2021 (July 1, 2020 – June 30, 2021)

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Photo on Cover: Drone overview of a ditch restoration project in a peatland impacted by a road in Huscaran National Park, Peru (R. Chimner, PI)

ESC Mission Statement

“To promote understanding of ecosystem function through education and research at Michigan Technological University.”

The Ecosystem Science Center (ESC) seeks to advance our understanding of how ecosystems function and how human activities influence ecosystem processes. The Center’s two main objectives are to: (1) foster ecosystem research through the acquisition of extramural support; and (2) improve Michigan Tech’s ability to educate graduate and undergraduate students in the area of ecosystem science. These two objectives are met through collaboration among faculty, staff and students interested in ecosystem science.

Summary of FY2021 Activities and Highlights

The Ecosystem Science Center (ESC) has now completed its seventeenth successful year, and the fourth year of a renewal that continues through December 31, 2022. During the past year, the ESC welcomed three new members, while four others departed, giving us a year-end membership of 53. All ESC members have worked hard to develop and submit interdisciplinary research proposals involving multiple units across campus and collaborations with government and university partners both nationally and internationally. The ESC ranked first among the eighteen Centers and Institutes at Michigan Tech in terms of numbers of research awards (108) and projects (198) in FY21. The ESC also ranked fifth overall in research expenditures (\$5,006,687) and fifth overall in new research funds awarded (\$6,645,909) for FY21. These rankings only trail several of the Tier I Centers and Institutes and are first among the Universities Tier II Centers and Institutes. ESC award expenditures during FY21 generated \$642,781 in facilities and administration (F&A) funds for Michigan Tech, which is the highest amount ever generated by the ESC.

The ESC continued initiatives designed to further enhance our ability to obtain external research awards. This included funding two requests from members to support development of future medium to large proposals. These funds supported: 1) a key pilot study applying new methodological approaches for modeling nutrient transformation and export from Great Lakes coastal wetland complexes; and 2) development of the Ford Forest Hydrologic Observatory (FFHO) for understanding source waters and flowpaths in the Upper Sturgeon River. In addition, the ESC: 1) continued testing a pre-submission proposal review program, to ensure members submit the highest quality proposals examining novel research themes (one NSF Career proposal was reviewed internally); 2) accrued sufficient financial reserves to enable support of release time for the ESC members to work on large proposal development, if needed; and 3) hired a new Center Manager, Dr. Jeff Henquinet, to provide support for pre and post award support for grant development. The Center Manager hiring process occurred during the second

half of FY2021, and Dr. Henquinet began his duties in July, 2021. His 0.75 FTE position is co-funded by the Tech Forward Natural Resources, Water and Energy Initiative. Core duties will include identifying funding opportunities, helping researchers develop externally funded research proposals, and assisting in the creation and management of multiple investigator proposal and project teams.

The ESC also supported research through equipment purchases. During the past year this included \$11,560 in cost share toward a successful NSF MRI proposal, led by ESC members, for a new Isotope Ratio Mass Spectrometer, to be housed in the Microanalytical Shared Facility. The availability of this equipment will aid existing research projects and allow ESC members to propose new avenues of research. The ESC also provided \$3,000 in cost share toward a new microwave digestion system that will enable researchers across Michigan Tech to prepare solid samples for elemental analysis via ICP-OES (inductively coupled plasma-optical emission spectroscopy).

External research funds obtained by ESC members currently help support their more than 50 graduate students. The combined efforts of our members and their students resulted in 97 peer-reviewed journal publications from July 2020 to June 2021 (per Web of Knowledge, see Appendix) and a number of additional technical reports and proceedings articles. During FY2020, the ESC directly enhanced graduate and undergraduate education and training by funding: 1) \$8,750 in new ESC research grants to 10 students (9 graduate, 1 undergraduate) to either expand their existing research projects or perform new additional research; and 2) \$1,500 in ESC travel grants for 2 students to present research results at national and international scientific conferences. The number of students awards, especially for travel, was greatly reduced in FY2021 due to COVID-19 impacts on travel for research and on decisions to hold virtual scientific conferences rather than in-person meetings. Finally, the ESC has continued supporting the Distinguished Ecologist Lecture Series, which gives our graduate and undergraduate students opportunities to discuss their research with internationally renowned experts.

Governance Structure

The ESC is governed by its Charter as approved in 2004. The ESC is led by a Director that serves for four-year renewable terms. The Director is elected by a vote of full members with voting privileges. The ESC holds at least four meetings each academic year with two in each academic semester.

Members collectively determine how center funds will be used at two meetings, one near the beginning of the fall semester and another at the beginning of the spring semester. Priorities for the distribution of resources will hopefully be decided by consensus, but a simple majority vote is used to resolve any disagreements. Members have the responsibility for making proposals for the distribution of resources.

Membership

Membership in the ESC is open to all faculty, staff, post-doctoral associates, and adjunct-faculty participating in research and graduate education in the subject area. However, full membership (including voting privileges) is limited to those members serving as Principal Investigator, Co-Principal Investigator or Official Collaborator on currently funded extramural projects that generate overhead return. The purpose of these restrictions is to keep the ESC focused on the generation of extramural grant support that will encourage growth of the Center. The Center cannot accomplish its mission without extramural grant support.

New members joining between July 1, 2020 and June 30, 2021 include: Jill Olin (Biological Sciences, Tao Liu (CFRES) and Yinan Yuan (CFRES). The ESC also lost four members: Yvette Dickinson, Audrey Mayer, Robert Froese and Matt Kelly, as they took new positions outside of Michigan Tech. A full list of members who were active during any part of 2020 and 2021 appears in Appendix A.

Budget Overview

Summary of Awards and Expenditures

In FY21, the ESC had a successful year in terms of research awards (Table 1). For FY21, the ESC amount of \$6,645,909 ranked fifth among Michigan Tech's eighteen centers and institutes, trailing only APSRC, GLRC, KRC, and MTRI. ESC expenditures of \$5,006,687 (Table 1) ranked fifth, trailing APSRC, GLRC, KRC and MTRI, all of which are Tier I centers.

At the time of this report, the ESC had approximately 198 active awards, with a total award value of nearly \$18 million. These awards came from a variety of federal, industrial, public and private sources (Table 2).

Table 1. ESC awards, projects and expenditures from FY14 through FY21.

	Number of Awards	Amount Awarded	Number of Projects	Expenditures
FY14	88	\$3,095,545	189	\$3,543,913
FY15	104	\$3,740,245	193	\$3,072,743
FY16	89	\$3,279,250	187	\$3,274,666
FY17	85	\$5,667,434	224	\$3,760,110
FY18	67	\$3,550,733	182	\$3,814,755
FY19	92	\$3,070,691	185	\$3,875,273
FY20	88	\$4,627,728	160	\$3,782,119
FY21	108	\$6,645,909	198	\$5,006,687

Table 2. Sponsors of ESC awards that were active as of October, 2021. The awards had a total remaining balance of \$9,384,114.

Sponsor Name/Type	Award Value (\$)	Remaining Funds (\$)
USDA (includes Forest Service)	\$6,823,873	\$3,874,896
National Science Foundation	\$3,745,143	\$2,138,970
Industry (primarily wood protection group)	\$3,159,373	\$1,535,626
Subawards from other universities (mostly federal pass-thru)	\$1,537,705	\$323,282
National Park Service	\$611,397	\$164,872
State of Michigan	\$541,891	\$433,348
US Department of Energy	\$496,014	\$418,351
US Fish and Wildlife Service	\$443,424	\$252,458
Other	\$346,251	\$137,148
Foundations/Trusts	\$182,388	\$105,193
Total	\$17,887,459	\$9,384,144

Use of IRAD Funds

For FY21, Institutional Research and Development (IRAD) funds generated by the ESC are distributed according to University guidelines, with 18% given to the ESC, 10% to each award’s PI, 9% each to the college and department of the lead PI (or 18% to the lead PI’s College), and 4% to support shared facilities. During FY21, the ESC IRAD expenditures were used as follows: 37.7% to support student development through travel grants, research grants and the ESC Student Research Forum; 26.9% for staff support; 20.8% for equipment purchase or repair; 2.1% for collaboration building activities, including funding speakers for the Distinguished Ecologist Lecture Series; 2.9% for supplies and services; and 9.5% for funding requests from ESC members (Table 3). These funds supported sample analysis, pilot studies and infrastructure development to be used in support of proposals in development for external funding. Member requests from both FY20 and FY21 were being supported during the past year.

The ESC is in sound financial condition. As of June 30, 2021, the ESC IRAD account (E35288) balance was \$107,799 (Table 3). This positive balance is the result of several years of reduced expenditures on equipment and member funding requests, combined with increasing IRAD income in recent years. In addition, expenses for student travel and grants have been lower than expected over the past two years due to COVID-19 impacts on travel and research. The positive balance enables us to support more expensive equipment purchases, to co-fund the new ESC Center Manager who will aid members with proposal development and post-award administration, and to support more member requests for travel to form collaborations and costs associated with the generation of preliminary data needed to develop large, complex proposals. Budget projects, provided later in the document, provide a continuing ability to support ESC members through these activities.

Table 3. ESC expenses, income and IRAD account (E35288) balances from FY17 to FY21.

		FY17	FY18	FY19	FY20	FY21
Expenditures	S&W & Fringes	\$12,565	\$11,606	\$16,958	\$18,801	\$18,806
	Supplies & Services	\$252	\$3,262	\$5,176	\$332	\$2,003
	Equipment	\$13,400	\$7,671	\$6,307	\$26,850	\$14,560
	Student Support*&	\$27,716	\$18,777	\$34,420	\$10,550	\$26,350
	Collaboration Building**	\$5,455	\$4,703	\$5,932	\$4,582	\$1,500
	Member fund requests^	\$41,810	\$24,601	\$8,346	\$28,031	\$6,654
Income	Total	\$101,198	\$70,619	\$77,138	\$89,146	\$69,873
	Incentive Transfers	\$92,157	\$92,020	\$92,369	\$90,161	102,513
	Other Transfers In	\$10,935	\$4,962	\$10,056	\$0	\$0
	Total	\$103,092	\$96,982	\$102,425	\$90,161	\$102,513
Carry Forward						
Year End Balance¹		\$20,600	\$22,495	\$48,858	\$74,144	\$75,159
		\$22,495	\$48,858	\$74,144	\$75,159	\$107,799

¹Excludes encumbrances at year end

*student travel and research awards, Research Forum

**DELS, ESC coffee, meetings

& \$11,000 in student research awards from spring 2020 were not funded until FY21

^FY21 values include expenditures from member funds requests in both FY20 and FY21

Progress towards Goals

Activity 1: Fostering quality ecosystem science through the acquisition of extramural grants and contracts.

***Goal 1.1.** Increase funding from extramural grants and the IRAD return generated.*

Evaluation Criteria. The ESC will increase the value of annual research awards by approximately 30% and F&A funds generated by 40% during the renewal period, relative to the values for FY17. Thus, the targets will be \$7,350,000 for grants awarded and \$685,000 in F&A generation by the ESC by the end of the renewal period. The ESC also will implement a pre-submission review program that is voluntary for smaller submissions and mandatory for larger submissions. Finally, ESC will fund staff to support proposal development, with approximately 20% of ESC funds devoted to this effort during the renewal period.

Progress. ESC awards increased to \$6,645,909 in FY21. This is due in part to the excellent efforts of our members in preparing competitive proposals, but also was influenced by several federal agencies decisions to fully fund proposals, rather the funding incrementally by year. Still

we anticipate high levels of funding for FY22, hopefully approaching or exceeding those in FY21.

ESC research expenditures increased greatly from FY20 to FY21 (Table 1), and given the lag between awards and expenditures, this should continue going forward. These increased expenditures led to an all-time high in ESC F&A generation (Figure 1). A total of \$642,781 in F&A funds were generated by ESC expenditures in FY21. This occurred despite negative impacts on research activity due to the COVID-19 pandemic. With award balances expected to remain high in FY22 (Figure 2), and expenditures expected to increase in FY22 relative to FY21, we anticipate achieving or exceeding our goal of \$685,000 in F&A generated. Currently, ASPIRE projects that up to \$950,998 in F&A will be generated in FY22 (Figure 3). In FY21, ESC F&A generation was 83.5% of the ASPIRE projection, which is consistent with the tendency for actual F&A for the ESC to be 80 to 85% of the ASPIRE projection. If this holds for FY22, then more than \$760,000 in F&A should be generated by the ESC. Thus, the ESC appears to be on track to achieve our FY22 goal for F&A generation.

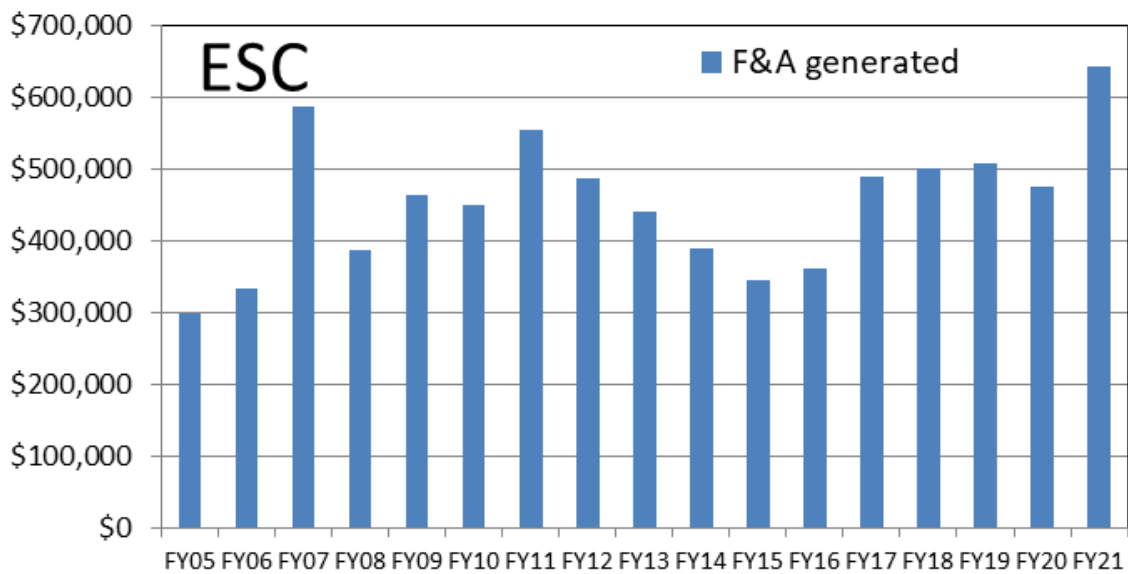


Figure 1. F&A generated by ESC grants from FY05 through FY21.

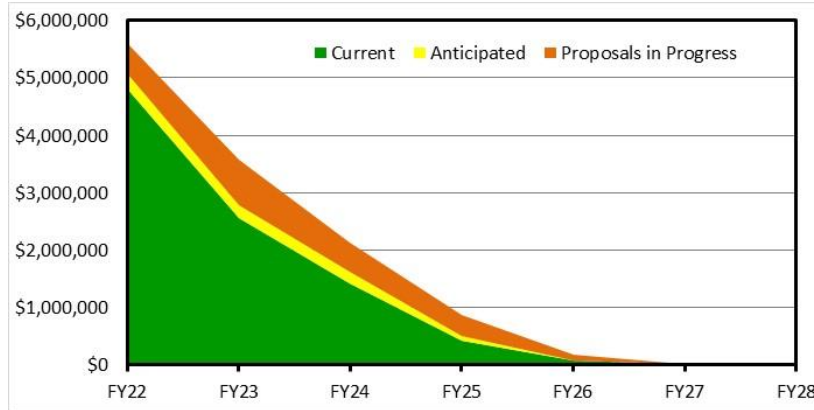


Figure 2 (including table). ASPIRE projections for ESC remaining award balance from existing awards, anticipated increments of existing awards, and proposals in progress for FY22 through FY28.

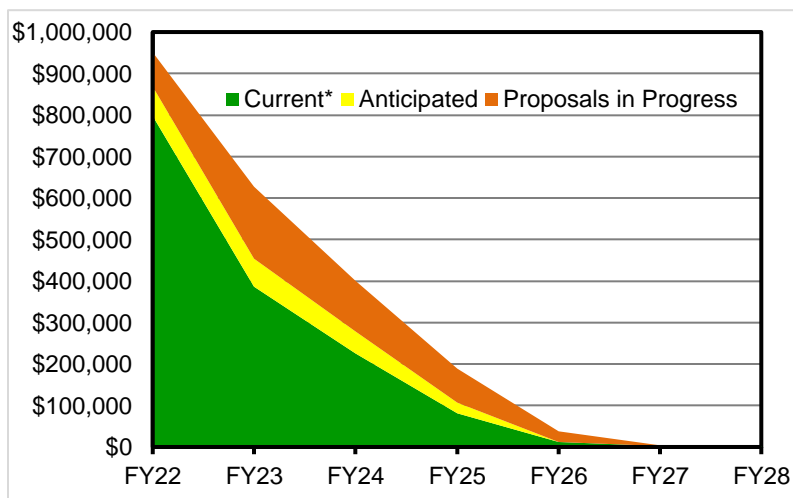


Figure 3 (including table). ASPIRE projections for ESC F&A generation from existing awards, anticipated award increments and proposals in review for FY22 through FY28.

We intended to hire a staff person to support proposal development and post-award administration for large grants during FY20, with the position co-funded by the Tech Forward NRW&E Initiative. The University was unable to fund several Tech Forward initiatives, including NRW&E for FY21, and this, combined with a hiring freeze associated with the COVID-19 pandemic in spring of 2020, delayed the hiring. In FY21, we were able to advertise for and hire a 75% FTE person to be supported by ESC and NRW&E funds. The hiring process took place in the second half of FY21, and the new ESC Center Managers, Dr. Jeff Henquinet began working in July 2021. This position is currently funded 1/3 by ESC and 2/3 by NRW&E. The cost of the position will gradually shift to the ESC over the next three years, and the ESC's budget surplus and increasing trend in F&A generation (and thus IRAD return to ESC) ensures stable funding for this position. In FY22, we anticipate devoting about \$28,500 for the Center Manager's salary and fringe. Our pilot pre-submission review program will be fully developed in FY22, now that the Center Manager is on-board, as they will coordinate the activities involved. Director Burton did provide pre-submission review for an ESC member's NSF Career proposal in FY21 and Dr. Henquinet, since his hire in July, has already aided the submission of a large, collaborative proposal submitted to the NASA ROSES program, helping coordinate completion of all required documents from multiple investigators and the preparation of data and project management plans, equipment and other resources descriptions, and the budget and budget justification.

Goal 1.2. Seek and obtain large, high-value, competitive grants that require the interdisciplinary teams and capabilities that a center can provide.

Evaluation Criteria. During the next five years the ESC will identify two to three large interdisciplinary grant topics and funding agencies and submit at least one proposal for each. To aid proposal development, the ESC will work with the lead investigators' home academic units to reduce that persons teaching and service load, including funding a portion of that person's effort if needed. The ESC will also continue collaborating with other centers and institutes on campus to obtain such grants, as has been done successfully with SFI, GLRC and MITRI.

Progress. In FY21, ESC members submitted a large proposal (circa \$1.6 million) to the NSF DISES program. The proposal was not successful, but its content is leading to additional proposal efforts and the further development of collaborations with researchers outside of Michigan Tech. Members also continue to collaborate with other centers and institutes at Michigan Tech. In FY20, several ESC members were working on a potentially very large effort (circa \$3 to \$5 million to Michigan Tech) in collaboration with multiple other universities, but this effort has been temporarily put on hold, as the funding entity postponed the solicitation due date indefinitely during the COVID-19 pandemic. This effort resumed late in FY21 with a potential proposal during FY22. In addition, a large (up to \$10 million) Coordinated Agriculture Project (CAP) proposal to the USDA AFRI Sustainable Agricultural Systems Program will likely occur in FY22, if the anticipated RFP remains reasonably consistent with that of previous years.

ESC members now do have the opportunity to request funds to reduce teaching load to work on large proposals, but none have done so to date.

Goal 1.3. *Ensure wide participation of ESC members in obtaining grants and generating IRAD and ensure that the ESC is not dependent on a few large grants for generating IRAD needed to sustain the center.*

Evaluation Criteria. We will continue the indicators that: 1) no more than four ESC members will generate greater than 10% of ESC IRAD each; and 2) ten or more ESC members will generate at least 3% of ESC IRAD. We also will add two additional criteria: 3) at least 50% of ESC members will generate IRAD in any given year (it was 40% in FY17), and 4) the ESC members will design and implement a research funding mentoring program for junior members during the 2018/2019 academic year.

Progress. Our first two criteria were met in FY21, although it should be noted that one ESC member generated close to 40% of the center's F&A. For criteria three, 36% of ESC members were lead PIs on F&A generating grants in FY21 (56% were PI or co-PI on F&A generating awards). Mentoring of junior members is still informal, but the Director continues to meet with several such members to gather information on their research interests and experience, as a first step toward formalizing mentoring and enabling ESC staff to help guide members to opportunities. The hiring of Center Manager Jeff Henquinet will help us make progress on criteria four, and the University also has instituted mentoring programs (Early Career Management; ECM and Advanced Career Management; ACM) in which several ESC members participate (as both mentors and mentees).

Activity 2: Improving educational opportunities

Goal 2.1. *Seek and obtain extramural funds for graduate and undergraduate education and research, professional training and public outreach and education.*

Evaluation Criteria. The ESC will investigate the possibility of pursuing an NSF NRT proposal or similar effort with other agencies. The ESC will set up formal meetings for interested members with USFS NIACS personnel to improve our working relationship with this important group. ESC members will continue to seek funding for outreach activities, such as those currently conducted in conjunction with NIACS and KISMA. The ESC will also support travel of ESC members to potential international collaborators to facilitate development of both collaborative research and student training and exchange programs.

Progress. This goal is being somewhat deemphasized during the current five-year renewal, as the ESC's primary efforts focus on increasing our overall success rate in research awards under Activity 1. Increasing sponsored research awards will in turn create funds needed for student education and public outreach. The proposed USDA CAP proposal for FY22 would have a

significant outreach component, and virtually all ESC grants to NIACS-associated members (Leopold, Schmitt, Zermeno and Ontl as PI) directly fund public and professional outreach and education, as do grants to KISMA (Resh as PI). In FY20, a 12-person team from ESC, led by Dr. Chris Webster, sought \$500,000 in funding from USDA's Research and Extension Experiences for Undergraduates program, but we learned in FY21 that this proposal would not be funded. Still the themes in the proposal could serve as a foundation for NSF REU or NRT proposals.

Activity 3: Promoting Ecosystem Science and Education

Goal 3.1. Continue supporting the Distinguished Ecologist Lecture Series (DELS)

Evaluation Criteria. Annual continuation of this existing, successful lecture series for course credit, with participation by at least 15 students per year.

Progress. ESC provided \$1,500 to support the DELS speaker series. Ten students took the DELS course in Fall 2020, but up to 15 graduate students typically attended the meetings and with the DELS speakers, and 20 to 30 students were among the 50+ persons attending the DELS presentations.

Goal 3.2. Support student attendance at national and international scientific meetings.

Evaluation Criteria. The ESC will help support meeting attendance for at least 20 graduate or undergraduate students per year. The ESC will also continue sponsoring the ESC Student Research Forum each spring, where students have a chance to prepare posters and present research to ESC faculty and their peers, gaining important skills that will improve their presentation skills for national/international meetings and position interviews.

Progress. In FY21 the ESC supported five students to present research at meetings and conferences and two students to attend training sessions. This included \$1,500 in new travel grants and the use of unexpended funds from prior travel grants. During the COVID-19 pandemic, many meetings were postponed or switched to a virtual format, leaving unspent funds from prior years' travel grants. All of the presentations and one of the training sessions listed above were virtual. The 16th ESC Student Research Forum was held virtually in the Spring of 2021, due to COVID-19 restrictions. We hope to return to an in-person forum in 2022.

Goal 3.3. Support internal graduate and undergraduate research grants.

Evaluation. The ESC will spend at least \$20,000 per year supporting graduate and undergraduate research grants.

Progress. In FY21, the ESC selected 12 graduate research awards and 1 undergraduate research awards for total funding of \$12,750. Due to COVID-19 related delays in students being able to start their summer research, \$11,000 of support from the Spring 2020 competition also was

funded in FY21, rather than FY20. The total amount of funding requested was likely reduced by COVID-19, as several students felt they would be unable to conduct their planned research and thus delayed requesting funding to future years. As our research awards and expenditures grow, we anticipate a return to spending of \$20,000 or more per year for this program.

Goal 3.4. *Obtain multi-user advanced instrumentation to support the research of ESC members and other researchers at Michigan Tech and to enable training of graduate students in state-of-the-art analytical techniques.*

Evaluation. The ESC will apply annually for REF-IE funds to obtain equipment needed to support the research of ESC members and to enhance their ability to obtain research funding. We will lead large equipment initiatives (such as NSF MRI) as needed to benefit our members and will annually assess potential future use for our aging Isotope Ratio Mass Spectrometer (IRMS), to determine whether or not it should be replaced. The ESC will help support maintenance and repairs for instruments the ESC helped purchase.

Progress. Michigan Tech's REF-IE program has been discontinued. The ESC did receive funding in FY20, during the final year of the program. In FY21, an NSF MRI proposal to replace the IRMS was funded for \$327,067 plus \$140,172 in cost share. The ESC provided \$11,560 of this cost share. The new IRMS will enable analysis of isotopes of additional elements beyond those 20-year old IRMS it is replacing can analyze, as well as analysis of isotopes in a wider variety of sample types, greatly expanding the types of ecological questions that can be addressed with stable isotopes and supporting the research thrusts of several newly hired faculty. In addition, the ESC provided \$3,000 in cost-share towards a Microanalytical Facility (MAF) purchase of a new microwave digester to replace a failed unit. This system enables preparation of solid samples for ICP-OES analysis, and maintains a capability needed by multiple departments across campus. The original microwave digester was purchased as part of an ESC REF-IE grant for the ICP-OES instrument.

Future Plans

The ESC was reauthorized in June of 2018 for a five-year period from January 2018 through December, 2022. At that time, several opportunities to improve the ESC's abilities to achieve its goals and support both the ESC and Michigan Tech visions were identified. As described above, we have made good progress toward our goals in FY21. Director Burton's term will end on December 31, 2021, and Dr. Amy Marcarelli will be the new Director, for a four-year term commencing January 1, 2022. As Director Marcarelli takes over, and the ESC applies for reauthorization next year, a new set of five-year goals, strategies and metrics will be developed. During this final year of our current authorization, the ESC will:

1. Provide ESC staff to support proposal development support to ESC members;
2. Identify very large, collaborative proposal topics and funding sources;

3. Institute a successful pre-submission proposal review program;
4. Develop and institute mentoring programs for early and mid-career members;
5. Support professional development of members' students

We continue adjusting our spending priorities to help achieve our goals. Relative to our spending goals set forth in 2018 (Table 4), we will likely spend a greater proportion of funds on staff salary and member requests and less on release time, in order to optimize our ability to prepare successful proposals. FY2021 values for some categories are lower than normal, due to impacts of COVID-19 on student support activities. For FY2022, spending priorities include:

1. Funding a portion of the Director's annual salary to support efforts described above.
2. Increasing funds allocated to staff (i.e. the new Center Manager) to support proposal development and post-award project management for large proposals.
3. Funding member requests likely to lead to successful proposals, such as preliminary data generation, travel for collaborative proposal development, help in purchasing needed equipment and repair/refurbishment of existing essential research capabilities.
4. Funding release time from teaching for ESC members who are developing and preparing large (\$1 to \$10 million), collaborative proposals (lower priority).

Table 4. Comparison of 2018 renewal goals and recent allocation of ESC IRAD expenditures.

	FY18-21 goal	FY22 goal	FY21 Actual	FY22 Projected
	\$ (%)	\$ (%)	\$ (%)	\$ (%)
S&W & Fringes ¹	32,000 (29.5)	36,000 (29.2)	18,806 (26.9)	39,360 (33.7)
Supplies	1,500 (1.4)	1,500 (1.2)	2,003 (2.9)	2,000 (1.7)
Equipment	15,000 (13.8)	22,800 (18.5)	14,560 (20.8)	20,000 (17.1)
Student Support*	26,000 (24.0)	30,000 (24.3)	26,350 (37.7)	31,000 (26.5)
Collaboration Building**	6,000 (5.5)	6,000 (4.9)	1,500 (2.1)	4,500 (3.9)
Member requests ²	20,000 (18.4)	15,000 (12.2)	6,654 (9.5)	20,000 (17.1)
Release time	8,000 (7.4)	12,000 (9.7)	0 (0.0)	0 (0.0)
Total	108,500 (100.0)	123,300 (100.0)	69,873 (100.0)	116,860 (100.0)

Challenges and Barriers

One challenge facing ESC is maintaining sufficient funding, going forward, to ensure long-term support for the new Center Manager. Co-support from the Tech Forward NRW&E and increasing F&A generation by ESC, largely overcome this challenge. One potential barrier is the decreasing rate of IRAD return, which has declined, over time, from 20% to 18% and now to 15.5% for FY2022. This can potentially limit future growth of the ESC and its programs.

To meet goals for research growth at Michigan Tech, more large collaborative projects will be needed. This will require centers and institutes to collaborate. However, this creates challenges as well. A good system is needed for enabling members of multiple centers to work together, which each center or institute receiving credit for a portion of the award and regular IRAD distribution, based on the efforts of its members. Currently, Center and Institute Directors can do this through MOUs, but a better, more automated system is needed.

Appendix A: ESC Members & Focus Areas

First Name	Rank	Areas of Expertise
Carrie Andrew	Research Assistant Professor, CFRES	Fungi and plant ecology; Data science and spatiotemporal modelling
Tara Bal	Research Assistant Professor, CFRES	Forest Health Management and Monitoring, Earthworm Invasion Ecology, Wood Decay Testing, Insect, Fungi, and Environmental Education, Wild Foods
Kristin Brzeski	Assistant Professor, CFRES	Conservation genetics, Canid genomics, Noninvasive methods in wildlife management, Wildlife immuno- & epi- genetics, Applied conservation in Central Africa
Andrew Burton	Director, ESC, and Professor/Associate Dean, CFRES	Forest responses to global change factors, Belowground processes, Carbon and nutrient cycling, Physiological ecology of tree roots, Undergraduate involvement in research
Patricia Burton	Financial Manager, ESC	Accounting and ESC student grant administration
Angie Carter	Assistant Professor, CFRES	Environmental sociology, Rural sociology, Community-based and participatory research, Social movements and social change
Molly Cavaleri	Associate Professor, CFRES	Forest canopy structure and function, Forest response to global change, Carbon and water cycling through forests, Tree ecophysiology, Stable isotope ecology, Invasive tree species
Rod Chimner	Professor, CFRES	Peatland and wetland restoration, Peatland and wetland carbon cycling, Mountain wetlands, Tropical peatlands, Ecosystem carbon cycling, Wetland ecohydrology
Paul Doskey	Professor, CFRES	Environmental Biogeochemistry, Biogeochemistry of Surface- Atmosphere Exchange, Atmospheric Organic Chemistry, Environmental Analytical Chemistry
Jennifer Eikenberry	Assistant Research Scientist, CFRES	Stable isotopes, Forest ecology, Mass spectrometry

David Flaspohler	Professor, CFRES	Conservation biology, Avian ecology and reproduction, Cascading effects of deer overbrowse, Island ecology
Robert Froese	Associate Professor, CFRES Director, Ford Center and Forest	Forest inventory, mensuration, and biometrics; Silviculture, quantitative silviculture, and growth & yield; Empirical, process and hybrid forest modelling; Biomass and carbon inventory, management, and life cycle assessment
Kathleen Halvorsen	Associate Vice President for Research Development Professor Social Sciences/CFRES	Woody bioenergy, Climate change, Natural resource policy, Biodiversity policy, Bioenergy policy
Jeffrey Henquinet	Center Manager, ESC	Grant proposal and post-award support, NEPA, Natural resources policy
Erika Hersch-Green	Associate Professor, Biological Sciences	Plant evolutionary ecology, Ecological genetics, Eco- evolutionary dynamics
Kathryn Hofmeister	Post-doctoral Research Fellow, CFRES	Watershed hydrology and biogeochemistry, Forest and wetland hydrology, Geographic Information Systems(GIS), Science outreach and communication
Casey Huckins	Professor, Biological Sciences	Ecology of lakes, streams, and riparian interface with terrestrial systems, Fish ecology, biology, functional morphology, Effects of land use on ecological systems, Biomonitoring for research and restoration, Effects of invasive species
Mike Hyslop	Principal Lecturer, CFRES; Master of GIS Program Director	Geographic information systems, Cartography, Global positioning systems, Great Lakes Quaternary (glacial) geomorphology
Maria Janowiak	NIACS Deputy Director, USFS Northern Research Station	Translating science related to climate change and carbon into usable information, resources, and tools for forestry and conservation professionals
Mickey Jarvi	Lecturer, CFRES	Forest ecology, Use of multispectral and hyperspectral imagery attached to unmanned aerial vehicles investigate forestry and natural resource issues

Chandrashekhkar Joshi	Department Chair and Professor, Biological Sciences	Cellulose and lignin biosynthesis in trees, Wood formation, Tree growth and development, Engineering trees, Forest bioinformatics
Martin Jurgensen	Research Professor, CFRES	Forest soil productivity, management and sustainability, Global climate change impact on soil biology, Organic matter decomposition and ecosystem nutrient cycling
Evan Kane	Associate Professor, CFRES	Soil carbon, Plant/soil relationships, Decomposition, Dissolved organic carbon, Wildfire, Black carbon
Matthew Kelly	Assistant Professor, CFRES	Forest operations, Forest and natural resource management, Human dimensions of natural resources, Watershed management, Natural resources policy
Carsten Külheim	Associate Professor, CFRES	Genetic basis of trait variation, Plant adaptation to local environment, Plant secondary metabolism, Functional genomics of plant defenses
Nancy Langston	Professor, Social Sciences	Toxics, forested watersheds, and northern lakes, Environmental history, Watershed change and water quality, Mining history
Glenn Larkin	Senior Research Scientist I, CFRES	Wood protection and composites, Forest natural products
Patricia Leopold	Research Scientist I, CFRES Climate Change Outreach Specialist, NIACS	Ecosystem response to climate change, Climate change adaptation and management strategies, Outreach and technical transfer of climate change tools and resources
Erik Lilleskov	Research Ecologist and Director's Rep., USFS NRS; Adjunct Professor, CFRES	Forest ecology, Ecosystems ecology, Physiological ecology, Community ecology, Fungal ecology, Mycorrhizal fungi, Molecular ecology, Soil ecology, Global environmental change impacts on forest ecosystems, Invasive species impacts, Biogeography of invasive soil organisms

Fengjing Liu	Associate Professor, CFRES	Ecohydrology in forests, Watershed hydrology in montane and lake-dominated catchments, Biogeochemistry in snow-dominated, agricultural and forested catchments, Numerical modeling in watershed hydrology, Forensic hydrology with natural geochemical and isotopic tracers
Tao Liu	Assistant Professor, CFRES	Remote sensing, Change detection, Natural disaster mapping, Invasive species mapping Landcover mapping, Vegetation property extraction with remote sensing techniques
Ann Maclean	Professor, CFRES	Remote sensing, Digital image processing, Geographic information systems, Spatial modeling
Carol MacLennan	Research Professor, Social Sciences	Environmental anthropology/political ecology, Anthropology of industry (mining, sugar), Hawai'i and the Pacific, Anthropology of public policy
Amy Marcarelli	Associate Professor, Biological Sciences	Limnology, Ecosystem ecology of streams and rivers, Biogeochemistry
Jill Olin	Assistant Professor, Biological Sciences	Ecology of aquatic systems, Fisheries science, Aquatic-terrestrial energy linkages, Dietary biomarkers (e.g., stable isotopes, fatty acids, compound-specific isotopes of AA and FA), Trophic ecology of top predators in marine, estuarine and coastal communities, Predator-prey interactions
Rebecca Ong	Assistant Professor, Chemical Engineering	Development of fuel and products from lignocellulosic materials and upcycled waste plastics, sustainability of the bioenergy and bio-based product industries.
Todd Ontl	USDA Northern Forests Climate Adaptation Specialist, NIACS	Understanding the motivations for and implementation of climate adaptation actions on forests across the Midwest and Northeast region
Judith Perlinger	Professor, Civil and Environmental Engineering	Air and water quality, Atmosphere-biosphere exchange of chemicals, Micrometeorology, Environmental analytical chemistry, Sustainability

Rolf Peterson	Research Professor, CFRES	Mammalian ecology, Predator-prey relationships, Ecology and behavior of gray wolves
Sigrid Resh	Research Assistant Professor, CFRES Coordinator, Keweenaw Invasive Species Management Area	Forest carbon dynamics, Soil sustainability, Invasive species education/outreach, control, and research
Mark Rudnicki	Professor of Practice, CFRES	Forest Biomaterials, Tree biomechanics, Wind and trees, Dendrochronology, Extension and Outreach
Kristen Schmitt	Research Scientist I, Climate Change Outreach Specialist, NIACS	Ecosystem response to climate change, Climate change adaptation in natural resource management, Science synthesis and communication
Terry Sharik	Research Professor, CFRES	Academic leadership in natural resources, Educational reform in natural resources, Trends in natural resource enrollments, Regeneration ecology of forests
Andrew Storer	Dean and Professor, CFRES	Forest insect ecology, Insect/fungus/plant interactions in forest ecosystems, Impacts of exotic species on forest ecosystems, Interactions among fire, insects and disease in forests, Urban forest health
Christopher Swanson	Research Ecologist USFS and Director, Northern Institute of Applied Climate Science (NIACS) Adjunct Professor, CFRES	Soil organic carbon stabilization and cycling, Radiocarbon analysis and interpretation, Forest response and adaptation to climate change, Landscape scale conservation
Stephen Techtmann	Assistant Professor, Biological Sciences	Environmental microbiology, Next-generation sequencing technology and bioinformatics, Microbial physiology and biochemistry, Microbes as sensors for the environmental impacts of oil and gas production, Microbial-mediated remediation of crude oil contamination
Colin Tucker	Ecologist/Lab manager, USFS Northern Research Station	Analysis of environmental samples for understanding carbon cycling and potential impacts of climate change on ecosystems

Noel Urban	Professor, Civil and Environmental Engineering	Environmental cycles of major and trace elements, Sediment diagenesis and stratigraphy, Chemistry of natural organic matter, Wetland biogeochemistry, Environmental impact and fate of pollutants, Influence of organisms on the chemical environment, Role of chemical environment in controlling populations
Trista Vick-Majors	Assistant Professor, Biological Sciences	Microbial ecologist who studies the reciprocal relationships between microbial communities and biogeochemical processes in aquatic ecosystem
Ken Vrana	Director, Isle Royale Institute	Wildland experiential outreach
John Vucetich	Professor, CFRES	Demographic and genetic elements of population biology, Ecology of wolves and moose, Environmental ethics
Leah Vucetich	Research Assistant Professor, CFRES	Isle Royale wolf genetics, Field research methods
Christopher Webster	Professor, CFRES	Gap dynamics and disturbance ecology, Invasion biology of exotic species, Landscape ecology, Plant community response to herbivory, Restoration silviculture, Wildlife habitat relationships
Hairong Wei	Professor, CFRES	Identification of genes regulating complex traits via systems biology approaches, Gene expression data analysis, Gene network construction and decomposition, Developing software for mining large-scale biological data, Genomics of wood formation
Richelle Winkler	Associate Professor, Social Sciences	Rural sociology, Population and environment, Environmental sociology, Community engaged scholarship, Internal migration, GIS and spatial analysis
Jared Wolfe	Research Assistant Professor, CFRES	Wildlife conservation in working landscapes, Temperate and tropical avian ecology, Demographic modeling, Avian molts and plumage

Xinfeng Xie	Assistant Professor, CFRES	Carbon materials derived from wood, lignin, and cellulose; Integrated thermochemical conversion and fractionation of lignocellulosic biomass; Carbon-polymer composites and hybrid materials; Wood protection and preservation; Wood properties, quality, and modification
Yinan Yuan	Assistant Professor, CFRES	Identification and characterization of natural antisense transcripts in woody plants, Alternative splicing and salicylic acid metabolism in <i>Populus</i> , Sequencing complex plant genome through gene-enriched methods

Appendix B: List of Member Publications from 2020

The Web of Science Core Collection lists the following 97 refereed publications from 2020 authored or co-authored by ESC members (bold) and their students and postdocs (bold italics).

- Ackerer J, Steefel C, **Liu FJ**, Bart R, Safeeq M, O'Geen A, Hunsaker C, and Bales R.
Determining How Critical Zone Structure Constrains Hydrogeochemical Behavior of Watersheds: Learning From an Elevation Gradient in California's Sierra Nevada.
FRONTIERS IN WATER Volume: 2 Article Number: 23 DOI: 10.3389/frwa.2020.00023
Published: AUG 21 2020
- Albert S, **Wolfe JD**, Kellerman J, Sherry T Stutchbury BJM, Bayly NJ, and Ruiz-Sanchez A.
Habitat ecology of Nearctic-Neotropical migratory landbirds on the nonbreeding grounds.
ONITHOLOGICAL APPLICATIONS 122, Issue 4, 2 November 2020, duaa055,
<https://doi.org/10.1093/condor/duaa055>
- Anwar G**, **Lilleskov EA**, and **Chimner RA**. Arbuscular mycorrhizal inoculation has similar benefits to fertilization for Thuja occidentalis L. seedling nutrition and growth on peat soil over a range of pH: implications for restoration. NEW FORESTS Volume: 51 Issue: 2 Pages: 297-311 DOI: 10.1007/s11056-019-09732-x Published: MAR 2020
- Bachelot B, Alonso-Rodriguez AM, Aldrich-Wolfe L, **Cavaleri MA**, Reed SC, and Wood TE.
Altered climate leads to positive density-dependent feedbacks in a tropical wet forest.
GLOBAL CHANGE BIOLOGY Volume: 26 Issue: 6 Pages: 3417-3428 DOI:
10.1111/gcb.15087 Published: JUN 2020
- Bal TL**, Rouleau MD, **Sharik TL**, and Wellstead AM. Enrollment decision-making by students in forestry and related natural resource degree programmes globally.
INTERNATIONAL FORESTRY REVIEW Volume: 22 Issue: 3 Pages: 287-305 DOI:
10.1505/146554820830405627 Published: OCT 2020
- Bal TL**, **Schneider KE**, and **Richter DL**. Decay Of Birdseye Sugar Maple (*Acer Saccharum*) and Curly Red Maple (*Acer rubrum*) Figured Woods. WOOD AND FIBER SCIENCE Volume: 52 Issue: 3 Pages: 292-297 DOI: 10.22382/wfs-2020-027 Published: JUL 2020
- Batcher K, Dickinson P, Maciejczyk K, **Brzeski K**, Rasouliha SH, Letko A, Drogemuller C, Leeb T, and Bannasch D. Multiple FGF4 Retrocopies Recently Derived within Canids.
GENES Volume: 11 Issue: 8 Article Number: 839 DOI: 10.3390/genes11080839
Published: AUG 2020
- Berry ZC, Jones KW, Aguilar LRG, Congalton RG, Holwerda F, Kolka R, Looker N, Ramirez SML, Manson R, **Mayer A**, Munoz-Villers L, Colin PO, Romero-Urbe H, Saenz L, Von Thaden JJ, Bravo MQV, Williams-Linera G, and Asbjornsen H. Evaluating ecosystem service trade-offs along a land-use intensification gradient in central Veracruz, Mexico.
ECOSYSTEM SERVICES Volume: 45 Article Number: 101181 DOI:
10.1016/j.ecoser.2020.101181 Published: OCT 2020
- Brosemer K, **Schelly C**, **Gagnon V**, Arola KL, Pearce JM, Bessette D, and Olabisi LS. The energy crises revealed by COVID: Intersections of Indigeneity, inequity, and health.
ENERGY RESEARCH & SOCIAL SCIENCE Volume: 68 Article Number: 101661 DOI:
10.1016/j.erss.2020.101661 Published: OCT 2020

- Bruning JR, Ghannam RB, Chen QH, Shan ZY, Miodonski G, **Techtmann S**, and Chapp AD. Microbial Derived Short Chain Fatty-Acids and Autonomic Regulation of Cardiovascular Function. *FASEB JOURNAL* Volume: 34 DOI: 10.1096/fasebj.2020.34.s1.06549 Supplement: 1 Published: APR 2020
- Bruning J, Chapp A, Kaurala GA, Wang RJ, **Techtmann S**, and Chen QH. Gut Microbiota and Short Chain Fatty Acids: Influence on the Autonomic Nervous System. *NEUROSCIENCE BULLETIN* Volume: 36 Issue: 1 Pages: 91-95 DOI: 10.1007/s12264-019-00410-8 Published: JAN 2020
- Burkett E, and **Carter A**. It's Not about the Fish: Women's Experiences in a Gendered Recreation Landscape. *LEISURE SCIENCES* DOI: 10.1080/01490400.2020.1780522 Early Access Date: JUN 2020
- Carter KR**, Wood TE, Reed SC, Schwartz EC, Reinsel MB, Yang X, and **Cavaleri, MA**. Photosynthetic and Respiratory Acclimation of Understory Shrubs in Response to in situ Experimental Warming of a Wet Tropical Forest. *FRONTIERS IN FORESTS AND GLOBAL CHANGE* Volume: 3 Article Number: 576320 DOI: 10.3389/ffgc.2020.576320 Published: SEP 30 2020
- Cavaleri MA**. Cold-blooded forests in a warming world. *NEW PHYTOLOGIST* Volume: 228 Issue: 5 Pages: 1455-1457 DOI: 10.1111/nph.16916 Published: DEC 2020
- Cavigliasso P, **Phifer CC**, Adams EM, **Flaspohler D**, Gennari GP, Licata JA, and Chacoff NP. Spatio-temporal dynamics of landscape use by the bumblebee *Bombus pauloensis* (Hymenoptera: Apidae) and its relationship with pollen provisioning. *PLOS ONE* Volume: 15 Issue: 7 Article Number: e0216190 DOI: 10.1371/journal.pone.0216190 Published: JUL 8 2020
- Christian WC, Butler TM, Ghannam RB, Webb PN, and **Techtmann SM**. Phylogeny and diversity of alkane-degrading enzyme gene variants in the Laurentian Great Lakes and Western Atlantic. *FEMS MICROBIOLOGY LETTERS* Volume: 367 Issue: 23 Article Number: fnaa182 DOI: 10.1093/femsle/fnaa182 Published: DEC 2020
- Collins SF, Baxter CV, **Marcarelli AM**, Felicetti L, Florin S, Wipfli MS, and Servheen G. Reverberating effects of resource exchanges in stream-riparian food webs. *OECOLOGIA* Volume: 192 Issue: 1 Pages: 179-189 DOI: 10.1007/s00442-019-04574-y Published: JAN 2020
- Deng C, Zhang SG, Lu YC, **Froese RE**, Xu XJ, Zeng J, Ming AG, Liu XZ, Xie YS, and Li QF. Thinning effects on forest evolution in Masson pine (*Pinus massoniana* Lamb.) conversion from pure plantations into mixed forests. *FOREST ECOLOGY AND MANAGEMENT* Volume: 477 Article Number: 118503 DOI: 10.1016/j.foreco.2020.118503 Published: DEC 1 2020
- Deng C, **Froese RE**, Zhang SG, Lu YC, Xu XJ, and Li QF. Development of improved and comprehensive growth and yield models for genetically improved stands. *ANNALS OF FOREST SCIENCE* Volume: 77 Issue: 3 Article Number: 89 DOI: 10.1007/s13595-020-00995-5 Published: SEP 7 2020
- Dumroese RK, **Jurgensen MF**, and Page-Dumroese DS. Vegetative and Edaphic Responses in a Northern Mixed Conifer Forest Three Decades after Harvest and Fire: Implications for

- Managing Regeneration and Carbon and Nitrogen Pools. *FORESTS* Volume: 11 Issue: 10 Article Number: 1040 DOI: 10.3390/f11101040 Published: OCT 2020
- Euskirchen ES, **Kane ES**, Edgar CW, and Turetsky MR. When the Source of Flooding Matters: Divergent Responses in Carbon Fluxes in an Alaskan Rich Fen to Two Types of Inundation. *ECOSYSTEMS* Volume: 23 Issue: 6 Pages: 1138-1153 DOI: 10.1007/s10021-019-00460-z Published: SEP 2020
- Figueira L, Martins P, Ralph CJ, Stephens J, Alexander JD, and **Wolfe JD**. Effects of breeding and molt activity on songbird site fidelity. *AUK* Volume: 137 Issue: 4 Article Number: ukaa053 DOI: 10.1093/auk/ukaa053 Published: OCT 1 2020
- Ghannam RB, Schaerer LG, Butler TM, and **Techtmann SM**. Biogeographic Patterns in Members of Globally Distributed and Dominant Taxa Found in Port Microbial Communities. *MSPHERE* Volume: 5 Issue: 1 Article Number: e00481-19 DOI: 10.1128/mSphere.00481-19 Published: JAN-FEB 2020
- Golding SA, and **Winkler RL**. Tracking Urbanization and Exurbs: Migration Across the Rural-Urban Continuum, 1990-2016. *POPULATION RESEARCH AND POLICY REVIEW* Volume: 39 Issue: 5 Special Issue: SI Pages: 835-859 DOI: 10.1007/s11113-020-09611-w Early Access Date: SEP 2020 Published: OCT 2020
- Goltz SM, **Mayer AL**, and **Orr B**. Applied Behavior Analysis as a Development Tool: Examples from Agroforestry. *JOURNAL OF SUSTAINABLE FORESTRY* Volume: 39 Issue: 8 Pages: 785-799 DOI: 10.1080/10549811.2020.1730906 Published: 2020
- Gordon TR, Reynolds G, Kirkpatrick SC, **Storer AJ**, Wood DL, Fernandez DM, and McPherson B. Monterey pine forest made a remarkable recovery from pitch canker. *CALIFORNIA AGRICULTURE* Volume: 74 Issue: 3 Pages: 169-173 DOI: 10.3733/ca.2020a0019 Published: JUL-SEP 2020
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- He C, Lin GF, **Wei HR**, Tang HB, White FF, Valent B, and Liu SZ. Factorial estimating assembly base errors using k-mer abundance difference (KAD) between short reads and genome assembled sequences. *NAR GENOMICS AND BIOINFORMATICS* Volume: 2 Issue: 3 Article Number: lqaa075 DOI: 10.1093/nargab/lqaa075 Published: SEP 2020
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Huo Y, Song X, Zhu SY, Chen Y, Lin X, Wu YQ, Qu Z, Su T, and **Xie X**. High-purity recycling of hematite and Zn/Cu mixture from waste smelting slag. Source: SCIENTIFIC REPORTS Volume: 10 Issue: 1 Article Number: 9031 DOI: 10.1038/s41598-020-66077-8 Published: JUN 3 2020

Hupperts SF, Webster CR, Froese RE, Lilleskov EA, Marcarelli AM, and Dickinson YL. Increasing ground-layer plant taxonomic diversity masks declining phylogenetic diversity along a silvicultural disturbance gradient. CANADIAN JOURNAL OF FOREST RESEARCH Volume: 50 Issue: 12 Pages: 1259-1267 DOI: 10.1139/cjfr-2020-0055 Published: DEC 2020

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Jarvi MP, and Burton AJ. Root respiration and biomass responses to experimental soil warming vary with root diameter and soil depth. PLANT AND SOIL Volume: 451 Issue: 1-2 Special Issue: SI Pages: 435-446 DOI: 10.1007/s11104-020-04540-1 Early Access Date: MAY 2020 Published: JUN 2020

Jones KW, **Mayer A**, Von Thaden J, Berry ZC, Lopez-Ramirez S, Salcone J, Manson RH, and Asbjornsen H. Measuring the net benefits of payments for hydrological services programs in Mexico. ECOLOGICAL ECONOMICS Volume: 175 Article Number: 106666 DOI: 10.1016/j.ecolecon.2020.106666 Published: SEP 2020

Jurgensen MF, Miller CA, and Page-Dumroese DS. Wood Decomposition After an Aerial Application of Hydromulch Following Wildfire in a Southern California Chaparral Shrubland. FRONTIERS IN FORESTS AND GLOBAL CHANGE Volume: 3 Article Number: 93 DOI: 10.3389/ffgc.2020.00093 Published: JUL 30 2020

Kelly MC, and Germain RH. Applying Theory of Constraints to Timber Harvesting: A Case Study from the Northeast USA. CROATIAN JOURNAL OF FOREST ENGINEERING Volume: 41 Issue: 1 Pages: 59-69 DOI: 10.5552/crojfe.2020.534 Published: 2020

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Kerfoot WC, **Urban N**, Jeong J, MacLennan C, and Ford S. Copper-rich "Halo" off Lake Superior's Keweenaw Peninsula and how Mass Mill tailings dispersed onto tribal lands. JOURNAL OF GREAT LAKES RESEARCH Volume: 46 Issue: 5 Pages: 1423-1443 DOI: 10.1016/j.jglr.2020.07.004 Published: OCT 2020

Kozich AT, Gagnon VS, Mensch G, Michels S, and Gehring N. Walleye Ogaawag Spawning in the Portage Waterway, Michigan: Integrating Mixed Methodology for Insight on an Important Tribal Fishery. JOURNAL OF CONTEMPORARY WATER RESEARCH & EDUCATION Volume: 169 Issue: 1 Pages: 101-116 DOI: 10.1111/j.1936-704X.2020.03335.x Published: APR 2020

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