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Pregledni naučni rad

ICT SISTEMI ZA PRAĆENJE I ZAŠTITU DIVLJIH ŽIVOTINJA U NJIHOVOM PRIRODNOM OKRUŽENJU

Branko MARKOVIĆ[1]*, Drago NEDIĆ[2], Savo MINIĆ[3]

1 Branko Marković, dipl.ing, „Prointer" IT Solutions and Services, Vuka Karadžića 2, Banja Luka, Republika Srpska
2 Prof.dr Drago N. Nedić, redovni profesor, Fakultet veterinarske medicine Univerziteta u Beogradu, Bulevar oslobođenja 18, Beograd Srbija
3 Savo Minić, dipl. pravnik, Ministarstvo poljoprivrede, šumarstva i vodoprivrede, Trg Republike Srpske 1, Banja Luka, Republika Srpska
* korespodentni autor: Branko Marković: markovic.branko@prointer.ba

Kratak sadržaj: Rad se bavi sistemima za praćenje i zaštitu divljih životinja u njihovim prirodnim okruženjima, te primenom navedenih tehnologija i rešenja u zaštićenim rezervatima prirode. Rad razmatra razloge i mogućnosti primene navedenih tehničkih rešenja, posebno u smislu zaštite vrsta sa crvene liste ugroženih vrsta. U ovom smislu rad razmatra i tehnološka rešenja te mogućnosti njihove primene kroz IoT radni okvir, koncept Interneta životinja, te primene navedenih tehnologija kroz različite poslovne i istraživačke modele. Konačno, rad daje primere rešenja kako sa stanovišta neophodne infrastrukture (serveri, skladište, internet, ogrlice za životinje, stacionarne kamere i dronovi), tako i sa stanovišta obrade podataka i pravnog okvira za primenu navedenih rešenja.

Ključne reči: IoT, divlje životinje, ugrožene vrste

UVOD

Problem istraživanja, ali i popularizacija divljih životinja u njihovim prirodnim ekosistemima danas dobija na svojoj aktuelnosti iz više razloga. Osnovni razlog ovog pojačanog interesovanja za terensko istraživanje divljih životinja u njihovom prirodnom okruženju leži kako u mogućnostima daljinskog praćenja životinja ali i obrade dobijenih rezultata i merenja koje otvaraju nove ICT tehnologije, tako i u činjenici da je usled industrijskog razvoja veliki broj prirodnih okruženja ovih životinja naprosto nestao kao posledica izgradnje civilne infrastrukture, te povećanih potreba civilizacije za životnim prostorom. Na taj način se smanjuje životni prostor divljih životinja pa samim tim i mogućnosti

ekosistema za obezbeđenje životnog prostora, hrane i drugih vitalnih potreba za određeni broj životinja. Ovi procesi su nezadrživi i direktno vode ka izumiranju pojedinih ugroženih vrsta, uglavnom predatora, koji se nalaze na vrhu lanca ishrane u nekom ekosistemu. Kako se smanjuje mogućnost da divlje životinje pronađu hranu, tako se povećava mogućnost susreta civilizacije i divljih životinja, odnosno, mogućnost da divlje životinje u očajanju hranu potraže izvan ograničenih i izolovanih ekosistema. Ovo dovodi do novog pritiska, kako od strane farmera, koji su ovakvim ponašanjem predatora direktno pogođeni, tako i na sam ekosistem, jer se u akcijama koje slede izlovom ograničava broj predatora na način da se on konstantno smanjuje, pa pomenuta vrsta uskoro dolazi na ivicu izumiranja. A kako je u prirodi sve povezano, ovo ima nesagledive posledice za ceo ekosistem koji se vremenom urušava i iz živog ekosistema u relativno kratkom vremenu pretvara u civilni park čije su osobine u skladu sa očekivanjima stanovništva i koji služi kao prostor za rekreaciju umesto kao prostor za život ugroženih vrsta, što mu je i bila prvobitna namena.

Mogućnost praćenja divljih životinja u njihovom okruženju pomaže da se navedene situacije preduprede i to je jedan od osnovnih komercijalnih razloga povećane zainteresovanosti za tehnike i tehnologije praćenja divljih životinja u njihovom prirodnom okruženju.

Drugi značajan faktor koji uzrokuje povećano interesovanje, a samim tim i upotrebu tehnika za praćenje životinja ogleda se u delovanju grupa za zaštitu ugroženih vrsta koje se trude da u ograničenim i de facto nefunkcionalnim ekosistemima omoguće opstanak divljih životinja onako kako je to uredila priroda.

Treći značajni faktor svakako predstavljaju pokušaji biologa da detaljno prouče ponašanje divljih životinja tako da ih zahvaljujući novim neinvazivnim tehnologijama prate sa udaljene lokacije izbegavajući svaku moguću interakciju sa ekosistemom kao takvim, te na taj način izvrše adekvatno istraživanje ponašanja jedinki ali i grupa životinja, pri čemu se posebna pažnja posvećuje socijalnom i teritorijalnom ponašanju divljih životinja. Sa ovim u vezi treba naglasiti sledeće – ako želimo da upoznamo život i ponašanje divljih životinja do sada smo bili ograničeni na pojedinačna posmatranja i biološke ekspedicije, pri čemu bi biolog ulazio u neki ekosistem i posmatrao ga i proučavao trudeći se da ne narušava njegove tokove, u nadi da će otkriti obrasce ponašanja divljih životinja / posmatrane vrste i njenu interakciju da drugim elementima ili vrstama u okviru ekosistema. Ovakav način proučavanja životinja osim što je dugotrajan, neizvestan i krajnje naporan za istraživača ujedno je i zasnovan na ekonomski najpovoljnijem modelu, jer se celokupno istraživanje zasniva na očekivanju da će pojedinac biti dovoljno kadar da u prihvatljivom roku i pod prihvatljivoj ceni uoči, klasifikuje i sortira ključne događaje, te uoči i razume ponašanje grupe životinja koju posmatra

i iz navedenog prepozna obrasce, te izvuče zaključke i formalizuje stečeno znanje na način uspostavljanja naučnih zakonitosti koje su suštinski logički konzistentne, proverljive i dokazive. Treba naglasiti da je primarni zahtev u vezi sa razumevanjem ponašanja životinja vezan sa saznanjem gde se životinja nalazi i šta trenutno radi, jer ovo saznanje praćeno i evidentirano u dužem vremenskom periodu predstavlja obrazac ponašanja dotične životinje i osnova je za dalje proučavanje. Od navedenoga, između ostalog, zavise, odnosno, mogu se reversnom analizom iskristalisati, prirodne potrebe za hranom, vodom, kretanjem, odmorom, te druge fiziološke potrebe i navike.[1]

Ovakva praksa prvenstveno biološkog izučavanja divljih životinja donekle je počela da se menja tokom 1960-tih, kada su se po prvi put u svrhu praćenja divljih životinja počele primenjivati metode daljinskog praćenja zasnovane na opremanju praćenih životinja sa adekvatnim aktivnim ili pasivnim tagovima (ogrlicama, prstenjem za označavanje…) i korišćenju radiogoniometrijskog pristupa za lokaciju i određivanje položaja i dnevnog hodograma životinje.

Četvrti faktor koji uzrokuje pojačano interesovanje za tehnologije praćenja divljih životinja ogleda se u činjenici da se zahvaljujući pomenutim tehnologijama i primeni drugih ICT tehnologija na mnogo adekvatniji način mogu prezentovati kako pomenuti ekosistemi i pripadajuće životinje, što je zanimljivo kako sa komercijalnog stanovišta, tako i na edukativnom nivou. Ovaj trend će rasti kako se bude menjala demografska struktura publike kojoj su ovakvi sadržaji namenjeni, jer mlade generacije percepciju stvarnosti pre dobijaju kroz tehnologije socijalnih mreža koje su primenjive i na životinje u nekom ekosistemu, nego na direktnom susretu sa navedenim životinjama. Tako se pitanje osnivanja i očuvanja nacionalnih parkova svodi praktično na pitanje prepoznatljivosti njihove funkcije, odnosno, na pitanje načina kako se prezentuju razlozi njihovog postojanja i način upravljanja u njima, odnosno, način na koji se životinje u okviru njih tretiraju i koju vrstu i kakve popularnosti postižu na globalnom tržištu informacija.

Ovo praktično znači da je uslov opstanka pojedinih nacionalnih parkova ali i životinjskog sveta u njima, posebno kada su u pitanju veliki predatori sa vrha lanca ishrane, adekvatna prezentacija istih, kroz ICT tehnologije, prvenstveno socijalne mreže i profile, jer je to način na koji moderna populacija ne samo percipira stvarnost nego i odlučuje o potrebama i uslovima finansiranja istih.

Ostali društveni uticaji koji utiču na potrebu boljeg sagledavanja životinja

1 W. W. Cochran, D. W. Warner, J. R. Tester, V. B. Kuechle, Automatic Radio-Tracking System for Monitoring Animal Movements, Reprinted from BioScience, Vol. 15, No.2, 1965, pp 98-100, dostupno na mreži: https://www.researchgate.net/publication/247840577_Automatic_Radio Tracking_System_for_Monitoring_Animal_Movements

i njihovog ponašanja u prirodnom okruženju

Delovanjem grupa za zaštitu životinja stvoren je pritisak na zoološke vrtove i korisnike životinja u izvođačke svrhe da se životinjama u ovoj vrsti zatočeništva obezbedi što prirodnije okruženje kako u smislu habitata tako i u smislu socijalnog okruženja i načina ishrane. Da bi se ovo obezbedilo, mnogi zoocentri sada stvaraju simulirane prirodne habitate i posmatraju socijalne sposobnosti i ponašanje čak i najuobičajenijih životinja.[2] Upravo ova društvena inicijativa, koja je pokušavala da zaštiti divlje životinje u zoo vrtovima, dovela je do povećane potrebe da se te iste vrste životinja proučavaju u njihovim prirodnim okruženjima kako bi se odgovorilo zahtevima u smislu čuvanja i privređivanja životinjama koje pred njih postavljaju grupe za zaštitu prava životinja.

Problem lova, izlova i upravljanja lovnim resursima u predelima koji nisu pod posebnim režimom zaštite (šume, planinsko gorje) ogleda se u nedovoljno jasnoj metodologiji za određivanje izlovnih kvota, koje često ne korespondiraju ni sa jednom priznatom metodologijom već sa trenutnim potrebama civilnog društva naslonjenog na date ekosisteme. Naime, u prostorima van posebno zaštićenih prirodnih rezervata problem opstanka velikih predatora svodi se na upravljanje lokalnim interesima, kako interesima lovačkih udruženja, tako i interesima lokalnih farmera. Jedan od ozbiljnih problema, naročito kada su u pitanju predatori sa vrha lanca ishrane koji su i najugroženiji, jer ponajpre ostanu bez dovoljne količine hrane ogleda se u činjenici da se oni, što opet na našim prostorima znači vukovi i medvedi, zapute da hranu traže van šumskih gazdinstava gde su još uvek neprimetni pa samim tim i donekle zaštićeni od lovaca. Naime, ako se desi da neki vuk napadne neku domaću životinju, u prvom redu stoku na slobodnoj ispaši, kao mera prevazilaženja problema predmet izlova postaće ne samo on, već verovatno i mnogi drugi članovi čopora, jer se on automatski proglašava za štetočinu, pa se prema njemu, ali i pripadnicima iste vrste, sprovode najrestriktivnije mere u smislu odstrela. Sistemi za kontinuirano daljinsko praćenje predatora predstavljaju moguće rešenje ovog problema, jer se na taj način stvara konstantni uvid u ponašanje životinja i njihovu prisutnost na određenoj teritoriji, pa je moguće stvoriti i preduslove za njihovo oslobađanje od stigme krivice za napade na stoku. U ovom slučaju može se reći da postoji i jak društveni aspekt upotrebe tehnologija za praćenje životinja, jer oslobađanje životinja sa socijalne tačke gledišta takođe znači oslobađanje ljudi. Više autora naglašava činjenicu da problemi vezani za ekološku

2 ERIC SCHMITT, 'Natural' Habitats Offer Insights Into Social Behavior of Animals, The New York Times, January 26, 1988, dostupno na mreži: http://www.nytimes.com/1988/01/26/science/natural-habitats-offer-insights-into-social-behavior-of-animals.html

krizu koja je postala globalna potiču od antropomorfnog gledišta i ličnih interesa i da je, da bi očuvali postojeće zaštićene ekosisteme, neophodno da ovaj pogled na svet promenimo.[3]

Usled neprestanog civilizacijskog napretka, dolazi do prenamene pojedinog zemljišta, između ostalog i onog koje je ranije bilo deo posebnog ekosistema, koji se usled prekida prirodnih ciklusa i procesa nasilne urbanizacije ubrzano osiromašuje do nivoa njegovog prelaska u potpuno nenaseljeno zemljište, pa poseban značaj danas poprima desertifikacija zemljišta. Prema mišljenu i radovima biologa Alana Sejvorija, ovaj proces se može sprečiti ako se zemljište upotrebljava tako da se oponašaju prirodne fluktuacije ekosistema. Uticaj predatora prema njemu je da teraju životinje kojima se hrane sezonskim biljem da se kreću, te sami time ne ostvaruju lokalni uticaj u smislu njihovog zagađivanja sredine preko granica samoodrživosti nekog ekosistema. Na taj način predatori u stvari omogućavaju opstanak kompletnog ekosistema sa svim vrstama u njemu. Odstranjivanje predatora iz ekosoistema neće spasiti ni jednu zaštićenu vrstu, a dugoročno će dovesti do urušavanja tog ekosistema u dezertifikacijsko zemljište.[4] Upravo gledano sa ovog stanovišta, postaje jasno koliko je važno imati mogućnost realnog i redovnog uvida u kretanje i ponašanje divljih životinja, posebno predatora, jer se mimikovanjem prirodnih ciklusa može, u kraćem vremenskom periodu, povratiti deo dezertifikovanog zemljišta u samoodržive ekosisteme.

Mnoge zemlje danas su suočene sa potrebom da usklade i orkestriraju javno zdravlje, zdravlje stoke i zdravlje divljih životinja na slobodi. Pojave kao što su bolesti koje se prošire iz prirodnih staništa ka urbanim sredinama više nisu tako retke, setimo se samo ptičijeg gripa, hantavirusa, te virusa Zapadnog Nila. Suočene sa potrebom da zaštite prirodne ekosisteme, ali i sopstveno stanovništvo, mnoge zemlje poput Kanade osnovale su posebne agencije koje će pratiti mortalitet divljih životinja, tražiti njegove uzroke, predviđati i pokušati da umanje rizike koje on izaziva po javno zdravlje.[5] Ovakve široko rasprostranjene mreže omogućavaju da zdrastvene organizacije rade preventivno pre nego reaktivno, te

3 Jessica Ellis, Mel Hall, Phil Ong, Leif Wege, Natalie Paterson, Chelsea Smith, Animal Testing at Dalhousie University: A brief insight into social, economic, and environmental effects of nonhuman animal testing, Dalhousie University, 2010, dostupno na mreži: https://www.dal.ca/content/dam/dalhousie/pdf/science/environmental-science-program/ENVS%203502%20projects/2010/AnimalTesting.pdf

4 Allan Savory, How to green the world's deserts and reverse climate change | Allan Savory, Published on Mar 4, 2013, video, 02.03.2017, dostupno na mreži: https://www.youtube.com/watch?v=vpTHi7O66pI

5 Tyler Stitt, Julie Mountifield, Craig Stephen, Opportunities and obstacles to collecting wildlife disease data for public health purposes: Results of a pilot study on Vancouver Island, British Columbia, Canadian Veterinary Journal, 2007 Jan; 48(1): 83–90., dostupno na mreži: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1716737/#

umnogome izbegnu i umanje negativne efekte bioloških hazarda koji nam dolaze od divljih životinja, a osnovni preduslov za operativni rad ovakvih agencija je široko rasprostranjena mreža senzora, kako u ekosistemima tako i na samim životinjama, jer tek ovako prikupljani podaci imaju dovoljnu gustinu, a samim tim i pouzdanost da se možemo osloniti na njihovu tačnost te izbeći pretpostavke sumnjive tačnosti koje danas dominiraju ovim poljem usled nedovoljno podataka, odnosno, zbog skupljanja podataka tek kad je neka pojava toliko uzela maha da je postala prepoznatljiva. Tehnologije za daljinsko praćenje životinja te njihovih navika u ovome predstavljaju ključnu tehnologiju koja obezbeđuje prikupljanje neophodnih podataka kako u realnom vremenu tako i u smislu istorijskog loga, pa ih je moguće podvrgnuti tehnikama *Big Data* analitike koja obezbeđuje zadovoljavajući nivo tačnosti predviđanja, ali se mogu koristiti i kao alati za pretragu unazad, ka izvoru zaraze odnosno pronalasku biološkog hazarda i okidača koji je doveo do pojave navedenih bolesti.

Proces zaštite i pravne mere za obezbeđivanje pravnih, organizacionih i operativnih aktivnosti na zaštiti ugroženih vrsta

Proces zaštite neke ugrožene vrste počinje njenom indentifikacijom i evidentiranjem, te procenom ugroženosti, u svrhu izrade Crvene liste ugroženih vrsta koje predstavljaju prikaz stepena ugroženosti pojedinih vrsta na određenom prostoru. Ove liste su dinamičke prirode i kontinuirano se dopunjuju, odnosno, menjaju u skladu sa promenama na terenu.

Ovde je posebno važno napomenuti da stepen ugroženosti raste sa smanjenjem prirodne raširenosti vrste, odnosno raste u slučaju endemičnosti vrste. Najveći broj ugroženih vrsta je endemičan, odnosno usko lokalizovan u rasprostranjenju i ekološki stenovalentan, pa se nestajane (izumiranje) takvih vrsta ne može nadoknaditi iz nekog drugog „rezervnog" genetičkog izvora, kao što je slučaj sa regionalno iščezlim vrstama koje se mogu (re)introdukovati iz sačuvanih populacija negde drugde.[6]

Nažalost, u Bosni i Hercegovini još uvijek ne postoje Crvene liste na nivou države. U RS je 2012. godine donesena lista zaštićenih vrsta čiji je naziv „Crvena lista zaštićenih vrsta flore i faune Republike Srpske" („Službeni glasnik RS" br. 124/12) u kojoj nisu date kategorije ugroženosti pojedinih vrsta. S druge strane, u FBiH je 2014. godine usvojena „Crvena lista divljih vrsta i podvrsta biljaka, životinja i gljiva" („Službene novine Federacije BiH", broj: 7/14) u kojoj je uz svaku vrstu koja se navodi u dokumentu data i kategorija ugroženosti.[7]

6 Tatjana Ratknic, 2017: UGROŽENE BILJNE VRSTE U SRBIJI, Ekološko-šumarski centar "Sylva", dostupno na mreži: http://sylva.rs/doc/Ugrozene%20biljne%20vrste%20u%20Srbiji.pdf

7 Zaštita ugroženih vrsta u BiH, blog biolog.ba, 24.05.2017, dostupno na mreži: http://biolog.ba/58-zastita-ugrozenih-vrsta-u-bih.html

Iako su Crvene liste dokumenti koji bi se trebalo da se zasnivaju na istoj, međunarodno prihvaćenoj metodologiji, u realnosti, u BiH postoje dva potpuno različita dokumenta za koje je potpuno nejasno na osnovu kojih parametara je vršen izbor i kategorizacija vrsta.

Upravo ovde leži i problem indentifikacije realne ugroženosti pojedinih, prvenstveno životinjskih vrsta, sa specifično velikim radijusom dnevnih i sezonskih migracija. Ovo dolazi i stoga što navedene životinje često prelaze iz jednog u drugi pravni entitet, pa se procena ugroženosti vrši na osnovu „duple evidencije“ a nije adekvatna situaciji na terenu.

Sa druge strane, tehničke, organizacione mere zaštite i operativne aktivnosti moraju imati svoje obrazloženje i pravno utemeljenje koje bi trebalo da se zasniva na realnoj proceni ugroženosti ili uvidu u stanje populacije na terenu. Za ovo je potrebno obezbediti tehnički sistem kojim se omogućuje stalni uvid ili barem dovoljno frekventni uvid u stanje populacije, što je jedino moguće izgradnjom sistema za daljinsko praćenje životinja, te organizovanjem usluga rendžerske i tehničke zaštite ugroženih vrsta kroz neki potvrđeni pravni okvir.

Objedinjene na jednom mestu, Crvene liste za određeni geografski region predstavljaju takozvane Crvene knjige – naučno-stručne publikacije u kojima su navedene sve vrste organizama koje podležu zaštiti prema međunarodnoj klasifikaciji stepena ugroženosti:

- vrste pred istrebljenjem;
- vrste u opasnosti od istrebljenja;
- ranjive (osetljive vrste);
- retke vrste.

Retke i ugrožene vrste su zaštićene zakonom tako da se njihova staništa proglašavaju za stroge rezervate prirode u kojima vlada poseban režim i u kojima je aktivnost ljudi svedena na najmanju meru. Odvajanje ugroženih vrsta i obezbeđivanje staništa u okviru nekog zatvorenog ekosistema predstavlja najefikasniji način zaštite ugroženih vrsta. Ipak, ovakim zakonskim rešenjima stvara se i određena ekskluzivnost, te se daju posebna prava kako upravama parkova tako i posebnim organizacijama koje se bave zaštitama vrsta. Iako je namera zakonodavca da na ovaj način omogući i potpomogne zaštitu neke ugrožene vrste, činjenice na terenu pokazuju da je davanje širokih a posebno ekskluzivnih ovlaštenja često i izvor korupcije te osnov za obavljanje mnogih nezakonitih pa čak i kriminalnih aktivnosti. Tako nije neuobičajena praksa da se u okviru pojednih rezervata prirode uprave parkova ponašaju kao monopolisti nad prirodnim resursom koji im predstavlja kako izvor egzistencije, tako i izvor za sticanje materijalne i finansijske dobiti trgovinom i/ili krivolovom vezanim za ugrožene vrste koje bi upravo uprave parkova trebalo najviše da štite. Mere tehničke zaštite, a posebno infrastruktura za daljinski nadzor nad ugroženim vrstama biljaka i životinja omogućava da mere zaštite i

operativnog postupanja u okviru zaštite ugroženih vrsta i rezervata prirode postanu transparentne i javne, te da se na osnovu njih uvede adekvatna kontrola zaštite ugroženih vrsta ali i habitata kao takvog. Činjenica da se pojedine uprave parkova ovom protive samo je posredni indikator koji jasno nagoveštava da se poslovanje dotičnih uprava ne obavlja na adekvatan i zakonom propisan način. Sa druge strane, navedena infrastruktura omogućava i široku popularizaciju te podizanje svesti šire društvene zajednice u vezi sa potrebom očuvanja prirodne sredine i ugroženih vrsta u njoj.

KONZERVACIJA I UPRAVLJANJE NACIONALNIM PARKOVIMA

Da bi se zaštitile ugrožene vrste i njihova staništa, danas se primenjuju institucionalne ali i neinstitucionalne mere. Institucionalne mere uglavnom su vezane za aktivnosti država i vlada dok neinstitucionalne mere predstavljaju sve oblike privatnih inicijativa na očuvanju živog sveta i biodiverziteta. Ujedinjene nacije kao krovna organizacija koja se između ostalog bavi i krovnim organizovanjem nacionalnih i međunarodnih inicijativa za očuvanje prirode dala je niz preporuka i definicija, kao i standarda iz oblasti očuvanja prirode i zaštite ugroženih vrsta. Akt o ugroženim vrstama prepoznaje da ribe, divlje životinje i biljke za ljude imaju estetske, školske, obrazovne, istorijske, naučne i rekreacione vrednosti i da se prema ovim vrednostima, koje su zajedničke svim ljudima, čovek mora odnositi na način da štiti pomenute vrednosti.[8]

U prethodnom periodu učinjeni su institucionalni koraci za zaštitu posebnih rezervata prirode u okviru kojih je jedan broj zaštićenih životinjskih vrsta dobio zaštićena staništa na način da se deo teritorije na kojima obitava navedena vrsta dobio status nacionalnog parka ili drugog rezervata prirode. Pojačani zahtevi za proširenje civilne infrastrukture ipak su dovodili do pojačanog pritiska na ove rezervate, pa su primetne i pojave indirektnog slabljenja, odnosno, indirektnog negativnog uticaja na zaštićena područja. Ovi indirektni uticaji najčešće su posledica promene mikroklime do koje dolazi usled promene geofizičkih osobina susednog zemljišta – izgradnja brana i veštačkih jezera može da uzrokuje promenu obrazaca duvanja vetra, promeni lokalnu vlažnost, i kapilarnu irigaciju, što sve direktno utiče na sposobnost nekog ekosistema u smislu produkcije hrane za biljojede, a samim tim i predatore koji se njima hrane. Sličan uticaj imaju i izgradnja termoelektrana ili velikih industrijskih kapaciteta, prolazak auto-puta ili neke druge globalne saobraćajnice u neposrednoj blizini zaštićenog rezervata. Da bi se ovo izbeglo postoji zakonska obaveza izrade studije uticaja. Studija uticaja na životnu okolinu često je

8 Randall Abate, What Can Animal Law Learn from Environmental Law?, Environmental Low Institute, West Academic,2015 pp 160, ISBN 978-1-58576-176-0

pogrešna u smislu davanja dugoročnih procena kako će izgradnja nekog infrastrukturnog objekta (civilnog, komunalnog ili energetskog sistema) delovati na životnu sredinu.

Takođe, treba naglasiti i da se usled globalnih klimatskih promena sposobnost ekosistema dodatno smanjuje u smislu produkcije neophodne količine hrane za određeni broj životinja, što dovodi do smanjenja broja jedinki i do njihovog de fakto izumiranja, ako se čovek, u smislu direktne intervencije, ne umeša u kritičnim periodima. Pod ovim se prvenstveno podrazumeva opcija hranjenja izgladnelih životinja putem organizovanih hranilišta bez direktnog susreta između rendžerske službe i divljih životinja. Da bi ovakav vid privremenog hranjenja bio uspešan, on mora korespondirati sa navikama životinja, odnosno, sa njihovim prirodnim migracijama i dnevnim potrebama, za šta je takođe neophodno da rendžerska služba, a posebno veterinari i biolozi imaju na raspolaganju adekvatne i aktuelne informacije koje pruža sistem za daljinsko praćenje životinja. U smislu navedenog, važno je napomenuti da konzervacija i upravljanje nacionalnim parkovima ne mogu više biti izolovani pokušaji uprave parkova i njihovih timova za zaštitu, već se zaštita, u smislu monitoringa uslova, mora proširiti i van graničnih oblasti zaštićenih područja, te rad na projektima zaštite izvoditi u široj zajednici.[9]

U smislu zaštite prirode i konzervacije pojedinih izolovanih ekosistema, kakvi su nacionalni parkovi, moderne ICT tehnologije pružaju višestruke prednosti u odnosno na klasične metode i tehnike upravljanja zaštićenim područjima. ICT tehnologije pružaju sledeće prednosti[10]:

- Omogućavaju da se odredi kolika je tačno populacija koja naseljava habitat unutar zaštićenog područja
- Omogućavaju jasan uvid kolika je teritorija po pojedinim jedinkama i vrstama (teritorija jedne životinje, teritorija krda ili čopora grabljivaca)
- Ima li viška životinja koje nemaju svoju teritoriju i koje se mogu premestiti u neko drugo zaštićeno područje
- Omogućavaju uvid u distribucione šablone pojedinih vrsta na datom području, po prostoru i vremenu
- Ove tehnologije omogućavaju praćenje i očuvanje biodiverziteta

Pružaju brze feedback podatke

Najveći problem prilikom primene novih ICT tehnologija na zaštićene rezervate prirode predstavlja pitanje mrežne infrastrukture. Naime, većina

9 Fish and Wildlife Service I&M: Connecting Science-driven Monitoring to Management, National Wildlife Refuge System Inventory and Monitoring (I&M) initiative, Published on 4 Aug 2012, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=XutmC7QRGUM

10 Priya Joshi, Wildlife conservation through innovative technology: Priya Joshi at TEDxKathmandu, TEDx Talks, Published on 10 Jan 2013, video, 24.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=bgM5kHZYrO8

ICT tehnologija primenjuje se na način da su procesi prikupljanja podataka odvojeni od procesa obrade informacija i dobijanja vrednosti, kako naučnih, tako operativnih u smislu upravljanja i njohove popularizacije. Za potrebe prvih neophodno je u zaštićene rezervate prirode obezbediti mrežu i/ili internet, dok se ostali obrađuju u zasebnim data centrima i/ili u okviru nekog cloud rešenja. Iz navedenog jasno proizilazi da je najskuplji i tehnički najzahtevniji deo izgradnje neophodne infrastrukture vezan za uvođenje interneta na celokupnom prostoru zaštićenog područja. U područjima kod koji je stepen zaštite niži, ovo se ostvaruje primenom standardne wi-fi tehnologije uz minimalno privremeno narušavanje prirodnog staništa tokom postavljanja kablovske infrastrukture kojom se povezuju krajnji nodovi i bazne stanice. U slučaju uvođenja interneta u oblasti sa višim nivoom zaštite ovo se izvodi isključivom primenom wi-fi tehnologija pri čemu se bazne stanice postavljaju na obodu zaštićenog područja. U slučaju prašume, usled velike gustine vegetacije, navedena rešenja ne bi bila dovoljno efikasna na celokupnom zaštićenom teritoriju prašume, pa je potrebno i pokrivanje jednog dela prašume sa pristupnim tačkama kojima se obraćaju mrežni uređaji instalisani u ogrlicama životinja koje se prate iz vazduha (AP montirani na dronove, balone ili male vazdušne brodove). Da ideja o instalisanju i korištenju wi-fi tehnologije dobija svoje pristalice najbolje govori podatak da Kanada planira da u svoje nacionalne parkove uvede wi-fi i time omogući brži i lakši prenos podataka od dosadašnjeg koji se zasnivao na tehnologijama mobilne telefonije.[11] Ovakvi planovi i izvedena rešenja jasno govore o tome da se teži smanjivanju operativnih troškova nacionalnih parkova uz istovremeno poboljšanje i podizanje kvaliteta oglašavanja, te pružanja usluga prisustva na daljinu, kako ljubiteljima životinja tako i u naučne i obrazovne svrhe. Važno je naglasiti da bez izgradnje odgovarajuće mrežne wi-fi infrastrukture praktično nema mogućnosti primene modernih ICT tehnologija u oblasti praćenja i upravljanja prirodnim rezervatima i zaštite ugroženih vrsta. Ovo dolazi i stoga što je za adekvatno prikupljanje podataka neophodno imati mreže čija propusna moć odgovara količini saobraćaja koji se generiše, a poznato je da IoT uređaji, posebno senzori od kojih se zahteva emulacija kontinuiranog praćenja stanja, generišu velike količine podataka koje treba transportovati do centralnog servera na kojem će se raditi obrada podataka i generisati neophodne informacije.

11 Wi-Fi in the woods: Canada plans to install web hotspots across its national parks and historic sites, Daily Mail, 29 April 2014, On Line izdanje, 24.12.2016, dostupno na mreži: http://www.dailymail.co.uk/sciencetech/article-2616007/Wi-Fi-woods-Canada-plans-install-web-hotspots-national-parks-historic-sites.html#ixzz4TmNxjQeH

IOT FRAMEWORK

Jedan od značajnih prednosti sistema praćenja divljih životinja u njihovim prirodnim habitatima pomoću IoT tehnologija ogleda se u većoj transparentnosti procesa u ekosistemu, pa možemo naučiti kako ekosistem funkcioniše, a ne se samo usresrediti na spasavanje jedne ugrožene vrste, jer takav ogoljen pristup zaštite ugroženih vrsta često ne daje rezultate. Ako pretvorimo praćenu životinju u neku vrstu digitalnog proizvoda, ona će kreirati na milione specifičnih merenja,[12] odnosno, podataka neophodnih da stvorimo dublji i bolji uvid u njen život ali i ponašanje, običaje, navike i ukupne biološke potrebe cele vrste. IoT i BigData rešenja omogućavaju da se prikupi i obradi veliki broj podataka, te da se na osnovu toga generišu novi uvidi. Koliko je ova tehnologija napredna, u smislu omogućavanja novih uvida, najbolje govori podatak da se u stručnoj literaturi danas sve češće govori o Biotelemetrijskoj revoluciji. Razlozi usled kojih se današnje stanje razvoja može opisati kao Biotelemetrijska revolucija su:

- Uređaji su sve manji po dimenzijama i masi, na tržištu postoji veliki broj malih integrisanih GPS uređaja
- Zahvaljujući Cloud tehnologijama omogućeno je prikupljanje parcijalnih data strimova i njihovo kombinovanje u cilju dobijanja što pouzdanijih informacija bilo da se do njih dolazi u realnom vremenu ili odloženo

Treba primetiti da IoT i Big Data omogućavaju ne samo nove naučne uvide već i jedan novi oblik upravljanja resursima koji se može nazvati upravljanje prema realnim informacijama u realnom vremenu, ili posredno direktivno upravljanje na bazi uvida u realnost. Ovakvo upravljanje predstavlja kvantitativni i kvalitativni skok sa dosadašnjeg načina upravljanja i gospodarenja prirodnim resursima. Takođe, IoT radni okvir predstavlja mogućnost da se ideje pretvore u digitalne proizvode, sa tim u vezi postavlja se pitanje može li se upotrebom ovog metoda prašuma pretvoriti u digitalni proizvod i taj proizvod učiniti samoodrživim ekonomskim modelom koji bi štitio prašumu. Jedna od ideja koja se kristališe jeste i iznalaženje novih poslovnih modela kako bi se olakšalo poslovanje zaštićenih rezervata prirode. Pretvaranjem nacionalnog parka ili zaštićene vrste u digitalni proizvod omogućava se ne samo popularizacija ideja zaštite, već je moguće i ostvariti dodatna finansijska sredstva kojima će se potpomoći rad samog rezervata prirode.

ICT pomaže u izgradnji kapaciteta

12 Daniel Smith, 2015 September Webinar IoAHTedited, TheCSAlliance, University of Cambrige, Cambrige Service Alliance, Published on Sep 15, 2015, video, 23.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=DQew3ESgZoQ

13 John Houghton, ICT and the environment in developing countries: opportunities and developments, Centre for Strategic Economic Studies, Victoria University, Australia, *October 2009,*

kako društvenih tako i infrastrukturnih koji predstavljaju preduslove za širenje svesti o neophodnosti zaštite ugroženih životinjskih vrsta na sledeće načine[13]:

- Podizanje opšteg nivoa javne svesti o problemima opstanka i zaštite ugroženih vrsta
- Pruža mogućnosti za obrazovanje
- Pruža mogućnosti za profesionalni razvoj kadra nephodnog da bi se navedene vrste zaštitile.

INTERNET ŽIVOTINJA

Jedan od načina pretvaranja zaštićenih životinja u digitalni proizvod je i njihova popularizacija kroz takozvani internet životinja i animal social network. Internet životinja predstavlja nivo usluga direktno proizašlih iz IoT rešenja, dok se animal social network može opisati kao marketing strategija primene tehnika socijalnih mreža za popularizaciju zaštićenih životinjskih vrsta, stvaranje i jačanje povezanosti između pripadnika mlađe generacije i ugroženih životinja te kao marketing i biznis platforma na kojoj se obavljaju komercijalne poslovne aktivnosti i prikupljanje sredstava za očuvanje navedenih vrsta – prilozi za rendžersku službu, hranilišta, neophodnu infrastrukturu, prodaja umetničkih predmeta i suvenira kako bi se pribavila sredstva.

Neke od tehnika kako se navedeni koncepti primene ICT tehnologija koriste u realnom poslovanju vezanom za očuvanje zaštićenih vrsta su:

Nacionalna geografija je podigla veb sajt – agregator – na kojem se vide slike sa svih životinja na koje su prikačene kamere pa korisnici sajta vide isto što i životinje.

Možemo koristiti infrastrukturu i trigere na način da životinja pošalje tvit ili poruku kad ulovi plen (recimo mačka ulovi miša).[14] Na ovaj način se drži pažnja publike a brišu se svi „nezanimljivi kadrovi, odnosno, „dosadni“ periodi kada se životinja odmara i ne radi ništa“.

Mogućnost da u svakom trenutku korisnik mreže može locirati i pronaći životinju, te je snimiti (ekskluzivni snimak) – zahvaljujući činjenici da ogrlice šalju GPS koordinate korisnik mreže može pozicionirati na iste koordinate dron i snimiti ekskluzivan snimak što se posebno tarifira.

Mogućnost interaktivnog prenosa u slučaju kada vukovi ili risovi love (takođe korišćenjem više dronova čime se omogućava interaktivni prenos).

Takođe, u slučaju mogućnosti da se posetioci nacionalnog parka nađu u direktnom susretu sa velikim predatorima

14 Dr Genevieve Bell, The Internet of Beings: Or, What are the Animals Telling Us?, Research Computing Centre, Published on Aug 9, 2016, video, 23.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=iEosTaPyxOs

15 Vint Cerf, The interspecies Internet? An idea in progress..., TED, Published on Jul 10, 2013, video, 23.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=wGMLhaa98GI

postoji mogućnost pravovremenog daljinskog obaveštavanja o nailasku opasnosti. O mogućnosti da se internet koristi kao interfejs za povezivanje različitih bioloških vrsta jedan od dizajnera interneta, Vint Cerf, izneo je sledeće mišljenje: „Kada je internet dizajniran mislili smo da je to sistem koji povezuje računare, a ispostavilo se da je sistem koji povezuje ljude, ono što sada vidimo je da ne treba da delujemo restriktivno i ograničimo mrežu samo na postojeće vrste povezivanja, već da i druge inteligentne vrste treba da koriste mrežu takođe.“[15]

Kako raste opterećenje nacionalnih parkova turistima tako raste verovatnoća slučajnog susreta između turista i životinja unutar parka. Ovo je utoliko važnije zbog toga što se divlje životinje u prirodnom okruženju često povređuju i boluju od bolesti koje se mogu preneti na ljude, pa je od velikog značaja sanirati povrede i bolesti divljih životinja, kako se ne bi širile van granica nacionalnog parka. U vezi sa ovim, od presudnog značaja je što brže i sa što neinvazivnijom metodom pronaći bolesne životinje i izlečiti ih. U ovakvim slučajevima od posebne važnosti je brzo i lako lociranje životinje i njenog kretanja, što je veoma olakšano primenama GPS modema i wi-fi uređaja smeštenih u ogrlice i/ili narukvice pričvršćene na životinje (Project Code: 1810, 2017).[16] Na ovaj način stiče se i jasan uvid u kretanje životinja pa se mogu pratiti životinje koje napuštaju zaštićena područja i napadaju stoku farmera. Na ovaj način moguće je locirati životinje počinioce i identifikovati njihove navike, a farmerima po potrebi nadoknaditi realnu štetu.

ELEMENTI SISTEMA

REPETITORI I AP

Osnovni problem jednostavnog i lakog daljinskog praćenja životinja ogleda se u činjenici da su se za to ranije koristile tehnologije zasnovane na emisionoj tehnici u području javno dostupnih frekvencija, te radio uređaji. Ova tehnologija je pouzdana, ali prilično zastarela u smislu da su uređaji gabaritni, te da je za njihovo napajanje potrebno dovesti relativno veliku količinu energije. Takođe, jedan od nedostataka pomenute tehnologije ogleda se u tome da je za potrebe praćenja potrebno izgraditi veći broj stacionarnih primopredajnika koji su masivne građe i moraju biti postavljeni na antenske stubove koji se nalaze na međusobnom odstojanju srazmernom polovini talasne dužine EMS koji koriste. Ovaj tehnički zahtev često je ograničavao primenu radio talasne tehnike u posebno zaštićenim ekosistemima kao što su prašume, jer bi njihovo postavljanje u zaštićeni ekosistem bitno narušavalo isti, što zakonima o zaštiti rezervata prirode nije bilo dozvoljeno. Usled masivnosti primopredajnih antena nije bilo moguće

16 GPS based Wildlife animal tracking system, Microtronics Technologies, blog, 24.02.2017, dostupno na mreži: http://www.projectsof8051.com/gps-based-wildlife-animal-tracking-system

ni njihovo smeštanje u vazduhu, pa je ovo predstavljalo dodatni nedostatak u smislu adekvatnog praćenja divljih životinja. Pojavom novih ICT tehnologija, prvenstveno wifi tehnologije, a zatim i tehnologija mobilnog interneta, postalo je moguće prevazići navedene nedostatke, te napraviti odgovarajuću neinvazivnu infrastrukturu neophodnu za praćenje kretanja divljih životinja. Kako se zaštićeni nacionalni parkovi i drugi rezervati prirode nalaze daleko od urbanih sredina, upotreba ICT tehnologija, posebno u okruženjima kao što je džungla, skopčana je sa mnogim tehničkim, organizacionim i ekonomskim ograničenjima. Teško je na ekonomski prihvatljiv način ostvariti internet infrastrukturu u zabačenim i nepristupačnim regijama. Gugl projekat Loon omogućava način da se u zabačenim i ruralnim predelima obezbedi pouzdan internet pristup sa velikim brzinama i propusnim opsezima na ekonomski prihvatljiv način.[17] Projekat Loon zasniva se na pokušaju da se baloni postavljeni u stratosferu iskoriste kao nosači repetitora, odnosno WiFi AP uređaja, već je pokazao visok nivo pouzdanosti, a repetitor postavljen ovako visoko omogućava ljudima i životinjama da imaju signal i tamo gde ga ranije nisu imali, ali i mogućnost da se odmah nakon velikih katastrofa mogu povezati na internet. Korištenjem LTE tehnologije i balona omogućuje se ostvarivanje brzina 15 MB/s i 40 MB/s, u zavisnosti od radnog opsega i karakteristika antene klijentskog wifi uređaja.[18] Ove brzine dovoljne su za IoT uređaje za prenos senzorskih podataka. Za velika prostranstva i šire zaštićene oblasti Wi-Fi tehnologija postaje neadekvatna i onda se mora preći na GPS i GSM tehnologiju, kako bi se životinje pratile na širem području. Ukoliko se broj predajnika povećava u smislu povećanja gustine, povećava se i gustina mreže koja se koristi za pozicioniranje. Za tačno prostorno pozicioniranje neophodan uslov je da je tag koji se prati dostupan odnosno povezan na bar tri AP. Još jedna prednost wi-fi tehnologije ogleda se i u tome da se AP može pozicionirati i u vazduhu, odnosno postaviti na dronove i/ili balon iznad oblasti koja ne sme biti narušavana unošenjem elemenata infrastrukture.

OGRLICE

Drugi važan element sistema za praćenje divljih životinja u njihovom prirodnom okruženju je pasivni tag, odnosno, ogrlica koja sadrži wi-fi uređaj u novije vreme integrisan sa senzorima za praćenje fiziologije i metabolizma životinje. Veće životinje, posebno predatori kakvi su lavovi, medvedi,

17 Project Loon : Now Google launches BALLOONS in bid to bring internet to the remotest places on Eart, PatrynWorldLatestNew, Published on Jun 15, 2013, video, 24.02.2017, dustupno na mreži: https://www.youtube.com/watch?v=_0iqX9Lq5B8

18 Inside Google's wildly ambitious internet balloon project, The Verge, Published on Mar 2, 2015, video, 24.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=OFGW2sZsUiQ

risovi ili vukovi sa lakoćom nose ove ogrlice i one im ne smetaju u normalnom obavljanju svih dnevnih aktivnosti. Kod ptica, ova vrsta taga najčešće se stavlja u obliku prstenova na noge jer je zbog ograničenja mase najčešće izvedena samo u vidu pasivne antene čime je omogućeno praćenje lokacije životinje ali ne i praćenje nekih drugih životnih funkcija. Svi sistemi praćenja koji se zasnivaju na postavljanju ogrlica ili drugih aktivnih markera /senzora na životinje imaju jedan nedostatak, naime oslanjaju se na baterije kao energetski izvor pa se ogrlice, odnosno baterije, povremeno moraju menjati kako bi uređaji za lokaciju radili. Jedan od načina prevazilaženja ovih problema je korištenje senzora i modema sa malom potrošnjom i niskim zahtevanim profilom energetskog budžeta, ali i u ovim slučajevima problem trošenja baterija veoma je izražen. Kod nekih većih ptica pretežno lešinara moguće je i postavljanje ogrlice sa ograničenim brojem senzora dok se za lociranje koristi GPS modem. Preciznost praćenja pomoću ove vrste ogrlica definisana je na rezoluciju od 500 metara ako se za goniometrisanje koriste samo bazne stanice, dok se znatno povećava ako se goniometrisanje vrši i sa pokretnim objektom (dronovima za aktivno goniometrisanje) i može se smanjiti na ispod 10 metara.[19] 3D pozicija se najčešće dobija interpolacijom između mernih tačaka dobijenih direktnim merenjem.[20] Ovo dolazi i stoga što se većina kopnenih životinja relativno malo kreće u vertikalnoj ravni – retke, uglavnom periodične sezonske migracije.

Uređaji za praćenje (ogrlice) mogu se razvrstati prema primeni na osnovu sledećih karakteristika:

- Tip uređaja i tehnologija koja se koristi
- Energetski budžet i autonomija rada uređaja
- Veličina uređaja
- Broj senzora integrisanih u uređaj i njihova tačnost
- Data rate i network truthput
- Prilagođenost uređaja ponašanju životinje
- Način i mesto pričvršćivanja uređaja

Moderni sistemi za praćenje moraju podržavati i 2D i 3D mod praćenja divljih životinja. 3D mod praćenja posebno je zanimljiv za ptice, ribe, velike sisare koji žive u moru ili jezerskim vodama, životinje koje žive u krošnjama drveća, te životinje sa periodičnim migracijama sever–jug ili vertikalnim migracijama u više i niže predele.

- Neke od oblasti gde se danas primenjuju tehnologije ogrlica su[21]:
- Indentifikacija pojedinačne životinje u grupi

19 M.K.Nor, M.S. Masbop, Smart Livestock Tracker, The International Journal of Engineering And Science (IJES), 2015, Volume 4, Issue 7, PP 25-29, ISBN (e): 2319-1813, ISSN (p): 2319-1805

20 Dr Robert Sinkovits: Improving Wildlife Tracking via HPC, Research Computing Centre, Published on 7 Dec 2015, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=uubLZwIuEjU

21 Lena M Holmberg, Internet of Animals, 05.07.2016, blog, 03.03.2017, dostupno na mreži: http://lenamholmberg.blogspot.ba/2016/05/internet-of-animals.html

- Praćenje životinje i njenog kretanja, kao i socijalnog ponašanja
- Praćenje zdravlja životinje
- Komunikacije između životinja i ljudi i između životinja i stvari (npr. hranilica, pojilica i slično)
- Mehanizmi za regulisanje ponašanja (razne vrste zvučnika koji se nose na ogrlici a koji se mogu daljinski aktivirati kad god životinja zađe u predeo koji je za nju zabranjem)

Kako autonomija rada uređaja zavisi od broja logova koje će urađaj poslati na neki server u jedinici vremena traži se prihvatljiva periodika za svaku vrstu praćene životinje. Ova periodika zavisi od vrste i roda ali i načina života i ponašanja jedinke. Tako na primer, tagovane ribe mogu da se prate i do dve godine nakon postavljanja uređaja za lokaciju i praćenje. Energetski budžet mora da bude takav da omogući barem polovinu godišnjeg ciklusa – ogrlice se ne smeju menjati u sezoni parenja usled agresivnosti mužjaka. Takođe, mladunci se ne smeju opremati ogrlicama dok ne postignu punu polnu zrelost usled intenzivnog rasta. Valja napomenuti i činjenicu da se kada se potroši baterija, ogrlica se cela menja, jer mora biti nepromočiva da bi senzorski sistem i antena mogli da rade, te da se većina ogrlica izvodi u takozvanim vandal proof kućištima u delu koji je vezan za smeštaj antene, napajanja i senzora (IP67 standard).

DRONOVI

Problem pokrivanja teritorije, odnosno, praćenja populacije sa minimalnim brojem statičkih i dinamičkih senzorskih sistema rešava se optimalnom kombinacijom statičkih uređaja i dinamičkih robotizovanih autonomnih sistema (često nazivani i dronovi) za prikupljanje podataka. Optimalan broj dronova za visoko popularnu veb digitalnu platformu, dakle socijalnu grupu životinja koje su ekstremno popularne, može se proceniti na otprilike polovinu populacije, odnosno, jedan dron može da adekvatno prati više jedinki, posebno kod onih vrsta koje se okupljaju u čopore i krda. Veliki broj dronova u ovakvim scenarijima koristi se za pojedinačno praćenje mužjaka samaca od kojih se može očekivati da uskoro napadnu dominantne mužjake i pokušaju da obezbede svoj položaj i pravo na ženke. Upravo zahvaljujući ovakvom fokusu izbegava se da se previše vremena ostavi na nezanimljive sadržaje kada se životinje odmaraju i ne rade ništa, što bi publici bilo posebno interesantno. Osim što služe za praćenje, snimanje i kontrolu pojedinačnih životinja, dronovi se u nacionalnim parkovima koriste i za kontrolu oboda i sprečavanje krivolova na zaštićene vrste i/ili seču šume u zaštićenom području.

22 Ibrahim Volkan Isler, Associate Professor, University of Minnesota, RI Seminar: Ibrahim Volkan Isler : Robotic Data Gathering in the Wild, November 04, 2016, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=tcTUv0wW7J8

Na ovaj način dronovi postaju esencijalni alat za poboljšanje rada rendžerske službe, ali i za kontrolu njenog rada, jer omogućavaju globalni uvid šire javnosti u dešavanja i moguće nelegalne aktivnosti unutar nacionalnih parkova. Dronovi se koriste i za prikupljanje podataka o distribuiranim sistemima kao što su jata riba ili jata komaraca ili drugih letećih insekata i ptica. Upotreba autonomnih robota pri tome omogućava sagledavanje mnogo šire slike od one koju bi dali statički raspoređeni uređaji, jer pored geometrijskih podataka (položaj, distribucija, trajektorija) daju i izvestan broj semantičkih informacija kao što je na primer broj defektnih plodova (jabuka) na stablu.[22]

Prvi zadatak automatizovanih robotskih sistema za praćenje divljih životinja u prirodi je pronaći, odnosno, detektovati signal sa ogrlice, odnosno, taga. Ovaj zadatak u smislu disperzno distribuiranih sistema kao što su jata riba ili jata ptica moguće je izvršiti automatskim algoritmima za pretraživanje: dron (brodić) obilazi neku površ i u njoj traži signale koje obrađuje (broji, sakuplja podatke nakon što inicijalizuje komunikaciju i slično) zatim ih obrađuje i u agregatnom obliku šalje na neku cloud lokaciju gde se nalazi poslovna logika i softevr za mapiranje koji daje GIS podatke preko mape nekog terena.

Pokrivanje teritorija autonomnim robotima vrši se sledećim tehnikama pretraživanja:

- Stacionarni model pretrage pokrivenosti
- Stohastički model – random kretanje dronova koji prikupljaju podatke
- Kontradiktorno – unakrsno prikupljanje podataka sa sledeća dva modela teorije igara:
  - Aktivno izbegavanje susreta
  - Igra pokušaja izbegavanja (igra mačke i miša)

U smislu aktivnih uređaja za snimanje stanja, na dronovima se često koriste LiDAR kamere sa rezolucijama snimanja dovoljno velikim da se pomoću njih izvrši mapiranje svih snimljenih elemenata ekosistema, pri čemu se dobijaju realni 3D prikazi trenutnog stanja sistema, odnosno, omogućava realno kretanje kroz elemente sistema u svim pravcima.

Prednosti korištenja dronova u smislu zaštite nacionalnih parkova, ali i uvida u život i ponašanje divljih životinja na slobodi u odnosu na druge tehnologije ogledaju se u[23]:

- Jeftina tehnologija (u poređenju sa avionima, i velikom on site patrolnom službom)
- Laki za korištenje

23 Wildlife conservation with the help of drones: Kitso Epema at TEDxUtrecht, TEDx Talks , Published on 28 Apr 2014, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=LT9q6kra9Oc

24 Using drones to conserve natural habitats | Professor Serge Wich | TEDxLiverpool, TEDx Talks, Published on 20 Aug 2014, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=GTsMi43Mugo

- Dostupni za korištenje (standardna tehnologija koja se brzo razvija)
- Multifunkcionalna platforma – mogu da se koriste za praćenje životinja, prikupljanje podataka sa ogrlica i senzora koje životinje nose ili imaju prikačene na svom telu, snimanje prirode i životinja u prirodi, praćenje ljudi (turista, zalutalih osoba, traganje i onemogućavanje delovanja lovokradica i onih koji pokušavaju nelegalnu seču drveća), rano otkrivanje i lokalizacija požara, obaveštavanje najbliže patrole rendžera i podrška za operacije na terenu, podrška za brze odgovore

U dodatne prednosti primene dronova mogu se ubrojati[24]:

- Laka lokacija prilično teško uočljivih životinja koje retko izlaze na čistinu (orangutani, gorile, šimpanze u tropskim šumama) – zahvaljujući dronovima lako ih je otkriti i pratiti migracije
- Zahvaljujući Ai tehnologijama (automatic optical rekognition) raste verovatnoća prepoznavanja naseobine u krošnjama;
- Dronovi mogu da se koriste u scenariju „data mule“, pri čemu u letu prikupljaju podatke sa senzora i kamera (statičkih) kako bi im oslobodile memoriju za budući rad, pražnjenje data logera, zbog mogućnosti niskog leta moguća je komunikacija u bliskom polju, pa se koristi manje energije za komunikaciju i postoji mogućnost prenosa velikih fajlova (snimci sa kamere u HD rezoluciji);
- U odnosu na klasične tehnike ručnog prikupljanja podataka o životinjama, dronovi su i do 200 puta efikasniji od ljudi (dronovima je potrebno oko 20 minuta da lociraju životinju i prikupe podatke sa uređaja za praćenje. Biolozima i rendžerima je za isti zadatak potrebno do 3 dana (uz korištenje tehnike lovačkog praćenja).
- Dronovi mogu da lete dovoljno nisko i da daju slike velikih rezolucija, kao i da snimaju u infracrvenom opsegu;
- Sve ULL pa i dronove moguće je izraditi u DIY izvedbi;
- Usled velikih ušteda zasnovanih na visokoj efikasnosti letilica moguća je realokacija budžetskih sredstava i nabavka dodatne opreme (drugih vrsta hardvera i softvera koji mogu da se koriste na dron platformama)

PRAVNA OGRANIČENJA KORIŠTENJA AUTOMATSKIH ROBOTIZOVANIH SISTEMA I RUČNO VOĐENIH DRONOVA

Iako su dronovi možda i najefikasnije platforme za praćenje života divljih životinja u njihovom prirodnom okruženju i stoga izuzetno zanimljiva tehnička rešenja koja bi koristili mnogi pojedinci i uprave nacionalnih parkova, njihovo masovno uvođenje u upotrebu na ovom polju otežano je usled činjenice da su dronovi novo pravno područje u kojem ne postoji jasna regulacija, te

činjenicom da zakonodavci kasne sa pravnim okvirom za njihovu upotrebu. Poseban problem primene dronova u ovu svrhu predstavlja i činjenica da se dronovi obično i ne proizvode u zemljama upotrebe te da za njihovu proizvodnju ne postoje jasni standardi kvaliteta kojeg bi se proizvođači i uvoznici trebali pridržavati. Ovome treba pridodati i mogućnost da dronovi budu izrađeni u kućnoj radinosti, odnosno, DIY verziji proizvodnje pa je jasno o kakvoj vrsti disperzije raznorodnih rešenja je reč. Kako dronovi spadaju u letelice, tako su u većini zemalja za njih nadležne posebne regulatorne komisije i kontrole letenja (ako plafon leta prelazi određeni prag definisan lokalnim zakonima) i let se izvodi mimo ograničenih areodromskih područja. Poseban problem predstavljaju i činjenice da se dronovi najčešće koriste u svrhu vazdušnog izviđanja, te na sebi imaju montirane kamere koje se mogu zloupotrebiti za neovlašten nadzor, praćenje pa čak i u svrhu voajerisanja, što sve potpada pod posebne zakone koji još u većini država nisu proširени i na ovaj novi pravni domen. Razmatrajući mogućnosti i pravna, moralna i druga ograničenja upotrebe dronova moramo se zapitati i razrešiti sledeća pitanja[25]:

- Ko reguliše prava korišćenja letelice i na koji način?
- Kako se dobija dozvola za upravljanje dronovima? Ko izdaje dozvolu ili ovo područje još nije regulisano?
- Ko je odgovoran u slučaju pada letelice? Posebno ako ona svojim padom načini materijalnu štetu i/ili ugrozi ljudske živote?
- Postoje li propisane zakonske procedure za održavanje letelice? Postoje li sertifikati i koja stručna tela ih izdaju kako za letelice tako i za one koji ih održavaju?
- Treba li dron da ima svoju knjigu – log upotrebe i kako se vodi?
- U slučaju DIY izvedbe, ko izdaje upotrebnu dozvolu? Kako se kontroliše kvalitet izrade i da li su zadovoljeni bezbednosni standardi?
- Kako je regulisano pitanje upotrebe dronova koji nose instrumente za snimanje u vidljivom spektru – kamere, s obzirom na privatnost onih koji mogu biti obuhvaćeni snimljenim materijalom?
- Koja je minimalna visina leta – koju propisuje regulatorna agencija za vazdušni saobraćaj?
- Da li neki državni autoritet – agencija kojoj se obraćate, uopšte ima kompetencije da odgovori na vaša pitanja u vezi sa regulativom iz oblasti upotrebe dronova?

Ono što je posebno potrebno naglasiti je činjenica da, iako su dronovi idealna platforma za primenu u oblasti nadgledanja i praćenja divljih životinja, u njihovim prirodnim habitatima određene

25 Best and worst states when it comes to drone laws, Drone U, Published on 6 Sep 2016, video, 24.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=p7DEAXLXeZY

zemlje pravno zabranjuju njihovu upotrebu u nacionalnim parkovima. Tako je na primer u Meksiku zabranjena upotreba dronova u nacionalnim parkovima, dok je u pojedinim Američkim saveznim državama ova zabrana proširena usled mogućeg voajerizma i / ili trgovine narkoticima preko granice te se za korišćenje ove tehnologije u graničnim područjima može dobiti i do 5 godina zatvora.

Čak i u slučajevima da su pojedina područja primene dronova regulisana pravno, postoji mogućnost tužbe, ali u tom slučaju onaj ko se žali na narušavanje privatnosti mora dokazati da je postojala namera da se ova tehnologija zloupotrebi u svrhu narušavanja privatnosti žalioca. Protivargument u ovakvoj pravnoj borbi svakako je pozivanje na razumno očekivanje privatnosti s obzirom na moderne tehnologije koje imaju slične mogućnosti uvida u nečiju privatnost. Ovo je posebno interesantno s obzirom na to da se na povredu privatnosti najčešće pozivaju lovokradice i turisti koji su prekršili neko od pravila nacionalnog parka (palili vatru, bacali smeće, oštećivali rastinje i slično) pa je u svrhu primene dronova kao mere zaštite prirodnog okruženja za divlje životinje neophodno doneti odgovarajuću jasnu pravnu regulativu kojom bi se ova oblast jasno i nedvosmisleno uredila.

SERVERSKA INFRASTRUKTURA I SOFTVER

Sledeći značajan deo infrastrukture je serverska i storage infrastuktura koja se može izvesti i kao Cloud rešenje, odnosno, ne mora biti direktno vezana za lokaciju. Prednosti ovakve izvedbe ogledaju se prvenstveno u mogućnosti da se na taj način izvede adekvatna infrastruktura koja bi u zavisnosti od prava pristupa i mogućnosti namenskog klijentskog softvera različitim zainteresovanim stranama davala upravo informacije i podatke koji su im potrebni, te odvajala komercijalne podatke koji bi se koristili u obliku pogodnom za marketinško predstavljanje životinja, kako bi se stvorila kritična masa onlajn pratilaca i obezbedilo finansiranje nacionalnog parka ili drugog oblika organizacije na zaštićenoj teritoriji i podataka koji se dostavljaju biolozima, veterinarima i analitičarima neophodnih u smislu dobijanja adekvatnih analiza te naučno i stručno proučavanje ponašanja životinja. U elemente hardverske infrastrukture sa strane data centra spadaju: Server, Storage uređaji, frireawall, DRC, odnosno sledeća virtualna innfrastruktura: VM-web server, VM-RBDMS, VM-image, FTP, VM-AVServer, VM-AppServer, VM-InteroperabilitiSistem, VM-ImageSocijalneMreze. Sva navedena hardverska i softverska infrastruktura može biti izvedena i kao usluga koja se iznajmljuje na određeni period, pa se na ovaj način može omogućiti lakše finansiranje projekata zasnovanih na praćenju životinja, bilo da su oni komercijalne prirode ili su deo nekog naučnog istraživanja.

PRIKUPLJANJE PODATAKA

Sposobnost prikupljanja i obrade verodostojnih informacija o raznim aspektima okoliša omogućuje kvalitetan nadzor i upravljanje, kako prirodnim resursima tako i spoljnim uticajima koji mogu ugroziti okoliš.[26] Prikupljanje podataka modernim ICT tehnologijama umnogome je diktirano i činjenicom da dobrim odabirom tehnologije prikupljanja podataka, podatke možemo prikupljati na minimalno invazivan način sa stanovišta uplitanja u ekosistem, pa se i rizici po sigurnost okoliša u vezi sa prikupljanjem podataka mogu minimizirati.

Prikupljanje podataka može se odvijati na dva zasebna nivoa: na nivou podataka o samoj životinji, pri čemu se prate i beleže podaci –indikatori stanja životinje i na nivou ekosistema, pri čemu se prate i beleže parametri okoline preuzeti iz šireg ekosistema. Praćenje ovih potonjih ne zahteva mobilne uređaje, već se zasniva na stacionarno postavljenim senzorima koji samim tim što su nepokretni nemaju ograničenja po masi, a samim tim ni energetskom budžetu koje moraju da zadovolje ogrlice koje se stavljaju na životinje.

Ovako primenjeni ICT sistemi na proaktivan način osiguravaju održivost i zaštitu ekosistema u celini, a ne samo pojedinačnih bioloških vrsta.

Takođe, važno je napomenuti i sledeće činjenice. Bez upotrebe IoT tehnologija u praksi veterinari zasnivaju svoje znanje o pacijentima i njihovim tegobama na kratkim konsultacijama sa rendžerima i biolozima koji su primetili neuobičajeno ponašanje životinje.[27] Činjenica je da se većina nacionalnih parkova na ovaj način brine o svojim životinjama, pa i posebno zaštićenim vrstama, jer je to do sada bio uobičajeni oblik praćenja i upravljanja životinjama. Kako je ovo vrlo nepouzdan način praćenja zdravlja, pravac razvoja integrisanih cloud baziranih rešenja nad prikupljenim podacima ide u pravcu iznalaženja algoritama koji bi za svaku pojedinačnu životinju pravili matricu obrazaca ponašanja i upoređivali je sa trenutnim ponašanjem životinje, te na osnovu toga zaključivali da li se životinja ponaša u granicama uobičajenog ili van tih granica, kada bi se uključili mehanizmi za automatsko dodatno praćenje i uključivanje veterinarskog tima. S ovim u vezi važno je napomenuti da za većinu divljih životinja ne postoje jasne referentne vrednosti bioloških indikatora, jer jednostavno nikada nije izvršeno dovoljno merenja koja bi mogla

26 Mira Mileusnić Škrtić, Karolina Horvatiničić, Dragutin Vuković, Rizici i mogućnosti primjene novih tehnologija s obziorom na zaštitu okoliša i održivost – s aspekta primjene ICT-a, znanstveni simpozij RAZVOJ I OKOLIŠ – PERSPEKTIVE ODRŽIVOSTI, 2011, dostupno na mreži: https://bib.irb.hr/datoteka/550944.Rizici_i_mogucnosti_primjene_novih_tehnologija.pdf

27 Anne Accardi, How the Internet of Things is Impacting Animal Health Part 2: Companion Animals, 11.09.2017, Engage Mobile, 03.03.2017, dostupno na mreži: http://www.engagemobile.com/how-the-internet-of-things-is-impacting-animal-health-part-2-companion-animals/

omogućiti da se na osnovu trenutnih očitavanja mogu pouzdano predviđati buduća ponašanja životinje, te procene njenog zdravstvenog stanja.[28] Ova okolnost vodi ka smanjenoj tačnosti predviđanja ponašanja životinja, ali govori i o neophodnosti da se do ovih podataka u što kraćem vremenskom roku dođe, pa je pored klasičnog BigData modela vrlo verovatna primena algoritama mašinskog učenja i veštačka inteligencija.

Takođe, navedene tehnologije za prikupljanje podataka imaju velike prednosti i kada se gleda na procene u vezi sa opterećenjem nekog izolovanog ekosistema brojem jedinki određene vrste. Danas se najčešće upravlja šumskim gazdinstvima na osnovu podataka koji predstavljaju procenu populacije neke vrste. Za predatore je na primer potrebno proceniti broj najmanje 3 puta godišnje u zavisnosti od smene godišnjih doba i perioda parenja i podizanja mladunaca, pri čemu se kao metode za procenu uzimaju sledeći podaci: direktno prikupljeni, indirektno prikupljeni, metoda ponovnog hvatanja i brojanja označenih životinja i procena populacione gustine na osnovu pretpostavljenog socijalnog ponašanja životinja uz primenu statističkih metoda.[29] Na ovaj način se često ne dobijaju dovoljno tačni podaci, a moguće su i zloupotrebe te kalkulacije u vezi sa izlovom krupnog i kapitalnog plena. Brojanje populacije i statističke metode u budućnosti će zameniti sistemi za direktno praćenje divljih životinja koji će istovremeno postati i medijska platforma za širenje svesti o potrebi očuvanja datih vrsta. Prikupljanjem realnih podataka sa terena moguće je donositi dobro zasnovane i informisane odluke u vezi sa održavanjem ekosistema u granicama bioloških mogućnosti ali i predviđanja adekvatnih scenarija za kritične situacije. Tako se u slučaju prenaseljenosti, odnosno naglog porasta populacije neke vrste može odlučiti i za tehnički premeštaj dela mladih nedozrelih životinja u lokalne ili udaljene zoološke vrtove čime bi se sprečila restriktivna politika odstrela. Takođe, moguća je primena scenarija hranjenja na način koji oponaša prirodne procese u ekosistemu – hranjenje se izvodi u skladu sa periodičnim migracijama životinja.

ZAKLJUČAK

Iz svega navedenog vidljivo je da moderne ICT tehnologije predstavljaju ne samo tehnološku osnovu za prikupljanje podataka za naučna i stručna izučavanja ponašanja divljih životinja, već i vrlo pogodnu osnovu za nadzor i upravljanje

28 Dr Elisabetta Canali, ANIMAL WELFARE ASSESSMENT THROUGH SMARTPHONE APPLICATIONS: CHALLENGES AND OPPORTUNITIES, OIEVideo, Published on Dec 7, 2016, video, 02.03.2017, dostupno na mreži: https://www.youtube.com/watch?v=FK1vcb-G9nk

29 ESTIMATING WILDLIFE POPULATIONS, FW (ZO) 353, Wildlife Management, 02.03.2017, dostupno na mreži: https://projects.ncsu.edu/cals/course/fw353/Estimate.htm

nad realnim operacijama unutar nacionalnih parkova. Kao prioritet se u bliskoj budućnosti stvara potreba da se navedene tehnologije implementiraju kako bi se postigli obrazovni, naučni i komercijalni ciljevi i dugoročno omogućilo dodatno finansiranje parkova i svih radnji i operacija vezanih za zaštitu životinja. Ovo je utoliko važnije kada se uzme u obzir činjenica da se navedenim poslovnim modelom zasnovanim na poslovnom modelu interneta životinja i same ugrožene vrste uključuju u obezbeđenje finansijskih sredstava neophodnih za zaštitu, te se samim tim smanjuje opterećenje na budžet i procesi zaštite divljih životinja postaju kako transparentni tako i samoodrživi.

LITERATURA

1. W. W. Cochran, D. W. Warner, J. R. Tester, V. B. Kuechle, Automatic Radio-Tracking System for Monitoring Animal Movements, Reprinted from BioScience, Vol. 15, No.2, 1965, pp 98-100, dostupno na mreži: https://www.researchgate.net/publication/247840577_Automatic_Radio Tracking_System_for_Monitoring_Animal_Movements
2. ERIC SCHMITT, 'Natural' Habitats Offer Insights Into Social Behavior of Animals, The New York Times, January 26, 1988, dostupno na mreži: http://www.nytimes.com/1988/01/26/science/natural-habitats-offer-insights-into-social-behavior-of-animals.html
3. Jessica Ellis, Mel Hall, Phil Ong, Leif Wege, Natalie Paterson, Chelsea Smith, Animal Testing at Dalhousie University: A brief insight into social, economic, and environmental effects of nonhuman animal testing, Dalhousie University, 2010, dostupno na mreži: https://www.dal.ca/content/dam/dalhousie/pdf/science/environmental-science-program/ENVS%203502%20projects/2010/AnimalTesting.pdf
4. Allan Savory, How to green the world's deserts and reverse climate change | Allan Savory, Published on Mar 4, 2013, video, 02.03.2017, dostupno na mreži: https://www.youtube.com/watch?v=vpTHi7O66pI
5. Tyler Stitt, Julie Mountifield, Craig Stephen, Opportunities and obstacles to collecting wildlife disease data for public health purposes: Results of a pilot study on Vancouver Island, British Columbia, Canadian Veterinary Journal, 2007 Jan; 48(1): 83–90., dostupno na mreži: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1716737/#
6. Tatjana Ratknic, 2017: UGROŽENE BILJNE VRSTE U SRBIJI, Ekološko-šumarski centar "Sylva", dostupno na mreži: http://sylva.rs/doc/Ugrozene%20biljne%20vrste%20u%20Srbiji.pdf
7. Zaštita ugroženih vrsta u BiH, blog biolog.ba, 24.05.2017, dostupno na mreži: http://biolog.ba/58-zastita-ugrozenih-vrsta-u-bih.html

8. Randall Abate, What Can Animal Law Learn from Environmental Law?, Environmental Low Institute, West Academic,2015 pp 160, ISBN 978-1-58576-176-0
9. Fish and Wildlife Service I&M: Connecting Science-driven Monitoring to Management, National Wildlife Refuge System Inventory and Monitoring (I&M) initiative, Published on 4 Aug 2012, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=XutmC7QRGUM
10. Priya Joshi, Wildlife conservation through innovative technology: Priya Joshi at TEDxKathmandu, TEDx Talks, Published on 10 Jan 2013, video, 24.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=bgM5kHZYrO8
11. Wi-Fi in the woods: Canada plans to install web hotspots across its national parks and historic sites, Daily Mail, 29 April 2014, On Line izdanje, 24.12.2016, dostupno na mreži: http://www.dailymail.co.uk/sciencetech/article-2616007/Wi-Fi-woods-Canada-plans-install-web-hotspots-national-parks-historic-sites.html#ixzz4TmNxjQeH
12. Daniel Smith, 2015 September Webinar IoAHTedited, TheCSAlliance, University of Cambrige, Cambrige Service Alliance, Published on Sep 15, 2015, video, 23.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=DQew3ESgZoQ
13. John Houghton, ICT and the environment in developing countries: opportunities and developments, Centre for Strategic Economic Studies, Victoria University, Australia, October 2009,
14. Dr Genevieve Bell, The Internet of Beings: Or, What are the Animals Telling Us?, Research Computing Centre, Published on Aug 9, 2016, video, 23.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=iEosTaPyxOs
15. Vint Cerf, The interspecies Internet? An idea in progress..., TED, Published on Jul 10, 2013, video, 23.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=wGMLhaa98GI
16. GPS based Wildlife animal tracking system, Microtronics Technologies, blog, 24.02.2017, dostupno na mreži: http://www.projectsof8051.com/gps-based-wildlife-animal-tracking-system/
17. Project Loon : Now Google launches BALLOONS in bid to bring internet to the remotest places on Eart, PatrynWorldLatestNew, Published on Jun 15, 2013, video, 24.02.2017, dustupno na mreži: https://www.youtube.com/watch?v=_0iqX9Lq5B8
18. Inside Google's wildly ambitious internet balloon project, The Verge, Published on Mar 2, 2015, video, 24.02.2017, dostupno na mreži: https://www.youtube.com/watch?v=OFGW2sZsUiQ
19. M.K.Nor, M.S. Masbop, Smart Livestock Tracker, The International Journal of Engineering And Science (IJES), 2015, Volume 4, Issue 7, PP 25-29, ISBN (e):

2319-1813, ISSN (p): 2319-1805
20. Dr Robert Sinkovits: Improving Wildlife Tracking via HPC, Research Computing Centre, Published on 7 Dec 2015, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=uubLZwIuEjU
21. Lena M Holmberg, Internet of Animals, 05.07.2016, blog, 03.03.2017, dostupno na mreži: http://lenamholmberg.blogspot.ba/2016/05/internet-of-animals.html
22. Ibrahim Volkan Isler, Associate Professor, University of Minnesota, RI Seminar: Ibrahim Volkan Isler : Robotic Data Gathering in the Wild, November 04, 2016, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=tcTUv0wW7J8
23. Wildlife conservation with the help of drones: Kitso Epema at TEDxUtrecht, TEDx Talks, Published on 28 Apr 2014, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=LT9q6kra9Oc
24. Using drones to conserve natural habitats | Professor Serge Wich | TEDxLiverpool, TEDx Talks, Published on 20 Aug 2014, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=GTsMi43Mugo
25. Best and worst states when it comes to drone laws, Drone U, Published on 6 Sep 2016, video, 24.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=p7DEAXLXeZY
26. Mira Mileusnić Škrtić, Karolina Horvatiničić, Dragutin Vuković, Rizici i mogućnosti primjene novih tehnologija s obziorom na zaštitu okoliša i održivost – s aspekta primjene ICT-a, znanstveni simpozij RAZVOJ I OKOLIŠ – PERSPEKTIVE ODRŽIVOSTI, 2011, dostupno na mreži: https://bib.irb.hr/datoteka/550944.Rizici_i_mogucnosti_primjene_novih_tehnologija.pdf
27. Anne Accardi, How the Internet of Things is Impacting Animal Health Part 2: Companion Animals, 11.09.2017, Engage Mobile, 03.03.2017, dostupno na mreži: http://www.engagemobile.com/how-the-internet-of-things-is-impacting-animal-health-part-2-companion-animals/
28. Dr Elisabetta Canali, ANIMAL WELFARE ASSESSMENT THROUGH SMARTPHONE APPLICATIONS: CHALLENGES AND OPPORTUNITIES, OIEVideo, Published on Dec 7, 2016, video, 02.03.2017, dostupno na mreži: https://www.youtube.com/watch?v=FK1vcb-G9nk
29. ESTIMATING WILDLIFE POPULATIONS, FW (ZO) 353, Wildlife Management, 02.03.2017, dostupno na mreži: https://projects.ncsu.edu/cals/course/fw353/Estimate.htm

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Review scientific paper

ICT SYSTEMS FOR MONITORING AND PROTECTION OF WILDLIFE IN THEIR NATURAL ENVIRONMENT

Branko MARKOVIĆ[1]*, Drago NEDIĆ[2], Savo MINIĆ[3]

1 Branko Marković, B.Sc.Mech.Eng, „Prointer" IT Solutions and Services, Vuka Karadžića 2, Banja Luka, Republika Srpska
2 Dr. Drago N. Nedić, full professor, The Faculty of Veterinary Medicine, University of Belgrade , Bulevar oslobođenja 18, Beograd Srbija
3 Savo Minić, LL.M , Minister of Agriculture, Forestry and Water Management of Republic of Srpska, Trg Republike Srpske 1, Banja Luka, Republika Srpska
* corresponding author: Branko Marković: markovic.branko@prointer.ba

Abstract: The paper deals with systems for monitoring and protection of wild animals in their natural environments and the use IoT technologies and solutions in protected nature reserves. The paper also examines the reasons and possibilities for implementing the above mentioned technical solutions, especially in terms of protecting species from the red list of endangered species. In this sense, the paper also discusses technological solutions and the possibilities of applying IoT working framework, the concept of the Internet of animals, and the application of these technologies through various business and research models. Finally, the paper provides examples of solutions from the point of view of the necessary infrastructure (servers, storage, internet, animal necklaces, stationary cameras and drones), as well as from the point of view of data processing and the legal framework for the application of these solutions.

Key words: IoT, wild animals, endangered species

INTRODUCTION

The problem of research, but also the popularization of wildlife in their natural ecosystems today, is gaining on its actuality for several reasons. The main reason for this increased interest in field research of wildlife in their natural environment lies in the possibilities of remote tracking of animals, but also the processing of results and measurements, which are posible with new ICT technologies, and in the fact that due to industrial development, a large number of natural environments of these animals simply disappeared as

a consequence of the construction of civilian infrastructure and the increased needs for the living space. In this way, the living space of wild animals is reduced, and thus the ecosystem's ability to provide living space, food and other vital needs for a certain number of animals. These processes are unsustainable and lead directly to the extinction of certain endangered species, predominantly predators, which are at the top of the food chain in an ecosystem. As the chances of finding food decrease, wild animals might desperately seek food outside of limited and isolated ecosystems which increases the possibility of an encounter between wild animals and people. This leads to a new pressure, for farmers who are directly affected by this behavior of the predators, as well as for the ecosystem itself, because taken actions include hunting which limits the number of predators making it constantly reduced and the mentioned species is is soon coming to the brink of extinction. As everythung in nature is connected, this has unimaginable consequences for the entire ecosystem which over time collapses and in a relatively short time transforms into a civil park whose characteristics are in line with the expectations of the population and serves as a recreation space instead of a living space for endangered species which was his original purpose.

The ability to monitor wildlife in their surroundings helps prevent these situations and this is one of the main commercial reasons of increased interest in techniques and technology for monitoring wildlife in their natural environment.

Another important factor causing increased interest and the use of animal tracking techniques, is reflected in the activities of the groups for the protection of endangered species that try to ensure the survival of wild animals in restricted and de facto dysfunctional ecosystems in a way that it is regulated by nature.

The third important factor is definitely the attempt of the biologist to study the behavior of wild animals in a way that thanks to new non-invasive technologies they follow them from a distant location avoiding any possible interaction with the ecosystem as such, and in that way they conduct an adequate investigation of the behavior of both individual members and groups of animals, paying special attention to the social and territorial behavior of wild animals. With this in mind, we should emphasize the following: in order to learn about the life and behavior of wild animals, so far we have been limited to individual observations and biological expeditions. A biologist would enter an ecosystem trying not to disturb it by his observing and studying while hoping to discover patterns of wild animal / species behavior and its interaction with other elements or species within the ecosystem. This method of studying animals, apart from being long-lasting, uncertain and extremely tough for the researcher, is also based on the most economically advantageous model.

The entire research is based on the expectation that an individual will be able to see, classify and sort key events in an acceptable time and at an acceptable price. He should also be able to learn and understand the behavior of a group of observed animals, recognize the patterns, draw conclusions and formalizes the acquired knowledge by establishing scientific principles that are essentially logically consistent, verifiable and provable. It should be emphasized that the primary requirement regarding the understanding of the animals' behaviour is related to the knowledge of where the animal is and what it is currently doing, because this knowledge, monitored and recorded over a longer period of time, is the basis for further study. Based on the aforementioned, the natural necessity for food, water, movement, rest, and other physiological needs and habits can be crystallized by a diligent analysis.[1]

This practice of primarily biological studies of wild animals began to change somewhat during the 1960s when, for the first time, monitoring methods based on the equipping monitored animals with adequate active or passive tags (collars, marking ring) began to be used, along with a radiogoniometre to approach the location and determine the position and daily walk of the animal.

The fourth factor causing an increased interest in wildlife monitoring technologies is reflected in the fact that, thanks to the mentioned technologies and the application of other ICT technologies, the mentioned ecosystems and animals can be presented in a more adequate way, which is interesting both from the commercial point of view and at the educational level. This trend will grow as the demographic structure of the audience, to which such content is intended, is changing. Young generations experience the perception of reality through social networking technologies, that are applicable to animals in an ecosystem, rather than in direct contact with those animals. Thus, the question of the establishment and preservation of national parks is reduced practically to the recognition of the function of the same, that is, on the presented reasons for their existence and managing, that is, the way in which animals are treated within them, and what popularity they could achieve on global information market.

This practically means that the survival of individual national parks and the animal world in them, especially when it comes to large predators from the top of the food chain, depends on an adequate presentation of them, through ICT technologies, primarily social networks and profiles, as this is the way in which the modern population not only perceives reality, but also decides on the needs and conditions of funding them.

1 W. W. Cochran, D. W. Warner, J. R. Tester, V. B. Kuechle, Automatic Radio-Tracking System for Monitoring Animal Movements, Reprinted from BioScience, Vol. 15, No.2, 1965, pp 98-100, available at: https://www.researchgate.net/publication/247840577_Automatic_Radio Tracking_ System_for_Monitoring_Animal_Movements

Other social impacts that affect the need for better observation of animals and their behavior in the natural environment

The activities of the animal protection groups have created pressure on zoos and animal users to provide a more natural environment for animals in this type of detention, both in terms of habitat and in terms of the social environment and nutrition. To ensure this, many zoocentres now create simulated natural habitats and observe the social abilities and behavior of even the most common animals.[2] This initiative for protecting wildlife in zoo gardens, has led to an increased need for these same animal species to be studied in their natural environments in order to respond to the requirements, set up by groups for the protection of animal rights, in terms of keeping them.

The problem of hunting, fishing and managing hunting resources in areas not under a special protection regime (forests, mountain hills) is reflected in an insufficiently clear methodology for the determination of hunting quotas, which often do not correspond with any recognized methodology but with the current needs of civil society around these ecosystems.

In the areas outside protected nature reserves, large predators' survival depends on the management of local interests, both the interest of hunting associations and the interests of local farmers. One of the serious problems, especially when it comes to predators from the top of the food chain, which are also the most endangered ones One of the serious problems, especially when it comes to predators from the top of the food chain who are also the most endagered because they tend to remain without enough food, is reflected in the fact that they, in our area especially wolves and bears, are trying to look for food outside forestry farms where they are still imperceptible and therefore protected from hunters to some extent. If a wolf attacks a domestic animal, in the first place the cattle on pasture, not only he will be hunted , but probably many other members of the pack. They are automatically proclaimed vermins and the most restrictive measures are taken toward all the members of the same species. The systems for continuous remote tracking of predators represent a possible solution to this problem, as this creates a constant insight into the behavior of animals and their presence in a certain territory, and it is possible to create preconditions for releasing the same from the stigma of guilt for cattle attacks. In this case, it can be said that there is a strong social aspect of the use of animal tracking technologies, since the

2 ERIC SCHMITT, 'Natural' Habitats Offer Insights Into Social Behavior of Animals, The New York Times, January 26, 1988, dostupno na mreži: http://www.nytimes.com/1988/01/26/science/natural-habitats-offer-insights-into-social-behavior-of-animals.html

release of animals from a social point of view also means freeing people. Several authors emphasize that problems related to the ecological crisis that has become global are due to anthropomorphic point of view and personal interests and that in order to preserve the existing protected ecosystems it is necessary to change this view of the world.[3]

Due to the continuous civilization progress, there are land conversions. Due to the interruption of natural cycles and the process of violent urbanization, tha land that was previously part of a special ecosystem rapidly depletes to the level of its transition to completely uninhabited land which leads to desertification.

According to Allan Savory, a biologist, this process can be prevented if the land is used to mimic the natural fluctuations of ecosystems. He claims that the predators'role is to force animals they feed on to move, and thus they do not realize local influence in terms of polluting their environment beyond the limits of self-sustainability of an ecosystem. In this way, the predators actually enable the survival of a complete ecosystem with all kinds in it. Removing the predator from the ecosystem will not save any protected species, and in the long term it will lead to the collapse of this ecosystem into desertification land.[4] From this point of view, it becomes clear how important it is to have a real and regular insight into the movement and behavior of wild animals, especially predators, because by mimicking natural cycles, part of the desertified soil can be recovered into self-sustaining ecosystems in a shorter period of time.

Many countries today face the need to harmonize and organize public health, cattle health and wildlife health. Occurrences such as diseases that spread from natural habitats to urban environments are no longer so rare, as we've witnessed with bird flu, hantavirus, and Western Nile virus. Faced with the need to protect natural ecosystems, as well as their own population, many countries, such as Canada, have set up special agencies to track wildlife mortality, look for its causes, foreknow and try to reduce the risks for public health.[5] Such widespread networks enable healthcare organizations to work preventively rather than reactively, and largely avoid and reduce the negative effects of biological hazards that come

3 Jessica Ellis, Mel Hall, Phil Ong, Leif Wege, Natalie Paterson, Chelsea Smith, Animal Testing at Dalhousie University: A brief insight into social, economic, and environmental effects of nonhuman animal testing, Dalhousie University, 2010, available at: https://www.dal.ca/content/dam/dalhousie/pdf/science/environmental-science-program/ENVS%203502%20projects/2010/AnimalTesting.pdf

4 Allan Savory, How to green the world's deserts and reverse climate change | Allan Savory, Published on Mar 4, 2013, video, 02.03.2017, available at: https://www.youtube.com/watch?v=vpTHi7O66pI

5 Tyler Stitt, Julie Mountifield, Craig Stephen, Opportunities and obstacles to collecting wildlife disease data for public health purposes: Results of a pilot study on Vancouver Island, British Columbia, Canadian Veterinary Journal, 2007 Jan; 48(1): 83–90., available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1716737/#

from wildlife. The basic precondition for the operational work of such agencies is the widespread sensor network both in ecosystems and on the very animals. Only the data collected in that way have sufficient density, and we can rely on their accuracy to avoid the assumptions of the suspicious accuracy that today dominate this field due to insufficient data, that is, the collection of data only when a phenomenon has already become recognizable.

Remote animal tracking technique is a key technology that provides the gathering of necessary data both in real time and in terms of the historical log, so it can be subjected to Big Data analytics techniques that provide a satisfactory level of predictive accuracy, but can also be used as tools to search back to the source of the infection or find a biological hazard and trigger that has led to the onset of the disease.

The process of protection and legal measures for providing legal, organizational and operational activities for the protection of endangered species

The process of protection of an endangered species begins with its identification and recording, and the assessment of threat for the purpose of making the Red List of Threatened Species. The Red List is an indication of the level of threat of certain species in a given area. These lists are dynamic in nature and are continually updated, that is, they change according to changes in the field. It is especially important to note that the level of threat increases with the decrease in the natural spread of the species, ie growing in the case of endemic species.

The largest number of endangered species is endemic, ie narrowly localized in the distribution and ecologically stenovalent, and the disappearance of such species can not be compensated from another reserve "genetic source, as is the case with regionally disappearing species that can be reintroduced from of the preserved populations somewhere else.[6]

Unfortunately, in Bosnia and Herzegovina, there are still no Red Lists at the state level. In RS, a list of protected species was adopted in 2012, entitled "Red list of protected species of flora and fauna of the Republic of Srpska" ("Official Gazette of RS" No. 124/12) in which the categories of endangered species of certain species are not given. On the other hand, in 2014, the "Red List of Wild Species and Subspecies of Plants, Animals and Mushrooms" was adopted in the FBiH ("Official Gazette of the Federation of BiH", No. 7/14) in which there is category of threat in addition to each species listed in the document.[7]

Although the Red Lists are documents that should be based on the same internationally accepted methodology, in reality, in BiH there are two completely

6 Tatjana Ratknic, 2017: ENDAGERED PLANT SPECIES IN SERBIA, Centre for ecology and forestry "Sylva", available at: http://sylva.rs/doc/Ugrozene%20biljne%20vrste%20u%20Srbiji.pdf

7 Protection of endagered species in BiH, blog biolog.ba, 24.05.2017, available at: http://biolog.ba/58-zastita-ugrozenih-vrsta-u-bih.html

different documents and it is completely unclear on which parameters the selection and categorization of species was made.

Due to this, it is difficult to identify the real threat for certain animal species primarly those with a specific large radius of daily and seasonal migrations lies. These animals often migrate from one legal entity to another, so the threat assessment is based on a "double record" and is not adequate to the situation on the ground.

On the other hand, technical and organizational protection measures and operational activities on must have their explanation and legal foundation that should be based on a realistic assessment of the threat or insight into the state of the population on the ground. This requires a technical system that provides a permanent insight or at least insight with sufficient frequency, which is only possible by building a system for remote animal tracking and by organizing the systematic and technical protection of endangered species through a certified legal framework.

So-called Red books are Red Lists for a specific geographical region that are put together- these scientific professional publications list all types of organisms that are subject to protection according to the international classification of the level of threat:

- Critically endagered species;
- Endagered species;
- Vulnerable species;
- Rare species.

Rare and endangered species are protected by law in the way that their habitats are declared as strict nature reserves in which a special regime is governed and in which the activity of humans is minimized. Separation of endangered species and provision of habitats within a closed ecosystem represents the most effective way of protecting the species. However, such legal solutions create specific exclusivity and give special rights to park management as well as to special organizations dealing with species protection. Although the legislator's intention is to provide and support the protection of some endangered species in this way, the facts on the ground show that giving wide and particularly exclusive powers is often the source of corruption and the basis for many illegal and even criminal activities. So it is not unusual for the park management to behave as monopolists, using the natural resources as a source for acquiring material and financial profits through trade and / or poaching of the endangered species that they should protect. Measures of technical protection and, in particular, infrastructure for remote control of endangered species of plants and animals, enables the protection and operational measures for protection of endangered species and nature reserves to become transparent and public, and to introduce adequate control of the

protection of endangered species and habitats as such. The fact that certain park managements oppose this is an indirect indicator that clearly shows that the operations are not carried out in an adequate and legally prescribed manner. On the other hand, the mentioned infrastructure enables wide popularization and raising awareness of the wider community regarding the need to preserve the natural environment and endangered species in it.

CONSERVATION AND MANAGEMENT OF NATIONAL PARKS

In order to protect endangered species and their habitats today, institutional as well as not institutional measures are applied. Institutional measures are mainly related to the activities of states and governments, while non institutional measures represent all forms of private initiatives to preserve the living world and bio diversity. The United Nations, as an umbrella organization that, among other things deals with the organization of national and international nature conservation initiatives. It has provided a number of recommendations and definitions, as well as standards in the field of conservation of nature and protection of endangered species. The Act on Endangered Species recognizes that fish, wildlife and plants have aesthetic, educational, historical, scientific and recreational values for people and that a person must protect these valuse, common to all people.[8]

In the past, institutional steps have been taken to protect special nature reserves, within which a number of protected animal species have been provided with protected habitats in such a way that a part of the territory in which that species is inhabited is given the status of a national park or other nature reserve. Increased demands for the expansion of civilian infrastructure have nevertheless led to increased pressure on these reserves, so there are indirect negative impacts on protected areas. These indirect effects are mostly the consequence of the change in the micro-climate due to changes in the geophysical properties of the adjacent land - the construction of dams and artificial lakes can cause changes in wind blow patterns, change in local humidity and capillary irrigation. The mentioned changes directly affect the ability of an ecosystem to produce food for herbivores and therefore for the predators that feed on them. The construction of thermal power plants or large industrial capacities, a highway or some other main road in the immediate vicinity of the protected reservation has a similar impact. In order to avoid this, there is a legal obligation to develop an impact study. An environmental impact study is often wrong in terms of giving long-term estimates about how the construction of an infrastructure object (civil, utility or energy system) will affect the environment.

8 Randall Abate, What Can Animal Law Learn from Environmental Law?, Environmental Low Institute, West Academic,2015 pp 160, ISBN 978-1-58576-176-0

Also, it should be emphasized that due to global climate change, the ecosystem's ability is further reduced in terms of producing the necessary amount of food for a certain number of animals. This leads to a reduction in the number of animals and their extinction unless a person intervenes in critical periods. The intervention primarily involves feeding starved animals through organized feeding facilities without a direct encounter between the rangers and the wild animals.

In order to be successful this type of temporary feeding must correspond with the habits of animals, with their natural migrations and daily needs. That is why adequate and current information provided by the remote animal tracking system is necessary for rangers and especially veterinarians and biologists. In this regard, it is important to note that the conservation and management of national parks can no longer be isolated attempts of park management and their teams to protect them, but the protection in terms of monitoring the conditions must be extended beyond the sphere of protected areas and work on protection projects must be performed in the wider community.[9]

In terms of nature conservation and conservation of individual isolated ecosystems such as the national parks, modern ICT technology provide multiple advantages compared to classical methods and techniques. ICT technologies offer the following advantages:[10]

• Enable determination of the exact population that settles the habitat within the protected area

• Provide a clear insight into the extent of the territory by individual members and species (one animal's territory, herd territory)

• Show if there are 'surplus' animals that do not have their own territory and which can be transferred to another protected area

• Provide insight into distribution patterns of particular species in a given area, by space and time

• Enable the monitoring and preservation of biodiversity

• Provide quick feedback data

Network infrastructure is the biggest problem with applying new ICT technologies to protected nature reserves. Most ICT technologies are applied in a way that data collection processes are separated from the process of processing and obtaining information, both scientific and operational

9 Fish and Wildlife Service I&M: Connecting Science-driven Monitoring to Management, National Wildlife Refuge System Inventory and Monitoring (I&M) initiative, Published on 4 Aug 2012, video, 23.12.2016, available at: https://www.youtube.com/watch?v=XutmC7QRGUM

10 Priya Joshi, Wildlife conservation through innovative technology: Priya Joshi at TEDxKathmandu, TEDx Talks, Published on 10 Jan 2013, video, 24.12.2016, available at: https://www.youtube.com/watch?v=bgM5kHZYrO8

ones in terms of management and popularization. For the former ones, it is necessary to provide a network and / or internet to protected nature reserves, while the latter ones are processed in separate data centers and / or within a cloud solution. It is clear that the most expensive and technically demanding part is equipping the entire protected area with the necessary infrastructure to provide internet access.

In areas where the degree of protection is lower, this is achieved by using standard wi-fi technology with minimal temporary disturbance of the natural habitat during the installation of the cable infrastructure connecting the end nodes and base stations. In the case of bringing the Internet in the areas with higher level of protection, this is done exclusively by the use of wi-fi technologies where the base stations are placed on the periphery of the protected area. In the case of the rainforest, due to the high density of vegetation, the above solutions would not be sufficiently effective. Therefore it is necessary to cover one part of the rainforest with access points used for network devices installed in the animal collars that are monitored from the air. (AP mounted on drones, balloons or small airships). The fact that Canada is planning to introduce wi-fi in its national parks and thus enable faster and easier data transfer than that one based on mobile technology proves that the idea of installing and using wi-fi technology gets its supporters.[11] Such plans and implemented solutions clearly point to the aim of reducing the operational costs of national parks, while improving and raising the quality of advertising and the provision of distance attendance, for animal lovers and for scientific and educational purposes.It is important to emphasize that without the construction of the appropriate wi-fi network infrastructure there is practically no possibility to apply modern ICT technologies in the field of monitoring and management of nature reserves and protection of endangered species. For adequate data collection, it is necessary to have a network whose transmission latency corresponds to the amount of generated traffic. It is known that IoT devices, especially sensors requiring emulation of continuous monitoring, generate large amounts of data to be transported to the central server on which the data processing will be done and the necessary information will be generated.

IOT FRAMEWORK

One of the important advantages of the wildlife monitoring system in their natural habitats using IoT technologies is reflected in the greater transparency

11 Wi-Fi in the woods: Canada plans to install web hotspots across its national parks and historic sites, Daily Mail, 29 April 2014, On Line izdanje, 24.12.2016, available at: http://www.dailymail.co.uk/sciencetech/article-2616007/Wi-Fi-woods-Canada-plans-install-web-hotspots-national-parks-historic-sites.html#ixzz4TmNxjQeH

of the ecosystem process. In that way we can learn how the ecosystem works and not only focus on the salvation of one endangered species, because such a restricted approach often does not give results. If we turn the monitored animal into a kind of a digital product it will create millions of specific measurements[12], that is, the data needed to create a deeper and better insight into its life, but also the behavior, habits and overall biological needs of the whole species. IoT and BigData solutions allow us to collect and process a large number of data and to create new insights based on it. The best indicator of how advanced this technology is in terms of providing new insights is the fact that it is being increasingly mentuoned in scholarly literature.

The reasons why today's development can be described as the Biotelemetry Revolution are:

• Devices are smaller in size and mass, there are a large number of small integrated GPS devices on the market

• Thanks to Cloud technologies, it is possible to collect partial data streams and combine them in order to obtain the most reliable information either in real-time or delayed.

It should be noted that not only does IoT and Big Data provide new scientific insights, but also a new form of resource management which can be called real-time management based on real information. This kind of management represents a quantitative and qualitative leap from the former management style. Also, the IoT framework is an opportunity to turn ideas into digital products and this raises the question of whether this method can turn a rainforest into a digital product which would be self-sustainable economic model that would protect the rainforest. There is an idea to find new business models to facilitate the operation of protected nature reserves. By converting a national park or protected species into a digital product, it is possible not only to popularize the idea of protection, but it is also possible to obtain additional financial resources to support the work of the nature reserve itself.

ICT helps build both social and infrastructural capacity that is a prerequisite for spreading the awareness of the necessity of protecting endangered animal species, and it does so in the following ways:[13]

• Raising the general level of public awareness of the problems of survival and protection of endangered species

• Provides educational opportunities

• Provides opportunities for professional development of necessary staff to protect endagered speices

12 Daniel Smith, 2015 September Webinar IoAHTedited, TheCSAlliance, University of Cambrige, Cambrige Service Alliance, Published on Sep 15, 2015, video, 23.02.2017, available at: https://www.youtube.com/watch?v=DQew3ESgZoQ

13 John Houghton, ICT and the environment in developing countries: opportunities and developments, Centre for Strategic Economic Studies, Victoria University, Australia, *October 2009,*

ANIMAL INTERNET

One way of transforming protected animals into a digital product is their popularization through the so-called animal Internet and animal social networks. Animal internet represents the level of services directly derived from the IoT solution while the animal social network can be described as a marketing strategy for applying social networking techniques to popularize protected animal species, creating and strengthening links between younger generation and endangered animals and as a marketing and business platform for commercial business activities and raising funds for the preservation of the mentioned species - contributions to the rangers, the nutrition, the necessary infrastructure, the sale of art objects and souvenirs in order to obtain funds.

Some of the techniques used in the application of ICT technologies in real business related to the conservation of protected species are:

• National Geographic has made a website - aggregator - showing images of all the animals to which cameras are attached, and site users see the same things as animals.

• We can use the infrastructure and triggers in such a way that an animal sends a twit or a message when it catches a prey (for example, the cat catches the mouse)[14]. In this way, the attention of the audience is maintained, and all "uninteresting frames, that is," boring "periods when the animal rests and does nothing" are deleted.

• The ability of the user to locate and find an animal at any time and record it (exclusive recording) - thanks to the fact that the necklaces send GPS coordinates,

• Possibility to locate and locate an animal at any time and record it (exclusive recording) - Due to the fact that necklaces send GPS coordinates, the users of the network can position themselves at the same dron coordinates and capture an exclusive recording which is additonally charged.

• Possibility of interactive transmission of wolves or lynx hunting (also using multiple drones allowing interactive transmission)

Also, if the visitors of the national park find themselves in direct contact with large predators, there is the possibility of timely remote notification of the danger. About the possibility of using the Internet as an interface for connecting different biological species, one of the Internet designers Vint Cerf made the following statement: "When the internet was designed, we thought it was a system that connects computers, and it turned out to be the system that

14 Dr Genevieve Bell, The Internet of Beings: Or, What are the Animals Telling Us?, Research Computing Centre, Published on Aug 9, 2016, video, 23.02.2017, available at: https://www.youtube.com/watch?v=iEosTaPyxOs

15 Vint Cerf, The interspecies Internet? An idea in progress..., TED, Published on Jul 10, 2013, video, 23.02.2017, available at: https://www.youtube.com/watch?v=wGMLhaa98GI

connects people, what we now see is that we should not restrict the network to existing types of connections, but other intelligent types should use the network as well.[15]" As more and more torists are visiting national parks, the likelihood of a casual encounter between tourists and animals within the park increases. More importantly, wild animals in the natural environment often suffer from illnesses that can be transmitted to humans, so it is of great importance to treat the injuries and illnesses of wild animals so they wouldn't spread beyond the boundaries of the national park. Because of this it is crucially important to find diseased animals as quickly as possible with the non-invasive method and cure them. In such situations it is particularly important to quickly and easily locate the animal and its movement, which is greatly facilitated by the use of GPS modems and wi-fi devices embedded in necklaces and / or bracelets attached to animals (Project Code: 1810, 2017)[16] In this way, a clear insight into the movement of animals is achieved and animals leaving the protected areas and attacking farmers' livestock can be traced. Therefore, it is possible to locate the attackers, to identify their habits and to compensate the damage to farmers.

ELEMENTS OF THE SYSTEM

REPETITORS AND AP

Remote monitoring of animals was earlier done by using technologies based on emission techniques in the area of publicly available frequencies and radio devices. This technology is reliable, but rather obsolete because devices are bulky, and a relatively large amount of energy is required to power them. Also, one of the disadvantages of the mentioned technology is that for monitoring purposes it is necessary to build a number of stationary transmitters that are massive and they must be placed on the antenna poles that are at a mutual distance in proportion to the half of the wavelength EMS they use. This technical requirement often limited the use of radio waves devices in specially protected ecosystems such as rainforests, because placing them in a protected ecosystem would essentially disrupt them which was not allowed by the laws on nature conservation. Due to the massiveness of the transmitter antennas, it was not possible to put them in the air so this was an additional disadvantage in terms of adequate monitoring of wild animals. The emergence of new ICT technologies, primarily wifi technology and then mobile Internet technology has made it possible to overcome these shortcomings, and to make the appropriate non-

16 GPS based Wildlife animal tracking system, Microtronics Technologies, blog, 24.02.2017, available at: http://www.projectsof8051.com/gps-based-wildlife-animal-tracking-system/

17 Project Loon : Now Google launches BALLOONS in bid to bring internet to the remotest places on Eart, PatrynWorldLatestNew, Published on Jun 15, 2013, video, 24.02.2017, available at: https://www.youtube.com/watch?v=_0iqX9Lq5B8

invasive infrastructure necessary to track wildlife movements. As protected national parks and other nature reserves are located far from urban areas, there are many technical, organizational and economic constraints on the use of ICT technologies, especially in environments such as the jungle. It is difficult to achieve an economically viable Internet infrastructure in remote and inaccessible regions. Google's project Loon secures reliable internet access at high speeds and bandwidths in remote and rural areas in an economically viable way.[17] The project uses high-altitude balloons as repeaters or WiFi AP devices placed in the stratosphere to create an aerial wireless network and it has shown a high level of reliability. The repetitor set up so highly allows people and animals to have a signal where they have not previously had it and to connect to the Internet immediately after major disasters. By using LTE technology and balloons, the speed of 15 MB / s and 40 MB / s can be achieved, depending on the operating range and characteristics of the client's WiFi wifi device.[18] For large areas and wider protected areas Wi-Fi technology becomes inadequate and it has to be replaced with GPS and GSM technology to keep track of animals in the wider area. If the number of transmitters increases in terms of increasing the density, the density of the network used for positioning also increases. For exact spatial positioning, the tag being tracked has to be accessible or connected to at least three APs. Another advantage of wi-fi technology is that the AP can also be positioned in the air, or placed on the drones and / or balloons above the area that should not be disturbed by placing infrastructure elements.

COLLARS

Another important element of the wildlife monitoring system in their natural environment is the passive tag, that is, the necklace containing the wi-fi device recently integrated with the sensors to monitor the physiology and metabolism of the animal. Larger animals, especially predators, such as lions, bears, lynxes or wolves with ease wear these collars easily and they do not hinder the normal performance of all daily activities. Due to the weight limit, when it comes to birds, this tag is most often a ring placed on a leg in the form of a passive antenna, enabling tracking of the animal's location, but not the monitoring of some other life functions. All monitoring systems based on placing necklaces or other active markers / sensors on animals have one drawback. They rely on batteries as an energy source, so the necklaces, or batteries, must be changed from time to time in order for the device to work. This problem could be solved by using low power consumption sensors and

18 Inside Google's wildly ambitious internet balloon project, The Verge, Published on Mar 2, 2015, video, 24.02.2017, available at: https://www.youtube.com/watch?v=OFGW2sZsUiQ

modems but even in that case battery consumption is a problem.

For some larger birds, predominantly vultures, it is possible to use a collar with a limited number of sensors while GPS modem is used for locating them. The accuracy of monitoring with this type of collar is defined at a resolution of 500 meters if the base stations are used for goniometry, while it is significantly increased if the goniometry is performed with the moving object (drones for active goniometry) and can be reduced to below 10 meters.[19] The 3D position is usually obtained by interpolation between measuring points obtained by direct measurement.[20] This is due to the fact that most land animals fairly move in the vertical plane - rare, mostly periodic seasonal migrations.

Tracking devices (collars) can be sorted according to the following characteristics:

• The type of device and technology used

• Energy budget and operating autonomy

• Device size

• Number of sensors integrated in the device and their accuracy

• Data rate and network truthput

• Adaptability of the device to animal behavior

• Attaching method and location

Modern tracking systems must support 2D and 3D modes of wildlife monitoring. The 3D monitoring mode is especially interesting for birds, fish, large mammals living in the sea or lake waters, animals living in tree canopy, animals with periodic migration from north to south, or vertical migrations to more and lower regions.

Some of the areas where collar technology is applied today are:[21]

• Identification of an individual animal in a group

• Tracking the animal and its movement, as well as social behavior

• Monitoring of animal health

• Communication between animals and humans and between animals and things (eg feeder, warer troughs, etc.)

• Behavior regulatory mechanisms (various types of speakers that are carried on the collar and can be remotely activated whenever an animal enters forbidden area)

Since the autonomy of the device depends on the number of logs that the device will send to a server in the unit of

19 M.K.Nor, M.S. Masbop, Smart Livestock Tracker, The International Journal of Engineering And Science (IJES), 2015, Volume 4, Issue 7, PP 25-29, ISBN (e): 2319-1813, ISSN (p): 2319-1805

20 Dr Robert Sinkovits: Improving Wildlife Tracking via HPC, Research Computing Centre, Published on 7 Dec 2015, video, 23.12.2016, available at: https://www.youtube.com/watch?v=uubLZwIuEjU

21 Lena M Holmberg, Internet of Animals, 05.07.2016, blog, 03.03.2017, available at: http://lenamholmberg.blogspot.ba/2016/05/internet-of-animals.html

time, an acceptable flow time is required for each type of monitored animal. This flow time depends on the species and gender, but also the lifestyle and behavior of the individual. For example, tagged fish can be tracked for up to two years after setting up a tracking devices. The energy budget must enable at least half of the annual cycle - the collars must not be changed during the mating season due to the aggressiveness of the males. Also, cubs must not be equipped with collars until they reach full maturity due to intense growth. Once the battery dies the whole collar should be changed because it has to stay impermeable so that the sensor system and antenna can work. Most collars are made in so-called vandal proof housings in a part related to antenna, power supply and sensor storage (IP67 standard).

DRONES

The problem of covering the territory, namely, monitoring the population with a minimum number of static and dynamic sensor systems is resolved by an optimal combination of static devices and dynamically robotized autonomous systems (often called drones) for data collection. The optimum number of drones for the highly popular digital web platform, that is, the extremely popular social group of animals, can be estimated at about half of the population, meaning that one dron can adequately monitor more members of species, especially those species that gather in packs and herds.

A large number of drones in such scenarios are used for individual monitoring of single males, who may be expected to attack dominant males and attempt to secure their position and entitlement to females. In this way not too much time is spent on unattractive content when animals rest and do nothing that would keep the audience particularly entertained. In addition to being used for monitoring, recording and controlling individual animals, drones are also used in national parks to control the periphery, prevent curls and/or cutting of forest in a protected area. In this way, drones become an essential tool for improving the work of the ranger service, but also for controlling their work, as they enable the global insight of the public into events and possible illegal activities within national parks. Drones are also used to collect data on distributed systems such as flocks of fish or mosquitos or other flying insects and birds. The use of autonomous robots allows a much wider image than the static devices because, besides the geometric data (position, distribution, trajectory), it also provides a number of semantic information such as the number of defective fruits (apples) on the tree.[22]

The first task of automated robotic systems for the monitoring of wild animals in nature is to find or, to detect the signal from the necklace, ie, the

tag. This task in terms of dispersedly distributed systems such as flocks or bird flies can be performed with automatic search algorithms: a dron travels over some surface and searches for the signals which then are processesed (counts, collects data after initiating communication, etc.), then it sends to some cloud location where business logic and mapping software, that gives GIS data through a map of a terrain are located.

Covering the territory with autonomous robots is done using the following search techniques:

• Stationary coverage search model

• Stochastic model - the random movement of the drones that collect data

• Contradictory - cross-collecting data with the following two game theory models:

o Active avoidance of the meeting

o Avoidance game (cat and mouse game)

LiDAR cameras are often used as active devices for capturing the state of the drones. Their resolution is large enough to map all recorded elements of the ecosystem, giving real 3D views of the current state of the system, that is, allowing real movement through the elements of the system in all directions. The advantages of using drones in terms of protecting national parks, as well as insights into the life and behavior of wild animals compared to other technologies are reflected in:[23]

• Cheap technology (compared to airplanes, and a large on-site patrol service)

• Easy to use

• Available for use (standard technology that is rapidly evolving)

• Multifunctional platform - can be used for tracking animals, collecting data from collars and sensors attached to animals, capturing nature and animals in nature, tracking people (tourists, lost people, searching for and preventing the activity of hunters and those who try illegal logging), early detection and localization of the fire, notification of the closest patrol of the rangers, supporting field operations, support for quick responses

Additional advantages of using drones can be counted as follows:[24]

• Easy location of fairly hard-to-spot animals (Orangutans, Gorillas,

22 Ibrahim Volkan Isler, Associate Professor, University of Minnesota, RI Seminar: Ibrahim Volkan Isler: Robotic Data Gathering in the Wild, November 04, 2016, video, 23.12.2016, available at: https://www.youtube.com/watch?v=tcTUv0wW7J8

23 Wildlife conservation with the help of drones: Kitso Epema at TEDxUtrecht, TEDx Talks, Published on 28 Apr 2014, video, 23.12.2016, available at: https://www.youtube.com/watch?v=LT9q6kra9Oc

24 Using drones to conserve natural habitats | Professor Serge Wich | TEDxLiverpool, TEDx Talks, Published on 20 Aug 2014, video, 23.12.2016, available at: https://www.youtube.com/watch?v=GTsMi43Mugo

Chimpanzees in tropical forests) - thanks to dronos it is easy to detect and track migrations

• Ai technologies (automatic optical recognition) increase the probability of recognizing settlement in tree canopies

• Drones can be used in the "data mule" scenario, where they collect data from sensors and cameras (static) to free memory for future work, emptying data loggers. Due to the low flying potential, communication is possible in the near field, so less energy is used for communication and there is the possibility of uploading large files (HD cameras)

• Compared to conventional manual animal data collection, drones are up to 200 times more effective than humans (it takes about 20 minutes for drone to locate animals and collect data from monitoring devices while biologists and the rangers need up to 3 days for the same task (using hunting tracking techniques)

• Drones can fly low enough and give images of large resolutions, as well as record in infrared

• They can be made as DIY project

• Due to the high cost-savings based on their high efficiency, it is possible to reallocate budget resources and purchase additional equipment (other types of hardware and software that can be used on drone platforms)

Legal restrictions on the use of automatic robotic systems and handheld drones

Although drones are perhaps the most efficient platforms for monitoring the lives of wildlife in their natural environment and therefore extremely interesting technical solutions, their usage is hampered by the fact that the drones are a new legal area in which there are no clear regulations

and the legislators are late with the legal framework for their use. A particular problem of the use of drones for this purpose is the fact that drones are usually not produced in the countries of use and that for their production there are no clear quality standards that producers and importers should adhere to. Since drowns belong to aircraft, in most countries, they are subject to special regulatory commissions and air traffic control (if the flight exceeds a certain threshold defined by local laws) and the flight is carried out beyond the limited airport areas. A special problem is also the fact that drones are most commonly used for aerial scouting with mounted cameras that can be misused for unauthorized surveillance, monitoring and even for the purpose of voyaging, which all falls under special laws that are not extended in most of the countries even to this new legal domain.

Considering legal, moral and other limitations of the use of the drones, we must ask and resolve the following questions:[25]

• Who regulates the rights to use the

25 Best and worst states when it comes to drone laws, Drone U, Published on 6 Sep 2016, video, 24.12.2016, availabe at: https://www.youtube.com/watch?v=p7DEAXLXeZY

aircraft and in what way?

• How to get a drone license? Who issues a license or this area hasn't been regulated yet?

• Who is responsible for the fall of the aircraft? Especially if, with its fall, it causes material damage and / or endangers human lives?

• Are there legal procedures for the maintenance of the aircraft? Are there any certifications and what kind of experts issuethem to both aircraft and those who maintain them?

• Should a dron have its own logbook and how it is being kept?

• In the case of a DIY drone, who issues an operating license? How to control the quality of production and whether the safety standards are met?

• How are the drones with instruments in the visible spectrum regulated, regarding the privacy of those that can be covered with recorded material?

• What is the minimum flight altitude - prescribed by the air traffic control agency?

• Does any state authority - the agency you are addressing, have the competencies to answer your questions regarding the regulations governing the use of drones?

What is particularly important to emphasize is the fact that although drones are an ideal platform for application in the field of monitoring wild animals in their natural habitats, certain countries legally prohibit their use in national parks, for example Mexico.

In some US states, this ban has been expanded due to possible voyeurism and / or drug trafficking across the border, and the use of this technology in border areas can lead to up to 5 years in prison.

Even in cases where certain areas of application of drones are regulated, there is a lawful possibility of a lawsuit, but in that case, one who complains about a breach of privacy must prove that there was an intention to abuse this technology in order to violate the complainant's privacy. Counterargument in such a legal battle is certainly a reference to a reasonable expectation of privacy with regard to modern technologies that have similar possibilities of insight into someone's privacy. This is particularly interesting since the hunters and tourists who have violated some of the rules of the national park (burning fire, throwing garbage, damaging the crop etc) are most often the ones who complain about the violation of privacy, so for the purpose of applying drones as a means of protecting the natural environment for wildlife it is necessary to have the appropriate clear legal regulation to clearly and unambiguously regulate this area.

SERVER INFRASTRUCTURE AND SOFTWARE

The next significant part of the infrastructure is the server and storage infrastructure that can be implemented as a cloud solution, which means that it does not have to be directly connected to the location. The benefits of such performance are primarily reflected in the ability to provide an adequate infrastructure that would, depending on the access rights and capabilities of the client software, give the various interested parties exact information and data they need. Also it would seperate obtained data in those that would be used for marketing presentation of animals in order to create a critical mass of the on-line followers and provide funding for a national park or other form of organization in the protected territory and necessary data for biologists, veterinarians and analysts to make adequate analysis and scientific and expert studies of animal behavior. The hardware infrastructure elements of the data center include: Server, Storage devices, frirewall, DRC, or the following virtual inn infrastructure: VM-web server, VM-RBDMS, VM-image, FTP, VM-AVServer, VM-AppServer, VM-InteroperabilitySystem, VM-ImageSocialNetwork. All of the above hardware and software infrastructure can be implemented as a service that is rented for a certain period, so in this way it is possible to facilitate the financing of animal tracking projects, whether they are of the commercial nature or part of a scientific research.

DATA COLLECTION

The ability to collect and process credible information on various aspects of the environment enables quality control and management, both of natural resources and of external influences that can endanger the environment.[26] With good selection of data collection technology we can collect data in a minimally invasive way regarding interference in the ecosystem, so the risks related to environmental security related to data collection can be minimized. Data collection can take place at two separate levels: at the data level of the animal itself, monitoring and recording data - animal status indicators and and at ecosystem level, monitoring and reporting environmental parameters taken from a wider ecosystem. ICT systems implemented in a proactive way ensure the sustainability and protection of the ecosystem as a whole, and not just of individual biological species. It is also important to note the following facts. Without the use of IoT technology in practice, veterinarians base their

26 Mira Mileusnić Škrtić, Karolina Horvatiničić, Dragutin Vuković, Risks and opportunities for applying new technologies in terms of environmental protection and sustainability - from the aspect of ICT application, , scientific symposium DEVELOPMENT AND ENVIRONMENT - PERSPECTIVE OF SUSTAINABILITY , 2011, available at: https://bib.irb.hr/datoteka/550944.Rizici_i_mogucnosti_primjene_novih_tehnologija.pdf

patient knowledge and their concerns on short consultations with rangerss and biologists who have observed unusual behavior of the animal.[27] Most of the national parks take care of their animal and protected species in this way, because so far it has been the usual form of animal monitoring and management. Since this is a very unreliable way of monitoring health, the development of integrated cloud based solutions over the collected data is directed towards finding algorithms that would create a matrix of behavior patterns for each individual animal and compare it with the current behavior of the animal, and on the basis of it, determine whether the animal behaves in the limits of the usual behavior or beyond those boundaries. In case of unusual behavior mechanisms for additional monitoring and veterinary team would be included. It is important to state out that for most wild animals, there is no clear reference range for biological indicators because enough measurements, that could be a reliable predictor of future animal behavior and assessment of its health status, have never been performed.[28] This circumstance leads to reduced accuracy in prediction of animal behavior, but also the necessity to reach this data as quickly as possible, so besides the classic BigData model, application of machine learning algorithms and artificial intelligence is very likely. Also, these data collection technologies have great advantages when assessing the load of an isolated ecosystem with the number of members of a certain species. Today forestry farms are most often managed on the basis of data representing the population's estimation of a species.

For example, for predators, it is necessary to estimate the number at least 3 times a year depending on the change of seasons and the period of mating and raising the young. the following data is taken as the methods for assessment: directly collected, indirectly collected, re-capture and counting of animals and estimation of population density based on presumed social behavior of animals using statistical methods.[29] In this way, accurate data are often not obtained, and abusive calculations of both large and capital prey are also possible. The population counting and statistical methods in the future will be replace with systems for direct monitoring of wild animals, which at the same time will become a media platform for spreading awareness about the need to preserve the species. By collecting real-time data from the field, it is possible to make well-

27 Anne Accardi, How the Internet of Things is Impacting Animal Health Part 2: Companion Animals, 11.09.2017, Engage Mobile, 03.03.2017, dostupno na mreži: http://www.engagemobile.com/how-the-internet-of-things-is-impacting-animal-health-part-2-companion-animals/

28 Dr Elisabetta Canali, ANIMAL WELFARE ASSESSMENT THROUGH SMARTPHONE APPLICATIONS: CHALLENGES AND OPPORTUNITIES, OIEVideo, Published on Dec 7, 2016, video, 02.03.2017, available at: https://www.youtube.com/watch?v=FK1vcb-G9nk

29 ESTIMATING WILDLIFE POPULATIONS, FW (ZO) 353, Wildlife Management, 02.03.2017, available at: https://projects.ncsu.edu/cals/course/fw353/Estimate.htm

based and informed decisions regarding the maintenance of ecosystems within the limits of biological capabilities and anticipate adequate scenarios for critical situations.

CONCLUSION

From all of this, it is evident that modern ICT technologies represent not only a technological basis for collecting data for scientific and professional wildlife behavior studies, but also a very useful basis for monitoring and managing real operations within national parks. An implementation of these technologies in order to achieve educational, scientific and commercial goals, and in the long term, allow the additional financing of parks and all operations related to the protection of animals is a priority in the near future. This is even more important given the fact that the above-mentioned business model based on the business model of the animal internet and endangered species itself involves the provision of financial resources necessary for protection, thereby reducing the burden on the budget and the processes of wildlife protection becoming transparent and self-sustainable.

REFERENCES

1. W. W. Cochran, D. W. Warner, J. R. Tester, V. B. Kuechle, Automatic Radio-Tracking System for Monitoring Animal Movements, Reprinted from BioScience, Vol. 15, No.2, 1965, pp 98-100, dostupno na mreži: https://www.researchgate.net/publication/247840577_Automatic_Radio Tracking_System_for_Monitoring_Animal_Movements
2. ERIC SCHMITT, 'Natural' Habitats Offer Insights Into Social Behavior of Animals, The New York Times, January 26, 1988, available at: http://www.nytimes.com/1988/01/26/science/natural-habitats-offer-insights-into-social-behavior-of-animals.html
3. Jessica Ellis, Mel Hall, Phil Ong, Leif Wege, Natalie Paterson, Chelsea Smith, Animal Testing at Dalhousie University: A brief insight into social, economic, and environmental effects of nonhuman animal testing, Dalhousie University, 2010, available at: https://www.dal.ca/content/dam/dalhousie/pdf/science/environmental-science-program/ENVS%203502%20projects/2010/AnimalTesting.pdf
4. Allan Savory, How to green the world's deserts and reverse climate change | Allan Savory, Published on Mar 4, 2013, video, 02.03.2017, available at: https://www.youtube.com/watch?v=vpTHi7O66pI
5. Tyler Stitt, Julie Mountifield, Craig Stephen, Opportunities and obstacles to collecting wildlife disease data for public health purposes: Results of a pilot

study on Vancouver Island, British Columbia, Canadian Veterinary Journal, 2007 Jan; 48(1): 83–90., available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1716737/#

6. Tatjana Ratknic, 2017: ENDAGERED PLANT SPECIES IN SERBIA, Centre for ecology and forestry "Sylva", available at: http://sylva.rs/doc/Ugrozene%20biljne%20vrste%20u%20Srbiji.pdf
7. Protection of endagered species in BiH, blog biolog.ba, 24.05.2017, available at: http://biolog.ba/58-zastita-ugrozenih-vrsta-u-bih.html
8. Randall Abate, What Can Animal Law Learn from Environmental Law?, Environmental Low Institute, West Academic,2015 pp 160, ISBN 978-1-58576-176-0
9. Fish and Wildlife Service I&M: Connecting Science-driven Monitoring to Management, National Wildlife Refuge System Inventory and Monitoring (I&M) initiative, Published on 4 Aug 2012, video, 23.12.2016, available at: https://www.youtube.com/watch?v=XutmC7QRGUM
10. Priya Joshi, Wildlife conservation through innovative technology: Priya Joshi at TEDxKathmandu, TEDx Talks, Published on 10 Jan 2013, video, 24.12.2016, available at https://www.youtube.com/watch?v=bgM5kHZYrO8
11. Wi-Fi in the woods: Canada plans to install web hotspots across its national parks and historic sites, Daily Mail, 29 April 2014, On Line izdanje, 24.12.2016, available at: http://www.dailymail.co.uk/sciencetech/article-2616007/Wi-Fi-woods-Canada-plans-install-web-hotspots-national-parks-historic-sites.html#ixzz4TmNxjQeH
12. Daniel Smith, 2015 September Webinar IoAHTedited, TheCSAlliance, University of Cambrige, Cambrige Service Alliance, Published on Sep 15, 2015, video, 23.02.2017, available at: https://www.youtube.com/watch?v=DQew3ESgZoQ
13. John Houghton, ICT and the environment in developing countries: opportunities and developments, Centre for Strategic Economic Studies, Victoria University, Australia, October 2009,
14. Dr Genevieve Bell, The Internet of Beings: Or, What are the Animals Telling Us?, Research Computing Centre, Published on Aug 9, 2016, video, 23.02.2017, available at: https://www.youtube.com/watch?v=iEosTaPyxOs
15. Vint Cerf, The interspecies Internet? An idea in progress..., TED, Published on Jul 10, 2013, video, 23.02.2017, available at: https://www.youtube.com/watch?v=wGMLhaa98GI
16. GPS based Wildlife animal tracking system, Microtronics Technologies, blog, 24.02.2017, dostupno na mreži: http://www.projectsof8051.com/gps-based-wildlife-animal-tracking-system/
17. Project Loon: Now Google launches BALLOONS in bid to bring internet to the

remotest places on Eart, PatrynWorldLatestNew, Published on Jun 15, 2013, video, 24.02.2017, available at: https://www.youtube.com/watch?v=_0iqX9Lq5B8

18. Inside Google's wildly ambitious internet balloon project, The Verge, Published on Mar 2, 2015, video, 24.02.2017, available at: https://www.youtube.com/watch?v=OFGW2sZsUiQ
19. M.K.Nor, M.S. Masbop, Smart Livestock Tracker, The International Journal of Engineering And Science (IJES), 2015, Volume 4, Issue 7, PP 25-29, ISBN (e): 2319-1813, ISSN (p): 2319-1805
20. Dr Robert Sinkovits: Improving Wildlife Tracking via HPC, Research Computing Centre, Published on 7 Dec 2015, video, 23.12.2016, available at: https://www.youtube.com/watch?v=uubLZwIuEjU
21. Lena M Holmberg, Internet of Animals, 05.07.2016, blog, 03.03.2017, dostupno na mreži: http://lenamholmberg.blogspot.ba/2016/05/internet-of-animals.html
22. Ibrahim Volkan Isler, Associate Professor, University of Minnesota, RI Seminar: Ibrahim Volkan Isler : Robotic Data Gathering in the Wild, November 04, 2016, video, 23.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=tcTUv0wW7J8
23. Wildlife conservation with the help of drones: Kitso Epema at TEDxUtrecht, TEDx Talks, Published on 28 Apr 2014, video, 23.12.2016, available at: https://www.youtube.com/watch?v=LT9q6kra9Oc
24. Using drones to conserve natural habitats | Professor Serge Wich | TEDxLiverpool, TEDx Talks, Published on 20 Aug 2014, video, 23.12.2016, available at: https://www.youtube.com/watch?v=GTsMi43Mugo
25. Best and worst states when it comes to drone laws, Drone U, Published on 6 Sep 2016, video, 24.12.2016, dostupno na mreži: https://www.youtube.com/watch?v=p7DEAXLXeZY
26. Mira Mileusnić Škrtić, Karolina Horvatiničić, Dragutin Vuković, Risks and opportunities for applying new technologies in terms of environmental protection and sustainability - from the aspect of ICT application, Scientific Symposium DEVELOPMENT AND ENVIRONMENT - PERSPECTIVES OF SUSTAINABILITY, 2011, available at: https://bib.irb.hr/datoteka/550944.Rizici_i_mogucnosti_primjene_novih_tehnologija.pdf
27. Anne Accardi, How the Internet of Things is Impacting Animal Health Part 2: Companion Animals, 11.09.2017, Engage Mobile, 03.03.2017, available at: http://www.engagemobile.com/how-the-internet-of-things-is-impacting-animal-health-part-2-companion-animals/
28. Dr Elisabetta Canali, ANIMAL WELFARE ASSESSMENT THROUGH SMARTPHONE APPLICATIONS: CHALLENGES AND OPPORTUNITIES,

OIEVideo, Published on Dec 7, 2016, video, 02.03.2017, available at: https://www.youtube.com/watch?v=FK1vcb-G9nk

29. ESTIMATING WILDLIFE POPULATIONS, FW (ZO) 353, Wildlife Management, 02.03.2017,available at: https://projects.ncsu.edu/cals/course/fw353/Estimate.htm

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